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THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.

No. 1,666. [VOL. LXV.] FRIDAY, APRIL 15, 1910.

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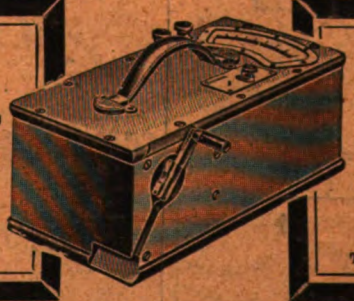

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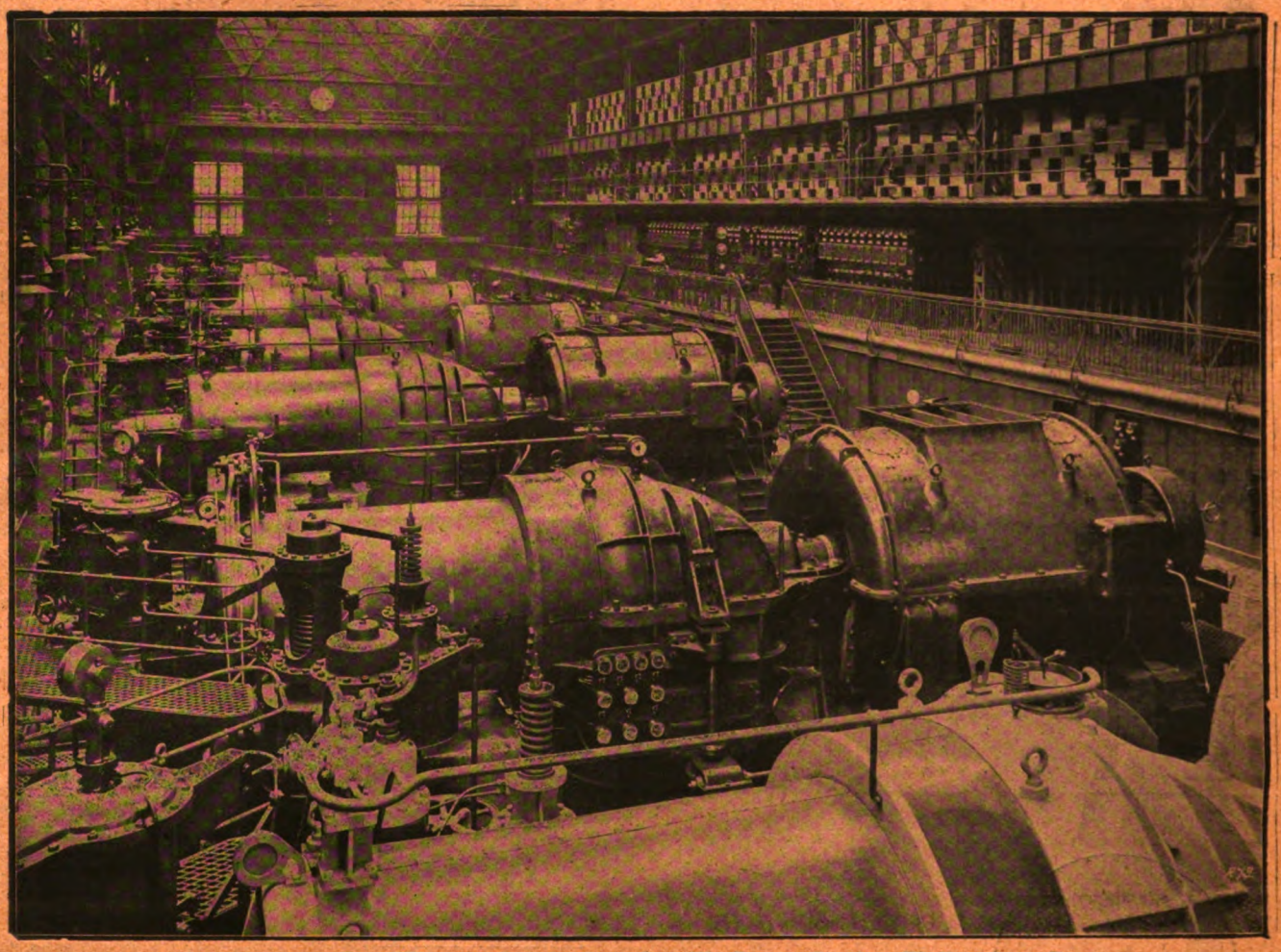

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VOLUME LXV.

(Second Series.)

FROM APRIL 15, 1910, TO OCTOBER 7, 1910.

ALSO

"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT,

APRIL, 1910, TO SEPTEMBER, 1910.

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Printed and Published by GEORGE TUCKER, at the Editorial, Printing and Publishing Offices of "THE ELECTRICIAN," Salisbury-court, Fleet-street.

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,665. [No. 1. Vol. LXV.] FRIDAY, APRIL 15, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Electromagnetic Physiological Effects.

FROM the earliest days of voltaic electricity the stimulation of nerve and muscle by electric currents has been familiar to the physicist, and within the last 20 years the application of this property has been extended to a marked degree in medical treatment and physiological research. So far, however, no corresponding magnetic effects have been discovered. This is not for want of investigation. Many years ago Lord LINDSAY (now the EARL OF CRAWFORD), assisted by Mr. CROMWELL F. VARLEY, constructed an enormous electromagnet, between the poles of which any observer might place his head; but the results were negative. Recently Prof. SILVANUS THOMPSON has turned his attention to the subject and has constructed a solenoid sufficiently large to admit an observer's head, the winding being traversed by an alternating current. This current is sufficient to produce a virtual field of about 1,000 C.G.S. units at the centre of the coil, or a maximum instantaneous value of 1,400 C.G.S. units. As will be seen elsewhere, on inserting the head into the interior of the coil there is a marked effect, a faint flickering illumination being perceived over the whole region of vision.

THROUGH the courtesy of Prof. THOMPSON we have had an opportunity of experiencing this new phenomenon. There is no question that a very distinct result is produced by the alternating field, though in all probability the effect will vary somewhat, depending on the subject. This is only to be expected with such an organism as the eye, which varies enormously in individuals and is often somewhat abnormal. The sensation we experienced was chiefly one of mechanical twitching of the eyelids when these were closed; there was also a sense of flicker, or rather the discomfort of flicker, though very little illumination was noticeable. In some eyes there might very possibly be more illumination and less twitching, and in any case the full effect on the eye, as in most experiments on vision, is liable to be missed unless the observations are fairly prolonged. It is somewhat curious that a current with a frequency of 50 periods per second should give rise to flicker effects which appear to have a frequency of, say, one-tenth this number, or less. As to the prime cause of the phenomena, it will, no doubt, be agreed that the effect is due to induced currents rather than to any magnetic effect pure and simple. The magnetic properties of the constituent parts of the eye, including nerves, are feeble, but their sensitiveness to currents is well known, though it must be remembered that in speaking of currents in such cases we imply the use of electrodes. In the present instance we are dealing with electrode-less currents. Possibly, such currents may find a useful application in electromedical work, but whether this be so or not Prof. THOMPSON'S observations open up an interesting field for investigation, and we do not doubt that the subject will be taken up with eagerness.

Allocation of Profits.

A DECISION of considerable importance to local authorities was given on Tuesday last by a Select Committee of the House of Commons. The point arose in connection with a clause in the Glasgow Gas Consolidation Bill, whereby the Glasgow Corporation sought powers to apply moneys out of the profits of the gas undertaking to the relief of rates. As proof that they did not intend to make undue use of this power, it was mentioned that during the last 40 years the Corporation had so applied

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only £21,000; but, nevertheless, the Select Committee struck out the clause, being probably influenced by the contention of the other boroughs and districts within the area of the gas supply that any profits should be applied to the reduction of the price of gas. This decision, of course, only applies to Glasgow, and, moreover, only to the gas undertaking in that city, but it probably marks the advent of a new feature in municipal finance.

It has been the custom in some cases for large contributions to be made from the profits of municipal tramway and electricity undertakings to the relief of rates. As an instance of this, we may mention that a sum of over £320,000 has been paid by the Manchester Corporation Tramways department to the City Fund during the last six years, whilst a similar sum has been contributed by the Glasgow Corporation Tramways in the last 15 years. Compared with these amounts, the use made of the profits of the Glasgow Gas department for the relief of rates is but trifling, so that the action of the Select Committee is the more noteworthy. It is true that the ruling of the Committee is an isolated case, but it is not unlikely that similar restrictions will be placed in the future on the use made of the profits of other municipal undertakings. In that case, ardent advocates of municipalisation will no longer be able to appeal to the public on the ground that municipally controlled undertakings provide large funds for relieving the rates. From a logical point of view little can be said in support of the policy of utilising the profits of any particular municipal undertaking for the benefit of all sections of the community, so that we think the action of the Select Committee will be to the benefit of municipal enterprise generally.

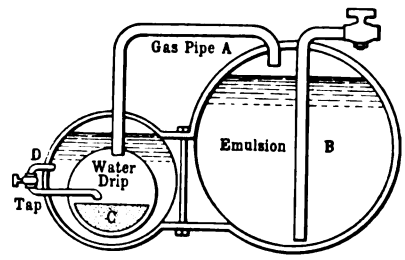
Comparisons.

There is an old and not untrue saying that "comparisons are odious." Nevertheless—particularly in technical matters—comparisons are often necessary, and many of the Papers that are written for our institutions deal very largely with the qualities of one kind of apparatus as compared with another. In some cases the comparisons are made in such a way that the reader is left in complete ignorance of the particular device to which allusion is made, and although this method fails to give the most complete information, it is sometimes adopted of necessity. The reader must then guess, as best he can, the identity of the inferior or superior article. In other cases the names are plainly stated, and this, no doubt, is preferable from the reader's point of view. We think that authors should in any case make up their minds quite definitely which course they mean to adopt. In an otherwise excellent paper by Mr. A. Gerrard, read before the Institution of Electrical Engineers at the last meeting, comparisons were made between the Westinghouse track brake and another track brake, of which the name was not given. In the case of the Westinghouse brake the name was plainly stated, and as a drawing was given of the brake with which it was compared, anyone familiar with the subject could recognise the latter. Other readers, however, would be in ignorance, and this brought forth a reasonable protest from Mr. A. W. Maley, the inventor of the anonymous specimen, and led to some personalities which could only be regarded as a "regrettable incident" in an otherwise interesting discussion. Mr. Gerrard's plain statement, that he had omitted the name because he did not wish to include it, does not seem to us to be a very satisfactory conclusion of the affair. At least, we hope that other authors will take warning and not put themselves in the wrong by including names in certain cases and omitting them in others, a course which is on neither side of the hedge.

Personal.—The King has granted to Mr. William Bullard, manager of the Eastern Extension Telegraph Co. at Shanghai, His Majesty's Royal licence and authority to wear the Insignia of the Third Class of the First Division of the Imperial Order of the Double Dragon conferred upon him by the Emperor of China in recognition of valuable services rendered.

Electrolytic Disinfecting Fluid.—In Poplar, for over four years, a plant has been at work making electrolytic disinfecting fluid for disinfecting purposes, and last year the Council resolved to have another plant installed. This plant is now in working order with all improvements, the outcome of over four years' work. The two plants work absolutely automatically by the aid of electricity, turning out within eight hours 400 gallons of the fluid with over 5 grammes of chlorine per litre.

A Gas-Pressure Sprayer Worked with Acetylene.—At a recent meeting of the Faraday Society Mr. E. Kilburn Scott gave an account of a gas sprayer which has come largely into use in Australia, the pressure being obtained by the action of water upon acetylene. The construction of the apparatus is sufficiently indicated by the adjoining illustration. It is



Gas-pressure Sprayer.

used for horticultural work, whitewashing buildings, distempering rooms, spraying sheep instead of dipping, suffocating rabbits, and many other purposes. The saving in labour is found to be very large, and the effect on the consumption of calcium carbide has been quite marked. Five years ago the consumption was just over 2,000 tons per annum, but in four years the consumption rose to over 8,000 tons, and the price at Sydney fell from about £18 to £10.

Toronto Railway System and Electrolysis.—An interesting report on this subject has lately been issued and is summarised in the "Canadian Electrical News." The report classifies the various methods of protection against electrolysis under three heads: (1) The conduit system for return wires, as used in New York and Washington, &c., and now being installed in certain sections in Winnipeg; (2) the double overhead trolley system as operated in Cincinnati and on various suburban lines in the District of Columbia, and (3) the modern bonding system, as used by the Toronto Railway Co. Mr. Strickland is of opinion that the latter system, very carefully installed, is the equal of either of the others. The bonds are in very good order, and the loss of pressure in the track circuit is only ½ volt to every 500 ft.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Balik Papan—Kwandang	Nov. 1, 1909
Para—Maranham	Mar. 16, 1910

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Royal Society.—Among the Papers read at the meeting of this Society yesterday afternoon was : "A Physiological Effect of an Alternating Magnetic Field," by Prof. S. P. Thompson, F.R.S. An abstract of this Paper will be found in another column of this issue.

Transmitting Observations on Halley's Comet.—The Spanish Telegraph Administration, acting on instructions of the Government, has made arrangements, in view of the coming observations to be carried out by an International Commission at Teneriffe, to construct a telegraph line from Orotava to the base of the Teide mountain (Peak of Teneriffe), and communication will be completed from this point to the spot selected for the observations by a land cable up the slope of the mountain.

The Effect of Electricity on Plant Growth.—Some interesting observations on this subject are given in the "Journal" of the Bath and West and Southern Counties Society. It is held that such fruits as strawberries are most suitable for treatment, since there seems to be some fear of "over-stimulation" in the case of fruit trees, and wheat is said to be less responsive, while legumes are adversely affected. Actual increases of production recorded are 39 per cent. in wheat, 65 per cent. in roots, and 80 per cent. in strawberries.

Engineering Standards Committee. — Mr. Leslie S. Robertson, the secretary of the Engineering Standards committee, states that the Government have intimated their willingness to contribute £500 per annum for three years to the committee. The Secretary of State for India in Council has also made a grant to the committee of £300 towards the expenses incurred in the preparation of the Third Report on Standard Locomotives for Indian Railways, a work which was undertaken at the request of the Indian Government.

The New Buenos Ayres-Ascension Cable.—Much interest is being taken in Argentina in the operations connected with the laying of the new cable from Ascension Island to Buenos Ayres. The land-line work is considerable and is being carried out by W. T. Henley's Telegraph Works Co. Two lines are being provided, one placed overhead and the other laid underground in iron pipes, representing a length of about 50 miles in all. It is anticipated that the first message will be sent over the new cable on or about May 25th.

Thermic Effects of Undamped Electric Oscillations on the Human Body.—In a recent issue of the "Elektrotechnische Zeitschrift" the thermo-penetration of oscillations was studied by Prof. von Klingmüller and Mr. F. Bering. The heating is a maximum in the neighbourhood of the electrodes, especially on the skin, and becomes more rapid as the electrodes are brought closer together. When the electrodes are some distance apart the heating effect cannot be noticed to any great depth even when it is quite unbearable near the electrodes. The temperature does not become normal for some considerable time after the electrodes have been removed.

Nitric Acid from the Air.—The "Engineering and Metallurgical Review" states that Mr. F. I. Dupont, who has paid considerable attention to the production of nitric acid by electric discharges through air, has been granted another patent for a furnace for this purpose. The air is passed through a silica tube containing the electrodes between which the arc is formed. The silica tube is surrounded by a glass tube through which a cooling liquid is passed. The field magnets are energised by a polyphase current, thus producing a rotary magnetic field which causes the arc to rotate around the inner surface of the silica tube. Air is forced through the passage into the zone between the electrodes; it is heated by the rotary arc, but as soon as the rotating arc passes from any portion of the air, this air is immediately subjected to the cooling action of the walls, and its temperature is so rapidly reduced as to prevent the formed nitrogen oxide from being again largely decomposed.

Regulation of Wireless Telegraphy.—According to a proposal which has been approved by the Navy Department and the Department of Commerce and Labour in the United States, and has been submitted to the House of Representatives, wireless telegraph stations must be licensed and the operation of an unlicensed station will be made a misdemeanour, for which a fine of £100 can be imposed. The President may, in time of war or public peril, order any station to be closed. Interference with messages, which has been the source of much trouble, is placed under a penalty of £100. The fee for first-class licences, which are those for land stations, will be £20, and that for the second class, those on ships, is to be £1. Messages relating to ships in distress are to have priority. Fraudulent messages are forbidden, and a fraudulent distress signal may be punished by a fine of £500 and imprisonment for five years. The House Merchant Marine Committee has determined to report favourably upon a bill requiring the equipping of ocean-going steamers with wireless telegraphic apparatus.

Obituary.—W. L. Harvey.—We regret to record the death of Mr. W. L. Harvey, Secretary of the Government of India for Commerce and Industry, which occurred at sea between Aden and Suez. At Calcutta, Mr. Harvey was responsible in the Executive Council for the railway, postal, telegraphic and other revenue-earning departments, as well as for the promotion of the general, industrial and commercial development of the country. The outstanding feature of his tenure was the reform of the telegraphic service and reconstitution of the department under the expert advice of Mr. J. Newlands, whose services were lent by the Postmaster-General. The strike of the traffic staff in consequence of the new arrangements was firmly and tactfully handled by Mr. Harvey, and though at first the commercial community took alarm, he was able eventually to secure its general support.

Sir Walter Scott.—We also regret to record the death of Sir Walter Scott, who was best known to electrical engineers for his connection with the building of the Tube railways of London.

James Tomkinson, M.P.—We also regret to announce the death of Mr. James Tomkinson, M.P., Chairman of the North Wales Power & Traction Co. Mr. Tomkinson took part in the House of Commons steeplechase on Saturday; his horse stumbled, deceased was thrown and received injuries to which he succumbed.

Electrically Controlled Ventilation for Mines.—"Le Génie Civil" describes an electrically controlled fan which has recently been set to work at Rheinelbe. It supplies the mines with 200,000 cubic ft. of air per minute under a water pressure of 470 mm. when running at 363 revs. per min. The 1,000 H.P. motor used is connected to the mine network, the voltage being 5,000 volts and the frequency 50, through a regulating transformer consisting of a 200 kw. three-phase motor and an 85 kw. asynchronous generator. This latter motor is connected in cascade with the fan motor rotor whose slip energy it absorbs and, being in turn connected to the asynchronous generator, returns this energy to the line. A regulator is provided by means of which the motor-generator group can be run at any speed. The generator is then connected to the network and its speed raised by gradually short-circuiting the regulator. The fan motor is then started up, and when it has reached full speed its slip rings are automatically connected to the transformer group. The speed is regulated by altering the excitation of the motor in the transforming set, 20 speeds being possible between 268 and 363 revs. per min. For each position of the regulator the speed is constant, whatever the load.

New Accumulator Car for the Prussian State Railways.—According to the "Elektrotechnische Zeitschrift," the new accumulator car which has recently been set to work on the Prussian State Railways differs somewhat in its construction from that described in The Electrician, Vol. LXII., p. 419. The principal alteration consists in the adoption of two further axles, the new car possessing six. It was found that with four axles the axle-pressure was too great, while with six it does not exceed 6 tons per axle. The new axles are placed under the battery boxes at each end of the double car and all six are free to move independently of the others. The second alteration is the obligatory provision of electric, in addition to compressed air, braking, though some

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of the older cars were also so fitted. In the course of tests, on one of these latter, it was found that the car when running at 35 miles per hour could be brought to a standstill in 230 yards with the air-brake, and in 115 yards with the electric brake. This result led to the compulsory provision of the electric brake. The third modification is the attachment to the arrangement, whereby the controller handle was brought to the "off" position and the brake applied if the driver released his hold, of a time-limit device whereby the action is delayed for several seconds. In this way, accidentally releasing the handle does not bring the car to rest, while safety to the passengers in case the driver is taken ill is still ensured.

Electricity in the Manufacture of Iron and Steel.—"Stahl und Eisen" has compiled a list of the electric furnaces now at work smelting iron or steel. The list totals 114 furnaces for steel making, of which 77 are classed as arc furnace two generate their heat by a combination of arc and resistanes and 35 are induction furnaces. Seven of the steel furnaces are at work in England and a number in America, but the great majority are on the Continent, principally in France and Germany. Most of the furnaces are of small capacity, generally between one and five tons, and are engaged upon high-class steels, but a fair proportion are working on ordinary steels such as structural steels, steel castings and railway material.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. W. C. Clinton contributes an article on "The Determination of the Efficiency of Continuous-Current Machines."

We give an account of the discussion which followed the reading of Mr. A. Gerrard's Paper on "The Progress of Electric Braking on the Glasgow Corporation Tramways," before the Institution of Electrical Engineers.

At the recent meeting of the Association of Teachers in Technical Institutions (Yorkshire Branch) Dr. R. Pohl read a Paper on "The Movement Towards a National System of Technical Education."

We give an account of the discussion on the Paper by Dr. R. Pohl, read recently before the Yorkshire section of the Institution of Electrical Engineers on the subject of "The Testing of Intermittent Motors."

A lengthy Board of Trade enquiry was held at Radcliffe last week into the application of the Lancashire Electric Power Co., for a Provisional Order, to enable them to supply electricity in the municipal area in competition with the Council. In the course of the enquiry it was intimated on the part of the company that they only required an order to enable them to supply power to consumers who required over 30 H.P.

The Wolverhampton Corporation decided on Monday to apply for sanction to a further loan of £23,000 for extensions to the Electricity Undertaking.

On Monday the Manchester Corporation adopted a recommendation of the Electricity committee to borrow £40,000 for the Electricity department.

An inquiry was held on Tuesday into the application of Gillingham Council for permission to borrow £3,000 for electric generating plant.

Parliamentary.—A Select Committee of the House of Lords approved the tramway clauses of the Handsworth District Council's Bill.

The Metropolitan District Railway Bill (to provide increased railway facilities from Hammersmith to Turnham Green) was passed by a House of Lords Committee on Monday.

Directors' Reports.—The report of the directors of the Metropolitan Electric Tramways gives particulars of the progress made during the past year, and states that four additional sections of light railway were opened in Middlesex during the year, bringing the total length of the system to 51½ miles, and that 4¼ miles are under construction. The traffic receipts show a considerable increase.

The directors' report of the North Metropolitan Electric Power Supply Co. gives particulars of the progress made during the past year. The units sold were 16,402,447, an increase of 2,332,836, or 16·5 per cent. The business of the North Metropolitan Electrical Power Distribution Co. (at Barnet, Enfield, Hertford and St. Albans) is also stated to be expanding satisfactorily.

At the meeting of the South Wales Electrical Power Distribution Co., on Tuesday, the chairman gave particulars of the progress made by the Treforest Electrical Consumers Co. The South Wales Co. was now making a trading profit. Some new collieries had made arrangements to take electrical energy, and the installations of some of the old collieries had been extended.

Messrs. Babcock & Wilcox have increased their dividend from 20 per cent. for 1908 to 24 per cent. for 1909.

INSTITUTIONS AND SOCIETIES.

BRITISH ASSOCIATION.—A preliminary programme of the annual meeting of this Association, which begins at Sheffield on August 31st next, has now been issued. The president (the Rev. T. G. Bonney) will have the assistance of a strong body of representatives of the municipal, educational, ecclesiastical and commercial interests of the city, who have been appointed as vice-presidents for the meeting, headed by the Lord Mayor, Lord Fitzwilliam. To the list of sections already announced there has been added, as in previous years, a sub-section of Agriculture, which this year will be formed under the section of Chemistry, with Mr. A. D. Hall, F.R.S., as chairman. The conference of delegates of corresponding societies will assemble this year, as usual, at Sheffield during the meeting, and not in London, as last year, when the meeting was in Canada. Its chairman will be Dr. Tempest Anderson. The reception-room and administrative offices during the meeting will be established in the Cutlers' Hall. It is centrally situated, and most of the sectional meeting rooms will be within a very short distance of it. The opening meeting will be held in the Victoria Hall on Wednesday evening, August 31st, when Prof. Bonney will deliver his inaugural address. In the same hall the first evening discourse will be delivered on Friday evening, September 2nd, by Prof. William Stirling, on "Types of Animal Movement," and the second on Monday evening, September 5th, by Mr. D. G. Hogarth, on "New Discoveries about the Hittites." The concluding meeting will be held on Wednesday, September 7th. Receptions will be given by the Lord Mayor and by the University, and a number of garden parties will be arranged. Arrangements have been made with the railway companies to issue return tickets at reduced fares to members attending the meeting.

ARRANGEMENTS FOR THE WEEK

FRIDAY, April 15th (to-day).

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "The Chemical Significance of Crystal Structure," by Prof. W. J. Pope, F.R.S.

TUESDAY, April 19th.

FARADAY SOCIETY.

3:30 p.m. Visit to the Electrolytic Depot of the Stepney Corporation, Violet-road, Bromley-by-Bow.

THURSDAY, April 21st.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Meeting at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Paper on "Hydro-Electric Installations of Sweden," by Mr. A. V. Clayton.

FRIDAY, April 22nd.

PHYSICAL SOCIETY.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: "Further Tests of Brittle Materials under Combined Stress," by Mr. W. A. Scoble, and "The Magnetic Balance of Curie and Cheneveau," by Messrs. C. Cheneveau and A. C. Jolley.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "The Telegraphy of Photographs, Wireless and by Wire," by Mr. T. Thorne Baker.

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Saturday, April 16th, "A" and "B" Companies.—Parade at Headquarters 3:30 p.m., Drill Order.

Monday, April 18th, "A" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 9:30 p.m.

Tuesday, April 19th, "B" Company.—Infantry Drill, 7 to 8 p.m. Technical Drill, 8 to 10 p.m.

Wednesday, April 20th, Gymnasium.—6 to 9:30 p.m.

Thursday, April 21st, "C" Company.—Recruits' Infantry Drill, 6 to 6.45 p.m. Company Drill, 7 to 8 p.m. Technical Drill, 8 to 9:30 p.m.

Friday, April 22nd, "D" Company.—Recruits' Infantry Drill, 6:15 to 6:45 p.m. Company Drill, 7:30 to 8:30 p.m. Technical Drill, 8:30 to 9:30 p.m.

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THE AUTOMATIC REGULATION OF ALTERNATORS*

BY M. SEIDNER.

Summary.—After discussing the object and possibilities of regulation, and outlining the general theory, the author passes on to discuss regulators of general interest, and more especially those types due to Alexanderson, Walker, Thury and Tirrill, which are of practical value.

In a previous article ("E.T.Z.," 1908, p. 450) the author has shown that the methods used for the inherent pressure regulation of alternating-current generators do not comply with modern requirements in either a technical or an economical sense. The inherent regulation of the alternator limits the pressure rise by means of saturation. In this way it is not possible to provide economically for a less rise of pressure than 16 per cent. from full load at $\cos\phi=0{\cdot}7$ to no load with constant speed and excitation. The difficulty to improve on this figure explains why it is accepted in practice. A lower pressure rise would, however, be very desirable, especially for mixed loads. But even the above value of 16 per cent. is only obtained by sacrificing efficiency and output. So long, however, as these deficiencies were only regarded as a feature of the installation as a whole they did not appear very serious, but increasing competition and the present-day practice of considering the several parts of the installation separately, has convinced manufacturers that radical changes must be made if the expensive means of inherent pressure regulation are to be replaced by other and cheaper methods. Another important factor in connection with this problem is the rapid advance of the turbo-alternator. In these machines, owing to the difficulty of carrying away the heat, high magnetic densities become undesirable, and a pressure rise of 25 to 35 per cent. is often allowed.

The first alternators were machines with a large pressure rise, so that the necessity for providing good regulation soon became apparent, and the idea to provide alternators with self and compound excitation, similar to the compound continuous-current dynamo, came quite naturally. This method was soon given up, however, for the means of calculation and workshop arrangements at that time were quite inadequate for such work. A closer study of the design of generators resulted in the adoption of inherent pressure regulation. Heyland was the first to show that alternators with external pressure regulation are much cheaper than normal generators with a low pressure rise. The former machines, with large self-induction, are also better for parallel working than the latter.

The Regulator.

A good method of regulation should possess the following characteristics:—

The *factor of safety of working* is certainly the most important. The factor of safety of a construction is greater the smaller number of movable parts. Consequently, in this respect, the best methods of regulation are those that require fewest machines and movable elements. Arrangements, therefore, which, in addition to the exciter, require separate machines and apparatus are disadvantageous.

The Speed of Regulation.—Regulation should take place so quickly that pressure changes are avoided. The pressure of an alternator depends on the equilibrium of the magnetising forces due to the alternating and continuous currents. If this equilibrium is disturbed a corresponding change of the field energy is necessary. The time taken for this change depends on the time-constant of the magnetic circuit. In the case of alternators with exciters, the field energy of both generator and exciter must change with the load. The flux in the exciter must be adjusted so that its terminal pressure corresponds to the load on the generator. The adjustment of this flux takes a certain time, consequently the change in the continuous-current excitation does not occur simultaneously with that in the alternating-current excitation, and a variation in the pressure of the alternator will ensue. The new pressure of the generator must now be adjusted, which is accompanied by a corresponding change in its field energy. The time taken to accomplish this increases rapidly with the inertia of the exciter. If the pressure of the exciter were to respond immediately there would be no change of pressure at the generator. This is the ideal case, which cannot, however, be attained in practice. For quick action, therefore, the ideal method would be to regulate by armature reaction without the aid of an exciter. The regulation is also very rapid with arrangements where no exciter is present, but the exciting current is part of the alternating current rectified.

In arrangements where exciters are used the speed of regulation depends on the rapidity with which the exciting current of the exciter can vary. When the exciter pressure is controlled by means of a shunt regulator, there are three ways in which the shunt resistance can be varied. Either the resistance is slowly switched in or out until it reaches its final value, or it is made to attain its final value in one step; or a greater resistance than that corresponding to the proper value is used, which is switched in or out as soon as the pressure reaches its normal value.

It is clear that the first method leads to the slowest regulation, whilst the last leads to the quickest. The same means are also applicable where, instead of the shunt resistance, the exciting current is varied by introducing a corresponding E.M.F.

Those methods where the regulator plays the part of a relay—that is, where the variation of the exciter pressure due to the regulator causes a further change of pressure—can only admit of a slower regulation than those where the exciting current is adjusted independently of the terminal pressure. Consequently, exciters excited with constant pressure are always more quickly excited than self-excited machines; compound exciters always excite more slowly than shunt machines, whilst differentially excited machines accelerate the excitation. Likewise, the permanent resistance in the shunt circuit always accelerates excitation. Methods where the current for regulation requires a current transformer assist quick regulation. The current transformer produces the secondary current corresponding to the rate of conversion, independently of the secondary resistance, and therefore independently also of the inductive resistance of the magnet windings (which latter retards the change of current and consequently the regulation).

Stability of Regulation.—The regulation following a disturbance is completed when the condition of equilibrium is restored and the pressure correctly adjusted. These two conditions should occur simultaneously. If this is not the case, the regulating mechanism will continue to operate further, and conditions may arise whereby hunting occurs.

This action does not occur in compounding methods, for here the exciting current is made to correspond to the load current independently of whether the resulting pressure is correct or not. Thus the question of stability has only to be reckoned with in mechanical regulators which act on an astatic principle and continue to operate until the correct pressure obtains.

Effective means of preventing this over-regulation are the retarded and step-by-step methods which are employed in most mechanical regulators. These devices, however, lead to slow-speed regulation, and are therefore unsuitable for alternators. Over-regulation can best be avoided—without sacrificing speed—by the use of a "back- or reverse-control," and the best regulators are now designed on this principle (see below).

Cost.—The regulator should be as cheap as possible to justify its replacing inherent regulation. If the arrangement can be adapted so that an overall economy in the outlay results, we have the further advantage of, say, a 5 per cent. regulation instead of an 18 per cent.

Parallel Working.—The regulation of machines running in parallel, or the automatic distribution of the wattless current between the various units, should be possible without regard to type and output. With regulators which are not actuated by pressure variations, but by current variations—that is, by compounding—this is possible. Each machine can be provided with a separate regulator or compounding device which adjusts the excitation of the machine in question, so that the wattless current is properly divided between the several machines.

The astatic pressure regulators, and more especially the modern quick-acting regulators, cannot work in parallel. Machines in parallel are provided with a single regulator. From this point of view, astatic regulators have two important disadvantages. Firstly, the magnitude of the energy controlled by a single regulator cannot be increased indefinitely, so that the regulation of large central stations and units becomes difficult; and, secondly, only machines of the same type and size can be governed in this way, since the apparatus cannot distribute the wattless currents between the several machines.

Overload.—The maintenance of a constant pressure on overloads and short-circuit is a source of danger, so that a good regulator should allow the pressure to fall when the current exceeds a certain value.

As regards *manufacture*, it is well to have a regulator that can be fixed to machines already in operation, or, in other words, no constructional alterations in the machines should be necessary. It is also desirable to have the regulation as *accurate* as possible, so that the limits of pressure variation are reduced to a minimum; further, the pressure variations due to changes in speed should not be too large.

The Pressure Rise.

We can now see how the exciting current must vary in order to obtain a constant pressure at the terminals. It is not necessary to follow this into close detail, for, as pointed out above, great accuracy in maintaining the pressure constant is not the chief object

* Abstract of an article in the "Elektrotechnische Zeitschrift."

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of regulation; in addition to this, there are so many disturbing influences at work (heating of field coils, brushes, &c.) which make such exactness superfluous. For this reason the effects of leakage will also be neglected.

In Fig. 1, let OA represent the ampere-turns required on no-load. The induced pressure OB of the generator lags 90 deg. behind this. Let the machine be loaded with a current, i, lagging behind the pressure OB by the angle ϕ; then we can represent by OC the ampere-turns in the armature, which react on the main flux. In order to keep OB constant, the ampere-turns OA must be increased in magnitude and direction to AC.

When $\phi=0$, the point C lies on OB and moves along this line as the load varies. Hence, to compensate the pressure drop, an alternating current is required proportional to the load current of the generator, or, rather, to the ampere-turns of the armature. Further, the vector of the compensating M.M.F. must vary with the phase displacement. The resultant alternating-current ampere-turns CA are formed from the terminal pressure and the load current of the generator and converted into continuous current by some suitable means. Under normal conditions two transformers—namely, a current and a pressure transformer—are used to give CA. The two transformers which produce the components CO and OA cannot merely be connected together. If, for example, they are joined in parallel, the secondary pressure is already fixed by the potential transformer, and cannot be altered by the current transformer (assuming the latter of normal construction). On the other hand, when connected in series, the current transformer determines the magnitude of the secondary current, and this cannot be altered by the pressure transformer. The continuous current for excitation would, therefore, be regulated either by the pressure transformer alone or by the current transformer alone.

The remedy suggests itself. With transformers in parallel, the pressure transformer must have the property of neutralising the secondary current produced by the current transformer by means of a primary winding of equal magnitude but opposite direction. This is accomplished by inserting in series an inductive or ohmic resistance with the primary or secondary winding of the potential transformer, whereby the latter assumes more or less the properties of a current transformer. With the transformers in series, on the other hand, the primary or secondary winding of the current transformer must be placed in parallel with a corresponding resistance, which gives this transformer more or less the characteristics of a pressure transformer. The same result can be obtained by including these resistances in the transformers themselves. Thus, with the parallel connection, the pressure transformer is given a large leakage, whilst with the series connection the current transformer is made to take a large magnetising current.

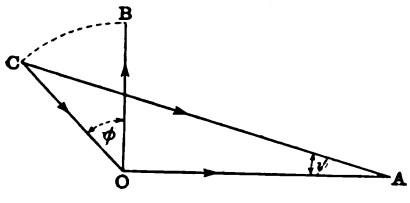

Fig. 1.—Diagram for Regulation.

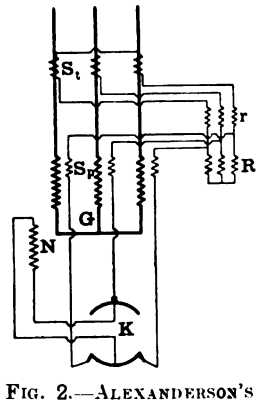

Fig. 2.—Alexanderson's Arrangement.

Classification of the Methods of Pressure Regulation.

Several different methods are described and criticised in the last section. Although there are many arrangements for compounding asynchronous generators, only methods for regulating synchronous machines will be discussed, as the former type has not yet become of great practical importance. The several methods may be classified into the following six groups:—

Group I.—In this group are classed all methods where the exciting current necessary to neutralise the pressure changes due to the varying current or load is produced in such a way that the corresponding alternating current is converted into continuous current by means of a commutator rotating synchronously with the generator. To this class belong the methods used by Ganz, General Electric Co. and Corsepius. These methods have recently been greatly improved by Heyland and Alexanderson.

Group II.—In this group the current required to compensate the pressure variations is also converted from alternating into continuous, but here a special field is produced to assist commutation. This group can be split up into two classes. The former includes those methods where the no-load current is also taken from the alternator; these are the converter methods. In the second class the exciting current on no load is supplied from an exciter. Here we have the arrangements of Hutin, Leblanc, Boucherot, Blondel, Rice, Danielson, Steinmetz, Ziehl, Roth, Union, &c.

Group III.—This includes all arrangements where the alternating current required for regulation is obtained electrolytically or thermally by means of stationary apparatus. Such a method is that due to Dobrowolsky.

Group IV.—The magnetic reactance of the armature is used for regulation. Examples, Walker and Heyland.

Group V. includes the arrangements where the alternating current is not converted into continuous, but the former actuates a resistance by mechanical means and inserts the same in the exciter field circuit. Here may be mentioned the regulators of Blatly, Thury, Dick, Thieme, Tirrill, Schwaiger and the various contact voltmeter methods.

Group VI.—Here, as in the last group, a rheostat is operated not mechanically, but purely electrically, magnetically or thermally, as illustrated by the methods due to the author, Crompton & Co. and Parsons.

With the exception of Group V., all methods have some similarity to the compounding of continuous-current machines, and have been referred to as such in the literature on the subject.

(To be concluded.)

EFFECT OF TEMPERATURE UPON THE MAGNETIC PROPERTIES OF ELECTROLYTIC IRON.*

BY E. M. TERRY.

Summary.—The author describes investigations of the magnetic constants of pure electrolytic iron at various temperatures, to determine to what extent the phenomena already observed are characteristic of the iron itself. The principal characteristics of Burgess electrolytic iron established by this investigation are: Freshly prepared iron is very hard magnetically. Different samples show marked dissimilarities at low fields, which differences disappear upon annealing at 1,000°C. For large fields, all samples are quite similar. Plunging into liquid air produces no permanent hardening. The retentivity has a maximum in the neighbourhood of room temperature. Marked softening magnetically occurs at the hydrogen transformation points. Ferromagnetism reappears on cooling at the same temperature at which it disappears on heating. This temperature is 785°C. The depression in the permeability temperature curves obtained by Morris does not exist for this iron. The best temperature for annealing is 1,100°C. Although when properly annealed it has a lower coercive force and a higher maximum permeability than Swedish iron, its high retentivity causes a large hysteresis loss.

Although much study has been devoted to the magnetic properties of iron as a function of temperature, in most cases the purity of the iron has been considered only in a general way. Since the magnetic properties of iron depend to so great an extent upon the presence of certain impurities, notably carbon, silicon and manganese, and in Burgess electrolytic iron we have an iron of extraordinary purity, it seemed worth while to repeat and extend some of the earlier experiments with a view to determining to what extent the observed phenomena are characteristic of iron itself, and to correlate them with metallurgical changes. The author first gives a brief summary of previous work.

In 1900, Wills studied the effect of temperature on the field which gives the maximum permeability. Working with wrought iron and alloys of aluminium, nickel and manganese he found that the maximum permeability occurs at lower fields as the temperature is raised, the relation being nearly linear. After his work the question of the effects of temperature on the magnetic properties of iron seems to have been regarded as settled, attention having been turned for the most part towards alloys. However, the recent perfection, by Prof. C. F. Burgess,† of the University of Wisconsin, of an electrolytic process for the production of very pure iron in large quantities has afforded an opportunity to study further the magnetic properties of this element.

Electrolytic Iron.—Owing to the difficulties of production, electrolytic iron has hitherto been very little studied magnetically, the work having been confined to room temperatures. The author, therefore, investigated the magnetic constants of this pure iron at various temperatures, ranging from that of liquid air to the temperature of magnetic transformation, with a view to determining, as far as possible, to what extent the phenomena already observed

* Abstract of an article in the "Physical Review."

† "Iron and Steel Mag.," Vol. VIII., p. 48, 1904.

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are characteristic of iron itself, and to point out the effects of impurities.

The iron used was twice deposited from an electrolyte consisting of ferrous and ammonium sulphates, the current density being about 6 amperes per square foot, and requiring about four weeks to produce a plate 1 in. thick. Plates have been made weighing 75 lb. Chemical analyses have shown that this iron is very pure. In fact, the impurities are so slight that special methods have had to be devised to determine them. The average of several analyses is given below and may be taken as a fair indication of the purity.

Sulphur.	Silicon.	Phosphorus.	Manganese.	Carbon.	Hydrogen.
0·001 %	0·003 %	0·004 %	None	0·012 %	0·072 %

It will be noted that the amount of hydrogen present greatly exceeds that of all the other impurities combined, and it is to the presence of this element that the characteristic properties of electrolytic iron are usually ascribed. Burgess and Taylor* made a preliminary study of single refined iron about two years ago, and found that it is both magnetically and mechanically very hard. During the past year Burgess and Aston have been making an extensive study of the magnetic properties of alloys of this iron, but their results have not been published.

Of the various methods that have been used for magnetic testing, the Rowland ring seemed best suited for the present work. Since it gives a continuous magnetic circuit without a joint of any kind, no correction for demagnetising effect is necessary, and with a fairly uniform winding of the magnetising coil, it may be safely assumed that the flux crossing each section of the ring is the same, and that the leakage is negligible. If a D'Arsonval galvanometer is used, this method is independent of the earth's field or any other extraneous effects. It is, however, subject to three sources of error: (1) The field is not uniform across the specimen, and further, the mean field is not the field at the centre of the section calculated from the ampere turns. (2) Since permeability is a function of field strength, the mean flux density, calculated from the deflections of the galvanometer, is not the flux density at the centre of the section. (3) As pointed out by Ewing and Lord Rayleigh, for small fields and fields for which the differential permeability dB/dH is large, iron changes its magnetic state slowly, sometimes requiring several seconds or even minutes. Since the ballistic method requires that the total change shall take place before the galvanometer swings appreciably from its zero position, a serious error is introduced in testing iron possessing magnetic viscosity.

The first two errors may be reduced to negligible magnitudes by choosing the width of the ring small in comparsion to its diameter. Lloyd† has shown, for a ring with rectangular cross-section, that $\frac{H_0}{H_R} = \frac{1}{2p} \log \frac{1+p}{1-p}$, where H_0 = average value of field, H_R = field at mean radius of ring, p = ratio of radial width to mean diameter of ring. The value of "p" for the rings which I have used in this work was approximately 0·084. Substituting this value in the above formula we find $H_0/H_R = 1{\cdot}0024$.

The calculation of the error mentioned under (2) is very complex and has never been handled mathematically. Taking, however, a formula given by Richter,‡ we find values 1·0024 and 1·0021 in unannealed and annealed specimens respectively for W_0/W, where W_0 = hysteresis loss for uniform flux density, and W = hysteresis loss for actual flux density.

The effects of magnetic viscosity are nearly eliminated by a method suggested by Taylor.§ The essential feature of this modification is that all observations are referred to one of the retentivity points of the curve. For instance, to locate the point representing positive saturation, subject the specimen to maximum field: then close the secondary circuit through the galvanometer, and break the primary. The deflection of the galvanometer measures the difference of induction between the saturation and retentivity points. Points on the curve between these two are obtained in a similar manner, the iron having been first carried to saturation and the induction reduced to the desired value without breaking the magnetising current. For points between retentivity and negative saturation, the iron is first taken to positive saturation as before, and at once returned to retentivity by breaking the primary current. The secondary is then closed and the deflection taken when the proper magnetising current has been applied in the opposite direction. The calculation of the induction in terms of the field, as is ordinarily given, is then merely a matter of changing the origin by the amount of the retentivity, for computing which the necessary data are at hand. The advantages of this method are: (1) Observations on any one point may be repeated as many times as desired. (2) The magnetising current need be applied for only a few seconds, thus reducing its heating effect. (3) The errors due to magnetic viscosity, while not entirely eliminated, cease to be cumulative, as in Rowland's original method, and are reduced to negligible quantities. The work may be divided into three parts: To test the iron magnetically at different temperatures; to find the best temperature for annealing; to investigate the relation between crystalline structure and magnetic properties. The procedure in the first part was to run hysteresis and magnetisation curves at various intervals from the temperature of liquid air up to that at which iron ceases to be ferro-magnetic. For the lowest temperatures, the rings, after being wound, were dipped for an instant in melted paraffin then plunged into liquid air, and tested when the temperature had become uniform. To obtain temperatures intermediate between those of liquid air and the room, the following method, which is due to Knipp,* was used. A hollow copper sphere, with walls about 0·8 cm. in thickness, was mounted inside a cylindrical Dewar flask. To the lower side of the sphere was attached a copper spindle which dipped into liquid air. The Dewar flask was placed upon a platform which could be raised or lowered with a slow motion, while the sphere remained fixed. By properly adjusting the depth of the spindle in the liquid air, any desired temperature could be very constantly maintained. While there was an appreciable temperature gradient from top to bottom of the enclosure, the fall of temperature across the ring, which was placed horizontally, never exceeded 2 deg. For the production of high temperatures, an electric furnace of the Heræus type was used. For the measurement of temperature, two thermo-elements, whose E.M.F.s were determined by means of a specially constructed low resistance potentiometer, and an optical pyrometer were used.

Making the rings proved to be a matter of some difficulty, since freshly deposited iron is so hard and brittle that it cannot be cut

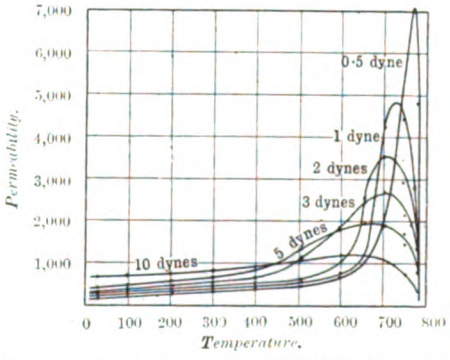

Fig. 1.—Varieties of Permeability with Temperature—Plate A—Unannealed.

with a tool. The rings had to be cut from the deposited plate by means of a rotating tube fed with emery dust, after which they were mounted in a lathe and ground into shape, the process requiring from two to three days for each ring. The dimensions of the rings were, roughly, as follows: external diameter, 3·5 cm., internal diameter, 3 cm.; height, 0·4 cm. One of the chief difficulties encountered was the problem of insulation between primary and secondary windings, since most substances which are good insulators at ordinary temperatures begin to conduct when heated, and a very slight leak is sufficient to give the galvanometer an uncertain drift, rendering accurate work impossible. The method finally adopted was to use rings cut from thin magnesia plates prepared by roasting the oxide between two plates of graphite in an electric furnace at a temperature of about 1,700°C. In order to ensure insulation between turns, a paste, made of fine magnesia powder and alcohol, was worked into the spaces, which, when dry, could be kept solid by careful handling. Another problem was the protection of the rings against oxidation. Since the magnetic properties of iron oxide are very different from those of metallic iron, and the cross-section of the specimen was always small, even a thin film would result in serious error. The first attempt to overcome this was to fill the furnace with an inert gas; but it was difficult to close the ends sufficiently tight, and even then the water of crystallisation of the mica, upon which the primary was wound, given up on heating, produced considerable oxidation. This difficulty was finally met by plating the rings electrolytically with copper. It was found that with a plate 0·7 mm. in thickness, a ring could be heated several times in perfect safety

Results.—Ten rings in all were studied, being cut from two different plates here called A and B. The iron in these two plates was quite

* "Proc." Am. Inst. of Elec. Engrs., May, 1906.
† "Bull. Bur. Stnds.," Vol. V., p. 435.
‡ "E.T.Z.," Vol. XXIV., p. 710, 1903.
§ "Phys. Rev.," Vol. XXIII., p. 95, 1905.

* "Phys. Rev.," Vol. XV., p. 125.

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different, A having a finer crystalline structure and being much harder than B, both mechanically and magnetically. Rings cut from the same plate were quite similar, slight discrepancies being doubtless due to the difference in depth in the plate from which they were taken. Since the deposition of a single plate is a matter of several weeks, the unavoidable changes in acidity of bath and strength of current would necessarily result in non-uniformity of deposit. The results obtained are summed up in Figs. 1 to 3. Permeability-field strength curves at different temperatures were plotted for each sample, and the field giving the maximum permeability was determined from them. Its variation with temperature is given in Fig. 4.

To study the effect of annealing at temperatures higher than 800°C., a cylindrical box with a tight-fitting cover was turned from a bar of Swedish iron in which the ring to be tested was packed in finely powdered electrolytic iron. The ring could then be heated to any desired temperature with practically no oxidation, and at the same time be free from contamination with carbon. The time of cooling was about 24 hours. After each heating the ring was unpacked, re-wound and tested. The results are shown in the following table:—

Hysteresis Constants after Annealing at Various Temperatures.

Temperature, °C.	Energy loss.	Retentivity.	Coercive force.	Maximum induction.	Maximum permeability.
23	21,300	7,940	3·80	17,100	1,040
780	11,280	8,450	1·30	17,300	3,070
1,000	5,060	14,100	0·75	17,280	9,080
1,100	4,900	12,800	0·53	17,600	11,000
1,200	5,600	13,000	0·85	17,400	8,750
1,300	7,160	13,800	0·97	17,400	7,120

Experiments were performed on rings from plate B only, since it had previously been determined, that after annealing at 1,000°C.

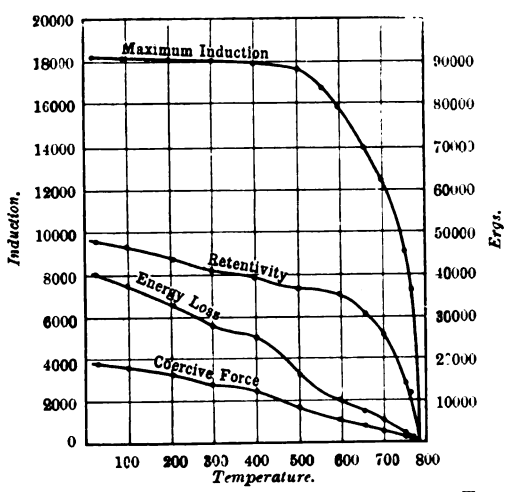

FIG. 2.—VARIATION OF HYSTERESIS CONSTANTS WITH TEMPERATURE. PLATE A, UNANNEALED.

all of the iron prepared by this process becomes practically identical. The field in these tests was carried to 80 dynes.

Before discussing these results, the author makes a brief digression on the temperature changes in the physical state of iron, upon which its magnetic properties so largely depend. According to Osmond, iron presents itself in three allotropic phases: Alpha, beta and gamma. Alpha iron is weak, ductile, ferromagnetic, stable below 785°C., and is characteristic of wrought iron and low carbon steels. It crystallises in cubes. Beta iron is weakly paramagnetic, stable between 785°C. and 890°C., and is probably hard and brittle. It is characteristic of certain self-hardening steels, also of normal carbon steel when hardened by sudden cooling, and like alpha iron crystallises in the cubic system. Gamma iron is stable above 890°C., is paramagnetic and characteristic of nickel and manganese steels. It is probably hard, but ductile, while its crystals are cubic with octahedral modification. The relations between these phases are best shown by means of the Roozeboom* diagram of Fig. 5, where the lines separating the different regions indicate the temperatures at which the transformations take place, when different amounts of carbon are present. Although the significance of this diagram is quite apparent, perhaps the field AaB requires special explanation, since it represents a mixture of the solid and liquid phases. The line Aa gives the greatest amount of carbon a solid solution may contain, while AB shows the least amount for a liquid; and any point, such as K, representing a given carbon content at a particular temperature, divides a horizontal line drawn through it into parts proportional to the relative amounts of the liquid and solid phases. As a molten mass of iron, containing 1 per cent. of carbon, for instance, is cooled, the point p represents the composition of the first crystals that are formed. As the temperature falls, the remaining liquid, being enriched in carbon, follows along the line AS until the temperature r has been reached, when the whole mass is solidified, the process having covered the temperature interval qr. The point B is called the *eutectic* point, and represents the combination which gives an abrupt solidification to a mixture of pure iron and graphite crystals. The line SED represents the formation of a definite compound Fe_3C, called cementite, while FL gives the transformation known as "recalescence" which consists of two simultaneous changes, the separation of the alloy of iron and carbon into alternate layers of ferrite, or pure iron, and cementite, and the transformation of the ferrite to alpha iron. The magnitude of the recalescence increases with the carbon content. The line MOSE is of special interest in this Paper since it corresponds to the disappearance of ferro magnetism.

Roberts-Austin* has studied the transformation points of electrolytic iron deposited from a solution of ferrous chloride by heating the specimen and determining its cooling curve. Besides the normal transformation points at 895°C. and 785°C., he found three others, namely, at 1,130°C., 475°C. and 270°C. The first of these had already been noted by Ball, and is of no particular interest in connection with this Paper. The second and third points he attributed to occluded hydrogen, and suggested that the one at 475°C. may be due to the separation of a hydride of iron from the solid solution, while the one at 270°C. is the corresponding eutectic point. He has further shown that by repeated heating in a vacuum, pumping out the liberated hydrogen, these points vanish. By making the iron the cathode of an electrolytic cell, it may again be partially saturated with hydrogen, when the point at 475°C. will reappear. These points are of special interest, for as pointed out later, certain changes in the magnetic properties have been found to occur near these tem-

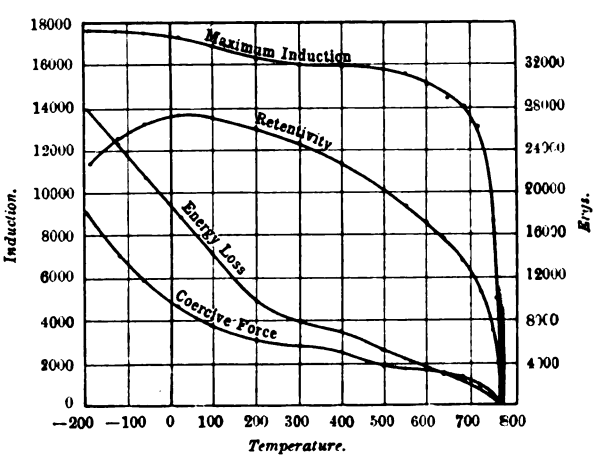

FIG. 3.—VARIATION OF HYSTERESIS CONSTANTS WITH TEMPERATURE. PLATE A, ANNEALED AT 800°C.

peratures. It is an interesting fact that the recalescence point' which is due to the presence of carbon, was found to be absent. Its absence in Burgess iron also has been shown in this laboratory.

Discussion of Results.—One of my first conclusions is that freshly deposited electrolytic iron is very hard magnetically, which agrees with the work of previous investigators. It is to be noted, however, that the magnetic properties of different samples are not at all uniform. In all respects, mechanically as well as magnetically, B is much softer than A, although they were prepared, as far as I am aware, under exactly similar conditions. This is not in agreement with the results of Leick, who found a marked uniformity in all samples, whether deposited from a chloride, sulphate, or ammonium sulphate solution. My results show, however, that these differences exist for small fields only, vanishing for fields of 100 dynes. I have found that after annealing at 1,000°C. they become practically identical for all fields. Some samples of single refined iron were much harder than either of these, one having a coercive for ce of 20 dynes. In this connection it would seem that Schild's criticism of Leick's results is not entirely justified. (Leick obtained results consistently higher than Schild's, obtaining for a field of 125 dynes an induction of over 19,000, while Schild obtained only 15,770. I have obtained 18,600.)

Plunging a ring in liquid air and leaving it for several hours produced no measurable permanent hardening. As the temperature is reduced below that of the room, the permeability decreases for

* "Metallographist," Vol. III., p. 293, 1900.

* "Metallographist," Vol. II., p. 187, 1899.

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small fields, but increases for large fields, this effect being greater after annealing. The hysteresis loss continually increases as the temperature is lowered, the rate of increase being greater after annealing. This is entirely at variance with Fleming and Dewar's results on transformer iron, for they found no change in hysteresis loss at the temperature of liquid air. They also found the permeability to increase for all fields in the case of unannealed and hardened iron, which is again contrary to my results. A very curious effect is the decrease of the retentivity for low temperatures, giving a maximum of about 50°C. A careful search through the literature has revealed no mention of such a phenomenon, and it does not exist for several samples of commercial iron which I have tested. It is believed to be characteristic of electrolytic iron.

The temperature of transformation from the ferro- to the para-magnetic state has been found to be 785°C., which is in good agree-

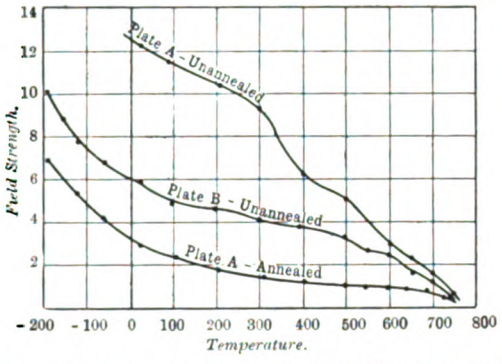

FIG. 4.—FIELD STRENGTH FOR MAXIMUM PERMEABILITY.

ment with the best data available on the temperature of transition from the alpha to the beta state. Hopkinson has obtained the following values :—

	Carbon content.		Temp. of transf.
Soft iron	0·01	per cent.	786°C.
Mild steel	0·126	,, ...	734°C.
Hard steel	0·962	,, ...	695°C.

Morris gives 780°C. for a sample containing 0·08 per cent. carbon. Referring to Fig. 5 these values are in accord with what we should expect from metallurgical considerations. Other experimenters have given values differing somewhat from the above, but unfortunately they have not included chemical analyses, hence their results are of little value for comparison. If the temperature were raised a few degrees above this critical value and allowed to fall slowly, magnetism always reappeared at the same temperature at which it disappeared. This seems to be characteristic of the purity of the metal.

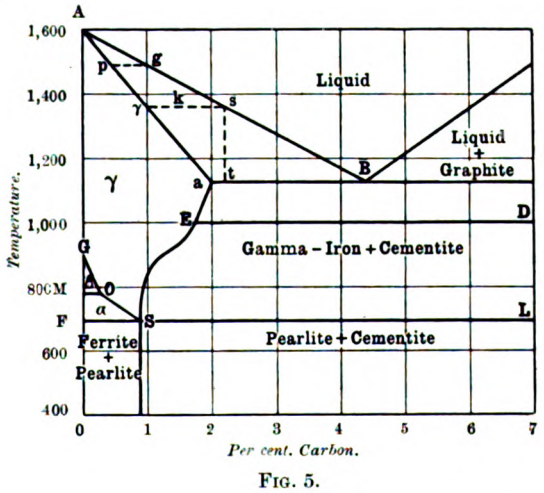

FIG. 5.

The change in the hysteresis loss with temperature shows some interesting variations. Kunz* concluded from his experiments on soft iron that hysteresis loss is expressible as a linear function of the temperature, while Morris' curves show distinct departures from a straight line. An inspection of Figs. 2 and 3 shows marked depressions just after the temperatures 300°C. and 500°C. have been passed. These are in accord with the hydrogen points of Roberts-Austin, already mentioned. It is worthy of note that sample A, after annealing, shows this effect to a less extent than before, a large portion of the occluded hydrogen having been driven off in the process. Perhaps a still more striking proof of the existence of these points is given in the curves of Fig. 4, where the field which gives maximum permeability is shown as a function of the temperature. As stated before, this point of maximum permeability was chosen by Ewing to mark the change from the second to the third stages of magnetisation, and the field at which it occurs furnishes a convenient index to the softness of the iron. It will be noticed that, in sample A, very marked depressions appear in this curve at the temperatures in question before annealing, but that after annealing, they can barely be detected. The changes in the magnetic properties at these temperatures can also be traced in the curves for coercive force and retentivity. Sample B, being much softer, and probably containing less hydrogen, shows this effect less. The corresponding curves of Wills for wrought iron and alloys show no such abrupt changes.

Probably the most striking effect, the variation of permeability with temperature (Fig. 1), is the sudden rise in permeability for low fields just before the transformation to beta iron takes place. The highest value of permeability which I have obtained is 11,000, occurring at a field of 0·5 dyne. Morris obtained a maximum of 14,600 for H = 0·2 in the case of Swedish iron, while Wills gives 17,200 for wrought iron for H = 0·172. Although this last value seems large, the comparison shows that electrolytic iron is not so soft as some commercial irons. The chief respect in which my permeability curves differ from those of Morris is in the matter of regularity. It is well-known to metallurgists that the transition from alpha to beta iron is not abrupt, but covers a considerable temperature interval, the temperature at which the transition begins being greatly lowered by the presence of impurities. The depression in Morris' permeability curves has been interpreted as marking the lower limit of this transition. In view of the fact that I have found no indication of such an effect in electrolytic iron, it would seem as though this depression cannot be characteristic of iron itself in changing from the alpha to the beta state, but must be due to the formation of a molecular combination of the iron with some impurity.

As to the effects of annealing at low temperatures, the maximum permeability is increased about 50 per cent. by heating to 800°C., while for small fields the increase is many fold. The results of heating to higher temperatures show that the iron is in its best state magnetically when annealed at 1,100°C. Further heating decreases the magnetic quality very decidedly. Comparing electrolytic iron with Swedish iron I found that while it has a slightly lower coercive force and a higher maximum permeability, its high retentivity gives it an energy loss nearly 60 per cent. greater.

Stansfield* has studied the physical changes that take place in iron when heated to temperatures that are high but insufficient to melt it. He recognises two stages, (*a*) overheated, (*b*) burned. The first refers to cases in which the temperature has not been carried above the line A*a* in the Roozeboom diagram. Although the point of incipient fusion has not been reached, there has been a marked diminution in the closeness with which the crystals are held together. He has given no lower limit for this stage, but from my results it would appear to be just above 1,100°C. The iron can practically be restored by annealing at a lower temperature. The second stage refers to cases in which the temperature has been taken above the line A*a*. A highly carburised liquid is here formed which accumulates in the intercrystalline joints, and if the metal is held at this temperature too long this is forced out by the carbon-monoxide gas which is formed, leaving interstices in which oxidation may take place. If there has been no oxidation the metal may be restored by reheating to a temperature a little above that represented by the line GOS, and cooling slowly, giving the carbon time to diffuse through the mass of the metal.

* "Electrotech. Zeitsch.," p. 196, 1894.

* "Journal" of the Iron and Steel Inst., Vol. II., p. 433, 1903.

THE SINGLE-PHASE SERIES MOTOR.

In our issue of February 11th we gave an abstract of a Paper read by Messrs. W. S. Franklin and S. S. Seyfert before the American Institute of Electrical Engineers. In this Paper the authors suggested a striking departure from the standard design of single-phase series motors—viz., to employ an internal field, external armature machine, and to remove the commutator away from the motor. A very interesting discussion took place in connection with this suggested design, and below we give an abstract of the remarks of the various speakers.

DISCUSSION.

Mr. S. M. KINTNER thought that a comparison of the output of the proposed 500 H.P. motor, which the authors submitted as one that could be operated within the space limits of the present New York, New Haven

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& Hartford Railway Co.'s locomotive motors, with one of those motors, showed that there was no gain in output per unit weight of active material. The attempt to gain had been made by dividing the motor up into two parts, one of which was made up of the magnetic circuit and inductors which occupied all of the available space at present used by the entire motor on the New Haven locomotives, and the other part, made up of the commutating device, with its necessary choke coils for keeping down the short-circuit currents, which the authors proposed to place in some convenient location outside the motor frame, and which had its own additional space requirement. With the proposition then that an increased output could be effected in direct proportion to the increase in active materials that could be placed in the available space, the discussion hinged on (1) the feasibility of the external commutator with revolving brush-holders, and (2) the value of balanced choke coils for limiting the short-circuit currents. In passing, he noted that, estimating the dimensions of the copper conductors from published I²R losses, the insulation allowances in the proposed 500 H.P. motor were much too small, there being but one-half that allowed in the armature slots of standard machines. Further, the method of getting the windings in place with the proposed slot, copper and insulation dimensions was by no means evident, and the number of commutator bars selected was such as to cause some difficulty in connecting the equalisers. He did not believe an external commutator with revolving brush-holders could be built for this class of service so as to be a commercial success. The difficulties involved were: (1) The construction of the commutator with its 504 flexible connections from the motor windings through the choke coils mounted on the locomotive cab down to the commutator bars, (2) the mechanical arrangement necessary for driving the brush-holders synchronously. It seemed well-nigh impossible to devise a satisfactory arrangement of this kind when viewed from the standpoint of reliability, accessibility for inspection and repairs, freedom from mechanical injury during overhauling other parts of the locomotive, first cost, &c. Again, the increased complication, cost and maintenance expense of the two sets of collector systems for supplying current to the brush-holders and to the rotating field were another serious feature of this type of motor. It would be very difficult to construct a drive which would be absolutely positive and not liable to any interruption, and which would maintain accurately for long periods of time the correct brush setting on the commutator. Single-phase commutator motors were very sensitive as regards brush setting, and great care was taken to insure a correct setting on the present types of such motors to within less than $\frac{1}{4}$ in. All the brush-holders if rotated at motor speeds would need to be carefully balanced, and the carbon springs would require some form of compensator on account of centrifugal forces which would otherwise cause unequal brush pressures. Many other difficulties suggested themselves, but the foregoing were sufficient to indicate the character of trouble that would be encountered. On considering the question of balanced choke coils for limiting the magnitude of the short-circuit currents, one was surprised to find how large these coils became. In connection with the 500 H.P. motor proposed by the authors, the voltage between consecutive commutator bars was not as great as that on the New Haven motors. The magnetic density in the various parts of the proposed motor was also somewhat less. From this it might reasonably be argued that the size of the choke coils and the motor power factor proved to be the limiting conditions which prevented an increase in output per unit mass of material. There were two other points that should be considered in connection with the choke coils, as determining factors of their value: (1) Their ability to withstand without injury heavy momentary overloads, and (2) the character of their construction combined with an adaptability for ready assembling in a suitable manner and at a reasonable cost. In considering the first point, an examination of the choke coil for the small machine shown in the Paper indicated that there was approximately as much resistance in the copper of the choke coil as would ordinarily be used in a regular resistance lead, and that this alone would have been sufficient to limit the short-circuit current without the inductive effect. This, then, indicated a serious sacrifice in sturdiness and overload capacity in order to keep down the size to such proportions as would allow the choke coils to be mounted inside the armature. The authors stated: "It does not seem possible, however, to produce a single-phase motor that will operate satisfactorily without the use of special devices for the prevention of excessive short-circuit currents." He wished to take exception to this statement, as it was perfectly feasible to build motors without any special devices of this nature, provided the induction per pole was kept low enough. There were a great number of motors of this kind in operation giving satisfactory service. Considering the second point, that of cost and adaptability for assembling, he had found on calculating suitable coils for the proposed 500 H.P. motor that the sizes were rather startling, and one was inclined to the belief that the authors were so glad to find a place large enough to accommodate the choke coils that the mechanical difficulties involved in the use of the external commutator looked small. The space available for the motor of a locomotive depended so much on the type of motor mounting and drive that comparisons on the basis of the output of different types were misleading.

Mr. E. H. Anderson thought the Paper brought out very clearly the difficulties of designing a single-phase commutator motor. The scheme of placing reactances so as theoretically to reduce sparking was ingenious. The criticism was that it did not make for simplicity. It appeared from the text that the leads of the stationary winding were connected into the stationary commutator, although space and details of construction were not shown. In order to take the motor apart for repairs, it was necessary to pull off a driving wheel, or separate the stationary member, and in this case it became necessary to disconnect the winding and all the commutator leads coming from the lower half. The driving mechanism for the revolving brush-holders must be positive and rigid. No slack or looseness could be allowed, for the exact position of the brushes on a single-phase commutator motor was very essential for proper operation and speed. Such a motor as described usually had about an 8 in. commutator and 18 in. of core iron between heads. The power of a motor was dependent largely upon the length of core, and if all the commutator length could be put into core—viz., by adding 8 in. to 18 in.—it became possible to increase the power about 45 per cent. However, all the commutator length could not be added to the core, for the reason that there must be a circular conduit at each end to allow the leads of the lower portion of the stationary member to be brought up to the stationary commutator. This would require approximately 3 in. on each end, thus leaving 2 in. to be added to the core length, giving 20 in. instead of 18 in., or an increase of 11 per cent. After the leads left the conduit they must be spread around the commutator and held firmly, as well as properly ventilated. Usually from a given space a certain amount of heat could be blown out, so that with a given efficiency only a given amount of work could be done in that space. The driving device for the revolving brush-holder rigging must take up some space on the axle. This would no doubt use up the spare 2 in., with the result that the iron core between heads was not increased. The serious question about the construction, to the speaker's mind, was that it was not the simplest. A prominent railway company built and installed a motor on a single-truck car, which should act as a counterweight to the real motor. The motor was a chunk of cast iron, with armature bearings on it, mounted outward on a single-truck car, and over-balanced the effect of the real motor, which was outwardly hung on a single-truck car. This was put on as it was thought the real motor might tip up end-wise and block the system. These motors were used for a long time, and gave no trouble, probably on account of their simplicity.

Mr. E. F. W. Alexanderson preferred to look at the subject in a somewhat different light rather than discuss the schemes presented in the Paper. The three principal limitations in the design of an alternating-current railway motor were heating, commutation and starting torque; of these three, the starting torque was, however, the most important. The first attempts to design the alternating-current railway motors were naturally along the same lines as those of direct-current motors. The motors were completely enclosed, and the service capacity was determined from the heating characteristics. As soon as forced ventilation was adopted in an alternating-current motor the whole basis of the design was changed, and heating was no longer the limiting feature. Commutation difficulties could be entirely overcome at any normal operating speed by application of a commutating field of suitable phase and strength. They could also be counteracted, to a great extent, by the use of so-called resistance or preventive leads. The ruling feature was, therefore, the starting torque. This applied to the three-phase railway motor, as well as to the single-phase railway motor, although for entirely different reasons. In the single-phase railway motor, the starting torque was limited by local heating on the brushes, commutator bars and certain parts of the winding. Various methods had been devised to increase the starting torque of single-phase commutator motors, and were agreed to be essential. The starting torque of the single-phase commutator motor was limited by the voltage per bar on the commutator, and the current per bar in the winding. Generally speaking, it could, therefore, be said that the starting torque was proportional to the size of the commutator. The special methods used to increase the starting torque consisted in providing means for either raising the voltage per bar or for raising the current per bar. In other words, both systems required space in the motor which could otherwise be usefully employed if the motor was intended for direct current. The scheme presented by the authors of the Paper was the first of the two mentioned principles for increasing the starting torque, carried to the extreme. The system was, according to the authors, very effective, but there was also every indication that it took room in proportion to its effectiveness, and there was no convincing evidence in the Paper that the space occupied by the motor with its elaborate non-sparking devices would not be quite as large as the space of a motor of more familiar design. The scheme, apart from its complication, did not solve the problem of space factor as it was worked out in the design shown in the Paper, because no provisions had been made for materially increasing the diameter of the commutator, which, after all, was a measurement of the starting torque. A natural solution was, however, given by the use of side rods which allowed the commutator as well as the rest of the motor to assume its necessary dimensions as well as its natural proportions. It was interesting to observe that the results obtained by the four or five manufacturers of single-phase railway motors in America and in Europe agreed closely in regard to weight and space per horse-power. In order to give some more concrete figures as to the space and weight factor of moderate size single-phase motors, the following data might be mentioned. A 25-cycle motor of the series repulsion type designed for 36 in. wheels had a weight of 5,900 lb., and delivered 150 H.P. at 600 revs. per min. in accordance with standard rating. This was in close agreement with recent developments of motors of several other types and makes. The various schemes employed for overcoming commutation difficulties could not, therefore, be judged by the space factor or the weight per horse-power. The nearest to a practical comparison was undoubtedly a test that had been embodied in the specifications for locomotives in connection with the contemplated electrification of two of the large western railroads, that the motor should be able to develop full torque at stand-still for a specified time, one minute or five minutes.

Mr. S. S. Seyfert thought that during the discussion the non-sparking devices proposed were assumed to be a necessary part of the inversion

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of the relative positions of field and armature. It was not necessary, however, to use these choke-coils in the case of a motor with external armature, and as a matter of fact he had often thought that it might be desirable to use resistance leads only under certain circumstances, especially if the short-circuit volts were reasonably small. They had found it extremely difficult to design a motor of so large size with a reasonable short-circuit voltage per turn, for with a reasonable number of poles, say 12, the flux per pole on a 500 H.P. motor became so large as to produce 12 volts or more per turn on the armature circuit. He thought, however, that motors could be built on the resistance-lead principle that would commutate well enough, and in that case the stationary character of the armature, with the available space for placing the leads, would enable us to design the leads somewhat more generously, and therefore their liability to burn out at starting would be less, which would mean a lessening in the cost of repairs and an increase in the reliability of service. On the basis of resistance leads alone, dropping entirely the question of choke-coils, it would seem an advantage to have the leads so located that they could be easily and separately repaired. This would compensate for a great deal of the otherwise complicated arrangement. As to the length of commutator, one speaker had mentioned that the length of the commutator on the present New Haven motor was about 7 in. or 8 in., and in case of the removal of this commutator that space would be gained. If they attempted to build a 500 H.P. motor the commutator would be about a foot long. In that case, assuming the commutator on the motor concentric with the axle, they would gain a foot of space by removing the commutator. Should they decide to make the commutator concentric with the armature this 1 ft. of space needed would necessitate a greater driving-wheel diameter. It should be plain, therefore, that the increase in gross length of useful iron made possible by the removal of the commutator would be 12 in. instead of 7 in. or 8 in. as would be the case in changing a 250 H.P. motor. As to design, the inverted motor had, among others, the following advantages: (1) The long external yoke or armature core had to carry the effective armature flux only, whereas, in the old type of motor, the corresponding core had to carry the total field flux. (2) The placing of the armature externally allowed the use of a wider and shallower armature slot, resulting in a better commutation constant and a slightly better power-factor. The compensating slots through the poles must be deeper in this case, which condition might be easily met. Because of the comparatively low voltages at which single-phase motors must operate, it had been found somewhat difficult to satisfy the direct-current commutating condition on a motor of large size with such a small number of poles. (3) The air-gap periphery was somewhat increased in the case of the external armature motor mainly because the armature required less radial depth than the field. (4) The end-windings of the compensating coils were very much shorter, as was mentioned in the Paper. The authors had made some experiments on core losses in field and armature, which might be of interest. For some time they were under the impression that the core losses per unit of volume in the armature of the alternating-current motor should diminish as synchronous speed was reached. Upon going into the theory of the matter this seemed to be so, but for some reason the core losses actually increased somewhat with speed, and grew very rapidly above synchronous speed. This might be due to the fact that the losses caused by the bunching of flux by the teeth were such a large percentage of the armature core loss. In the Paper it was stated that they had selected the 10-pole type of motor; it was found later that 12 poles would have been better, and thereby they could make a better machine, one that would commutate better and have a smaller short-circuit voltage.

President STILLWELL said he did not propose to enter into the discussion, but one or two points had occurred to him. One was that the argument in favour of the increase of output in proportion to dimensions was greatest in the case of multiple unit equipment. In which case the Paper made no suggestion as to the location of the commutator and its leads. In the case of the electric locomotive, taking the state of the art as it existed when the New Haven locomotives were designed, the designers were undoubtedly cramped for room in attempting to place the motors underneath the floor of the locomotive. The tendency was now rather towards raising the motors and gearing to a shaft, in which case the argument in favour of separate commutator and its leads from the field armature was somewhat minimised.

Prof. W. S. FRANKLIN, in replying to the discussion, said in regard to the location of the detached commutator in the multiple-unit car, Prof. Seyfert and the speaker had considered that matter in some detail and came to the conclusion that a very great advantage would be realised by placing the motor on one side of the axle and the commutator on the other side of the same axle, taking the commutator leads across through a covered passage-way over or under the axle. In regard to the general question of detaching a commutator, a commutator was a switchboard, and it was proper to detach a switchboard from the machine which it controlled. In regard to simplicity, he pointed out that the motor under discussion was about the nearest approximation that he knew of to a "piece of cast iron." In answer to Prof. Kintner, the short-circuit voltage of the No. 5 (500 H.P.) motor was 12 volts per turn. As to the necessary size or carrying capacity of the individual choke-coils, it was stated in the Paper that a short-circuiting arrangement could be provided so that choke coils or resistance leads could be cut out or in at pleasure. Therefore, at starting, very high resistances might be inserted in the leads and these resistances might be cut out with increase of speed after starting. He wished to emphasise a point brought out in the Paper, namely, that one of the most important features in the suggested design was that it was possible to treat the problem of starting and the problem of running as two distinct and separate problems.

THE DETERMINATION OF THE EFFICIENCY OF CONTINUOUS-CURRENT MACHINES.

BY W. C. CLINTON, B.Sc.

Various modifications have been proposed from time to time of the original Hopkinson method of testing two similar machines.

These modifications have had two objects in view:—Firstly, the supply and measurement of all the power used electrically, and secondly, the realisation of exactly similar conditions of test for each machine. This second object becomes of importance if accurate values of efficiency are desired.

It is known that both conditions cannot be secured together, as the core and frictional losses can only be supplied by a torque from the common shaft. Recognising this, Blondel* has suggested a method of attaining the second object, by supplying the core and friction losses to two similar machines coupled mechanically, by the aid of a third motor, and the copper losses from a battery or dynamo in series with the two armatures, the field circuits of the two machines being separately excited to an equal degree. A disadvantage of this method is the introduction of the efficiency of the third motor, although the method gives the nearest approximation to a complete separation of the copper and core losses yet suggested.

If all the power is supplied electrically, as in Kapp's methods, the power represented by the core loss and frictional torques for the two machines must be supplied by the motor over and above that required for the dynamo output. The motor will be, therefore, always more heavily loaded than the dynamo.

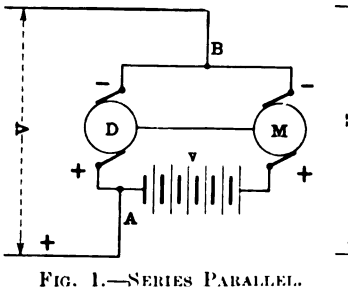

FIG. 1.—SERIES PARALLEL.

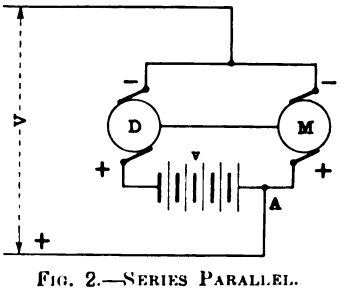

FIG. 2.—SERIES PARALLEL.

When the armatures are in series with the supply, the fields being separately excited, the difference between the field currents of the two machines must be great for light loads and must be diminished as a heavier load is required. This difference may be made to vanish or even change sign with interpole machines heavily loaded.

When the armatures are in parallel with the supply, light loads are obtained with the two excitations nearly equal, and the difference between the two excitations must be increased for heavier loading.

By combining the series and parallel arrangement as in Hutchinson's method,† the ampere-turns on the field of each machine may be kept equal, and at their normal value, over the whole range of loading, so that the full heating effect of the field coils on the machines is obtained. A careful comparison of the Blondel and Hutchinson methods has been made recently by G. Brion.‡

Two cases arise in dealing with Hutchinson's method. The constant voltage in parallel with the armatures may either be applied direct to the dynamo terminals, as in Fig. 1, or direct to the motor terminals, as in Fig. 2.

If the normal voltage is supplied at A and B, then in Fig. 1 the dynamo will be running at constant P.D. from no load to full load, while the motor voltage and the speed of the combination will be above their normal values. In Fig. 2 the motor voltage will be normal at all loads, and the dynamo voltage and the speed of the combination will gradually fall

* Blondel and Dubois, "Traction Electrique," Vol. II., 1898, p. 370.
† "Electrical Engineer," 1893.
‡ G Brion, "E.T.Z.," September 16, 1909, p. 865.

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from no load to full load. The connection in Fig. 2 is a good one to use if it is desired to realise working conditions for the motor.

To do this for the dynamo as a separately excited machine running at a constant speed and excitation, the contact A may be made at an intermediate point on the voltage v, when conditions intermediate between those of Fig. 1 and Fig. 2 will be obtained.

There is one position for the contact A which will give constant speed over the whole range of loading provided that V is constant, and at the same time will ensure that the drop of pressure at the dynamo terminals for a given current will be the same as that which would be observed for that current if the machine were on an actual resistance load.

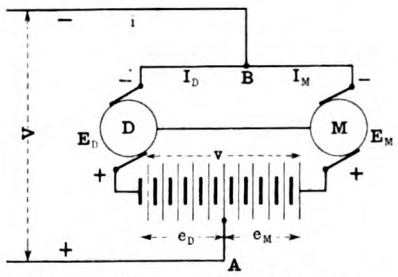


FIG. 3.—DIVIDED SERIES PARALLEL.
The battery v may be replaced by suitable generator separately driven.

Referring to Fig. 3, the loading is determined by v, that is, by e_D+e_M, the motor current I_M exceeding the dynamo current I_D by the current i. The position of the point A should be such that the internal E.M.F. of the dynamo is as much below V as the internal E.M.F. of the motor is above it. Let f be this defect or excess, then $V=E_D+f=E_M-f$.

V is also equal to $E_D-I_DR+e_D$

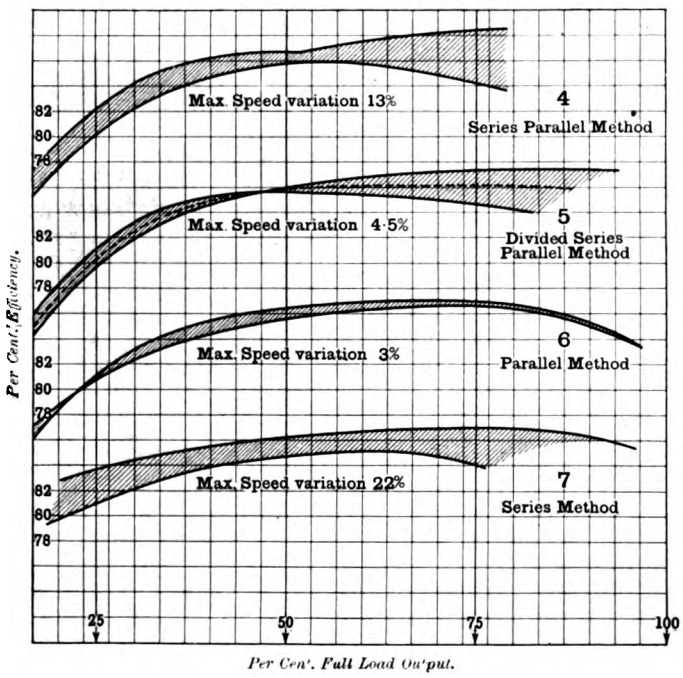
and $E_M+I_MR-e_M$,

where R is the resistance of the armature circuit of either machine.

It follows that $e_D-I_DR=e_M-I_MR$

or $e_M-e_D-R(I_M-I_D)=iR$.

The nearest approach to identity of conditions of test for two similar coupled machines, when the whole of the power



FIGS. 4, 5, 6 AND 7.

is supplied electrically, will be obtained by using the connections of Fig. 3 and arranging that e_M and e_D shall be in the above relation.

Usually iR is very small compared with e_M and e_D, especially at heavy loads, when i may become zero, or even reverse. It is therefore sufficient to make e_M equal to e_D. This is conveniently done by bridging v with two adjustable resistances in series and making the contact A at their junction, or using one resistance with a sliding contact, and making this the point A.

The curves shown in Figs. 4, 5, 6, 7 give the results of tests carried out on two similar shunt-wound interpole machines each rated at 6 kw. and 220 volts in the Pender Laboratory of University College, London. The machines were directly coupled together and were supplied with separate excitation of their shunt windings. These excitations were kept exactly equal throughout the tests, the results of which are shown in Figs. 4 and 5, at a value that gave the normal speed as a motor running light. The machines were loaded for the parallel test (Fig. 6) by altering the field currents by an equal amount on either side of their initial equal values. Different loads for the series test (Fig. 7) were obtained by altering the dynamo field and the applied voltage, the motor field being kept constant.

The efficiencies shown are for the rotating parts only, in all cases, the field losses being left out of account.

The method adopted for the subdivision of the total loss was the same throughout. Each armature was debited with its appropriate copper loss, including that of the interpole winding, and with one-half of the total core and frictional losses, obtained by difference.

The efficiency curves of the machines, either as dynamo or motor, lie within the shaded areas of Figs. 4, 5, 6 and 7. These areas are defined by four curves in Figs. 4 and 5 and by two curves in Figs 6 and 7.

In Figs. 4 and 5 each machine was in turn dynamo and motor; this accounts to some extent for these shaded areas being so much greater than that in Fig. 6, where only one curve was plotted for each machine. This was also the case in Fig. 7, where the great width of the diagram is an indication of the inferiority of the series method.

The mean value of the efficiencies at a given output by the divided series parallel method should give the true efficiency of the rotating portion of either machine very nearly, as the only difference between them under the conditions of operation lies in their internal E.M.F.s, the dynamo being as much below the normal voltage as the motor is above it. The dotted curve in Fig. 5 gives this result. The efficiency of the whole machine can then be obtained by allowing for the known copper loss in the separately excited shunt winding.

AN EXPERIMENTAL CATENARY LINE.*

Summary.—A description is here given of the equipment used by various contractors on an experimental catenary line in the U.S.A.

Since May, 1909, the Connecticut Co. has been conducting an elaborate service test of catenary suspension systems on a line between Middletown and Hartford, Conn. The total trial section is about 11,000 ft. long, of which 10,050 ft. are over the Valley Branch (steam) of the New York, New Haven & Hartford Railroad, and 950 ft. over public highways. The purpose of this installation is to develop the characteristics of commercial catenary line material. Six prominent manufacturers, the Ohio Brass Co., the Westinghouse Electric & Manufacturing Co., the Electric Service Supplies Co., the Electric Railway Equipment Co.(through Elmer P. Morris Co.), the Johns-Manville Co. (through the Johns-Pratt Co.), and the General Electric Co. were each requested to erect an installation of about 1,700 ft. of single catenary for wheel operation at speeds of 40 miles per hour. The messenger sag, the types and spacings of hangers and the general details of design and installation were left to the manufacturer, subject, however, to the following conditions: The poles were to be spaced 150 ft. apart on tangents and 75 ft. apart on curves with the nearest face of the pole distant at the level of the top of the rail, 10 ft. 6 in. from the centre line of the steam track and 7 ft. 6 in. from the centre line of the track in the highways. Bracket construction was specified for tangents, and both span and bracket construction for curves. For bracket work, the poles were

* Abstract of an article in the "Electric Railway Journal."

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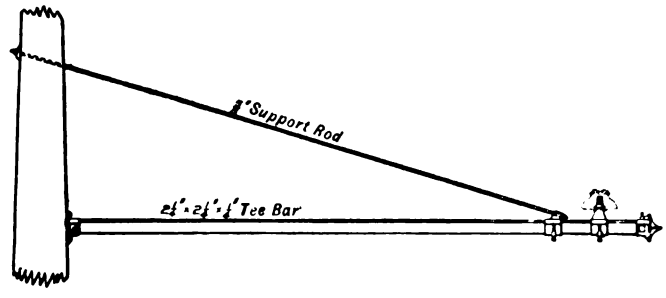
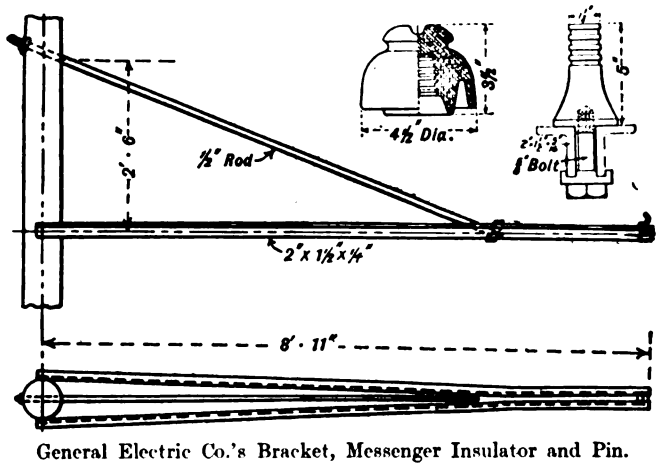
to have a rake of 6 in. in 24 ft.; for span work, 12 in. in 24 ft. With the exception of the General Electric Co.'s division, it was ordered that the trolley wire should be of No. 0000 grooved copper, and the messenger wire of 7/16 in. extra galvanised, seven-strand Bessemer steel. For experimental purposes the General Electric Co.'s section was equipped with a trolley wire of No. 0000 grooved mild steel and a messenger of No. 0000 hard-copper cable made of 19 wires, each of 0·1055 in. diameter.

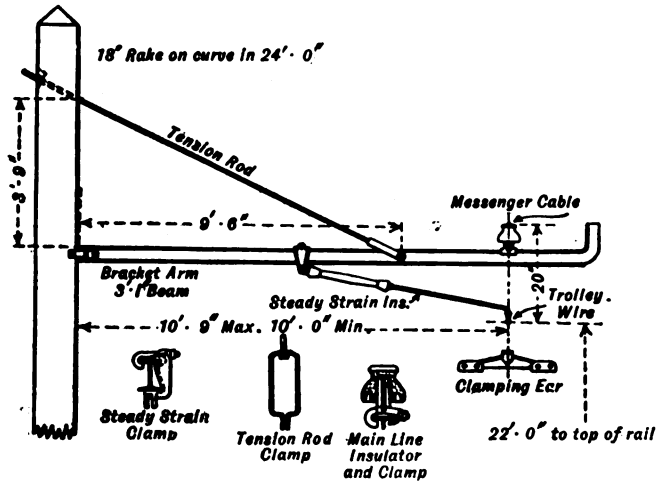
Up to the present time the behaviour of this installation has been very satisfactory. In a few cases one of the types of mechanical clamps gave some trouble due to the working out of the short screws with which it was furnished. With these exceptions, the entire line continued to remain in first-class condition.



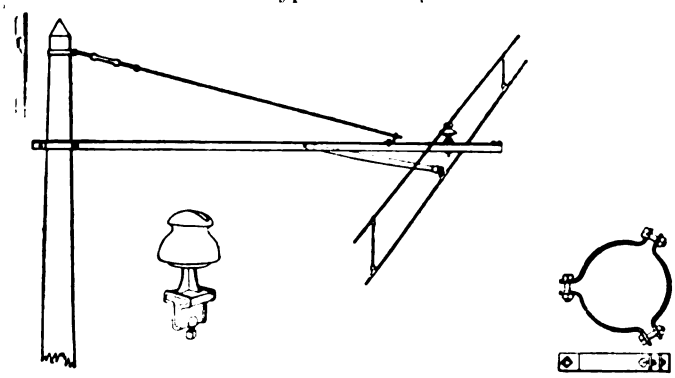
Ohio Brass Co.'s Standard Bracket.



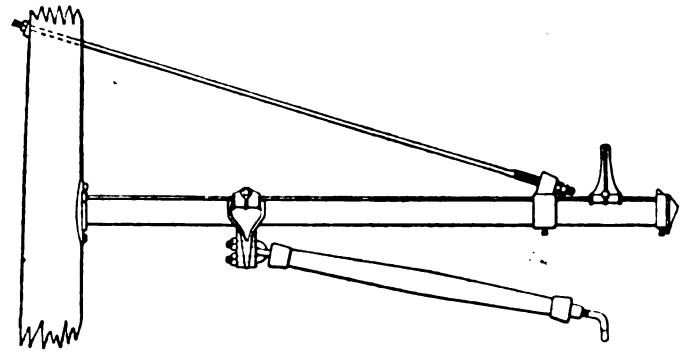
General Electric Co.'s Bracket, Messenger Insulator and Pin.



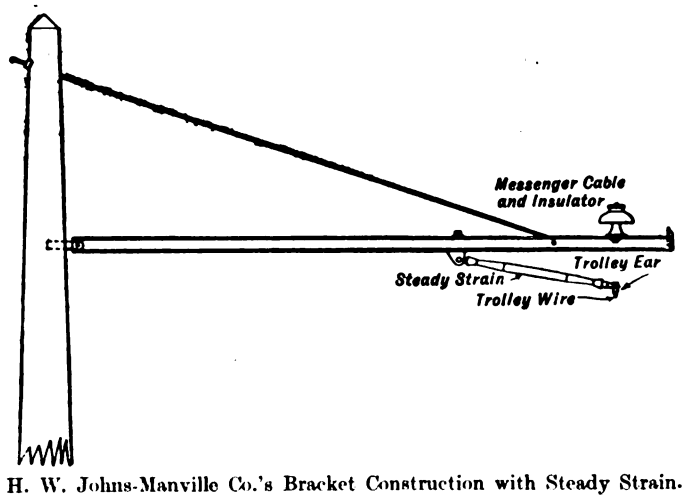
Westinghouse Co.'s Bracket and Fittings.



Details of Elmer P. Morris Co.'s Bracket.



Electric Service Supplies Co.'s Bracket with Wood, Steady Strain and Steel Goose Neck.



H. W. Johns-Manville Co.'s Bracket Construction with Steady Strain.

FIG. 1.—CATENARY TEST LINE. DETAILS OF THE DIFFERENT TYPES OF BRACKETS.

Installation of the Ohio Brass Co.—All of the construction is of the bracket type with a hanger spacing of 15 ft. The sag of the messenger wire is 4 in. for 75 ft. spans and 16¾ in. for 150 ft. spans. The distance from the messenger wire to the trolley wire at the messenger support is 23 in., at the centre of 150 ft. spans 6¼ in., and at the centre of 75 ft. spans 19 in.

The pole bracket is shown in Fig. 1. All the bracket arm castings completely surround the T-bar, and the support rod and insulator pin castings are adjustable along the arm. For convenience in erecting, the bracket is so arranged that the messenger wire can be lifted over the end of the arm without having to thread it under the support rod. The messenger insulator pin is known as type C.E., form 1, and is made of black japanned malleable iron. The base of the pin completely surrounds the T-bar to make accidental disengagement impossible.

The hangers (Fig. 2) have hinged clamp ears closed by a conical wedge screwing down into conical jaws. There are three types, as follows: C.A., form 1, with a loop-top strap hanger; type C.B., form 1, with a sister-hook-top rod hanger; C.D., form 1, saddle-top strap-hanger with a hinge at the ear. The pull-off hangers are of type C.A., form 1, having sister-hook-top, rod hanger, double-grip screw curve ear and a spool above the ear for the bridle. The anchor hangers, located at the brackets, are known as type C.B., form 1, and also have a sister-hook-top and rod hanger, as well as special half-ears of the soldered type with an eye at the butt end. From this eye a guy with a turnbuckle leads over the insulator to the anchorage on the next pole. No steady strains were used by this Company.

Installation of the Westinghouse Co.—All of the construction is of the bracket type with a hanger spacing of 37 ft. 6 in. on 75 ft. spans and 50 ft. on 150 ft. spans—in other words, two-point suspension is used on the short spans and three-point suspension on the long spans. The sag of the messenger wire is 3½ in. on the 75 ft. spans and 16 in. on the other spans. The distance from the messenger wire to the trolley at the messenger support is 20 in.; at the centre of the 50 ft. spans, 4 in.; at the centre of the 75 ft. spans, 16½ in.

The pole bracket is the maker's 3 in. I-beam design with upturned ends and ½ in. tension rod. Fig. 1 includes, in addition to the bracket

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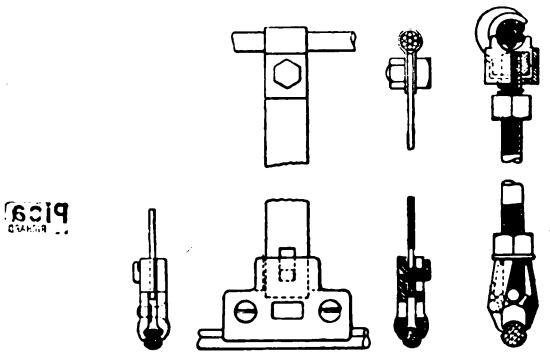
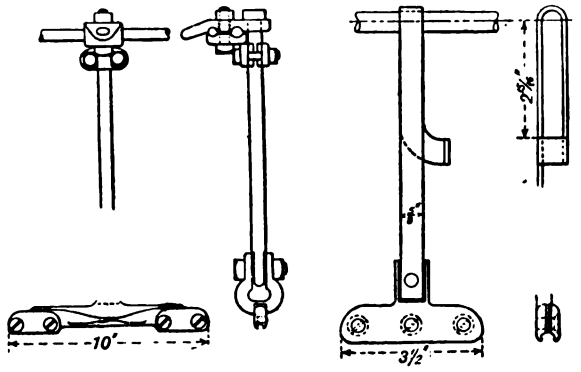
details of the various fittings, such as the steady strain and its clamping ear, main line insulator, insulator clamps, &c. The weights of the several parts are as follows: Bracket arm, without main line insulator or steady strain, 64 lb.; main line insulator, 4 lb.; steady strain with clamp, 14 lb.; clamping ear for steady strain, 0·8 lb.; total weight, 82·8 lb.

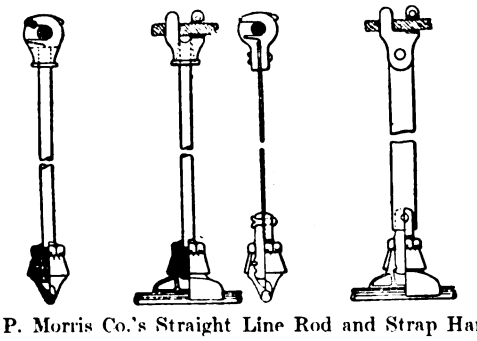
Fig. 2 shows the anchor hanger, the anchor clamp and the new rocker type trolley hanger. The anchor hanger is provided with



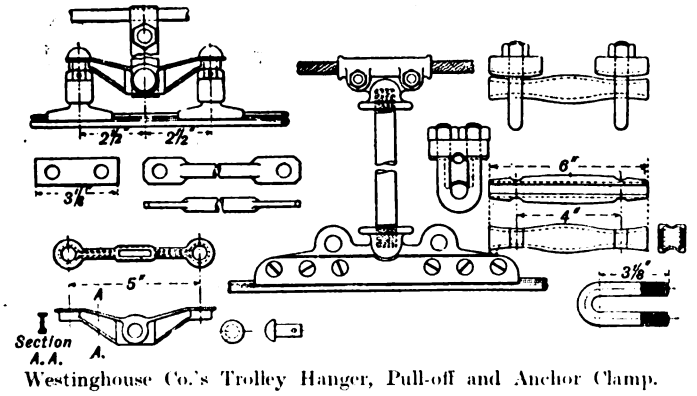
H. W. Johns-Manville Co.'s Flexible and Rigid Hangers.



General Electric Co.'s Curve Pull-off Ear and Form C.F. Catenary Hanger.



Elmer P. Morris Co.'s Straight Line Rod and Strap Hangers.



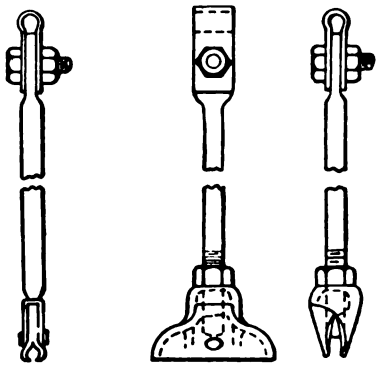
Westinghouse Co.'s Trolley Hanger, Pull-off and Anchor Clamp.

top. The trolley is tied to the messenger by an anchor clamp, which also ties to the messenger four head guys leading to adjacent poles.

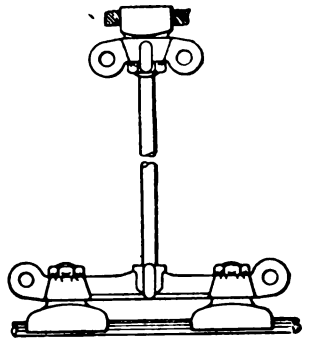
Installation of the Electric Service Supplies Co.—The hangers are spaced about 15 ft. throughout. The sag of the messenger wire is 4 in. on 75 ft. spans and 16 in. on 150 ft. spans. The distance from the messenger wire to the trolley at the messenger support is 22 in.; at centre of the 75 ft. spans, 18 in.; at the centre of the 150 ft. spans, 6 in.

The brackets (*see* Fig. 1) are of the maker's T-bar type with an end-piece and tension rod. They carry Locke No. 5 A insulators for the messenger wire. The weight of a standard bracket equipment is 60·76 lb., distributed as follows: T-iron, 2½ in. × 2¼ in. × 9 ft. 6 in., 40 lb.; pole socket, with bolt, 2·13 lb.; two lag screws for pole socket, 0·22 lb. each; guy-rod clamp with set-screw, 2·63 lb.; guy rod and fittings, 8·17 lb.; cast-iron angle washer, 0·5 lb.; insulator pin and bolt, 5·36 lb.; and outer end ornament, 1·53 lb.

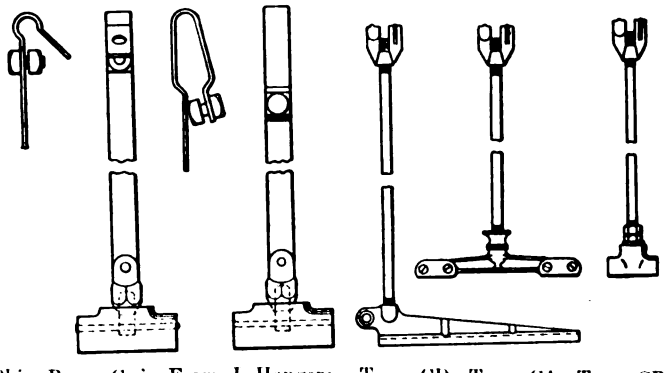
Two styles of hangers are used, known respectively as the "Interlocker" and the "Nuckelock" (*see* Fig. 2). The first is of the rocking type, consisting of stamped-steel ear-plates with interlocking fingers, a rod hanger with flat ends, a pin-hinged bottom and a saddle top; the second is of the rigid type with jaws rocking on a ball-and-socket joint and locked by means of a lug on one of



Electric Service Supplies Co.'s Interlocker and Nucklelock Hangers.



Elmer P. Morris Co.'s Curve or Anchor Hanger.



Ohio Brass Co.'s Form I Hangers. Type CD, Type CA, Type CB (anchor), Type CA (Curve Pull-off), Type CB.

FIG. 2.—CATENARY TEST LINE. DIFFERENT TYPES OF HANGERS AND FITTINGS.

heavy clamp grips for the trolley wire and the messenger cable. The trolley wire jaws have eyes for the attachment of guy cables. The rocker hanger has two ears, each consisting of a pair of jaws screwing into a socket. These sockets are mounted at the ends of the rocker arm at the centre of which the hanger rod is connected by a hinge pin. The hanger is of the rod type, with flattened ends and saddle the jaws. The steady strains shown in Fig. 3 are used in curves only. An anchorage as made in the centre of the span consists of a single strain ear on the trolley wire either side of the centre, each having a guy with a turnbuckle tied to the messenger by a clamp anchor plate with four heads guy from corners of the latter to adjacent poles, as illustrated. No pull-offs are used on this section.

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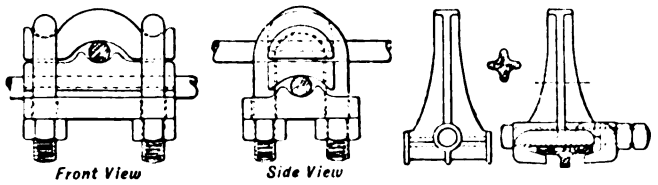
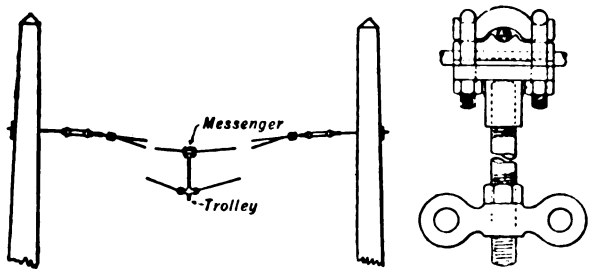
Installation of the E. P. Morris Co.—The hanger spacing is 19 ft. for 75 ft. spans and 30 ft. and 37½ ft. for 150 ft. spans. The sag of the messenger wire is 4½ ft. on 75 ft. spans and 17 in. on 150 ft. spans. The distance from the messenger wire to the trolley at the messenger support is 21 in.; at the centre of the 75 ft. spans, 16½ in.; at the centre of the 150 ft. spans, 4 in. The brackets are of galvanised double angles bent to clamp the pole, with a guy rod and a special three-bolt pole clamp, as illustrated in Fig. 1. The messenger is carried on Thomas No. 1,037 insulators. The steady strains are installed only on curves. Several specimens of span construction were installed as follows: One span with spool type insulators; four cases in which the span was made up with an eye-bolt in the pole head and porcelain goose eggs on either side of and close to the messenger; and the 10 remaining spans having wood strains instead of goose eggs.

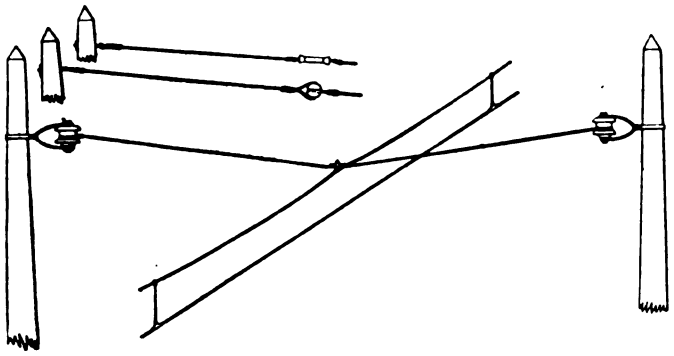
All of the hangers embrace what the designer calls the "Sure Grip" clamp. This consists of two clamping jaws, a threaded and tapped stud and a compression cup and hexagon nut for locking all parts together and clamping the trolley wire. The locking is completed by bending down one of the small clinch points on the hexagon nut. The forcing nut acts directly on the 1 in. stud, so that no strain is imposed on the threaded end of the hanger rod. The clamp has no exposed threads nor pockets to retain moisture.



Electric Service Supplies Co.'s Span Wire, Clamp and Insulator Pin.



Electric Service Supplies Co.'s Span and Steady Strain Fixture.



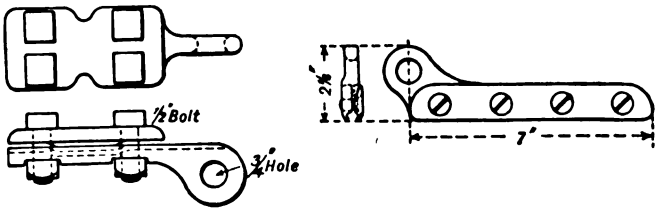
Elmer P. Morris Co.'s Three Types of Spans.

FIG. 3.—CATENARY TEST LINE. SPECIMENS OF SPAN CONSTRUCTION AND MISCELLANEOUS FITTINGS.

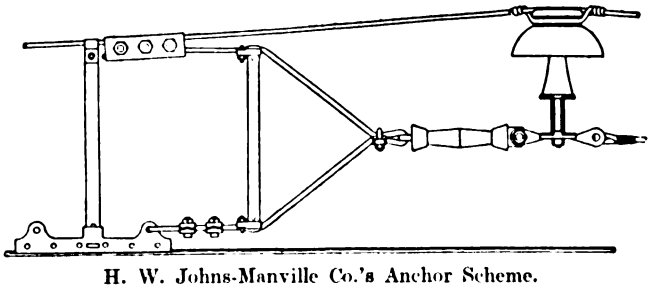
The straight-line hangers installed are of both the rod and strap types, including the clamp described and sister-hook tops. The sister-hooks are secured to the messenger wire and locked in place by two small clinching points. The latter are directly under the main holding points and when bent up in position serve to bind the messenger wire together instead of forcing it out of shape. The ½ in. suspension rod has a T-head which so engages the sister-hook that the rod can retain its perpendicular position by adjusting itself to the unequal expansion or contraction of the messenger and trolley wire. In the case of the straight line, strap type hanger the sister-hook top and the trolley-wire clamp are attached to the strap by ½ in. rivets, the whole making a very flexible suspension. The pull-off hangers are modifications of the straight-line rod hangers in having one or two eyes on the compression cup and in substituting one or two-eye messenger clamps for the sister hooks. The curves were pulled off with equal chords, the bridle being led back to a backbone stretched from pole to pole in accordance with the standard practice of the Connecticut Co.

On one side of a bracket an anchorage consists of a half-strain ear on the trolley with a guy led to a turnbuckle attached to a strain plate on the bracket and a guy wire clamped to the messenger over the strain ear also leading to the same turnbuckle. On the other side of the bracket guy wires from the opposite turnbuckle lead to the top and bottom of an anchor hanger. The anchor hanger illustrated (Fig. 2) is also used on curves. An anchorage on the span section consists of a two-clamp trolley ear, with a four-eyed compression cup at the top of the hanger rod. A guy wire is led from each side of the ear to the clamps on the messenger, and from the four-eyed compression cup guys are led in four directions to adjacent poles.

Installation of the Johns-Manville Co.—The hanger spacing is 10 ft., 12 ft. or 15 ft. for spans ranging in length from 75 ft. to 150 ft. The sag of the messenger wire is 5 in. on the 75 ft. spans and 16 in. on 150 ft. spans. The distance from the messenger wire to the trolley at the messenger supports is 20 in.; at the centre of the 75 ft. span, 15 in.; at the centre of the 150 ft. span, 5 in. One of the brackets is illustrated in Fig. 1. On curves the bracket is provided with a steady strain. It is 14 ft. long, and is composed of two rolled steel channels 2 in. deep and in 1. wide and weighing 2·6 lb. per foot. These channels are riveted together with spacing blocks between to increase the strength of the bracket as a strut. The blocks offer excellent means for fastening the various fittings by passing bolts between the channels and holding them in place with a washer, lock washer and nut. The tension rod is made of ½ in. hot rolled steel, having a head on one end and being threaded at the other. This rod passes up through a casting riveted between the channels, the head engaging the lower side of the casting. The tangent bracket differs from the curve bracket in being made of



General Electric Co.'s Messenger Clamp and Strain Clamping Ear.



H. W. Johns-Manville Co.'s Anchor Scheme.

FIG. 4.—CATENARY TEST LINE. PULL-OFFS, ANCHORS, &C.

two steel channels 3 in. deep and 1 in. wide pressed from ⅛ in. sheet stock. The tension rod is fastened to the bracket by a bolt passing through the two webs of the channels and an eye at the end of the rod. The messenger insulator is of the ordinary petticoat porcelain type with a malleable iron pin cemented into the porcelain. The pin is held to the bracket by means of a bolt passing up between the channels and screwing into the bottom of the malleable iron pin. Both flexible and rigid hangers have been provided, the former being of the bottom slide strap type with a two-screw ear and the latter of the rod type with a toggle clamp ear. The flexible hanger is made up as follows: The strap is stamped from steel stock 1 in. × ⅛ in. in section, a thickness which has been found stiff enough to prevent buckling from the blows of trolley wheels. Flexibility is obtained by a finger passing from one of the clamping plates through a rectangular slot at the lower end of the strap and through a rectangular hole in the other plate, the two plates being held together by flat-head machine screws. The strap is fastened to the messenger cable by a loop of flat stock, a bolt passing through the two loops and the upper end of the strap. In the rigid hanger the holding power of the trolley-wire clamp is secured by a pair of toggles. The weight of the trolley wire comes directly on the first point of the toggle arms so that the clamping effect on the wire increases automatically with the load. The nut and lock washers above the jaws prevent the opening of the latter with the upward pressure of the wheel. The messenger clamp consists of a malleable-iron hook screwed to the end of the hanger rod and having a grooved, hollow casting forced upward by a nut to hold the messenger firmly and to

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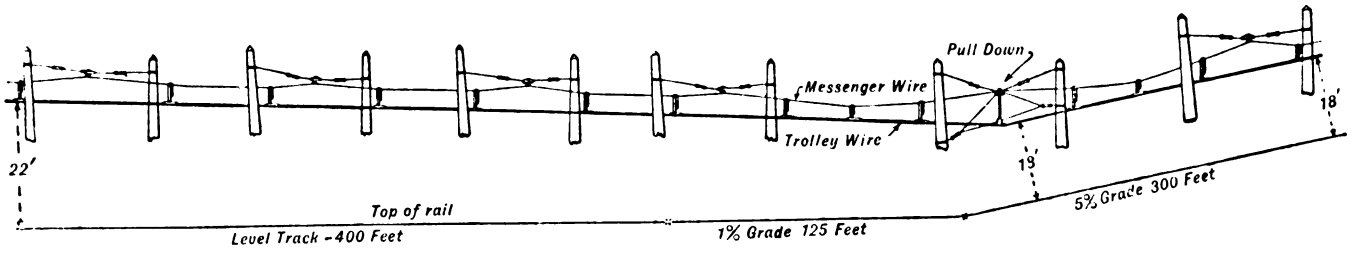
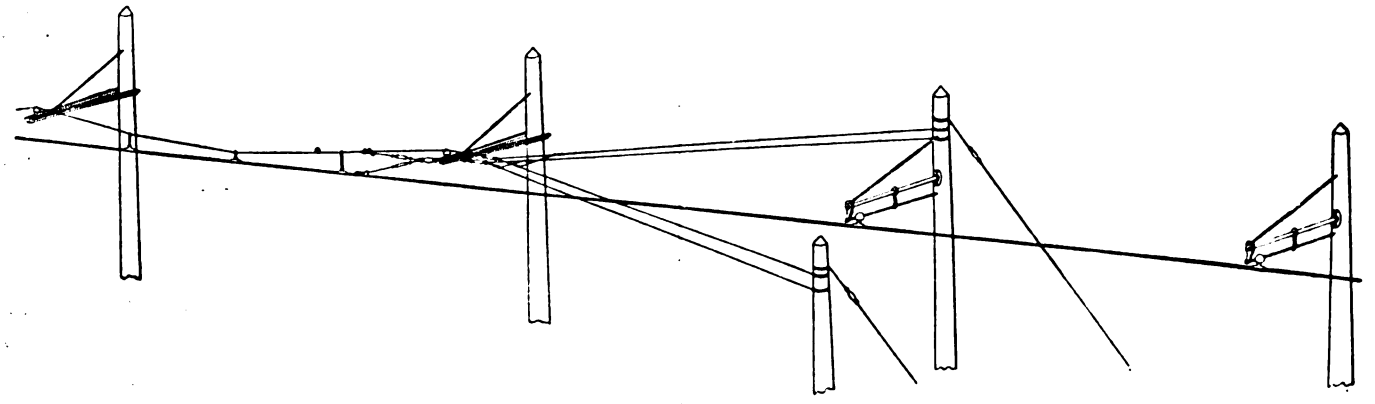
prevent its slipping from the hook. Both flexible and rigid pull-offs are used, corresponding to the sections with flexible and rigid hangers. The flexible pull-off construction illustrated is used to avoid hard spots at pull-off points. Its messenger clamp consists of two interlocking plates clamping the messenger cable between them, the pull-off cable passing around grooves at the middle of the plates and holding them together on the messenger cable. The trolley wire is held by means of an ordinary single-curve yoke and curve clamp ear. A spacing bar is placed between the pull-off cables at a distance of about 15 in. from the line, beyond which they converge and fasten to a wooden strain. The rigid pull-off illustrated is made up of a steel tube with a clamp at the upper end similar to the messenger clamp of the flexible pull-off. The lower end of the steel tube is provided with a four-screw clamp ear. The pull-off cable loops around a shoulder at the lower clamp and loops over the two plates at the messenger cable. The steel tube is fastened to the messenger and trolley clamps by necks extending into the ends of the tube and being riveted to it. The two pull-off cables converge to a wood strain. The anchorage scheme is also illustrated in Figs. 4 and 5. The messenger cable and trolley wire are anchored to a plate held against the bottom of the bracket by the messenger insulator bolt. This plate is then anchored to the adjoining poles. The eye for attaching the anchor cable is placed far enough from the strain clevises to avoid the formation of a pocket to catch the trolley wheel. A spreader is placed between the cables attached to the messenger cable and trolley wire to avoid cupping the latter when the strain is applied. This construction also permits the use of a flexible hanger at this point to prevent hard spots.

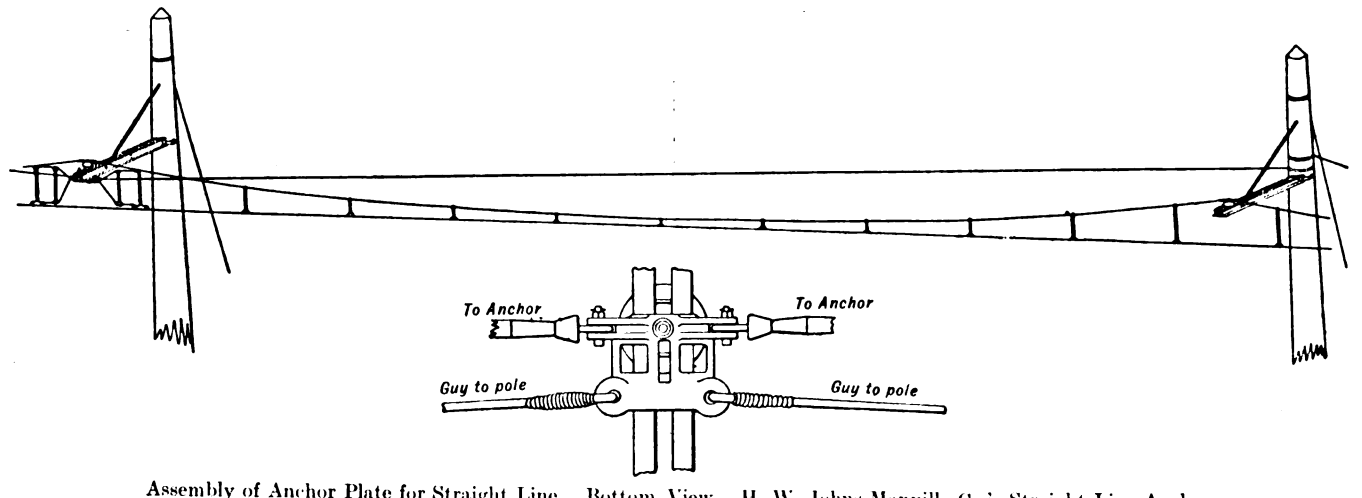
Installation of the General Electric Co.—The hanger spacing varies from 17 ft. to 50 ft. The sag of the messenger wire is 6 in. for 75 ft. spans and 24 in. for 150 ft. spans. The distance from the messenger wire to the trolley at the messenger support is 30 in.; at the centre of the 75 ft. spans, 24 in.; at the centre of the 150 ft. spans, 6 in. Steady braces were not used on this section. In this installation the trolley wire is of No. 0000 grooved mild steel, and the messenger of No. 0000 hard copper cable, made of 19 wires, each of 0·1055 in. diameter. The brackets consist of two pieces of 2 in. × 1½ in. × ¼ in. angle irons, 11 ft. 6 in. long, joined at the extreme end by a space block and rivet, and by a second space block 2 ft. nearer the pole. The ½ in. steel guy rod which supports the bracket from the pole top passes through this second space block, the weight resting on the large button head on the end of the rod. The inner ends were sprung apart to span the pole and fastened with lag screws. The slot formed between the angle irons by the space blocks is used for attaching a malleable iron insulator pin to the bracket. The base of the pin is shaped to engage the slot and secured by a bolt passing up between the angles, thus providing means for transverse adjustment of the messenger with respect to the track. A standard single-piece, one-petticoat porcelain insulator, 4½ in. in diameter by 3½ in. high, was cemented to the pin for supporting the messenger cable. A piece of No. 8 iron wire was used for tying in. The end space block is provided with a lug which prevents the messenger cable from dropping off the end of the bracket in case the porcelain insulator is broken. It is also valuable during construction while pulling up the wires. In the span construction, the messenger support consists of two malleable-iron castings, one of which is



General Electric Co.'s Special Pull-down Scheme to allow for a Change in Trolley Clearance.



General Electric Co.'s Pass-over from the Ordinary Bracket Suspension to the Catenary Bracket Suspension.



Assembly of Anchor Plate for Straight Line. Bottom View. H. W. Johns-Manville Co.'s Straight Line Anchor.

FIG. 5.—CATENARY TEST LINE. DETAILS OF ANCHORAGE AND OTHER ADJUSTMENT METHODS.

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sprung on the span wire similar to a round-top hanger; the other casting having sister hooks for gripping the messenger cable is adjustable so as to accommodate the varying angles of the cross-spans. On curves this support was not located over the centre of the tracks, but directly over the trolley wire, the alignment of the trolley and messenger being made by the adjacent pull-offs. A wood strain insulator was inserted in the span wire 2½ ft. to 3 ft. either side of the messenger support.

The straight line hangers are of the flexible type and consist of a 3½ in. three-screw clamping ear, similar to the well-known screw clamp grooved wire ear, and a ⅛ in. cold rolled steel strap ⅝ in. wide. The supporting strap is bent so as to form an open loop 2½ in. long at the upper end, and is shaped to prevent the hanger from becoming unhooked, no bolts or clamps being used. The extreme lightness of these hangers, the heaviest weighing 8 oz., and the long loop allow maximum flexibility. The pull-off hangers are of the semi-flexible type, consisting of a 10 in. curve screw-clamp ear, a ⅝ in. stem and clamps for gripping the messenger wire and for adjusting the hanger lengths. The stem is provided with an eye at one end and a "T" at the other, the eye being bolted to a clevis on the trolley clamp to allow movement parallel to the trolley wire, and the "T" end is passed through the messenger clamp and limits the travel of the stem after a wheel has passed under the hanger. On curves of large radius appreciable flexibility is obtainable, and on small radius curves the adjusting clamp is used to maintain the proper distances between messenger and trolley. The loop hangers and the jointed pull-offs permit taking out the slack in the messenger and trolley wires independently.

The anchor scheme shown is designed to give maximum flexibility by avoiding hard spots in the line, and at the same time providing for the independent adjustment of both the trolley and the messenger wires. A special malleable iron two-piece clamp, with eye, was used for anchoring the messenger wire, and a single and soldered strain ear was employed for anchoring the trolley wire. A turnbuckle was used in each anchor wire, these, in turn, being attached to the bracket. The strain plate is fastened to the bracket by the insulator pin bolt. A separate plate is bolted to the bracket, from which the guys are run to adjacent poles. A space of 5 in. was left between the plates to avoid a pocket for the trolley wheel.

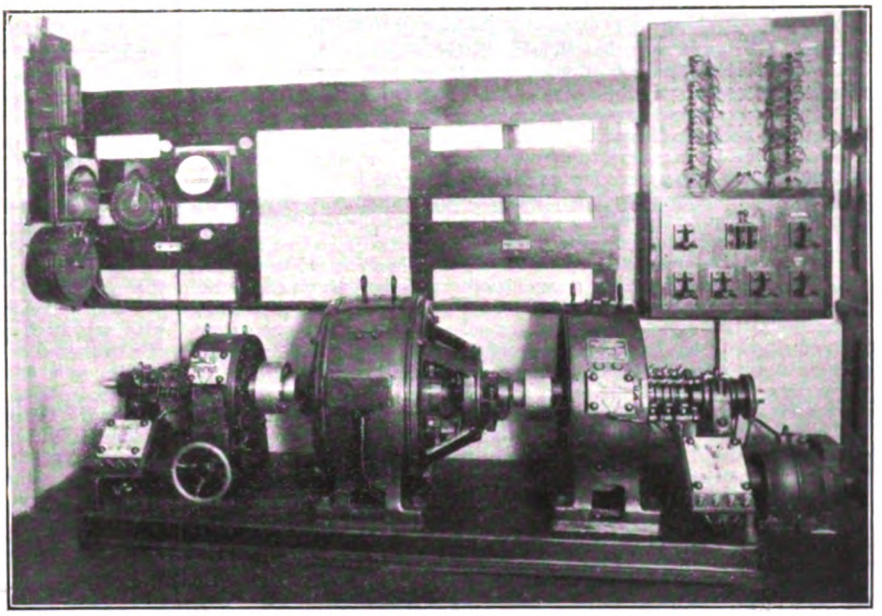
A special condition was encountered on this division and was overcome as shown in Fig. 5. The height of the trolley wire over the steam tracks was 22 ft., and after turning on the highway the wire descended while passing over a level section of 400 ft. to a height of 18 ft. above the rail. At this point ascending grades of 1 per cent. for a short distance and 5 per cent. for several hundred feet were encountered. It was desired to keep the height of the trolley wire 18 ft. above the track through this low section and up the grades. The whole structure tended to lift 12 in. to 18 in. Hence a pull-down was installed, located at the base of the 5 per cent. grade, consisting of a standard pull-off hanger guyed on either side to the poles supporting the span wires and pulling the wires down to the desired height above the rail. The weight of the structure was sufficient after the pull-down was attached to give the desired height above the rail at the base of the 1 per cent. grade. A hard spot is formed in the line by this method, but recent inspection shows no excessive wear upon the wire.

NEW TESTING SET AT THE MUNICIPAL SCHOOL OF TECHNOLOGY, MANCHESTER.

The latest addition to the already admirably-equipped electrical engineering laboratories at the Manchester School of Technology is a small testing set specially designed for testing meters and carrying out experimental work. This set, which was manufactured by the British Westinghouse Electric & Mfg. Co., and of which a view is given in the accompanying illustration, consists of three machines rigidly coupled together on a combined bedplate. It is driven by a 13 H.P. direct-current shunt-wound motor, suitable for operating on a 400-volt circuit. This motor is of the variable-speed type, and capable of running between speeds of 500 to 1,700 revs. per min., giving its rated output throughout this range. Two generators of the revolving armature type are arranged one on each side of the motor. These have ratings of 1 kw. and 5 kw. respectively, three-phase, 25 to 85 frequency, 100 to 340 volts at 500 to 1,700 revs. per min. Each machine is designed to give a sine wave, and is fitted with six slip rings. The motor is fitted with a terminal board arranged for connecting the field coils in parallel, as they may occasionally have to be excited from a lower voltage than 400.

The 1 kw. generator has its yoke machined on the outside and fitted into a circular seat on the bedplate, and is arranged with a worm gear for rotating the field. This enables the machine to be given a displacement of as much as 200 electrical degrees with respect to the 5 kw. generator. A gradual variation of phase adjustment is obtainable by this means while the set is running. This is necessary, as the phase has to be adjusted for each variation in current output on account of the varying lag with a varying current in the armature. By this arrangement it is possible to vary from maximum lagging to maximum leading current. Terminals are also provided for making easy and rapid connection with the external circuit.

The set is specially balanced, so as to run with no vibration and not to disturb the instruments in the standardising room in which the set is installed. The engineering staff are carrying out, by means of this set, a number of very interesting and valuable experiments on the effect of wave form, &c., on the indications of induction type meters.



NEW TESTING SET AT THE MUNICIPAL SCHOOL OF TECHNOLOGY, MANCHESTER.

ELECTRIC BRAKING ON THE GLASGOW CORPORATION TRAMWAYS.

Below we give an account of the discussion that took place last week at the meeting of the Institution of Electrical Engineers, when Mr. A. Gerrard read his Paper on this subject. An abstract of this Paper appeared in our last issue.

Mr. J. S. PECK (British Westinghouse Co.) said that Mr. Fell had shown very conclusively, both in his Paper before the Tramways and Light Railways Association in 1906 and in other communications since, that it was possible to obtain a brake which, with proper handling, would give as great a retarding effect as could be desired. There was, however, always the possibility of improper handling, and he thought that the device described in the Paper was one which eliminated as far as possible the human element. It was as skid-proof and as nearly fool-proof an attachment as one could ever hope to obtain. Having eliminated the human element, there was yet another element which had received scant attention in the past—namely, the effect of the braking apparatus upon the rest of the equipment. The author had shown very clearly that with rheostatic braking, and also with the old type of magnetic brake, very heavy currents flowed during the braking period. Those currents added very materially to the heating of the motor, and therefore to the rate of deterioration of the installation. The reason why the Glasgow Corporation had such extremely low maintenance costs for their tramway equipment was to a large extent due to the careful supervision which was given the equipment. Yet the author said that the bulk of the troubles and breakdowns of armatures and controllers were due to the

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heating of motors during braking, and to the voltages generated when braking at high speeds. The new type of magnet gave a great reduction in the braking current, while the skid-proof or shunt-field device appeared to eliminate entirely the excessive voltage rise. He thought that if Glasgow—having already such a low cost of maintenance—found it a good commercial proposition to put in the latest type of magnet with the skid-proof device, the managers of other tramway systems should certainly consider the same procedure.

Mr. E. H. COCKSHOTT (Leeds Corporation Tramways) said he had been associated with the development of the brake referred to by the author as the 1908 type. The real name of this 1908 brake was the Maley electro-magnetic rail brake, of which 30 had been supplied to cars of the Leeds Corporation. They had now had three years' experience of them under actual running conditions and on the steepest gradients, and they also had had many Newell brakes with No. 21 magnets, as well as the latest type of this brake fitted with No. 25 magnets. The latest type of this brake was undoubtedly a very powerful one under favourable conditions. The trouble experienced with it was that at high speeds it became a most difficult matter to prevent the wheels skidding when the brake was applied, and also, contrary to the author's remarks, they did not find it satisfactory at moderate speeds. In fact, so many reports were received regarding passengers who complained of being severely shaken, due to the alleged irregular and jerky action of the brake, that it was decided to remove it. The coupling of the wheel shoes to the magnets certainly reduced the currents and voltage generated, if the controller were operated with great care, but should all the resistance be cut out, as generally happened in cases of emergency, it was evident that while the wheels continued to revolve there would be at equal speeds the same maximum voltage and current generated with the two types of brake. The trouble with the Newell brake was, however, that in such cases the wheels, having an excessive torque on them, commenced skidding, and continued to do so for some few seconds, during which time the sudden reduction in the braking force often caused a considerable increase in speed. In a test made at Leeds with one of these brakes on a gradient averaging 1 in 11, the speed attained previous to applying the brake was 26 miles per hour. On the application of the brakes the wheels ceased to revolve, and did not again reach their normal speed until the bottom of the hill was reached, a distance of about 130 yds. from the point where skidding commenced. He quite agreed that the solenoid device to some extent reduced skidding, but he thought, nevertheless, that the addition of such complications into the braking circuit might cause trouble under the rough usage it was likely to get in actual service. It would have been more useful if the author had given results of tests of the Newell brake and solenoid device at speeds exceeding 20 miles per hour. He also questioned some of the figures quoted for the 1908 brake, in view of the great number of similar experiments they had made, from which very different results were obtained. As to the tendency of this brake to skid, it had for some considerable time been one of the chief claims that the wheels never really skid unless the brake was outrageously misused, and even then it was of such momentary duration that the retardation was unaffected. Throughout extensive series of trials on this brake, in the presence of independent experts, it had invariably been observed that skidding was entirely absent. He could not agree with the author's remarks regarding the uneven retardation of the 1908 brake, because, provided the rheostat was regulated correctly, experience showed that the operation of the brake in this respect was all that could be desired. The Tramways and Light Railways Association's report, in fact, remarked on the delicate graduation of the stops made by this brake. In the summary of his Paper the author remarked that with a 1908 brake it was doubtful whether a solenoid would reduce the tendency to skid or ensure more even retardation. The speaker failed to see why such a device should operate differently with a 1908 brake from the way it did with the Newell brake. There had, however, up to the present been no need to consider the advisability or otherwise of adding any such device.

Mr. A. W. MALEY (Electro-Mechanical Brake Co.) said it seemed clear that the real purpose of the Paper was to make a comparison of the Westinghouse brake and the brake of which he was the inventor, denoted in the Paper as the 1908 brake, greatly to the disadvantage of the latter. It was very strange and unfair that the author had suppressed the name of the inventor, and not even let his Company know of the proposed tests. It also seemed difficult to know why the Paper had ever been written, as there were two brake investigation committees, one appointed by the Municipal Tramways Association and the other by the Tramways and Light Railways Association, both of which had been at work for the past three years. He believed they had not, in fact, concluded their labour, and their reports, which had been widely circulated, covered all the brakes tested by the author. Further, the author's tests were not even recent, having been made 15 months ago. He thought that the tests were of such a rough character as to be misleading, and in view of the very exhaustive tests with accurate recording instruments which were made at Leeds on behalf of the Tramways and Light Railways Association by Mr. Fell, and further tests by the Brakes Committee of the Municipal Tramways Association, he did not think there was any call for the present Paper, which surely could not pretend to anything like the same accuracy. The conclusions reached by the author were so different from those of the Brakes Committee that they should in any case be most closely investigated. The first part of the Paper, dealing with the Westinghouse old type of brake, was of general interest, as it emphasised what had often been said, that the power of that brake was very small. He thought the addition of a solenoid to this old type would be to restrict the brake to its own power, so preventing the motors doing the large amount of work necessary on the old brake if a good stop were required. It would be of interest to many to know that solenoid control was patented by Newell, the inventor of the Westinghouse brake, in 1900, 10 years ago. Yet the London County Council had not, he believed, more than two or three cars fitted with it, although the tests were made on the solenoid by Mr. Fell two years ago. Skidding was a very serious matter, because the motorman was absolutely helpless whilst it was going on. When a brake was skidding the retarding effect was roughly about one-third of that when the wheels were rolling whilst being braked to the fullest extent. He next drew attention to the unfair way in which the Glasgow tests had been carried out, and stated that the Paper was certainly not an impartial one. Mr. Maley proceeded to give his reasons, and invited contradiction to his statement that an interested person was present during the tests, whilst he (Mr. Maley) was not. (The time limit having been exceeded, the president invited Mr. Maley to communicate his technical observations on the Paper for inclusion in the "Proceedings.")

Mr. W. H. BOOTH said it was generally admitted that electric brakes caused a good deal of injury to the car equipment, and a great many engineers thought it desirable to have a mechanical stand-by to an electrical brake. He asked the author whether a magnetic brake was of very much service when a car left the rails. Also, was there any serious reason why cast-iron brake shoes, which were so much more efficient in a mechanical brake, should not be used with a magnetic brake if the resistance and coils were designed accordingly. He showed two slides illustrating the purely mechanical arrangement adopted in the Freund brake as an addition to a magnetic brake, and tried for some time on the Yorkshire (Woollen) Tramways. However useful the electric brake might be for light work, he considered that there should be some safeguard in the way of a mechanical equipment; and if a mechanical stand-by were an admitted necessity, why not work the magnetic brake directly off the trolley wire? Probably the cost of current would be less than the repairs to equipment which resulted from the so-called economy of using the motors to provide retardation, and the risk of de-wiring the trolley would not exceed the risk from failures with the present electrical methods.

Mr. H. M. SAYERS pointed out that neither the author nor any of the speakers had mentioned the outstanding difference between an electro-mechanical brake of the Westinghouse type and mechanical brakes acting either on the wheels or on the rails. The difference lay in the fact that with the magnetic brake one could get a retarding effect which was not limited by the available weight of the car. That was not the case with any mechanical brake. In the ordinary wheel brake the amount of retardation depended on the coefficient of friction between the wheels and the rails, and was a function of the weight of the car, the same being the case with the track brake, whether applied by hand, spring or air pressure. The brake shoes simply took some proportion of the weight of the car, and that was the limit of retardation that could be obtained. Numerically, 32·2 × coefficient of friction = retardation in feet per second per second. With the magnetic brake the force available was that of the magnetic attraction between the poles and the rails, the limit of which was the area of the pole shoes. There was practically no limit to the retarding effect that could be obtained, except as regards the comfort of passengers carried; but it was quite impossible by any kind of mechanical brake to rely upon anything approaching the 8, 9 or 10 ft. per second per second retardation that was available with the magnetic brake. The latter was a very marked advance on other systems of braking. He thought that the author was to be thanked for giving them such a long series of brake tests, which were very difficult to carry out. It was well known that brake tests by different people in different places did not give consistent results. However, he could vouch for the accuracy of the tests on the Maley brake at Leeds as he saw the instrument records of that occasion. The author's results confirmed the view that the magnetic type of brake was the best brake for conditions requiring frequent stops at high speeds under more or less emergency conditions, such as heavy traffic. The application of the solenoid control—which obviated the original difficulties of excessive current and voltage—added considerably to the electrical wiring and control apparatus. Mr. Fell, in his Paper, pointed out that the Westinghouse brake had to operate through an electric circuit containing a large number of electrical contacts. It was not only necessary that the circuit should be intact throughout the whole of the operation, but it was also necessary that the original resistance of that circuit should be very low, and that could only be assured by very careful supervision. He did not think that the magnetic brake was the best for the purpose of controlling cars down steep gradients. If it was used, however, there should be some means of applying it mechanically at the beginning of the descent.

Mr. H. E. YERBURY (communicated) considered it had been amply demonstrated that the rheostatic brake was unsuitable as a service brake, and although there were hundreds in operation at the present moment, the constant application of such a brake had a serious effect on the electrical equipment, and it should only be looked upon as an expensive yet effective brake for emergency stops. The development of the magnetic track brake, apart from the wheel brake shoes, was a step in the right direction, and, undoubtedly, solenoid control of the motor fields had given excellent results. It was regrettable that the author had confined his attention to one particular form of brake, as it would have been interesting to have comparative data concerning other well-known forms of magnetic track brakes, where auxiliary brake shoes were pressed down on the rails; but, presumably, the author desired simply to emphasise the fact that with solenoid control much less work was put upon the motors, and "locked wheels," which had caused so many serious accidents in the past, could now be avoided. Tramway engineers could not fail to agree with the points set out in the author's summary, and it appeared that it was only a question of time before brakes in general would be magnetically operated, and manual labour would be reduced as much as possible.

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Mr. A. GERRARD, in reply, said that from his remarks Mr. Cockshott evidently considered the solenoid would reduce the voltage. The Paper was practically written to demonstrate the advantage of solenoid control. The solenoid in conjunction with the 1908 brake would, undoubtedly, reduce the voltage, but it would not prevent skidding, the reason being that the 1908 brake transferred a portion of the weight from the driving wheel to the track blocks. The reason why he had not carried out tests at 28 miles per hour was because they had no hills on which to get up that speed. In reply to Mr. Maley's question as to why the Paper was written, he was asked by the local section to write a Paper, and decided on the present one, as it was some time since a Paper on electric braking was read before the Institution. The tests were certainly rough ones, but he had no idea when they were carried out that they would be embodied in a Paper. He thought, however, that the apparatus used gave conclusive results. Neither the Westinghouse Co. nor he himself knew of the Newell patent when they started on the subject. He had not inserted the name of the Maley brake because he did not wish to. Mr. Booth's slides were irrelevent to the Paper. It was, however, the easiest thing in the world to have a mechanical attachment. Mr. Sayers' remarks as to the difference between the electromagnetic brake and the mechanical slipper brake were also irrelevant to the subject. The Paper dealt entirely with the equipment and tests at Glasgow, where there was no mechanical slipper attachment. Regarding the difference in surging at Leeds and Glasgow, the equipment at Leeds was quite different from that at Glasgow, and he could only deal with the Glasgow results. The reason he did not test the brakes on gradients greater than 1 in 13 was because they had no steeper gradients at Glasgow.

DEVELOPMENT AND OPERATION OF HYDRO-ELECTRIC PLANTS.*

BY H. L. DOHERTY.

Summary.—The author first deals with the relation of water power development to the conservation of natural resources, and then proceeds to consider methods to insure against interruptions of supply. Recent penalties for interruptions of service are discussed, as well as methods of charging, classes of service which can be advantageously supplied, the amount of power it would pay to develop, &c.

The object of this Paper is to call attention to certain features of hydroelectric work deserving of more general or more careful consideration than they have had heretofore, and to point out such work as can be carried on to advantage.

There is probably no other class of securities which deserves so well the support of the public as those issued by companies owning and operating successful water-power properties, and having a permanent and relatively non-competitive market. Except for the possibility of further development in heat engines which will materially increase their commercial efficiency, thus tending to reduce the cost of power from fuel, water-power plants will tend to grow more and more valuable, as it is improbable that fuel will ever sell at a lower cost, and more than probable that the cost will gradually increase. Compared with almost every other class of investment, a water-power plant is far preferable, the source of supply being, in the main, perpetual, although in some instances somewhat modified by timber operations and changes in meteorological conditions.

Probably the greatest stroke of statesmanship of the last national administration was the interest aroused in the conservation of our natural resources. Unfortunately, the efforts of the administration were either largely misdirected or very generally misunderstood in regard to water-powers. Immense amounts of power are daily going to waste. The tendency of the Federal Government, and of many of the State Governments, seems to be directed toward obstructing rather than encouraging the development of water-powers. This institute can do valuable work in educating the public as to the restrictions which should be made and the encouragement which should be given to enterprises of this character. The most pressing need in the matter of the conservation of our natural resources lies in the direction of conserving our various sources of fuel supply. Every undeveloped water-power means a constant unnecessary fuel consumption; and Government, both State and national, should remove as far as possible every unnecessary obstacle to water-power development.

Combination projects both for irrigation and power can often be made highly profitable where commercial success for either project alone would be impossible. It is, therefore, necessary that the engineer who has the responsibility of determining the value of prospective power developments should be proficient in the engineering of irrigation. This opens up to this Institute a necessary field of work which even now seems somewhat strange and a few years ago would have been entirely remote. Power and irrigation projects, wherein the power must be generated at one point and transmitted to another point, and there provide irrigation by means of pumping, is alone worth serious consideration.

The present state of the art in electrochemical processes is a factor which makes possible the profitable development of many water-powers. Still further developments along electrochemical lines may add materially to the value of water-power projects which now have no available market. Special attention should be paid to processes which do not require a continuous supply of current, thus permitting the utilisation of power from water which would otherwise run to waste.

Failure to realise expectations in regard to cost of development, amount of power to be sold, existence of market (or of market at the price anticipated) and reliable service has played an important part in the retardation of development of water-power projects. If we are to learn by experience, then the broadest possible discussion of these subjects is to be desired. It would contribute much to the ease of developing the now unused water-powers if these difficulties could be overcome, or if the public could be made to understand the degree of risk and the cause for the existence of the risk. Generally speaking, there is no more reason why anticipations should not be realised in water-power enterprises than in other enterprises, if the proper amount of investigation and preliminary work is done. Unfortunately, however, the engineering investigation to determine the cost of a hydroelectric power proposition, and the exact amount of power available, is often a very expensive matter, requiring data obtainable only as the result of measurements extending over a term of many years.

A confused condition exists in the popular mind in regard to the marketing of power. The inability of the public to understand this matter has been a great obstacle in the development of power propositions—and in this matter the electrical engineering fraternity has been more or less to blame. Cost of power is sometimes stated on a kilowatt-hour basis, and at other times on the basis of peak load, or what might be termed a capacity basis. Without knowledge of load factor, or simultaneous demand factor, figures stated in these different ways may prove very misleading. The problem of reliable service from long transmission lines is much further from solution than all the other problems that have done so much to contribute obstacles to rapid development. The best of engineering talent does not seem able to promise for a transmission line the same continuity of operation that can be secured from a steam plant located at the point where the power is to be used, and this introduces many serious obstacles to the development of our water-power projects. The importance of continuity of service varies in degree with almost every customer served. To some industries a mishap which causes even a fall in voltage or a change in frequency may be a serious matter.

The author next considers in detail the following matters which deserve further thought and consideration by engineers connected with water-power work:

Methods to Ensure against Interruptions or to Lessen their Harmful Effect.—With reliable reverse circuit-breakers the linking up of several hydroelectric plants offers some insurance against interruptions. If central-station companies are to be supplied, it might sometimes be commercially practicable, where the available market greatly exceeds the capacity of the plant, to run the transmission lines to several central stations, with the idea that no one of the stations will attempt to take more than a portion of its base load, and will always have some steam apparatus in operation, the capacity of which can be quickly increased to take care of any interruption of service from the hydroelectric plant. In a recent power negotiation, where the supply was to be furnished from two hydroelectric plants, it was suggested that one of these plants should be run in connection with a steam turbine, the generator normally be run as a motor and the water-wheel governor arranged to open the steam valve to the turbine if the speed fell off perceptibly. The vacuum on the turbine blades is maintained to reduce the windage loss. In such cases the steam turbine, or water turbine, could be driven with a small amount of steam, or water, and the fields of the generator magnetised so that the load would be promptly picked up in case of interruption to service. This latter method, however, would be relatively less economical than to drive electrically, using steam or water only when service from the unit was demanded.

Equipment to Ensure against Interruptions or to Lessen their Harmful Effect.—It is customary on all important transmission lines to use either two circuits on the same pole line or two circuits on its own pole line. The latter plan is far preferable. Perhaps greatly added reliability could be secured by the use of extra conductors on each pole line, with effective switching apparatus that would enable the extra conductor to be brought into use as quickly as possible,

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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The use of storage batteries immediately occurs to one as a protection against interruptions, but their high investment cost and high cost of maintenance make them practically prohibitive when used purely to prevent interruptions of service. Gas engines would be almost ideal, but the high investment charges make them practically impossible. They, however, have been adopted in one or more instances. Gas storage can be provided at a cost of approximately £10 per 1,000 cubic ft., with no operating stand-by loss. This means an investment of about £80 per 1,000,000 B.T.U. for producer gas, or £16 for coal gas, and less than £14 for California oil gas. Where producers are used, if the fires in the producers are maintained in proper condition, no storage capacity is needed; and perhaps no other similar class of apparatus can be run with such a small stand-by operating charge as a gas producer. Unfortunately, however, a gas-engine power station represents such a high first cost that, in spite of the higher efficiency of the gas engine and the lower stand-by losses of the gas-generating apparatus, the commercial cost for purely relay service is higher than for steam equipment. If provision must be made for protection to service, a modern steam equipment offers about the lowest commercial cost.

The boilers chosen should be able to have their fires withdrawn without causing leaks, and should have the least stand-by loss in relation to their maximum capacity. Ordinarily we choose the boilers having the least consumption of fuel at full load, but for relay service we want the boiler having the least consumption of fuel at no load. It is the writer's opinion that for this class of service the internally fired boiler deserves careful consideration, but perhaps only in a modified form. This type of boiler, however, would be apt to be limited before other limiting features were reached by the lack of flue-gas conductivity of its fire tubes, which could be compensated for by a high draught pressure, but better compensated for by a modification in design.

If boilers are not to be run banked, but are to be fired up if an interruption occurs, the methods to be used for quickly starting the boilers are of great importance. The uses of oil for fuel probably ensures the greatest speed in tarting up, but this fuel is often prohibitively expensive. It is, however, possible to use oil simply as an auxiliary in the starting of the boilers and then substitute coal, either hand fired or machine fired. The writer does not remember ever having seen the suggestion made that powdered coal firing be used for this class of work. Powdered fuel is almost the equivalent of oil or gas, and is ideal for the class of service under consideration.

In the choice of steam engines the steam turbine would seem to be the only one worth consideration. The total first cost of steam turbines, including building, foundations, &c., should alone be enough to warrant their adoption; and if it were decided to run the engines idle, but with the fields of the generators magnetised, the steam consumption should prove materially less than for any other type.

Penalties for Interruptions of Service.—In a recent negotiation for the purchase and supply of power between a central-station company and a hydroelectric supply company, the question of continuity of service was given serious and detailed consideration. As ensurance against excessive interruption was being sought, and as the only ensurance possible was that to be obtained through operation of the steam plant, it was decided that ensurance should be obtained by running the steam plant (fully energised and ready instantly to take the load in case of interruption to the hydroelectric service) at such times and for such lengths of time at a stretch as might be necessary to ensure against interruptions coming oftener than at certain intervals. For example, to take an extreme case of the simplest form, suppose it had been decided that no interruptions of any kind whatsoever were permissible more than twice in any 12 months. Then, after any interruption, the steam plant would be run for six months, ready to take the load at any time in case of failure of the hydroelectric supply. This would ensure only two interruptions per year.

As the above assumes that a steam plant is never subject to failure, an allowance mentioned later has to be taken into account. As all interruptions are not equally disastrous, allowance was also made for both the length of interruption and the damage to different kinds of service, as follows: The load of the central station was divided arbitrarily into two classes, which we will call class A and class B. The power and the business district load together were considered as class A, requiring the greater ensurance against interruption, and the residence load as class B. The central station company demanded that the length of time which the steam plant should be run after any given interruption should be fixed with reference to the duration of interruption and to the number of interruptions which had occurred during the year preceding and up to and including the interruption in question. If the interruption in question was the first during said year, then the steam plant should be run of sufficient capacity to carry the class A load for 10 days for the first minute (or less), plus an additional day for each additional minute of duration of interruption; the time of running for each succeeding interruption to be compounded 20 per cent. That is to say, for the

First interruption	10	days plus	1	day per additional min.	
Second „	12	„ „	1·2	days „	„
Third „	14·4	„ „	1·44	„ „	„

and so on. Also that at the same time sufficient additional capacity of steam plant should be run to carry the class B load for 10 days for the first minute (or less), plus an additional day for each additional minute of duration of interruption; the time of running for each succeeding interruption to be compounded 10 per cent. That is to say, for the

First interruption	10	days plus	1	day per additional min.	
Second „	11	„ „	1·1	days „	„
Third „	12·1	„ „	1·21	„ „	„

In case an interruption should occur before the ensurance feature had been entirely worked out on a previous interruption, then the remaining days of operation of the steam plant for the interruption previously experienced should be discarded and a fresh start made for another run of the steam plant, just as though the new interruption had occurred after instead of during a running period. It was further provided that for the first two interruptions experienced in the 12 months period, the steam plant was to be run at the expense of the central-station company, on the assumption that two interruptions might occur even if the supply were from the steam plant alone. The expense of all subsequent operation of the steam plant was to be borne by the hydroelectric company.

Many other methods of penalties and ensurance are in vogue, but as this plan is believed to be new it is submitted for discussion and for comparison with other methods already known to the members of the Institute.

Methods of Charging.—While not always recognised, the cost of operation will be influenced, not only by the load factor but by the form of the load curve. Similar load factors do not necessarily mean the same cost for current, unless the shape of the load curve is the same. While the value to the user of the service of the hydroelectric company as compared with his own source of supply depends largely upon his absolute peak, the cost to the supplying company depends primarily on the demand of this consumer at the time of the hydroelectric company's simultaneous peak. Non-coincidence of maximum demands is, however, a legitimate source of profit to any supplying company, and this non-coincidence of maximum demands is generally a primary source of profit to the supplying company. In each case, however, the value of the service to the consumer and the cost of service to the producer depends primarily on the capacity demanded and the amount of current used. This is assuming that we are dealing with relatively large consumers.

In central-station practice large numbers of consumers are eventually connected having so small a current consumption and maximum demand that what might be termed the "consumer charge" assumes so much greater importance that it cannot be neglected. In fact, the condition has been reached where a large group of central-station consumers requires a greater investment and maintenance expenditure for meters alone than is required for the generating equipment necessary to supply them.

It is unfortunate that it is not better understood that there is more than one factor which goes to make up the cost of electric service. Talking of power in terms of charges per unit of demand only, or in terms of kilowatt-hours only, has led to much confusion and many costly blunders. If capacity and current were not jumbled together, and if the value and cost of each were better understood, it would do much to contribute to further development of electric service sales. The capacity cost to supply many consumers is far greater to the hydroelectric company than would this same cost be if the consumer supplied himself. On the other hand, the cost for current to the hydroelectric company is generally very small compared with the cost to the consumer were he to supply himself. The capacity the consumer should pay for should generally be based upon his absolute maximum peak experienced at any period throughout the year. Any other method of arriving at the capacity charge is apt to lead to great inequities.

Classes of Service which can be Advantageously Supplied.—If we were to assume that the maximum demands of all consumers occur simultaneously, then it is apparent that a point is apt to be reached where the total cost of service for any consumer is greater to the hydroelectric company than would be the cost of service to the individual consumer were he to supply himself, because, if the capacity cost is greater, there may not be enough current sold at the price charged to overcome the higher cost for capacity. Many consumers

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could therefore supply from their own plants all, or a portion, of their demand, over and above their average demand, at a cost to themselves less than to the hydroelectric company.

By securing a number of consumers of a diversified character, even though more transmission lines are necessary, a good load factor can often be secured in spite of the fact that the individual consumers may have poor load factors; and by getting consumers to adapt their operations to the ability of the hydroelectric company to supply—that is to say, by some form of "limited service"—this same end can be realised. The future situation in the hydroelectric supply business will, however, eventually be that of the market greatly exceeding the supply, and the natural remedy will be the installation of steam plants by the hydroelectric companies to enable all possible available water to be used. Central-station steam-power plants have been made a success in competition with individual steam plants, and the success of steam plants in connection with hydroelectric plants should be even more pronounced.

How to Develop the Market Selected.—Few people seem to realise the costliness of tardy operations. A completed plant with an undeveloped load can create a deficit of expected earnings which will require many months of subsequent operations to wipe out. If the writer were to attempt the development of many of the large prospective water power undertakings, the transmission lines would be completed at the earliest possible moment, regardless of when the hydraulic generating plant could be put in commission; and if steam plants could not be taken over from prospective consumers to give in the aggregate enough capacity to carry on the development of the load, a relatively small steam plant in connection with the initial development of the water-power plant would be installed new, and would be added to as rapidly as required to ensure a proper load when the hydroelectric generating station was placed in commission.

The Amount of Power it would Pay to Develop.—It is the writer's belief that hydroelectric companies will eventually develop and sell all of the power that can be generated economically. To do this, in the absence of extensive reservoir capacity, will necessitate a heat engine auxiliary plant to supplement the hydraulic plant during low-water periods.

As to the maximum development, let us assume a hydroelectric scheme having simply a dam from which the water immediately enters the turbines and is immediately discharged to the river below the dam without any expensive canals, flumes, &c. Hydraulic apparatus can then be installed for carrying the peak load at a very much lower cost per kilowatt of capacity than by the use of steam. Not only this, but in this character of development all inequalities of load should be taken care of by the hydraulic plant; and if it is necessary to run steam plant, the steam load should be run for such time, and at a uniform rate, as will secure the most economic generation of steam power. Steam plants or steam units can be started up and shut down only at considerable expense, while water units can be started up and shut down at practically no expense.

In the character of development used above as an example, with a market which far exceeds the water supply, and where the price of fuel is relatively high, the hydraulic capacity installed can be equal to the maximum four days' supply of the stream. That is to say, the operation of a water turbine for 100 hours per year will, in some cases, warrant its installation. Under present practice most of us are only developing the so-called secondary power, which can be secured for a period of 10, or at least 8, months.

Depreciation.—The writer does not wish to appear as viewing the water-power problem from a purely financial standpoint, but still it is the financial standpoint which determines whether a water power shall or shall not be developed. Practically all of the present assumptions for depreciation are too high, and consideration should be paid to what the plant comprises.

Methods to Determine the Accuracy of Engineers' Estimates.—Without anything new to offer, the writer desires simply to lay stress upon the point of greatest value. Checking and re-checking plans by the same or other engineers may not disclose omissions or errors, while complete independent reports by two or more separate engineering corps, and the comparison of these reports, will practically ensure against all omission and all miscalculations, making it possible to do the development work for the cost anticipated with a realisation of all the power and the expected market at the price predicted.

It is hoped that the discussion which this Paper may provoke will bring out much of value to further the development and operation of hydroelectric plants and lead to effective future work along these lines. The problem is worthy of consideration from many different points of view. The whole public has been aroused by and applauds the movement to conserve our natural resources. Nothing can contribute more to this desired end that the speedy development of our water powers.

THE ELECTROCHEMICAL EQUIVALENT OF SILVER.*

BY F. LAPORTE AND P. DE LA GORCE.

The results of the three last researches published by Smith, Mather and Lowry (National Physical Laboratory), by Jaeger and von Steinwehr (Physikalisch-Technische Reichsanstalt), and by P. Janet, F. Laporte and P. de la Gorce (Laboratoire Central d'Electricité) are given in the following table:—

National Physical Laboratory	1·11827 mgm.	per coulomb
Reichsanstalt	1·11818	do.
Laboratoire Central	1·11863	do.

In compiling this table the original values have been corrected so as to express the electrochemical equivalent in terms of the units of resistance and E.M.F. used at the National Physical Laboratory. The last international conference having defined the ampere by the deposit of silver, a difference of 4 parts in 10,000 such as appears in the table was inadmissible.

Thanks to funds placed at M. Janet's disposal by the Scientific Research Fund Committee, a fresh series of measurements was carried out at the Laboratoire Central from June to December, 1909.

The test arrangements and method of working were the same as in the previous research of the Laboratoire. Two voltameters in series were, however, generally used with a view to facilitating the comparisons. The current density was about $\frac{1}{3}$ ampere, the duration 5 to 6 hours, and the mass of the deposit 7 to 8 grammes. During an experiment the current was kept constant within 2 parts in 100,000. The anode was placed in an envelope formed of a sheet of filter paper, evenly folded so as to prevent any particles of the anode from reaching the cathode. The filter paper used was that supplied by Schleicher and Schüll (No. 595, chlorine free). The authors have also employed a voltameter composed of a small silver bowl as anode placed alongside a like bowl, of platinum, as cathode, the two bowls being connected by a glass syphon 4 cm. in diameter. In this case great difficulty was found in maintaining the constancy of the current owing to the heating of the electrolyte. The mean of three experiments seems to indicate that the mass of the deposit thus obtained is greater by 1 part in 10,000 than when the filter paper form is used.

Purification of the Silver Nitrate.—The authors have tested electrolytes made with silver nitrate purified by various processes. As a general rule, only the quantity of salt necessary for a single experiment was treated at one operation.

Sample (1) was crystallised at reduced pressure and at a temperature between 30°C. and 40°C. After two crystallisations, the solution, prepared immediately before the experiment, was decanted into the bowl of the voltameter.

Calculating the results in terms of the English units (which were chosen for the purpose of rendering the results comparable), the authors found as the mean of eight experiments:—

Electrochemical equivalent of silver: 1·11827 mgm. per coulomb, the maximum variations from this mean being −13 and +8 parts in 100,000.

Sample (2) was crystallised by evaporation over a water bath. This method of purification, employed in the previous experiments at the Laboratoire Central, had led to results which were too high by 3 to 4 parts in 10,000, doubtless because the precautions taken either for the purification of the salt itself or for the preservation of the purity of the solution during the whole of the experiment were insufficient. The concentrated solution of silver nitrate appeared to absorb the impurities of the air easily.† By taking care to cover the solution so as to avoid prolonged contact with the air, and by purifying the salt by two successive crystallisations (the mother liquor being decanted and the crystals washed), the authors obtained as the mean of four experiments:—

E.C.E. = 1·11831 mgm. per coulomb, with maximum variations from the mean of −6 and +14 parts in 100,000.

Sample (3) was from Dr. Glazebrook, Director of the National Physical Laboratory. He sent the authors some silver nitrate from his laboratory, which gave the normal result there. This salt, used in six experiments, gave:—

E.C.E. = 1·11827 mgm. per coulomb, the maximum differences from the mean being −6 and +8 parts in 100,000.

Sample (4) was prepared by M. Etaix, Chief Demonstrator in Chemistry at the Faculty of Sciences, Paris. He purified some silver nitrate by crystallisation, the solution being evaporated in a

* Translated and slightly abbreviated from the "Comptes Rendus de l'Académie française des Sciences."

† A solution of nitrate left for 30 minutes in an atmosphere laden with tobacco smoke, and then employed in the voltameter, gives a deposit which is 5 parts in 100,000 above the mean value.

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vacuum at ordinary temperature. The result of four experiments has given :—

E.C.E. = 1·11832 mgm. per coulomb with maximum variations from the mean of −11 and +7 parts in 100,000.

Sample (5) was commercially sold as "pure" and tried in two experiments. It has given 1·11825 as the silver constant.

Conclusion.—These experiments show that the improvements introduced into the purification of silver nitrate have caused the disappearance of the difference of 4 parts in 10,000 which existed between the authors' 1908 experiments and the measurements of the National Physical Laboratory. Thus the figures obtained in France, England and Germany appear to agree satisfactorily.

The general mean of the Laboratoire Central results is 1·11829, the English units, as already mentioned, being employed.

TESTING OF INTERMITTENT MOTORS.

We give below an account of the discussion which took place at the meeting of the Yorkshire local section of the Institution of Electrical Engineers when Dr. Pohl read his Paper on this subject. An abstract of this Paper appeared in our issue of March 25th.

Mr. W. Hartnell, in opening the discussion, said the importance of this subject was by no means exaggerated. The ordinary testing of enclosed motors was most unsatisfactory and the statements regarding them made by various makers were misleading. Dr. Pohl had put the matter forward in almost abstract form, but it was one of those subjects which did not lend itself to an abstract discussion. In abstract reasoning on a complicated subject one should be able to ignore many facts, as being of minor importance, in order to deal clearly with the main matters. Here the difficulties of obtaining a formula or mode of testing that would enable the final temperature of an enclosed motor to be predicted from a brief test seemed almost insuperable on account of the many unknown variables of almost equal importance. He had investigated this subject from an experimental point of view, and had given some of the results in a Paper on "Heating of Ventilated and Closed Motors" ("Proceedings," I.E.E. Vol. XLI., 1908). He agreed with Dr. Pohl wherever the latter had touched on practical points. The speaker found that although the heating and cooling curves of different sizes of motors had a general resemblance they were far from identical. The larger the enclosed motor the higher the final temperature. Thus he was forced to the conclusion that no large, totally enclosed, unventilated direct-current motor could be run at full-load continuously. Dr. Pohl stated that the heating and cooling curves approximately represented the logarithms of the ratio of two factors. This might be so, but the factors themselves were involved quantities, only discoverable by experiment. The speaker asked the author to give complete heating and cooling curves of, say, two enclosed motors. He entirely agreed with the author that from such curves the final temperature of a motor under intermittent loads could be found by means of a zig-zag line such as shown in the Paper. Practical engineering obliged us to search for truth by statistical methods where the result depended on many indeterminate variables. Having experimentally obtained a complete standard curve for a given motor, the test of a similar (or nearly similar) motor need only be carried far enough to obtain the tangent and, say, three points in the heating curve. The complete curves could then be surmised and drawn from the standard curve. By these means the behaviour of an enclosed motor under all ordinary circumstances could be demonstrated from a short test in a convincing manner and with sufficient accuracy for all practical purposes.

Mr. A. J. Cridge (Sheffield) thought it was not immediately obvious why the ratio mentioned should be the load factor. If the area of the current curve as taken on a recording ammeter were divided by the area of the rectangle representing the product of the maximum current and the total time, the ratio would correspond more nearly to what was generally called load factor. If Dr. Pohl had come to the conclusion that the two ratios were usually identical, he would ask the author to explain this. The curves and data asked for by Mr. Hartnell would, no doubt, be very interesting, but he (Mr. Cridge) rather approved of the way in which the author had reduced them to general equations, and with a little expansion they should be sufficiently practical for manufacturing purposes. He agreed with Dr. Pohl that the present practice in regard to the testing of motors for intermittent use was not satisfactory, and the institution ought to lay down some rules not only for this but for other testing work. This had been done in America. The rules were so frequently quoted that he felt British engineers ought to have something of the same sort. There seemed, however, to be a feeling that it would lower the dignity of this institution to deal with any particular subject; it must indulge in generalities. He did not think this attitude was helpful to the profession.

Mr. J. C. B. Ingleby thought it was not easy work to predetermine the rating of this class of motor. The method of circulating the air inside the motor had a great deal to do with the temperature rise in totally enclosed machines; for instance, taking a 20 H.P. motor with a one hour rating and a speed of 775 revs. per min., if this motor were rated for half an hour the speed could drop to about 510 revs. per min., or for a quarter hour rating to about 350 revs. per min. The temperature coefficients mentioned by the author would take quite a lot of finding, and even when found would probably soon have to be found again due to some drop in motor prices necessitating some slight change in the general design.

Mr. H. E. Yerbury (Sheffield Corporation Tramways Department) considered the subject matter of the Paper was important, but that it would be advisable to dissociate traction motors for tramways from such admittedly intermittent work as cranes, hoists and lift motors. Now that electric braking was being used to such a large extent in tramway work one could look upon motors for traction work as machines for short period working. The guiding principle enunciated by Dr. Pohl, as to the testing of any finished machine accurately representing its future working conditions, might be satisfactory from a designer's or manufacturer's standpoint, but he would go further and from a user's standpoint suggest that a machine should be subjected to continuous load above that for which it would be normally run. In the case of traction motors the usual period of test was four hours full load, but for crane and lift work a shorter test would be satisfactory, especially if it were at full load and continuous. Undoubtedly the heat-generating ability and heat dissipating quality of a motor were most important matters, and his experience of troublesome motors had been invariably traced to overheating and consequent failure of insulation. This applied to traction and other motors. He was pleased to hear that the author considered a very short time run unsuited even for intermittent running machines, and also that he favoured cast-steel yokes for motors. Some contractors preferred to use cast-iron yokes and did not like cast-steel yokes to be specified, presumably because they were not in a position to cast them in their own shops. He agreed with the author that there should be an established basis of rating and testing for all machines, but manufacturers should always be in a position to quote to an engineer's specification respecting, say, temperature rise for a certain machine working under exceptional conditions. Standardisation was good, but conditions of working often required specially designed machines.

Mr. W. T. Wardale believed the auxiliary motors on the battleships of our Navy were tested as intermittently working motors, and he thought that Dr. Pohl had brought forward a point in showing that for the first half-hour one got a misleading test: because in the case of motors working in connection with ammunition hoists on these ships, in the event of a long-fought action the temperature of the whole ship would go up tremendously, and, further, every shot which the ship received would, of course, strain to some extent the whole ship's framework, and it was quite possible the guides on which the hoists ran might be jammed. If these motors gave out at a critical time it would be a serious matter. With regard to designers running as near the wind as they dared by using cast-iron yokes, he thought in the long run they would reap what they deserved, because such motors would get classed as those that might stand the test on the test plate, but would not do the work outside. He suggested that the author should carry out tests in the following manner: Test in the ordinary way on the test plate with a set of motors for a crane, and afterwards equip a crane with these motors. If this was done under a full working day, a relation might be established between the practical working conditions and the test-plate conditions which might be valuable.

Dr. Pohl, in reply, said Mr. Hartnell had suggested that a series of tests should be carried out to ascertain exactly the heating and cooling curves of a number of motors, and that from such curves it would be possible to find out beforehand what the running conditions would reveal. The author had taken a number of such curves for direct-current and alternating-current machines, both of the totally enclosed and open type, but did not include them in the Paper because a fair amount of information had been published on these lines, and he thought he would be going to undue length by introducing a great deal of known matter. Curves of that kind were published, for instance, by Goldschmidt, to which reference was made in the Paper. The investigation of the working results by means of heating and cooling curves had been suggested by various authors referred to in the present Paper and, no doubt, reliable results could be obtained in that manner. If one knew the time constant at a certain speed it was possible to draw the whole of the heating curve, and if one knew the time constant for cooling one could draw the cooling curve. If one had then an intermittent load with any given load factor one might construct a curve almost exactly representing what obtained in practice. It was necessary, however, to know what the time constants were, and to find them by experiment. It was on this account that he thought such procedure was far too complicated to be adopted as a standard test for intermittently working motors. The time constant was a most complicated figure. His experience agreed with that of Mr. Hartnell, in that three-phase motors when totally enclosed showed more satisfactory results than direct-current machines. This was, perhaps, due to the cast-iron casing being in close contact with the stampings which were the seat of a great part of the losses, and also to the very small gap between stator and rotor that facilitated the rapid transfer of the heat from the interior to the surface. Mr. Cridge expressed some doubt as to the definition of load factor. The author put it forward as a suggestion and was inclined to think that it was largely a matter of choice what definition one adopted, so long as it was clearly understood what was meant. The reason he put it in the form $f=(\text{virtual current})^2/(\text{full load current})^2$ was, firstly, that by so doing the connection $f=(\text{mean loss under working})/(\text{loss at full load})$ was maintained, and, secondly, that it comprised as a special case the older definition $f=t'/(t'+t'')$. It was possible to test this latter point by a concrete example. These were two strong reasons for adopting the new definition. Mr. Hartnell had pointed out that it was not much good

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putting a fan inside a totally-enclosed motor. This agreed entirely with the author's experience. At the same time, however, it would be wrong to deny that the circulation of air inside the casing had something to do with the heat dissipation of the armature. If a motor was run at an extremely low speed it was found that the temperature rise of the armature became very much greater than that of the enclosed air. He was much interested in Mr. Yerbury's remarks, but did not think it necessary to dissociate traction motors from crane motors. Heavier duty simply meant that the specified load factor for which they must be tested was correspondingly higher. He mentioned, as a concrete example, that some large railway motors which the Phœnix Dynamo Mfg. Co. recently supplied for most onerous duty on express passenger trains were, in accordance with the specification, designed and tested for unity load factor—*i.e.*, continuous running at full load. He could confirm what Mr. Wardale pointed out, that motors for ammunition hoists for the Navy were specified to be tested intermittently for a great length of time. This met Mr. Yerbury's point, that the heaviest possible duty which a motor might be called upon to perform was specified as the normal duty of the motor. He agreed with Mr. Yerbury that manufacturers should be capable of dealing with the requirements of buyers when specially designed machines were needed. At the same time, however, a large number of machines were special ones, and were in consequence more expensive, although they need not be special at all. This was due to the absence of rules on the rating and testing of machines backed up by the authority of the Institution of Electrical Engineers. He failed to see why the institution should not proceed to remedy this serious defect, which weakened English manufacturers in home and foreign markets in their competition with Continental and American rivals.

SOME APPLICATIONS OF THE "EOA" MOTOR.

In talking about electric motors the time has now come to leave the motor itself alone and to come to its applications. Every electrical engineer knows the motor so well and how it works that it

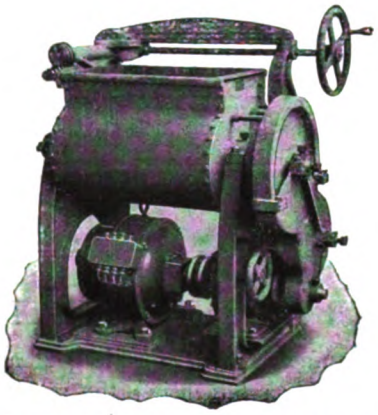

FIG. 1.—2 H.P. "EOA" MOTOR DRIVING DOUGH MIXING MACHINE.

would be more or less of an insult to attempt to teach him about these matters. But as regards the applications of the motor he is not, perhaps, so well-informed as he might be. Although he knows to a cer-

FIG. 2.—"EOA" VERTICAL MOTOR.

tain extent what a motor will do, he is not always very clear as regards particulars. These reflections are engendered by a glance through a booklet entitled "The Modern Method of Driving Machinery," recently issued by the Electric & Ordnance Accessories Co., in which are given some rather out of the way examples of what the electric motor can be and is being made to do.

It may be confidently anticipated that this pamphlet will do much towards inducing manufacturers in all branches of industry, who are at present "Philistines," to take up the employment in their works of the electric motor. The efficiency, simplicity, reliability, adaptability, and what may be called the other "ilities" of this machine are clearly, though concisely, argued out, the arguments being supported by financial details of the advantages derived by the employment of a motor as a substitute for the steam or gas engine.

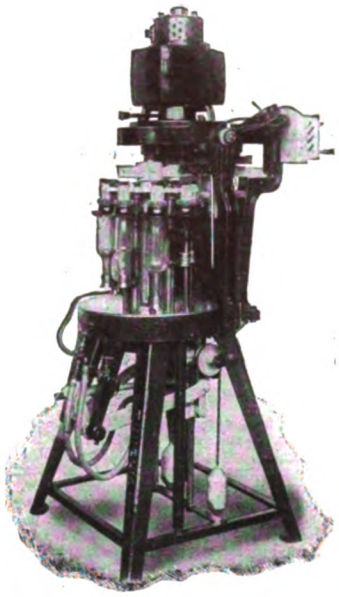

FIG. 3.—1 H.P. "EOA" VERTICAL MOTOR DRIVING BOTTLE-WASHING MACHINE.

In this connection attention may be called to the hire-purchase system devised by the firm with the idea of allowing manufacturers with small capital to obtain the benefits of the electric drive through easy payment arrangements. Under this system the Electric Ordnance & Accessories Co. are prepared to supply motors with the necessary controlling apparatus for a certain monthly or quarterly charge, the payments being spread over a period of one, two or three years, as may be desired. At the end of this time the motor becomes the sole property of the hirer. It should be noted that while the Company are always prepared to advise a customer on the best method of laying out his installation, they do not, save in exceptional cases, fit or erect the apparatus, but leave the work to the local contractor.

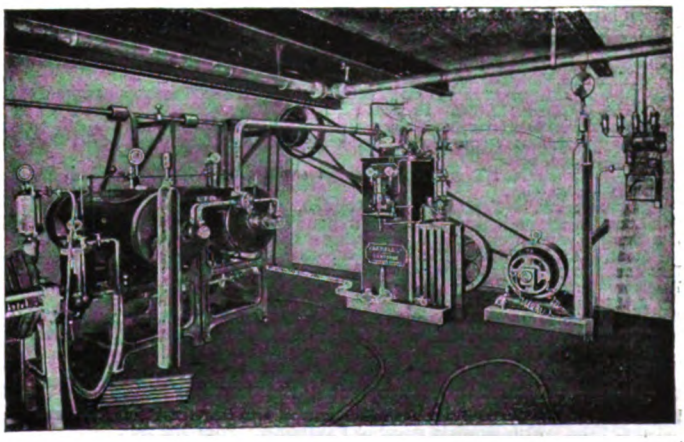

FIG. 4.—10 H.P. "EOA" MOTOR DRIVING REFRIGERATING PLANT.

The accompanying illustrations clearly show the general arrangement of some of the "EOA" installations and the uses to which the motors are put.

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SPECIAL NOTICE.

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POWER SUPPLY EXTENSIONS.

Although manufacturers of electric generating plant in this country have been lamenting the small demand for new generators during the last few years, important developments have, nevertheless, been taking place in the electricity supply world, particularly in the case of the larger undertakings, in which the growing demand for electrical energy has necessitated during recent years the laying down of additional power stations. Our Annual Tables show that a considerable proportion of the large supply undertakings now possess at least two stations, and the number of undertakings possessing more than one station is increasing every year. Thus, within the past 12 months, we have described new power stations at Stepney and Dundee, and the names of other undertakings which have extended, or are extending, in this way will at once recur to the minds of our readers.

The question of laying down an additional station is one of the most important with which the central station engineer has to deal. In many cases the equipment and design of the original station probably leave much to be desired in the light of recent experience. Old stations usually contain a number of small units which were installed when the extent to which electricity supply would develop was not fully appreciated. In fact, there has always been a tendency when installing plant to underestimate considerably the requirements of even the near

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future, so that extensions frequently became almost an annual procedure. This was, of course, to some extent unavoidable, as efforts were mainly directed to keeping down the capital expenditure of the undertaking, though this did not always result in a low cost per kilowatt of plant installed. As the smaller units become obsolete it is, of course, possible to remove them and instal larger plant, but this is at best only a temporary arrangement unless contemplated from the start, and the question of an entirely new station has eventually to be faced. This position is also brought about by the necessity of reducing the cost of generation to the lowest possible figure, so that electrical energy can be offered to manufacturers at a sufficiently low price to compete with private plants and with gas and other forms of light and power. In many cases the want of facilities for obtaining coal is such as seriously to handicap the undertaking, whilst to provide for efficient condensing may require an excessive outlay. Much has been written in regard to the various points to be considered in choosing a site for a power station, but with that question we are not for the moment concerned. It may be remarked, however, that in deciding to erect a new station it is frequently found desirable to modify the system of supply adopted. Thus, in the majority of cases where additional stations have been erected during the last few years three-phase alternating-current plant has been installed, notwithstanding that the existing system of distribution is continuous current or single phase alternating. A high-tension supply not only gives much greater freedom in the selection of a site, but is also particularly desirable where a large power load is being developed.

In this connection electrical engineers generally will take considerable interest in the forthcoming extensions of the Glasgow electricity undertaking, which is one of the largest and most important in this country. A report has been presented by Mr. W. W. LACKIE, city electrical engineer, in which he draws attention to the importance of making early provision for the probable demand for electrical energy in Glasgow, not only two years hence, but also during the next ten years. The existing stations at Port Dundas and St. Andrew's Cross are at present full of plant, and although the smaller units might be removed to make room for plant of larger capacity, Mr. LACKIE points out that at best this would only be a temporary expedient, and he therefore recommends the Committee to look out at once for a site upon which a new station may be erected. In coming to this conclusion Mr. LACKIE draws attention to the objections to extending the existing station at Port Dundas, viz. (1) the unsatisfactory supply of water for condensing purposes, the temperature of the canal water before entering the works being between 80° and 90°F., and (2) the high price which has to be paid for the delivery of coal at the works. In this connection it may be noted that coal at Port Dundas costs about 10d. per ton more than at St. Andrew's Cross, due to the former station possessing no railway siding accommodation. With the high load factors which electrical engineers are hoping for in the future, the cost of coal will become an increasingly important item, so that the facilities for obtaining coal cheaply are of almost first importance. In regard to suggestions for installing plant in the Pinkston power station of the Tramways Department, the same objection as to the use of the canal water applies, as this would involve heavy capital expenditure for condensing apparatus.

Mr. LACKIE sets forth the chief points to be kept in view in selecting a site for a power station as follows: (1) There should be suitable foundations for heavy machinery; (2) the site should be adjacent to a railway or canal, or otherwise situated so that a cheap supply of coal can be easily obtained; (3) there should be an ample supply of water at hand for condensing purposes; and (4) the site should be within a reasonable distance of the area to be supplied. It may be, of course, impossible to obtain a site with all these desirable attributes, in which case it is necessary to decide how far any, and also which, may be sacrificed. Mr. LACKIE comes to the conclusion that a site near Dalmarnock Road, with a frontage to the Clyde and adjacent to the Caledonian Railway, best meets the requirements, and possesses at least the two principal features desired, namely, the second and third mentioned above. As announced in our last issue the Electricity Committee have unanimously recommended the Council to approve generally of the report, and that the proposal to erect an additional generating station be further considered; meanwhile the ground is to be tested as regards its suitability for the erection of a large generating station, Mr. LACKIE having obtained an option on the land at 8s. per yard, the offer remaining open for acceptance until May 31st. The site also has the advantage that the new station could be easily and inexpensively connected up with the whole existing system.

In view of recent developments in America in the way of large generators, it will be of interest to see what size of plant will be installed in the new works. The latter certainly offers great possibilities in the way of economical generation of electricity, and in spite of the fact that the costs at Glasgow are already very low for an undertaking which has not the benefit of a traction load, there should be considerable reductions when the new plant gets to work. The question of a combined lighting and traction station will then probably again recur to the minds of electrical engineers, and the case for centralising the supply of electricity will undoubtedly be strengthened.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electric Cables: Their Construction and Cost. By D. Coyle and F. J. O. Howe. (London: E. & F. N. Spon.) Pp. vi.+456. 15s. nett.

This book is mainly a collection of arithmetical tables, which the computer in the estimating office of a cable factory would calculate for his own special use, or, in other words, contains the "tools" which have accumulated in the authors' hands during their "(46 years in total) experience" gained at the various works mentioned on the title page, which experience they pit in the matter of the temperature coefficient for the electrical resistance of copper against (the how many years total?) experience embodied in the recommendation of the Engineering Standards Committee.

To continue the simile, these tools have not been fitted in all cases with suitable handles and have been heaped in with

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lavish hand, but without adoption of definite system or sufficient explanation for the amateur, for without any intended disparagement the electrical engineer for whose use this book is intended may be so termed in this connection.

The metrical system is adopted to some extent, and prices are always given in shillings, no doubt as equivalent to the marks of the authors' continental experience, but tables exhibiting values per nautical mile, statute mile, 1,000 yds., &c., are added, just as fancy, or most likely factory, has determined, and with a minuteness of scale which is excessive; for example, 26 pages are covered with figures detailing the items for steel tape armouring of lead-covered cables for each $\frac{1}{10}$ mm. diameter from 10 mm. to 70 mm., and the want of system is illustrated by this same table, one column of which presents the "shop expenses" for each of the 601 sizes as a percentage on the wages and increasing by large steps at certain sizes from 25 per cent. to 75 per cent., but on referring to the sole brief paragraph on "shop expenses," we are told they "vary between 100 per cent. and 200 per cent." Even in the authors' hands these tools turn out curious results, for in detailed tables giving the prices of concentric cables, those for 2,200 volts working pressure are cheaper than for low pressure in all the larger sizes, and many such like things occur; while there is a general looseness in terms and weakness or even error in explanations of the formation of the tables that will require wariness and discretion on the part of the casual consultant of this book.

"The conductors are treated exhaustively" in the first 100 pages, but no reference is made to the B.O.T. sheath. Insulating materials are next considered, and incidentally we notice that some factories are stated to take liberties with "specific gravity," which term in this book often means anything but itself, and so the book proceeds at great length with the armouring and outside protection of the various types of cable, and closes with the description of the "grading of the insulation" of E.H.T. cables and the calculation of inductance and electrostatic capacity. The actual tests of the latter would have been more useful if the specific values of the insulation had been inserted in the diagrams.

In the section treating of telephone cables, a confusion arises in not distinguishing between "quad cores" and "quad pairs," while the dimensions calculated from the formulæ for the pre-determination of sizes for specified electrical values appear to give results far in excess of the demands of modern specifications.

Manufacturing wages are given mostly in the form of diagrams, which exhibit them, for various types of completed cable, as a variant with the size of the conductors, but far too much space is here devoted to jute insulation, which has been discarded for many years.

What with the standardising of E.L. cables, both here and on the Continent, what with the number and excellence of price lists and catalogues received by the electrical engineer, and what with the detailed specifications which the factories have to fulfil, and the obligations under which they have to work, we should hardly have expected that any "long-felt want" for a work of this genus existed; but, at any rate, a perusal of this book can only confirm the electrical engineer in his satisfactory contentment, if such he need, that the estimates in a cable factory, as elsewhere, are the result of a careful application of ordinary methods of arithmetical calculation. F. J.

Sammlung Elektrotechnischer Lehrhefte. By FRITZ HOPPE. Part II., "Grundgesetze der Wechselstromtheorie." Part VII., "Messungen der Stromstärke, Spannung, Leistung und Arbeit bei Gleich- und Wechselstrom, Eichung und Graduieren von Messinstrumenten." Part VIII., "Messungen an Maschinen und Motoren für Gleichstrom." (Leipsig: J. A. Barth.) Part II., pp. vi.+144. M.5. Part VII., pp. vi.+132. M.4.40. Part VIII., pp. vi.+168. M.5.80.

These three volumes form part of a series of booklets covering the elementary principles of electrical engineering. Each of the 10 sections in the series is made complete in itself in order that the student may buy separately such sections as he requires. The idea of bringing out these manuals in this form is a very good one, and the reviewer finds them the most suitable little handbooks for elementary students that he has come across recently.

The problems treated are handled in a practical way, and the writer is evidently an experienced teacher, as can be judged from the manner in which he expresses himself on points that usually present difficulties to the beginner. Great stress is laid on the discussion of actual test results and the working out of arithmetical examples, and, on the whole, one must admit that the writer has succeeded in his object, as expressed in the preface, of making the pupil "picture to himself clearly the phenomena that are described" and learn to "think electrically."

Part II. contains the general theory of alternating currents worked out with the aid of vector diagrams, and is concerned mainly with principles and only to a small extent with their application to alternating-current apparatus. It is somewhat confusing that one direction of rotation of the vectors is not used throughout the book, and although arrows are drawn in most of the figures to indicate the direction that is being used, yet it would be preferable to adopt one convention throughout.

The first item of importance taken is the determination of the winding factors for various types of alternator windings. These are not only tabulated, but a great number of cases are worked out fully. The effects of self-induction are then treated and the relations of the currents and voltages in circuits containing resistance, capacity and reactance in various connections.

In this part a serious error has been made in the calculations concerning an arc lamp controlled by a choking coil. The voltages across the lamp and the choking coil are added arithmetically instead of vectorially, and the power factor for the whole circuit is confused with that for the choking coil considered alone.

The student will get an exaggerated impression of the importance of losses in condensers from the fact that in nearly every case in which condensers are mentioned, they are represented as being equivalent to a capacity in series with a non-inductive resistance of such a magnitude that the voltage drops across the two parts are of the same order of magnitude.

After a very simple discussion of the regulation of an alternator at various loads and power factors the book concludes with vector diagrams relating to the working of transformers on various types of loads and some quite elementary remarks about polyphase systems.

The paragraph on p. 124 in which a proof is attempted of the fact that the approximate ratio of the currents in the primary and secondary windings of a transformer is inversely as the number of turns on these windings, is full of mistakes and should be re-written.

The following misprints appear in this volume:—Table on p. 84, *interchange* 40 and 60 and *read* 51 for 61; p. 90, Fig. 100, *read* 0·0306 henry for 0·036 henry; p. 96, last lines, *read* 0·62 for 0·643 and 0·785 for 0·766, and make the necessary changes that follow in consequence; p. 117, *read* W_i for W_2.

Part VII. treats of measurements with the voltameter, tangent galvanometer, electrometer, calorimeter and potentiometer, and of the use of most of the usual technical instruments and some useful hints on the method of calibrating and preparing scales for measuring instruments. The reviewer is of the opinion that the tangent galvanometer is treated at an unnecessary length, seeing that it has little more than a historic interest and is hardly ever used nowadays.

On p. 78, concerning the measurement of power by the wattmeter (not voltmeter, as stated in line 21), it should be stated that the deflection of the instrument is determined by the mean value of *the product of* the simultaneous instantaneous values of the currents in its two coils. (The words in italics are omitted in the text.) In the final equation on the same page containing the correcting factor for the reading of a wattmeter with self-induction in its shunt-circuit, the resistance of the shunt-circuit should appear in the numerator instead of in the denominator.

The measurement of polyphase power is well done, but there

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are a few points that are open to criticism. The connection, as shown in Fig. 87, would be correct on a low-voltage system, but, as the full potential between two of the lines is bridged by the short air-gaps between the fixed and moving coils of the two wattmeters, both instruments would be liable to destruction by flashing-over if this connection were used on a high-tension circuit.

The connection for reading the power on a three-phase system by one wattmeter, as shown in Fig. 90, is wrong; it is there stated that a wattmeter connected with its current coil in one main and its potential coil between that main and one of the others will read $\frac{1}{\sqrt{3}}$ times the total power. A wattmeter so connected would read half the power on a balanced non-inductive load but in all other cases the total power could not be deduced from its reading alone. It is strange how prevalent this fallacy is. It should also be stated that the single wattmeter methods of measuring three-phase power, shown in Figs. 91 and 92, are only correct for balanced load.

Part VIII. is excellent throughout and will form a most useful aid to those who are engaged in the testing of continuous-current machines in the laboratory or in practice.

Each type of motor and generator is fully treated theoretically, and its characteristics thus determined checked by the results obtained by actual tests. Some of the theoretical formulæ have become somewhat complicated through the fact that Frölich's formula for the saturation curve has been used. It would perhaps be preferable in the interest of simplicity to refrain from attempting to express mathematically the somewhat complicated relation that exists between the flux and the number of ampere-turns on a machine.

A novel feature is the experimental investigation of the armature reaction of a continuous-current machine by a short-circuit test analogous to the tests commonly performed on alternators. The results obtained by this method are interesting, but in their discussion some confusion is caused by the printing of OD for OA near the foot of p. 39.

A. J. MAKOWER.

A PHYSIOLOGICAL EFFECT OF AN ALTERNATING MAGNETIC FIELD.*

BY SILVANUS P. THOMPSON, D.SC., F.R.S.

Hitherto it has been generally held that magnetism produces no physiological effect on any living organism, and although many persons have looked for such effects the results have been negative. Some years ago the author observed a faint visual effect when an alternating current magnet was placed near the forehead, and recently means have been found of producing the visual effect in a way that succeeds with every person upon whom it has yet been tried.

An alternating magnetic field of sufficient intensity and extent was produced by passing an alternating electric current around a specially constructed magnetising coil. This coil, consisting of 32 turns of stranded copper wire, having an equivalent cross-section of about 0·2 square in. in each turn, was wound upon a wooden cylinder about 9 in. in diameter, and about 8 in. long; the cylinder being then removed. The alternating current, of a frequency of 50 periods per second, could be increased up to 180 amperes at will; so that the total number of ampere-turns of the coil reached 5,760. The intensity of the alternating magnetic field at the centre of the coil had therefore a virtual value (quadratic mean) of about 1,000 C.G.S. units; and its instantaneous maximum value (at the centre of the coil) was therefore about 1,400 C.G.S. units. The value at the mouth of the coil was not much more than two-thirds of this amount, and was not uniform over the cross-section of the interior space.

On inserting the head into the interior of the coil in the dark, or with the eyes closed, there is perceived over the whole region of vision a faint flickering illumination, colourless or of a slightly bluish tint. The period of the flicker is not well defined. It does not seem to be the same over the whole region of vision at the same time, nor is it equally bright over the whole region of vision, but is somewhat brighter in the peripheral region than in the central parts. Even in daylight, with the eyes open, one is conscious of a sensation of flicker superposed upon the ordinary vision.

The effect is diminished by lowering the intensity of the field, and increased by raising it. Attempts to discover whether the brightness of the phenomenon stands in any relation to the direction of the axis of the field with respect to the directions of the principal axis of the scull have not yet revealed any definite result. It will be necessary to apply more intense fields than have yet been tried. No after-effects of any kind have been experienced, either by myself or by any of the persons who have made the experiments with me.

As yet it has not been possible to ascertain whether the phenomenon is dependent upon frequency. No effect upon the senses of smell or hearing has been observed, but there is an effect upon taste.

* Abstract of a Paper read before the Royal Society yesterday.

THE MOVEMENT TOWARDS A NATIONAL SYSTEM OF TECHNICAL EDUCATION.*

BY DR. R. POHL.

The problem of remedying the admitted inefficiency of our present methods of technical education, and of invigorating the industries of this country with progressive scientific spirit, while at the same time increasing the supply of skilled workmen, is of the greatest national importance, and is a problem the solution of which, in view of international industrial competition, becomes daily more pressing. It is only natural, therefore, that expressions of discontent with the present conditions, and suggestions for improvement, should be heard from many sides; they come not only from the educationists, but also from the employer, the representatives of the working classes, and the ratepayers, and with especial force from the social reformer; finally, we hear from Cabinet Ministers themselves, that legislation on the subject is under consideration. In view of this fact, it is most important that this Association of Technical Teachers should, at the coming Annual Conference, fully discuss this subject, and complete the constructive proposals laid down at the last Conference.

If we proceed to analyse the expressions of opinion, revealed during the last 12 months, there is a clear indication that, barely concealed under a superficial diversity of view point, the ideas have already crystallised round two fundamental principles which are certain to form the basis of all future constructive work. These are: (1) There should be a thoroughly organised system of technical education, leading up from the primary and secondary schools to the technical school, and having, as its crown, the technical university, every stage of the system being in intimate contact with the next, so far as possible without overlapping, and the educational work must be carried out in the closest possible co-operation with the employer. (2) This system should be a national one; that is to say, the Board of Education should not only inspect and supervise the individual institutions, but should ensure proper co-ordination; extend by law the leaving age for children, when and where necessary; enlist by all available means the co-operation of employers, and introduce a uniform system of examinations and degrees; and it should, from its exalted position, watch the working of the system, comparing it with that of other nations, and generally employing and developing the powerful weapon of technical education in the interests of the industries and the progress of the nation as a whole.

It has been stated that the proposals contained in my previous Paper were nothing more or less than a suggestion to adopt the Prussian system root and branch. I choose to deal with this entirely erroneous view, because it gives me an opportunity of showing what, to my mind, are the points of excellence and the faults, both in the Prussian and the average English systems. It will then be seen that by organically combining the good features of both, one can arrive at a system which, I believe, will meet the requirements of this country in a most efficient manner. I take it as being agreed upon that the scientific leaders of industry require much more complete training than the rank and file of the industrial army, chiefly the additional training of strict scientific accuracy, of research, and originality. That in view of the numbers to be dealt with in both sections, respectively, there must be a large number of schools for the rank and file in close contact with local industries, and a small number of colleges for the officers. This means decentralisation in the case of lower technical schools, and centralisation for the technical universities. How does Prussia attend to the needs of the rank and file? There were, in 1909, 23 national engineering schools, 24 national building schools, 7 national art and artisan schools, and 45 State-supported municipal technical schools of different kinds, including 6 textile schools, and 7 higher textile schools. Most of these institutions do no evening work, and the students pass through systematic courses extending over several years. During this time they are not in contact with practice, except that the building students, making the best of climatic con-

* Abstract of a Paper read before the Association of Teachers in Technical Institutions (West Yorkshire branch).

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ditions, frequently work in summer and study during the winter months, and that other students sometimes do practical work during the summer vacations. Generally speaking, however, the students are not in contact with practice. I also incline to the view that there has been too much centralisation in this branch of technical education. As a consequence, there is a lack of intimate contact with local industries, and insufficient amalgamation of theory and practice. Furthermore, most of these schools do not really train skilled workmen and artisans, but what may be termed the non-commissioned officers of the industrial army. The courses are somewhat expensive, and, through the almost complete absence of a system of scholarships they cater more for the middle classes than the working classes. Another defect, and a very serious one in my opinion, is the absence of systematic co-operation between these schools and the technical universities, whereby students of exceptional ability would be sent up to the latter.

In England, the corresponding educational work is carried on in evening classes, whose most valuable and unique features are first and foremost, the intimate and continued contact of the students with practice, which infuses their daily work with heightened interest derived from the application of their studies, and which, on the other hand, reacts on the teacher and makes the courses, though they must remain theoretical, yet of a thoroughly practical nature and best suited to the needs of the local industries; and, secondly, the complete elimination of the bitter disappointment which many day students, in proud possession of first-class certificates and diplomas, now experience when they find that they cannot secure any suitable employment. This "Sandwich" or "half-time" system, which we so justly condemn when it is applied to primary education, is in my view, the ideal system for the training of the industrial rank and file. I am, therefore, of opinion that those who desire to see the present evening work abolished, and the day schools developed on the German lines, are very ill-advised. Whatever we do, let us retain the great feature of the English principle, that is, the concurrent training in factory and school. Let us make the present evening courses much more efficient by establishing proper co-operation with the employers, and by reducing the hours of labour, so that it becomes possible gradually to shift the centre of gravity from the evening to the day. Thus we shall obtain all we are striving for, without losing the great features I have emphasised, as well as the truly democratic spirit of the present system and its hold on the masses of the population.

I desire to offer one or two suggestions in connection with this important subject. We all agree it is not sufficient bringing pressure to bear on employers to give facilities for attendance at classes, but it is highly important, indeed it is essential, that we should secure their continued interest and willing assistance. There exists already a growing interest in evening classes. Let us do everything to enhance this sympathy, and convince employers that the developments which are shortly to take place are first and foremost in their own interests. But there is a further, and, if possible, more important point to be considered. The technical school, as thus firmly established by law, must not be an isolated unit in our educational system, but it must be a link in a complete chain. It must join at the bottom with the secondary school, especially with the technical secondary laid down as a desideratum in our resolutions of last year, and it should lead up to the technical university above. It is the need for an organic connection of the ordinary work with the highest form of technical education, on which I wish to lay particular stress. No better form can I imagine for this link than that of a comprehensive and national scheme of maintenance scholarships, by means of which the students of exceptional ability and enthusiasm are lifted up and trained to be the scientific leaders and original workers.

Thus we have arrived at the technical university, and, in passing, I will only remark that, up to this level of technical education, there is every likelihood of Prussia having shortly to learn a great deal from England. The aspect changes completely, however, when we contemplate the higher branches. In the latter, in Prussia, we find thorough organisation and efficiency, in England we find chaos and waste of energy and money. The explanation is simple: the Prussian technical high schools are national institutions, just sufficient in number for the needs of the whole nation so as to allow of intense specialisation in all branches. The many English institutions attempting higher technical work were founded by private persons, guilds, societies, municipalities, and whosoever liked to distinguish himself in this direction. The national government has made the sad mistake of generously supporting all these well-meant efforts, so far with little regard, apparently, to the effect of the one on the other. We must lose no time in remedying these defects before reaction becomes general, to the detriment of technical education and to the status of the technical teacher in particular. The borough, and even the county, is far too small a feeding area for a modern technical university, with its large staff of specialised experts in all branches, training original workers, carrying out industrial research and generally permeating the industries with progressive ideas.

As an introduction to a discussion on this question of the formation of these universities, one or two suggestions may perhaps be acceptable. Inquiries would have to be made to discover a ready means of correlating the work of universities with that of other institutions, which, as yet, is non-existent. Another important point to be settled is the number of technical universities needed, and their respective feeding areas. I believe that three for England and Wales, one for Scotland and one for Ireland, or even less, would be found to be sufficient for many years to come. And finally, the most difficult point as to the method of procedure will have to be decided. May I suggest, with the greatest deference, that in this connection the early and recent history of the Imperial College of Science and Technology may serve as a lesson how not to proceed. A further increase in the already excessive number of competitive institutions is clearly not wanted, but instead, a thorough amalgamation of the same and the replacement of mutually destructive competition by effective co-operation.

It is not unlikely that such amalgamation may soon be brought about so far as London is concerned, and an early extension of the principle to the provinces would then be within the range of probability. The leading institutions at present existing, in each university area decided upon, would form the constituent colleges; they might have the first and second years' courses in common, which, of necessity, would be generally scientific and educational in character, including such subjects as national economy, industrial history, industrial legislation, patent laws, &c., but the higher branches would be distributed according to the nature of the institutions and the industrial activities of the districts. Thus the desired concentration of effort and of students would be secured, and, by a process of natural development, the formation of a large staff of specialists in each branch working in intimate contact with their respective industries. In common justice, the old associates and graduates of the existing institutions should on application receive the corresponding degree of the new university into which their Alma Mater would be merged, a remark which applies more particularly to such historical seats of learning as the Royal College of Science, Royal School of Mines, City and Guilds Institute, &c., and to the leading provincial universities and colleges.

A scheme of more or less compulsory amalgamation as outlined above is, I know, distateful to many, and I am thinking more particularly of the remarks to that effect in Dr. Glazebrook's weighty and thoughtful Presidential Address to the Association of Technical Institutions. Yet I cannot bring myself to believe that there is the slightest hope of securing really efficient co-operation, and not merely a superficial affiliation, without some pressure from above. Needless to say, the amount of such pressure would be kept down to the lowest practicable minimum; to this end the detailed scheme of amalgamation, on the basis of certain guiding principles, might well be left to be settled by the institutions concerned, and no doubt the new universities, thus created, would be self-governing.

Higher technical education in England, if developed on such lines, would have adopted only one important point from the Prussian system, that is, organisation on a national basis, a point which, in my opinion, is indispensable to success. Other and less important points of similarity, such as the uniform system of examinations and of legally protected degrees, would come as a natural consequence. In more than one regard, of profound importance, however, the English would be far in advance of any existing system, so far as my knowledge goes; firstly, in its democratic principle, culminating in the character of its students, who, gathered by a process of sifting and selection, represent the genius of the rising generation in whatever sphere it may have been born—a class not of aristocratic idlers, but of enthusiastic workers. This ideal we shall approach only gradually, yet it is in sight, and we may accelerate its coming by advocating, that the fees of the new universities, for all except the scholarship students, shall not be kept low, but shall be at any rate in proportion to the cost of such institutions. The scholarship students will thus predominate more and more, which makes it possible at the same time to adjust the number of highly-trained men to the needs of the industries. We shall thus avoid excessive supply, which is a social and economic danger, and is a blame, often and not unjustly, attached to the German high schools. And finally, the close co-operation of the new universities with the respective industries would be a unique feature. It would be maintained not only, as in Germany, through the professors and lecturers, but through their advisory boards, and, what is perhaps most important, through the students themselves, who have been in contact with practice not merely for a short term of pupilage, like the average German student, but who have passed "through the mill."

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STANDARDISATION OF ELECTRICAL MACHINES.

At a recent meeting of the Birmingham local section of the Institution of Electrical Engineers a paper was read by Mr. R. Orsettich on this subject, an abstract of the paper appearing in our issue of March 11th. The following is an abstract of the discussion which took place.

DISCUSSION.

Mr. M. Railing said that all manufacturers would agree on the advantages of standardisation. From the point of view of the public, standardisation was still more important. It aided cheap production by saving capital expenditure, ensured production being concentrated upon proved types rather than experimental types, and enabled existing stocks to be drawn upon in case of breakdown. He urged that more use should be made of the Institution rules. If these did not cover sufficient ground, attempts should be made to enlarge them. But only by the co-operation of the consumer, his advisory consulting engineer and the manufacturer in working to these rules could they arrive at complete standardisation. The question was one of national importance. Those who had to compete against large outputs of well-designed machines coming from the Continent and the United States could only hold their own by standardising as much as possible.

Mr. S. P. Smith (General Electric Co.) said that many points in connection with standardisation appealed to the designer, but particularly the question of relative cost of labour and material. A satisfactory solution could only be obtained by studying the total cost of the machines. Generally in electrical machinery the material was a more expensive item than the labour, and it would therefore seem that the designer would do well to cut the material as far as possible, at the same time allowing for better workmanship. Another important point related to the quality of the material, and on the whole it would be found that the best possible material was the cheapest. Closely connected with standardisation were the questions of ventilation and insulation. Most modern designs of machines were based on improved ventilation and consequently increased output. It might be thought a strange idea, but he believed that by the introduction of new insulating materials it would become possible to raise the heating limit in machines considerably, drawing the line at, say, 170 deg. rise instead of 70 deg. But it was quite true that such an insulating material had yet to come. He then referred to the lack of standardisation in the speed of direct-current machines. It made one wish that there was something corresponding to frequency that would fix the speed of direct-current machines. A difficulty in connection with standardisation was due to customers insisting so much on their own specifications. He suggested that it would be better to take the manufacturers' specification and work to that. There was always the safeguard of competition, and if the buyer could not get what he wanted from one maker he could get it from another.

Mr. N. B. Rosher thought considerable restraint had been shown in not attacking the great number of types of machines which had to be made nowadays. In the case of alternating-current machines there were no less than 16 different frequencies in use in this country. He agreed with the author that for alternating-current motors the best position for the slip-rings was outside the bearing. A slight disadvantage was that should it be required to take out the rotor it was necessary to remove the rings unless the bearings were split. The material of which rings were made were anything but standardised. Cast iron, cast or drawn copper, gunmetal and phosphor bronze were all being used. He would like the author's opinion as to the most suitable material. Another detail difficult to standardise was the arrangement of terminals. He preferred a cast terminal box which could be secured to a flat face on either side of the machine, and suggested flexible metallic tubing between the terminal box and the conduit. Mr. Smith had talked of 170 deg. as a possible future limit of temperature rise. He believed that the Admiralty were now allowing a temperature rise of this order in some machines which were being regularly supplied for special work.

Mr. A. E. Gott said the lecturer had laid stress upon the importance of stocking for orders. They would all like to do that, but it was only possible when everything was standardised. It was surprising the amount of money that was spent and sometimes wasted in little defects which greater standardisation would have prevented. In the examples mentioned he could not help thinking that the 1,000 and 2,000 revs. per min. speeds for the 1 H.P. machines were much too high; he did not know whether these were intended to be standardised or not. In regard to voltage, they could not have standard machines without standard voltages, and he was struck with the extraordinary number which prevailed in this country and on the Continent. He did not think that manufacturers paid sufficient attention to the details of electric motors, the terminals especially being frequently neglected by the designer. Nothing had been said in the Paper about split frames and split bearings which were absolutely necessary in certain cases. As to reduction gearing, he entirely disagreed with the practice of putting the gear on top of the motor. The case was never designed to stand the strain, and was consequently liable to be broken. He thought that in standardisation allowance ought to be made for fitting flywheels to the motor shafts.

Mr. A. E. Anderson thought that by keeping one's workmen constantly employed on the same line of work there was a danger of making machines of the men. The same thing applied to the standardisation of designs. It was a very fair question to ask whether that did not tend to stultifying invention. It seemed a fair argument that with three or four different varieties of work they would reach a much higher point of efficiency and economy of material. Dealing with the question of general standardisation and diameter of core, he did not agree with the author's statement that for continuous-current machines it was advisable to have a separate diameter for every length. Personally he thought they ought to have at least two lengths to get the requisite degree of flexibility, because it was a very difficult matter to standardise armature windings. The same would also apply to the author's statement that the stampings of continuous-current machines should be arranged for one or at the maximum two numbers of slots only.

Mr. A. Willmott said that the Paper rather appeared to miss the initial start of standardisation. What was wanted to start with were correct drawings. Also there was no mention made of the question of inspection. This was a very important point in standardisation and shop production. If they did not want to waste money they must have good men who could be relied upon to see that when machines were going through the shop there should not occur trivial defects, to be discovered afterwards on testing. The Paper only mentioned cast iron for the yokes, but they could now get a very good quality of steel casting which could be obtained at a fair competitive price. The delivery might be quicker with cast iron, but with standardisation this was not of such great importance. With regard to brushholders he thought it was better to increase the number of carbon blocks than to increase their thickness.

Mr. Holt said, with regard to the possibility of standardisation stultifying progress, he thought one of the reasons why it had not been carried to such an extent in electrical machinery as in some other things was that the electrical machine so far had not reached finality. They must not begin to consider the question of standardisation until they had standard requirements, and in that matter their Institution must play a large and important part. With regard to field coils, where these were standardised at 220 volts he found that when used on 230-volt circuits where the regulation was bad they were liable to overheating and breakdown. It seemed best to design standard machines for ordinary standard voltages and to treat any departure from these as a case for a special machine. As regards patterns, his experience was that wooden ones had a very short life, and that iron ones, except in very small sizes, were too cumbersome. He thought that the outlay on patterns should be kept as small as possible. As to the use of enamelled wire, he had found it satisfactory in field coils where it could be wound in regular layers, but it was quite useless in armatures where it was subjected to a great deal of twisting and handling and where wires crossed one another at the coil ends. He had had a number of ball bearings running quite satisfactorily, and believed that in many cases their failure was due to faulty mounting.

Mr. Orsettich, in reply, said that Mr. Smith perhaps did not mean to be so radical as he seemed to be. He probably meant to say that the specifications of consulting engineers should lay down the principal lines of the specifications, stating their requirements, but should not insist on small details of construction. If this was what Mr. Smith meant they were perfectly in agreement, and he believed every consulting engineer would be of the same opinion. With regard to Mr. Rosher's remarks concerning the large number of machines proposed as a basis of standardisation, this was an essential condition of its acceptance. If the number of standard machines was not sufficiently large there would be occasion for special machines to be made. The material used for slip-rings was not of great importance, especially where short-circuiting gear was fitted to the motor. Phosphor bronze, steel and malleable iron had all been employed. Malleable iron was more satisfactory than steel for shrinking purposes. Phosphor bronze answered equally well, but it was more expensive and less durable. The brushes in standard machines should be of carbon only, but in certain cases with low voltages made-up carbons with copper plugs inserted could be employed. Copper brushes could be used with slip-rings, especially if the latter were of malleable iron. As regards ball bearings, his own experience had been that the balls sometimes broke, and the broken pieces damaged the shaft badly before they were found out and removed. If it were possible to come to an agreement as to the position of terminals manufacturers would be very glad to comply with clients' requirements. He was afraid that the Home Office regulations would hardly regard a tube clamp on the terminal board as an effective earthing device, a definite section of copper would have to be allowed. He agreed with Mr. Gott that the speed of machines should be kept as low as possible, but there was a large market for high-speed machines. The general practice with regard to split frames was that where the armature became too heavy to be lifted out by two men it was necessary to split the frame. This happened at a diameter of about 14 in. In reply to Mr. Anderson, he was not afraid that the adoption of strict standards would lead to a crystallising of types and stopping of progress. As regards the use of two or three lengths of core, from the point of view of the cost of dies, he did not know whether speakers had in their minds the idea of combination dies. The question of cost was not so serious if they had blank dies, when one die could be used for two or three sizes. As to drawings and inspection, he had pointed out at the beginning of his Paper that he was not dealing with the question from the shop point of view. He was afraid that Mr. Willmott's suggestion of altering the number of brushes instead of their thickness was hardly practicable, because it meant increasing the length of the commutator every time the current was increased. As regards the question of armature stampings, he believed that when the diameter of the centre piece saved by the use of a spider was 10 in. or less the saving was not sufficient to warrant the use of the spider. A heavy machine with ball bearings had been mentioned in the discussion, but he believed that roller bearings had been substituted in that machine about six months ago.

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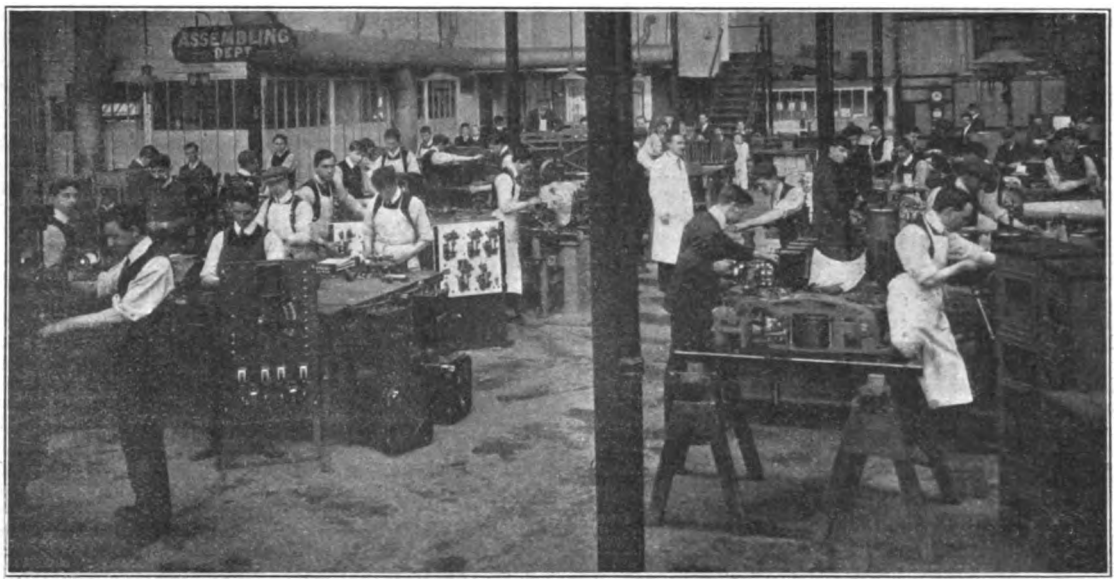
"IGRANIC" ELECTRIC CONTROL APPARATUS.

A VISIT TO THE BEDFORD WORKS OF THE ADAMS MFG. CO.

On Friday last, at the invitation of the Adams Mfg. Co., a party of technical journalists travelled down to Bedford and were given an opportunity of inspecting the latest types of Igranic electrical control gear, and also the works from which the specialities of the Adams Mfg. Co. emanate. The party were entertained at luncheon by Mr. A. H. Adams and the officials of the Company, and immediately following an excellent repast a large number of lantern slides depicting the principal Igranic standard gears were thrown on the screen. Mr. Adams briefly emphasised the importance of standardisation in motor control gear, and explained that it was the object of his Company to specialise in this branch of manufacture with a view to the production of the most efficient forms of apparatus for controlling motors of every size and type. He pointed out that considerable difficulties had been experienced in bringing about a satisfactory standardisation of apparatus owing to the variety of types, but that by a close study of the results of experience it had become possible to put forward a regular range of control gear which could be relied upon in every respect. We have from time to time directed attention to the many improvements which the Adams Co. has introduced into its Igranic apparatus; consequently, it is not necessary for us to go into the special details of design and construction which distinguish this form of motor control gear. The details of the various slides were explained by Mr. J. T. Mould, and many interesting types were depicted. Among these were three large Igranic gears installed in the works of Messrs. Cammell, Laird & Co. for the control of three overhead cranes which handle hot steel ingots. Each of these gears controls some 350 H.P. of motors, and the whole of the operations are performed on a drum type master controller which is connected to the circuits of solenoid operated contactor switches fixed at some distance from the operator. Other slides showed examples of Igranic apparatus in use in American steel works and rolling mills, one of the most interesting of these being a gear which controls a motor hoisting a hot bloom weighing some 60 tons, the whole of the operations of starting, accelerating and stopping the motor occupying a space of only 2½ seconds. Examples of printing press controllers were also thrown on the screen, and Mr. Mould laid special emphasis on the fact that the Igranic gear has overcome the difficulties attendant upon the "inching" of heavy flat bed and newspaper printing presses. We have described this form of gear in the columns of THE ELECTRICIAN (Vol. LVIII., p. 929). Probably the most interesting slide was that showing a novel application of the lifting electromagnet. As our readers are probably aware, this crane accessory has been brought to a high pitch of perfection by American electrical engineers. We understand that the Adams Co. is acting in this country for the Cutler-Hammer Co. for the sale of



IGRANIC WORKS, BEDFORD. A CORNER OF THE ASSEMBLING SHOP.

IGRANIC WORKS, BEDFORD. A PORTION OF THE RHEOSTAT GALLERY.

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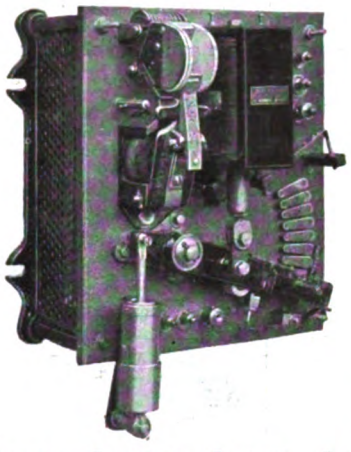
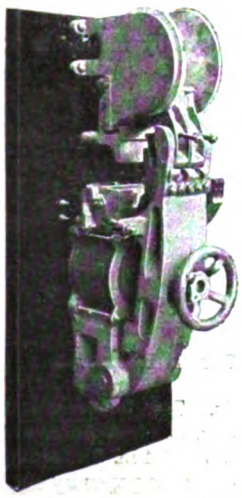
the latest form of these lifting magnets. The slide in question depicted one of these magnets raising from the bed of the river Mississippi a portion of a cargo of nails which had fallen through the bottom of a barge and had slipped from the bank into the bed of the river. We were informed that the whole of the cargo was recovered in this novel manner, and the Company is of the opinion that there is a considerable future for the lifting electromagnet in salvage operations. The difficulty which has previously been experienced is the keeping of the magnet winding quite dry, moisture usually finding its way in and breaking down the insulation. The illustration of this novel incident, which we are able to reproduce, had only arrived from America on Friday morning, so that the Company must be complimented on its enterprise in showing it to the party present.

LATEST FORM OF STEP-BY-STEP STARTING SWITCH WITH NO VOLT AND OVERLOAD RELEASE.



IGRANIC SOLENOID STARTER COMBINED WITH "CLAPPER" TYPE CIRCUIT BREAKER AND NO VOLT RELEASE.

After luncheon the party adjourned to the Company's works, which occupy a site of some 6 or 7 acres lying in an angle formed by the intersection of the Midland and London & North-Western Railways. Arrangements had been made to conduct the guests over the works in parties, and the various stages of the manufacture of Igranic rheostats and control gear were explained and demonstrated seriatim. The electrical works have a floor space of some 22,000 sq. ft., and adjoin the automobile works, which are responsible for the production of the well-known Adams cars. The layout of the shops into departments has been carefully arranged so as to facilitate the passage of the raw material from the preliminary to the final processes with a minimum amount of delay and re-handling. The equipment of the testing department is complete in every way, and the party was given an opportunity of witnessing the operation of several new forms of control gear under actual service conditions.



IGRANIC CLAPPER TYPE CIRCUIT BREAKER MADE IN CAPACITIES FROM 5 TO 10,000 AMPS.

IGRANIC DISTANT STOP PUSH BUTTON WHICH OPERATES IRRESPECTIVE OF LENGTH OF LEADS.

As to Igranic apparatus, as we have already mentioned, the main features of this will be well known to our readers. We are, however, able to give illustrations of one or two of the Company's most recent productions, to which more than ordinary interest attaches. Special attention has been paid to the design of clapper and contactor type remote control switches, and these are now made in small size for direct attachment to Igranic starters, and in larger sizes for independent operation as circuit-breakers. We were shown in the testing room an example of one of these clapper switches having a capacity of 8,000 amperes 600 volts. The carbon and magnetic blowouts have been carefully designed, and every precaution has been taken to protect the costly laminated copper bridge pieces from damage which might arise if any arcing took place at this point. A decided novelty which was also shown is a distant-stop push button for short-circuiting the no-volt release coil of motor starters from some distant point. The ordinary arrangement does not make any allowance for the length of the push button leads; consequently, if these are unduly long, their resistance is sufficiently great to render the device inoperative. With the latest Adams device this difficulty has been overcome, and the push button can be placed at any distance from the starter. It can, of course, be utilised in conjunction with any ordinary starter without alteration. Another new form of Igranic gear is a combined auto-starter and main switch. The starter is solenoid operated and is upon standard Igranic lines. Immediately adjacent to the solenoid is a small clapper type electrically-operated circuit-breaker, which makes and breaks the main circuit. A combination of this type makes the whole apparatus much more compact and reduces erection expenses as well as the cost of the gear. Another interesting switch of recent introduction is that known as the "straight line multiple starter." This is one of the neatest step-by-step starting switches which has come under our notice for some time. The apparatus consists of a number of superimposed switches which are so connected to the operating handle

IGRANIC LIFTING MAGNET RAISING PORTION OF A CARGO OF NAILS.

that the oscillation of the latter brings each switch consecutively into circuit. The bottom switch, which is the first to close, is held in by a no-volt release magnet, and is provided with a carbon break and magnetic blowout. The other switches are automatically released after the fall of this bottom switch. If desired, an overload circuit-breaker interlocked with the first switch can be fitted to protect the motor against heavy starting currents. The device can be oil immersed or enclosed in dust-proof and watertight cover. An arrangement can also be made for speed regulation if necessary.

The visit to the Igranic works was pregnant with interest at almost every turn, and we found the time all too short in which to make closer examination of the Company's many interesting products. Nevertheless, abundant evidence was forthcoming that the strictest attention is paid to the minor as well as the important details of motor control gear, and it is doubtless upon this account that Igranic gear enjoys its present well-deserved reputation.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, postfree on receipt of published price, adding 3d. for books published under 2s., and 5 per cent, for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Téléphonie; Du Téléphone Bell Aux Multiples Automatiques." By Albert Turpain. (Paris: Gauthier-Villars.) Fr. 5.

"Motions Fondamentales sur la Télégraphie." By Albert Turpain. (Paris: Gauthier-Villars.) Fr. 5.

"Installations Electriques de Force et Lumière; Schémas de Connexions." By Adr. Curchod. (Paris: H. Dunod & E. Pinat.) Fr.4.50.

"L'Electrotechnique Exposée a L'Aide des Mathematiques Elémentaires." Vol. II.: "Production de L'Energie Electrique." By N. A. Paquet, A. C. Docquier and J. A. Montpellier. (Paris H. Dunod & E. Pinat.) Fr.16.50.

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FROSTING, ETCHING AND COLOURING INCANDESCENT LAMP BULBS.*

The Lamp Committee of the National Electric Light Association have prepared the following information on the subject of frosting, etching and colouring incandescent lamp bulbs :—

Frosting Lamps.—Frosted lamps improve lighting results by giving better diffusion and more agreeable lighting. A properly frosted bulb cuts off comparatively little light, averaging from 3 per cent. to 7 per cent. The useful life of frosted lamps is about 60 per cent. of that given by corresponding clear-bulb lamps, but the breaking life is practically the same for both clear and frosted lamps.

Lamp bulbs may be superficially frosted by dipping in a compound which can be purchased from various manufacturers ; this frosting is not permanent, however, nor as satisfactory as the etched frost given to the lamps by the manufacturers, which is effected either by sand blast or by acid. Both processes give very similar results, but for incandescent lamps the acid method is generally used. This employs a solution consisting of hydrofluoric acid and carbonate of ammonia thoroughly mixed in a proportion of about 10 qt. of acid to 8 lb. of ammonia. Where it is required to frost only a portion of the lamp, rubber hoods are placed over the lamps to a point where the frosting is to stop. The acid operation is dangerous and requires considerable experience in order to obtain successful results. The work should be done in a specially ventilated room, and the operator should be thoroughly protected by rubber gloves and apron.

Frosted lamps may be cleaned by dipping them in very hot water and rubbing them thoroughly dry with tissue paper. Where this is not sufficient, a little soap should be used with the hot water. Tungsten lamps should always be burning while being cleaned.

Etching on Lamps.—The acid etching of letters or symbols on lamps is not attended with the objections and difficulties of the complete frosting process, and can be readily employed by any company to mark its lamps permanently. It is suggested to the smaller companies that should they meet with difficulty or loss in the theft of lamps, a method of identification should be adopted. The formula suggested for making an etching fluid is as follows : To 1 lb. of ammonium fluoride crystals add 1 oz. of 52 per cent. hydrofluoric acid and 8 oz. of water. Stir this solution occasionally and let it stand over night, when it should be strained. Then strain the clear part of the solution through medium coarse muslin. Care should be taken in the selection of the ammonium fluoride crystals, which should be of fairly large size. Sheet lead or hard rubber vessels should be used as containers for the etching fluid.

Colouring Lamps.—Lamps of which the glass is permanently coloured are the only ones that are thoroughly weatherproof. As such lamps are rather expensive, superficially coloured or dipped lamps are quite generally employed. Old or dim lamps removed from the circuits may be used. The most desirable colours for lamps are opal, yellow and ruby. A very satisfactory opal dipping is available and can be employed in preference to frosting in many cases, as the dipping gives a smooth finish and the surface of the bulb is not so liable to collect dirt and get black, as in the case of the frosted bulb. Blue, green and purple are not desirable, as these colours absorb so much of the light that the lamps are hardly distinguishable at a distance.

THE RAYMOND-BARKER SYSTEM OF CABLE INDUCTIVE SIGNALLING.

During the making of the final splice of a recent repair by c.s. " Buccaneer " on one of the Atlantic cables (core mainly 450 Cu/|| 270 G.P.), very satisfactory working—involving rapid exchange of many actual messages, also questions from London and replies thereto concerning the operations of steam-trawlers—was carried on through the medium of the above system.

In order to test practically the more complex conditions accompanying the closing over of the sheathing wires in the making of an overlapping splice, the exchange of messages was purposely deferred until after the completion of the final joint, during the making of which inductive working—as frequently proved—encounters absolutely no difficulty.

The cable distance covered by the inductive signalling was—ship to shore—66·6 nautical miles. On the cable in question 100 miles would have been equally easy. One Gott fault-searcher coil of Silvertown make was attached outside the cable. To quote competent authorities ashore and afloat, two-tone signals sounded " as clear as a bell." Signals could have been made louder by the application of two or more Gott coils in series.

The " Buccaneer " is fitted with " wireless," and is well-known to the radio stations. Clearly, however, the two-tone vibratory inductive system, which keeps " ship " and " shore " in close signalling touch almost up to the moment of slipping the final bight, must be possessed of inherent advantages which do not attach to the present radio system, unless, indeed, the cable station is itself fitted with " wireless," a circumstance not frequently met with.

* Abstract from the " Electrical World."

AUTOMATIC COURSE RECORDER.

At the exhibition of apparatus last December by the Physical Society of London Messrs. C. F. Casella & Co. showed a new automatic safety course recorder, brief particulars of this instrument being given in our issue of January 7, 1910. The apparatus is intended for recording and indicating the fact of a vessel deviating from

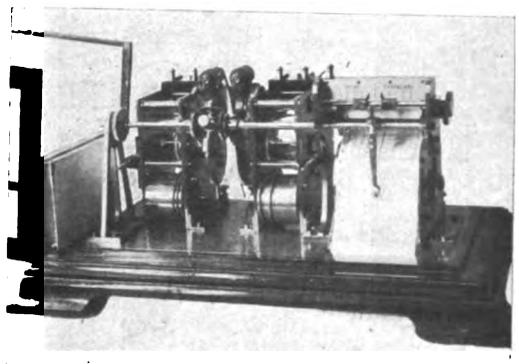

Fig. 1.—Course Recorder and Indicator.

the true set course, and for ringing an alarm bell when such deviation exceeds a certain prearranged limit. The value of such apparatus has long been recognised by navigators, but it has not come into extensive use, probably partly owing to certain objections which have been raised against existing apparatus. One of the principal difficulties in designing such devices is the extremely small directive power of the magnetic needle itself, so that the introduction of any electrical contacts is liable to cause trouble. An attempt to surmount this objection has been made in the Hennah and Rissel course recorder. In this apparatus no contact is made by the compass needle or card, but instead a variation of electrical resistance is caused of an amount corresponding to the amount of deviation of the vessel from the true set course. The change in the current flowing in two electric circuits brought about by this variation in resistance affects the speed of two differentially-geared clockwork mechanisms by means of electro-

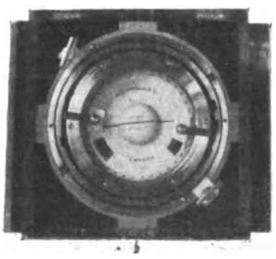

Fig. 2.—Compass used with Course Recorder.

magnets acting on the clock movements. The recorder and indicator consists primarily of a band of paper, which is made to travel by means of clockwork at a constant rate, about 4 in. per hour, and of a pen capable of being moved laterally across the paper by the difference in speed of the two differentially-geared clockwork mechanisms. So long as the vessel is on her true course and the recorder and indicator put in action by the compass being set to the proper course, both clocks will receive the same amount of current in their controlling electromagnets, and no motion of the stylus or pen will result. Should the vessel deviate from this course, however, one clock will be retarded and the other accelerated, thus causing through the differential gearing a motion of the pen in the required direction, recording the fact of the vessel's deviation, the angle of such deviation from the true set course and the period of time thereof. Two alarm contacts are placed above the stylus arm, and are capable of

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being set to the required alarm period by means of a right and left-handed screw. A divided scale coinciding with divisions on the paper band is also provided, facilitating the setting of the alarm period.

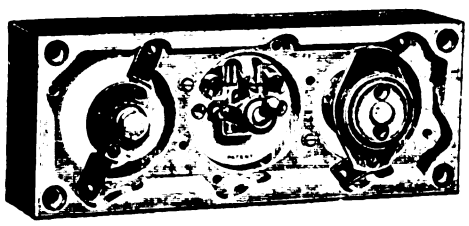
The compass is undoubtedly the most interesting feature of the apparatus. The card is composed of mica and has two slots cut in it, whilst the compass contains a solution of copper sulphate. Two pairs of electrodes, one pair for each electrical circuit, are employed, one electrode in each case being placed above and one below the card. It will be evident that the movement of the card relatively to the electrodes will affect the resistance of the circuit between each pair of electrodes, due to the position of the slot. The electrodes are arranged so that the reduction in resistance of one circuit due to the slot approaching one pair of electrodes is accompanied by an increase in the resistance of the other circuit. Current is provided by an accumulator, and when the compass is set to the desired course this results in the resistances of the two circuits being equalised, and consequently in equal currents flowing in the windings of the electromagnets affecting the clock mechanisms. It may be mentioned that the total current taken from the accumulator does not exceed about 90 milli-amperes.

Fig. 1 shows the course recorder and indicator, whilst Fig. 2 gives a view of the compass. The apparatus is being placed on the market by Messrs. Sharland & Co., of Eldon-street House, London, E.C., and is likely to arouse considerable interest in the marine world.

ADAPTABLE "SWITCH COMBINATION."

Messrs. A. P. Lundberg & Sons' ingenuity in the way of designing switches to do all sorts of wonderful things, to turn lights on and off from several points, and generally to cater for the present day lazy human being are well known. It is scarcely, therefore, surprising to find them turning their ideas to another matter, and attempting to introduce standardisation and uniformity into switch grouping.

They inform us that owing to a want of uniformity in the methods adopted, and the absence of articles standardised for the purpose, the satisfactory grouping of switches and kindred accessories together often becomes an awkward and expensive problem for the wiring



"Adaptable Combination" with the Front Removed.

contractor, and hap-hazard methods have often to be employed to meet special cases. To avoid these undesirable conditions they have, therefore, designed the "Adaptable Combination" shown herewith, which consists of a block of glazed porcelain arranged with three suitable recesses to take the Lundberg standard types of switches, wall connections and bell pushes. The need of such standardisation has, Messrs. Lundberg think, become more acute since special tariffs and cheaper and more reliable apparatus have made electric heating and cooking more popular. The combined bell and telephone systems, now so universally employed, also need to be properly installed, and grouping with other accessories is often found a convenience. On modern installations on board passenger ships the various accessories for controlling the lighting, heating, ventilating, telephone and call-bell arrangements are also conveniently grouped together.

The "Adaptable Combination" can be fixed either horizontally or vertically and with either surface and ordinary cover plates. The illustration herewith shows, as an example, the combination arranged for the horizontal fixing of a "Pixy" bell push, "Pivot" single-way switch and "Universal" wall connection. Metal straps of suitable shapes have been standardised, and these support the various accessories in a substantial manner, the fronts being screwed on in the usual way by threaded rings or by providing fixing screws for the block with tapped holes. The neatest effect is then obtainable, as no fixing rings are required on the accessories.

The "Adaptable Combination" is capable of accommodating any of the various types of Lundberg standard switches, wall connections (two and three pin) or bell pushes arranged in any desired manner. Additional contacts in connection with an electric bell system, or combined bell and telephone system, can also be simply arranged at small extra cost. Should circumstances require such, two single-way switches may be coupled by a bar in the usual way, and connected in parallel, and so control a wall connection of 10 amperes capacity fitted at the third hole, supplying current—*e.g.*, to a radiator. Two single-way switches may be similarly coupled by a bar and connected to form a double-pole switch.

RADCLIFFE (LANCS.) POWER SUPPLY.

A Board of Trade inquiry, which extended over five days, was held last week into the refusal of Radcliffe Council to allow the Lancashire Electric Power Co. to supply electricity in their district.

Mr. C. H. Pickstone, for the company, said the inquiry was being held because Radcliffe Council, who were the authorised distributors of electricity under a provisional order of 1895, had refused to consent to the application of the company for permission to supply current in Radcliffe, with the result that the Board of Trade had been requested by the company to dispense with that consent, and the Board of Trade, in order to satisfy themselves as to whether they ought or ought not to dispense with Radcliffe's consent, had sent an Inspector (Mr. A. Read) to inquire into the circumstances. Mr. Pickstone then gave particulars of the powers of the company. In 1904, he said, they got sanction to take transfers of the electrical undertakings of local authorities, and had taken a considerable number of transfers with the sanction of the Board of Trade. Parliament in 1906 gave them largely increased powers. The company was relieved of certain fetters and authorised to supply persons with power within their area, but there was a condition that the company should not supply energy in any area which formed a part of the area of supply of any authorised distributors without the consent in writing of those distributors. The Radcliffe Council were the authorised distributors within the area of their township, so that the company found themselves precluded from dealing with anyone in Radcliffe without their consent in writing. The company alleged that owing to the way the Council had dealt with the applications from the company the latter had found itself so fettered not only in regard to its own development, but in reference to the demands of the ratepayers of the town that they felt bound to go to Parliament for a provisional order so that they could supply in Radcliffe without the consent of Radcliffe Council.

The Inspector: Do you say that apart from any question of the particular way the Council have dealt with applications in the past it is desirable your powers should be extended and the Council's consent dispensed with?

Mr. Pickstone: Undoubtedly. The main issue is as to whether it is to the interests of Radcliffe that power users shall be able to freely treat with the company or get their supply through the Council. He contended that in granting Radcliffe its provisional order Parliament had not conferred upon it a monopoly that could not be given to anyone else. The company said that under their powers and under their application they were still in the same position as any other company who sought for a provisional order. Apart from clause 5 of their special Act they should be in a position to go to the Board of Trade for that provisional order, and the probabilities were there would have been no inquiry necessary; and he suggested that the Board of Trade desired to know before they dispensed with the consent of Radcliffe Council what were the circumstances of the case. In their request for the provisional order to dispense with that consent the company contended there was a large demand for electrical energy in Radcliffe, and that the Council were totally unable to meet that demand. Mr. Pickstone then quoted at great length from the correspondence which had passed between the parties, and cited certain applications to the company for a supply of electricity for power.

Mr. John W. Kenworthy chief engineer of the Bleachers' Association, said the association had two works in that district. His firm was one of those who attached their signature to the petition sent to the Board of Trade in support of the application, because they wanted power to Whittaker's at Mount Sion. They installed, in agreement with the company, a motor. They were particularly satisfied with the conditions and the general running received from that source, and ultimately decided upon making another extension of about 150 H.P. with the Lancashire Electric Power Co., so that they had now approximately 500 H.P. They would have liked to instal an extensive plant at Andrew Greenhalgh's. They approached the company, but the company said that under the present arrangements with Radcliffe Council they were not able to give a supply. Therefore, they put down their own plant at an expenditure of £800. They would naturally like to deal direct with the company they were going to deal with. If they wanted to deal with that question they wanted to deal with it promptly. Sometimes they wanted 200 H.P. or 300 H.P. very urgently. They would not be particular whether the supply was by the Council or the company so long as they got the same terms. They ought to be able to choose for themselves. The liberty of trading freely with consumers wanting power would be beneficial to the district.

By Mr. Keen (for the Council): They were not dissatisfied with the supply obtained for Mount Sion Works. He desired the company to obtain the provisional order so that the consumer could deal with the company direct.

Mr. S. Walker, ironfounder, said that his firm had signed the petition in favour of the company's application because the Council ought to

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afford the ratepayers every facility for getting the cheapest and best article to enable them to carry on their business and develop their trade. As the Council could not supply large quantities of electricity themselves, he believed in the company coming in It was very essential that Radcliffe, more than other places, should have cheap electricity, as the town was handicapped by dear water and dear gas. He was conducting a business outside Radcliffe which could not possibly succeed in Radcliffe owing to the high prices of gas and electricity. A cheap electrical supply would be the saviour of the town. If the company and the Council worked together he believed it would be an all-round advantage.

Mr. JAMES MARSH, Manager of the Black Lane Spinning Co., said there was delay when his firm wanted a large supply of electricity from the company, and negotiations had to proceed with the Council. Large firms ought to deal direct with the company. His firm alone could absorb the whole of the power from the Radcliffe Council's generating station straight away.

Mr. C. R. SEDDON, managing director of the East Lancashire Paper Mill Co., said his company's works were rated at nearly £3,000 a year. They had their own plant for generating electricity. They did at one time desire current from the company, and they made application in Feb., 1908, for power. They could have come to terms with the company, but they did not want the terms to be known to others. The Council could not give them either the power they wanted or the emergency power then desired. The matter went off with the company because his company would not negotiate through the Council. They must have bulk power at a low rate, and only the company would be able to give it them and give them an advantage they could never expect from the Council. They took a little supply from the Council for week ends which came to about £50 a year. For the bulk of the power it would be advisable for paper works to put their own plant in for electric power, but his company had no intention of considering it from that point of view. So long as he could get power at a remunerative price, he did not care whether it came from the company or the Council.

Mr. J. H. BLAKEY, smallware manufacturer, said that as the result of a fire at his mill a supply of electricity was required, and he made temporary arrangements with the Council. He found, however, that the Council's price for electricity was too heavy, although, considering the amount he was taking, he would not say it was an unreasonable price.

Other local manufacturers and traders having given evidence,

Mr. FRANCIS E. GRIPPER, director of the company, gave evidence of the financial position of the company, &c. He said he was interested in 40 or 50 distribution undertakings working under provisional orders, and in his experience it was quite impossible for any of those undertakings —some of which were smaller and some much larger than the Radcliffe undertaking—it was quite impossible in such stations to attempt to supply anything or anyone except power users of quite small requirements. It was practically impossible for the Council successfully to take a supply in bulk. Even supposing the Council took a supply from the company they could employ that power successfully for the development of their present undertaking, if it was required for small power users, lighting and tramways; but directly they attempted to retail or rather distribute that supply to larger power users there would be a very substantial additional cost involved. That substantial additional cost would affect the price. The Council could not distribute it from their existing plant and mains, and it would involve very heavy expense. They could not supply the consumer without making a loss unless they charged him a higher price than the company charged. They were quite satisfied with the progress of the company up to the present. They were doing very well now, making very good progress indeed, but they had been extremely hampered and kept back until they got their Act of 1906. Radcliffe was just the place where a cheap supply was absolutely required. They could distribute in Radcliffe better than anywhere else because it was next door. All the districts around them were taking their supply.

By Mr. KEEN: The company were asking the Board of Trade to make the order in the ordinary form. The Board expressed the opinion that they must do that, and they would then deal with any limitation of powers. They wanted an order giving power to distribute direct to all power users above a reasonable limit, that limit being fixed at the size which the Council were not reasonably able or not likely to be reasonably able to deal with. They wanted all the clauses in the order with the scope of them limited for power purposes only and over certain limits. They did not ask even for limited power for lighting, as they had no wish to have power to take away from the local authority. They did not require the tramway load. Anything over 30 H.P. would be a very fair limit. Two orders for competitive powers of distribution in detail had been granted by the Board of Trade in a number of cases in the metropolitan area. He was not suggesting it would be right to grant a competitive order for all general purposes. The company were supplying Farnworth in bulk and they were distributing it to large power users. The most sensible plan for the Council to adopt was to give the company sanction to supply direct to power users above a certain size. He should imagine that in Radcliffe there should be 5,000 or 6,000 H.P. supplied within a few years. The company's station was not big enough yet. At present it was about 12,000 H.P., and they were putting down about 6,000 H.P. more. They had about 8,000 kw. installed, and they were installing 4,000 kw. They were selling electricity at a low price, and not at a profit which it should yield them and would have to do. Until they had got to a big station they were not getting best results. Witness was cross-examined as to the cost of generating at different works, and expressed the view that, other things being equal, a big generating station would generate at a lower cost than a smaller one. The Bury result (working cost 0·58d.) was very good. The company had no absolutely fixed charges. They got the best price they could. They had to deal with cases on their merits.

Mr. KEEN asked if Radcliffe Council decided to have a 6,000 H.P. station could they not raise the money much more cheaply than the company?—"I do not think you could raise it at all. I do not think you would be allowed either by the L.G. or by the ratepayers to raise £100,000." Assuming they got consent, he did not think they could raise it as cheaply, for the Council had to meet interest and sinking fund at a higher ratio. The company's sales of current realised £15,119 last year, the output being 7,055,000 units, sold at something over ½d. a unit. At present the company was making no loss.

Dealing with the suggestion that the company should be allowed to supply in Radcliffe in cases over 30 H.P., Mr. Keen asked what would be the Council's position if a firm laid plant down for 35 H.P. but only used 25.—The draft order would be prepared in a way to avoid any improper action on the part of users.

Mr. KEEN: A firm might originally take 25 H.P. from the Council and then increase it. When they passed 30 H.P. would it be fair for the company to step in and take that consumer?—Then make the limit 50 H.P. Or we would be prepared to consent to take none of the old customers of the Council.

Mr. J. L. RUSHTON, director of Dobson & Barlow, machinists, of Bradley Fold and Bolton, said that when his company selected the land on the boundary of Radcliffe they were greatly influenced in their decision by the fact that they could obtain a cheap supply of electricity there. They were now taking 300 to 400 H.P. from the company, and it was very satisfactory. He became a director of the company in 1910.

Mr. C. D. TAITE, manager of the Lancashire Electric Power Co., gave a list of the townships to which the company were supplying current in bulk, and said that one of them (Farnworth) started with their own generating plant, but had shut down their works. They were supplying firms in Prestwich and Bolton with the consent of the local authorities. One Radcliffe firm was being supplied (Messrs. Whittaker's) at Mount Sion, but he did not know whether they had Radcliffe Council's consent or not. The Power Company had agreements with Bolton and Salford for supplying in their districts. The units sold during the last quarter had increased by 46 per cent. and the revenue by 69 per cent., in comparison with the corresponding period of last year. When he became the company's manager in 1907 he considered the conditions laid down by Radcliffe Council in connection with the company were not workable. An agreement ought to have been arrived at between the two bodies for the benefit of power users. He put forward a case of the loss of a consumer of electricity to the company and an industrial firm to Radcliffe by the Council's policy of insisting upon negotiations for current passing through them. His experience was that the "third party principle" was unworkable. Being prevented from canvassing in the town they had to sit still and wait for customers, and a further difficulty was that they could not negotiate with persons looking for sites for works in Radcliffe, for they were unable to tell them definitely whether they could supply electricity, but had to say that they were controlled by the Council and had no appeal from the decision of that body. It was essential for the company to disclose terms of contract to the Council, and firms objected to their business matters becoming the subject of public discussion. Again, firms objected to asking the Council for something which they knew the Council could not give them. The Council could not compete with a large power company like their company. At the one Radcliffe works which the company supplied the current delivered for one motor was as much as the Council's total output, part from that required for the tramways. If the Board of Trade granted a provisional order to the company sanctioning their entry into Radcliffe and the company's order was limited to power users using over a certain limit there would be practically no competition with the Council. The company had difficulty in keeping on friendly relations with the Council, and had always worked under difficulties. There was a large demand for electrical energy in Radcliffe which the Council could not supply and which the company was anxious to deal with, and the absence of a cheap and large supply had a deterring effect upon the development of Radcliffe. It would also be the means of inducing new power users to settle in the district.

In cross-examination by Mr KEEN, Mr. Taite stated that they had only one large consumer in Radcliffe but there were two others prospective. Messrs. J. & J. J. Mellor were referred to the company by the Council. He thought Messrs. Mellor came to the conclusion they could do without electric power and the matter dropped. It was not due to any fault of the Council that Messrs. Mellor were not being supplied. About 2,200 kw. out of 4,000 kw. at their station represented large consumers in places where they had got provisional orders.

This closed the case for the Power Company.

Mr. H. WILKINSON, electrical engineer to Radcliffe Council, gave evidence in opposition to the application. The total capital expended on the municipal undertaking, he said, was now about £36,700. He handed in a statement as to the Council's power consumers and the capacity of the motors installed. Some of the small consumers were charged 2d. a unit, and all the bigger consumers (excepting the East Lancashire Paper Mill Co.) 0·9d. Any consumer taking 25,000 units per annum or over was allowed 10 per cent. reduction off the schedule price. The profits had annually increased, although depreciation was charged. The profit for the year ended March, 1909, was £473, and for March, 1910, £609, allowing over £400 for depreciation. In comparison with those of other Lancashire towns, Radcliffe's electricity works could be regarded as a satisfactory business undertaking. Bury was one of the few towns tha

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could point to more satisfactory results, and they had the opportunity of coming to terms with Bury for a supply of current in bulk.

Mr. F. E. LACEY, consulting engineer, were of opinion that if the company's application for an order was granted as lodged it would be injurious to the Council's undertaking, and the open competition might result in the scrapping of their works.

Mr. S. J. WATSON, chief electrical engineer to Bury Corporation, said his Council would be able to supply electricity in bulk to Radcliffe, and were prepared to negotiate with them.

Coun. WALKER ALLEN, Chairman of Radcliffe Electricity committee, said the Council had acted reasonably with the Power Company, and he denied that the Council had been dilatory.

Other evidence was given and the case concluded.

STREET LIGHTING IN THE CITY OF WESTMINSTER.

Yesterday (Thursday), at a meeting of Westminster City Council, Mr. ABADY, chairman of the Works committee, moved the adoption of the following recommendations of the Works committee in regard to tenders received for street lighting :—

"That the lowest tender in each district—viz., that of the Gas Light & Coke Co.—be accepted for a term of five years, leaving for after consideration the settlement of what units of lighting shall be installed street by street, when only the actual figures of cost can be worked out ; and that the company be asked whether they are willing to continue the contract after the expiration of five years for a further period of five years, making 10 years in all, on the terms of the tender for 10 years, in the event of the Council so deciding and giving the company written notice not less than six months before the expiration of five years of the contract period that the contract shall be continued for such further period."

The electric lighting contracts in the Strand district, and in St. George's, do not expire until 1913, and are not affected by the above recommendations, but the district lighted by means of 71 arc lamps by the St. James' & Pall Mall Co. is affected.

It was stated that a petition had just been received from the ratepayers of the parish of St. James asking that the Council's decision on the matter should be deferred.

Mr. BINGHAM moved an amendment that the matter be referred back, although he still thought they had no alternative but to accept the gas company's tender ; but the inhabitants of Regent-street and Piccadilly were anxious that they should be quite sure they were going to give them as good a light as that now in Regent-street. It seemed to him, if they could maintain the candle-power, and it was equally effective, they ought to go in for gas. He had tried to read midway between two lamps in Fleet-street, and could not, but he could do so midway between two lamps in Regent-street.

Councillor FLINT seconded the amendment, so that the Council should be in harmony with the ratepayers. The result of the engineer's test was that the gas came out better under the photometer than the electric lighting taking it all through.

Mr. ABADY said both speakers had based their remarks on a misapprehension with regard to the arc lamps in Regent-street. It was proposed to remove these and put in their places on the same columns high-pressure gas lamps of a greater power than the light that at present existed, and they would be able to increase the light by about 50 per cent. at a cost which would be about 33⅓ per cent. cheaper than they could do it by electric light.

Mr. SPENCER SMITH said the electric lighting company had put up the price from £17 to £28 for the same light in the case of the 16 flame arcs.

Ald. EVERETT was in favour of deferring the matter for a fortnight. It was not fair to force this thing through without giving the ratepayers an opportunity of having their petition considered.

Mr. ABADY said there was no object to be served by deferring it. Someone must have got hold of an agenda, and, in the interests of one of the tenderers, gone into Regent-street shops and pitched a yarn about this being a retrograde movement.

Mr. WALLACE asked if it was suggested that the shopkeepers had no ideas of their own on the subject.

Mr. ABADY said the basis they had gone on to invite tenders was to fix units of 90, 180, 300, 1,800 an 3,000 c.p. One light was of the same value as another, except that one might be a nicer colour than another, in which respect he thought the advantage was on the side of gas, because when you got up to the high power units, which could only be produced by a flame arc, the electric light was a yellow colour, which he thought adversely affected shopkeepers. (A member : Quite the reverse.) The prices the gas company had quoted for each of these units was so much less than the prices of the electricity companies that they had no alternative but to accept the lowest tender. If they took a certain number of lamps of each of the capacities he had mentioned to make up a total of 400,000 c.p., they would get that for about 10 per cent. less than they now paid for 190,000 c.p. (viz., £13,000 a year). To do the same thing by electricity would cost £20,000. Fifty-three lamps with an aggregate candle-power of 50,000 cost £920 a year, and they could get double that candle-power for £7 more by gas, whereas 1,400 c.p. of electric lighting would cost £1,400.

An amendment, moved by Mr. PULMAN, "that the Council reserve the right to omit the lighting of Regent-street and Piccadilly from the contract" was defeated, as was also Mr. BINGHAM's amendment that the committee's recommendations be referred back, and a third amendment, by Ald EVERETT, "that the question of the 71 arc lamps in the Pall Mall district be referred back."

The committee's recommendations were adopted.

PARLIAMENTARY INTELLIGENCE.

WIMBLEDON & SUTTON RAILWAY BILL.

A Select Committee of the House of Lords, presided over by the Duke of Wellington, commenced on Friday the consideration of a bill to authorise the construction of an electric railway from Wimbledon to Sutton.

Mr. HONORATUS LLOYD, K.C., explained that the proposed line (5½ miles in length) would provide for an extension of the Metropolitan District Railway Co.'s electric train service, which at present ran from London to Wimbledon over a railway constructed by the L. & S.W. Railway Co., and on which there is also a steam service run by the latter company. The population of the district through which the line would pass, and which included Merton, Morden and Cheam, was between 110,000 and 112,000. There would be 10 stations. A great advantage of the proposed line would be that it would give communication with the whole of the London underground railways. The promoters were a local syndicate, and the proposed share capital was £350,000 and borrowing powers of one-third that amount. The engineer's estimate of the capital expenditure was £311,554. It was proposed that the District Co. should work the line, and that there should be a junction at Sutton with the L.B. & S.C. Railway if the L.B. & S.C. Co. so desired. There were petitions by two railway companies and also two by landowners against the bill, but the five local authorities through whose districts the line would pass supported the scheme.

On Monday numerous witnesses from the districts to be served by the proposed railway, including representatives of Wimbledon, Merton, Morden, Carshalton and Sutton Councils, gave evidence in favour of the scheme.

Mr. WM. VAUX GRAHAM, consulting engineer, gave technical details, and said the cost of the work was estimated at £181,140 and the land to be acquired was valued at £130,413.

Mr. PAGE, K.C., appeared for the L. & S.W. Railway Co., who objected to the proposed line, and said the junction proposed with their line was impossible.

On Tuesday Sir JOHN WOLFE BARRY said a Royal Commission recently expressed the opinion that it was not desirable that all railway passengers arriving in London should be discharged at one point, but that railways should be provided which would distribute them, and he thought the present project would assist in fulfilling that requirement. The curves and gradients were satisfactory, and the position for the station at Sutton seemed to be a suitable one. The railway would develop the district, and the Brighton Railway would derive benefit from it. He was satisfied with the prices on which the estimates were based. At first there would probably have to be interchange of traffic with the existing line at Wimbledon, but it would be preferable to project the trains forward from Wimbledon to Sutton. At another point on their system the South-Western Railway had extended their train service by a connection with the District Railway, and that was entirely on all fours with the present proposal.

Mr. A. R. COOPER, chief engineer of the District and other underground railways, said the drawings showed that the proposed line was well designed. He could see no objection to the District trains being projected forward from Wimbledon to Sutton as shown on the plans. There were curves on the District Railway as sharp as those shown on the plans. Per mile length, the gradients on the proposed line were more numerous than on the District Railway, but the stations had been so arranged that, except in one case, the gradients would be advantageous and lead to economical working, as they ran up into stations and down out of them.

Mr. R. H. SELBIE, general manager of the Metropolitan Railway, said the passengers on the Putney and Wimbledon line had increased, since the line was converted to electric traction, from 3,264,000 in 1906 to 5,460,000 in 1909. A similar traffic might be expected on the proposed line as the district became more developed.

Sir GEO. S. GIBB, chairman of the District and other underground railways, said no agreement had been entered into, but he thought the District Co. would undertake to work the new railway and use electric traction thereon.

Evidence was given that there would be no difficulty in raising the capital.

On Wednesday Mr. C. L. MORGAN, engineer in chief of the L.B. & S.C. Railway, said there were sharp curves and gradients on the plans of the proposed line. He would not say steam traction could not be used on it, but a slow speed and short trains would be required. He did not think the junction of the new line and the Brighton line would be for the convenience of the public.

Mr. FREEMAN, K.C. (for L.B. & S.C. Railway Co.) said the Brighton Railway carried passengers from Sutton to Victoria in half the time the promoters' line would take. A service of fast trains between Sutton and Wimbledon was tried some years ago, and was found not to be required. The estimate of the earnings was not justified, as the District Railway paid nothing on its ordinary capital.

Some residents in Sutton expressed the opinion that the new line was not required.

Mr. VICARY, assistant manager of the L. & S.W. Railway Co., objected to the proposed junction at Wimbledon, and Sir CHAS. OWENS, general manager, said the congested state of the line from Putney to Wimbledon would not allow of the proposed addition of trains.

Yesterday (Thursday) Mr. PAGE addressed the Committee on behalf of the L. & S.W. Railway. He said if the District Co. utilised the junction proposed, which left the South-Western line before reaching

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Wimbledon station, the South-Western would have half their expenditure on the station thrown away, as the District Co. only paid towards the expenditure in proportion to the number of trains they stopped at Wimbledon. The bill was not truly in the interests of the public, and would do incalculable damage to the South-Western Railway.

Mr. LLOYD, replying for the promoters, said the Brighton Railway Co. had spoken of the territory as theirs, but Parliament had granted them no monopoly, and there was no real opposition from landowners, except in regard to a few gardens over which it would, unfortunately, be necessary to pass. The line from West Brompton to Putney was made through green fields, and there has been great development there as a result.

The chairman said the Committee had decided to allow the bill to proceed. They, however, made the following conditions: That the junction with the South-Western line is to be made by agreement, and, failing that, by arbitration; they do not insist upon the junction with the Brighton line at Sutton, but access between stations is to be arranged; the South-Western Co. are to receive a sum not less than at present for the user of the present Wimbledon terminal station, so that they shall not lose by the trains running past, whether they stop or not.

CHARING CROSS, EUSTON & HAMPSTEAD RAILWAY BILL.

The consideration of this bill was continued by Lord Lamington's Committee on Friday.

Mr. D. HAY, consulting engineer to the promoting company, was examined in reference to the proposal in the bill to construct an extension from Charing Cross to the Embankment, where it is proposed to connect with the Baker-street line, and in reply to Mr. Szlumper, who appeared for the Gordon Hotels (Ltd.), said the proposed tunnel would pass the round end of the Hotel Metropole, facing the Embankment, at a distance of 6 ft. 6 in. from the wall. It could only be taken 2 ft. further away, and that would bring it directly in contact with the Baker-street tube. The tunnel would be 40 ft. below the surface at that point. He could not advise the promoters to accept a similar condition to that in the Baker-street Railway Bill of 1893, that there should be a cover over their tube at that part of the line of not less than 10 ft. of London clay.

Sir GEO. GIBB (chairman of the company) and Mr. L. R. VIGORS (surveyor) also gave evidence in support of the scheme. The former said if the condition as to the cover of 10 ft. of clay were imposed the whole project would have to be abandoned.

Lord BESSBOROUGH, chairman of the Gordon Hotels (Ltd.), and other witnesses were called in support of the theory that the Hotel Metropole, of which the Gordon Hotels (Ltd.) had an unexpired lease of 53 years, would be in danger of injury if the line were constructed as proposed.

The Committee rejected the scheme for making the loop line, but the other parts of the bill were allowed to proceed.

Mr. BALFOUR BROWNE (for the promoters) afterwards asked the Committee to restore the bill to the list, as communications had taken place between the Gordon Hotels (Ltd.) and the railway company, and it was now proposed to construct the tunnel some distance from the Hotel Metropole. The Committee complied with the request.

On Wednesday Mr. BALFOUR BROWNE informed the Committee that the promoters had come to an arrangement with the proprietors of the Metropole Hotel, but they were confronted with another difficulty, as the new plan provided for their going under the S.E. Railway Co.'s bridge at Charing Cross, and as Mr. Clode, counsel for the S.E. Co., could not say whether they would object, he thought it best to withdraw the proposal and come forward later with a properly devised scheme.

Subsequently the bill was allowed to proceed, but the portion relating to the loop from Trafalgar-square to the Embankment was deleted.

METROPOLITAN DISTRICT RAILWAY BILL.

The same Committee had before them on Monday a bill promoted by the Metropolitan District Railway Co.

The Hon. J. D. FITZGERALD, K.C. (for the promoters), said the bill sought power to construct two additional pairs of rails alongside the London & South-Western Railway Co.'s line (¾ mile in length) from Hammersmith to Turnham Green Junction and over which the District Co. and three other companies had running powers. An agreement had been come to with the South-Western Co. with regard to the construction of the new line. London County Council opposed because the promoters could not give them, in return for the ground they proposed to take for the erection of a viaduct to carry the railway through Ravenscourt Park alongside the old line, which is on a similar viaduct, an equal piece of land, to be thrown into the park. The existing railway, however, was constructed before the park was made, which should be in the company's favour. The additional width required was 27 ft.

Mr. A. H. STANLEY, general manager of the company, gave evidence as to the necessity for the additional lines. The District Co. ran 343 trains a day over the existing line.

The Committee decided that the bill should proceed.

BRADFORD CORPORATION BILL.

This bill, which seeks powers for the construction of four lengths of tramway and for various powers in regard to local administration and management, came before a Select Committee of the House of Commons on Wednesday.

Mr. HONORATUS LLOYD, for the Corporation, said that Bradford Corporation now owned practically every undertaking that it was practicable for a municipality to own, including gas, water, electricity and tramways, &c. The tramway clauses related to the construction of various new lines and the sanction of trackless cars, while there was also a proposal to carry goods and minerals upon the tramways. Four new tramways were contemplated in the bill. The next part of the bill dealt with the provision of motor omnibuses and powers to work them on the trackless system, and it was towards that that the opposition of the railway companies and carriers was mainly directed. There were many parts of the city where the public were clamouring for some means of access, but those responsible for the construction of tramways saw that the initial cost would prevent such enterprises from being remunerative for many years to come. Everybody was desirous of finding some more economical method of providing connection with the tramways that would meet the needs of these districts. A number of tramway experts had been abroad and had carefully investigated the railless tramway systems in vogue there. On the Continent the scheme was an assured success and worked admirably. One advantage was that it could be used as introductory to a permanent track when the traffic became heavy enough to justify such a step. The capital cost was from 20 to 25 per cent. of the cost of tramway construction, and many large centres were beginning to realise the convenience and economy of the method. General powers were asked for by Bradford, no routes at present being specified, these to be subject later to sanction by the Board of Trade or the L.G. Board. As to the actual running cost, the saving would be only about 1d. a mile, the main economy being in the capital charges. The Corporation regarded the Sticker-lane route as an example where trackless cars might be usefully adopted. The opposition was based to some extent on an objection to public money being spent on experimental undertakings, but the fact was that had long passed the experimental stage abroad. The Midland Railway Co. contended that it would be unfair competition, as the Corporation would be able to make up any loss out of the rates. But in point of fact it was with a view of avoiding any loss that the proposal was made. Bradford Corporation were not in the habit of being extravagant in these matters, for they had carried on their tramway undertaking in such a way as to make a profit in relief of rates, in spite of low fares and long distances, and the railway companies, so far from suffering loss from competition, would participate in the benefit by the reduction of the rates. They said the trackless trams would tend seriously to damage the surface of the streets. There would, of course, be ordinary wear and tear, but the Corporation would be liable to be rated to the full in respect of their earnings upon these routes, so that they would pay in rates for their share in the streets just as any other undertaking or ratepayer would. Then there was, of course, no serious danger of the overhead equipment damaging the bridges or signalling apparatus of the railway companies. A further objection taken was that it was not customary to grant powers of such a vague and wide character; but the object of the promoters was to provide for the needs of the public economically, and it would be too costly if for every little extension of this kind a special application had to be made to Parliament.

At a later stage Mr. Lloyd announced that the Corporation had been able to arrange their differences with the railway companies with regard both to trackless trams and the carriage of goods and minerals, subject to a safeguarding clause stating that the conveyance of those goods should be limited to such traffic as arose in and was destined for places within the city. Indeed, the tramways might be able to work in conjunction with the railways, the latter carrying from town to town and the tramways assisting in the local distribution. The establishment of the principle was agreed to, but that still left the opposition of the carriers and cab proprietors.

Mr. C. J. SPENCER (city tramways manager) said that the municipal tramways system comprised 54¾ route-miles and 99 miles of single track, 5½ route-miles being outside the city boundary. In recent years the Corporation had received many requests from people living in districts outside Bradford for instituting tramway services, but owing to the capital expenditure involved, and the probability that such expenditure would not prove remunerative, the requests had not hitherto been met. When the railless traction method came under their notice the Corporation appointed a committee to go abroad and inquire into it. With regard to the proposed new tramway routes, they considered that it would be desirable to instal the trackless system on that from Laisterdyke to Wakefield-raod, via Sticker-lane. The route, which would link up Brighouse and Bradford, was much desired by both towns. Powers for the line were obtained in 1901, but it was not constructed because a through route was not provided for. Reverting to the trackless tram proposals, Mr. Spencer gave particulars of the equipment and costs of working the railless system. Of all systems inspected by them he did not consider there was one failure. All were good, but some better than others. The capital cost of establishing a railless system in Bradford would, he estimated, be from £1,500 to £2,000 a mile, compared with £13,000 per mile, the cost of constructing an ordinary rail route. The weight of the vehicles, which would have a carrying capacity of 24 passengers, would be from 4¼ to 4½ tons, this being about half the size, carrying capacity and weight of an ordinary tramcar. With regard to cost, he took as an example the Sticker-lane route, which would be 1¼ miles in length, and estimated that the cost of the equipment would be £1,875. Five cars at £850 each would amount to £4,250, the total being £6,125. He estimated that the annual income would be about £4,000 and the annual profit £1,500. As to the upkeep of the roads, he said he had not calculated that in the cost, in view of the fact that the Corporation would pay rates and taxes on the route. The overhead equipment would be still available in case it should be found desirable to lay down rails.

The witness was cross-examined by Mr. POLLOCK, K.C., on behalf of the local carriers, and he admitted that some of the parcels were carried on motor vans and not on the tramcars. The cost of the parcels traffic was £6,322 last year and the net surplus £1,028. The great bulk of the parcels

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went on the tramcars and were collected and delivered by boys, but with regard to a small portion of the parcels it was found convenient to collect and deliver them by motor vans. There was no sanction to purchase the motor vans for carrying parcels, but the Corporation felt they were necessary.

Mr. W. F. MARWOOD, assistant secretary to the Board of Trade, was questioned by the Chairman with regard to applications for general powers to establish trackless equipment, leaving the Board of Trade to prescribe the routes subsequently, and he stated that at present, when a corporation required to extend its tramways, it had to seek Parliamentary powers or apply for a provisional order in respect to each extension. In no case, he said, had power been left with the Board of Trade to prescribe the route, except with regard to short connecting lines.

Ald. THORNTON, mayor of Brighouse, stated that there was a strong desire in Brighouse that a tramway should be constructed to connect the town with Bradford. It was believed that it would prove very advantageous.

The Committee adjourned.

LEEDS CORPORATION BILL.

A Select Committee of the House of Lords, presided over by Lord Ritchie, yesterday (Thursday) commenced consideration of a bill to authorise Leeds Corporation to construct and run railless trolley omnibuses in the city.

Mr. J. B. HAMILTON (general manager of the Leeds tramways) gave particulars of the proposals. The route on which it was at present proposed to run the railless trolley vehicles commenced in the City-square and passed along Wellington-street, Aire-street and Whitehall-road to the city boundary at Drighlington. The estimates were £5,000 for construction of omnibuses, £9,000 for provision of electrical equipment and £300 for street improvements. Mr. Hamilton said the proposed system would be installed at one-fourth or one-fifth of the cost of ordinary tramways.

Mr. ROBERT ARMITAGE, M.P., and a member of the City Council, supported the proposal.

The Great Northern and the Lancashire & Yorkshire Railways, who opposed, said the powers were unprecedented, but there was no real competition proposed with them. The omnibuses would be less dangerous than ordinary tramways.

After some slight modifications had been made by agreement between the promoters and the opponent, the chairman said the Committee would report the bill, but it might be found necessary to make some slight alterations in the clauses in the House.

HANDSWORTH URBAN COUNCIL'S BILL.

Part III. of this bill, which came before a Select Committee of the House of Lords (presided over by the Earl Kintore) on Thursday last week, relates to the making of new tramways.

Mr. TALBOT, K.C., said the Urban Council of Handsworth owned a length of tramway in Holyhead-road (1,027 yds.) which was electrically equipped and leased to the South Staffordshire Tramways Co. for a term which expired next year. Electric current was supplied by the Council, which also owned another length of tramway, but to get by this to the centre of Birmingham it was necessary to go through Aston, where it had been necessary to obtain through running powers to avoid the charging of three separate fares to passengers. Next year the whole of the existing tramways would come into the possession of the Council. If the Council's scheme were to be carried out, powers should be granted now, so that the Council would be in a position to equip and electrify and be ready at the time when they would become the owners of the whole undertaking. The net cost of the tramways was estimated at £203,875, and the estimated revenue was ample for sinking fund, interest and depreciation.

Mr. ALFRED SANDAS, chairman of the Urban Council, gave evidence, and said that the existing tramways would fall into the hands of the Council in June. They must get some alternative to go round Aston or they would be at the mercy of Aston and Birmingham.

Mr. GEORGE CONATY, tramway engineer, said the proposed tramway formed the necessary link with districts which were rapidly growing

Sir A. B. W. KENNEDY, consulting engineer to the promoters, said he had prepared the estimates. The new tramways were intended to link up existing tramways to Birmingham. The large residential district of Handsworth had not hitherto had tramway facilities. The new tramways would form part of the system of through east and west running. He estimated the revenue at 7¼d. and the working expenses at 6¼d. per car-mile, and the residue would meet capital and running charges and depreciation. Taken as a whole, he thought these tramways would be successful.

For Birmingham Corporation (who opposed), Mr. ALFRED BAKER, manager of the Corporation tramways, said the tramway proposals of the bill were unnecessary. Handsworth were losing £3,000 per annum on the piece of line they had, and under the proposals of the bill would lose more. Birmingham working expenses were 7¼d. per car-mile. He did not think Handsworth could run at less than 7¼d. Birmingham was itself suffering from piecemeal construction of tramway undertakings.

Other evidence having been called, the Committee found the preamble of the bill proved and passed its tramway clauses.

Devonport & District Tramways Bill.—This bill, which was promoted by the Devonport & District Tramways Co. for modifying the terms of the lease under which the company worked the Corporation tramways, was rejected by the Select Committee of the House of Commons last week.

Telephone Charges.—The Postmaster-General (Mr. H. Samuel) has promised to furnish a return, moved for by Lord Claud Hamilton, showing the telephone charges in operation in this country and abroad.

Trans-Atlantic Cables.—In the House of Commons last week Mr. J. P. Boland asked the Postmaster-General whether he was aware that considerable damage was still being caused to the trans-Atlantic cables by the operations of steam trawlers off Ballinskelligs Bay, and whether, in view of the fact that a number of cables had had to be renewed, and that it was now proposed to lay two new cables, he could state what steps would be taken to prevent damage in the future.

In reply, the Assistant Postmaster-General (Capt. NORTON) said that the most recent case brought to his notice of damage to a trans-Atlantic cable attributable to the operation of steam trawlers occurred in November last. The Inter-Departmental Committee which considered the question in 1908, reported in favour of the inspection of trawling gear as the most practical means of minimising the damage. Such a system of inspection was now in force at the ports concerned throughout the United Kingdom.

LEGAL INTELLIGENCE.

Anns v. Walker.

On Friday the Court of Appeal (Lords Justices Vaughan Williams, Moulton and Farwell) dismissed the application of defendant for judgment or new trial in this action, which was tried before Mr. Justice Grantham and a special jury. The action was brought by plaintiff, Mr. Albert Anns (secretary of the National Telephone Co.) against defendant (Mr. T. C. Walker), who was formerly head of the share department of the company, for alleged libel. Defendant pleaded justification. Plaintiff's counsel only asked for nominal damages, and the jury returned a verdict for him for 20s. Judgment was entered accordingly, and Mr. Justice Grantham granted an injunction restraining defendant from publishing similar libels.

Illuminated Advertisements.

Last week before a Divisional Court (the Lord Chief Justice, Mr. Justice Channell and Mr. Justice Bray), Mr. DALDY, on behalf of London County Council, applied for a rule nisi for a mandamus directed to the police magistrate at Marylebone requiring him to state a case for the opinion of the Court. A summons had been taken out by London County Council against W. Sandorides & Co., under sec. 73 of the London Building Act, 1894, in respect of an illuminated sign on premises in Oxford-street. The sign projected about 3 ft. from the building. The magistrate found that in point of fact the sign was a projection, but he considered himself bound by the decision in Hull *v.* London County Council and London County Council *v.* Schewzik; he held that it did not come within the section and dismissed the summons. Counsel submitted that the sign really formed part of the building, and that it was impossible to apply the principle of the cited cases to the case. The magistrate had not directed his mind to the question whether the sign was a projection forming part of the building.

The LORD CHIEF JUSTICE said that they would grant a rule, but he thought it might turn out that the magistrate had decided the question as one of fact with a perfect appreciation of the question of law involved. His Lordship thought that the true construction of sec. 73 (8) of the London Building Act, 1894, was that it dealt with parts of a building and not with mere projections from a building. It was, however, important that there should be no misunderstanding about the case, and the rule would therefore be granted.

Boulton v. Perry & Co.

The contract for the electric lighting and power installation at the Piccadilly Hotel came before Mr. Justice Hamilton last week in an action by Mr. S. A. Boulton (as assignee of a debt due to Blackburn, Starling & Co., Ltd.) against Messrs. Perry & Co. to recover £2,557. 9s. 10d. alleged to be due from defendants to Messrs. Blackburn, Starling & Co. The sum claimed was the amount certified by Mr. E. W. Bowles, consulting engineer of the Piccadilly Hotel, to be due to Messrs. Blackburn, Starling & Co. as the final instalment of payments for the electric lighting and power installation at the hotel. Defendants pleaded that it was a term of the contract between them and Messrs. Blackburn, Starling & Co. that defendants should only be liable to pay when they received the money from the Piccadilly Hotel. To this plaintiff replied that if defendants had not received payment it was because they departed from the terms of their contract, and were thus unable to obtain the certificate for payment.

Mr. Scrutton, K.C., and Mr. M. Hill for plaintiff; and Mr. J. A. Simon, K.C., and Mr. R. F. Colam for defendants.

Mr. SCRUTTON said so far as he could understand the matter, which was somewhat complicated, Mr. Bowles, who ought under the contract to have certified for 100 per cent. of the electric light work that was done, never did so, but only certified for a lump sum, which included 80 per cent. of the electric work. He then sent the certificate to Mr. Woodward, the architect, who added 15 per cent. to it, and included it in a lump sum which covered other items, and gave the certificate to Messrs. Perry & Co. This was for a large sum, some £27,000 or £30,000. Messrs. Perry & Co. were bound to get from the Piccadilly Hotel Co. a certificate for the full value of the electrical work done from time to time, and their contract would enable them to do so if it was enforced.

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His LORDSHIP: You say that whether you or Perry & Co. misunderstood the contract does not matter, and that defendants must be treated as not having insisted on their rights.

Mr. Scrutton agreed.

Mr. COLAM said the question was whose duty it was to get the certificate from Mr. Bowles. In fact, he thought it was the duty of Blackburn, Starling & Co..

Mr. SIMON said it was absurd to say that it was defendants' fault that the money had not been paid to them. Of course, Messrs. Perry had always recognised that when they got the money they must pay it to the sub-contractors, but they had not got it, and therefore he submitted they were not called upon to pay.

His LORDSHIP, in giving judgment, said plaintiff now made two points: (1) that a condition precedent was fulfilled prior to the commencement of the action and (2) that by delivering a reply subsequent to the decision on the preliminary issue he contended that if that condition precedent had not been fulfilled defendants themselves were responsible. Defendants wanted him to come to the conclusion that the contract was varied by consent, but he did not think he could do that on the evidence, and he must proceed on the footing of the formal contract. It was merely a question whether the payments had been received of the amount mentioned in the engineer's certificate. He came to the conclusion that it was the business of Blackburn, Starling & Co. to get the certificate and not that of Perry & Co., and he found no evidence of obstruction, interference or hindrance on defendants' part. His Lordship gave judgment for defendants, with costs.

Stay of execution was granted.

Electrical Co. (Ltd.) v. O. H. Thomas, Son & Co.

This action is still proceeding before the Official Referee, Mr. Pollock, and is expected to last some time yet. It will be remembered that plaintiffs sue defendants for balance of the price of an electrical pumping plant which they contracted to put down in defendants' coal mine in the Llynm Valley, South Wales. The plant was required to replace a steam pumping plant and to unwater the mine. Defendants refused to satisfy plaintiffs' claim because, they alleged, the plant supplied was inefficient and did not carry out the work required of it, they counterclaimed for some £30,000 damages in respect of this alleged non-efficiency. The case has had a hearing of 28 days in London and five days in Swansea. The Referee is now dealing with the counterclaim, and plaintiffs are adducing evidence to show that the mine never could have been worked at a profit and that the cost of working coal was some 50 per cent. more than the f.o.b. selling price.

We are informed that the cost of this lengthy action has already amounted to between £8,000 to £10,000.

Mr. Thomas, K.C., with Mr. Sankey, K.C., are counsel for the Electrical Co., and Mr. F. Williams, K.C., with Mr. Meager are for the defendants.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Torquay Town Council invite applications from qualified engineers for the position of borough electrical engineer. Commencing salary £250, rising to £300 per annum. Applications to the town clerk, Mr. Fredk. S. Hex, Town Hall, Torquay, by Saturday, April 23. See also an advertisement.

An assistant is required in the engineer-in-chief's department of the Westminster Electric Supply Corpn., to calibrate and keep in order all instruments and telephones in the company's generating stations. Commencing salary £120 per annum. Applications by the 25th inst. to the Engineer-in-Chief, Eccleston-place, London, S.W. See advertisement.

A leading draughtsman is required by a first-class electrical firm, to take charge of drawing office; must be used to h. and l.-t. switchgear. See advertisement.

A draughtsman is wanted for switchgear design, both h. and l.-t. See advertisement.

A responsible position in a scientific apparatus factory is vacant. Applications to Messrs. Reynolds & Branson (Ltd.), 14, Commercial-street, Leeds. See an advertisement.

The Committee of Visitors of the Essex and Colchester Lunatic Asylums require an engineering clerk of works, under the direction of their architects and consulting engineers, during the installation of electric lighting machinery, mains, wiring, telephones and heating apparatus, &c., at their new Asylum, Mile End, Colchester. Applicants must be capable of taking charge of the installation when completed. Salary as Clerk of Works £4 per week. Application forms from the clerk to the Committee of Visitors (Mr. Walter Payne Gepp), Essex and Colchester Lunatic Asylums, Chelmsford, to whom applications by April 28.

Swindon Corporation require an assistant electrical and mechanical engineer for their electricity and tramways departments. Applications by April 22.

Applications are invited for the position of principal of the Wolverhampton Technical School. Commencing salary £350 per annum. Applications (by May 5) to Mr. B. H. Preston, Town Hall, Wolverhampton.

Mr. E. S. Taylor, of Watford electricity works, has resigned, and Mr. J. E. Walley, engineer-in-charge, has been appointed to the vacant position at £110 per annum, rising by annual increments of £10 to £130. Mr. R. S. Savory (improver) has been appointed assistant mains superintendent and Mr. J. B. Dent engineer-in-charge.

Mr. H. H. Jeffcott, head of the meteorology department of the National Physical Laboratory (Teddington) has been appointed to the chair of Engineering in the Royal College of Science, Dublin.

Sheffield Council has appointed Mr. H. G. Bennett, motor canvassing engineer in the wiring and fittings department, to be chief motor assistant at £160 per annum, rising by annual increments of £10 to £180.

Mr. A. R. Chaytor has been appointed assistant mains superintendent to the Yorkshire Electric Power Co.

EDUCATIONAL NOTICES.

Summer School Lectures.—Glamorgan Education committee have arranged short summer courses of lectures during August, as follows: (1) Practical surveying course at Penarth; (2) Engineering course; Mining, mechanical and electrical engineering (laboratory work) and practical mathematics; (3) Metallurgy course: Metallurgy, chemistry and practical mathematics; (4) Teachers' course: Geology (lectures and field work), physics and chemistry (this course has been arranged to meet the requirements of teachers engaged in or preparing for technical work at evening schools or technical schools); (5) Evening lectures for colliery firemen on explosives and shot-firing; (6) Evening lectures on electricity in mines. Courses 2, 3, 4, 5 and 6 will be held at University College, Cardiff, the other courses at the County School, Penarth. Certificates will be issued to successful candidates. Particulars and admission forms from 35, Park-place, Cardiff.

Crystal Palace Engineering Society.—The Wilson premium for the best Paper read before this society during the present session has been awarded to R. Hook for his Paper on "Narrow Gauge Railways." The premium was presented to Mr. Hook by Sir Charles Rivers Wilson, G.C.M.G., C.B., on Tuesday last.

Barking.—The output of the electricity department for the year ended March 31 was 1,622,485 units, an increase of 38,772 units. The units sold were 1,374,960 an increase of 37,616.

Battersea (London).—Additional low-tension cables are to be laid in Nine Elms district and other work is to be carried out at a cost of £8,895. As there is an increasing demand on the route of the feeder cable from the station to Wellington-road a 0·5 sq. in. concentric feeder cable is to be provided and drawn into the spare conduits already fixed at a cost of £650.

Bexhill.—The Parade is to be lighted electrically at a cost of £226. Sanction has been received to loans of £137, excess expenditure, £3,260 expenditure on mains (20 years), and £600 for services (15 years). With certain unexpended balances of previous loans, the total now available for mains is £4,542.

Birkenhead.—At the last meeting of the Corporation the Electricity committee recommended that the charge to electricity consumers in Bidston, Noctorum, Upton and Prenton be reduced from 7d. to 6d. per unit. Mr. Russell moved that this report be not confirmed, and after discussion the amendment was carried.

Birmingham.—The Electric committee propose to hand over, in relief of rates, £10,000 out of the last year's profits of the electricity undertaking.

Canadian Water Power.—In a recent communication from one of the leading engineers in Canada our correspondent writes that there is in Quebec Province alone, he estimates, about 20,000,000 H.P. of water power awaiting development. This is taking into account only the known water courses in the Province.

Cookstown.—By a majority of one the Council have decided to postpone their proposed electricity scheme until the housing scheme has been settled.

Custom Duties.—The Belgian Minister of Finance recently introduced in the Chamber of Representatives a bill to make alterations in the import duties on various goods, including an increase in the duty on "electrical machines of cast iron" from fr.2 to fr.4 per 100 kilogs (1s. 7½d. per cwt.)

A Presidential proclamation has been issued extending the benefit of the U.S.A. minimum tariff to all British Colonies and possessions not hitherto mentioned.

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Derby.—An inquiry was held on Wednesday into the application of the Council for sanction to borrow £5,203 for the electricity undertaking.

In support of the application it was stated that in 1908-9 there was an increase of 600,000 units in the demand, and a similar increase was anticipated in the present year. A tender had been conditionally accepted for laying down additional plant, including generators (£4,076), conversion plant (£1,027) and contingencies (£100).

Dowlais.—It was reported at the last meeting of the Dowlais Chamber of Trade that the Merthyr Electric Traction & Lighting Co. had consented to lay underground cables in all the narrow areas and thoroughfares, and overhead wires would be fixed in no street less than 22 ft. wide.

Eastbourne.—An unopposed inquiry was held on Tuesday into the Council's application for sanction to borrow money for condensing plant at the electricity works.

Edinburgh.—It has been decided to adopt electric lighting for the common stairs in High-street, Cowgate and Canongate districts. The cost will be 21s. per lamp, against 17s. 6d. for incandescent gas.

Exhibition.—An Exhibition of Applied Electricity will be held at Nymegen (Holland) from July 2 to Aug. 15 next. Applications for space can be sent to 18, Kelfkensbosch, Nymegen. Regulations, &c., may be seen at 73, Basinghall-street, London, E.C.

French Government Telegraphs.—The Louis-Dakar submarine cable has been acquired by the French Government.

Gillingham.—An inquiry was held on Tuesday into the application of the Council for sanction to borrow £3,000 for additional generating plant, including a Diesel oil engine and dynamo.

Glasgow.—The Corporation have adopted the report of the Electricity committee (abstracted in our last issue) recommending that steps be taken to acquire a site for an additional generating station.

Glasgow-Kirkintilloch Tramways.—At a public meeting last week a deputation was appointed to wait upon Kirkintilloch Council to urge them to take immediate steps to open negotiations with Glasgow Corporation to extend the Glasgow tramway system from Bishopbriggs to Kirkintilloch.

Hampstead (London).—It has been decided to convert 317 street lamps from gas to electric lighting. The annual charge per lamp will be £2. 19s. 6d., against £3. 4s. 9d. for gas.

Honduras.—A concession has been granted to Mr. J. W. Grace authorising the Puerta Cortez and Baracoa Electric Co. to supply electrical energy in Puerta Cortez and Baracoa, and Mr. M. E. Lardizabel has obtained a similar concession for the Empresa de Luz Electrica de San Pedro-Sula in respect of Pedro-Sula town.

India.—"Indian Engineering" says a motor-generator set, control panels, &c., for the East Indian Railway workshops at Lillooah have been ordered from England.

The "Indian and Eastern Engineer" states that final estimates for he Simla hydro-electric scheme show that the total cost will be about 9½ lakhs of rupees (£63,333).

The Railways Board have given general approval of proposals to adopt electric driving in the Kanchrapara and Saidpur workshops of the Eastern Bengal State Railway, and to provide electric fans for the N.W. Railway offices at Lahore.

Italy.—The Societa Anonima Compagnia Italiana dei Grandi Alberghi, has obtained a decree authorising the construction and working of various sections of electric tramway on the Lido (Venice.)

Japan.—A company has been formed to construct an electric railway from Tokio to Yokohama, about 15 miles in length, and a branch to Kamata nearly four miles in length. The overhead system will be adopted, and the line will be double track and of 3 ft. 6 in. gauge. The cost of construction will be about £357,300. Further particulars can be obtained at 73, Basinghall-street, E.C.

London Chamber of Commerce.—At the annual meeting last week the Electrical Trades' Section reported that Mr. C. P. Sparks had been re-elected chairman, and Mr. W. J. Madgen deputy-chairman.

In regard to electricity in factories, as the Home Secretary, in issuing the Regulations, did not adopt all the recommendations made by the Commissioner, including that headed "Arbitration, Appeal or other Protection," the Home Office were approached with a view to receiving a deputation on this matter, but, finding the Department were unable to take any steps until the general law had been amended, it was not possible to take any further action in the matter. Members were, therefore, advised that the only further precaution that could be taken was to apply for exemption in those cases, at any rate, where there was a difficulty in applying the regulations. Such exemptions could be obtained under exemption No. 6.

In regard to electricity in mines and the appointment of a Departmental committee, a communication was addressed to the Home Office suggesting that there should be a representative of electrical manufacturers and electric supply undertakers, to advise more particularlyion the commercial aspects of the regulations. The committee appointed by the Home Office was small, but met with the approval of the electrical industry. The section considered the advisability of arranging for a witness to give evidence as to the working of the existing special rules for the use of electricity in mines, but up to the end of the year such witness had not been secured, and further steps were being taken in this direction.

The section considered the question of the installation of wireless telegraphy on passenger ships, and a resolution was unanimously passed to the effect that it was advisable that all passenger ships for oversea traffic should be fitted with wireless telegraphy. The Council of the Chamber was requested to urge his Majesty's Government to introduce a bill containing a compulsory clause.

The section approved the action of the manufacturers' section in opposing the proposal of London County Council to promote legislation to delete the word "black" from the clause in the Public Health Act, 1891, which provides that "any chimney (not being the chimney of a private dwelling house) sending forth black smoke in such quantities as to be a nuisance shall be a nuisance to be dealt with summarily under the act."

It was reported to the section that the Council had appointed a special committee in connection with the question of misrepresentation in trade, and would be willing to receive suggestions as to points affecting electrical manufacturers which might usefully be brought before the committee, and a witness was appointed to give evidence on behalf of the section before the special committee.

Manchester.—On Wednesday the Electricity committee recommended the Council to apply for sanction to borrow £40,000 for extensions of the electricity undertaking.

Ald. HOLT said the committee ought to be placed on the same footing as the other trading committees, and asked to pay more in aid of the rates. The Corporation had spent about £2,000,000 on the electricity undertaking and ought to have a better return. The Electricity committee were placing the Gas committee in a very unfair position.

Mr. HOWARTH, chairman of the Electricity committee, said the department was not instituted as a trading department, but to provide current which the citizens could not provide for themselves. The operations of the committee would be limited if they were compelled to pay a given sum every year in aid of rates. He did not think the Gas committee were justified in paying the large amount they did in aid of rates. The desire of the Electricity committee was to encourage firms to open works in the city.

Ald. HOLT moved that the Electricity committee's proposal be referred back, but after discussion the recommendation was adopted.

At the meeting of the City Council last week Mr. Thos Hudson, deputy town clerk, was appointed town clerk, in succession to Sir W. H. Talbot, who has been retained as consulting solicitor.

The traffic revenue of the Corporation tramways for the year ended March 31 amounted to £777,220, an increase of £3,185 over 1908. The number of car-miles run was 17,181,774, against 17,316,753. The number of passengers carried was 159,049,696 against 155,011,884.

Marylebone (London).—At the meeting of the Council last week Councillor Duncan Watson moved "That a committee be appointed, composed of the chairmen of the standing committees, to inquire into the complaints made by electrical contractors of the methods of the sales department of the electricity undertaking."

Mr. WATSON said he objected to the sales department carrying on that which was nothing more or less than municipal retail trading; it was speculative, and was detrimental, not only to the undertaking, but to the ratepayers who were contractors.

In reply to the statements by Mr. Watson, Ald. DEBENHAM, chairman of the Electric Supply committee, said the Borough Council decided three months ago that it was necessary to have a sales department so as to increase the sale of electric current; and the interests of the Council could never be the same as those of electrical contractors. It was not to the detriment of the latter, but rather did the figures prove the contrary, for active business made it good for everyone. The committee did not compete with contractors or cut prices, and although Marylebone had the largest number of electrical contractors, yet she had the biggest number of "dead services."

The motion did not receive much support, and ultimately it was rejected by a large majority, only four voting for it.

Palestine.—The "Daily Mail" announces that a scheme has been prepared by a French Company for supplying the whole of Palestine with electricity. Water power will be obtained from a fall on the Jordan between the Waters of Merom and the Lake of Galilee. The generating plant will be erected on the west bank of the river, and electricity will be transmitted to all the chief towns of the country.

Personal.—Mr. Justus Eck, engineer-in-chief to the Union Electric Co., Park-street, Southwark, S.E., sailed on April 9 by the ss. "Lusitania," for New York, with the intention of visiting the principal cities of the United States, for studying the latest American developments in street, shop and railway lighting, and in the applications of electricity to manufacturing and mining.

Mr. Henry C. Adams, junior partner in Henry Adams & Son, had the honour of being the first candidate elected a fellow of the Society of Engineers, the president and council being already fellows under the articles of association.

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ELECTRICITY SUPPLY TABLES AND DATA.

This Valuable Set of Tables and Engineering Data relating to Electricity Supply and to Electric Traction on Railways and Tramways in the United Kingdom, the Colonies, and some important places abroad, is now ready, and can be obtained complete in handy book form, price 6s. 6d. post free, or on very hard paper for rough or constant use, price 8s. 6d. post free. A complete Index is included.

Dr. J. Erskine-Murray asks us to state that the rumour that he has been appointed technical adviser to a wireless syndicate is untrue and calculated to injure his position as an independent consultant. He has no pecuniary connection with, or interest in, any particular system, his relations with all his clients being on the same basis, namely that of an occasional consultant.

Plymouth.—Cable extensions, estimated to cost £170, are to be made. Twelve metal filament lamps are to be installed in the market, the annual charge for which will be £2. 15s. per lamp.

Presentations.—On 1st inst. Mr. G. F. Craven, chief assistant tramways engineer to the Reading Corporation, was presented with a silver tea and coffee service by the employes and staff of the tramways department, as a mark of esteem and good wishes on his approaching marriage. The general manager (Mr. W. Binns) made the presentation.

Morecambe Borough officials have presented a kit bag to Mr. W. H. Hall, late borough electrical engineer.

Gravesend electricity staff have presented a gold mounted ebony walking stick to Mr. P. W. Naylor, who is leaving.

Provisional Order Revocation.—The Board of Trade have revoked, as from April 4, the Renfrew Burgh Electric Lighting Order 1905.

St. Anne's-on-the-Sea.—The following revised scale of charges for electric current has been adopted :—

Lighting : Maximum demand system, 6d. and 2d., instead of 7d. and 2d., or flat rate 4¾d., instead of 5¼d. Heating, power, &c. : First 200 units 2d. per unit, and for each additional unit 1½d., instead of 2½d. for first 100, 2d. for second 100 units and 1½d. after. A discount 5 per cent. is allowed for prompt payment.

Councillor HODGKINSON said : After making the reductions, there would still be £500 for relief of rates, bringing the sum so granted up to £4,000 in all. But it would be unfair for electricity users to have to pay an unreasonable price so as to provide funds to relieve gas users. Metal filament lamps and the revised scale made electricity compete with gas. The electricity undertaking was in the hands of an engineer (Mr. Clothier) who was worthy of a better post, and the successful results were largely due to his capable management.

The Council have agreed to contribute £20 towards the cost of promoting a bill to give local authorities power to undertake wiring work, &c.

Scholarships.—The London Inter-Collegiate Scholarships Board announce that an examination will be held on May 10 for 20 entrance scholarships and exhibitions of an aggregate total value of about £1,500 open to men and women, and tenable in the faculties of arts, science and engineering of University College, King's College and the East London College. Particulars from the Secretary (Mr. A. E. G. Attoe), University College, Gower-street, London, W.C.

Sheffield.—An agreement has been arrived at between the Electric Light committee and the Yorkshire Electric Power Co. with reference to the supply of electricity by the Corporation to certain premises in Tinsley.

The Electric Light committee recommend that the salary of the general manager of the electric supply department (Mr. S. E. Fedden) be increased from £800 to £900 per annum.

Southport.—In future the Tramways and Electricity undertakings will be controlled by one committee. Mr. A. S. Black remains borough electrical engineer and tramway manager, and Mr. T. Kendrew becomes deputy electrical engineer and tramway manager.

Spain.—The Cia del Tranvia Urbano de Bilbao have applied to the Direccion General de Obras Publicas, Madrid, for a concession to construct and work an electric tramway in Bilbao. The company have already obtained a concession for an electric tramway in another part of the city.

Swindon.—Mr. R. W. Grubb, the assistant electrical engineer, recently obtained an appointment at Dewsbury, and a successor is being advertised for.

Taunton.—The borough electrical engineer (Mr. E. B. Thornhill) has tendered his resignation.

The Rubber Boom.—In a well-reasoned review of the rubber situation the "Financial News," of the 12th inst., deals with the question of the effect of the great rise in the price of rubber shares and in the value of rubber properties on th revenue of the Eastern and Associated Telegraph Companies, and the Indo-European Co. (and, incidentally, other cable companies) arising out of this boom. The approaching issue of the Eastern Telegraph Co.'s report and accounts for the current half-year is made the occasion of an interesting résumé of the company's financial position, stress being laid upon the conservative policy of the directors in regard to the building up of substantial reserves.

Thurstonland (Yorks).—The Council have asked the Yorkshire Electric Power Co. to submit terms for the supply of electricity.

Tramway Men's Hours.—On Tuesday the Parliamentary committee of the Trade Union Congress waited upon the Parliamentary Secretary to the Board of Trade (Mr. H. J. Tennant) to lay before him matters affecting tramway men.

Mr. G. T. JACKSON, general secretary of the Amalgamated Society of Tramway and Vehicle Workers, said the question he had to submit was a reasonable one—namely, that the men should be allowed a minimum rest time of eight hours between the time of finishing their day's labour and taking up duty again. The system which prevailed split the men's time into, perhaps, three, four or five hours. The men journeyed once or twice in a car, were taken off, and put on again. He contended that to compel a man to spread his labour over 14, 15 or 16 hours a day for five days of the week was most unreasonable. The health of the men had been greatly affected by the long hours, and he suggested that the Board should ask for a return from the various tramway authorities, showing the system under which the day's labour was performed, the number of hours the men had to work, and the spread-over period to get their time in.

Mr. TENNANT, in reply, said he agreed that an eight hours' interval was a reasonable request, but there were difficulties with regard to the powers of the Board of Trade. They had wider powers in relation to railways than in relation to tramways. They could insist upon certain things on railways with regard to drivers and engines, but they had not similar powers in relation to the drivers of tramway cars. It had been stated that it was a common practice in certain trades to come to an agreement with employers in relation to an eight hours interval, and he suggested that the tramway men should come to a similar arrangement.

Mr. JACKSON said they had tried that method and failed. The only course that might be open to them was to withdraw their men. They would not do that unless they were driven to it.

Mr. TENNANT wished them to understand that the Board of Trade had no absolute powers of compulsion in the matter. If hard cases were brought to their notice, they would be glad to make representations to the Corporations employing the men. He could not make any promise with regard to advocating a double shift.

Venezuelan Coast Cables.—The "Journal Telegraphique" has announced that the following coast cables of the Cie Francaise des Cables Télégraphiques have been transferred to the Venezuelan Government :—Guayra to Puerto Cabello, la Vela to Coro à Maracaïbo, la Guayra to Carenero, Carenero to Guanta, Guanta to Cumana, Cumana to Porlamar, Porlamar to Carupano.

Watford.—Arrangements have been made for supplying electricity in Munden.

Wilmslow.—The Council have renewed the agreement with the Alderley and Wilmslow Electric Supply (Ltd.) for public lighting for another five years. The company undertakes to carry out improvements in the lighting of the main roads. Extensions have been passed for other districts, and it is stated that when these have been made nearly the whole of the main road from Manchester to Alderley will be lighted.

Wireless Telegraph Notes.—The British Vice-Consul at Ymuiden, Holland (Mr. S. C. L. Reygersberg) reports particulars of an interesting experiment made recently in fitting several steam trawlers with wireless telegraph apparatus, enabling them to communicate with the State wireless station at Ymuiden. The experiment seems to have been thoroughly successful, one experience in particular showing its value. During the dock strike that occurred in the autumn of 1909, steam trawlers at sea were warned not to return to Ymuiden harbour, but to proceed to British or German ports with their catches. It has also been found possible for the smack owners on shore to direct the trawlers at sea towards shoals of fish, of which information is received from the craft that arrive at Ymuiden.

The "Yorkshire Post" of 11th inst. states that, although the Board of Trade has repeatedly refused an inquiry into the various systems of wireless telegraphy, a Departmental Committee is about to be appointed with the view to the preparation of a measure to make wireless installation on board ocean-going passenger ships compulsory.

What is described as the first wireless message to be communicated between New Zealand and Australia took place on the 25th Feb., when Mr. J. H. A. Pike, who operates a private licensed station at Arncliffe, received a wireless message from H.M.S. "Powerful," which vessel had left a few hours previously the harbour at Auckland. Mr. Pike claims that with low aerial wires (50 ft.) he is able, by means of a specially sensitive detector he has invented, to obtain communica-

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tions which are not possible by any other means, and that he has "heard" messages from the "Powerful," said to be the best equipped vessel in Australian waters, a distance of over 1,350 miles.

The story goes that the undergraduates at Harvard University, U.S.A., have erected five wireless stations with the purpose of giving instruction and experience to the students, who are reported to have organised a joint stock company, and to have erected their central station in Holyoake House. The entire outfit is reported to be of the most modern type.

Wolverhampton.—The Corporation have approved a report of the Electricity committee, recommending that, owing to the continuously increasing demand for electricity, extensions of the generating plant at the electricity station and also the laying of additional distributing mains at a total cost of £23,000 be proceeded with.

The chairman of the committee (Mr. Gough Allen) explained that the maximum load had increased from 1,775 kw. in 1906-7 to 3,880 kw. in 1909-10. In consequence of the necessity of providing the machinery, tenders had been advertised for, and he hoped the committee would be allowed before the next Council meeting to accept a tender.

Workhouse Lighting.—Fulham (London) Guardians have decided to wire the administrative block of the Belmont workhouse at Sutton.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding **that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable** and of little value for **Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.**

TENDERS INVITED.

West Bromwich Electricity committee invite tenders for supply, delivery and erection of a 750 kw. d.-c. turbo-generator and surface condenser. Specification, general conditions, forms of tender, &c., from the borough electrical engineer (Mr. W. A. Jackson), Electricity Works, West Bromwich. Tenders to the Chairman of the Electricity committee, Town Hall, West Bromwich, by May 2. See also an advertisement.

The Secretary of State for War invites tenders for the supply of two plants for the production of hydrogen and oxygen by the electrolysis of water at the Balloon Factory, South Farnborough, Hants. Forms of tender from the Director of Army Contracts, War Office, Whitehall, London, S.W., where tenders are to be delivered by noon of May 4. See also an advertisement.

Hammersmith (London) Council invite tenders for supply of circular stoneware cable ducts, with Stamford joints, 1,750 yds. of 0·25 h.t. concentric cable, and prepayment meters. Specifications, &c., from the borough electrical engineer (Mr. G. Gilbert Bell), 85, Fulham Palace-road, Hammersmith, W. Tenders to the town clerk (Mr. H. Thompson), Town Hall, Hammersmith, W., by 4 p.m. April 20. See also an advertisement.

Tenders are required by June 8, 1910, for the supply of six sections of common battery switchboard and equipment jumper wire and cable to the Postmaster-General's department in Queensland. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W. See an advertisement.

Tenders are invited, up to May 18, for the supply of paper insulated lead-covered and brass ribbon taped cable to the Postmaster-General's Department in Queensland. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

Tenders are invited up to June 1, for the supply of eight sections of common battery switchboard to the Postmaster-General's Department, New South Wales. Tender forms, specifications, and general conditions may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W. See also advertisement.

Tenders are invited up to June 8 for the supply of protectors, switchboards (small) and common battery telephones to the Postmaster-General's Department, Queensland. Tender forms, specifications and general conditions may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W. See also advertisement.

Littleborough Urban District Council invite tenders for the supply and laying of h.t. feeder cables, l.t. distributors, roadwork, &c., for private lighting, and transformer kiosk, with transformers and equipment and switchgear in substation. Copies of specification, forms of tender, &c., may be obtained from the clerk to the Council, Mr. Geo. H. Wild. The works are to be carried out in accordance with plans and specifications, which may be seen at, but not obtained from, the offices of the consulting engineers, Messrs. Hawtayne & Zeden, 9, Queen-street-place, London, E.C., from whom further information can be obtained. Tenders to the Clerk to the Council, Council Offices, Littleborough, near Manchester, by May 2.

Walthamstow Urban District Council invite tenders for the supply and erection of one feeder booster set, switchboard and accessories. Copies of specification, &c., from the electrical and tramways engineer (Mr. G. R. Spurr), Priory-avenue, Walthamstow. Tenders (by post only) to the clerk of the Council (Mr. C. Sydney Watson) by noon April 22.

Whitwood Urban Council invite tenders for copper cables, steel and wooden poles, supports, arms, insulators, &c., watertight street light fittings, meters, switchboard, instruments, &c. Specifications from Mr. H. Marsden, Electricity Works, Honley, and tenders to Mr. V. Hulme, County Chambers, Bradley-street, Castleford, Yorks., by April 28.

Grimsby Corporation invite tenders for supply of a small three-wire balancer for c.c. system, and two years' supply of c.c. motor-meters. Specifications from the borough electrical engineer, Mr. W. A. Vignoles, M.I.E.E., Electricity Works, Grimsby. Tenders by first post April 18.

Llandudno Urban Council invite tenders for replating batteries and supply of paper and vulcanised cable, feeder and distributing pillars, joint boxes, &c. Tenders to Clerk of Council by April 23.

Dartford Council require tenders by noon April 20 for supply of one feeder pillar and 900 yds. of 0·15 and 450 yds. of 0·07 paper-insulated lead-covered cable. Specification, &c., from the engineer.

The Deputy Postmaster-General, Melbourne, will receive tenders until 3 p.m. May 17 for supply of 1,010 reinforced concrete telegraph poles, preferably of Australian cement. Local representation necessary. Specification from Commonwealth office, London.

The Deputy Postmaster-General, Brisbane, will receive tenders until noon May 18 for 1,760 yds. of paper insulated lead-covered cable. Local representation necessary. Specifications from the Commonwealth office, London.

The Consejo de Administracion del Puerto de Montevideo (Uruguay) require tenders by 3 p.m. July 4 for supply of 20 electric cranes.

TENDERS RECEIVED AND ACCEPTED.

Keen competition for a contract for the supply to the Danish Government of submarine vessels in which European and American contractors were competing, has resulted in the contract being placed with Messrs. Whitehead & Co. (Ltd.), of Fiume, Hungary.

Sheffield Tramways committee has accepted the tender of Hadfield's Steel Foundry Co. for the manufacture, supply and delivery of special track work at £1,000, plus £213. 7s. 10d. for rails and fish-plates to be supplied by the Corporation.

Plymouth Town Council has accepted the tender of Willoughby Bros. for tramway blocks at 6s. 6d. per cwt., brake slides, 2d. each, steel slipper block bolts, 5d. each, and steel suspension bolts, 1s. 4d. each.

Sheffield Electricity committee have accepted the tender of the Electric Construction Co. for a rotary transformer and switchgear at £302. 15s. 10d.

Battersea (London) Council has accepted the tender of the General Electric Co. for annual supply of arc lamp carbons, and of Callender's Co. for annual supply of cables.

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Warrington Council have accepted the tender of Chamberlain & Hookham for keeping the tramway meters in repair at 3s. 3d. per meter per annum.

The Clyde Navigation Trustees have accepted the tenders of Siemens Bros. Dynamo Works for additional generating plant at £6,442.

Tonbridge Council have placed an order with the British Thomson-Houston Co. for motor meters, with W. Geipel & Co. for carbons, and with the Western Electric Co. for cables for a year.

Colchester Corporation have accepted the tender of the Standard Cable Mfg. Co. for distributor cable at £242. 5s.

Bradford Corporation have accepted the tender of Thermit (Ltd.) for welding 600 tram-rail joints at £596.

Chester-le-Street Guardians have accepted the tender of G. H. Armstrong for an electric fan for the laundry at £27. 5s. 8d.

St. Helen's Council have accepted the tender of the British Insulated & Helsby Cables for cables.

Battery Contracts.—The storage battery at Rochester (Australia Commonwealth) central station, mentioned in our last week's edition was, we are informed, supplied by the D.P. Battery Co. through their local representative, Mr. T. K. Steanes.

The order for the large storage battery required by Guildford Electricity Supply Co. has been placed with the D.P. Battery Co., who have also undertaken its maintenance for 10 years.

Leek District Council and Letchworth Garden City, having found it necessary to enlarge their plant, have decided to adopt larger storage batteries, and have again placed orders with the D.P. Battery Co.

BUSINESS NOTICES.

Mr. J. E. Kingsbury has removed from Norfolk House, Victoria Embankment, to 7, Serjeant's Inn, Temple, London, E.C. Telegraphic address, "Rexinter London"; telephone 2418 Central.

The partnership between Wm. Taylor Thomson, Jas. Knox, Chas. Nugent Knox and Wm. Brown Macdonald (trading as Thomson, Knox Co.), electrical and mechanical engineers, &c., 10-12, Scrutton-street, Finsbury, London, E.C., 4, Marsden-square, Manchester, and 109, Argyle-street, Glasgow, has been dissolved. The business in Scotland and Ireland will be carried on by Mr. Thomson and the business in England by Mr. Jas. Knox, both trading under the style of Thomson, Knox & Co.

Robt. Arch. Dunt and Edwd. N. Bedells (trading as R. A. Dunt & Co.), electrical engineers, 91, High-street, Southampton, have dissolved partnership. Debts by Mr. Bedells, who continues as E. N. Bedells & Co., at 83, Above Bar, Southampton.

Electrical Engineering in Sweden.—The General Electric & Manufacturing Co. of Sweden (Allmana Svenska Elektriska Aktiebolaget) have recently opened offices at Norfolk House, Laurence Pountney-hill, Cannon-street, E.C., under the superintendence of Mr. S. H. Busch, who will act as representative in this country. An illustrated booklet issued on the occasion of the firm's 25th birthday gives a good idea of their activities. In this an interesting account of the work is to be found, while technical chapters on the "Development of Continuous-current Engineering" and "Switchboard Apparatus and Special Devices" are well worthy of study. A chapter on "Some of the installations and power schemes carried out by the Allmana Svenska Elektriska Aktiebolaget" contains details of power stations, rolling and paper mills and other applications of electrical machinery. Much of the plant now in use in Norway for producing nitrates from the atmosphere has been supplied by this firm.

For Sale.—In another column an electric light and power undertaking is advertised for sale as a going concern.

Factory Premises for Sale.—Mr. F. Warman, 52, Chancery-lane, London, W.C., has for sale some well-equipped factory premises in Reading. See an advertisement.

Telegraph Code Economiser.—Messrs. Sidgwick & Jacksou, of 3 Adam-street, Adelphi, London, W.C., have just issued, price 10s. 6d. net, a new and revised edition of Rose's "Universal Code Economiser," prepared by Mr. Sydney Rose, A.M.Inst.E.E., The "Economiser" is designed to work as an adjunct to all existing code books, and Mr. Rose claims that it is the only system by which a transposition error, of whatever magnitude, can be detected at sight, and rectified immediately by the recipient of the message. The fact that a new edition of this ingenious system has been called for indicates that code users, who are an increasing class, have found the method propounded by Mr. Rose of service. The bearing of such publications on the question of telegraph rates can perhaps be no more clearly shown than by a perusal of this work, which is a graphic example of the application of scientific treatment to everyday commercial transactions. In view of recent declarations as to the use of code vocabularies the new edition of Mr. Rose's "Economiser" is timely.

Osram Lamps for Ship Lighting.—Applied science has revolutionised ocean travel, and nowadays one is able to enjoy all the comforts of home life whilst travelling from continent to continent. Proper ventilation is secured by means of electric fans, heating by means of electric radiators; and clean, healthy and wholesome illumination by means of the electric light. For obvious reasons gas has never found a notch in the evolution of lighting on board ship, and it has been left to electricity to provide the long and keenly needed improvement in shipping illumination. Practically the whole of the large liners are now equipped with their own electric lighting plant, and the Osram metal filament lamp has come largely into favour on account of its remarkably long life and low current consumption. One of the White Star liners upon which Osram lamps are fitted throughout has just returned to port after a five months' cruise, and the engineer's report states that only one lamp has failed throughout the whole period of absence, although the average life of the lamps in question is already over 700 hours. We are informed that this liner is leaving for another cruise with identically the same lamps, and are taking only half the usual number of spares on account of the present perfect condition of the lamps now installed.

Welding of Rail Joints.—Thermit Limited are carrying out the welding of the joints in connection with the construction of an electric tramway in Edinburgh.

CATALOGUES, &c.

Combined Paper Knife and Bell Push.—A description of a useful piece of apparatus for the writing table is sent us by the General Electric Co. Its object is sufficiently explained by the accompanying illustration, which also shows the neat way the wires are led in so as not to interfere with the cutting part of the instrument. A further advantage is that, owing to the flex being always visible the paper knife cannot get lost under the documents on the desk, as so often happens with the ordinary type.

Dry Cells.—We have received from Messrs. Siemens Bros. & Co. copy of their latest catalogue dealing with dry cells and dry cell batteries, which supersedes the list of August last. It differs from the earlier list in certain minor respects, and information regarding ignition coils, suitable for use with Obach dry batteries is included.

We have also received from Messrs. Siemens two leaflets dealing respectively with bell wires and motor car leads. These are supplementary to their catalogue on vulcanised India rubber wires and cables.

"Venner" Time Switch.—We mean it to be a compliment when we say the most interesting part about the pamphlet recently issued by Venner & Co. dealing with their well-known time-switch is the way in which various well-known quotations have been adapted to what may be called electrical uses. There is, however, much useful information and diagrams anent the switch, whose advantages should certainly be considered by those who are likely to require time switches.

Switches.—We have received from Ernest F. Moy (Ltd.) a complete catalogue of their well-known switches. These cover a wide range and are easily adaptable for all kinds of electrical work.

Ediswan Specialities.—The Edison & Swan Company have ready a number of leaflets dealing with the numerous electrical articles turned out by them. These include combined switch sockets and plugs, instruments of various types, enclosed arc lamps and arc lamp accessories.

Installation News.—The current number of "Installation News" contains details of the new Simplex combined wall plug and lampholder adaptor, &c.

A.E.G. Zeitung.—The current number contains a well illustrated account of some electric pumping installations, and a hydro-electric scheme in Formosa is dealt with. An article by Mr. Forner gives some interesting details of the steam consumption of turbines, and there is a descriptive article on the harbour works at Constantza.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during March, 1910, and (*b*) during the current year from Jan. 1 to March 31, with the increases or decreases compared with the corresponding periods of 1909 :—

Electrical machinery (*a*) £54,275 (decrease £322), (*b*) £137,419 (increase £18,082); telegraph and telephone cables (*a*) £9,688 (decrease £275), (*b*) £37,178 (increase £12,373); telegraph and telephone appa-

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ratus (*a*) £16,721 (decrease £2,863), (*b*) £41,901 (decrease £2,421); other electrical wires and cables, rubber insulated (*a*) £12,421 (increase £8,188), (*b*) £36,240 (increase £22,291); with other insulations (*a*) £2,728 (decrease £9,936), (*b*) £6,069 (decrease £23,819); carbons (*a*) £12,342 (increase £941), (*b*) £35,746 (decrease £432); glow lamps (*a*) £55,580 (increase £27,282), (*b*) £139,968 (increase £21,365); arc lamps and electric searchlights (*a*) £101 (decrease £214), (*b*) £1,276 (decrease £6,086); parts of arc lamps and searchlights (other than carbons) £4,995 (increase £533), (*b*) £17,374 (increase £5,011); primary and secondary batteries (*a*) £3,624 (decrease £767), (*b*) £9,457 (decrease £4,750). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (*a*) £126,395 (increase £21,246), (*b*) £348,377 (increase £20,048).

Exports.—The exports of electrical machinery, material, &c. (*a*) during March, 1910, and (*b*) during the current year from Jan. 1 to March 31, and the increases and decreases compared with the corresponding periods of 1909, are as follows:—

Electrical machinery (*a*) £118,091 (increase £6,392), (*b*) £317,761 (decrease £16,837); telegraph and telephone cables (*a*) £640,004 (increase £594,878), (*b*) £743,240 (increase £644,996); telegraph and telephone apparatus (*a*) £12,221 (decrease £3,062), (*b*) £35,354 (decrease £14,596); other electrical wires and cables, rubber insulated (*a*) £23,788 (increase £2,079), (*b*) £98,197 (increase £35,582); with other insulations (*a*) £20,651 (increase £1,267), (*b*) £46,688 (decrease £13,218); carbons (*a*) £1,015 (increase £419), (*b*) £4,578 (increase £2,511); glow lamps (*a*) £10,720 (increase £3,328), (*b*) £31,830 (increase £14,421); arc lamps and searchlights (*a*) £1,529 (decrease £1,452), (*b*) £4,968 (decrease £1,121); parts of arc lamps and searchlights (other than carbons (*a*) £907 (decrease £1,454), (*b*) £3,518 (decrease £1,551); primary and secondary batteries (*a*) £6,042 (decrease £5,689), (*b*) £26,369 (decrease £4,064). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (*a*) £758,160 (increase £597,516), (*b*) £1,110,996 (increase £687,512).

BANKRUPTCIES, LIQUIDATIONS, &c.

At Liverpool Bankruptcy Court on Monday, before Mr. Registrar Howarth, Mr. Alfred Horswell Gibbings, electrical engineer, of Gambier-terrace, Liverpool, appeared for public examination. The liabilities were returned at £2,784, assets £56.

Debtor stated that he had held successively the posts of electrical engineer to the Hove Commissioners, Hull and Bradford Corporations. He had also been chief engineer to the South Lancashire Tramways Co. and the Stalybridge, Hyde and Dukinfield Tramways & Electricity Board. He commenced practice in Liverpool in February, 1906, as a civil and electrical engineer, and until June, 1907, was in partnership with a Mr. Chauntler. In May, 1908, he made an agreement with the North British Electrical Power Synd. to act as consulting engineer in regard to some proposed works for the distribution of electrical energy in Scotland, from which very lucrative results were anticipated, with the prospect of developments on similar lines in Lanashire and the north of England. The intended operations were stopped, however, by sec. 23 of the Electric Lighting Act, 1909. That section had been inserted by the House of Lords on the third reading of the bill without any intimation or publicity being given. The effect of the section was to render it impossible for a private company or individual to supply electrical energy to customers in any area in competition with a local authority or other statutory undertaker without obtaining a provisional order. The cost of obtaining a provisional order, owing to the opposition to be expected and the probable restrictions that would be imposed, placed it out of the power of the syndicate to proceed. His agreement with them was, therefore, terminated, and a scheme which he had in hand in Yorkshire was similarly frustrated. He attributed his position entirely to the act in question.

An order was made for an amended deficiency account, and the examination was adjourned to May 9.

Hy. K. P. Berham (trading as the South of England Electrical Engineering Co.), 60, Fratton-road, Portsmouth, has been adjudicated bankrupt.

A dividend is to be paid to the creditors of Thos. Louis Callender (lately trading as the Shamrock Cycle Co.), electrical engineer, Grove-place, St. Helier's, Jersey. Claims to Mr. E. W. Humphreys, 4, Castle-place, Nottingham, by April 28.

Mr. Geo. E. Corfield, Balfour House, Finsbury-pavement, London, E.C. has been appointed trustee in the bankruptcy of Joseph Aug. Bauer (trading as the Electrical & General Engineering Co.), 17, Gracechurch-street, London, E.C.

The Contraflo Condenser Co. (Ltd.) and the Contraflo Continental Patents Co. (Ltd.) have passed and confirmed resolutions to wind up the respective companies, and to appoint Mr. Wm. S. Gregg (3 and 5, Crown-court, Old Broad-street, London, E.C.) liquidator with authority to consent to the registration of and enter into an agreement with the Contraflo Condenser and Kinetic Air Pump Co. (Ltd.)

A receiving order has been made against Wm. Hy. Palmer electrician, lately trading at 7, Gt. Castle-street, Oxford-street, London, W. The first meeting of creditors will take place on April 27, and the public examination on May 6, both at Bankruptcy-buildings, London, W.C.

COMPANIES' MEETINGS AND REPORTS.

BABCOCK & WILCOX (LTD.)—The net profit during the year ended Dec. 31 last was £360,003. 15s., which, with £43,278. 19s. 9d. brought forward, made £403,282. 14s. 9d. Deducting the interim dividends (paid in October) of 3 per cent. on the preference and of 8 per cent. on the ordinary shares (£69,400), the balance was £333,882. 14s. 9d. The directors recommend that the following dividends be paid for the half-year ended Dec. 31—viz., 3 per cent. on the preference shares, less tax (£3,000), and 8 per cent. on the ordinary shares, tax free (£66,400), and also a bonus of 8 per cent. on the ordinary shares, tax free (£66,400); also that £100,000 be placed to reserve, £25,000 to dividend equalisation fund, £10,000 to a staff pension fund, leaving a balance to be carried forward of £63,082. 14s. 9d. Although the sales during 1909 did not show much improvement compared with the previous year, the year's trading was beneficially affected by some older large contracts which during 1909 came into the accounts. The companies with which the company is connected gave increased returns. The cost of production of certain of their manufactures was also reduced during the year by improvements in machinery and organisation. Those factors having increased the profit as compared with last year, the directors consider that they are justified in suggesting the distribution out of the profits of 1909 of a somewhat larger bonus.

BROMLEY (KENT) ELECTRIC LIGHT & POWER CO. (LTD.)—During 1909 the lamp connections increased from 84,052 to 89,282 8 c.p., and notwithstanding the introduction of metal filament lamps the sale of current shows a slight increase. Including £296. 19s. 11d. forward, the profit was £12,196. 1s. 5d., and after payment of interest, &c., (£3,202. 10s.) the balance was £8,993. 11s. 5d. The directors recommend a dividend at the rate of 7 per cent. (making 5¼ per cent. for the year). £2,096. 4s. 4d. is placed to reserve for renewal of plant and £2,600 to general reserve, leaving £172. 7s. 1d. to be carried forward.

CALCUTTA TRAMWAYS CO. (LTD.)—The receipts during 1909 were £174,430 and working expenses £107,677, leaving £66,752, which, with £333 brought forward, makes £67,085. Interest and dividend on preference and ordinary shares paid absorbed £42,449, leaving £24,636. The directors propose payment of a final dividend of 2s. 6d. per share (making 4½ per cent. for the year), adding to depreciation £7,000 and carrying forward £435. The year's traffic receipts exceeded those of 1908 by £8,879, due in a great measure to extensions.

CANADIAN GENERAL ELECTRIC CO. (LTD.)—The report for the past year stated that, owing to financial and industrial depression, the first half of the year showed discouraging results. Fortunately, the latter part of the year showed such decided improvement that the directors almost succeeded in equalling the earnings of the previous year. At the time of closing the books there was more work in progress in various stages of completion than since 1907. Since the close of the year the marked improvement in volume of orders received had been maintained, and present trade conditions warrant the belief that the improvement will continue. Within the last two or three months the company had secured some of the most important contracts for electrical apparatus ever awarded in any country, totalling nearly 200,000 H.P., including three generators of 15,000 H.P. each, three generators of 12,500 H.P. each, and two of 11,000 H.P. each and for size and importance had no counterpart in the world to-day.

CITY (OF BRISBANE) ELECTRIC LIGHT CO. (LTD.)—During the half-year ended Jan. 31 the output was 1,066,088 units, against 976,786 for the corresponding period of 1908-9. The revenue from sale of electricity increased by 20 per cent. The credit balance was £4,456. 3s. 5d., which, with balance forward, made £5,860. 1s. 1d. Besides the preference dividend, a dividend at the rate of 8½ per cent. on the ordinary shares, and at the rate of 8¼ per cent. on the contributing shares were paid, together with a bonus at the rate of 2 per cent. on both the fully-paid ordinary and contributing shares. The balance (£1,950. 11s. 6d.) was carried forward. Good progress has been made with the new waterside power house, and the directors have ordered another 700 kw. turbo-generator, which, with the necessary boilers, pumps, &c., will, it is hoped, be ready for use early in 1911. The laying of mains in the City Valley area has made steady progress.

INDIAN ELECTRIC SUPPLY & TRACTION CO. (LTD.)—Mr. J. G. B. Stone, who presided at the meeting on Tuesday, said that the loss which had previously resulted from the working of the tramway had been eliminated and their business was gradually improving. Electricity supply for lighting and power for fans and other purposes showed an increase, and the returns received for this year also showed improvements in all directions.

INDO-EUROPEAN TELEGRAPH CO. (LTD)—The directors' report for the year ended Dec. 31 last states that the company's traffics show a steady increase and have been carried with gratifying accuracy and speed, to which the direct working between London and Karachi has contributed to a marked extent. The company's lines are maintained in the highest state of working efficiency, but it has nevertheless become evident that the constantly increasing traffics render imperative a permanent increase in the carrying capacity of the system, and the directors are taking active measures with that object. The chief difficulty with which the company has had to contend during the year has been the simultaneous lengthy interruption of both the cables across the North Sea, in which the company has leased wires. The question of additional cross-Channel cable accommodation is also receiving the close attention of the directors.

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The revenue from message account and other sources amounts to £145,603. 17s. 5d., compared with £132,837. 4s. 4d. for 1908, an increase of £12,766. 13s. 1d. The expenses were, on commercial and general account, £49,386. 15s. 9d., and on maintenance account £28,909. 7s. 7d., total £78,296. 3s. 4d., against £75,733. 15s. 8d. for 1908, an increase of £2,562. 7s. 8d. After deduction of income tax paid and adding the balance from 1908, the available total is £70,478. 1s. 11d. Deducting interim dividend of £10,625 already paid, £59,853. 1s. 11d. remains for distribution. The directors now propose to declare a dividend for the six months ended Dec. 31, 1909, of 17s. 6d. per share (making with the interim dividend 6 per cent. for the year) and a bonus of 20s. per share, both tax free, and to make a special distribution of £12,750, equivalent to 15s. per share, out of interest upon certain investments and advance accounts. This distribution will also be tax free. They also propose to set aside £15,000 towards cost of increasing the carrying capacity of the system, and to hand over £5,000 further to the trustees of the retirement trust fund, carrying forward £7,978. 1s. 11d.

METROPOLITAN ELECTRIC TRAMWAYS (LTD.)—The total revenue for 1909 (including dividends from associated companies) amounted to £363,612. 16s. 6d. Traffic receipts (£326,441. 0s. 2d.) show an increase of £26,428. 7s. 9d. Deducting expenses, including £18,315 for reconstruction and renewals, and writing down preliminary expenses, &c., by £3,091, there remains £50,437. 9s. 11d., making, with £3,707. 8s. 3d. brought forward, a total of £54,144. 18s. 2d. The directors recommend that £6,000 be placed to reserve, that payment of the preference dividend (£25,000) be paid, and that an ordinary dividend of 5 per cent. (£19,566. 17s.) be declared, leaving £3,578. 1s. 2d. to be carried forward.

NORTH METROPOLITAN ELECTRIC POWER SUPPLY CO.—Revenue for 1909 amounted to £88,925. 8s. 11d., increase £14,051. 5s. over 1908, and expenditure was £44,504. 0s. 9d., an increase of £1,290. 18s. 4d. The balance of £44,421. 8s. 2d. at credit of net revenue account, together with interest receivable and amount brought forward, makes a total of £47,040. 0s. 8d. After providing for interest and transferring £2,000 to reserve for redemption of debentures, there remains £34,315. 6s. 3d. The directors recommend that £7,000 be placed to depreciation and £3,500 be written off preliminary expenses, &c. Cumulative preference dividend amounts to £1,976. 14s. 3d., and an ordinary dividend of 6 per cent. £21,001. 4s., leaving £837. 8s. to be carried forward. Capital expenditure during the year was £40,262. 12s. 8d., making £535,968. 5s. 9d. The total number of units sold during the year was 16,402,447, against 14,069,611, an increase of 2,332,836 (16·5 per cent.). Willesden Council have decided to continue to take from the company a supply of energy in bulk for seven years further from Februaly, 1911. The business of the North Metropolitan Electrical Power Distribution Co. (Ltd.) at Barnet, Enfield, Hertford and St. Albans continues to expand satisfactorily, the total connections to the mains at Dec. 31 being equivalent to approximately 61,450 30 watt lamps, compared with 45,200 at December, 1908. Four additional sections of light railway in Middlesex were opened for public traffic during the year, bringing the total length operated to 51¼ miles. The remaining 4¼ miles of the authorised light railways of Middlesex County Council are in course of construction, and will probably be completed before the end of 1910. The purchase of the portion of the Harrow-road tramway in London by London County Council was completed on Oct. 18 last. Since that date the company have continued to work the line under agreement. The extension of the tramway to Edgware-road is being constructed. The company holds 40,000 ordinary shares in the North Metropolitan Electric Power Supply Co., the revenue of which shows a satisfactory expansion, the number of units sold during the past year exceeding 16,000,000. The dividend receivable for 1909 amounts to £21,000 (6 per cent., against 5 per cent. for 1908).

SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO. (LTD.)—The chairman (Mr. W. Gascoyne Dalziel) stated at the meeting on Tuesday that, owing to the closing of the Cwmbran station and the working of the Treforest station by the Treforest Company, their own company was for the first time in its history not making a yearly loss on working. During last year the Treforest Company's output had increased from 7,645,125 units in 1908 to 9,833,032 units in 1909, and the cost of generating had been considerably reduced. An additional 1,300 H.P. had been connected with the Treforest area, and the total now connected was 9,825 H.P. An agreement had been entered into with Caerphilly Council for the acquisition of their provisional order. The Treforest Company were considering an extension of plant.

WYCOMBE [(BOROUGH) ELECTRIC LIGHT & POWER CO. (LTD.)—At the meeting last week it was reported that during the past year the connections had risen from 49,648 to 51,025 8 c.p., an increase of 1,377 8 c.p. Including £77. 5s. 2d. brought forward, the profit was £4,900. 4s. 7d., and after paying interest (£3,017. 4s. 2d.) the balance was £1,883. 0s. 5d., out of which payment of a dividend of 2 per cent. for the year was authorised.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

STEPHEN COTTON & CO. (LTD.) (3,548.)—Reg. in Dublin March 20, capital £20,000 in £1 shares, to take over the business of iron and brass founder, electrical engineer, &c., carried on at Belfast, by Chas. C. Cotton under the style of Stephen & Co. Private company. First directors, C. C. Cotton, J. S. Cotton and H. C. Kennedy. Reg. office, Sidney-street West, Belfast.

A. DEAN & CO. (LTD.) (108,457.)—Reg. March 29, capital £1,000 in £1 shares, to carry on the business of electrical engineers, dealers in electrical fittings, cables, wires and sundries, contractors for electric installations, &c. Private company. First directors, A. Dean and Mrs. M. St. C. Dean. Reg. office, London House, London-road, Norbury, Surrey.

ELECTRICAL ADVERTISING CO. (LTD.) (108,465.)—Reg. March 29, capital £1,500 in £1 shares, to carry on the business of engineers, machinists, electricians, machine makers and dealers, &c. Private company.

FOSTER & PULLEN (LTD.) (108,579.)—Reg. April 4, capital £5,000 in £1 shares, to carry on the business of electricians, gas engineers, &c., and to acquire the business of lighting specialists, brassfounders, &c., carried on at Bradford. Private company. First directors, W. Grange (managing director and chairman), G. Grange and H. Pullen.

STATUTORY RETURNS.

ATLAS CARBON & BATTERY CO. (LTD.)—Return to Dec. 15 gives capital as £2,000 in £1 shares, all of which have been taken up. £8 has been received and £1,992 is considered as paid. Mortgages and charges, £3,000.

BUDE ELECTRIC SUPPLY CO. (LTD.)—In return to March 26 capital is £7,000 in £1 shares, of which 4,773 have been taken up. £4,769. 12s. 6d. has been received, leaving £4. 7s. 6d. in arrears. Mortgages and charges, £2,500 mortgage debentures.

CAMBRIDGE ELECTRIC TRAMWAYS SYND. (LTD.)—Return to Feb. 21 gives capital as £5,000 in £10 shares, of which 107 have been taken up. £9. 0s. 4½d. per share has been called up on 90, £10 per share on 10 and nil on 7 shares and £911. 12s. 1d. has been received. Mortgages and charges nil.

CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO. (LTD. According to return to March 17 capital is £2,100,000 in £5 shares (130,000 preferred, 130,000 ordinary, 80,000 City Undertaking ordinary and 80,000 City Undertaking preferred). 80,000 preferred, 80,000 ordinary, 80,000 City Undertaking preferred and 70,000 City Undertaking ordinary shares taken up. £5 per share called up on 80,000 preferred, 80,000 ordinary and 80,000 City Undertaking preferred. £1,200,000 paid. £350,000 considered as paid on 70,000 City Undertaking ordinary shares. Mortgages and charges, £1,045,735.

ELECTRIC WIRING & FITTINGS CO. (LTD.)—The capital in return to Feb. 16 is £5,000 in £1 shares. 1,382 shares taken up. £1,375 paid, leaving £7 in arrears. Mortgages and charges, nil.

WASTE HEAT & GAS ELECTRICAL GENERATING STATIONS (LTD.)—In return to March 14 capital is £250,000 in £1 shares. 150,000 shares taken up. £150,000 paid. Mortgages and charges, nil. Return of allotments made up to March 19 shows a further 10,000 shares allotted for cash.

MORTGAGES AND CHARGES.

SUNBEAM LAMP CO. (LTD.)—Issue on March 23 of £600 debentures, part of a series of which particulars have already been filed.

TRAFFORD POWER & LIGHT SUPPLY (1902) (LTD.)—Debenture, dated March 30, to secure £25,000, charged on company's undertaking and property, present and future, including uncalled capital (if any). Holders, W. T. Glover & Co.

VACTITE WIRE CO. (LTD.) - Particulars of £3,000 debentures created Nov. 18, but have been filed, the whole amount being now issued. Property charged, company's plant, fixtures, stock and other assets. No trustees.

CITY NOTES.

MEMORANDA (April 14).—**Bank rate 4 per cent.** (since February 17, 1910). **Price of silver,** 24⅝d. per oz. Consols 81⅛—81⅜ for money, and 81¼—81⅜ **for account. Consols Pay Day,** May 5; **Stock and Shares Continuation Day,** April 27; **Ticket Day,** April 28; **Pay Day,** April 29; **Mining Shares Carry Over Day,** April 26.

PRICES OF METALS (London).—*Copper*, cash, 57½; three months, 58¼. *Lead*, English, 12⅞—13¼; foreign, cash, 12¾—12½. *Spelter*, foreign, 22⅜—22⅝. *Tin*, English, 146½—148½; foreign, cash, 148¼—148½; three months, 150½—150½. *Iron*, Cleveland, cash, 51/1, and three months, 51/10.

BABCOCK & WILCOX (LTD.)—The directors have declared a dividend of 3s. 2½d. per share (tax free) on the ordinary shares, making 24 per cent. for the year 1909, compared with 20 per cent. for 1908.

CONSOLIDATED SIGNAL CO. (LTD.)—The directors have declared an interim dividend for the half-year to Feb. 16 of 6d. per share (tax free) on the ordinary shares.

CUBA SUBMARINE TELEGRAPH CO. (LTD.)—The directors have declared a dividend at the rate of 6 per cent. per annum.

DIRECT UNITED STATES CABLE CO. (LTD.)—The Board have resolved to pay an interim dividend of 4s. per share (tax free) (being at the rate of 4 per cent. per annum) for the quarter ended March 31 last, payable 25th inst.

FLEMING, BIRKBY & GOODALL (LTD.)—A dividend of 6 per cent. ha been declared.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted a quotation to $20,000,000 4½ per cent. funding and real estate mortgage 50 year gold bonds (due 1950) of the *Western Union Telegraph Co.* The committee have been asked to appoint a special settling day in and grant a quotation to a further issue of £2,500,000 4½ per cent. first and general mortgage 30 year bonds (London issue) of the *New York Telephone Co.*, and also to allow 600,000 £1 fully-paid ordinary shares of *Mather & Platt (Ltd.)* to be quoted.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdire	April 1	228	+ 23	13	2,811	+ 101
Anglo-Argentine	,, 8	44.506	+ 2,290	14	604,028	+ 48,145
Ayr Corporation	,, 9	200	— 29	47	13,181	+ 4
Baker St. & Waterloo Ry.	,, 9	3,400	+ 530‖	14	48,075	+ 585
Barnsley	,, 1	219	+ 57	13	2,240	+ 187
Barrow	,, 1	280	+ 78	13	2,969	+ 439
Bath Electric Trams, Ltd.	,, 6	678	+ 3	14	9,768	+ 1,514
Birmingham Corporation	,, 9	6,412	— 136	¶1	8,449	— 1,328
Birmingham & Midland	Mar. 25	800	— 26	12	9,516	+ 301
Blackburn Corporation	April 6	912	— 59	‡2	2,200	+ 515
Blackpool and Fleetwood	.. ..	..	..	..	..	..
Blackp'l St. Anne's & Lytham	.. ..	..	..	..	..	..
Bolton Corporation	,, 10	2,132	— 1,124	2	3,094	— 1,506
Bombay	Mar. 11	2,808	+ 243	10	26,985	+ 1,839
Bournemouth Corporation	April 6	1,564	+ 135	1	1,564	+ 135
Bradford Corporation	.. ..	..	..	..	..	..
Brighton Corporation	,, 10	803	— 311	§1	1,156	— 407
Bristol Trams & Carriage	,, 8	5,336	— 240	47	269,696	+ 22,625
Burnley Corporation	,, 9	1,176	— 580	14	17,914	+ 644
Burton Corporation	,, 10	248	— 33	§1	350	— 33
Bury Corporation	,, 10	1,042	+ 617	§1	1,557	— 762
Calcutta Tramways Co.	,, 9	₹52,234	+ ₹5,970	14	₹734,214	+ ₹12,932
Camborne-Redruth	,, 9	110	— 23	14	1,652	— 17
Cardiff Corporation	,, 9	1,962	— 259	2	2,655	— 597
Cavehill	,, 1	289	+ 237	13	956	+ 261
Central London Railway	,, 9	5,680	+ 1,206	14	77,038	— 665
Charing C., Euston & H'stead	,, 9	3,785	— 25	14	53,695	+ 220
Chatham & Dist. Lt. Rys.	,, 7	754	— 60	14	10,670	+ 1,104
City & South London Rly.	,, 10	3,236	+ 445	14	46,416	— 537
City of Birmingham	,, 1	3,359	+ 673	13	36,819	+ 3,273
Colchester Corporation	,, 6	163	+ 23	14	2,245	+ 498
Cork Electric Trams Co.	,, 7	454	..	14	6,046	+ 312
Croydon Corporation	.. ..	..	..	..	..	..
Devonport & Dist. Trams	,, 1	482	+ 139	13	5,237	+ 599
Dover Corporation	,, 9	179	— 43	1	242	— 67
Dublin & Lucan Railway	,, 8	121	— 1	14	1,579	+ 70
Dublin United	,, 8	5,073	+ 202	14	70,291	+ 3,662
Dudley-Stourbridge	,, 1	1,120	+ 352	13	9,187	+ 185
Dundee Corporation	,, 6	1,165	+ 7	†47	54,750	— 490
East Ham Council	,, 9	959	— 81	¶1	1,281	— 8
Exeter Corporation	,, 8	271	— 36	1	271	— 36
Gateshead & Dist. Trams	,, 1	1,033	+ 55	13	12,428	+ 70
Glasgow Corporation	,, 9	17,259	— 202	‡45	759,076	+ 2,453
Glossop Trams	,, 3	115	+ 1	13	1,429	— 6
Gloucester Corpn.	,, 6	245	— 18	1	245	— 18
Gravesend-Northfleet	,, 1	257	+ 85	13	2,460	+ 243
Great Northern & City Rly.	,, 9	1,484	+ 144	14	21,289	— 625
Gt. Northern, Piccadilly, &c	,, 9	5,955	+ 880	14	84,970	+ 3,190
Greenock & Port Glasgow	,, 1	685	+ 218	13	6,685	+ 1,088
Hartlepool Tramways	,, 1	256	+ 48	13	2,684	+ 209
Hastings Elec. Trams Co.	,, 7	854	— 13	14	11,155	+ 1,435
Hong Kong	,, 9	$8,708	+ $512	14	$124,472	+ $10,730
Huddersfield Corpn.	,, 9	1,575	— 164	1	1,575	— 164
Hull Corporation	,, 9	2,585	— 71	1	3,443	— 435
Ilford District Council	,, 9	475	— 60	¶1	634	— 100
Ilkeston District Council	Mar. 30	155	+ 30	52	6,870	— 230
Ipswich Corporation	April 9	341	— 82	¶1	448	— 48
Isle of Thanet Co.	,, 9	313	— 176	¶27	8,125	+ 632
Jarrow	,, 1	162	+ 62	13	1,443	+ 146
Keighley Corporation	.. ..	..	..	..	..	..
Kidderminster & District	,, 1	167	+ 88	13	1,137	+ 131
Kilmarnock Corporation	,, 9	139	— 4	47	6,801	— 188
Lanarkshire Trams Co.	,, 7	1,336	+ 197	14	18,493	+ 2,081
Lancashire United	,, 6	1,094	— 103	14	17,104	+ 1,031
*Leamington	,, 1	202	+ 29	13	1,862	+ 72
Leeds Corporation	,, 9	6,367	— 512	¶1	8,622	+ 265
Leicester Corporation	,, 9	2,202	— 149	14	30,215	+ 2,747
Leith Corporation	,, 9	543	+ 34	47	27,730	+ 2,354
Lincoln Corporation	,, 9	113	— 23	2	243	— 1
Liverpool Corporation	,, 2	11,280	+ 916	13	139,437	+ 4,890
Liverpool Overhead Rly.	,, 10	1,325	— 2	15	19,420	+ 177
Llandudno & Colwyn Bay Ry.	,, 8	152	— 57	§18	2,547	+ 462
*London County Council	Mar. 26	39,091	+ 5,295	§51	1,938,003	+ 159,354
London United	April 9	5,610	— 1,423	§51	79,031	+ 8,115
Lowestoft	,, 9	137	— 11	25	4,172	+ 234
Maidstone Corporation	,, 9	205	— 62	1	205	— 62
Manchester Corporation	,, 9	13,911	— 2,749	¶1	18,619	— 1,473
Mersey Railway	,, 9	2,141	+ 87	14	27,994	+ 607
Merthyr	,, 1	290	+ 84	13	2,535	+ 8
Metropolitan Dist. Railway	,, 9	10,778	+ 1,824	14	151.168	+ 14,616
Metropolitan Elec. Trams	,, 1	8,842	+ 3,393	13	87,714	+ 20,993
Middleton	,, 1	491	+ 201	13	3,640	+ 15
Newcastle-on-Tyne Corp.	,, 9	3,573	— 331	¶1	4,827	— 998
Newport (Mon.)	,, 9	611	— 115	2	1,362	+ 17
Northampton Corporation	,, 8	426	— 24	1	475	— 77
Oldham, Ashton & Hyde	,, 1	787	+ 267	13	6,930	+ 341
Oldham Corporation	,, 10	1,551	— 721	2	4,668	— 518
Perth (N.B.) Corporation	,, 6	150	+ 10	§46	7,208	+ 78
Perth (W.A.) Elec. Trams	,, 8	1,567	+ 197	14	22,318	+ 1,572
Peterborough	,, 1	142	+ 35	13	1,293	+ 95
Portsmouth Corporation	,, 9	1,824	— 388	1	1,824	— 388
Potteries	,, 1	1,897	+ 109	13	22,133	+ 29
Preston Corporation	,, 6	654	— 19	14	9,934	+ 321
Rotherham Corporation	,, 7	551	— 34	1	551	— 34
Rothesay	,, 1	334	+ 285	13	865	+ 312
Salford Corporation	.. ..	..	..	..	..	..
Sheerness	,, 1	54	+ 14	13	544	+ 10
Sheffield Corporation	,, 10	5,560	— 97	¶2	13,830	+ 348
Singapore Trams	,, 9	$15,000	— $271	14	$138,116	+ $790
South Metropolitan	,, 1	1,047	+ 343	13	9,504	+ 1,317
South Staffs	,, 1	1,107	+ 325	13	10,464	+ 338
Southend Corporation	,, 6	424	+ 88	1	363	+ 27
Southport Tramways	,, 1	452	+ 231	13	3,125	+ 378
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 9	572	— 617	¶1	795	— 729
Sunderland Corporation	,, 10	964	— 244	2	1,426	— 394
Sunderland District	,, 9	359	— 50	23	9,390	— 520
Swansea Trams	,, 1	1,201	+ 330	13	12,648	+ 1,694
Swindon Corporation	.. ..	..	..	..	..	..
Taunton	,, 1	52	+ 16	13	515	+ 92
Tynemouth and District	,, 1	306	+ 172	13	2,004	+ 379
Tyneside Trams Co.	,, 6	345	— 46	14	5,347	+ 174
Wallasey District Council	,, 9	798	— 170	1	798	— 170
Walsall Corporation	,, 9	467	— 63	14	7,426	+ 516
Warrington Corporation	Mar. 31	416	+ 65	52	19,862	+ 541
West Ham Corporation	,, 31	3,051	+ 936	52	123,060	+ 10,008
Weston-super-Mare	April 1	183	+ 158	13	488	+ 178
Wolverhampton Co.	,, 1	590	+ 192	13	5,281	+ 372
Wolverhampton Corpn.	,, 6	856	+ 114	1	856	+ 114
*Worcester	,, 1	346	+ 107	13	3,133	+ 241
Wrexham	,, 1	129	+ 36	13	1,175	+ 61
Yorkshire W.R. Trams	,, 10	1,070	— 265	15	18,074	+ 1,811
Yorkshire Woollen District	,, 1	1,254	+ 413	13	12,145	+ 1,576

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	NAME.	Price Wed. April 13	Rate per cent. Yielded.	Dividend Due.	Business Week to April 13. High est.	Low est.
		Electricity Supply.		£ s. d.			
10	5/0	†Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½—9¾	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	9¾—10¼	5 17 0	Feb, Aug	10⅛	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	105	102
5	2/0	Bromley (Kent) El. Lt. & Power Shares	4¼—4½	5 15 9	April, Oct.	..	..
St.	4½%	Do Do. 1st Debs.	91 —94	4 15 9	May, Nov	..	..
5	5/6	†Brompton & Kensington Elec. Sup. Ord.	7⅞—7⅞	6 7 0	March	7⅞	7⅞
5	3/6	†Do. 7 per Cent. Pref.	7 —7⅛	4 13 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 9	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 —4⅛	5 11 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4⅜	4 17 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —100	4 0 0	Jan, July	98½	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	..	102½	102
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¾—4⅛	5 3 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜—4⅛	5 9 6	March	3⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	102	..
10	9/0	†City of London Electric Lighting Ord.	11⅛—12	5 16 6	Feb, Aug	11⅞	11⅝
10	6/0	†Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99 —102	4 8 0	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	†Do. 5 per Cent. non Cum. Pref.	2⅛—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7⅛—8⅛	6 1 6	Feb, Aug	8	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅛—11⅛	5 8 0	Mar, Sept	10⅜	10⅞
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103—106	4 5 0	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 0	May, Nov	..	..
5	3/6	†Folkestone Electricity Supply Co. Ord.	4¼—4⅜	5 15 0	April, Oct	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	4⅛—5¼	4 15 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	93 —96	4 14 0	Feb, Aug	..	..
5	4/6	†Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7½	5 6 8	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5¾—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94⅛—96⅛	4 3 6	..	..	..
St.	4%	†Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —97	4 1 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅛—2	4 10 0	Mar, Sept	..	..
St.	4%	Do. 6 per Cent. Pref.	4¼—5⅛	5 14 0	Mar, Sept	4⅛	..
5	2/6	Do. 4 per Cent. 1st Mort. Deb.	92 —94	4 4 0	Jan, July	..	..
5	2/3	Metropolitan Electric Sup. Ord.	4 —4⅛	5 0 0	April, Oct	4⅛	4⅛
St.	4½%	Do. 4½ per Cent. Cum. Pref.	4⅛—5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	84	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	96½—98½	4 11 6	June, Dec	..	..
100	4½%	Newcastle & Dist. Elec. Ltg. 4½ per Cent. Deb.	82 —86	5 2 6	Jan, July	..	..
5	4/0	†Newcastle Elec. Supply Ord.	4¼—4⅜	4 5 0	Feb, Aug	..	..
5	5%	†Do. 5 per Cent. non Cum. Pref.	4⅛—4⅝	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	99 —101	4 19 0	..	..	..
10	9/0	Notting Hill Electric Ord.	11¾—12¼	5 17 6	March	..	..
5	4/6	Oxford Electric Ord.	6¼—6½	5 4 0	March	6⅞	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 —97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅛—9	5 11 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6½—7⅛	4 16 9	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84—88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1⅜—2⅛	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3⅛	6 11 0	April	..	..
St.	5%	Do. 5% 1st Mort. Stock (red.)	100 —103	4 17 6	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅞—1	4 14 0	..	..	..
1	0/8⅓	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	..	..
St.	4½%	†Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	†Urban Electric Supply Ord.	⅛—1	..	April, Oct	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	1⅛—2	..	April, Oct	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8½—9	5 10 0	Mar, Sept	9	8⅞
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5⅛	4 2 0	Jan, July	5⅛	5⅛
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97⅛	96½
1	..	Bath Elec. Trams Pref. Ord.	⅛—¼	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	7/16—⅛	7 4 0	Jan, July	..	..
St.	4½%	†Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock	83 —86	5 5 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	7⅛—8	7 10 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7¼—8⅛	4 17 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	1 —1⅛	..	June, Dec	..	..
10	3%	Do. 6 per Cent. Cum. Pref.	3⅜—3⅝	7 14 6	Feb, Aug	3⅜	3⅛
St.	5%	†Do. 5 Cent. Perpetual Debs.	90 —93	5 7 6	April, Oct	90½	89½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 —72	6 5 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	70 —72	5 4 6	Feb, Aug	71	..
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	86½	..
St.	2%	Do. Deferred Stock	53 —55	3 12 0	Feb.	54	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	102	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk.	96 —99	4 2 0	Jan, July	97½	96½
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4⅜—5¼	4 17 5	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	99 —103	3 17 6	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	35 —36	4 9 0	Feb, Aug	35⅜	34
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	106 —108	4 12 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —105	4 15 0	Feb, Aug	..	..
St.	5%	Do. (1901)	100 —103	4 17 10	Feb, Aug	..	..
St.	5%	Do. (1903)	99 —102	4 18 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 —102	3 18 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	7/8	..
10	12/0	†Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¼—⅜	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 —98	4 2 0	Jan, July	97½	92½
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	†Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	70 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅜—1⅞	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2⅛—3⅛	..	Jan, July	3⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	71 —74	5 8 0	Jan, July	74	71⅜
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	10½	Metropolitan Elec. Tramways Ord.	25/32—27/32	..	..	¾	..
1	..	Do. Deferred	13/32—½	..	April	13/32	..
1	0/6	Do. 5 per Cent. Cum. Pref.	11/16—13/16	5 12 9	Feb, Aug	23/32	11/16
St.	4½%	Do. 4½ per Cent. Deb. Stock	96 —99	5 1 0	Jan, July	96½	96⅜
St.	1%	Metropolitan Railway Consolidated	44⅜—45⅛	1 1 3	Feb, Aug	45⅛	44⅛
St.	2½%	Do. Surplus Lands Stocks	68 —70	3 18 0	Feb, Aug	69	68⅛
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90⅛	89⅛
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	87⅛	86⅛
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87⅛	86⅛
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	93½	92½

* In calculating the yield allowance has been made for accrued interest, but not for redemption
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Wed., April 13	Rate per cent. Yielded.	Dividend Due.	Business Week to April 13. High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 0	Jan, July	92½	..
St.	..	Metropolitan District Railway Ord.	22⅞—23¼	..	Feb, Aug	23½	22⅝
St.	..	Do. Extension Pref. (5 per Cent.)	69 —71	..	Feb, Aug	70½	69
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	..	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	76¾	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	102¼	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	143 —145	4 2 9⅞	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	..	..
..	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅛—⅜	..	May	..	..
1	..	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅜	6 14 0	Feb, Aug	⅜	..
St.	4½%	Do. 4½ per Cent, Deb. Stock	84 —87	5 2 6	May, Nov	..	..
1	..	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—⅝	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	67 —71	5 12 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	62 —67	7 5 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoups	38 —40	..	June, Dec	40½	38½
..	5%	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103½	..
..	4½%	Do. 4½% Bonds with coup. 5	89 —91	4 19 0	..	90⅛	89½
..	4%	†Do. 4 per Cent 1st Power Ho. Dbs.	97 —99	4 1 0	..	..	..
1	..	Yorkshire (W.R.) Elec. Trams. Ord.	⅛—¼	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛—2⅛	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	80 —83	5 8 0	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101 —103	4 7 0	..	..	..
1	..	Aron Electricity Meter Ord.	1/16—⅛	..	..	3/32	..
1	7/16d.	Do. 6% Cum. Pf.	⅛—¼	6 8 0	April, Oct	7/32	..
1	1/7/16	Babcock & Wilcox Ord.	5¼—5⅜	3 14 3	April, Oct	5/11	5
1	0/7½	Do. Pref.	1 7/16—1 9/16	3 16 3	..	..	..
5	6/0	†British Insulated & Helsby Cables Ord.	6½—7⅛	6 18 0	July, Feb	7⅜	7¼
5	3/0	Do. 6 per Cent. Pref.	6 —6½	4 10 9	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	90 —94	4 15 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅜—⅝	..	Feb, Aug	9 7/16	..
100	6%	†Do. 6 per Cent. Prior Lien Dbs. (rd.)	97 —99	6 1 0	..	47	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	47 —51	7 16 0	Jan, July	..	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	25 —29	15 10 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.	10 —10⅜	6 3 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 11 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	102½—104½	4 6 0	Nov, May	..	..
1	1/9/16	Castner-Kellner Alkali Co.	2 1/16—2 1/8	5 1 9	May, Nov	2 3/32	2⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	104 —107	4 4 0	Feb. Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	1⅛—1 3/16	6 11 9	March ..	..	..
..	0/7½	†Do 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/7½	Consolidated Electrical Co.	⅜—½	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.	1/16—1 1/16	6 12 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	⅜—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	⅜—½	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	7/16—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	⅜—1	6 0 0	Sept.	..	..
5	0/7½	†Do. 6 per Cent. Cum. Pref.	1 5/16—1 5/32	5 5 3	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	1/16—⅛	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1⅛	9 3 0	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St.	5%	†Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	3/16—⅜	..	Jan, July	..	..
..	..	Do. 6 per Cent. Cum. Pref.	1⅛—1½	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	72 —75	6 0 0	Jan, July	..	..
2	..	Electric Construction Co.	⅜—½	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	10 4 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	61 —66	6 1 0	Jan, July	..	..
St.	5%	†Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	61 —66	7 11 6	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅛—8½	6 1 6	June, Dec	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Debs	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	5 —5⅜	4 3 9	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	105½—107½	4 3 6	Mar, Sept	16 1/16	15⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	15⅛—16⅛	6 3 0	Feb, Aug	..	..
10	15/0	India Rubber, Gut. Per., &c., Works	10⅜—11	4 11 0	..	..	..
10	5/0	Do. 5 per Cent. Cum. Pref.	98½—100⅛	3 19 6	April, Oct	..	..
100	4%	†Do. 4 per Cent. Debs. (red.)	1/16—⅛	..	April	..	..
1	..	National Elec. Construction Co.	3/16—¼	..	Nov	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	31/32—1	..	May, Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	80 —85	5 6 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	1½	..	..	..	..
1	..	Simplex Conduits Ord.	5 —5½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	34 —35½	5 16 0	Mar, July	35⅛	34
12	30/0	Telegraph Construction & Maintenance	100 —102	3 18 0	Jan, July	..	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	2 1/16—2¼	4 9 0	..	2⅛	2 1/32
1	1/0	†Vickers, Sons & Maxim, Ltd., Ord.	1 1/16—1⅛	4 4 3	..	..	..
1	0/6	†Do. 5 per Cent. non-Cum. Preference	109 —112	4 11 0	..	..	..
St.	5%	†Do. 5 per Cent. non-Cum. Preferred	102 —104	3 16 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	104 —106	4 5 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105½—107⅛	4 13 0	..	106¼	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip	9½—10½	7 12 0	..	..	..
10	8%	J. G. White & Co. 6% Cum. Pref	1 1/16—1⅛	..	..	..	..
1	..	Willans & Robinson Ord.	1½—2½	9 0 0	Apr, Oct	1⅞	..
5	1/6	Do. 6 per Cent. Cum. Pref.	68 —73	5 9 0	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.			May, Nov		
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3¾	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100 —102	4 18 0	June, Dec	..	..
St.	27/6	Anglo-American	59 —61	5 19 0	F,My,Ag,N	59	..
St.	30/0	Do. Preferred	102½—103½	5 17 0	F,My,Ag,N	103⅛	102
St.	25/0	Do. Deferred	18½—13¾	6 9 6	F,My,Ag,N	18⅜	..
St.	4%	†Commercial Cable 4 per Cent. Deb. Stk.	87 —89	4 10 0	Jn,Ap,Jy,O	88⅛	..
10	6/0	Cuba Submarine Ord.	8½—9⅛	6 10 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17 —18	5 11 0	Feb, Aug	..	..
5	2/0	†Direct Spanish Ord.	3⅛—3⅜	5 15 0	April, Oct	..	..
5	5/0	†Do. 10 per Cent. Cum. Pref.	7⅜—8⅛	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable	13½—14	6 1 0	Ja,Ap,Jy,O	13½	..
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.)	100 —102	4 18 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	137 —140	5 0 0	Ja,My,Jy,O	138½	..
St.	17/6	Do. 3½ per Cent. Pref. Stock	86 —88	4 0 6	Ja,My,Jy,O	88	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 15 6	May, Nov	104½	..
St.	2/6	Eastern Extension	12⅝—13½	5 7 6	Ja, Ap, Jy,O	13½	12⅝
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	102½	101
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	101 —103	3 17 6	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 78	31½—32½	5 15 6	Jan, July	31⅜	..
100	4½%	Halifax & Bermuda 4½% 1st Mt.Db.(red.)	100 —102	4 8 0	June, Dec	..	..
..	12/6	Indo-European	54½—56½	5 15 9	May, Nov	55	54½
100	$1½	Mackay Companies Common	92 —94	4 15 9	Ja,Ap,Jy,O	..	..
100	$1	Do. Preference	80 —84	4 15 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	3/16—¼	..	April	3/16	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	98 —100	4 0 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅜—1⅝	3 14 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	1/16—1/16	..	May, Nov	1/16	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9¼	6 10 0	May, Nov	9⅛	8⅛
0	20/0	Do. 6% 2nd Pref.	8½—9⅛	6 10 0	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	100½—102½	4 17 6	Jan, July	..	..
10	3/0	Western Telegraph	13⅜—14½	5 0 6	Mr,Jn,O,D	13 15/16	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	..	..
..	4%	Western Union Telegraph, $1,000 4% Bds.	103 —106	3 15 6	..	..	..

Share	Last Dividend	NAME.	Price Wed., April 13	Rate per cent. Yielded.	Dividend Due.	Business Week to April 13. High-est.	Low-est.
		Telephones.		£ s. d.			
100	2$	†Amer. Telephn. & Telegh. Cap. St.	140 —142	5 12 6	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	94½	..
St.	4%	Do. 4% Cons. Bonds 1936	104 —106	3 15 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99½—101⅛	4 18 6	Mar, Sept	..	..
5	3/0	Chili Telephone	8 1/16—8⅛	4 15 3	August ..	8⅛	..
1	0/7/8	Monte Video Telephone Ord.	1/16—1	7 0 0	Nov	1	..
1	0/6	Do. 5 per Cent. Pref.	1/16—⅞	5 14 6	May, Nov	..	..
St.	6%	National Co. Pref. Stock	104 —105⅛	5 15 6	Feb, Aug	105	104
St.	6%	Do. Def. Stock	123½—125⅛	4 15 6	Feb, Aug	124⅞	123
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—10⅞	5 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —10⅜	5 10 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜—5⅝	4 9 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	100	99
100	4%	New York Telephone Co. 30 yr. Bnds. Scrip	100½—101¼	4 8 9	..	101¼	100
1	0/7½	Oriental	1⅛—1⅜	5 7 6	April, Oct	1⅜	1 3/32
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16—1⅛	4 11 0	April, Oct	1⅛	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	87¼	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100 —102	4 8 0	Jan, July	101¼	..
5	3/0	United River Plate	7⅛—7⅜	5 9 0	July	7 3/16	7⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜—5⅝	4 9 0	June, Dec	5⅜	..
St.	4½	Do. 4½ Deb. St. Red.	103 —105	4 5 6	Jan. July	..	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	2⅞—3⅛	8 18 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10½—11	5 9 0	Sp,DcMrJu	10⅝	10¼
10	3/0	Do. 6 per Cent. Pref.	13½—13⅝	4 8 0	Sp,DcMrJu	..	..
10	6%	Submarine Cables Trust (Cert.)	13:—134	4 9 6	April, Oct	13⅛	131
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4 1/16—4 1/8	5 7 0	April, Oct	4⅛	4⅛
5	2/6	Do. 5% Cum. 2nd Pref.	4 1/16—4 1/8	5 5 6	Jan, July	4⅛	4⅛
St.	4%	Do. 4% Deb. Stock	90 —91¼	4 7 6	June, Dec	91¼	90½
St.	4½%	Do. 4½% Deb. Stock	96 —98	4 12 0	..	97⅜	97
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	105 —107	4 13 6	Jan, July	105¼	104½
St.	5%	Brisbane Electric Trams. Invest. Ord.	6½—7⅛	4 5 6	May	..	..
5	3/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 15 0	May, Nov	..	..
5	2/6	Do. 4½ per Cent. Db. Prov. Certs.	101 —104	4 6 6	Jan, July	..	..
St.	4½%	British Columbia El.. Rly. Df. Ord.	144 —148	5 8 0	Mar, Sept	148	145
St.	8%	Do. Pref. Ord. Stock	121 —125	4 16 0	May, Nov	123	120½
St.	6%	Do. 5% Cum. Perp. Pref. Stock	102½—111½	4 9 6	Jan, July	111⅛	110¼
St.	5%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 7 0	April, Oct	..	..
40	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
100	4½%	†Do. 4½% Perp. Con. Deb. St.	101½—103½	4 1 6	..	102½	101⅞
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	..	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	92 —95	6 4 6⅜	Feb, Aug	..	..
5	2/0	Calcutta Tramways (1 to 137,610)	4⅜—4⅞	4 2 6	Mar, Sept	4 1/16	4⅛
100	2/6	Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red)	99 —102	4 8 0	Jan, July	..	..
St.		Cape Electric Tram Shares	1/16—⅛	..	..	..	..
St.	5%	City of Buenos Ayres Trams Co. (1904) Sh.	5⅜—5⅞	4 8 3	F,My,A,N	5⅜	..
5	1/3	Do. 4 per Cent. Deb. Stock	97 —100	4 0 0	June, Dec	..	..
5	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 —99	5 1 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94½—97⅛	5 2 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	1/16—⅛	..	..	..	..
5	2/0	Do. 5 per Cent. "A" Deb. Stock	96 —98	5 2 0	Jan, July	..	..
10	6%	Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	77⅛	..
100	0/7½	Lisbon Elec. Trams. Ord.	1 1/16—1⅛	4 0 6	July	1⅛	..
100	5%	Do. 6 per Cent. Cum. Pref.	1 1/16—1⅛	5 5 3	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
100	$1½	Manila Elec. Ry. $1,000 Gold Bonds	95 —97	5 2 6	Feb, Aug	..	..
100	5%	Mexico Trams Co. Com. St.	132 —134	4 12 0	..	133⅛	..
100	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	95 —96	5 3 6	..	95⅛	94⅛
St.	6%	Do. 6% 50 yr. Mort. Bds.	99 —100	6 0 0	..	99½	92⅛
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..	103⅛	103
1	0/6	Perth Elec. Trams Ord.	1⅜—2	6 13 4	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅞	5 2 6	..	..	..
	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	..	..
	$1	Rio Janeiro Tram, Lt. & P. Co.	96 —95	4 2 0	..	97⅛	90⅜
	5%	Do. 30 yr. Gold Bnds.	97 —98	5 2 0	..	97⅜	96⅛
	5%	†Do. 50 yr. Mt. Bnds	86½—87½	5 14 0	..	87⅜	86⅛
	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	150½—152½	6 11 0	..	151	..
		Do. 5 per Cent. 1st Mt. $500 Db.	103 —105	4 15 0	June, Dec	1	3/4
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
100	5%	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅞	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 9 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 —96	4 13 6	Jan, July	96	..
St.	4½%	Do. 5 per Cent. 2nd Mort. Deb. Stock	96 —98	4 18 0	..	97⅛	..
5	3/3	Calcutta Elec. Supply Ord.	6⅛—6⅞	5 18 9	April, Oct	6⅞	6⅛
100	7/2½	Canadian Gen. Elec. Co. Com. St.	114 —117	6 0 6	..	116⅛	115½
100	$3½	Do. 7% Cm. Pf. Stock	117 —120	6 0 0	..	..	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
500	5%	Elect. Development Co. of Ontario	83 —85	5 16 0	..	84½	84
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅜—½	8 0 0	April, Oct	3/8	1/4
5	..	Madras E. S. Corp. Ord.	2⅛—2½	..	..	..	..
		Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock	92 —94	5 6 9	..	93⅛	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84⅛—85⅛%	5 16 6	..	85	..
		Mexican Lt. & Power Co. Com. St.	81 —83	4 16 6	..	83⅛	82⅛
	$1	Do. 5% 1st Mort. Gold Bnds.	90 —91	5 9 0	..	90⅛	90
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	137 —141	4 15 0	F,My,A,N	140⅛	..
		River Plate Electricity Co. Ord.	1⅞—2	4 0 0	April	..	..
		Do. 6 per Cent. non-Cum. Pref.	1 3/32—1⅜	4 18 0	May	..	..
100	4%	Do. 5 per Cent. Deb. Stock	103 —106	4 14 6	Jan, July	..	..
2½	1/3	†Rosario Ele. Co. 6% Pref. (1-20,000)	6 —6⅛	4 12 0	April, Oct	..	..
100	4%	†Do. 2nd Pref.	8⅛—8⅜	6 14 6	..	..	..
10	..	Shawinigan Water& Power Co.Ca.	103⅜—105⅛	4 5 3	..	104⅛	104
10	6/0	Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	109	..
0	20/0	Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102⅛	102
100	5%	Toronto Power Co. 4½% Db. St.	101 —103	4 7 6	..	..	..
10	3/0	Victoria Falls Power Co. Pref.(1 to 800,000)	⅜—½	5 14 0	Jan, July	⅜	..
		Do. (800,081 to 1,700,000)	⅜—½	..	..	..	..

‡ Accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,666. [No. 2. Vol. LXV.] FRIDAY, APRIL 22, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

The Institution of Electrical Engineers.

The following nominations for the new Council of the Institution of Electrical Engineers were announced at the meeting yesterday evening:—

President.

S. Z. de Ferranti.

Vice-Presidents.

W. H. Patchell. — W. Duddell, F.R.S.
J. H. Rider. — S. Evershed.

Members of Council.

H. Dickinson. — W. Judd.
J. E. Kingsbury. — Prof. T. Mather, F.R.S.
P. V. McMahon. — W. M. Morrison.
R. K. Morcom. — Major W. A. J. O'Meara, C.M.G
S. L. Pearce. — J. F. C. Snell.
W. W. Cook. — G. Stoney.
G. K. B. Elphinstone. — A. H. Walton.
C. H. Wordingham.

Associate Members of Council.

S. Morse. — E. Russell Clarke. — J. E. Taylor.

Hon. Treasurer.

Robert Hammond.

The names printed in italics are new nominations. The hon. treasurer retires annually, and is eligible for immediate re-election.

WE are sure that the nomination of Mr. FERRANTI as President will meet with unanimous approval, the only question that may arise being why this honour did not fall to his lot some years ago. His name was bound up with the industry in its early days, and those were days when problems of the greatest importance had to be solved with very little previous knowledge. The Deptford station, with its eight miles of high-tension transmission and special tubular mains, was regarded as a very doubtful experiment, and in the darkest days of the London Electric Supply Corporation young engineers used to travel to Deptford and view with wonder the castings of the (in those days) huge alternators, which, unfortunately, fate destined only for the scrap heap. It all seems very simple now, and what then appeared to be a mistake has turned out to be the right thing in the end. But Mr. FERRANTI, like many other men of note, was before his time, though we must confess this scarcely seems a good reason why he should be after his due time in filling the presidential chair of the Institution. Of the other new members, it may be said that they are all known to our readers as having attained to recognised positions in the electrical world or allied industries. Mr. PATCHELL and Mr. RIDER remain on the Council, but fill the more important positions of Vice-Presidents. We are glad to see the return of Mr. KINGSBURY, while Mr. MCMAHON, who has for so long been identified with the City & South London Railway, comes on as a new member. There is evidently a wish, which we think is highly desirable, to draw the local sections closer to the central body, for the remaining new members are chairmen, or past chairmen, of local sections, namely, Mr. DICKINSON, of Leeds, Mr. MORCOM, of Birmingham, and Mr. PEARCE, of Manchester. As an associate member of Council, Mr. MORSE once more places his legal and parliamentary knowledge at the service of the Institution.

The Westminster Street Lighting Contract.

THE proceedings at the meeting of the Westminster City Council, reported in our last issue, when the recommendations of the Works Committee regarding the renewal of the street lighting contracts were adopted, appear at first sight absolutely to rule out any claims that have ever been made on behalf of electricity for this purpose. Gas lighting is held up as being much cheaper in every way, while electric lighting is stated to be both expensive and of a disagreeable colour. When, however, we come to examine the question further we find that the Works Committee possess

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in their chairman, Mr. JACQUES ABADY, a gentleman who is an out-and-out supporter of gas, and who lost no time in bringing before the meeting his own somewhat biased views on the subject. It is further apparent that the desire of a section of the Council was to rush the matter through in spite of the fact that the existing contracts, with a few exceptions, do not expire until next December.

THIS being the case, it was not altogether a surprise to find, on examining the contract figures, that it was proposed to supply and maintain the gas equipment at a price which seems rather "over-cheap." To take the 90 c.p. unit, the smallest for which a price was given, the Gas Light & Coke Co. offer to maintain a lamp of this power for a period of 15 years for a sum of £2. 12s. 6d. per annum (3,940 hours). Now, Mr. J. W. BRADLEY, city engineer of Westminster, as a result of tests made by him on the street lighting in Westminster (*see* THE ELECTRICIAN, March 11, 1910), showed that a gas lamp giving on an *average* 83 c.p. cost £1. 18s. 6d. per annum to maintain, exclusive of the cost of the illuminant. Taking this figure in the present instance, we find that a sum of 14s. per lamp per annum is left to pay for the gas. The type of lamp under consideration consumes, according to Mr. BRADLEY, 7·5 cubic ft. of gas per hour, so that the Gas Company are supplying gas for street lighting in this instance at a price of 5½d. per 1,000 cubic ft.—a rather different figure from the 2s. 10d. which the ordinary private consumer is charged, and from the 2s. 5d. which the City Council has been paying up to the present for practically the same lamps in Victoria-street. Even if the new conditions permitted a reduction in the amount of gas by one-third, and a corresponding increase in the price, the difference would still remain very large. Another point to notice in this connection is that to obtain the requisite 90 c.p. the Gas Company must use two mantles per lantern, unless, of course, they employ high pressures — an arrangement which is practically impossible, considering the relatively small units and the length of streets that have to be covered, and would at any rate mean an even greater cost.

WITH regard to the cost of maintaining high candle-power lamps, Mr. A. A. VOYSEY, electrical engineer to the City of London, showed that a 3,000 c.p. gas lamp cost the Corporation £46 per annum. The Gas Light & Coke Co. propose to maintain a similar lamp in Westminster for a sum of £20. 5s. per annum, gas being included in both cases. The discrepancy is somewhat large. In this connection it may be noted that the Gas Company will have some considerable difficulty in obtaining and maintaining a unit of 3,000 c.p. Even with the most modern arrangements they will probably have to erect three lanterns on one post for the purpose, the great amount of heat given out by large mantles making it impossible to use more than a certain number of mantles in one lantern.

ONE other point in connection with the financial side of the question may be noted. The prices given for the installation of the two systems of illuminants show a large sum in favour of gas. But it should be pointed out that this sum includes, in the case of electric light, the laying of long lengths of new mains, while in the case of gas the mains are already laid and their first cost has been paid off under the previous contract. The whole of the figures dealing with this subject given in the Committee's report are set out on another page of this issue and we recommend them to our readers as being of great interest.

WE cannot congratulate the Gas Company on the tactics they have adopted on this occasion. It is true that they would have lost heavily if the street lighting had gone out of their hands, for they possess little other load in Regent Street; but, on the other hand, this example of price-cutting will scarcely help them in their relations with the other metropolitan authorities. They have extensive contracts for street lighting with both the Paddington and Holborn Borough Councils, for which they are being paid on a considerably higher scale than 5½d. per 1,000 cubic ft., and these Councils will not unnaturally inquire why Westminster should receive preferential treatment. We are often informed by gas engineers that electric lighting authorities in charging a private consumer 5d. a unit and the street authorities 2d. a unit are doing the ratepayers grievous wrong. May we not point out that the Gas Light & Coke Co., in charging 2s. 10d. and 5½d. respectively are analogously doing their shareholders about 2½ times more damage, without, moreover, a legitimate reason for so doing, as questions of load factor do not arise. We cannot help feeling that the Gas Company has set itself too hard a task. Its request for the reduction of the penalty for not supplying the proper candle-power from 5s. to 6d. seems to show that it is not quite so confident as it should be of carrying out the terms of the contract. We should like, therefore, to see the whole matter more fully discussed than has been the case up to the present. The Westminster ratepayers are entitled, we agree, to obtain the cheapest and most efficient light, but it must be pointed out that to supply an article at 4d which cost 2s. to produce, is in the long run neither cheap nor efficient for any one concerned.

ONE point in conclusion, from the standpoint of the electrical industry. A contract of this kind is important because the result is accepted by the general public without inquiry into the reasons underlying the decision. If, in future, the tenders for London street lighting are to be put in by gas companies at unremunerative figures, and excessive price cutting is to be the order of the day, this fact should be clearly realised. The gas companies are at an advantage in the fight because they are not numerous and they each cover large areas; consequently, they can afford to enter into unremunerative contracts if such a policy seems desirable. Electric light undertakings are not in such a fortunate position, and the loss to any one undertaking might be serious. Under these circumstances is not combination possible? There is already a joint Publicity Committee. If it is essential, in the interests of the industry, that unremunerative public lighting be undertaken in certain areas, such as Regent Street, why should not the various electrical undertakings combine to share the loss? It is a case of advertising.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Balik Papan—Kwandang	Nov. 1, 1909
Para—Maranham	Mar. 16, 1910
Malta—Tripoli	April 20, 1910

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Railway Electrification in Chile.—It is reported by Reuter that the Chilian Government will, in May, ask for tenders for the electrification of the railway from Santiago to Valparaiso and its branches, the total length of line being 156 miles.

Cross-Channel Telephones.—In addition to the new London to Paris telephone cable to be shortly laid between Dover and Cape Grisnez, preparations are, it is announced, being made at Dover for laying an additional telephone cable across the Channel to Belgium, in order to connect up the principal centres of England beyond London with Brussels and Belgium. The Continental telephone cables have been so successful that the demand for their use has far exceeded anything which was anticipated. The new cable contains four lines giving two complete circuits, and will be laid between St. Margaret's Bay, Dover, and La Panne, near Ostend. There are now eight distinct telephone services, and they are quite unequal to the demand.

Industrial England in the Eighteenth Century.—On Wednesday last a Paper with this title was read at the Royal Society of Arts by Sir Henry Trueman Wood, secretary of the Society. The Paper dealt in some detail with the condition of the various industries then existing. In 1754 England was just ceasing to be an agricultural country, with no exports except raw materials, and no manufactures, and was preparing for the industrial revolution which in another half century transformed her into the workshop of the world. The change was due to the improvement of the steam engine at the hands of James Watt, and the consequent development of a great manufacturing system dependent on the motive power which could only be provided by steam. In the first half of the century spinning and weaving formed a bye-industry carried on by the country folk to supplement their agricultural earnings. In the second half, the textile manufacture had drifted into the cities, and was becoming the enormous industry it now is. In 1754 the iron manufacture was almost dead, because all the available wood had been turned into charcoal and used up. A few years later iron was being made with coal supplied in inexhaustible abundance from deep pits drained by the steam engine. Power provided iron and coal; iron supplied the material for new engines, and for machines to be driven by them, while the coal afforded a limitless source of power. Taking this main fact for his text, the author showed how the different industries of the country had been affected by the reciprocal influence of one upon another, and how their development had started from a point which might fairly be taken as coincident with the date of the foundation of the Society. It was, indeed, this sudden industrial development that led to the foundation of the Royal Society of Arts, the only one, among several started at the same time, which had lasted to the present day.

Determination of Depreciation.—Users of industrial plant and machinery are often at a loss to know what amount should be charged to profit and loss as depreciation, or loss of value caused by wear and tear, natural decay and obsolescence. Depreciation is one of the most difficult (and often one of the most neglected) questions connected with the ascertainment of annual profit, and there has hitherto been no recognised means of determining it in a scientific way. The appearance, therefore, of "Leake's Register of Industrial Plant" (London: Henry Good & Son, 12, Moorgate-street, E.C., price 5s. 4d., post free) for the classification of capital outlay and the measurement of depreciation, with introductory notes by Mr. P. D. Leake, F.C.A., is opportune. This register enables depreciation to be calculated on the original cost of each class of industrial plant, the calculation being based, as it should be, on the estimated efficient life periods, enabling revised estimates of these to be made and recorded at any time, and accounting effect being given to such changes. We note that the register for the first time makes possible continuous co-operation between engineers and accountants in this difficult problem, a point of great importance, especially in large works, where the accountants' rule-of-thumb method of calculating depreciation is not to the liking of engineers, who point out the impossibility of forecasting accurately the length of the efficient life of any kind of plant, in consequence of which it is necessary to revise original estimates as time goes on and more becomes known of the behaviour and prospects of the plant. It is proposed by Mr. Leake to leave this part of the work entirely to the engineers, whose written instructions in the register will be automatically acted upon by the accountants in measuring the annual depreciation necessary to be charged in the annual accounts.

The Comparative Effects of Protection and Free Trade upon the Electrical Industry.—We are informed that the National Electrical Manufacturers' Association will hold a meeting at Caxton Hall, Westminster, on Monday, May 23rd, at 8 p.m., when a discussion on this subject will be opened by Mr. Hugo Hirst from the Protection point of view, and Mr. J. E. Kingsbury from the Free Trade point of view. The chair will be taken by Mr. H. W. Butler, of the Electric Power Storage Co., the chairman of the Association. No resolution will be placed before the meeting or vote taken, and only those who are directly connected with the electrical industry will be allowed to take part in the discussion. Any person desiring to take part in the discussion is requested to send his name to the Secretary before May 21st. The Association does not hold itself responsible for the views expressed at the meeting. This action will doubtless be welcomed by many members of the profession

Cable Barge for Rio de Janeiro Bay.—The following particulars of a cable barge which is being supplied by Messrs. Siemens Bros. & Co. to the order of the Director-General of Telegraphs of Brazil, for the purpose of laying and repairing submarine cables in the Rio de Janeiro Bay, will be of interest to our readers. The principal dimensions of the barge, which is built of mild steel, are: Length between perpendiculars 90 ft., breadth moulded 20 ft., depth 6 ft. It will carry 150 tons on a 5 ft. draught. The barge will be fitted with a two-sheave bow-sheave, a combined picking-up and paying-out machine supplied with steam from a vertical boiler, and a cable tank 13 ft. 6 in. in diameter by 5 ft. deep, over which a curved sliding cover is arranged, thus allowing sufficient head room for the men in the tank and, at the same time, protecting the cable from the sun's rays. A testing room has also been built in the vessel's hold, with a skylight projecting through the deck, and she will further be equipped with a complete outfit of buoys, ropes, chains and the usual tools for jointing and splicing cables. At the forward end the plating has been carried up to form a support for the bow girders, and aft the deck is raised so as to enclose the boiler and stoking space as well as to form a platform for the helmsman, who will thus have an uninterrupted view of the entire length of the vessel. The maximum depth of water in which the barge is expected to effect repairs is 25 fathoms, and she has been designed to carry her full load of 150 tons on a draught of 5 ft. The vessel was launched on the 12th inst., is now being fitted with masts and sails, and, all being well, will proceed under sail and unaccompanied by any other vessel on or about May 1st for Rio. She has permanent sleeping accommodation for two hands, and temporary arrangements will be made for the remainder of the crew of about seven hands who will navigate this small vessel to the other side of the Atlantic.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

We publish an article giving interesting particulars of the progress made in street lighting by means of high candle-power metal filament lamps, more particularly at Wimbledon.

Mr. G. W. O. Howe contributes an article "On the Effect of Shunting Inductive Coils."

Before the Institution of Electrical Engineers last night a Paper was read by Mr. A. V. Clayton on "Hydro-Electric Installations in Sweden."

We give an account of the discussion which took place last week before the Illuminating Engineering Society on the subject of "Recent Developments in the Measurement of Light and Illumination."

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An inquiry was held last week into the application of Ashton-under-Lyne Corporation for permission to borrow £48,424 for additional generating plant, &c.

Parliamentary.—On Wednesday Section B of the Local Legislation Committee of the House of Commons approved a proposal by Bradford Corporation to establish the railless trolley system of electric traction on one route.

Companies' Meetings.—At the recent meeting of the Pacific Oilfields (Ltd.), the chairman announced that, owing to the appearance of microscopic globules of water in the oil wells, they had decided to put down an electrical cleaning plant.

Mr. E. Garcke was able to make a very satisfactory statement as to the position of the Metropolitan Electric Tramways (Ltd.), and incidentally the North Metropolitan Power Co., at the meeting of the shareholders of the former undertaking last week. It also appears that the extensive network of tramways and light railways operated by the Metropolitan Electric Tramways is now completed, except for a few small linking-up lines.

INSTITUTIONS AND SOCIETIES.

Iron and Steel Institute.—The annual meeting of this Institute will take place on May 4 and 5 at the Institution of Civil Engineers, Great George-street, Westminster, under the presidency of the Duke of Devonshire. The Papers to be read will include, among others, the following: "On the Girod Furnace and the Electric Smelting Works of the Paul Girod System," by Prof. W. Borchers; "On the Progress of Electric Smelting," by Mr. D. F. Campbell, and "On Developments in the Production of Electric Power: Its Application and Bearing upon the Iron and Steel Industries," by Mr. D. Selby-Bigge. The annual dinner will be held at the Hotel Cecil on Wednesday, May 4th, at 7 p.m. The Great Western, the London & North Western, the Great Central, the Midland, the Great Northern, the North Eastern, the Great Eastern, the South Eastern & Chatham, the London & South Western and the Lancashire & Yorkshire Railway Companies, have arranged so that members attending the meeting can obtain a return ticket to London at the rate of a single fare and a quarter (minimum 1s.) on presentation of a voucher at the booking office of the station from which they travel. These tickets will be available from the day before, to the day after, the Meeting. The voucher will be supplied on application at the Institute offices. The autumn meeting will be held at Buxton on Tuesday, Wednesday and Thursday, September 27th, 28th and 29th. The morning sessions for the reading and discussion of Papers will be held, by kind permission of the municipal authorities, at the Pavilion, Buxton. An influential committee is in process of formation to carry out the necessary arrangements, of which due notice will be given to the members at a later date.

The Electric Sales Society.—We are informed that the staff of the Borough of St. Marylebone Electric Supply Department has formed a society with the above title for the furtherance of "business-getting" in connection with electricity supply. The Society meets every fortnight in the winter, and every month in the summer. At present the membership is confined to the staff of the St. Marylebone Electric Supply Department, but it is hoped in a short time to extend the scope of membership. Papers are given by experts on business-getting, points relating to electricity supply, electrical apparatus and work of all descriptions, particular attention being paid to all Papers concerning the commercial side of the question. The Papers given and discussion following will be printed for sale, and embodied in a monthly publication on electric sales work.

Royal Society.—Among the Papers read at the meeting of this Society yesterday afternoon was one on "The Total Ionisation produced in Different Gases by the Cathode Rays ejected by X-Rays," by Dr. R. D. Kleeman.

Institution of Mechanical Engineers.—The annual dinner was held on Thursday, April 14th, at the Hotel Cecil, the President of the Institution, Mr. J. A. F. Aspinall, being in the chair. Among those present were Sir Archibald Geikie, K.C.B., P.R.S., Sir David Gill, K.C.B., F.R.S., Surgeon-Gen. Sir Alfred Keogh, K.C.B., Sir Gerald A. Muntz, the Hon. Sir John W. Taverner, Mr. G. Lambert, M.P., Mr. A. H. D. R. Steel-Maitland, M.P., Col. H. C. L. Holden, F.R.S., Dr. Gisbert Kapp and Dr. R. T. Glazebrook, F.R.S. Mr. G. Lambert, in acknowledging the toast of the "Imperial Forces," proposed by Mr. J. R. Hoyle, remarked that the equipment of a modern battleship comprised, in addition to the main steam plant, 147 electrically-driven auxiliaries, 100 hydraulic machines, 96 auxiliary steam engines, 20 air-driven machines, and one oil engine, or a total of no less than 364 engines. It was evident from this how necessary to the Admiralty was the assistance of engineers. This toast was also acknowledged by Col. H. C. L. Holden. In responding to the toast of "The Institution of Mechanical Engineers," which was proposed by Mr. J. L. Griffiths, Consul-general of the United States, in an excellent speech, Mr. J. A. F. Aspinall queried whether we were represented abroad by the right kind of men to obtain for this country a fair share of the trade of the world. Scientific instruction in America and the eloquence of their consuls were abstracting our share of the world's work. Again, legislation considerably hampered railway enterprise in this country. In this connection he instanced the excessive cost of constructing light railways in the United Kingdom compared with the cost in Belgium, which latter country possesses about 5,000 miles of railways, some 2,500 miles being classed as light railways and having been constructed at a cost of about £3,400 per mile. By extending our railways we might develop our industries and so prevent, to some extent, the importation of manufactured articles. The toast of "Our Guests" was proposed by the President, Sir John Taverner responding.

ARRANGEMENTS FOR THE WEEK

FRIDAY, April 22nd (to-day).

Physical Society.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: "Further Tests of Brittle Materials under Combined Stress," by Mr. W. A. Scoble, and "The Magnetic Balance of Curie and Cheneveau," by Messrs. C. Cheneveau and A. C. Jolley.

Royal Institution.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "The Telegraphy of Photographs, Wireless and by Wire," by Mr. T. Thorne Baker.

MONDAY, April 25th.

Newcastle Local Section of the Institution of Electrical Engineers.

8 p.m. Meeting in the Armstrong College, Newcastle-on-Tyne. Paper on "Earthed *versus* Insulated Neutrals in Colliery Installations," by Mr. W. W. Wood.

TUESDAY, April 26th.

The Institution of Civil Engineers.

8 p.m. Annual General Meeting at Great George-street, Westminster, S.W.

Faraday Society.

8 p.m. Meeting at the Institution of Electrical Engineers, 92, Victoria-street. General discussion on "The Constitution of Water." Papers on "Is Water an Electrolyte?" by Prof. P. Walden; "The Nature of Molecular Association in the Special Case of Water," by Prof. P. Guye; "Liquid Water as a Ternary Mixture, Solution-Volumes in Aqueous Solutions," by Mr. W. R. Bousfield and Dr. T. M. Lowry; and "The Specific Heat of Gaseous, Solid and Fluid Water," by Mr. W. Sutherland and by Prof. N. Nernst.

WEDNESDAY, April 27th.

Birmingham Local Section of the Institution of Electrical Engineers.

7:30 p.m. Meeting in the Chemical Theatre, The University Edmund-street. Paper on "Magnetic Oscillations Occurring in D.C. Machines," by Mr. G. W. Worrall.

Students' Section of the Institution of Electrical Engineers.

7:45 p.m. Meeting at 92, Victoria-street, S.W. Paper on "Some Notes on Current Central Station Design in Germany," by Mr. J. C. Connan.

THURSDAY, April 28th.

The Institution of Electrical Engineers.

8 p.m. Meeting at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Paper on "Earthed *versus* Insulated Neutrals in Colliery Installations," by Mr. W. W. Wood.

FRIDAY, April 29th.

Students' Section of the Institution of Civil Engineers. Visit to Southampton Docks, and to Messrs. Harland & Wolff's Engineering Shops.

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, April 25th, "A" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 9:30 p.m.

Tuesday, April 26th, "B" Company.—Infantry Drill, 7 to 8 p.m. Technical Drill, 8 to 10 p.m.

Wednesday, April 27th.—Gymnasium, 6 to 9:30 p.m.

Thursday, April 28th, "C" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 8 p.m. Technical Drill, 8 to 9:30 p.m.

Friday, April 29th, "D" Company.—Company Drill, 7:15 to 8:30 p.m. Technical Drill, 8:45 to 9:45 p.m.

Saturday, April 30th, "A" and "B" Companies.—Company Drill, 3:30 to 5 p.m. "C" Company.—Company Drill, 3 to 4:30 p.m.

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HYDRO-ELECTRIC INSTALLATIONS OF SWEDEN.*

BY A. V. CLAYTON.

Summary.—After drawing attention to the characteristics of Sweden the author refers to the development of power transmission in that country. He then proceeds to describe typical installations, mentioning the features of particular interest.

It is impossible within the scope of this Paper to do more than briefly describe a very small number of the hydro-electric installations of Sweden, but before proceeding with the principal subject it may not be amiss to describe shortly the characteristics of the country, of which many people have only a very hazy knowledge. The length of Sweden is 986 miles, or nearly three times the length of England. Its area is 170,713 square miles, or about three times that of England and Wales together. The population is 5,377,713, or 32 inhabitants per square mile, so it will be seen that it is very sparsely inhabited compared with the 500 inhabitants per square mile of England and Wales. The population of Sweden is more dense in the South, where in one county it goes up to 240 per square mile, while in the North it is only 2·6. It seems remarkable that a country having such a small population should be able to supply itself with all its wants, and in many industries even a considerable export trade has been built up. The country is very hilly, abounding in lakes and watercourses, and the falls on these waterways have made it a busy hive for the electrical industry since the commercial development of electrical power transmission. At the same time, it may be stated that the present flourishing condition of many Scandinavian industries is due to the successful commercial development of electricity, whereby cheap power has become generally available. The area of lakes in Sweden is 13,900 square miles, and from this some idea of the enormous quantities of water available will be gleaned. My colleague, Lieutenant Lubeck, has estimated that the amount of water power available in Sweden is equivalent to 3,800,000 H.P. Of this only 550,000 H.P. is at present harnessed, so that there is plenty of scope for further development. That the equipment of the falls is proceeding very rapidly, however, may be gathered from the fact that in 1900 only 253,000 H.P. was utilised, or less than half of what is now employed. In the neighbouring country, Norway, there is available 4,800,000 H.P., of which in 1906 only 250,000 H.P. was utilised. However, since the advent in the last few years of new electrical processes for the production of fertilisers from the air, considerable additions have been made to this figure, so that now the falls harnessed, or in course of being harnessed, represent approximately 550,000 H.P., or about the same as Sweden.

The use of water power dates back to the very earliest ages; and there may still be seen in many places good examples of old-world water-wheels. These wheels were used for a variety of purposes, such as grinding mills or pumps, and very largely for ironworks. With the growth of the ironworks and the introduction of rolling mills, for which larger powers were required than could be obtained from the individual local falls on which the works were situated, a demand grew up for power transmission in order to bring the power from falls situated a little higher up or lower down the watercourses, and concentrate all to the point where the works were situated. This demand for power transmission was in part filled by wire-rope transmission, and some good examples still exist. Another system of transmitting power which is of much earlier date than wire-rope transmission consists of a number of wooden beams linked together at the ends and supported at intervals clear of the ground. These linked beams are placed in two parallel lines about 4 yds. or 5 yds. apart, and the cantilever supports, which hold them about 4 ft. from the ground, are hinged so as to allow them to be freely pushed or pulled longitudinally. To the ends of each line of these linked beams are attached a pair of connecting rods from cranks on the water-wheel shaft which give a slow reciprocatory motion to the links; one side of the line thrusting, while the other pulls. These transmissions were very widely used for mine pumps and for blast furnace blowers, in which cases the slow reciprocatory motion was very suitable for use at the receiving end of the line, as it was not necessary to reconvert to a rotatory motion. Some of them were quite long, and their efficiency is claimed to be very good.

With the advent of electricity a new era began, and between the years 1885 and 1889 power transmission by this means was touched on slightly. It was not, however, until the invention of the three-phase system that any real advance was made. The first three-phase transmission in Sweden was tried in 1890, and in 1893 a transmission on what was for that time quite a large scale was inaugurated. This was of 400 H.P. capacity, and the power was sent from the Hellsjon falls to the Grangesberg iron mines—a distance of about 10 English miles. The original plant consisted of four water-turbine driven generators, each of 100 H.P. Three of these are of three-phase design and supply power to the pumps, haulage gears, hoists, and other machinery at the mines, while the fourth is a single-phase generator for lighting purposes. All operate at 70 cycles, and run at 600 revs. per min. Current is generated at low voltage and transformed up to about 9,000 volts for the line transmission. The generators are of the rotating armature type, having inwardly projecting field poles, and the carcase, or yoke and poles, are of cast iron. This type of machine, while it presents some advantages, has been abandoned in favour of the rotary field type, except in the very smallest sizes. The General Electric & Mtg. Co., of Sweden, carried out the installation, and it may be mentioned that the original machinery is still at work 24 hours daily. As illustrative of the enormous development of the use of electrical power, it may be noted that the Grangesberg mines now employ about 6,100 H.P. electrically, and on account of scarcity of power have recently acquired new waterfalls of about 15,000 H.P., and the work of harnessing these electrically is at present in progress.

Alby.—Alby has been chosen among the power stations to be described on account of its having been partly acquired by English capital, and the name may be familiar to many. It is one of the older power stations, and was built in 1898-1899. The power from the Alby falls (which are situated on the Ljungan river) is used partly for the production of calcium carbide and partly for the manufacture of potassium chlorate. The original power plant consisted of two generators of 1,100 H.P. each, generating direct current at 220 volts for the manufacture of the chlorate by electrolysis; one two-phase 26 cycle 2,000 H.P. generator and two 500 H.P. single-phase generators for carbide production; besides two 360 H.P. continuous-current generators for excitation. All these machines are direct driven from horizontal shaft turbines. A few years later the power station was extended by erecting another 1,100 H.P. direct-current generator for chlorate manufacture, and another 2,000 H.P. two-phase generator for carbide. With the addition of some smaller sets for driving light railways, and some auxiliary machinery for making packing barrels, boxes, &c., these extensions brought up the total power installed at Alby to its present figure—9,760 H.P. The current from the 2,000 H.P. two-phase generators is delivered at 2,000 volts, and is transformed to the voltage required for the carbide furnaces by transformers situated immediately behind the furnaces. 1,000 H.P. is required for each of the larger furnaces, each phase of the two-phase generator supplying a furnace, while the 500 H.P. generators are of low-voltage type, work in parallel, and supply three smaller furnaces directly. In 1906 the carbide works were still further enlarged, and the power for these extensions is supplied from falls lower down the river at Ringdalen, about 1½ miles from Alby, and is transmitted at 10,000 volts.

As to the construction of the power plant, the first portion of the water intake canal is built of ordinary earthwork, and the latter portion near the power house end is constructed of stone masonry, the fall at this point being too high for earthworks. The total length of the canal is 700 yds., of which 170 yds. are built of masonry, and there are no less than 280,000 cubic ft. of stonework in it. The velocity of the water in the earthwork part of the canal is 1 ft. per second, while in the stone part it is 1·6 ft. In constructing the earthworks of the canal a sponting or core of tongued and grooved planking has been left in the middle of the earthworks to prevent percolation. From the end of the canal where it opens out into a large basin or settling pond, tubes of wrought iron convey the water directly to the turbines, which are situated in the power-house itself. There are seven tubes, five of these are 6 ft. diameter, and two are 8 ft. diameter. Of the five smaller tubes, three supply the turbines of the 1,000 H.P. direct-current generators, and two the turbines of the 500 H.P. alternators and exciters. The remaining two large tubes supply the turbines of the 2,000 H.P. two-phase generators. The length of these tubes is 72 ft. and the velocity of water in them is 5·5 ft. per second. The turbines work under a head of 69 ft. to 75 ft., of which 15 ft. is obtained from the suction draft tubes, the turbines being placed in flumes on the machinery hall floor, above the tail race level. The length of the tail race is 160 yds., and the velocity of water in it from 2·3 ft. to 3·3 ft. per second. The base of the power house is built of concrete, the station floor on which the turbines and generators are situated being supported on arches which form separated chambers for the water discharge from the turbines. The machinery in the power house cannot be considered as an example of good modern practice. The outer cases of flumes of the turbines were made of cast iron, a practice now abandoned for large-sized modern turbines. On one occasion, one of the outer cases burst owing to a flaw in the casting.

* Abstract of a Paper read before the Institution of Electrical Engineers.

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causing much damage to the station and loss of life, before the water at the inlet gates could be shut off.

Ringdalen.—The newer power station at Ringdalen also supplies power to the Alby carbide works. The fall is 52 ft., and in the power station are five 1,100 H.P. single-phase generators, one 600 H.P. three-phase generator for supplying motor and lighting load, and two 200 H.P. exciters. All the generators supply at 10,000 volts, at which pressure the power is transmitted to Alby. Each 1,100 H.P. generator supplies one carbide furnace and has its own transmission line with step-down transformers, so that they form five complete separate and independent units. All the generators are driven by direct-coupled single-wheel turbines. The length of the water intake canal is 450 yds., and the speed of the water in it is 1 ft. per second. There are six iron tubes to convey the water from the settling pond down to the turbines, one each for the five 1,100 H.P. three-phase generators and the two exciters. All the tubes are 6½ ft. diameter. The power station is built much on the same lines as that at Alby, but is more modern in its arrangements in the machinery hall.

Gullspang.—The power station at Gullspang possesses several points of interest. It is in the southern part of Sweden, and the falls are situated on a short river between the lakes of Skagen and Vänern. The falls are now owned by the Gullspang-Munkfors Power Supply Co. The power is transmitted at 40,000 volts, and

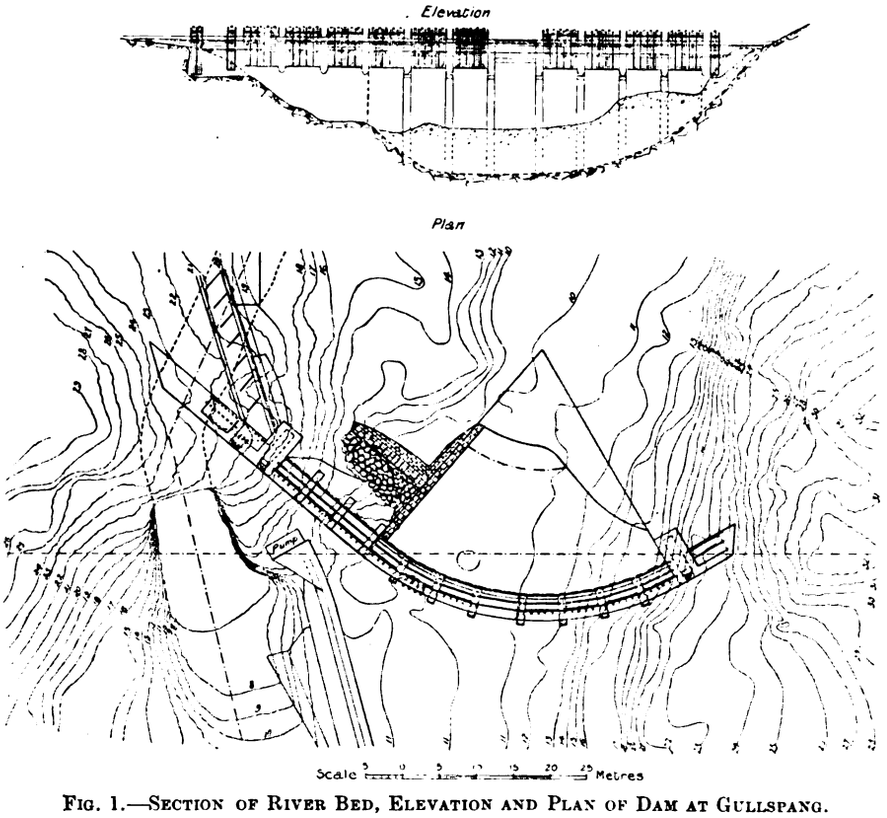

FIG. 1.—SECTION OF RIVER BED, ELEVATION AND PLAN OF DAM AT GULLSPANG.

the greatest distance to which it is at present delivered is about 50 English miles. Lake Skagen has an area of 50 square miles, and forms an ideal natural storage for the water supply, allowing of regulation for the wet and dry seasons. The mean water flow at Gullspang for high and low-water periods is about 2,550 cubic ft. per second. The distance by land from Lake Skagen to Lake Vänern is at one point only 1¼ miles, but the length of the river connecting the lakes, and upon which the Gullspang power station is situated, is 8 miles. In its course are two falls, or, more strictly speaking, rapids, namely, Gullspang Rapids, having a fall of 67 ft. in a distance of about ½ mile, and Aras Falls, of about 10 ft. It is intended eventually to utilise the second falls at Aras by deepening out the tail race from Gullspang down to Aras. At the point where the power station is situated the river runs through steep walls of rock, and in order to build a dam across the stream, the water had to be diverted from its natural course through a temporary tunnel blasted through the rock. This was, of course, a very costly proceeding, but under the peculiar circumstances no other way of doing the work satisfactorily was possible. This tunnel was about 60 yds. long and 30 ft. diameter. When the river bed was laid dry it was found not, as had been expected, to consist entirely of rock, but that to get to the solid rock considerable and expensive excavation would be necessary. The original plan of building a gravity dam straight across and supporting it on the solid rock bed was therefore abandoned, and, instead, an arch-formed dam was built on that portion of the river where the solid rock could not be got to without excavation.

Fig. 1 shows a section of the stream bed and plan of the dam. The straight part of the dam constructed on the gravity principle, and resting on the solid rock bed, was brought out as far as possible. The arch part of the dam has the crown of the arch, as it were, against the stream or head of water and the arch buttressed or wedged in between the solidly supported ends. By employing this means of construction an enormous saving both in the cost of excavation and of material employed was effected. The front of the dam is faced off with cement, and the bottom caulked with stamped clay to prevent leakage. Fifty regulating sluices are provided, grouped in 10 openings of five sluices each. The sluices are of wood, working in I-section steel girder frames. A large opening or spillway in the centre of the weir is provided for clearing off loose ice. A salmon pass and two eel passes are, as is usual, also provided. The water is led from the head race to the turbine house in an open canal. The bottom part of this canal has for a great part of the way been blasted out of rock and is built with concrete walls, while the upper part consists of earthworks. Where the junction between the concrete walls and the earthworks is made, a sponting of concrete prevents leakages, and the earthworks are for part of the way constructed with wood sponting, as in the case of the Alby canal.

The power station proper and the forebays are built close together. Fig. 2 shows a section of a forebay with ice racks, sluices, turbine flume, turbines with draft tube, tail race, tunnel, and power house. The forebays are built of reinforced concrete, and the power station partly of concrete and partly of brick. The turbines are of twin type, and are placed in open vertical tubes or flumes of boiler plate. These flumes are 43 ft. long and 18 ft. diameter. When completed, there will be six turbine flumes, each constructed for a pair of 4,500-5,000 H.P. turbines for driving the main generators, beside the auxiliary turbines for the exciters. Only four pairs of turbines and generators with exciters are installed at present, the remaining two being reserved for extensions. Each of these turbine flumes is separate in itself, and provided with its own forebay, ice rack and head gate. The head-gates are 18 ft. wide and 15 ft. high, and are of an interesting and novel construction, for which patents have been applied for. They consist of cylindrically bent iron plates stayed with horizontal struts, and are provided with oak sliding surfaces. As these gates are too wide to be manœuvred against the water pressure, by-passes are arranged to fill the forebays previous to operating the gates. The gates themselves are raised or lowered by a travelling crane, which can be moved over each sluice. Each of the forebays stands for itself; they are not connected to each other, and are free from the rock at the sides, being supported solely from the bottom on concrete walls which stand up between the turbine flumes. The joints between the boiler plate turbine flumes and the concrete floor of the forebays are of expansion type. In order to effect this each flume tube was well greased before the concrete was stamped in round it, while to ensure a watertight joint between the concrete and the tube, a V-shaped groove was left round the top of the tube in the concrete, and into this groove a packing of tow steeped in paraffin wax was inserted. The pressure of the water forces this wedge-shaped tow packing ring in against the tube, just in the same way as in an ordinary hydraulic ram joint, and makes a perfectly tight joint. The backs of the forebays are made of thin half-circle walls, while the sides are of heavy straight construction.

The turbines, with their supply tubes and draft tubes, as well as the concrete walls supporting the forebays, rest on a floor of massive steel girders and reinforced concrete, which is built on the solid rock. This floor is of immensely strong construction, as it has to carry not only the weight of the turbine chambers, &c., but also the volume of water in them. The draft tubes have cement coatings to protect them from rust, and discharge into a tunnel, blasted out of the rock, running lengthwise under the power station. Further down the discharge tunnel opens out into an ordinary open tail race.

The power house building itself is in three storeys, and is built on the solid rock, which has been blasted out to a depth of 33 ft. to

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accommodate it. The lower story is constructed of armoured concrete, with a view to better resistance to the damp from the adjacent rock; and, further, the walls of this chamber had to be of great strength in order to support the heavy transformers situated on the iron girder and concrete floor of the second story. The upper portion of the building is of brick. In the bottom story the generators are situated. On the first floor are the transformers and switchgear, while the top is devoted to the lightning protection devices and outgoing lines. The first floor is level with the ground outside, and on this floor run rails connected with a siding on the main railway lines. A 20-ton electric crane can take goods off the railway trucks and deliver them on to this floor, or drop them through an opening into the machinery hall below, which is served with another 20-ton electric travelling crane. A very complete system of ventilation has been arranged to keep the machinery hall cool, and there are channels running under the floor connected with the generator pits to conduct cool air to the generators.

The runners of the turbines are made with boiler-plate buckets, bent to the correct shape and cast into a cast-iron hub and ring.

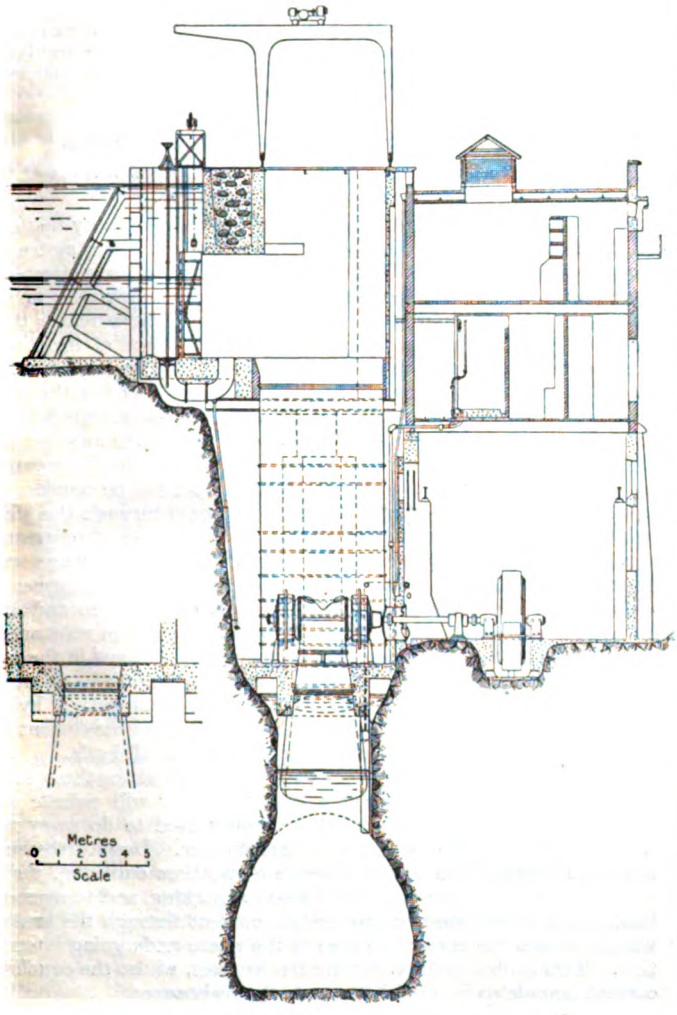

Fig. 2.—Section of Power Station at Gullspång.

This method ensures a smooth and even bucket, which minimises skin friction, and so improves the efficiency, and at the same time the bucket is stronger and less likely to be damaged by sticks, stones, ice or rubbish which may get in, than is a cast-iron bucket. This style of making runners is much employed for turbines working on falls up to about 65 ft., and up to sizes about as large as these—*i.e.*, 2,000 to 2,500 H.P. per wheel. For larger sizes and bigger falls cast-steel runners should be used. The guides or chutes leading the water into the wheel are movable on pivots, and by the movement of these chutes the openings between them are varied, and the amount of water admitted is regulated to suit the power required. This method of regulation ensures the water being always projected at the correct angle to the wheel buckets, and improves the efficiency at light load enormously. Fig. 3 gives the efficiency test curve of the turbines. Regulation of speed is effected by automatic hydraulic regulators operating directly on the shafts connected to the links of the afore-mentioned movable chutes. The governor balls are driven from the turbine shaft. They control a little valve, and in rising or falling with variations of speed admit water into either end of a cylinder. The piston in this cylinder operates, through a rack and segment gear, the shaft connected with the movable chutes. Speed regulation with regulators of this class is exceedingly sensitive. Tachograph records taken on the Gullspang turbines show that with the instantaneous application of full load to the turbine running light, or the throwing off of full load, there is a variation of only 5½ per cent. in speed; while for load variations of half or full load the speed varies only 2 per cent., and, what is still more important, there is absolutely no hunting even with these large changes of load.

The machinery in these power stations is much alike, and therefore the electrical plant in one station may be taken as typical of all. The chief interest centres about the hydraulic constructions and general layout of the installations. Before leaving Gullspang, however, there is just one point, namely, that of the cost of the equipment. At the present time there is installed machinery aggregating 16,500 H.P. exclusive of excitation, and this has been erected at a total cost of £173,000, or about £10. 10s., per horse-power. It must be remembered, however, that the hydraulic part of the scheme has been calculated for an equipment when completed of 25,000 H.P., and in order to carry out this extension there is little expense to be incurred beyond the cost of the machinery. Therefore, when completed for its full capacity of 25,000 H.P., the power station will cost £192,000, or about £7. 15s. per horse-power. The Hydraulic Association of Scandinavia, or "Vattenbyggnadsbyran," was retained as the consulting firm for the scheme, and not only prepared the plans, but supervised the carrying out of the entire work.

Graninge.—In the north of Sweden, at Graninge, a new power station has been completed which deserves notice. This station is built for a capacity of 10,000 H.P., of which 5,000 H.P. is now installed and at work. The units are each of 2,500 H.P. capacity, running at 300 revs. per min., and generate at 5,000 volts, at which pressure part of the power is used in the immediate neighbourhood, while the

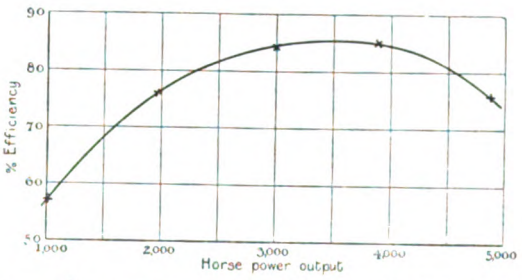

Fig. 3. Gullspång Efficiency Test Curve of 4,500 H.P. Turbines.

remainder is transformed up to 40,000 volts for the long-distance transmission. Fig. 4 shows a sectional elevation of the power house. There are not separate feeder tubes for each turbine, but three tubes lead into a common header from which the four turbines are fed. In addition to the gates on the turbines themselves, there are throttle-valve sluices between the turbine flumes and this common header. As regards the electrical outlay of the power station, all the low-voltage or 5,000 volt 'busbars, apparatus, and outgoing lines have been kept on one side of the building, and all the high-tension 40,000-volt apparatus on the other. The turbines operate under a 60 ft. head, and consist of twin wheels mounted on horizontal shafts. Each pair of wheels is mounted in a steel flume, and the discharge is through cast-iron quarter-turn discharge pipes and draft tubes, each discharge pipe and draft tube being common to a pair of twin wheels. As the flywheel effect of the generators is not in itself sufficient to enable the fulfilment of the speed regulation required, heavy flywheels are placed between the turbines and the generators. These flywheels have their own bearings, and are connected through leather band flexible couplings to the turbines, and through fast flange couplings to the generators. Governors of the type previously described are provided, and on test the speed variation was found to be 2½ per cent. for sudden variations of load equal to 20 per cent. of full load.

The three-phase generators are of 2,150 kw. capacity each, 50 cycle, 20 pole, 300 revs. per min., and generate at 5,000 volts. Their tested efficiency is 95·4 per cent. on full load of unity power factor, and 94·2 per cent. on full load of power factor 0·8. The inherent regulation is 1·5 per cent. for unity power factor, and 6·3 for power factor 0·8. It will be remarked that this inherent regulation is very good, but in general the regulation of generators employed in Sweden is not nearly so good, 7 per cent. and 16 per cent. being the more usual figures. The rotating magnet wheel with poles, arms and boss is in one single steel casting, and the pole shoes are of forged steel screwed

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to the poles with countersunk bolts. The flanges formed by the pole shoes hold the field spools in place. The stator winding consists of bars, one in each slot, and the slots are partially closed. The stator frame with punchings is in halves, and one of the feet on which the frame rests is bolted to the frame. By removing this loose foot the whole stator can be let down on to the field, and so turned round on the shaft to bring any part of the windings situated below the ground level into a convenient situation for inspection or repairs. The bearings are of the ordinary spherical seated self-aligning type, with babbit linings and ring lubrication.

Almost all the Scandinavian hydraulic power stations are employed for power transmission, hence they nearly all employ three-phase generators, and the generators described may be taken as typical of the general run of plant in Scandinavian hydraulic power stations. With the exception of a few electrochemical works, where low-frequency is necessary, 50 cycles has generally been accepted as the standard. The new State power scheme at Trollhättan is, however, designed for 25 cycles, partly with a view to the use of the power for railways. The City of Stockholm primary transmission is also at 25 cycles, but with these exceptions it may be said that for supply companies 50-cycle three-phase is universal. This is a very great convenience, as it simplifies matters and standardises plant considerably.

Four interesting generators, of 10,500 kw. capacity, 10,000 volts, 50 cycles, and 250 revs. per min., have been supplied by the General Electric & Mfg. Co. of Sweden to the Notoddens Saltpetre Works at Svälgfos in Norway. In this generator the steel poles and ring are

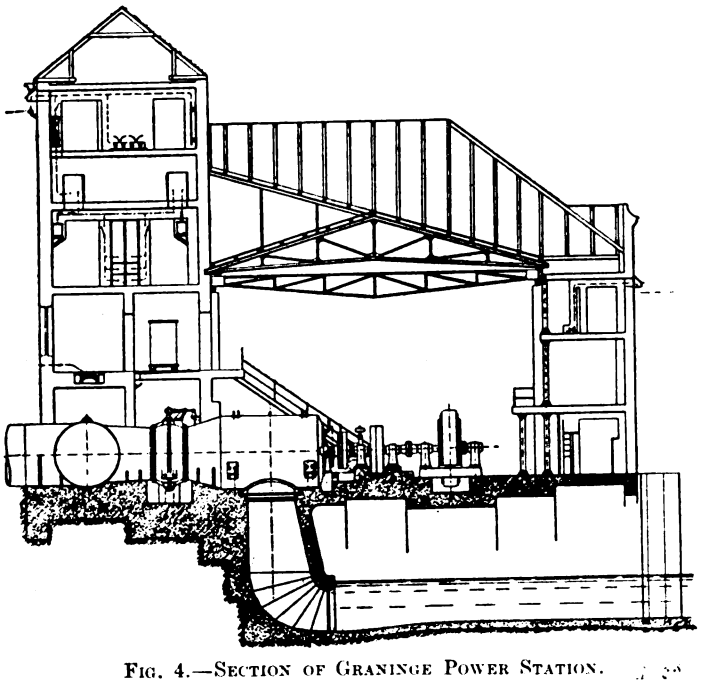

Fig. 4.—Section of Graninge Power Station.

cast together, and are supported on a cast-iron arm system. The magnet ring and poles are divided transversely, and an air duct is left between the halves. The width of iron axially in this machine is no less than 49 in., the bearings are of ring lubrication type, and are provided with water cooling in case it ever be required.

These enormous generators have been quite eclipsed in point of size by other generators which the same Company are building for the above-mentioned Trollhättan State power scheme. These are of 12,500 k.v.a. output, and recently the Company has received orders for generators for Rjukanfos, which are of 14,500 k.v.a. capacity. There are two unique generators, built and designed by the same Company, working at Brattfors. They are of 2,000 H.P. output each, and generate at 20,000 volts, at which pressure transmission is made, no intervening transformers being required. There are many instances of 10,000-volt directly generating and transmitting plants in use, even with machines down as small as 250 kw. output, but these 20,000-volt generators are the only ones of their kind in Sweden. Another rather interesting generator, designed and built by the author, is one in which no machining has been done to the stator frame. The diameter of the stator of this machine was larger than could be turned in any of the machine tools available, and so the segments of the stator punchings were built up against a ring of 1¼ in. bolts passing through the rough cast-iron frame. These bolts at the same time serve the purpose of clamping the press rings against the packet of laminations after the latter was built up. It often happens on old machines that the laminations shrink, probably on account of shrinkage of the insulation material between the plates. In order to safeguard against the possibility of the entire package of laminations dropping out of the stator frame, should the upper half of the latter be lifted after some years when the laminations had shrunk, ¼ in. steel pins were passed through holes in the laminations and the cast-iron flanges on each side of them and riveted over after the laminations were built up in place. This machine has been running night and day at full load and frequently for long periods (weeks at a time) at considerable overloads since the beginning of 1906, but no loosening of the laminations can be noticed, although it has been subject to frequent short-circuits.

(To be Concluded.)

THE AUTOMATIC REGULATION OF ALTERNATORS.*

BY M. SEIDNER.

(Concluded from page 6.)

Summary.—After discussing the object and possibilities of regulation, and outlining the general theory, the author passes on to discuss regulators of general interest, and more especially those types due to Alexanderson, Walker, Thury and Tirrill, which are of practical value.

Description of Some Methods of Regulation.

This abstract will be concluded with a description of a few of the more important and successful pressure regulators.

Alexanderson.—Among those in the *first* group probably that due to Alexanderson possesses the fewest weaknesses. His system is shown in Fig. 2. The exciting coils N of the three-phase generator G are excited by current produced in the special winding *Sp* in the generator, and by the current transformer *St*. This current is then rectified by the two-segment commutator K. Each of these segments extends over an angle of 120 deg., and there are three brushes placed at 120 deg.; consequently two brushes will stand on the same segment for a short time, and an equalising current—which is damped by the resistances R and *r*—will flow. *Sp* and *St* are in series with *r* between, and are both in parallel with R. At no-load the current *Sp* will flow through R; thus the pressure *Sp* must be considerably smaller than if the no-load current had to pass through the highly inductive transformer *St*. Consequently the no-load current is almost a pure watt current. On load, the current transformer impresses an E.M.F. on the circuit of the pressure transformer *Sp*, which, with increasing phase displacement, comes more and more into phase with the pressure *Sp*. Hence the current in resistance R will fall as the load and phase displacement increase, and in the same ratio the commutated current will increase, which we have seen is the condition for correct compounding. The part played by the resistance *r* is to diminish the phase displacement of the current and to produce as nearly a watt current as possible at all loads.

The commutator interrupts the current in each of the three phases periodically, and the resultant exciting current will pulsate very little; the special pressure winding is only used to do away with the self-induction of the potential transformer. Despite the small magnetic energy (due to the absence of wattless currents), the interruption of the current may still lead to sparking, and to overcome this, Alexanderson sends compensating current through the brushes, which reduces the current to zero in the phase undergoing interruption. This is obtained by shifting the brushes, whilst the equalising current completes its circuit through the resistances.

The various arrangements classed in this group all present sparking difficulties. Their factor of safety is not less than that of ordinary generators with exciters; the speed of regulation is all that could be desired, whilst over-regulation or instability is not possible. A great disadvantage of all these methods is the large commutator required with multi-polar machines, also large transformers are required and considerable energy is consumed in the resistances.

Rice.—As a practical example of the *second* group we can take Rice's method, which the General Electric Co. has developed and applied to a number of high-speed generators. The no-load exciting current is taken from a standard exciter, whose frequency is the same as that of the generator. Thus, if the exciter has the same number of poles as the alternator, it can be direct coupled, otherwise it must be driven through gearing. The alternating-current side of the exciter is connected in series with the alternator through a current transformer, so that the exciter E.M.F. opposes that of the generator. As seen from Fig. 3, the exciter E excites itself and also the generator G. At no load the exciter E provides the current transformer *St* with magnetising current, and the terminal pressure of the

* Abstract of an article in the "Elektrotechnische Zeitschrift."

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generator falls due to the pressure induced in the primary of the current transformer. On load the exciter is compelled to take the current of the alternator. This is a motor current, so that armature reaction will increase the excitation of the machine E. Hence its terminal pressure will rise as the load rises and as the phase displacement increases, which is what is required.

The method due to Danielson is almost identical with the above in principle, but the great weakness of both is the necessity for having the exciter running at the same frequency as the alternator. The factor of safety of these arrangements is good, and the commutation conditions favourable, but the speed of regulation none too satisfactory, owing to the changes that have to occur before the exciting current can be varied. The pressure changes are not retarded, but also are not made more frequent, which is an advantage compared with the methods in the first group.

The methods included in the *fourth* group are the nearest approach to inherent pressure regulation with respect to safety of working. If it were possible to find a method based on armature reaction that did not require any special construction of the generator, such a method would be the ideal solution to the problem of pressure regulation.

Walker.—The method due to Walker is based on the cross magnetising or watt component of armature reaction. This component displaces the magnetic axis from the centre of the pole by magnetising the one side of the pole and demagnetising the other, whilst the resultant flux remains practically the same. If now the demagnetising component can be neutralised, the magnetising component will be left and will increase the excitation as the current increases. Walker does this by saturating at no load those halves of the poles where the demagnetising effect acts and leaving the other half unexcited, so that when the load comes on, the former part will scarcely be affected, whilst the latter becomes magnetised.

This arrangement has a disadvantage. As is known, the pressure drop depends chiefly on the wattless component, but the present

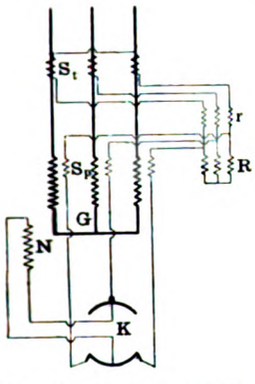

FIG. 2.—ALEXANDERSON'S ARRANGEMENT.

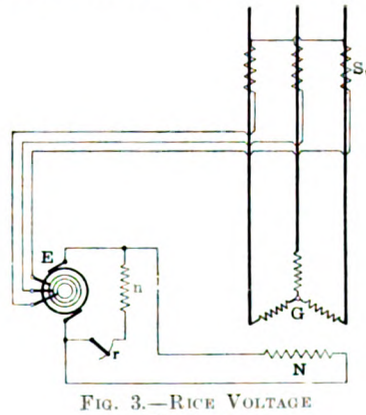

FIG. 3.—RICE VOLTAGE REGULATOR.

method cannot compensate for this, so that this device is only applicable for high power-factor loads (not less than $\cos\phi = 0{\cdot}85$). Despite this disadvantage, the method has been used by the British Westinghouse Co. for turbo-alternators.

In all the static methods of regulation discussed above the primary current is used to compensate the pressure drop it causes. On the other hand, the mechanical regulators now to be described are operated by the primary pressure variations. They act by varying the shunt rheostat of the exciter until the primary pressure is restored.

Static regulators do not retard the pressure changes, but even augment them, and increase the pressure rise due to change in speed. Astatic regulators, however, are very sensitive to pressure changes, and possess the tendency to prevent all variations in the pressure.

N.B.—An astatic regulator is one which is in equilibrium in any position when the pressure is normal. On the other hand, it will continue to operate until the pressure becomes properly adjusted.

Thury.—Thury's regulator is one of the most complicated though one of the best constructed. By a mechanism actuated to and fro by a small motor, the wheel of a shunt resistance is rocked forwards and backwards, and operates a control magnet. Regulation, therefore, takes place step by step, and is consequently very slow. The principle is seen from Fig. 4. The arm D, on which the escapements I and I′ are fixed, is kept swinging by a small motor. I and I′ are kept pressing on the toothed wheel H, the axis of which operates the rheostat. The levers K and K′ prevent I and I′ gearing into the teeth of H, so that the arm D cannot set the toothed wheel in motion so long as K and K′ retain their mid position.

The two levers K and K′ can be brought into their middle position by the double-acting lever E. When, however, K is shifted, the lever K′, in moving to the left, knocks against the contact C and sets the lever free, whereby the escapement I′ engages with the toothed wheel and moves the latter in a clockwise direction until E takes up its central position again.

On the other arm of the lever E the electromagnet B is fixed, which is excited from the terminal of the machine being regulated. The apparatus is adjusted so that with normal pressure the pull of the magnet B and the springs A and R keep the lever E in the central position. The toothed wheel can make one revolution in 30 seconds, so that if the contacts extend over two-thirds of the circumference the whole resistance can be switched in or out in 20 seconds. This speed, therefore, is rather too slow to be satisfactory. To prevent hunting, an oil damper, N, and spring O are added to check the movements of the lever E. The chief application of the Thury regulator is for lighting loads to maintain constant pressure without hand regulation. For regulating the pressure of alternators it is not so suitable.

Tirrill.—With respect to speed and accuracy of regulation, and at the same time an absence of over-regulation, the Tirrill regulator is the best mechanical regulator yet brought out, and is based on an entirely different principle from the foregoing. At one single step the whole of the resistance is inserted or cut out of the field circuit of the exciter, the time taken being 0·1 to 0·05 of a second, so that regulation is very rapid. To prevent the pressure surging or hunting the principle of "back control" is used, which now finds application in all modern indirect-acting mechanical regulators. In all previous descriptions of the Tirrill regulator neither the existence nor importance of the back control have been recognised, so that this important factor has not been fully appreciated. The characteristic property of this regulator does not only consist of the con-

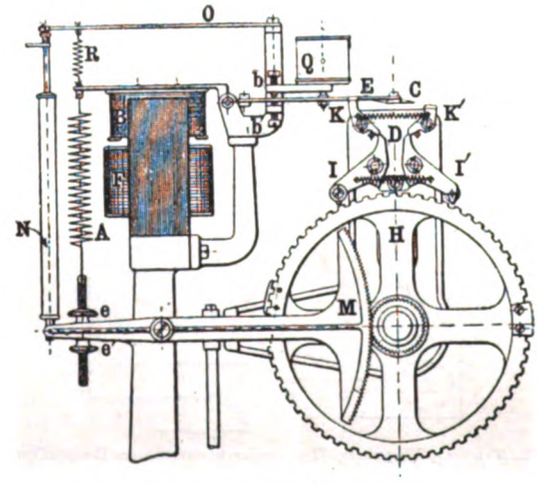

FIG. 4.—THURY REGULATOR.

tinuous switching in and out of the whole shunt resistance, but in its conjunction with the action of the back control.

In Fig. 5, let the coil Sp of a solenoid be excited with the pressure E of the alternator being regulated, and let the solenoid be adjusted so that with a certain pressure it attracts the iron core K_2, it breaks the contact made by C_1 and C_2, and with a lower pressure makes the same. The contact pieces C_1 and C_2 are made either to short-circuit the resistance r or insert the same in the exciter field circuit. If the machine pressure is less than that required to operate the apparatus, the contact is closed and the shunt resistance short-circuited. The pressure of the exciter, and with it that of the generator, will then continue to rise until the pressure is reached which causes the coil to be attracted and the contact broken. The sudden insertion of this resistance causes the pressure again to fall, but only momentarily, for the contact is again closed as soon as this takes place. It is thus clear that the core will swing to and fro like an electric bell, and the shunt resistance is continually inserted and short-circuited.

Owing to this switching in and out, the exciting current will maintain a periodic fluctuation between a maximum and minimum, and the mean value of the current will be larger the longer the period during which the resistance is short-circuited. This fluctuation will also appear in the terminal pressure of the alternator to such an extent as to make the use of the apparatus in this form impossible.

On account of the inertia of the magnetic fluxes and the mechanism over-regulation will ensue. To accelerate the regulation and overcome the inertia of the flux, Tirrill uses a very large shunt resistance in the field circuit of the exciter, so that when this is inserted or cut out the pressure of the exciter and alternator change suddenly, in order to reach a stable condition, which, however, lies well beyond

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the desired limit. The rough pressure variations must then be fixed in this way and the finer variations adjusted when the desired pressure is reached. The regulator, therefore, must act suddenly and at the exact moment in order to prevent a too large pressure variation occurring. Should this not occur at the right instant, the terminal pressure will at once begin to vary over wide limits, and a considerable over-regulation takes place. This latter is an inherent property of indirect regulators. By indirect regulators is meant devices where the governing mechanism does not produce equilibrium between the energy input and output directly, but indirectly by means of an auxiliary motor controlled by a relay.

The above depicted regulator consists of such a relay, and, with the exciter, has all the properties of an indirect regulator. Assume now the load is suddenly removed from the generator. The consequent pressure rise raises the core K_2 and inserts r in the exciter field. The pressure will not fall immediately, but continue to rise, for a certain time must elapse before the magnetic inertia is overcome. At the moment when the alternator pressure reaches its maximum, equilibrium exists between the continuous and alternating current ampere-turns. Since, however, the pressure is above the normal, the contact C_2 moves still lower, and the pressure falls until it reaches its proper value. The contact C_2 at this instant reaches its lowest position and comes to rest. As soon as the pressure falls below its normal value the core K_2 will begin to sink and C_2 to move upwards, and at a certain value of the pressure the contact is again closed and the operation is repeated again in the reverse sense. But the contact C_2—owing to the inertia of the movable part of the apparatus—will not come to rest at the instant the pressure reaches its proper value. The pull of the magnet Sp must fall off considerably to retard the moving masses and give them an acceleration in the opposite direction. Consequently, the moment of contact will be displaced and the lower limit of the pressure reduced. This limit will not be the same as when the contact is again closed. When the contact is made the exciting current and pressure do not immediately

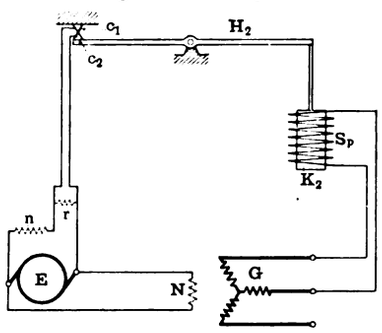

FIG. 5.—TIRRILL VOLTAGE REGULATOR WITHOUT BACK CONTROL.

rise, but after some little time, during which the pressure sinks further—even below the limit which sufficed to make the contact.

To prevent this over-regulation in indirect-acting regulators advantage is taken of the principle of "back control," as seen above. Over-regulation is due to the retarded completion of regulation. The movement of the mechanism which directly effects the regulation lags behind the movement of the governing mechanism, so that the regulator is not able to complete the regulation within the time over-regulation could be avoided. The principle of back control consists of taking away the task of completing the regulation from the governing organ and conveying it to the working part of the regulator directly responsible for effecting the regulation. The working part in this way comes to play an independent part; it finishes the regulation and brings the whole regulating device back into its position of rest, in which then the governing mechanism can exert a new impulse for a following regulation. By means of this back control the regulation can be completed at any pressure within the period of regulation. It is possible, for example, to complete the regulation at the moment when the pressure reaches its normal value, or even earlier. The time taken to complete the regulation depends only on the movements of the governing mechanism and the working part.

The working part can be brought into action during regulation in a variety of ways, as illustrated by the different kinds of hydraulic regulators. Usually the governor is operated by a lever, one end of which moves the regulator and the other the auxiliary motor. With alternators the exciter acts as the auxiliary motor. Tirrill moves the contact C_1 by means of the exciter pressure, so that both C_1 and C_2 are movable.

Tirrill's regulator differs from the above-mentioned indirect-acting hydraulic regulators in one particular. In the latter the working part completes the regulation process entirely, and the governor valve brings the apparatus back into its position of rest. In the Tirrill regulator, on the other hand, the working part not only completes the regulation in the direction in which the regulator started to act, by bringing the governing mechanism back into its position of rest, but the governor valve is also set in the opposite direction, so a regulation in this sense is set in action. Thus the Tirrill regulator has no position of rest. The working part is continually changing over, and not only completes the regulation, but also starts the same. An exactly similar action would take place in a steam turbine if the working part were allowed to carry the governor valve beyond the equilibrium position and bring itself to a movement in the other direction.

The arrangement of the Tirrill regulator can be seen from Fig. 6. The double-acting lever H_2, together with the parts belonging to it, are identical with those in Fig. 5. The contact C_1, however, is no longer fixed, but is attached to one end of the double-acting lever H_1, whose other end is operated by the spring F and relay Sg. Sg is excited from the terminal pressure of the exciter. Thus the contact C_1 C_2 is not only affected by the alternating current, but also by the continuous current of the exciter. The magnet Sp, as before, is astatic—that is, it comes to rest in any position with the proper pressure. On the contrary, a small variation in the pressure raises or lowers the core K_2. The other magnet Sg is static; each position corresponds to a definite pressure. The movement of K_2 is damped by a dash-pot, B.

Suppose the pressure of the alternating-current generator to fall, then Sp cannot counterbalance the astatically balanced core K_2, so that the latter falls and the contact C_1 C_2 is closed. As a result of this the pressure of the exciter and generator rises. If C_1 were fixed, the generator pressure would continue to rise until the movement of K_2 reversed and the contact interrupted. Actually, however, the magnet Sg draws the statically balanced core K_1 down as soon as the pressure of the exciter rises, so that C_1 rises and interrupts the contact and tends to come to rest. If the pressure of the generator is still too low, C_2 rises still further, and prevents the contact

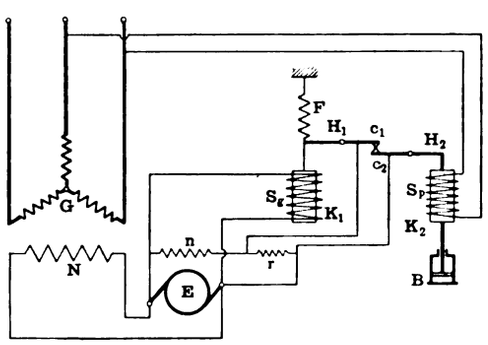

FIG. 6.—TIRRILL VOLTAGE REGULATOR WITH BACK CONTROL.

being broken. As soon, however, as the pressure approaches its normal value, the movement of C_2 is retarded and cannot follow C_1, so that the contact is broken and the action begins again in the opposite direction.

The regulation, therefore, is not concluded by the backward movement of C_2 caused by the over-regulation, but, before this can occur, by the upward movement of C_1. Thus the over-regulation has been reduced, the time of regulation decreased and the non-uniformity diminished.

The levers H_1 and H_2 are thus in constant swinging movement, even when the pressure has not altered. When a pressure change does occur, both levers change their position. The lever H_1 always assumes the position where the exciter pressure keeps the core K_1 in equilibrium, and the lever H_2 naturally moves with H_1. The whole movement of H_1 between no load and full load is about 1·5 mm.; the path of the swing about $\frac{1}{20}$ mm. The number of swings per minute varies from 400 to 1,000. The contacts C_1 C_2 are not used to switch in and out the shunt resistance directly, but are made to bring an electromagnet into action, which moves through a long distance and is more effective. A condenser is used to damp the sparking in the circuit.

The important advantage of this regulator is the speed with which the voltage of the exciter is altered, which can only be accomplished by switching in and out the entire resistance. Thus it does not regulate so quickly with large load changes as with small. Further, the regulation is so exact that in this respect it excels all others. But they cannot work in parallel, so that large stations must be governed by a single regulator and the same type and size of machines must be used.

To make these mechanical regulators sensitive to pressure changes due to variations in speed a large ohmic resistance is inserted in the field circuit of the alternator, so that the current in the solenoid becomes independent of the frequency.

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ELECTRIFICATION OF STEAM RAILROADS.

The Committee appointed by the New York Railroad Club to investigate the subject of the electrification of steam railroads recently presented its report. The Committee consisted of Messrs. W. J. Harahan (Erie Railroad), chairman, L. C. Fritch (consulting engineer, Illinois Central Railroad), H. M. Warren (Delaware, Lackawanna & Western Railroad), H. H. Vaughan (Canadian Pacific Railway), J. H. Davis (Baltimore & Ohio Railroad), G. W. Wildin (New York, New Haven & Hartford Railroad), W. McClellan (consulting engineer), C. O. Mailloux (consulting engineer), and E. B. Katte (New York Central & Hudson River Railroad). The following abstract of the report is contained in an article in the "Electric Railway Journal."

A number of the most important events in the history of the electric railway are first cited. Then, in referring to the characteristic features of electrification and in connection with the subject of flexibility, it is stated among the advantages of electricity that locomotives or motor cars may be coupled in a variety of ways and operated by means of the multiple-unit system from one point in the train. Public streets and highways may be occupied, if necessary, and operation in tunnels ceases to be objectionable. Trains may be shorter and more frequent, or they may be of any size that business conditions dictate, consistent with mechanical considerations. A distribution of driving wheels throughout the whole train permits high acceleration, which in turn permits increased schedule speed without excessive increase in maximum speed. All of these features have a varying weight according to the circumstances of the particular problem at hand. Referring to weather conditions, the report declares that electric service has been found to be but slightly affected by snow or other weather conditions, and that in cold weather the steam locomotive is at a disadvantage, but not an electric locomotive or motor car. The Committee believed that the electric locomotive would have much less idle time under the same conditions than steam locomotives, and can be designed for practically continuous operation over any length of run. It has also a very much larger power capacity and is much more cleanly.

The principal reasons for considering electrification, in the opinion of the Committee, are an increase of station and track facilities, an increase in gross earnings due to more frequent trains, and legislative enactment. In referring to the increase in gross earnings, however, the report states that the mere substitution of electricity for steam will not accomplish a very great increase in gross earnings, but by changes in schedule and stops the service must be made more convenient and attractive to the desired patrons. Inattention to this feature is preventing some roads at present from realising the full possible returns upon their electrification.

Upon legislative enactment requiring the substitution of electricity for steam the Committee says: The operation of a steam railroad in the heart of a large city is of necessity attended by features not always ideal. On account of the cost of land and other conditions, the amount of space for roadway is likely to be cramped and closely pressed by city and private property. The emission of smoke and gases from the locomotives, especially if a subway or tunnel is involved, often leads the community to demand that the railroad abolish the objectionable features. This demand, in its essentials, may be reasonable enough, and if by calm and considerate discussion it can be shown that conditions are unnecessarily bad, the public has a right to expect the railroads to provide a reasonable remedy. Unfortunately, however, the discussion is sometimes fanned into a condition where hostility and acrimony become the chief features. As a consequence, the public may make demands, the difficulty, expense and result of which it has no conception, and the railroad is compelled to refuse anything like the full extent of the demands because it knows it cannot afford to do otherwise. In this connection the following are a few broad considerations which common-sense and equity present: (1) A railroad has a charter franchise or special privilege from the commonwealth, and, therefore, belongs to a class of activities which must especially consider the interest of the public. (2) A railroad is also a business venture organised to make money, and those responsible to the stockholders must conduct its affairs so as to serve their best ultimate interest. (3) A nuisance, for example, smoke, incident to the operation of a property, whether factory, railroad, store or what not, may be deplored, but all sources of such nuisances must be treated alike, and it should also be determined how far a removal of the nuisance might endanger the industry itself and cause its failure. (4) It is only fair to assume that men who have worked in the public eye, at any particular business, for a number of years, are men of integrity and well informed as to their business. Action should be taken, therefore, by the community only when advised by well-informed persons and after comprehensive considerations. (5) There are not two sides to this problem. The interests of the railroads and those of the public are one.

The Committee made an effort to secure operating data for publication from the existing electrified steam railroads, but this attempt met with little favourable response, because, almost without exception, the men who are responsible for the operation of these properties did not think the conditions were sufficiently settled to permit them to publish data that would be just either to steam or electric operation.

The report concludes as follows: To sum up, the following may be stated as the advantages and disadvantages of electrification:

Advantages.—(1) Increasing the capacity of a given terminal by the elimination of switching movements, where multiple units are used, and increasing the scheduled speed of trains without increasing maximum speed by the higher acceleration possible with electric power; also increasing the capacity of the line and permitting shorter block signal spacing.

(2) Avoidance of smoke and steam nuisance, making unobjectionable tunnels, subways and underground stations, and reclaiming the aerial space above track for offices, stores, warehouses, hotels or other buildings; also a saving in deterioration of metallic structures, because of the corrosive products of combustion in steam locomotives.

(3) Uniform power over grades and greater tractive power of electric locomotives of equal weight with steam locomotives, including tender, making heavier trains possible over mountain divisions. Locomotives may be used in multiple without increasing the cost for enginemen.

(4) Economy of operation under conditions favourable to electric traction, such as frequent multiple-unit train service or cheap electric power as compared with the higher cost of locomotive coal.

(5) Electrical operation has proved itself reliable.

(6) Electric power is not a source of danger to the travelling or general public.

Disadvantages.—(1) A large investment for re-equipping the railroads with the new power, which can only be justified by definite financial or economic results.

(2) Increased danger to employés or the railroad due to the presence of the third rail or the overhead conductor, especially in yards or terminals.

Future Electrification.—The following features with reference to present conditions should be considered, having in view future electrification: (1) The signal system should be designed with a view of meeting the restrictions involved in electrification work. (2) Bridges, yards and terminal platforms should be designed to conform to the clearances necessary for the installation of working conductors. (3) Locomotives and cars should be designed to conform to electrification clearances. (4) The lighting system of cars should be designed for economical use on electrified roads. This applies also to the heating systems. (5) Steam, water, air and gas pipes in yards and at stations should be laid out to avoid current collectors on future electric equipment and working conductors, also bonded to avoid electrolysis.

Conclusions.—(1) No general information is available on the basis of which steam railroads, as a whole, would be justified in electrifying terminals or main lines, solely on the grounds of economy. (2) Careful investigation is necessary to decide if electrification of terminals and suburban districts would be warranted in order to increase earnings. (3) More attention should be given to the possibilities of electrification in connection with heavy grades, and at other places where an increase in facilities is needed. (4) It is not likely that conclusive data on the economy of electrification will be available until electrification is extended over a complete steam locomotive stage. (5) The electrification for passenger terminal and suburban service is now more or less settled as to method, but for freight and general trunk line service it is in the experimental stage. The types of locomotives for various service have not been determined, though progress is being made. The method of secondary distribution (working conductors) needs much development. The third rail is thoroughly reliable and efficient, but unsuitable for complicated switch work. In its present form it has only been used for voltages up to 1,200. The overhead system for high voltage working conductors also needs much development. Few, if any, are satisfied with present designs and many changes are proposed. (6) The steam railroad men and electrical engineers should work together in as close harmony as is possible, so as to produce results that will be as free from mistakes and experiments as is possible in any developing art. (7) Each problem must be studied on its merits, and a decision can only be made after careful study of the conditions pertaining to each situation. (8) The electrification of large freight terminals has not as yet been attempted, nor satisfactorily worked out, therefore it is necessary to proceed with caution in this matter, and the problem

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must be exhaustively studied and new developments made before it would be justifiable to make such an installation. The electrification of any large freight terminal would involve a number of roads, and cannot be undertaken independently, without the co-operation of all the railroads affected, on account of the relations existing among the various roads in the interchange of freight traffic.

RAPID ELECTROCHEMICAL ANALYSIS: A COMPARISON OF SEVERAL METHODS.*

BY L. S. PALMER AND R. C. PALMER.

Considerable information has appeared in recent years on the rapid deposition of copper, zinc and other metals. Various devices have been employed, such as rotating the cathode, rotating the anode, and lately even rotating the electrolyte. Some experiments on the determination of copper with the apparatus of Frary,† in which the electrolyte is rotated and the electrodes are stationary, led us to believe that the speed with which complete deposition was obtained was not wholly accounted for by the fact that the electrolyte rotated, but depended to a large extent upon the nature of the electrodes. The anode used in the Frary apparatus is a platinum spiral of about 1 mm. diameter; the cathode a platinum gauze, weight about 14 grammes, 15 mesh to 1 cm., size 11 cm. by 5 cm. To test this supposition we conducted a series of tests to determine the relative merits of the two factors—gauze cathode and rotating electrolyte,—in rapid depositions.

Three sets of tests were made with cupric sulphate solutions—one with a rotating electrolyte using the gauze cathode; a second set without rotation of electrolyte using a gauze cathode; and for comparison a series using the usual form of platinum cone as cathode, without rotation of the electrolyte. Two sets of test were made on zinc depositions similar to the first two for copper, with the exception that the electrolyte was cooled by means of water flowing through a lead spiral surrounding the vessel containing it, as described by Frary.‡ The conditions for the copper determinations were taken from data given by Fischer.§ The conditions for the zinc depositions were taken from data given by Frary.¶ At the end of each experiment the solution was siphoned off with the current still on and water added to dilute the electrolyte to prevent the re-dissolution of the deposit. The first 250 c.c. portion was saved for testing the completeness of the deposition by means of the usual potassium ferrocyanide test. In the zinc determination, in place of a nickel gauze cathode as described by Frary,¶ the cathode was plated with copper before each determination.

As a result of these experiments it was found that, under the conditions of our experiments, 0·31 gramme of copper was completely deposited on the gauze cathode in 25 minutes with magnetic rotation of the electrolyte; in 50 minutes without rotation, and in five hours using the platinum cone cathode. That is, the copper was deposited twice as fast with rotation as without, and 12 times as fast with rotation as by the old cone method. It seems from this that the rapidity of Frary's method is due, in a large measure, to the gauze cathode. Another test was made which showed the marked influence of the gauze cathode on rapid deposition, in which, without rotation of electrolyte, 0·5 gramme of copper was completely deposited on a platinum gauze from 50 c.c. of solution in five minutes. A current of 8 to 10 amperes was used with only a few drops of conc. nitric acid. The deposit, however, was slightly spongy.

The data show no difference in the time required for complete deposition of zinc. The only difference shown is that the bulk of the zinc was deposited slightly faster with rotation. Since Frary's result (the deposition of 0·1 gramme in 30 minutes) was reproduced in both cases, we concluded that the lead coil reduced the rotation of the electrolyte to such a large extent that the slight rotation that might still exist had very little effect on the rate of deposition. In fact, there was such a large evolution of gas during the electrolysis that it was difficult to tell whether the electrolyte rotated or not, showing that there was sufficient agitation of the electrolyte from this cause alone to produce the rapid deposition.

The use of the gauze cathode in rapid electrolytic determinations is shown by these tests of the efficiency of Frary's rotating electrolyte apparatus to play a sufficiently important part to warrant its use alone for simple rapid determinations, and thus dispensing with the various mechanical devices for agitation of the electrolyte.

* Abstract of a Paper read before the American Electrochemical Society, "Transactions," Vol. XV.

† "Jour." Amer. Chem. Soc., 29, 1592 (1907).

‡ *Loc. cit.*

§ "Elecktroanalytische Schnellmethoden," p. 106.

¶ "Jour." Amer. Chem. Soc., 29, 1596 (1907)

DISCUSSION.

Mr. F. C. FRARY said it would be a very good thing if this Paper and the one by Stoddard (*loc. cit.*) served to call the attention of American chemists to the great advantages which the gauze cathode has over all others. These were first emphasised by Paweck,* and later by Winkler† and others, who made the same point as Messrs. Palmer and Stoddard, that more rapid deposition at a higher current density was possible with its use. Its good points were clearly pointed out by Foerster‡ and Classen,§ and mentioned by Smith,¶ but did not seem to be generally appreciated. It seemed to the speaker, however, that the conclusion drawn from this Paper and that of Stoddard, that the rotation of the electrolyte might be dispensed with entirely was premature, and rested on too slight an experimental foundation. Copper was probably the easiest known metal to deposit with approximate completeness in an adherent form. That such results might be obtained even without the gauze cathode is shown by a Paper read by Prof. Exner before the Minnesota Section of the American Chemical Society in 1907. He showed that copper could be satisfactorily precipitated on a platinum cylinder with stationary electrodes in a short time by simply heating the solution from beneath with a flame, so that convection currents stirred in a little. Great results were hoped for from this method, but did not appear to have materialised. It seemed very probable that 0·3 gramme of copper could be as satisfactorily deposited from the electrolyte used by the Messrs. Palmer upon a platinum dish, without rotation, by 5 amperes in 50 minutes, as upon the gauze electrode. The ordinary cone or cylinder could not be expected to yield such results, on account of the large portion of the solution which was out of the direct line of current flow. But the electrolyte used was hardly the most suitable for the rapid complete precipitation of copper. Withrow|| had shown the retarding effect of large amounts of nitric acid; it might also be seen by a comparison of results obtained here with those given in this Paper. Students regularly get complete precipitation of 0·2 to 0·6 gramme of copper in 12 to 16 minutes with the use of a current of 5 amperes and magnetic rotation of the solution, as against 25 and 50 minutes found necessary by the Messrs. Palmer with and without magnetic rotation respectively. An electrolyte containing, apart from copper sulphate, from 10 drops to several cubic centimetres of concentrated sulphuric acid, and about 2 grammes of ammonium sulphate was employed, and the deposits were a little darker than those from a nitric acid solution, as stated by Winkler (*loc. cit.*), but are adherent and apparently of proper weight. It was also doubtful whether the Messrs. Palmer obtained complete precipitation of copper in any experiments reported here if, as appears from the Paper, this was determined by the use of a ferrocyanide solution. Experience indicated that quantities of copper in excess of a milligramme were often not indicated by this re-agent. Hydrogen sulphide seemed to be the best precipitant. The precipitation of zinc, as described here, was more to the point, but the conclusion that the lead coil largely reduced the rotation of the electrolyte was probably erroneous, since lead, water and air had practically the same permeability.** The authors were undoubtedly deceived by a phenomenon which the speaker had frequently observed with this apparatus, that the surface of the liquid became partly covered with foam or froth, which attached itself to the electrodes and did not rotate much for two reasons: (1) High electrical resistance, due to its porous structure, so that it carried practically no current, and hence was subject to no torque; (2) sufficient adhesion to the electrodes, due to surface tension, to prevent it from being carried around by the moving solution. This phenomenon was especially common in alkaline solutions. The Paper of Stoddard (*loc. cit.*) was inconclusive in its present form, and could not be cited in support of the conclusion mentioned, since he neglected to show in any case: (1) That precipitation was complete. He stated that such was the case, but did not determine the accuracy of his methods of testing. (2) That the precipitate was of proper physical character. In the case of zinc his description showed that it was not. (3) That it represented the actual amount of metal in the solution—*i.e.*, was neither oxidised on account of sponginess, as was often the case with metals deposited at too high a current density, nor deficient in weight due to mechanical losses caused by the same condition. The whole matter was worthy of a thorough investigation, preferably by several parties working independently.

Messrs. L. S. PALMER and R. C. PALMER, in reply, said, in regard to the copper depositions, they had called attention to the fact that their solutions contained considerable quantities of nitric acid. Mr. Frary stated that such solutions were not the most suitable for rapid and complete deposition. As the authors' object was not primarily to see how rapidly the deposits could be made complete, the fact that Mr. Frary and his students were able to obtain more rapid depositions with other solutions had only a remote bearing on the problem. In the case of zinc depositions, the

* "Chem. Ztg." 1900, 24, 854; Bericht über den III. internationalen Congress für angewandte Chemie, Wien, 1898, Vol. I., p. 202.

† "Berichte" 1899, 32, 2192.

‡ "Elektrochemie wässeriger Lösungen," 1905 edition, Vol. I., pp. 238, 239.

§ "Quantitative Chemical Analysis by Electrolysis," 1903 translation, pp. 114, 115.

¶ "Electro-analysis," 1907 edition, p. 72.

|| "Jour." Amer. Chem. Soc., 1908, 30, 381.

** "Standard Handbook for Electrical Engineers," 2, 30.

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permeability of lead, air and electrolyte, which Mr. Frary pointed out to be the same, has no bearing on the rotation. The rotation of the electrolyte was due to the number of lines of force or the magnetic flux through it. The lead coil introduced between the solenoid and the beaker evidently took up a large number of these lines of force, causing a smaller number to pass through the beaker itself and thus decreasing the rotation of the electrolyte. However, the question of rotation had no bearing here, as the data showed that the same results were obtained with and without passing current through the solenoid.

ON THE EFFECT OF SHUNTING INDUCTIVE COILS.

BY G. W. O. HOWE, M.SC.

Summary.—The author shows geometrically that although the effective resistance under certain conditions may be increased by shunting a highly inductive coil by a non-inductive resistance, the impedance is not increased.

Under certain conditions the effective resistance of a highly inductive coil is increased by shunting it with a non-inductive resistance. This, at first sight, striking fact has been pointed

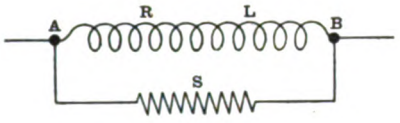

Fig. 1.

out recently by Mr. Albert Campbell (The Electrician, December 10, 1909). Mr. Campbell has worked out the increase of effective resistance, and has given the results of some experiments confirming the formulæ so obtained. He then states that the increase of *impedance* in such cases was pointed out some years ago by Mr. H. E. Harrison. Now, it can easily be shown that the *impedance* is not increased, but that the decrease of inductance is always more than enough to counteract the increase of resistance.

Although this is not very evident from the mathematical treatment, it can be seen at once from the vector diagram. This method has the additional merit of making the whole phenomenon quite plain and of removing the air of mystery.

Without the non-inductive shunt S, the current and P.D. may be represented by the vectors V and C_1. Since the coil

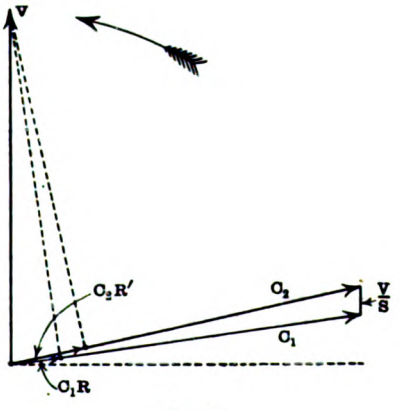

Fig. 2.

is assumed to be very inductive C_1 will lag nearly 90 deg. behind V. When the high-resistance shunt is connected across AB, a small current V/S will flow through it, in phase with V. The resultant current will now be C_2. Since C_2 is evidently larger than C_1, *the impedance has been decreased.*

The effective resistance is obtained in either case by dropping a perpendicular from V on to C_1 or C_2. This gives the energy component of the applied P.D., which must be divided by the current to obtain the effective resistance. The length of the perpendicular gives ωLC. It is evident that C_2 is slightly greater than C_1, that $\omega L'C_2$ is smaller than ωLC_1 and that C_2R' is considerably greater than C_1R, where R′ and L′ are the effective values of the coil when shunted. Hence L′ is smaller than L, and R′ is greater than R.

From the geometry of the figure it is evident that, under the assumed conditions

$$\frac{V/S}{C} = \frac{C(R'-R)}{V} \text{ (approximately),}$$

or

$$R'-R = \frac{V^2}{SC^2} = \frac{Z^2}{S},$$

where $Z = V/C$ = the impedance of the coil only.

This is the formula evolved and experimentally verified by Mr. Campbell.

The correction for distributed capacity in an inductive coil can be obtained in the same way.

We see from Fig. 3 that the perpendiculars alter very little in spite of a large change in the current. Hence

$$\omega LC_1 = \omega L'C_2 \text{ (approximately)}$$
$$\therefore \quad \omega LC_1 = \omega L'(C_1 - C_K)$$
$$\therefore \quad \omega(L'-L)C_1 = \omega L'C_K$$
$$\therefore \quad L'-L = \omega^2 L^2 K \text{ (approximately).}$$

This is the well-known correction for distributed capacity. It is equation (4) in Mr. Campbell's Paper.

While the mathematical method is undoubtedly preferable where an accurate knowledge of the errors and corrections is required, the graphical method has the great advantage of giving one a clear mental picture of the relative magnitudes and phase relations.

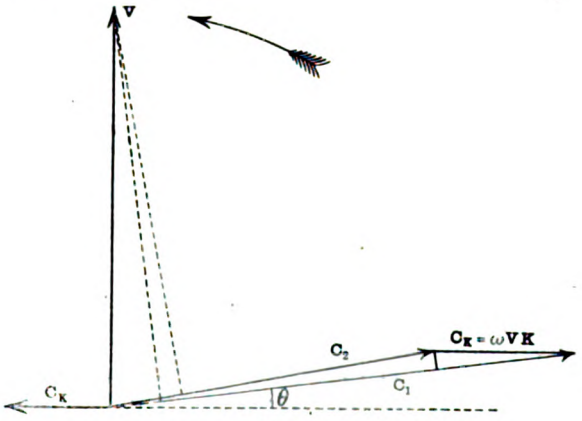

Fig. 3.

It should be stated, in justice to the late Mr. H. E. Harrison, that he does not make the statement with which he has been credited, although the experiment he describes might lead one to imagine that the impedance had been increased by the addition of the shunt.

THE POLARISATION OF DIELECTRICS IN A STEADY FIELD OF FORCE.*

BY W. M. THORNTON, D.SC., D.ENG.

Summary.—This Paper contains an account of experiments on the polarisation of dielectric ellipsoids and cylinders suspended in a steady electric field. From measurements of the field intensity, the dimensions of the ellipsoids and the frequency of torsional swings with and without the field, the dielectric constant is determined. From the rate of increase of the dielectric constant the specific resistance of various substances is calculated.

The slow polarisation of a dielectric ellipsoid suspended in a steady field of force can be followed by observing from time to time the period of small swings about the line of the field.† In a perfect insulator the polarisation reaches its full value in a much shorter time than the period of such a moving system, and a single observation of the latter would suffice to determine the dielectric constant of the ellipsoid. In all solid dielectrics there is, however, slow electrical movement under the influence of the field within the ellipsoid and a consequent accumulation of charge at each end. The restoring couple, and therefore the apparent dielectric constant, increase

* Abstract of a Paper read before the Physical Society. A short account of the discussion was given in The Electrician, February 11, 1910, p. 728.

† Roy. Soc. "Proc." A, Vol. LXXXII., p. 422, *et seq.*

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until the limit to molecular polarisation is reached. The advantage of the method is that the "conduction" current is confined to the separation of charge within the solid symmetrically about the central section.

An account is here given of observations made upon the behaviour of various solid dielectrics, in which the total polarisation is expressed in terms of the apparent dielectric constant. From these observations the resistivity of insulators has been found in a new way. A difference of one part in a thousand in the dielectric constant can be readily measured by the suspended ellipsoid method. On account of this sensitiveness three stages in the polarisation were found to be present in all the homogeneous substances examined. First, a sudden very rapid yield, then a slow change at a uniform rate, and finally an approach to saturation. The first suggests a normal slackness of charge in the dielectric molecule, the second is probably a continuation of the polarisation by the influence of adjacent molecular charges, a slow linear change of the nature of a simple strain. In the third stage the rate of displacement ceases to be uniform, and the polarisation reaches a maximum which is shown in the Paper to be independent of the intensity of the polarising field within the specimen.

According to this "three stage" theory, the quantity passing in the instantaneous charge or discharge of a condenser with a solid dielectric, involving as it does the first stage only, should be proportional to the voltage; the total residual *charge* corresponding to the later stages, the apparent dielectric constant of which is independent of voltage, should also be proportional to the voltage, as shown by Hopkinson* to be the case. Dielectric hysteresis loss should decrease with rise of frequency, on account of the smaller range possible in the second stage, which agrees with the experimental results of Threlfall.† It was found, further, that there was no permanent residual electrification in the dielectrics examined, showing that the polarisation, however long continued, and slow in action, was quasi-elastic in type. When testing electric cables the charging current is sometimes measured after one minute's electrification. With the usual insulators this is only in part a true conduction current, the rest being the second stage of polarisation. What the latter would be in any condenser can be calculated from the curves of rate of change of apparent dielectric constant given later, and in this way the true conductivity found.

Experiments on Quartz.—The quartz was cut parallel to the optic axis and formed into an ellipsoid 2 cm. long and 0·2 cm. diameter. It was very carefully cleaned, dried and suspended by a quartz fibre about 0·001 cm. diameter and 20 cm. long between flat brass plates 6 cm. apart, contained in a vessel dried under vacuum and by phosphoric anhydride for several weeks. The leak between the plates would therefore be exceedingly small, and with a P.D. of 480 volts between the plates the observed periods were the same in dry air and in vacuo. In order to obtain more than two-figure accuracy by this method it is necessary to take the mean of at least five observations of the period. In the first few minutes this was as a rule changing quickly, and it was only in the later stages of the polarisation that several readings could be taken.

Particulars of the form and dimensions of the specimens used in this Paper are given in that dealing with alternating fields.‡ The free period of the quartz ellipsoid was 63·3 seconds. A table in the Paper gives the observed periods in fields of various strength for the first 20 minutes of polarisation. Later observations showed that 20 minutes was not long enough to establish full polarisation. The ellipsoid was therefore re-suspended, having now a free period of 34·73 seconds. After 120 hours in a field of 0·137 electrostatic unit the period was 17 seconds; after 24 hours longer in a field increased to 0·266 unit, 9·72 seconds.

Values of the dielectric constant calculated from the restoring couple on an ellipsoid making small swings in an alternating field of force are in close agreement with the best previous determinations. The assumption made in calculating the couple is that the polarisation is taken up instantaneously in any position, and the agreement shows this to be justified. When, however, the field is unidirectional the components of polarisation are not the same along and at right angles to the axis of the ellipsoid. It will be shown, subsequently, that several days are, in general, required to reach a steady state when the ellipsoid is allowed to stand in line with the field. There is in this position no transverse polarisation, but if the ellipsoid is then given small swings there will be one which alternates with the motion and may thus be considered to be proportional to the constant obtained in alternating fields.

The ellipsoid behaves, in fact, as if it were in effect crystalline, and the restoring couple at unit angular displacement is

$$\left(\frac{\kappa_1}{1+\kappa_1 N}-\frac{\kappa_2}{1+\kappa_2 L}\right)VF^2,$$

where κ_1 is the longitudinal and κ_2 the transverse susceptibility, N and L the longitudinal and transverse reaction coefficients, V the volume of the ellipsoid, and F the intensity of the external field. This couple is equal to $4\pi^2 I(n^2-n_0^2)$, where I is the moment of inertia of the suspended system; n, n_0, the frequency of swing with and without the field.

Hence $$\left(\frac{\kappa_1}{1+\kappa_1 N}-\frac{\kappa_2}{1+\kappa_2 L}\right) VF^2=4\pi^2 I(n^2-n_0^2).$$

Writing $$\frac{4\pi^2 I(n^2-n_0^2)}{VF^2}+\frac{\kappa_2}{1+\kappa_2 L}=a,$$

we have $\kappa_1=a/(1-Na)$, and the dielectric constant

$$K_1=\frac{1+(4\pi-N)a}{1-Na}.$$

For a *quartz ellipsoid cut parallel to the optic axis* L=6·133, N=0·3013, V=0·0534 c.c., I=0·02912, K_0=4·60. From the later set of observations given above n^2=0·0106 in a field 0·266, n_0^2=0·00083. Thus $F^2/(n^2-n_0^2)$=7·25 and a=3·069, giving finally K=508. (Quartz ||.) In the weaker field, F=0·137, $F^2/(n^2-n_0^2)$ =7·16, giving K=610.

An *ellipsoid of quartz cut perpendicular to the axis* had L=6·125, N=0·313, V=0·056, I=0·0307, K_0=4·548. Its free period was 33 seconds. After exposure to a field 0·26 for 48 hours the period was 19·3 seconds: after 41 hours longer in a field 0·132, 26·75 seconds. From these we have the steady values $F^2/(n^2-n_0^2)$=36·5, F=0·26, and $F^2/(n^2-n_0^2)$=36·4, F=0·132, a=0·6705, and K=11·66. (Quartz ⊥).

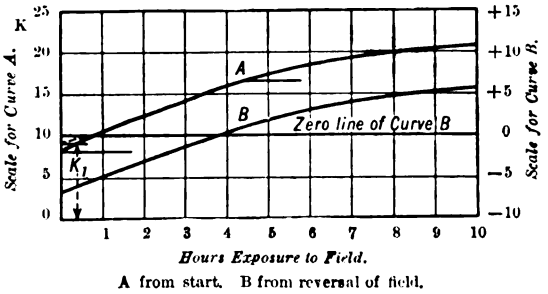

FIG. 1.

Thus both in alternating and direct fields quartz || has the larger values, but whereas in the former the ratio of the dielectric constants is 1·012, in the latter it is about 45.

Observations recorded in the Paper show the exceedingly slow rate of polarisation of quartz ⊥ compared with quartz ||. The mean of $F^2/(n^2-n_0^2)$ is 8·81, and since the derived value of K depends upon this we have the remarkable fact that the polarisation approaches the same value irrespective of the intensity of the polarising field. This suggests that the slow polarisation is a consequence of internal molecular attractions started by the initial polarisation and maintained to a limit by the continuance of the field, but not in any way proportional to it.

Fused quartz has been largely employed in the construction of electroscopes for use in measurements of radioactivity. It is conceivable, though not highly probable, that some of the earlier observed feeble radioactive effects may have been in some measure due to the slow absorption of charge by the quartz support, for the rate of charge or discharge of such an instrument must be influenced by the polarisation of the support.

Experiments on Flint Glass.—Similar measurements to those on quartz were made with flint glass specimens. In the case of an ellipsoid, of density 3·3, free period 14·9 seconds, after 22 hours in F=0·271, period 12·33; after 48 hours longer in F=0·136, period 13·9. For the former $F^2/(n^2-n_0^2)$=26·85, and the latter 27·2. Fig. 1 shows the *forced depolarisation* of a dielectric by a method distinct from discharge through a galvanometer. The chief interest lies in the fact that whether the polarisation is increasing from zero or being reversed the rate of change is for a long time the same. It is also noticeable that the time occupied in the linear polarisation is nearly the same in both cases. The value of K before the field was reversed was 25, of which 9 was the sudden rise at the start. At reversal there was a rapid change equal to twice that from zero—*i.e.*, of 18, leaving a polarisation of K=7 in a direction opposite to that of the field. It will be seen that curve B starts from a value—7.

* Roy. Soc. "Phil. Trans," Vol. CLXVII., part ii., pp. 599-626 (1877).

† R. Threlfall, "Physical Review," Vol. V., p. 65.

‡ Roy. Soc. "Proc.," *loc. cit.*

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The ellipsoid was then exposed to the field for three weeks and acquired a value of K = 6,075. The following numbers give the *free depolarisation* from this high value. The periods from which K was calculated were taken by applying a weak field and measuring the period after it had been on for a minute in each case, after which it was cut off. There is no doubt a sudden rise of polarisation at the moment of applying the field, but since the conditions are the same in each case the figures give an approximation to the rate of relaxation.

Time	10 m.	1 h.	2 h.	3 h.	4 h.	5 h.	19·5 h.
K	6,075	426	79·7	28·0	12·73	9·0	8·17

Four typical substances were next examined, and the results show that for different substances and over a wide range of values the effective polarisation of an insulated rod approaches the same final value whatever the intensity of the field may be.

Rate of Polarisation.—In the foregoing observations of the rate of change of K in steady fields there appear then to be three stages, a sudden yield, followed by a change at a uniform rate for intervals of time differing in the various substances from a few minutes to several hours, and later an approach to saturation. In order to see how these, especially the second, hold over a wider range of substances a number of measurements were made. These show that gutta-percha, upon which so much depends in the working of submarine cables, has the highest values of all the substances examined. It is at least possible that some of the difficulties of cable working arise from this cause. If by mixing a suitable insulator of lower

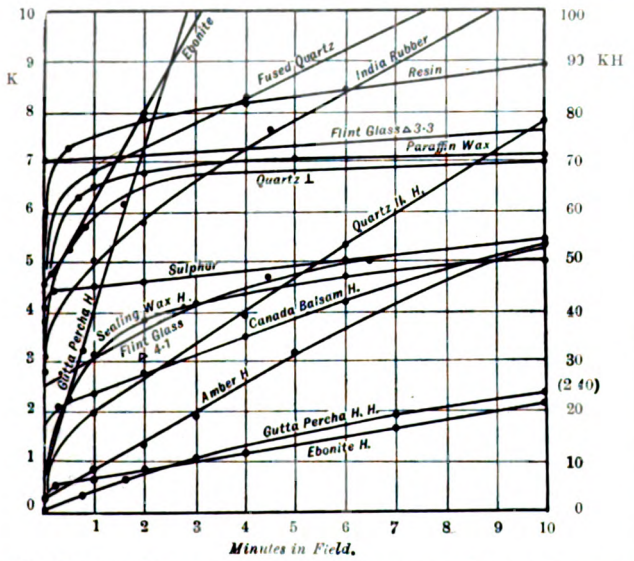

FIG. 2.—RATE OF POLARISATION OF DIELECTRICS IN STEADY FIELDS.

dielectric constant with it, or by some system of grading, retaining at the same time the impermeability to water, the effective constant could be reduced, the rate of signalling might be accelerated. Curves of the rates of change are given in Fig. 2 for the first 10 minutes of electrification, and it will be seen that the features of a rapid rise at the start and a straight line change following it are present in all but sealing-wax, a mechanical mixture. The linear change in most cases lasts for several hours. In the case of fused quartz the polarisation is steady in half an hour, and no increase was observed after several days in the field. This rapid polarisation is possibly the reason for its use as an insulator in electroscopes. The initial rush is in almost every case over within a minute. This may explain why observations of cable resistance are taken after this interval.

Measurement of Specific Resistance.—The fact that the rate of change of the effective dielectric constant is uniform for some time after the field is applied, provides a method of measuring the specific resistance of a dielectric during polarisation as distinct from that using the "time of relaxation." Whatever the nature of the electrical movement during the polarisation of an insulated ellipsoid may be it is in effect a current, the density of which is the rate of change of the total polarisation in unit volume. The field within the ellipsoid is given by $F_1 = F/(1+\kappa N)$, where $\kappa = (K-1)/4\pi$. The polarisation is then KF_1, and writing the apparent specific resistance ρ, we have $\frac{d}{dt}(KF_1) = \frac{F_1}{\rho}$. The resistance measured in this way differs, though not to a marked extent, from that found by the passage of a steady current through the dielectric.

Specific Resistance of Dielectrics at 17°C.

—	ρ ohms per cm. cub.	—	ρ ohms per cm. cub.
Paraffin-wax	$4{\cdot}9 \times 10^{16}$	Ebonite	$4{\cdot}5 \times 10^{14}$
Quartz ⊥	$2{\cdot}0 \times 10^{16}$	Canada balsam	$2{\cdot}8 \times 10^{14}$
Flint glass Δ 3·3	$9{\cdot}9 \times 10^{15}$	Flint glass Δ 4·1	$2{\cdot}5 \times 10^{14}$
Sulphur	$8{\cdot}2 \times 10^{15}$	Amber	$1{\cdot}55 \times 10^{14}$
Resin	$7{\cdot}0 \times 10^{15}$	Quartz ∥	$1{\cdot}53 \times 10^{14}$
Fused quartz	$1{\cdot}6 \times 10^{15}$	Gutta-percha	$6{\cdot}21 \times 10^{13}$
Indiarubber	$1{\cdot}5 \times 10^{15}$		

It may be said that in view of the facts of slow polarisation the measurement of the current after one minute's electrification is meaningless as an indication of the resistance of the insulation. A large part of the current is polarisation change. The leakage method of measuring the resistance of insulators is also complicated by this slow depolarisation of the dielectric and greatly influenced by the time of charge. We have from the above

$$\frac{\rho}{4\pi}\frac{dK}{dt} = 1 + \left(\frac{K-1}{4\pi}N\right),$$

from which ρ may be found at any stage of the polarisation. Since the measurements are in electrostatic units, ρ is also, and in electromagnetic measure is $= v^2\{4\pi + (K-1)N\}/dK/dt \cdot 10^9$ ohms per centimetre cube, where v is the ratio of the electromagnetic to the electrostatic unit of charge.

The above table gives values of the specific resistance found in this way from the observed rates of change of Fig. 2. The indiarubber and gutta-percha were not specially prepared for cable work. The ratio of Curie's values for quartz ⊥ and ∥ is 240; those now

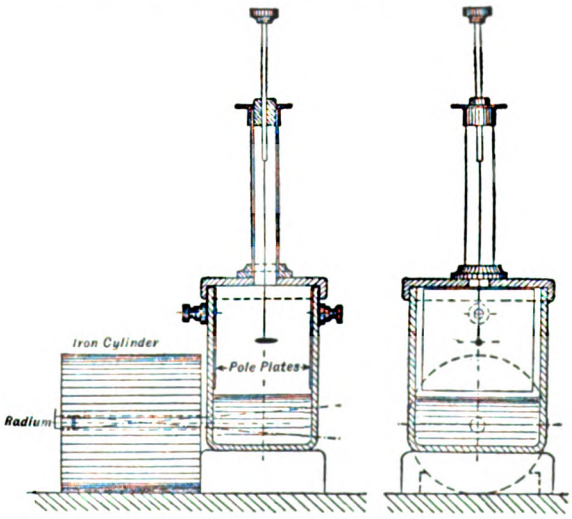

FIG. 3.—TESTING CELL FOR EXPOSURE TO RADIUM.

obtained give 130. It is interesting to note that the velocity of light in quartz is greatest when the wave-front and current are in the direction of least electrical conductivity. In accordance with previous observations the lighter flint glass has the higher resistivity. Paraffin-wax was the most perfect insulator examined.

Slow Polarisation.—The electrical movement within the substance during slow polarisation may be a translation of free electrons, as in metallic conduction, a transfer of charge, as in electrolysis, or a separation of the internal charges of the molecule, so that its electrical moment increases. In order to determine which of these occurs in the present case, a flint-glass ellipsoid was suspended in a glass cell (Fig. 3), the upper part having pole plates, so that a field could be maintained there, and the lower being filled with disulphide of carbon. Outside the cell a massive iron cylinder was placed, having a small central hole pointing towards the line of suspension. The ellipsoid was exposed to the field for several days, and its steady period noted. It was then lowered into the liquid and exposed to the radiation from a strong tube of radium bromide placed in the end of the iron cylinder. After five minutes' exposure the ellipsoid was raised, allowed to stand in the field for the same time that it had been removed from it, and its period then found to be unchanged. The liquid was used to shield the specimen from any ions which might possibly gather on it from the poles, and to prevent any change in the gradient between the poles by the diffusion of ions from the line of the radium discharge. If the charge on the ellipsoid had been in any sense free, whether residing on the surface or inside, it would have been rapidly removed and the period

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Ratio of the Initial Values of Dielectric Constants in Steady Fields to those in Alternating Fields.

—	K_{∞}.	K_0.	K_0/K_{∞}.
Quartz II ..	4·6	13·0	2·8
Flint glass Δ 4·1	8·5	25·0	2·9
Resin	3·09	7·0	2·3
Canada balsam	2·72	19·5	6·3
Paraffin wax	2·32	5—6	c.2·4
Gutta-percha	4·43	7·0	1·58
Sulphur	4·03	4·38	1·07
Indiarubber	3·08	3·4	c.1·1
Ebonite	2·79	4·2	1·5
Quartz ⊥	4·54	4·55	1·0
Flint glass Δ 3·3	6·98	7·0	1·0
Amber	2·3	2·8	1·0
Sealing wax	4·56	c. 4·6	1·0

lengthened by exposure to the radium. The experiment was repeated with the conditions varied in several ways with always the same result. It would appear from this that the electrical movement in a dielectric when isolated in the field is entirely confined to the molecule, and is therefore neither metallic nor electrolytic in type, but is the continued displacement of the atomic charges to a greater degree of separation than has been hitherto recognised.

It may be remarked here that the high values of the dielectric constants obtained in the Paper are confirmed by measurements on electric cables. Ashton* found that an ozokerit-ised rubber cable charged at 20·5·5 volts for 7,200 seconds absorbed $13·8 \times 10^{-5}$ coulomb. From the given dimensions the dielectric constant corresponding to this is 13·1. In this case also the slow polarisation was elastic in type, as shown by the fact that the quantity discharged on short-circuit was just twice that absorbed at constant potential.

It was early suggested by Mossotti that the behaviour of a dielectric can be explained on the assumption that it is made up of isolated conducting spheres. On any of the present electronic theories of matter the separation of charge under the influence of the field gives an arrangement similar to this. It is now suggested that the first stage of polarisation produces such a charged system, but that it differs from a system of conductors in that the charges undergo further separation automatically by reason of the attraction and quasi-elastic approach of opposite charges on adjacent molecules. The limit of the first stage of rapid polarisation is that of the rearrangement of atomic charge within the molecule, that of later stages the establishment of electrical strain throughout the mass under new conditions of internal stress set up by the first polarisation.

The range of the dielectric constant in the first stage may be taken as the intercept on the vertical axis in Fig. 2. Writing this K_0, it is of interest to compare it with the values found for the same substances in alternating fields,† as in the above table. The influence of frequency may from this be anticipated. For those substances in which the ratio is nearly unity it will be at low frequencies small, but for the first few in the list a greater change may be expected between zero and 80 alternations a second than from 80 to the frequency of light.

THE CHANGE-OVER TO CONTINUOUS CURRENT ON THE WASHINGTON, BALTIMORE & ANNAPOLIS RAILWAY.‡

This railway, which previously employed single-phase apparatus for operating its cars, substituted a 1,200-volt direct-current equipment on February 15th last. The reason for making the change is stated to have been the lighter weight of the continuous-current equipment. The Company's 60-ton cars, equipped for operation on the single-phase system, could not enter Washington because, owing to the limited strength of the yokes which support the city tracks, the maximum weight of the cars was restricted to 40 tons. As the railway company desired to run into the centre of Washington, it was confronted with the problem of securing a car of this weight equipped with motors of sufficient size to provide the high speed and high-class service required by the character of its patronage. A careful investigation of the engineering features involved showed that it was impossible to meet these requirements with the existing single-phase equipment. The Company then made an investigation into the relative merits of the two direct-current systems, and found that a large saving in first cost and operating expenses would result from the adoption of the 1,200-volt system in preference to the 600-volt.

The results under the new system substantiated the expectations formed of it. During the first day of operation the cars ran over 4,500 car-miles, and not a trip of the regular schedule was lost. Moreover, a saving of over 25 per cent. in energy was indicated by the watt-hour-meter records of the first few days.

Energy is still purchased from the Potomac Power Co., and is transmitted three-phase to the sub-stations at Ardmore, Naval Academy Junction, Annapolis and Baltimore, at a potential of 33,000 volts and a frequency of 25 cycles. The transformer primaries are Y connected and the neutral point is earthed. The transmission line is in duplicate, the conductors being of aluminium. The sub-station equipment consists of rotary converters, each set comprising two 300 kw. machines operated in series to supply energy at a potential of 1,200 volts. The converters operate in every way similarly to standard 600-volt machines, and are started from half voltage taps on the transformer secondaries in the usual manner. For the protection of the sub-station apparatus 33,000-volt aluminium lightning arresters are installed. Each transmission line is protected by an overhead earth wire.

The rolling stock consists of 30 passenger cars and three service cars. Each passenger car is equipped with four 75 H.P. 600-volt commutating-pole railway motors, and each service car with four 140 H.P. 600-volt motors, also of the commutating-pole type. The motors are insulated for 1,200 volts and are joined permanently two in series for 1,200-volt operation. The cars are equipped with automatic-relay control and have control couplers for operation in trains if desired. A potential of 600 volts for controlling and lighting the cars is obtained by means of a motor-generator, as on other 1,200-volt equipments. This is used only on the 1,200-volt section. On the 600-volt section the control lighting circuits are supplied direct from the trolley. The cars are equipped with Westinghouse automatic air brakes with graduated release. The air compressors are operated by 1,200-volt motors.

The cars run over the tracks of other companies in Baltimore and Washington, and have, therefore, to operate with a 1,200-volt single trolley and earth return; with a 600-volt double overhead trolley metallic circuit; and also on the 600-volt underground conduit system. The earth connection for single-trolley operation is obtained by means of a circuit through the negative trolleys and their holding-down hooks in such a manner that when either negative trolley is raised for operation on the double overhead trolley section the earth circuit is broken. The change from double-trolley overhead to conduit is made by a double-pole double-throw transfer switch, which may be operated either by compressed air controlled from the motorman's cab or by hand. All the electrical apparatus, both for the original single-phase and for the later direct-current equipment, was furnished by the General Electric Co., of Schenectady.

ELECTRIC DRIVING OF A LEAD MILL.

Messrs. Foster, Blackett & Wilson, who have for the past 50 years been established at Hebburn-on-Tyne as well-known lead manufacturers, recently decided to equip electrically the whole of their works. The contract was entrusted to Messrs. C. Martin & Co., of Newcastle-on-Tyne, the wiring to Messrs. Warren Beattie & Co., of Middlesbrough, and the complete equipment of motors, auto-starters and controllers to the British Westinghouse Electric & Mfg. Co. The result of last year's running has, we understand, fully justified the decision arrived at.

The raw materials are hauled in trucks by a single drum haulage running from the company's private jetty on the Tyne. On conversion, the crankshaft of the vertical double-acting steam engine formerly used was taken out and a gear wheel and countershaft put in, by means of which the haulage is now driven by a 60 H.P. motor operated by a drum controller. In carrying out the conversion, care was taken to avoid delays, by using as far as possible existing gear. The capital outlay, therefore, was kept down, and is, we are informed, very low for this class of work. The process of conversion was carried out without a shut-down and without any serious hitch in the operation.

In the separating house, the lead pigs are refined and the pure lead is run into a mould about 8 ft. square, in which a mass of metal, weighing about 8 tons, is formed. This metal slab, lifted by a jib crane, was formerly operated by a two-cylinder, double acting steam engine. The crankshaft and cylinders of the engine were taken out, a countershaft and gear wheel put in, and the drive effected by a motor and drum controller.

* A. W. Ashton, "Phil. Mag.," No. 52, 1901, p. 501, "On the Resistance of Dielectrics."

† *Vide* Roy. Soc. "Proc." A., Vol. LXXXII., p. 422, *et seq.*

‡ Abstract of an article in the "Electrical World."

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The lead mill has rolls about 20 in. in diameter and 8 ft. 3 in. long. Six live rolls, standing in series, facilitate the passing of the billets through the mill. The flywheel, which weighs 7 tons, and has a diameter of 19 ft., was retained for equalising the load on the motor. In contrast with this, the motor is almost lost sight of.

FIG. 1.—HAULAGE CONVERTED TO ELECTRIC DRIVING.

The mill was originally driven by a two-cylinder horizontal engine of 200 I.H.P. and 4 ft. 5 in. stroke, working at 60 lb. steam pressure. On conversion, the crank was replaced by a gear wheel, and the countershaft carrying the pinion engaging this wheel is now belt driven by a 90 H.P. slip-ring motor. A pair of rolling cutters at each side of the bed trims the edges of the sheets when necessary, and also acts as a guillotine for cutting the sheets into lengths, both of these being operated from the gearing of the mill.

We gather that the electric drive now installed has largely increased the output of the mill, in consequence of the steadier drive afforded. A 3-ton jib crane used for loading the finished lead from the mill bed has been equipped with a 10 H.P. motor, the motor and controller being mounted on a bracket which swings with the crane. Two pipe presses lie adjacent to the lead mill. each consisting of an hydraulic press forcing the solid lead out of a steel container through a die. A steel core bedded in the container settles the inside diameter of the pipes, which can be made from $\frac{3}{16}$ in. to 9 in. inside diameter, a maximum hydraulic pressure of $3\frac{1}{2}$ tons per square inch being exerted on an 18 in. diameter ram. The flywheel of the three-throw plunger pump, formerly steam driven, has been replaced by a 6 ft. diameter pulley belt driven by a 30 H.P. slip-ring motor. In addition to the quiet drive now obtained, there has been considerable improvement in the class of pipes turned out. owing to the even turning moment of the motor.

A group of machinery, consisting of a lathe, flue paddles, circular saw and cupola blast fan, formerly driven by an old type horizontal single-acting steam engine, is now driven by a 20 H.P. motor. Five overhead electrically-driven jib cranes are used for loading and unloading the sacks. This is a great improvement on the nine cranes formerly used, these being driven through an endless rope by a 50 H.P. gas engine. The simplicity, convenience and economy of the electric drive is strikingly demonstrated.

The two white lead grinding equipments driven by two steam engines (one of 120 B.H.P. and the other an old beam engine with a 5 ft. stroke and 20 ft. flywheel running at 26 revs. per min.) have been replaced by 50 H.P. motors driving the existing shaft through a belt and a 10 to 1 reduction gear. The two large Torrance mixing machines for converting the white lead into white paint are driven by a 60 H.P. motor geared to the old shafting. This motor also works a 1-ton hoist, an oil pump and a dust extractor. The grinding plant is driven by a 50 H.P. motor geared to the original shafting. On account of the danger which might occur from heavy overloads, a large-faced ammeter is placed in front of the operator with a danger line indicating the overload point.

A dust extractor fan and a mixing and sifting machine are driven by a 10 H.P. motor, and a Sturtevant fan about 3 ft. in diameter, running at 900 revs. per min., which is used to avoid dust in the packing rooms, is driven by a 5 H.P. motor. Loose sheet iron covers fixed over the motors and suspended by pulleys from the cross beams protect the motors from dust.

Figs. 1 and 2 herewith show the haulage and part of the works of Messrs. Foster, Blackett & Wilson.

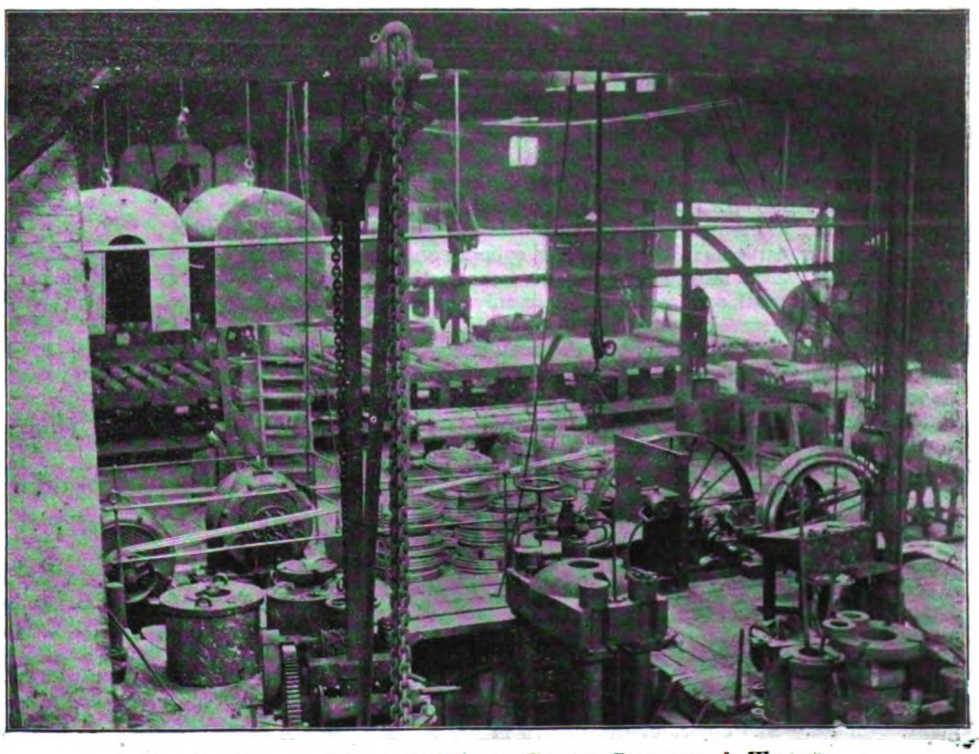

FIG. 2.—VIEW IN WORKS OF MESSRS. FOSTER, BLACKETT & WILSON.

In conclusion, we desire to express our indebtedness to the British Westinghouse Electric & Mfg. Co. for supplying us with the particulars of this interesting installation and with the illustrations.

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DEPENDENCE OF THE WEIGHT OF A BODY ON ITS STATE OF ELECTRIFICATION.*

BY L. SOUTHERNS, B.SC.

In a previous Paper† the writer described an experiment designed to detect any alteration which might occur in the weight of a body when its temperature was changed. The present Paper deals with an experiment which seemed naturally to follow the former one—viz., an attempt to detect change of weight due to electrification. A general idea of the method employed may be gained from consideration of Fig. 1. Suppose a delicately but stably-balanced earthed conductor, A, to be placed between two fixed charged conductors, B, C, at potentials $+V_1$, $-V_2$ respectively. Two electrostatic fields, F_1, F_2, will be set up, and these will be quite independent of each other, provided all lines of force from B to C are intercepted by the conductor A, which is at zero potential, or by some other earthed conductor. Charges will be induced on the ends of A, which will now be subject to electrostatic forces which will in general deflect it to a new position inclined at an angle, say, θ from its original equilibrium position. If now the fields F_1, F_2 be reversed each independently of the other, so that we have B at potential $-V_1$ and C at potential $+V_2$, there will be no change in this deflection θ caused by electrostatic forces, for these are independent of the direction of the fields. But now let us suppose that a gravitation effect exists such as to cause the end of A, which is positively charged, to be a little heavier than the negatively charged end. This will give a deflection $+\delta$, which must be added to θ. The difference between the two observed deflections will thus be 2δ.

There is no theoretical necessity for making the fields or the conductors symmetrical or the potentials V_1, V_2 numerically equal to each other. In practice, however, it is desirable to make the apparatus and fields as symmetrical as possible. With symmetrical apparatus the deflection θ, due to electrostatic forces, will be small, and any deflection due to a gravitation effect will be more readily observed. The form of apparatus indicated in Fig. 2 is therefore

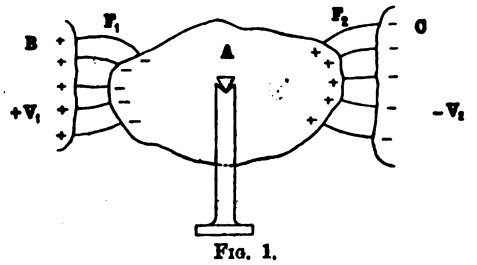

Fig. 1.

adopted. The beam AA with its curved end pieces is supported by a steel knife edge and grooved plate by means of which it is electrically connected to earth. The pierced guard cylinder D and metallic case E are also earthed. The field plates B, C are insulated and connected through a double reversing key to the sources of potential, which are separate for the two plates. Some of the lines of force from these plates fall on the guard cylinder and on the case. The apparatus can be adjusted so that the forces acting on AA are very nearly horizontal, so that they produce only a very small deflection from the uncharged position. This deflection is usually made small for practical convenience, but the resulting value of δ is the same for large as for small deflections. Variations of weight corresponding to $\frac{1}{5000}$ or $\frac{1}{15000}$ mgm. are easily detected in practice. This method of arranging the apparatus and of applying and reversing the fields eliminates several errors which might be expected to cause difficulty in an experiment of this nature. In most of the experiments the balance was screened from any possible external electrostatic effects; this, however, made no difference to the result.

The balance itself is shown in Fig. 3. It is rigidly made, so that the applied electric forces shall not produce distortion. The case, guard cylinder, field plates and beam are constructed of magnalium. Referring to the figure, AA represents the beam with its arresting arrangements *aaa*, B one of the end pieces, CC the guard cylinder and DE the insulated field plates. The beam is electrically connected to the guard cylinder by means of its steel knife edge, which bears on a grooved steel plate attached to a pillar screwed to the guard cylinder. The object of the groove in the bearing plate is to prevent side slipping of the knife edge under the action of the electric forces. The guard cylinder itself is rigidly fixed to the back of the case, and the whole earthed. A small amount of play is allowed between the piece B and the guard cylinder. This allows a few lines of force from D to pass between the two, and some of these will terminate on the edges of B. Those falling on the upper and lower edges in the figure give rise to forces tending to deflect the beam. If everything is symmetrical these forces will be equal above and below, and therefore the beam will not actually be moved. But if B is slightly higher than its central position, the lower gap will be wider than the upper one and more lines of force will, therefore, fall on the lower edge of B than on the upper edge. These will tend to bring B back again to its central position. The beam is always in stable equilibrium under the action of the field. The application of the field, however, affects to a slight degree the sensitiveness of the apparatus as a balance, and it is therefore necessary to have some means of determining the sensitiveness while the field is on. This is provided by the arrangement shown in the upper part of the figure. It is an adaptation of a method employed in a balance de-

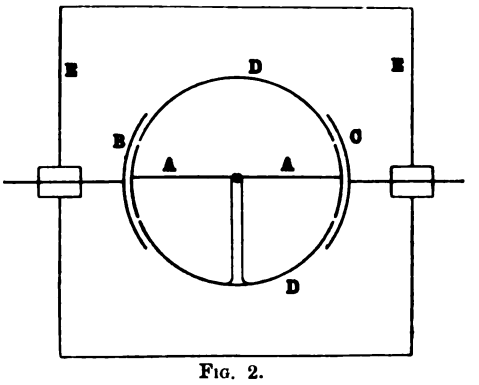

Fig. 2.

signed by Dr. Hicks and used by the writer in the research previously alluded to. A small and feeble magnet is attached to the beam, as shown by the dotted lines at F. This can be attracted or repelled by a small current passing round the coil G. The deflection produced by a given current can be compared once for all with that produced by moving a rider a certain distance along the bar H. By observing the deflection produced by this current during an actual experiment with the plates charged, the sensitiveness can be determined, and the value of any deflection produced by the charges expressed in megohms of weight. The current is not, of course, allowed to pass during actual observations. The deflections are observed by telescope and scale, and a double suspension mirror, the position of which is indicated by the circle K. The field plates D, E are insulated by sulphur plugs, and have various adjustments not shown

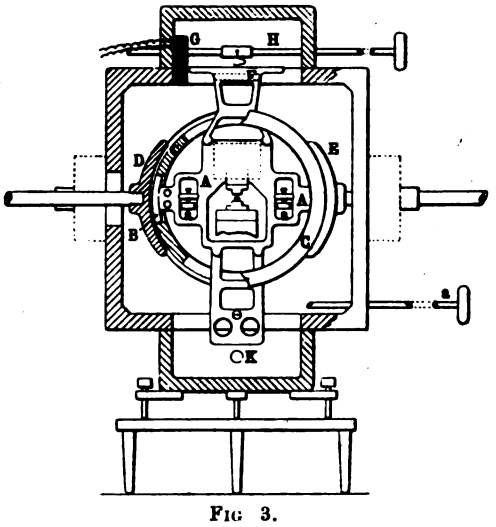

Fig 3.

on the figure. Other details, such as knife edge adjustments, &c., are also left out of the figure to avoid complication. The front and back of the case are of thick magnalium with plate glass windows. The latter have been covered inside with tinfoil in the later experiments, with the exception of a small space for observing the mirror K, which has been closed in with a grid of fine wire. The results, however, are exactly the same whether the windows are covered or left bare. The whole apparatus is enclosed in a box of wood 2 in. thick and provided with double windows of plate glass. The diagram is approximately to scale. The diameter of guard cylinder is 14·3 cm., distance between this and field plates 3 mm., the end pieces B, which are square with rounded corners, 4·9 cm. square. Weight of end pieces about 28 grammes each, total weight of beam about 260 grammes.

*Abstract of a Paper read before the Cambridge Philosophical Society.

†*Proc.* Roy. Soc., A, Dec. 20, 1906.

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Details of the tests and readings obtained are given in the Paper, and also a few sources of error are discussed. The author reaches the following conclusions:—

Conclusions.—Whether the effect be due to a modification of gravity or not, the experiments appear to show that a body positively charged with 20 electrostatic units of electricity behaves as though it were heavier than the same body negatively charged, by an amount of the order of 0·0007 milligrams. If the effect be due to a change in gravity, there will exist in an electrostatic field a small amount of energy due to this cause, and this will involve a very slight alteration in the configuration of the lines of force from that given by ordinary electrostatic laws. This would be so small as to pass unnoticed in ordinary cases. It would be such that, with given conductors charged in a given way and then reversed as to sign of charge, we should obtain two slightly different configurations of field. Delicate instruments might detect this, and it is possible that the different zeros of a quadrant electrometer, with the needle positively and negatively charged, and quadrants earthed, may be due to this cause, though the writer has not investigated these effects, for the explanation of which the above suggestion may be quite inadequate.

It was suggested to the writer that the effects might possibly be caused by an accumulation of air condensed on the surfaces of the metal, the quantity being greater when the surface was positively than when negatively charged. From an experiment made it would appear difficult to explain the result in any such way as this. For we may liken the metal surface to a series of buckets which are filled with condensed air when the surface is charged positively, but empty when it is charged negatively. Now, if we have a number of such surfaces fixed to spokes radiating from a central axis so as to form a kind of wheel (like a water wheel), and place this between charged field plates, we should have all the buckets on one side full and those on the other side empty, and the wheel would revolve. It is difficult to see where the energy would be drawn from to keep up this rotation.

It may be of interest, as a mere speculation, to see whether the theory of gravitation which supposes that the attraction between unlike charges is somewhat greater than the repulsion between like charges, could be modified to suit the present results. Let us suppose that the repulsion between two positive units at a given distance apart is P, and that between two negative units, N, and that the attraction between a positive unit and a negative unit is M. Then the attraction between a neutral body (containing a unit of positive and a unit of negative electricity) and a positive unit will be M−P, and that between the neutral body and a negative unit M−N. The difference between these will be N−P, which is the effect found in the experiments. Again, the attraction between two neutral bodies (each containing one positive and one negative unit) will be 2M −(P+N), and this will be ordinary gravity. The last expression is much smaller than N−P, and thus we should have the result that, while N and P both differ considerably from M, their mean is very nearly equal to M. Since in the attraction M one charge of each kind is employed, it is perhaps not unnatural to suppose that this might be the case. The actual differences between M, N and P would, of course, be exceedingly small in comparison with their absolute magnitudes. Assuming M to be the ordinary electrostatic attraction, we have two equations for finding N and P. It should be remembered that in the experiment, as in this theory, no lines of force pass between the attracting masses. In the experiment the lines do not pass to the earth, but sideways to the field plates. Turning aside from such hasty speculations, the writer would be most grateful for suggestions as to possible sources of error in the experiments, as he hopes to have an opportunity of repeating them later with improved apparatus, the design of which might be modified in view of any suggestions thus made.

PHYSICAL SOCIETY.

At the meeting held on April 8th, Prof. H. L. Callendar, F.R.S., president, in the chair, a Paper entitled

"Demonstration of Telephone Currents in Loaded and Unloaded Lines"

was read by Mr. B. S. Cohen. The demonstration showed the relationship between the sent and received currents in telephone lines under the various conditions which occur in practice. As mentioned by Prof. Perry in his Paper* read before the Society a few weeks ago, it is of little or no practical value to make calculations on the current attenuation in lines of infinite length and with the terminal conditions neglected. The effects of the line length and of the terminal apparatus must be taken into account. By the aid of Prof. Kennelly's formulæ it is possible to calculate the relationship between the sent and received currents under any conditions met with in practice, and for some of the conditions used in the demonstration the calculated results had been obtained. Four essentials were necessary for the experiments shown: (1) A current comparable with the actual telephonic speech current. This was obtained from a vibrating wire interrupter giving a wave with a fundamental of about 100 ∿ per second with a damped oscillation of about 800 ∿ per second superimposed. (2) A telephone line with or without its load in the shape of inductance coils. (3) Terminal apparatus. The lines were terminated by receivers and induction coils as used in practice for what is known as local battery working. (4) Current measurers. For this purpose barretters arranged as alternating-current ammeters were used. The first experiment showed the relationship between the received and sent current for various lengths of standard cable unloaded. The second experiment illustrated the variation in the current sent when the receiving end was open or closed circuited and the length of cable was varied. The third experiment showed the current distribution along the loaded cable by inserting a barretter at different points along the cable. The author gave explanations of the various phenomena illustrated in the experiments. He pointed out that it is now possible to make both calculations and quantitative telephonic tests which give mutual confirmation.

Dr. A. Russell congratulated Mr. Cohen on the admirable demonstration he had given of the effects of "loading" a telephone cable with Pupin coils. He pointed out that much of the success of the demonstration was due to the barretters and the vibrating wire generator which Mr. Cohen had himself perfected. It was now well known that the effect of the loading coils was to improve both the volume of the sound and the clearness of the articulation. He asked whether the diminution in the value of the attenuation constant and the consequent increase in the volume of the sound, or whether the equalising of the velocities of the damped trains of waves proceeding along the wires was of the greater importance in practice. He asked also whether the Pupin coils were inserted in such a way that the going and return currents tended to magnetise the cores of the coils in the same direction. He suggested that the higher efficiency of the loaded cable might be partly due to the diminution in the value of the current and the consequent increase in the value of the potential at the sending end, the gain in efficiency owing to this cause being due simply to the smaller expenditure of energy in heating the wires.

Mr. A. Campbell asked what was the minimum current which would give reasonably clear speech, and what was the usual ratio between the current received and the current sent in good working conditions. The author had used frequencies of 800 ∿ per second. If a line were loaded so as to transmit well at this frequency, would it transmit equally well at frequency 2,000?

Mr. Whalley remarked that the experiments shown did not quite conform with working conditions where constant currents were flowing. He asked whether the results would agree with those which would be obtained with constant currents flowing in the circuit.

Dr. W. H. Eccles called attention to an apparent paradox which arose when the barretter at the receiving end was giving a larger reading than the similar instrument at the sending end of a cable. The barretter deflections were, of course, a measure of the *power* being sent in the instrument, and the paradox might be expressed by saying that in the above circumstances the power indicated at the receiving end was greater than that indicated at the sending end. The series of detached trains of oscillations produced by the author's vibrating wire interrupter led to difficulties in the mathematical discussion of cable problems which were vastly greater than those met with in the sine wave problem, for which alone the currently used formulæ were correct. He asked how far experimental results obtained with damped trains disagreed with the sine wave formulæ. For practical purposes the damped trains used by the author were a better imitation of speech sounds than pure sine oscillations. He asked if the indication of a barretter when used with ordinary speech sounds or with damped trains corresponded strictly with the volume of sound.

The Author, in reply to Dr. Russell's remarks about the diminution of the attenuation constant, remarked that, by loading, both advantages referred to were obtained. The limit was determined in practice by the volume of sound transmitted, and not by articulation conditions. In reply to Mr. Campbell he said he was working with an attenuation of 1·5 per cent., and the sending current was 3 or 4 milliamperes. The apparatus would work quite well up to frequencies of 1,500. In reply to Mr. Whalley, he said that increasing the current in the circuits up to 0·1 ampere would have no effect on the inductances. In reply to the remarks of Dr. Eccles, the barretters used were measuring current and not energy. The current received was a most important factor in determining the volume of sound transmitted.

* The Electrician, March 11, 1910, p. 901.

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STREET LIGHTING IN WESTMINSTER.

In our last issue we gave an account of the meeting of the Westminster City Council, at which a report of the Works Committee recommending that the tenders of the Gas Light & Coke Co., for street lighting, should be accepted was adopted. As this report contains some figures of interest regarding the cost of lighting we reproduce that part of it herewith. After mentioning the districts in which the new scheme of lighting is to be carried out the report continues:—

Competitive tenders were therefore obtained from the Gas Light & Coke Co. and the several electric light companies for the *installation* of lighting units of different powers—viz., 90, 180, 300, 1,800 and 3,000 candles, the Council being placed in a position to select one or other of the lighting units, according to the needs of each class of street as may be determined by considerations of widths, conditions of traffic, &c. For the *supply* of gas or current, as the case may be, to these several units and for general *maintenance*, further tenders were obtained, any of which may be accepted for a term of 5, 10 or 15 years at the option of the Council.

It should be pointed out that the basis on which tenders were invited was so much light for a given number of hours per annum, and as a given candle-power, for instance 90 or 3,000 candles, has exactly the same value whether produced by gas or by electricity, all we have had to consider has been the cost of installation, and also the annual cost for the different units.

The classification of streets for lighting purposes, another important matter, will be for the council to decide at a later date upon a further report from us; but whatever classification is adopted will not affect the *comparative* costs of the different methods of illumination. It may, however, be stated that in settling the specification, certain streets of importance were named in each district in which the council might, as foreshadowed above, wish to effect greater improvements by the adoption of higher lighting power units. Certain experimental installations have been set up in Victoria-street and elsewhere at the expense of the competing companies, which constitute a practical and valuable exhibit of different forms of lighting in juxtaposition; and besides viewing these exhibits we have made a tour of inspection of the different systems now in use in Westminster, and have extended our inspection to the City of London, where (in Fleet-street) a notable example of gas lighting is set up.

Table I.—*Showing Existing Units of Light under Contracts terminating in* 1910.

No. of lamps.	System.	Average candle-power and cost per lamp per annum.	No. of lamps in			
			District A.	District B.	District C.	District D.
1,568	Low-pressure gas.....	53 c.p., at £3. 2s. 10d. ...	363	951	254	...
1,235	Do. (2 burners)	83 c.p., at £5. 9s. 6d. ...	20	79	580	556
27	Do. (3 ,,)	130 c.p., at £8. 12s. 6d....	3	10	8	6
9	Do. (4 ,,)	— c.p., at £9. 15s. 0d. ...	...	1	8	...
6	Do. (5 ,,)	— c.p., at £10. 12s. 3d. ...	...	...	6	...
43	High-pressure gas....	1,044 c.p., at £15. 1s. 0d....	...	33	20	...
8	Do. ...	473 c.p., at £13. 0s. 9d. ...				
2	Do. ...	284 c.p., at £8. 0s. 4d. ...				
46	Open arc electric ...	911 c.p., at £17. 0s. 0d. ...	...	...	...	46
16	Flame arc do. ...	3,575 c.p., at £17. 0s. 0d.	...	...	...	20
4	Do. do. ...	1,656 c.p., at £17. 0s. 0d.				

Table I. shows the existing units of light under contracts terminating in 1910, and with which therefore this report deals. It will be seen from this table that the districts now being dealt with are the districts lighted by gas together with the district lighted by 71 arc lamps by the St. James's & Pall Mall Electric Light Co. The electric lighting in the Strand district and the electric lighting throughout the parish of St. George are not affected.

The present lighting in these districts is as follows:

Strand District Electric Lighting Contract, terminable in 1913 or 1920 at option of Council:—

121 arc lamps, average c.p. 614, at £27. 18s. 3d. (average) each per annum.

3 flame arc lamps, average c.p. 1,270, at £27. 13s. 4d. (average) each per annum.

St. George's Parish Electric Lighting Contracts:—

(*a*) Terminating in 1913—

5 flame arc lamps, average c.p. 1,573, at £14 each per annum.

(*b*) Terminating in 1931—

957 arc lamps, average c.p. 449, at £21. 2s. 5d. each per annum.

216 lamps (various) at £3. 9s. 0d. (average) each per annum.

Table II. deals with the first cost—*i.e.*, installation—and the only remark to be made upon this is that the gas company offer to spread any installation cost over the contract period without interest, thus further increasing the difference in the cost of installation which a glance at the table will show exists between gas and electric light tenders.

Table III. deals with annual cost—*i.e.*, supply of various units of light, together with lighting, extinguishing, maintenance, &c.

Table II.—*Summary of Tenders for Installation, at per Unit.*

Candle-power units.	——	Gas. District A.	Gas. District B.	Gas. District C.	Gas. District D.	Electric. Districts A, C and D.	Electric. District B.
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
90	Fitted to existing gas pillars	†0 7 6	0 7 6	0 7 6	0 7 6	...	...
		‡1 5 0	1 5 0	1 5 0	1 5 0	2 10 0	2 10 0
180	Do. with extension to 12 ft.....	†0 12 6	0 12 6	0 12 6	0 12 6	...	...
		‡1 5 0	1 5 0	1 5 0	1 5 0	2 15 0	3 0 0
		*3 10 0	3 10 0	3 10 0	3 10 0	6 10 0	6 10 0
300	Do. do. to 15 ft.	†1 10 0	1 10 0	1 10 0	1 10 0	4 0 0	4 0 0
		‡4 0 0	4 0 0	4 0 0	4 0 0	7 10 0	8 0 0
1,800	Special design pillar, 20 ft.	‡ ...	2 10 0	2 10 0	...	...	...
		§10 0 0	10 0 0	10 0 0	10 0 0	...	...
		*20 0 0	17 0 0	17 0 0	20 0 0	30 0 0	35 0 0
3,000	Do. do.	‡ ...	2 10 0	2 10 0	...	...	...
		§10 0 0	10 0 0	10 0 0	10 0 0	...	...
		*21 0 0	18 0 0	18 0 0	21 0 0	35 0 0	35 0 0

* New pillars.
‡ New lantern where necessary,
† Converting existing lanterns.
§ New lantern on electric pillars.

Table III.—*Summary of Tenders for Maintenance, at per Unit per Annum* (3,940 *Hours*).

Candle-power units.	Gas. A, B, C and D Districts. 5 yrs.	10 yrs.	15 yrs.	Electric. A, C and D Districts. 5 yrs.	10 yrs.	15 yrs.	Electric. B District. 5 yrs.	10 yrs.	15 yrs.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
90	2 16 6	2 15 0	2 12 6	5 0 0	4 0 0	3 7 6	5 0 0	4 10 0	4 0 0
180	4 10 0	4 7 6	4 4 0	8 0 0	6 10 0	5 15 0	8 0 0	7 5 0	6 10 0
300	6 10 0	6 6 0	6 0 0	12 0 0	10 10 0	9 5 0	11 0 0	10 0 0	9 0 0
1,800	15 10 0	15 0 0	14 5 0	21 0 0	19 5 0	17 10 0	20 0 0	19 0 0	18 0 0
3,000	22 0 0	21 5 0	20 5 0	30 0 0*	25 0 0	22 0 0	28 0 0	27 0 0	26 0 0

* £28 in C and D.

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The above quotations in Tables II. and III. for *identical units of lighting* need little comment. The Gas Company's tender for installation (Table II.) is very much below the electric supply companies' tenders. For lighting and maintenance (Table III.), that is to say, the annual charge, the same marked difference in cost is shown in favour of gas, light for light. Not to labour the point too much, one comparison only is made. Worked out, the difference in cost (Table III.) for a term of five years for the five units specified is 76·99, 77·77, 80·77, 33·87, and 29·54 per cent. respectively in favour of gas. That is to say it would cost these percentages more for maintenance year by year if electricity were preferred to gas, and, for such extra cost not a single candle power better lighting would be obtained.

FARADAY SOCIETY.

At the meeting of the Faraday Society held on Tuesday, April 5th, at the Institution of Electrical Engineers, Dr. J. C. CAIN in the chair, the President, Mr. JAMES SWINBURNE, referred to the sad death of Prof. Richard Abegg, as a result of a balloon accident on April 4th, by which the Society then lost one of its most distinguished members. He moved that a vote of condolence be transmitted to Frau Abegg on behalf of the Society. This was seconded by Dr. V. H. Veley, and carried in silence. After Mr. W. P. Dreaper had read a Paper entitled "Nature of the Action of Dyeing," Prof. W. W. HALDANE GEE and Mr. W. HARRISON contributed a Paper on

"The Electrical Theory of Dyeing."

The literature relating to the causes of dyeing reveals great differences of opinion as to the physical and chemical phenomena involved. The basis of the electrical theory is that when any two bodies are placed in contact they are oppositely electrified. In the case of tinctorial chemistry one of the bodies is a non-conducting solid and the other a liquid. There does not seem to be any direct method of obtaining the value of the P.D. between such bodies. The authors avail themselves of the classic theory of von Helmholtz, which enables the P.D. between a liquid and a porous diaphragm to be deduced. This may be done in four different ways: (1) By measuring the rate of flow of the liquid through a diaphragm of the substance under electrical stress (electrical endosmose). (2) By measuring the mechanical pressure obtained by electrical endosmose. (3) By determining the speed of the solid in the form of small particles when immersed in the liquid under electrical stress. (4) By measuring the difference of electrical pressure between the two sides of a diaphragm when the liquid is filtered under mechanical pressure.

The authors have determined the nature of the charge on the particles in suspension and in colloidal solution, and find that in water all basic substances are positive, the hydrochlorides of basic dyes positive, all acid substances negative, and most neutral substances negative. They find the speed of the particles under electrical stress to be of the order 20×10^{-5} cm. per second, per volt, per centimetre. Negatively charged particles attain their maximum speed at about 40°C. By using method (4), the authors find the approximate value of the contact difference between fibres and water to be:—

Cotton	0·06 volt.
Silk.....	0·22 ,,
Wool	0·90 ,,

The influence of temperature shows a maximum charge at about 40°C., and a minimum at about 80°C. The electrical theory may be stated as follows: Suppose the dye to be basic and represented by $n-P$, where n is a small negative ion and P a large positive basic ion. These ions will be free, and when wool or silk is placed in the solution the basic ions will be attracted by the negatively charged fibres, and be fixed by some process which is not yet properly understood. The small ions will combine with the H ions present in the so-called double layer. If inorganic electrolytes are also present in the solution, and are of an alkaline nature, they will tend to make the fibre still more negative, and will assist the process of dyeing.

In the case of acid dyes they deal with substance of the nature $p-N$, where p is now a small positive ion and N a larger negative ion. In this case acid is either added to the bath or the fabric has been previously boiled with acid. In each case the fibre takes a positive charge. The result will be that N will be attracted by the positively charged fibre, whilst p will form a salt in the vat. A strong confirmation of the theory is afforded by the amount of absorption of dye stuffs at different temperatures. Brown has shown that with basic colours the maximum amount of dye stuff is absorbed at about 40°C. and the minimum at about 80°C. The authors' results show that the maximum negative charge is attained at about 40°C. and the minimum at about 80°C.

Ultramicroscopic examination of pure benzopurpurine is given after filtration, and the solution was found to contain no visible particles in the ultramicroscope. An experiment is given on the destruction of the colloidal nature of an impure sample by heating the solution. Important analogies are given between the laws of contact electricity, colloidal coagulation, dyeing and capillary ascension, and the effects of temperature are discussed.

In the course of the joint discussion which took place on the two Papers,

Dr. W. C. McC. LEWIS (communicated) drew attention to the importance of the work of Prof. Gee and Mr. Harrison, especially their beautiful method of showing the gradual transition from the charged colloidal state to the state of a non-electrolyte in true crystalloidal solution, as well as the remarkable temperature effects which the P.D. of the particles undergo. Had the authors determined the P.D. water/glass? This was of great importance in endosmotic work. The potential gradient at the surface of the particles could be shown to be of the order 10^{-6} volts per centimetre. Could this be withstood by water without something analogous to sparking taking place? It was possible that the high values obtained by Lodge for the velocity of the hydrogen ion as measured in a set gelatine solution were really owing to the velocity with which the solvent as a whole carried the hydrogen ion along with it as it was impelled through the network of the jelly by the external E.M.F. Hydrolysis would seem to complicate the simple electrical theory, because the conditions of temperature and dilution under which dyeing took place were favourable to hydrolysis as well as to ionisation.

Dr. V. H. VELEY remarked on the peculiar maxima values obtained by Messrs. Gee and Harrison at 40°C. Remarkable effects occurred at this temperature in many physical and chemical actions, such as the evolution of carbonic acid from leaves, or the coagulation of muscle and nerve stuff.

Dr. H. BORNS drew attention to some recent ultramicroscopic work in which had been observed the movements not only of colloidal suspensions, but of ions, or groups of ions, themselves.

Mr. W. P. DREAPER, commenting on the Paper of Messrs. Gee and Harrison, showed that in many cases of dyeing the conditions favourable to electrolytic dissociation were not obtained. The dissociation of the dye salt into ions and transference of one of these to the fibre area required further confirmation. Possibly the function of the electrical action was merely one of concentration of the dye within the fibre area rather than controlling the true dyeing action. Anyhow, there were many difficulties, which the speaker instanced, in the way of accepting the electrical theory so far as the fixation of the dye was concerned.

Dr. E. FEILMANN also mentioned some facts that seemed difficult to reconcile with the electrical theory, such as that many dyes were used in the form of paste, and not in solution at all, and that a large class of fast dye stuffs formed true colloidal suspensions. There were, he thought, a great variety of dyeing processes.

Mr. W. R. COOPER asked whether basic dyeing would take place if a positive charge were impressed on the fabric; if not, support would be lent to the electrical theory.

Mr. F. J. FARRELL quoted instances in which the splitting of the ultimate fibre, without any chemical alteration, prevented the dyeing action in the case of silks. He agreed with Mr. Dreaper that the maximum effects found at 40°C. bore no relation to actual results in practice. As a rule, no good results were obtained at less than 95°C.

The CHAIRMAN was of opinion that many of the phenomena observed in dyeing could be explained merely from a mechanical point of view; the effect of temperature was an instance of this. At the same time, the electrical theory might be useful in explaining the initial attraction between the dye and the fibre, even if it did not explain the fixing, which perhaps was to be attributed to the ultimate attraction of matter for matter, namely, cohesion.

High Tension Electrical Transmission in Italy.—According to "The Times Engineering Supplement" the equipment of an electrical power station to utilise the water power of the river Pescara, in the neighbourhood of Torre del Passeri, is now in progress. The plant will comprise four three-phase alternate-current generators, each of 8,200 to 9,000 H.P., delivering current at from 6,000 to 6,600 volts, with a frequency of 42, when running at 420 revs. per min. These sets will be direct coupled to water turbines. There will also be two exciter machines of 400 kw. each, delivering current at 220 volts when running at 600 revs. per min.; and seven single-phase alternate current transformers of 3,600 k.v.a. each, six of which are combined in two three-phase sets (star-connection), while the seventh serves as a stand-by. These single-phase transformers are calculated for a ratio of 6,000/46,200 or (with constant output) 6,600/51,000 volts, and are insulated for 90,000 volts. The linked-up phase tension at the secondary terminals is 80,000 and 88,000 volts respectively. The whole of the electrical energy generated at the station is to be conveyed through a double line about 125 miles long to Naples, where it will be reduced in a substation partly to 5,300 volts for the City of Naples and partly to 27,000 volts for transmission to Torre-Annunziata.

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STREET LIGHTING.

Since the early days when electrical energy was first produced by means of a dynamo, arc lamps have always been in favour for the illumination of important public thoroughfares and open spaces. Originally this was due, perhaps, partly to the fact that they provided a very high candle-power and good illumination, coupled with a low cost per candle-power-hour. The result was that for a long time public lighting by electricity was largely confined to streets where more than an average illumination was required. With the development of electricity supply electrical engineers naturally turned their attention to extending the field of electric lighting into those streets where smaller units of light were required. Although the carbon filament lamp was able to compete satisfactorily with the flat flame gas lamps, the extensive adoption of incandescent gas mantles limited, in the majority of cases, the extension of electric lighting into side streets. For many years, however, the 10-ampere open type arc lamp held the field in the main streets, enclosed arcs, although requiring less attention and reducing the cost of carbons, being generally considered scarcely as efficient. The introduction of the flame arc came at an opportune moment, for improvements in gas lamps, as regards efficiency and the possibility of obtaining large units, were

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threatening to bring these lamps into effective competition with the electric arc. The flame lamp has, however, given electrical engineers an effective weapon to repel the attacks of the gas undertakings, attacks which, during the past year or two, have shown increasing keenness, due probably to the growing evidence of the steady inroads made by electricity into those fields hitherto supposed to be the strongholds of gas.

The advent of metal filament lamps a year or two ago was quickly recognised by electrical engineers as affording an exceptional opportunity for extending the field of electricity in public lighting; and with what success may be judged from our Annual Tables and from the reports in our columns from week to week of the substitution of electricity for gas. The full effect of the metal lamp is, however, only now becoming fully apparent. At first these lamps were only made in units of from 20 c.p. to 50 c.p., but during the past year there have been placed on the market lamps ranging from 100 c.p. up to even 1,000 c.p., and, as will be seen from another column of this issue, these high candle-power lamps are giving excellent results, both as regards life and efficiency. So much is this the case that they have been substituted in many cases for arc lamps, and further developments in this direction are foreshadowed.

As compared with an arc lamp, a glow lamp has several advantages. Of these may be mentioned less attention and the absence of "trimming," the possibility of using reflectors more effectively, the absolute steadiness of the light, and the ease with which the candle-power can be changed if desired. A further point is that 500 c.p. lamps located, say, every 30 yards, might give a more desirable illumination than 2,000 c.p. lamps placed every 60 yards. Each case, however, must, of course, be decided on its merits, and the higher efficiency of the arc lamp offset against the advantages which can be put forward in support of the glow lamp. There is no doubt, however, that considerable attention is now being paid to the claims of the high candle-power metal filament lamp, which bids fair to play an important part in the future in the problem of street lighting. Perhaps these lamps will, to some extent, oust arc lamps from their hitherto unassailable position, though we think the flame lamp is still likely to hold its own where a large space has to be illuminated at a low cost, or where a high degree of illumination is required.

In regard to the competition between gas and electricity in street lighting, the near future promises to be of the first importance. It is well known that the Corporation of London have been investigating for some time the merits of the two illuminants. The Corporation of Westminster also have the matter under consideration, as will be seen elsewhere. There is, of course, some difficulty in the partisans of either side forming a calm judgment in such cases, but there is one point to the disadvantage of gas that is not as fully realised as it should be, although reference is often made to it. We refer to the falling off in candle-power of incandescent mantles. For example, a mantle consuming 4¼ cubic ft. per hour gives 82 c.p. to 85 c.p., and it is stated that such mantles do not depreciate appreciably with 200 hours' use. Actual tests do not bear out this view, and in support of this statement we may mention some tests which were carried out not so very long ago by a well-known firm who are certainly not biased in favour of electricity. In the case of 58 single-burner lamps they found that the maximum candle-power was 86 and the minimum 26, with an average of 49. In the case of 36 two-burner lamps a maximum of 111 c.p. was obtained with a minimum of 58 and an average of 76. In the case of six three-burner lamps the maximum was 150 c.p., the minimum 89 and the average 115. In this respect electricity is usually at a disadvantage when competing with gas, because quotations are given with metal filament lamps for a standard of illumination which will not depreciate, whereas the quotations for gas generally involve the assumption that depreciation is non-existent. It is time that the public realised that illumination obtained from gas mantles does depreciate, or if it is maintained at a given value, money is required for the purpose.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Wireless Telegraphy and Telephony. By A. E. KENNELLY. (London: T. Fisher Unwin.) Pp. 271. 4s. nett.

This is a book that can be read and appreciated by anyone who has had just a little practice in the study of physics; it gives a survey of the principles underlying wireless telegraphy and "wireless" apparatus, and strictly avoids descending to details. The exposition of principles is accomplished carefully and clearly and usually with unimpeachable accuracy. We are glad to note that the author adopts Oliver Heaviside's pellucid method of explaining the formation of electromagnetic waves by the oscillation of a charge on a vertical straight antenna: it is strange that this, the best (and oldest) of all ways of discussing wireless waves has been singularly neglected by English authors. Unfortunately, in the present case, the diagrams concerned with these matters are even worse than the bad diagrams scattered through the rest of the book.

A principal and striking feature of Dr. Kennelly's book is the very complete omission of historical matter. This has its advantages and disadvantages. Among the latter we may put the fact that the reader finishes the volume without the faintest notion of the order of development of this branch of engineering. This feature is pushed so far that the reader is left in absolute ignorance of the names, even, of the engineers and inventors who have counted most in the technical progress of wireless telegraphy. Indeed, we noticed the name of only one inventor, Fessenden, in all the 280 pages; and thus the author can boast the distinction of having written a work on wireless telegraphy without even mentioning the names of, say, Lodge and Marconi. Except for these blemishes the outlines of wireless telegraphy are excellently presented, the writing displays considerable literary skill and taste, and the book is very suitable for those who desire no other contact with wireless telegraphy than an intellectual one.

W. H. ECCLES.

Drawings for Medium Sized Repetition Work. By R. D. SPINNEY. (London: E. & F. N. Spon, Ltd.) Pp. x.+91. 3s. 6d. nett.

This book is intended for engineers who supervise the making of drawings for such parts of a machine as are made in quantity. The illustrative examples refer to motor-car practice, but the underlying principles can be applied to any class of work. There are many details in the book which are open to criticism, but on the whole it is an excellent attempt to indicate how to make, and what ought to be thought of in the making of, drawings for repetition work. The writer betrays a sound knowledge of shop practice throughout, and gives many useful hints to the designer who has had little shop experience. Apart from manufacturing considerations, the design of machine parts is not dealt with.

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Chapter I., on drawings generally, includes a set of model rules for a drawing office.

In Chapter II., on standard lists, it is evidently a mistake to give elongation in tons per square inch and to call a steel having 45 to 55 tons per square inch mild. In giving the elongation it would be an improvement if the author would include the diameter of the test piece as well as its length.

In the chapter on indexes it is unfortunate that card indexes are not given more consideration, and the method of recording alterations "in a book" seems clumsy compared with the methods used by many large firms.

Chapter IV., on tolerances and allowances, and the following one, on dimensioning, are perhaps the most useful in the book, and contain some valuable information. The press fit allowances in particular are the most reasonable which we have seen published. In Chapter VI., on designing, the statement "material cannot be called saved which is cut away in the form of scrap," cannot surely be applied to, say, copper scrap from a punching machine; and in the concluding chapter, on drawing office routine, the statement that general arrangement drawings need only be dimensioned as regards centres, &c., contradicts rule 27. R. L.

STREET LIGHTING BY HIGH CANDLE-POWER METAL LAMPS.

In a recent issue we commented upon the increasing use of high candle-power metal filament lamps for street lighting, and in connection with most of the work which has already been done in this field we associated a well-known make of tungsten lamp. We remarked upon the satisfactory emergence of this lamp from the experimental stage and its practical value as an illuminant for streets and thoroughfares previously only lighted by ineffective and more costly methods. Our remark that this particular make of lamp appeared to be the only one which had emerged from the experimental stage elicited a certain amount of criticism. As we hold no brief for any particular lamp, and are only too pleased to see the spread of electric lighting now rendered possible, we have made a number of inquiries and have received replies from a number of central station engineers who have been good enough to supply us with interesting particulars. In what follows we reproduce this information, and we are thus able to indicate pretty fully how the position at present stands:—

Mr. H. Tomlinson-Lee, of Wimbledon, is in a position to speak with authority on the subject of street lighting, since the whole of the public lighting of that borough is carried out by the electricity department. In fact, gas lamps disappeared from the streets in a comparatively distant past; and it will probably come as a surprise to many electrical engineers to learn that at that time oil lamps displaced the gas lamps, being themselves in turn displaced by electric lamps. For many years the public lighting has now been carried out entirely by electricity, and to judge by the satisfaction evinced by the Council and ratepayers at the present system of illuminating the streets, electricity in this locality should long continue to reign supreme.

To give an idea of the extent of the street lighting at Wimbledon, we may mention that at the present time there are 91 flame arc lamps, of the Foster and Excello types, and 1,136 metal filament lamps. These latter are in all cases Osrams, and comprise 44 of 300 c.p. (330 watts) and 1,092 of 50 c.p. (55-63 watts).

It is interesting to notice that special mains have been laid for supplying the street lighting, and duplicate trunk mains are run from the power station, one of these trunk mains serving as a standby. Switching-on individual lamps or circuits is in this way rendered unnecessary, the whole of the street lighting being controlled simultaneously from the works. It will be understood that it would be impossible, or at any rate inadvisable, to switch the whole of this load on to the ordinary generating plant simultaneously, so the following arrangement has been adopted. The trunk main for the street lighting is connected on to special 'bus-bars, and a special machine is run up on the load. When the normal pressure has been reached the special 'bus bars are paralleled with the main 'bus bars, the generators being, of course, first synchronised, and the street lighting load can then be taken charge of by the main plant, the special machine being shut down, if desired.

Considering now more in detail the street lighting by metal filament lamps, it may be mentioned that the 300 c.p. Osram lamps have been substituted in most cases for enclosed arc lamps, and the existing arc lamp columns have been utilised. This results in the lamps being about 18 ft. from the ground,

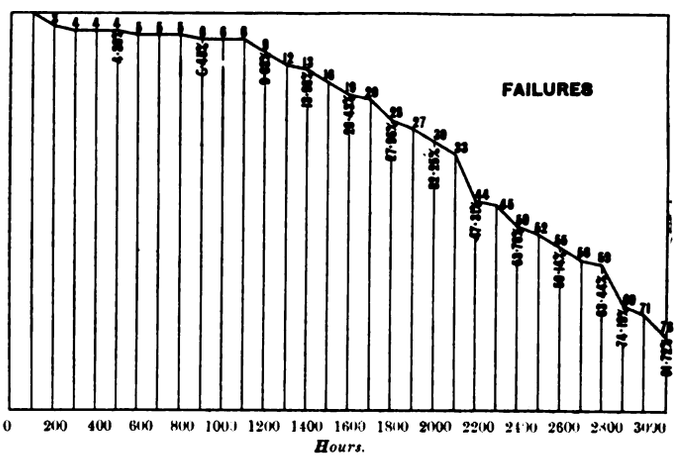

Fig. 1.—Chart showing Test on 93 Osram Lamps installed on Sept. 15, 1908.

(The total number and percentage of failures are recorded every 100 hours.)

and the light is distributed over an extensive area. To increase the efficiency of the distribution, Holophane reflectors have been fixed over the 300 c.p. lamps. Judging by the illumination of the surface of the roads, the lighting so obtained leaves little to be desired, and on inspecting the street lighting last week we were struck by the excellent results obtained, the illumination provided by the 300 c.p. lamps far exceeding what we had anticipated. A feature of the street lighting by these large metal lamps is the absolute steadiness of the light, this being, undoubtedly, a great recommendation; and the fact that practically no attention is required, should result in bringing them into increasing favour with central station engineers.

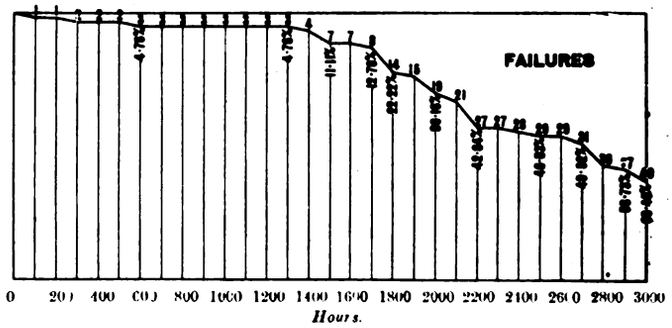

Fig. 2.—Chart showing Test on 63 Osram Lamps installed on Sept. 29, 1908.

(The total number and percentage of failures are recorded every 100 hours.)

As to the spacing of the lamps, the distance apart of the 300 c.p. Osrams averages about 100 yds.; but it varies from 70 yds. to, say, 120 yds. It is obvious, of course, that a fixed distance is inadvisable, since, given a certain latitude, the lamps can, with advantage, be arranged to come at street corners, so illuminating most effectively the positions where a good illumination is necessary.

The Osram lamps of smaller candle-power—viz., 50 c.p.—are used for side street lighting, and are situated about 60 yds. or 70 yds. apart, at a height of 12 ft. 6 in. above the road. In all cases the existing lanterns and columns, which had done duty in the days of gas and subsequently of oil, have been

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utilised. No reflectors or special fittings are necessary, the lamps being suspended vertically downward from the rubber-covered wires. It may here be mentioned that a separate service is laid for each lamp column, rubber-covered wires being employed. Before Osram lamps were adopted, two 16 c.p. carbon filment lamps were fixed in each lantern.

From what has been said above it will be evident that each lamp is an independent unit, and the failure of any one lamp does not affect other lamps. The pressure of supply is 220 volts in the case of the incandescent lamps, whilst a separate transformer is installed at the base of every arc lamp, these latter taking about 550 watts each.

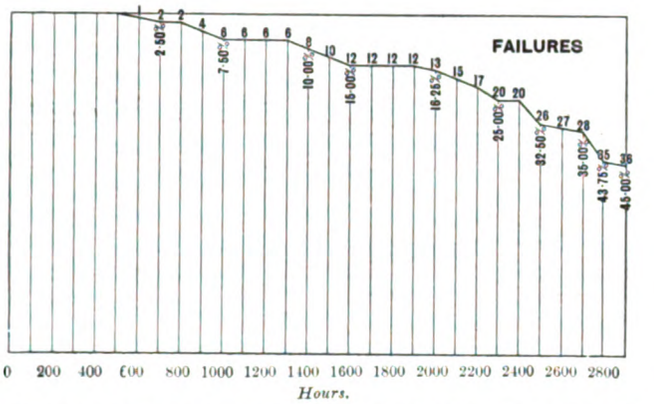

FIG. 3.—CHART SHOWING TEST ON 80 OSRAM LAMPS INSTALLED ON OCT. 8, 1908.

(The total number and percentage of failures are recorded every 100 hours.)

A point concerning which electrical engineers are most anxious to obtain information is the life of metal filament lamps employed for street lighting. We are, therefore, pleased to be able to publish typical results obtained at Wimbledon during the last year or two. It will be seen from Figs. 1, 2, 3 and 4 herewith that the records go back to September, 1908. An interesting system of keeping records of the life of lamps has been adopted by Mr. Tomlinson-Lee. Thus, considering Fig. 1 (which refers to a batch of 93 Osram lamps installed on September 15, 1908), at each 100 hours the total number of lamps which have failed is shown by the respective figures, whilst against the curve the percentage of failures is recorded. Thus, after 1,100 hours it will be noticed that 6 lamps, or 6·45 per cent. of the total, had failed; after 2,000 hours 30

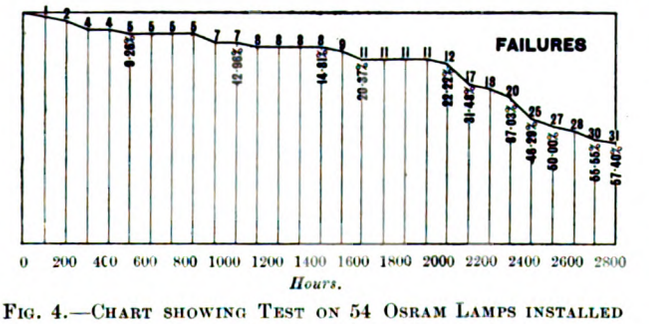

FIG. 4.—CHART SHOWING TEST ON 54 OSRAM LAMPS INSTALLED ON OCT. 13, 1908.

(The total number and percentage of failures are recorded every 100 hours.)

lamps, or 32·25 per cent.; whilst after 3,100 hours 76 lamps had failed—that is to say, at the conclusion of the chart 17 lamps, or over 18 per cent. of the total, were still in use.

Again, Fig. 2 shows a similar record for 63 Osram lamps installed on September 29, 1908. From this it will be seen that no less than 23 lamps, or about 37 per cent. of the total, were still burning after 3,000 hours. Fig. 3, which relates to 80 Osram lamps installed on October 8, 1908, shows a wonderful record of life, 55 per cent. of these lamps being in use after 2,900 hours; whilst of the batch of lamps referred to in Fig. 4, 43 per cent. were still alive after burning 2,800 hours.

Great attention has been paid by Mr. Tomlinson-Lee to facilitating the keeping of records of the life of lamps, and as, owing to the whole of the street lighting being switched on simultaneously from the electricity works, it is easy to keep a record of the exact period during which the lamps are lighted, a chart has been prepared which enables the life of a lamp to be at once read off. We may mention that the street lighting is divided into districts, for each of which a lamp attendant is responsible. Each attendant devotes an hour or two every evening to inspecting the lamps in each district, and in the case of any lamp having failed, the attendant usually replaces the lamps immediately, climbing up the lamp pillars in the case of the short columns in the side streets, so as to minimise extinctions. Payment is made to the police for reporting extinguished lamps, but we understand that the lamp attendants are so attentive that the police make few claims.

The lamp charts given above refer entirely to Osram lamps of 50 c.p. Complete charts have not yet been made for the 300 c.p. Osrams, but Mr. Tomlinson-Lee informs us that the 300 c.p. lamps are giving even better results than those mentioned above for the lower candle-power lamps, and he is enthusiastic in his praise of Osram lamps of all candle powers. It is worth mentioning that experience at Wimbledon shows that the useful life of an Osram lamp is determined solely by breakage, the blackening, except in cases where lamps fail at an early stage of their life, being unnoticeable.

The following particulars of the cost of street lighting at Wimbledon may probably prove of interest. The cost of current, including all capital charges of the distributing system and lamps, &c., to March 31st, was approximately, £4,700 for 502,420 units metered on the trunk mains at the station, and the cost usually works out at about 2¼d. per unit. In addition, the attendance, repairs and renewals together amount to about £1,800 per annum.

In conclusion, we may mention that Councillor Dudley Stuart, vice-chairman of the Electricity Committee, has taken a very keen interest in the question of street lighting by metal filament lamps, and has devoted a considerable amount of time to its development at Wimbledon. It will be remembered that Mr. Stuart made a valuable contribution to the discussion on Mr. E. E. Hoadley's (Maidstone) Paper on "The Influence of Metallic Filament Lamps on the Electrical Industry and on Street Lighting" at the I.M.E.A. Convention at Manchester last year.

Turning now to other districts, we have been favoured with a number of interesting letters, the substance of which we give below:—

Mr. G. G. BELL, of Hammersmith, informs us that his Council are using Osram lamps. Fourteen 400 c.p. lamps were fixed on November 4th last, and the average life of the seven which have failed was 1,360 hours, whilst the remaining seven are still burning after about 2,500 hours.

Mr. P. E. RYCROFT, electrical engineer to Heston and Isleworth District Council, states that about 80 100 c.p. 250-volt Meta lamps are in use by his Council, and have given good results. Experiments are, however, being made with other makes of lamps, including the "Z" lamp, the Mazda lamp, Osrams and the "Onewatt" lamp. The average life of the 100 c.p. Meta lamps during the last 12 months was about 1,700 hours.

Mr. A. J. FULLER, of Fulham, informs us that 400 c.p. metal filament lamps have been tried in Fulham; but whilst they are satisfactory from the point of view of life, Mr. Fuller is of opinion that a better light is obtained by fixing a cluster of three or five smaller lamps aggregating the same candle-power. Osram and Aegma lamps of 75 c.p. have proved very satisfactory from a maintenance point of view.

Mr. W. C. P. TAPPER has installed six 100 c.p. Osram lamps in Wentworth-street, Stepney. His opinion is that the street is very well lighted. The average life of the lamps is 1,267 hours.

Mr. TREVOR DUESBURY, of Sutton Coldfield, mentions that the Corporation have replaced six enclosed arc lamps by fittings each containing four 100 c.p. tungsten lamps, and the light is considered to be at least equal to that of the arc lamps

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displaced. It is proposed eventually to replace the whole of the arc lamps in this way. Although really outside the present subject, it is interesting to learn that at Sutton Coldfield there are also 209 posts carrying lanterns each containing two 32 c.p. or 50 c.p. lamps of Osram or Sunbeam manufacture, and the maintenance costs are said to be very satisfactory.

Mr. S. Cameron Gibson, of Nuneaton, has sent us some very interesting information in regard to street lighting by high candle-power metal lamps. The main streets at Nuneaton are at present lighted by means of open-type arc lamps, in series of 10 lamps. These lamps have been in use for some six or seven years, and consequently it was felt that steps ought to be taken to bring the lighting of the main streets up to date. The Committee were so pleased at the effect obtained with an experimental fitting containing five 100 c.p. metal filament lamps, erected in place of one of the arc lamps, that they gave instructions for the whole of the existing arc lamps to be replaced by clusters of metal lamps, and this is now being done. Mr. Gibson informs us that he is obtaining a life of over 2,000 hours with the 50 c.p. Osram lamps used for side street lighting, and that the 100 c.p. lamps have not been installed long enough for him to give particulars of their life, but he anticipates obtaining a life of 2,000 hours with these 100 c.p. lamps, among which are some of "Stearn" manufacture. On the basis of a life of 2,000 hours, Mr. Gibson estimates that the cost of renewals will work out at about two or three times the cost of renewals with arc lamps, but a considerable saving, more than sufficient to compensate for these renewals, will be obtained in labour. It must also be remembered that substantial reductions in the price of high candle-power metal lamps are probable at an early date. Mr. Gibson also mentions that, in his opinion, it is preferable to use a number of low candle-power units rather than one lamp of, say, 500 c.p., in order to lessen the risk of a standard being in darkness.

Mr. S. J. Watson, of Bury, mentions that he is experimenting with high candle-power metal lamps, and that it is not unlikely some of the existing arc lamps may be replaced by groups of these metal lamps.

Mr. W. H. Miller, of Fleetwood, states that of the 350 electric street lamps in that town, two-thirds have already been changed from carbon to metal filament lamps. The results have been so satisfactory that it has been decided to change over at once the remaining third of the lamps. The candle-powers of the lamps used are 200, 100 and 50, and when the change-over is complete 60 per cent. of the lamps will be Osrams, 20 per cent. "Auriga" and 20 per cent. "Effesca." Mr. Miller is obtaining very good results with these lamps.

Mr. J. A. Gow Russell, of Dalkeith (the Electric Supply Corpn.), replies that 50 c.p. and 100 c.p. Osram and Auriga lamps are used in Dalkeith. They are giving satisfaction in spite of a great deal of vibration, the 50 c.p. lamps being attached to arc lamp pillars fitted with lowering gear.

Mr. J. Pilling writes that at King's Lynn there are between 600 and 700 Osram lamps of 50 c.p. and 100 c.p. in use for street lighting, and he states that the 100 c.p. Osrams are particularly satisfactory, burning almost indefinitely without replacing. The filaments in the 50 c.p. lamps are found to be more liable to fracture than those of higher candle-power.

Mr. C. Furness, of Blackpool, mentions that he has recently installed about half-a-dozen cluster fittings, each made up of eight 50 c.p., and one 600 c.p. lamp. Osrams are used almost entirely in Blackpool for street lighting, in 32, 50 and 100 c.p., at 200 volts, and the average life is found to be about 1,000 hours, though in a number of cases the lamps have burnt as long as 2,000 hours.

Mr. C. A. Blascheck replies that a few high candle-power Osram lamps have been installed at Canterbury for street lighting, and at present he has no fault to find with them.

Mr. A. D. Chalmers, of Gillingham (Kent), states that high candle-power Osram lamps have been used for street lighting in Gillingham, but only for the last two months, so that the results are hardly yet ascertainable. Osram and Cryselco metal lamps of 50 c.p. and 32 c.p. have been used, however, for side street lighting for about two years. It is interesting to note that Mr. Chalmers recently photometered about half a dozen of the incandescent gas lamps in use for street lighting, for which the local gas company claim 140 c.p., and he obtained an average figure of only 39·4 c.p., the highest being 47·5 and the lowest 36. A Harrison flicker photometer was used in making these tests.

Mr. S. L. R. Price, of Pembroke (Co. Dublin), substituted, some six months ago, high candle-power metal lamps for two circuits of arc lamps (nine lamps on each circuit), of which the cost of repairs after nine years' running had become considerable. In place of each arc lamp a cluster of five 100 c.p. metal lamps was fitted, the total cost of 17 clusters amounting to about £120, including an independent service to each post. The eighteenth post was allowed to remain as an arc lamp for special reasons. It may be mentioned that the cost of the change was approximately the same as if the existing lamps had been replaced by modern arc lamps. At the start, Osram, Sunbeam and G. M. Boddy & Co.'s lamps were installed. Equally good results were obtained with the Osrams and Sunbeams, but, due to breakages in transit and the consequent delay caused in obtaining replacements, it was decided only to use Osrams, as these could be obtained locally. So far the cost of renewals has worked out practically equal to the cost of carboning the arc lamps previously installed, but it has been possible to dispense with the services of an arc lamp trimmer, thereby saving about £65 per annum, in addition to which there has been considerable saving in repairs. Mr. Price draws attention to the fact that at the end of every 9 or 10 years the arc lamps would require to be replaced, whereas with metal lamps no such question arises.

Mr. C. M. Shaw, of Worcester, informs us that 50 c.p. and 100 c.p. metal lamps, mainly Osrams, have been fixed in pairs on the tramway poles of all routes not hitherto illuminated by arc lamps or small electric standards. General satisfaction is expressed with the lighting given by two 50 c.p. lamps on each pole, and the general distribution of light, Mr. Shaw considers, is much superior to any other he has seen for the same amount of energy consumed.

At Horsham, the largest metal lamps used for public lighting are 63-watt Osrams, but Mr. J. B. Morgan's reply to our letter draws attention to several interesting features. The bulk of the street lighting at Horsham is by 23 c.p. Tantalum lamps in series, but at prominent street corners two high-voltage tungsten lamps are installed. His experience with Tantalum lamps is uniformly satisfactory, the average life of these lamps being about 1,600 hours; but with tungsten lamps the results are far from uniform, probably due to local circumstances, though precisely what causes the premature failures in certain situations is at present unknown, for all makes of lamps tried on these particular posts give the same inferior results. As the lamps are under-run 5 per cent., the failures are not caused by excessive voltage at these points.

THE DIRECT MEASUREMENT OF MEAN SPHERICAL CANDLE-POWER BY DIFFUSION METHODS.*

BY W. E. SUMPNER, D.SC.

Although the Ulbricht globe yields good results, there are some sources of error. Its accuracy is dependent on at least four assumptions. (1) The inner surface must reflect light of all colours equally well, and the reflecting power should be high. (2) It is assumed that there are no surfaces within the globe which absorb or reflect light. This cannot be quite true in practice. (3) A third assumption which is well understood, is that the surface of the Ulbricht globe reflects light by diffusion only. (4) It is assumed that the photometer window transmits light by diffusion only—that is, it is assumed that none of the rays pass straight through it, as would be the case with transparent glass. The material used for this window must be most carefully chosen, for unfortunately any translucent substance like milky glass transmits light partly by diffusion, and partly by direct transparency, and it may quite easily happen that the amount of light leaving the sphere through the photometer window is quite as much

* Abstract of a communication to the Illuminating Engineering Society.

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due to transparency as to diffused transmission. In such a case the effect on the photometer measurement would be serious, because the light received would consist of two parts following different laws. In 1892 I gave a proof of the following statement, which forms the basis of the action of the Ulbricht globe. "If any complete (or if any portion of a) spherical surface be illuminated in *any* manner by the *direct* rays of a combination of light sources, the actual illumination I will exceed I_0 the initial illumination by a *constant amount* all over the sphere, owing to the reflective action of the surface."

This theorem is remarkable for two things—for the ease with which it can be proved and for its extreme generality. It does not matter how uneven the candle-power of the light is, or where it is placed. It need not be at the centre. There may, indeed, be any number of lamps placed anywhere within the sphere. It does not matter what the reflecting power of the surface is, or how the reflecting power may vary from part to part. In particular a portion of the surface may have zero reflecting power, which is equivalent to the removal of that part of the surface, and this portion may be of any shape we please. In all these cases the increase of the illumination due to the reflection is the same for every part of the surface, though, of course, the amount of this increase will depend on the particular circumstances of the case.

Now the brightness B of any part of the surface is related to its illumination I by a simple formula involving ρ the reflecting power of the portion of the surface considered. The formula is

$$\pi B = \rho I,$$

each of these expressions representing the total light sent out by the surface per unit area. If we denote by the suffix zero the values of the corresponding quantities, assuming no increase due to internal reflection, we have also

$$\pi B = \rho I_0.$$

Now by the above theorem we know that for a sphere I exceeds I_0 by the same amount for every part of the surface. It is well known that for a complete enclosure (of *any* shape) whose walls have a reflecting power, ρ, the average illumination I is related to the average initial illumination I_0 due to the direct rays of the light sources, by the formula

$$I = \frac{I_0}{1-\rho}, \text{ or } I = I_0 + \rho I,$$

so that the constant increase of illumination is ρ times the mean illumination. A similar formula applies to B. Now, if ρ is only 10 per cent., B is essentially the same as B_0, and varies to the same extent; but if ρ is 90 per cent., B is on the whole 10 times as large as B, and consists of a small portion B_0, which varies from one part of the surface to another, together with a portion, about nine times as large, which is constant. With the surfaces actually used in an Ulbricht globe the value of ρ is probably about 80 per cent., which means that the constant portion of B is 80 per cent. of the average value of B, the rest is B_0, due to the direct action of the lamp's rays, and varies with the candle-power in the corresponding direction. With such a high value of ρ the error of the measurement yielded by the globe is probably not serious. But there would be a great error if ρ were small and the photometer window partially transparent.

Since the Ulbricht globe is not perfect, I have considered the simpler case of a rectangular box surrounding the lamp and lined with a good white reflecting surface, such as white paper or white enamelled iron. Investigation shows that there is not any simple accurate formula connecting I with I in the case of a rectangular box, as there is in the case of a sphere. But if the reflecting power of the surface is high the brightness will tend to become uniform all over the surface, and I find that *whatever the shape* of the surface is we can assume as a *first* approximation that the brightness of the surface is constant; we have as a *second* approximation

$$I = I_0 + \rho I_m \text{ and } B = B_0 + \rho B_m,$$

or for *every portion* of the surface I exceeds I_0 by a constant amount equal to ρ times the average illumination, the same as for a sphere. This second approximation must be very close indeed to the truth in the case of a nearly cubical enclosure with highly reflecting surfaces.

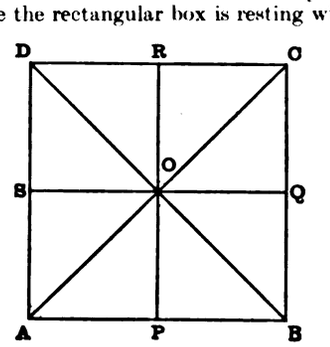
Now suppose the light to be tested is placed at the centre of a cubical wooden box whose inner surfaces are white and have a reflecting power of about 80 per cent. Let the length of each side be 1 yd., and let the box rest on some horizontal surface. Suppose on one of the vertical sides a hole is cut of dimensions 2 in. by 1 in., and that into this hole is fitted one end of a rectangular wooden tube 8 in. long, the other end being closed by one of a pair of blocks constituting a Joly photometer. The tube is assumed to be horizontal and to be at right angles to the surface of the box. For the present we assume that the tube is open at the end fitted to the box, and not closed by a glass window, as in the case of the Ulbricht globe. The illumination falling on the inner Joly block can be balanced by that due to a comparison lamp of K candle-power placed at a distance D feet from the outer block along the line of the tube.

To calibrate the apparatus it will be necessary to put a light of known mean spherical candle-power within the cube, as in the case of the Ulbricht globe. The mean candle-power of any light used with the cube will then be inversely proportional to the square of the balancing distance D. The only assumption made is that the brightness of the patch of surface used by the photometer is always proportional to the mean candle-power of the light within the cube. As already stated, this assumption is accurate enough provided the reflecting power ρ is sufficiently high. There still remains the question of the best position for the photometer tube. It should be so placed that it does not point to any part of the arc lamp. This is easily arranged, because the area of the patch of surface used is small, less than half a square foot in a side having an area of 9 sq. ft. The part of the surface chosen should not be that where the rays from the arc are strongest, or where they are weakest. We have

$$B = B_0 + B_m,$$

where B is always small compared with the total. All we want for *perfect* accuracy is to have the value of B_0/B_m the same for the patch of surface chosen, whether we test a light of uneven candle-power, like an arc lamp, or calibrate the sphere by a light of fairly uniform candle-power, such as a Fleming standard glow lamp. This end is essentially secured if we choose a portion of the surface the direct illumination of which due to an arc lamp is about the average value due to that lamp. For arc-lamp testing the photometer tube is probably best placed on the middle horizontal line of one of the vertical faces of the box and a few inches in from one of the vertical edges.

There is an entirely different way of using a rectangular box for the present purpose. The theory of this method depends simply on the principle of symmetry. There are few, if any, commercial forms of lamp the light from which is not distributed symmetrically about an axis. Suppose the rectangular box is resting with two of its surfaces horizontal, and that the light is placed at the centre of the box with its axis vertical. It is then obvious that there are four vertical planes through the axis, each of which divides the surface of the box into two halves, and that on each of these halves the total light received is the same. If ABCD is a horizontal section of the box (*see* Fig.), and O represents the axis, the four planes in question are represented by the two diagonals and by the two central planes parallel to the sides. The light received by the portion of the surface consisting of the vertical strip AP, and the two horizontal triangles AOP, will always be a fixed fraction of the total light emitted by the lamp, and in the case of a box of square section this fraction will be $1/8\ (1-\rho)$, or 5/8 if ρ is 80 per cent. Now suppose the box is formed of wood, and that its internal surfaces are well whitewashed. Suppose the part of the box represented by AOP is cut out, and that in its place is fixed a framework supporting three surfaces replacing the missing portions of the box. Let these surfaces consist of a substance transmitting and diffusing light such as opal glass or engineers' tracing cloth. The light received by these new surfaces will still be a fixed fraction of the total light emitted by the lamp, and this will also be true of the amount of light diffused outwards. All that remains to do is to arrange some suitable way of illuminating a photometer by this outwardly diffused light. This object can be attained by the use of two good mirrors, one touching the top and the other the bottom of the box along an edge parallel to SO. Each mirror should be inclined 45 deg. to the surface of the box so as to reflect the light from each triangular area AOP along the line OP. The photometer should be placed along the line OP produced, and from its position the appearance will be that of three flat bright surfaces each perpendicular to the line of the photometer. If the box is a yard cube the size of these surfaces will be considerable, and the photometer distances will have to be large for accuracy. This will be no novelty in arc-lamp testing, since the intensity of the light necessitates large photometer distances. For glow-lamp testing the dimensions of the cube can be made much smaller, as well as those of the rest of the apparatus.



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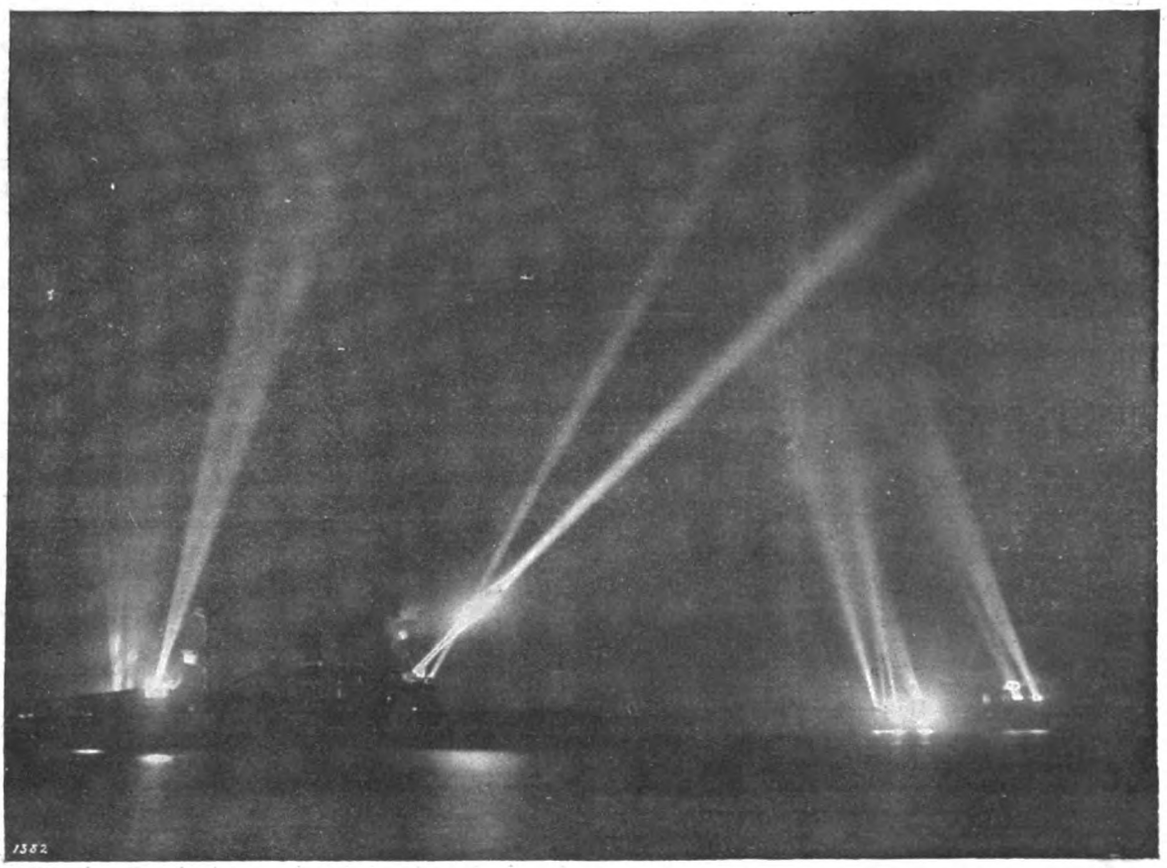
USE OF THE SEARCHLIGHT IN LIFE SAVING.

To the ordinary person the searchlight is often looked upon as an accessory for the killing of people—that is to say, it is used on battleships to help the gun firing and on our coast defences for very similar purposes. That it can, however, be successfully employed for life saving is shown by an incident which occurred at South Shields the other day.

In 1907 our contemporary the "South Shields Daily Gazette and Shipping Telegraph" presented to the South Shields Volunteer Life Brigade a searchlight for use in connection with its work. This brigade was founded in 1866 and has its headquarters at the pier. The projector equipment is placed in the watch house on the South Pier, the generator being in the basement and the projector on the first floor. This floor is fitted with windows all round, so that the projector can be wheeled to any position and throw its light in any required direction. The set operating the light consists of a vertical petroleum engine of Messrs. Norris & Henty's make, delivering 10 H.P. when running at 800 revs. per min. This is coupled to a 65-volt 85-ampere Crompton dynamo, which feeds through the usual switchboard and controlling apparatus a 24 in. Crompton projector.

The formal opening ceremony of this set took place on October 24, 1907, and the volunteer brigade have practiced with it in conjunction with the rocket apparatus every Friday night since. It had not, however, been employed for actual life saving until a week or two ago, when it was used in connection with the rescue of the crew from the Norwegian barquentine "Alphonse." In the course of a storm this ship was driven on the beach 200 yards north of the Trow Rocks, South Shields. Although the rocket apparatus was despatched, the crew did not seem capable of using it, so that after several attempts the lifeboat was launched, and all hands were successfully brought off in it. In connection with the rescue work the searchlight proved itself of great value both to the rescued and the rescuers. From every part of the beach the vessel could be seen as easily as in daylight, although it was nearly a mile distant from the pier. It is, therefore, not surprising to hear that testimonials to the usefulness of the equipment were paid both by the lifeboat brigade and the captain of the wrecked vessel.



CROMPTON SEARCHLIGHTS IN USE DURING THE FLEET ILLUMINATION AT SOUTHEND-ON-SEA.

Messrs. Crompton's searchlights are also being employed for warlike purposes, though the accompanying illustration shows these sometime warriors assisting in the illumination of Southend-on-Sea.

RECENT DEVELOPMENTS IN THE MEASUREMENT OF LIGHT AND ILLUMINATION.

We give below an account of the resumed discussion on the above subject, which took place at the meeting of the Illuminating Engineering Society on Thursday, March 14th, at the Royal Society of Arts.

Prof. SILVANUS P. THOMPSON (president) said that it was intended to confine the discussion on that evening almost entirely to the measurement of illumination and to the carrying out of the principles which had been discussed a month ago in the practical estimation of illumination. It had been hoped that Sir William Preece would have been present to open the discussion, but owing to ill-health it was not possible for him to attend. Happily, however, he was represented more or less by Mr. Trotter, who was associated with Sir William from the beginning.

Mr. A. P. TROTTER said that the subject chosen for that meeting was the photometry of illumination. Query No. 6 of the Paper, which had been circulated, was as follows: "What are the main qualifications of an illumination photometer for practical work? With what degree of accuracy can the illumination in streets and buildings be measured, and what limits of accuracy should at present be permissible?" A member had suggested at the last meeting that there appeared to be too many different kinds of photometers, and he seemed inclined to wait until the best one had been decided upon. There were many kinds of pens and many French dictionaries, but nobody put off learning to write or to study French for such reasons. The fact was that the large variety afforded opportunity for different persons to suit themselves. It would be found that there was no "best" photometer, but each person would generally do the best work with the instrument to which he was accustomed, and, if he happened to be the inventor of one, there could be no possible doubt which instrument he would prefer. He considered that the first of the qualifications of an illumination photometer, which, in fact, distinguished it from a portable candle-power photometer, was the provision of a horizontal test plate having no obstruction, but a clear view all round. Illumination might be measured by measuring successively the candle-power of each lamp which contributed to the illu-

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mination and then calculating the combined effect. Such measurements might be made on inclined test plates, but the total could only be considered on a horizontal plane. Most illumination photometers could be used also as candle-power photometers. Some instruments, such as the Martens, Kruss and one of Weber's were intended for measuring the illumination on school desks, or at a lathe or bench in a workshop, and the instrument itself obstructed half the view from the test plate, and, in cases of general illumination, might obstruct half of the light. Such instruments were very useful for certain purposes, but were not suitable for measuring illumination in streets, railway stations, &c. The second qualification of an illumination photometer was that the test plate should be as matt as possible—that is, have no appreciable glaze—and should obey the law of cosines as closely as possible—that is, it should have no appreciable angle errors. The third qualification was a good lamp. In Germany a small benzine lamp was often used. The height of the flame had to be adjusted carefully. It could not be used until it had burned for 10 minutes, and he did not know how long it would burn without adjustment. He preferred a small electric lamp worked from an accumulator. If it were switched on only during each reading, which did not take more than 20 seconds, the total over a long evening's work would not amount to more than about half an hour. It was easy to ensure that the lamp would not vary more than 2 per cent. in candle-power during an evening. He did not believe in using voltmeters or adjustable resistances. The fourth qualification was a practical range. The maximum need not be more than 4 foot-candles, but the minimum should reach 0·02 or lower. The minimum illumination for street lighting was sometimes specified as 0·1 foot-candle. It might be interesting to measure the higher values, but in case the lighting was deficient the most important one to be able to measure accurately was the minimum allowed. It was quite possible to make very fair measurements of 0·005 foot-candle, but the scale of the instrument must be expanded at the lower part to make this possible. The fifth qualification was capability for dealing with coloured lights. The speaker's personal opinion was that the value of the flicker photometer was over-rated, but he admitted that good work was done with it in some cases. He considered that the principle of free and rapid motion of the adjustment, whatever it was, of the instrument was sufficient for all practical purposes. The sixth qualification was a convenient arrangement for measuring the angle of incidence, and the last was the important one of portability. The second part of the query related to the degree of accuracy. Any good instrument set up on a tripod should be able to give an accuracy of 2 per cent. But it was useless to attempt high accuracy in outdoor work. Irregularities in glass globes, dirt, variation of gas or electric pressure and other accidental causes introduced unknown errors. If on repeating a number of measurements it was found that they lay within a range of 5 or 6 per cent.—that is, not more than 2½ to 3 per cent. from the mean of the whole—the work might be considered satisfactory. Mr. Trotter then showed one of his illumination photometers, made by Messrs. Everett, Edgcumbe & Co., and explained its use.

Mr. Lancelot Wild (Westminster Electrical Testing Laboratories) said that there were many ways of measuring the insensitiveness of photometers. His way was to move the carriage from the left until one ceased to see any out-of-balance, and then to move the carriage to the right until one again failed to see any out-of-balance, and take the difference between the two. That should be repeated for about a dozen times and the average taken of the different pairs. In that way he had tested a good many photometers, and had taken some of the most notable examples, which were shown in the Table below:—

Insensitiveness of Photometers (Lights of Similar Colour).

Type of photometer.	Equality of brightness. Per cent.	Flicker. Per cent.
Joly prism, paraffin	2·5	—
Simmance wheel	2·4	1·6
Whitman sector	2·0	1·0
Inclined cards	1·2	—
Common Bunsen, viewed one side	1·2	—
Ditto viewed both sides	1·5	—
Special Bunsen, viewed one side (38 lb. Ford)	0·4	0·8
Ditto viewed both sides	0·8	0·2
Special Bunsen, viewed one side (60 lb. Ford)	0·8	—
Ditto viewed on both sides	1·2	0·4
Lummer	0·7	—

The fault of the Joly prism was the separation between the surfaces. With the Whitman sector photometer a great improvement was found by using it as a Flicker. He had come to the conclusion that the reason why the Lummer results were not so good as he managed to get from the Bunsen was because the Lummer was viewed with one eye only, and he showed a photometer of the Lummer type, which was so enlarged that it could be viewed with both eyes without any eye-piece. This proved to be more sensitive than any other photometer that he had ever tried, and had the added advantage that it was comfortable to use.

Mr. J. G. Clarke (Gas Light & Coke Co.) said he could not share the bad opinion that had been expressed of the Bunsen disc photometer. It was part of his duty to keep an eye upon the quality of the mantles belonging to his Company, and for that purpose he found the Bunsen disc a very useful piece of apparatus indeed. In the first place, one could work for very long periods without fatigue, and secondly it would permit an adjustment to be made while one was looking at the screen, which was an important matter. In regard to the testing of lamps, he preferred to test a lamp to ascertain its lower hemispherical value. He mentioned that because a good deal of interest had been displayed in regard to integrating photometers. Of course, it was nice to be able to ascertain such an important value by one observation, but he did not think that one could do with anything less than a complete distribution curve for the light—*i.e.*, to know not only how much light was coming from it, but where it was coming. It was well recognised that a source of light was a sort of raw material for the lighting business, and it was necessary, having obtained an efficient source of light, to consider the best method of distributing it by means of reflection. If one only knew the total flux of light, one was not much better off than if one had no data upon which to base calculations or drawings for the design of reflectors and refracting apparatus. Nothing short of the distribution curve could be of any use. The Simmance-Abady flicker photometer was eminently adapted for the work of getting out such a curve, as it had precise methods of measuring, was easy to manipulate, and with it one could get a distribution curve in about an hour. There were one or two points in regard to the use of the flicker photometer which were rather important. Firstly, there was the speed of the flicker wheel. The speed at which that wheel should run depended upon the illumination which was to be measured, it being necessary that in practical use the flicker should have a lower speed the lower the illumination. In public lighting it was necessary that the various kinds of installations should be maintained at their proper value. In doing that he found it most convenient to conduct the work on the basis of candle-power. Of course, illumination was highly important, and its value should be known at times; but when an installation was once fitted up and the candle-power and height were adjusted to give a desirable illumination, a knowledge of the candle-power which produced that illumination could be taken as an index of the value of that illumination from time to time. For the purpose of taking candle-power measurements he used the Simmance-Abady flicker photometer, which was a very handy instrument for outdoor work that had to be conducted under rough-and-ready conditions, as it was quite firm, and that was a good factor where heavy traffic was encountered. He then demonstrated the use of the above-mentioned photometer, in which he said there was one limitation—viz., that it could only take three sides. That, however, was more or less the case with the Trotter photometer, in which the shadow of the operator was bound to have some effect.

Mr. Haydn T. Harrison said that the query on which they were discussing depended a little upon what one called "practical purposes." For instance, he had had to test over 150 lamps in one evening, each of which were about 80 yds. apart. Simplicity was a great thing, and he thought that Mr. Trotter in his photometer had got simplicity; but he did not agree with Mr. Trotter's remarks concerning the lack of necessity to level the photometer for every reading when using a horizontal screen. He made his photometer so that the angle for nearly all street illumination work varied so little from 90 deg. that the cosine did not have any effect. He found it much quicker when measuring the illumination between two posts to measure the ray at a point where he could measure it accurately; that was where the illumination on the photometer screen was not less than 0·1 candle-foot, and so, as a rule, he raised the height of the photometer and then measured the ray. That was one reason why he objected to the horizontal screen—viz., that the illumination was so low owing to the cosine of the angle. As to permanency of standards, he had been making some tests in that direction, and he found that the small tungsten lamp—preferably tungsten, because the variation of candle-power with pressure was less than in a carbon lamp—remained for over a year within 1 per cent. Another great advantage was that by inserting a resistance the standard of a tungsten lamp could be reduced to one-tenth, and still remained accurate. So that instead of having to put in two lamps in a photometer in order to get a double scale, he put in one lamp and the plug simply introduced the necessary resistance to reduce the standard. He agreed with Mr. Trotter as to accuracy, and never attempted to be more accurate than 5 per cent. for street work. Indoor work, of course, was another matter, and the accuracy obtained depended on how much time one had to spare. Turning to the query as to what were the best methods of studying and measuring daylight illumination, he never attempted to measure daylight illumination in the interior of a building, but always measured the dark spots. He then showed a model of his photometer, manufactured by Elliott Brothers. In all his measurements he used the flicker photometer wherever he could, being thus able to get through much more work in a given time than with a comparison instrument. At the request of the president, Mr. Harrison then measured the illumination of the room in which the meeting was held, the result being, with electric light, 0·7 candle-foot; with gas light, 0·08 candle-foot. In fairness to the gas, however, it should be stated that, owing to it not having been used for some time, probably a number of the burners were out of order.

Mr. P. J. Waldram thought that one important class who neglected the study of illumination was the architect, upon whom great responsibility rested in designing both the daylight and artificial illumination of a building. He considered the human eye capable of absurd fallacies. It would be interesting, he thought, to know what was Mr. Harrison's standard for the adequate illumination of a room.

Mr. K. Edgcumbe said that he agreed with Mr. Trotter that the reflection from houses had a most important effect on the horizontal illumination. For that reason it was not enough merely to take candle-power readings and then to calculate the illumination in a street, as Mr. Harrison did.

Prof. Silvanus P. Thompson thought the Martens photometer, which was extremely simple and portable, was an ideal one for measuring the illumination on a scholar's desk. It certainly stood in its own light, but that was more or less true of every photometer, and, as a matter of fact, the scholar sat in his own light also.

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CORRESPONDENCE.

ELECTROMAGNETIC PHYSIOLOGICAL EFFECTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As bearing upon Prof. Silvanus Thompson's interesting discovery of a physiological effect, due to an alternating magnetic field, and as supporting your view that the effect is due to induced currents rather than to any magnetic cause pure and simple, I may mention that it is easy to produce the visual flickering effect by passing through the head the current from an ordinary continuous-current magneto generator, such as is supplied with the Evershed ohm-meter. One terminal of the generator should be held in one hand, while a wire from the other terminal should be held in the other hand in contact with a small piece of wet sponge, and the latter pressed lightly on one side of the head just behind the eye. If the generator handle is then slowly turned (and it is wise to turn it slowly to avoid unpleasant results) the flickering effect will at once become very noticeable, and as the frequency of the flicker increases with the speed of revolution it apparently is connected with pulsations in the current due to the slow revolutions and the few segments on the commutator. The current through the head must be very small, as the bulk of that generated goes from hand to hand through the arms and body.

I first noticed this phenomenon some twelve or fifteen years ago when treating myself electrically for neuralgia, but I fancy that the effects of electric currents on vision have been known much longer than that.

Passing electric currents through the head in certain directions also produces a metallic taste in the mouth.

Electrodeless currents in the body produced by electromagnetic induction from a coil carrying so-called high-frequency currents, have, of course, been in use in medical practice for some years.

Employing as primary a coil of wire of many turns, and some two feet in diameter, carrying high-frequency currents from the discharges of a large battery of Leyden jars, and using as secondary the body and the two arms bent so as to form a circle, sufficient current can be induced in the circuit formed by the arms and body to light a miniature incandescent lamp connected between the two hands; or a sufficient difference of potential can be produced between the two hands to cause small sparks to pass visibly between them when they are held near together.—I am, &c.,

A. A. CAMPBELL SWINTON.

66, Victoria-street, Westminster, April 18.

CONTRACTS IN INDIA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As an electrical engineer resident in the city of Bombay I have noted with interest, on p. 910 of your March 11th issue, that Messrs. Greaves, Cotton & Co., of this city have received contracts for the Cama and Allbless Hospitals, Bombay, and also an order from the Bombay Government amounting to about Rs.100,000. Probably it will be of interest to you to know that the Cama and Allbless Hospitals are also under the Government, and it will be probably very interesting to you and your readers to know that none of these contracts were called for tender. I think this kind of thing would not be tolerated for one moment at home, and I am sure that any self-respecting Government or public body would never dream of handing over large contracts of this sort without at first calling for public tenders.

Of course, I am fully aware that there are many of these contracts for which tenders are called, but it is simply a matter of form, as it is fairly well known beforehand who the particular party is who will receive the order, but still these formulas must be gone through for appearance's sake.

I am also personally aware that there were two or three other contracts given to the same firm, and it seems a most strange thing that the three or four leading electrical engineering firms in Bombay had not even an inkling that this matter was coming forward until the order was given.

I should thank you to give this matter prominence in your paper, and probably some of the powers that be at home might take the matter up and give us all the chance to make a bid. The Government will get much better value for their money if they will call for public tenders, giving the tenderers ample time to go into details, and not, as is the usual practice at present, to call for public tenders for contracts amounting to one to two lacs, which have to be submitted within a day or two.—I am, &c.,

Bombay, April 1. ONE INTERESTED.

[We have somewhat modified our correspondent's letter (of April 1st), as there are statements made therein that we are not able to verify. The subject of public tendering is one that demands publicity and, if the facts are as stated, "One Interested" does good service in calling attention to them.—ED. *E.*]

ELECTRICITY IN MINES.

At a meeting of the Mining Institute of Scotland, held last week in the Technical College, Glasgow, an interesting discussion, of which we give an abstract below, took place in connection with Mr. Robert Nelson's Paper on "Electricity in Mines."

The PRESIDENT, Mr. Robert McLaren (H.M. Inspector of Mines) stated that in Scotland electrical power was now largely utilised, and he, personally, did not see why Scottish mining engineers should not be able to contribute usefully to a discussion of this subject.

Mr. C. A. ATCHLEY thought that the completeness of Mr. Nelson's Paper made for criticism, owing to the fact that so many controversial points were discussed. Mr. Nelson's strong defence of the three-phase system of supply as against continuous current would, no doubt, meet with cordial agreement on the part of most engineers as a general statement. Unfortunately, mining conditions might also have to be taken into consideration, and in these days of extremely thin seams continuous current had perforce to be adopted for coal-cutting, owing to the greater power which could thereby be obtained from a small motor of given size. In any case, judging from the extremely satisfactory results which continuous-current machines had given for this class of work, it would appear doubtful whether a change to three-phase supply would be a great improvement, especially as the nature of the work rendered slip-rings almost a necessity. There did not seem to be a great deal to choose between a commutator and slip-rings, both, in his opinion, being equally objectionable in places coming under Section 8 of the Coal Mines Regulation Act. He felt bound to question Mr. Nelson's advocacy of the concentric system, as in his (Mr. Atchley's) experience it had been a source of trouble, owing to its very construction inviting a breakdown of the insulation, and a proper repair was difficult to carry out satisfactorily. Vulcanised bitumen had undoubtedly proved the most satisfactory insulating medium, and in conjunction with this, armoured cables in all main roads, as suggested by Mr. Nelson, would seem to offer a cable as good as any that could be devised. On the other hand, Mr. Nelson's recommendation as to the use of a copper sheath for earthing purposes, in addition to armouring, might be desirable and necessary in parts of the country where it was the practice to work over very large fields, but in Lanarkshire it would surely appear to be quite unnecessary. Mining engineers would welcome Mr. Nelson's definition of satisfactory earthing, as this had been a contested point almost since the time when the necessity for earthing in connection with mining electrical installations became an acknowledged fact. To those engineers who had become used to the unarmoured cable system and who had adopted the armoured system it would seem necessary to emphasise Mr. Nelson's warning that such a system was much more dangerous than that embodying unarmoured cables unless every precaution was taken to ensure that the whole armoured system of the pit was made electrically continuous to suitable earths. In regard to the new system of protection referred to by Mr. Nelson, since the suitability of this apparatus had yet to be determined, it was, perhaps, too early to comment upon it, but he (Mr. Atchley) could not help expressing the opinion that it did not appear to be so simple as it looked.

Mr. F. ANSLOW (Glasgow) said Mr. Nelson's Paper contained so many useful hints for the design and carrying out of electrical mining equipment that from that point of view it must be of great practical value to those engaged in the equipment or management of mines. When, however, in this and the Paper read recently at Birmingham, Mr. Nelson dealt with the various systems he was scarcely so convincing. In the present transient state of electrical matters it appeared quite an erroneous procedure to advocate that any particular system of supply, source of supply, or class or type of cable should be universally used. As regards the system of supply, being interested in a large amount of alternating-current plant at present being installed, he (Mr. Anslow) was satisfied that that system possessed many valuable features, especially for use in fiery mines, but its application, he thought, was limited. Direct current had also its special points, not the least of which was its more general adaptability for driving any class of machinery, and it appeared

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to be quite within the region of possibilities that this power would regain its once pre-eminent position. In many cases, indeed, where alternating current was used, converting apparatus had to be installed for supplying direct current to machinery which could not be operated efficiently by alternating current. Regarding the source of supply, no doubt the various power companies had been a boon to collieries in isolated districts; on the other hand, however, it was not clear, in view of many instances which had come under his notice, that power companies could supply electricity at a cheaper rate than that at which it could be generated in even a moderately-sized power station situated at a colliery. It must not be forgotten that in many existing collieries use could be made of exhaust steam, and further, especially in Scotland, there was frequently a quantity of dross available which had no marketable value, and which, having quite a good calorific value, could be economically used for steam-raising purposes. He thought Mr. Nelson was quite right when he stated that the use of armoured cables ensured the work being properly carried out. Such cables were particularly adaptable, of course, to the protective system recommended by Mr. Nelson.

Mr. Sam Mavor (Glasgow) thought that Mr. Nelson's official capacity gave his Paper exceptional authority. The author curtly dismissed continuous current in favour of the three-phase system. Now, the speaker did not think that was warranted. For large areas of supply, and in the case of large collieries requiring to transmit power a considerable distance, there was no question whatever that three-phase was the right system. In Scotland, however, there was a large number of relatively small colleries requiring relatively small quantities of power, and it was not, in his opinion, to be accepted that the three-phase system was necessarily the best for these conditions.

Mr. Anderson supported Mr. Mavor as to direct-current versus three-phase coal cutters. In many cases colliery managers were badly advised to adopt the three-phase system. It had, he noticed, been represented in one of the contributions read that evening that the use of armoured cables tended to better workmanship. His experience in coal mines, however, had been the very opposite. He did not think that he had seen more shoddy work carried out anywhere than where the armoured system was adopted, possibly due in a measure to the fact that those in charge of armoured cables did not realise the great responsibility. He also considered that there should only be one earthing point in connection with a colliery installation, and that earthing point should be on the surface.

The President stated that he was not greatly taken up with armoured cables, because they got twisted in all sorts of ways and the wires got away from the cable.

Mr. Martin remarked that in the Newcastle area he happened to know, from practical experience, that the protective system advocated by Mr. Nelson had proved of real value.

Mr. James T. Forgie (Bothwell) thought that those who had had experience of electricity for a number of years found that in a great many mines in Scotland the continuous-current system had proved remarkably satisfactory. They must remember that Mr. Nelson's experience had been mostly gained in large collieries; and in such places, with long transmissions, the alternating system was certainly the best. The speaker had no hesitation in saying, however, that for a small installation the continuous-current system was the best.

ELECTROLYTIC DISINFECTANTS.

In our issue of November 23, 1906 (p. 205) we described the Hermite plant installed at Poplar for the electrolytic production of hypochlorites; and details of the results obtained with this plant are contained in the annual reports of Dr. Alexander, the medical officer of health, which reports have been abstracted from time to time in our columns.

As mentioned briefly in our last issue, additional plant has recently been installed at Poplar, and on Tuesday last the complete installation was visited by the Faraday Society, the particulars of the process being explained to the members by Dr. Alexander.

The new plant has been installed by the side of the existing plant in a building adjacent to the Poplar electricity works, from which current is obtained for the electrolytic process. The most important feature of the new plant is the new type of trough, or cell. These cells are now made of earthenware. Slate was employed in the old troughs and has not proved satisfactory, owing to the difficulty of obtaining a slate without metallic veins. The presence of these veins causes the slate to be destroyed, and earthenware has been found to give much better results.

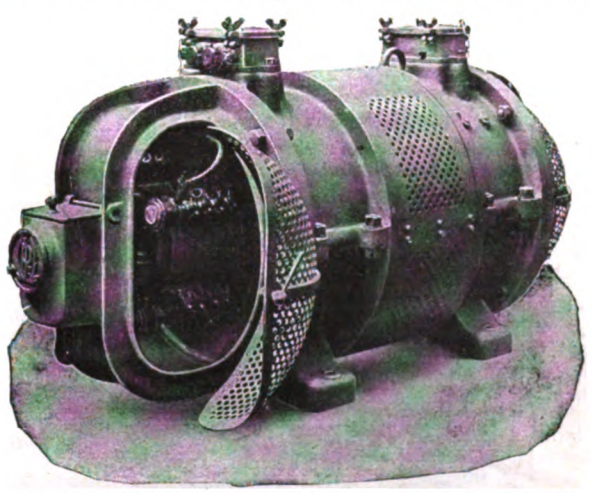
It will be remembered that the system adopted at Poplar is to mix sodium chloride and magnesium chloride in an elevated tank and then to allow this fluid to flow through troughs containing the electrodes. Each trough is divided by a partition, and five elements, each consisting of one positive and two negative electrodes, are placed in each division. There are four troughs, so that the total number of elements in series is 40. The positive electrodes consist of thin platinum wire wound upon slate slabs, and the negative plates are of zinc. The liquid passes through all the troughs and finally discharges into a carboy. The preservative is added as the liquid leaves the last trough, and an electrically-driven stirrer in the carboy is now employed in place of the hand stirring formerly necessary. A pump has also been installed for raising the fluids into the elevated tank. Improved forms of electrode have also been adopted in the new installation, facilitating connecting up.

A current of about 25 amperes at 240 volts is used for each plant, and, of course, a new switchboard panel with resistances has been installed in connection with the new plant. It may be mentioned that the cost of the new plant, which has been supplied by the Farringdon Engineering Co., is about £400, including the new switchboard. The complete installation comprising the two plants has cost about £1,000, and approximately 400 gallons of disinfectant fluid are produced per day, this being the amount of the present requirements. The cost of production is a little more than ¼d. per gallon for electricity and materials. The disinfectant fluid is supplied free to all applicants. We must congratulate Dr. Alexander on the success attending this pioneer installation.

SELF-REGULATING DYNAMO FOR USE WITH SEARCHLIGHTS.

The advantage of using a source of electricity supply giving a current of constant value for the lighting of arc lamps of any description is well known. For searchlight work, where the lamps are used independently of each other, the advantages of such a supply are still more noticeable, and the want of a suitable dynamo for generating a constant current has been the main reason for resorting to less efficient means of operating this type of apparatus.

A dynamo which Messrs. Mather & Platt, of Park Works, Manchester, have designed and put on the market for this class of work, is said completely to solve this difficulty. It generates current at practically constant value throughout a range of voltage far beyond



Constant Current Dynamo of Messrs. Mather & Platt.

the limits required for arc lamp working, and is further free from many of the objections which might be raised on the score of complication. The regulation of the machine is entirely automatic, while this condition is obtained without the use of any external regulating "devices," either mechanical or electrical. The terminals of the machine may be completely short-circuited, or may be closed through a resistance of a value sufficient to maintain a potential of over 100 volts at its terminals with a variation in current of practically negligible amount. The current can, it is claimed, be further increased or diminished within wide limits without in any way affecting the self-regulating properties of the dynamo, merely by an alteration of the existing current. The same generator may, therefore, be used for arc lamps of varying current requirements, thus much increasing its utility, as it is perfectly practicable to run a 15 ampere or a 125 ampere projector off the same size of machine.

Apart altogether from the chief advantages which this system possesses, in virtue of its high efficiency, it has other recommendations no less interesting. Not only is the dynamo itself simple in construction and operation, but the whole management of the projector is much simplified by its use. The current is switched on by merely closing the circuit of the dynamo; an arc forms immediately and is drawn out to the correct length, either automatically by the solenoid of the projector, or by hand if automatic regulation is not used. There is no sudden rush of current, no flickering of the arc and jumping of the carbons, and the time required to get the full brilliance of the arc

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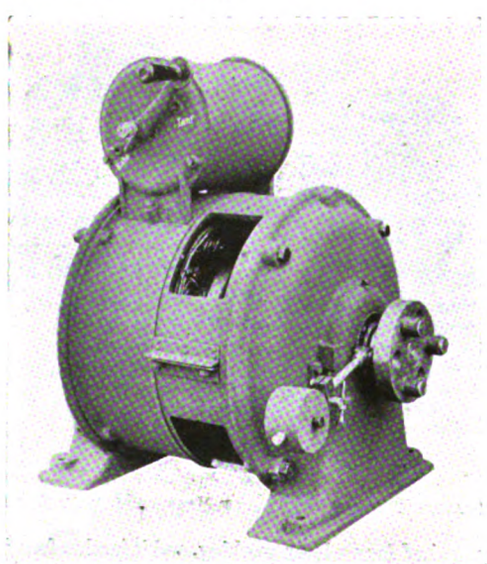
is very much shortened. There is no risk of fuses blowing, due to excessive current being taken, and no need to burn the arc a moment longer than is actually necessary, as it can be re-started instantaneously. The saving on this score alone, both in carbons and in energy, is by no means insignificant, as frequently arcs are kept burning solely on account of the difficulty in re-starting them. Owing to the steadiness of the current obviating the slightest tendency of the arc to hunt, the candle-power of the arc is found to be appreciably greater for the same current consumption and voltage across the arc, or, in other words, the same candle-power can be obtained with a lower pressure across the arc. The difficulty often experienced on low-voltage circuits of the arc being extinguished by being drawn out too far, or too quickly, is almost entirely absent, as the dynamo voltage accommodates itself to the conditions of the arc, and it is possible to draw out an arc 25 mm. to 40 mm. long with a current of 50 amperes. The dynamo can be arranged either for direct coupling to a prime mover, belt driving, or for coupling to a motor in cases where a supply of current is available, as shown in the accompanying illustration.

ELECTRIC DRIVE FOR RING SPINNING FRAMES.

The ring frame has brought about great changes in cotton spinning, and the self-acting mule has, in consequence, been more and more restricted to fine spinning. For this class of work the ring frame has not hitherto been seriously considered, since owing to the comparatively low tensile strength of fine yarns, the quality of the production is very seriously affected by the varying tension to which the yarn is subjected in ordinary ring spinning. A special motor with provision for the periodical variation of its speed has now been placed on the market by the Oerlikon Co., by means of which more favourable results can be obtained on fine counts than are possible with a constant speed drive.



OERLIKON MOTOR FOR RING SPINNING FRAMES.

The tension in the thread varies with the different diameters of the cop, and is greatest when the smallest portion of the cop is being formed. This varying tension in the thread is the chief cause of broken ends, and also results in uneven winding. On the self-acting mule the tension in the yarn is readily regulated through the medium of an arrangement of the most ingenious mechanism, whilst on the ring frame a modification of the frictional resistance to the traveller is the only means which can be resorted to in order to regulate the tension in the yarn. This variation of frictional resistance to the traveller can only be obtained by altering the speed of the traveller and the spindle speed with each upward and downward movement of the ring rail. The introduction of a varying spindles peed also affords a means of considerably increasing the output of the machine by gradually increasing the speed at the middle and lower end of the bobbin, the utmost speed being applied according to the diameter spun.

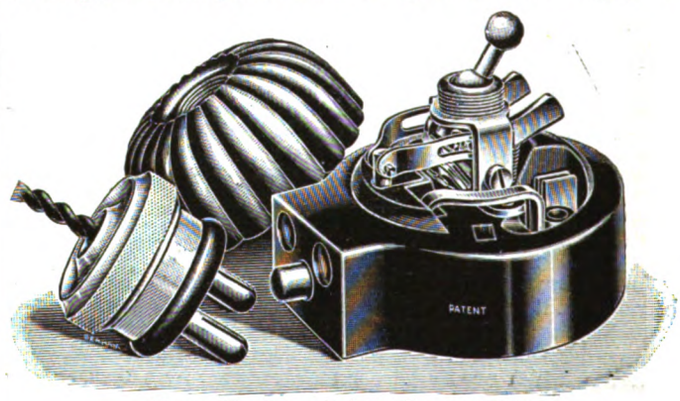
The single-phase repulsion type of motor has furnished the desired solution of the problem, for by means of a simple device for changing the position of the brushes a regulation of speed without shock has been obtained with very little change in the efficiency of the motor. The Oerlikon ring-frame motor (illustrated herewith) possesses a speed variation from 600 to 1,430 revs. per min., and may be adjusted to any speed between those limits whilst work is in progress. The Oerlikon motor possesses the advantage of having only one set of brushes for each pair of poles, thereby simplifying the construction, and it is claimed to have an electrical efficiency little inferior to that of the three-phase induction motor. It may also be mentioned that the motor is dust-tight, and is provided with ball bearings. The starter is fixed on the top of the motor, the lever handle moving between two fixed stops.

As to the automatic apparatus for the periodical variation of the spindle speed corresponding with the mechanical formation of the cop, the Oerlikon arrangement consists essentially of a rope fixed at one end, and the other end connected with the lever noticed in the illustration herewith; this lever is provided with a weight to hold the rope in its normal horizontal position, and connects its movement with that of the brushes on the motor. Attached to the centre of this rope is a second rope which receives a downward pull actuated from the mechanism.

To show the economies which may be effected by the application of the Oerlikon electric drive, some tests on a Rieter ring frame at the Niedertöss spinning mill may be cited. Three frames of the same manufacture were compared, two of these being belt-driven, and the third fitted with the variable speed Oerlikon drive. The actual production over 52 working hours was 122 lb., 133 lb., and 162 lb., respectively, for the three machines. Besides the increase in production, it was observed that a lighter traveller could be used on coarse and medium counts with the variable speed drive.

LUNDBERG'S "AUTO-COMBINATION,"

Messrs. A. P. Lundberg & Sons' ingenuity has, if they will allow us the phrase, broken out in another place. The increasing use of electric heating and cooking apparatus, taking a fairly large current, requires that some efficient means should be taken to protect the equipment, while at the same time any design adopted must be simple enough to allow the ordinary householder to operate it with safety. These conditions are, it is claimed, fulfilled by the 10 ampere capacity auto-combination, a specimen of which has been sent for our inspection. A smaller size, having a capacity of 5 amperes, is in preparation. This piece of apparatus is a combined switch and wall connection, fitted with an automatic release, the latter device being covered by a recent patent taken out by Messrs. Lundberg. The



MESSRS. LUNDBERG'S AUTO-COMBINATION.

switch movement is of Messrs. Lundberg's well-known standard patent pivot type, with the valuable double action, and is of essentially up-to-date construction, that is, it is fitted with knife-blade contact arms and double contacts, while the mica insulation has been successfully tested to withstand a 2,000-volt flashing test before breaking down. By the provision of a spring embodied in the base, which is in connection with the rocking cradle of the switch arm, a device has been arranged to ensure automatic release of the switch contact arm before the plug can be withdrawn. Messrs. Lundberg claim the following advantages from the use of such a device :—

The contact arm flies automatically into its "off" position before the plug can be withdrawn, and remains there. The rupture of the circuit on the withdrawal of the plug is rapid and independent of the operator, the break occurring at its proper place—viz., at the switch contacts. While the plug is in position the device does not prevent actuation of the switch in the usual way. The withdrawal of the plug is thus only necessary when the apparatus connected requires removal. The plug must first be pushed into full contact before the switch arm can be made to remain permanently in its "on" position. As the circuit cannot be broken where the plug pins leave the socket tubes any destructive arcing at these points is effectually prevented. The article can be fitted with any of the standard plugs, and is suitable for ordinary or locked-type covers.

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PARLIAMENTARY INTELLIGENCE.

BRADFORD CORPORATION BILL.

The Local Legislative Committee of the House of Commons (presided over by Mr. C. N. Nicholson) has continued the consideration of this Bill, by which means powers are sought to construct tramways and to run rail-less trolley omnibuses, &c., in Bradford.

Mr. C. J. SPENCER, general manager of Bradford tramways, was recalled and stated that if the trackless tramways proved unsuccessful, the Corporation would not desire to continue them. They were convinced that the scheme could be worked at the fares indicated, without loss. There was no suggestion of going below the 1d. per mile in the first experiments. Owing to the enormous cost of electrical traction they must have a route which would stand a very frequent service of trams. On the Laisterdyke route there was no such demand as would justify a constant service. It would be possible to work the trackless trolley system on even crowded routes by a driver only. What they wanted to have power to do, was, subject to the clause that had been agreed with the railway companies, to carry goods and minerals on the trackless system within Bradford, and, with regard to motor vans and omnibuses, to carry parcels up to 56 lb., as they were doing now.

Col. YORKE, of the Board of Trade, called by the Committee, said the Board had nothing to do with omnibuses, whether mechanically propelled or horse-drawn. They did not come under the Board of Trade except in the case of Eastbourne, where certain special clauses were put in the Act of 1902. In regard to the proposed trackless trolleys, the original proposal in the Bill was that there should be no restrictions on the Corporation at all, but that they should be given a general power and be allowed to settle their routes as they chose. And in consultation with the Board, an arrangement was come to by which they were to be consulted before any fresh route was adopted. It might be that if a trackless trolley system were authorised on a certain route, the Corporation owning it might propose hereafter to lay down rails on the route; they might consider that they would have a sort of right, and it was possible that that route might not be suitable for a tramway, although suitable as an experiment for the trackless trolley. That was one of the points they had in mind. He thought it would be a sufficient safeguard, in the interests of the general public, that an inquiry should be held by the Board of Trade, instead of the Corporation being bound to come up for power for a fresh route.

Mr. HELME, M.P.: If we gave powers, subject to a local inquiry by the Board of Trade, to be confirmed by a provisional order, that would give the right to the public on the one hand, or to the Corporation on the other, to come to Parliament, and if necessary oppose the provisional order, that would relieve the Corporation in future from the greater expense of prosecuting the Bill?—Yes, that may be a way to meet it.

Replying to the Chairman, Mr. JEEVES (for the Corporation) submitted that the necessity of coming to Parliament would not exist in the case of the trackless system, and he was understood to say that he thought they would be prepared to continue the trackless tramway, taking the risk whether they got permission to convert into a tramway later on. He pointed out that there was an intermediate course. It would be possible to provide that an order should be made by the Board of Trade, and to come into operation unless within a specified time objection were taken, in which case it should, ipso facto, become a provisional order, and be subject to provisional order procedure. It would make an appeal to Parliament possible, but not obligatory.

Mr. A. R. FEARNLEY, general manager of Sheffield Corporation tramways, gave evidence in favour of rail-less traction, and said it was intended in their next Bill to come to Parliament for powers. He had recommended the system to the Corporation. He hesitated to say it would be suitable for carrying heavy goods, but he certainly endorsed it for light goods.

Mr. J. M. MCELROY, general manager of Manchester Corporation tramways, regarded the system as a cheap and ready mode of transit which, if powers were granted, could be operated without loss.

Mr. J. B. HAMILTON, general manager of Leeds Corporation tramways, said there had been found in that city the same sort of agitation in outlying places for electric traction in some form, which they had not been able to comply with because of the cost. He was satisfied the rail-less trolley system could be worked at the cost of an ordinary tramway. If the powers asked for were granted, they would be enabled to have this kind of traction in districts where it was altogether impracticable to have it to-day. He had been delighted with the practicability of the scheme, and he was in general agreement with all that had been said by Mr. Spencer.

On Tuesday, Mr. C. J. Spencer submitted a statement dealing with the operations of the parcels department on the tramways. The average amount received per parcel was 3·36d. For the past year there was a net profit of £1,028 on the carrying of parcels, or about 14 per cent. on the turnover. They carried 600,000 parcels, and £50 was included in the balance-sheet for parcels carried over the tramways. The point of view of the Tramways committee was, "What does it cost the tramways department extra to carry these parcels?" That was not quite the same thing as if the committee were dealing with an outside firm who wanted a concession. It was agreed that £50 was an outside figure, but if it were ten times the amount it would not wipe out the profit. £169 was included in the balance-sheet to cover wear and tear of the car by reason of the parcels being put on in addition to the ordinary user. With regard to the allegation that the Corporation carried parcels outside the city boundaries, Mr. Spencer said he found some two years ago that the Corporation did run some goods to Huddersfield, but their practice at present was for goods to districts outside their area to be handed over to the local carriers and to other tramway systems. At least 95 per cent. of the parcels carried went by tram.

Further evidence in opposition to the tramway clauses by the carriers and cab proprietors was then taken, and Mr. Pollock addressed the Committee in support.

Mr. JEEVES, on behalf of the Corporation, said the bill as first submitted provided for powers to deal with trackless trolley and other vehicles in one clause. It was pointed out that such a clause would enable the Corporation not merely to run these trackless trolley vehicles, but also to run self-contained motor vehicles to any part of the city. That was not really the desire of the promoters, and he at once undertook that the clause should be so amended as to make it perfectly clear that the special powers asked for should be limited to trackless trolleys only. All that was now asked was that they should have power to run these vehicles on such routes as the Board of Trade might determine, and then they would merely become part of the tramway system, feeding the main routes from thinly populated districts which could not afford to maintain a more permanent form of track. It was said there was no precedent for this power. It was true no precedent had been carried out, but at Stroud powers were granted to construct trackless trams to a company, a company which found itself unable to raise the money. In that case the routes were defined, but since then the question had been raised before a Parliamentary Committee on the Leeds Corporation Bill, and there the desirability of the principle had been admitted. With regard to motor-omnibuses, in some of the earlier cases routes were prescribed, but in the later cases power had been granted to run these vehicles within a defined area, so that there was nothing so revolutionary in applying the principle to the trackless trams. The power to carry parcels and goods on tramways and trackless trolleys, while new to Bradford, was not new as regarded tramway undertakings as a whole. The powers were merely those which Manchester Corporation had, and Bradford did not ask for any powers which would interfere with what was known as the Manchester judgment.

At the close of the speeches the Chairman intimated that the Committee would reserve their decision on the tramway clauses, as it was a matter of very considerable importance, and especially considering that the point was raised by another bill before the other House.

On Wednesday Mr. NICHOLSON, in giving the committee's decision, said the Committee approved of the principle of the trackless trolley system for experimental purposes on the route described as tramway No. 1. Its extension to other routes should be sanctioned only under the powers of either a private bill or of a provisional order, and the same procedure would apply to any possible conversion from the trackless trolley system to an ordinary tramway. The Committee suggested that the accounts of the trackless trolley system should be kept separate from those of the general tramway undertaking of the Corporation, so that, if future similar applications were made, the Committee could have the financial results of the experiment in Bradford put before them.

RHONDDA URBAN DISTRICT COUNCIL (TRAMWAYS EXTENSIONS, &c.) BILL.

On Tuesday the Local Legislation Committee of the House of Commons, presided over by Sir F. Layland Barrett, considered this bill.

Mr. FREEMAN, K.C., for the promoters, said the Council's tramways were at present leased to and worked by the Rhondda Tramways Co. The lease was for 42 years. A small portion of the system was opened in July, 1908, and the remainder on Nov. 9, 1908. In 1909 8,821,000 passengers were carried, and the gross profit was £22,419. In the present year the results, so far, were even better. It was now proposed to take powers for the construction of three extensions (about 3 miles in all) from Treherbert to Tynewydd, from Ferndale to Maerdy, and from Pen-y-Graig to Williamstown. Under the Council's 1902 bill they would take over the present system at the expiration of the lease at an amount equal to the accumulated annual rent paid, with compound interest at 3½ per cent., but the company would only carry out the extensions now proposed on condition that they were ultimately taken over at their market value as a going concern, and the Council were prepared to agree to that. The estimated cost of the extensions was £35,000. The Taff Vale Co. opposed on the ground of competition, and also as ratepayers on the ground that the lines might not pay, and the South Wales & Monmouthshire Coal Traders' Association opposed on the ground that there was not sufficient protection for the ratepayers. The only portion which would compete with the Railway Co. was that between Treherbert and Tynewydd, but that was sanctioned in the Council's 1902 bill, and it was now proposed that the power with regard to that should be revived. The tramways were rated at about £2,000 a year, and they would have been more beneficial to the district if, owing to opposition to their former bills, they had not been precluded from constructing the tramways themselves. The present population of the district served by the tramways was 138,700.

Mr. ROBT. HAMMOND gave evidence in support of the Bill, and said the estimate of cost of construction appeared reasonable. The company had not allowed for depreciation during the past year, but it was probable that the increase of traffic would in future cover depreciation, and also permit of the payment of rent and dividends.

On Wednesday Mr. LLOYD, K.C. (for the Taff Vale Railway Co.), said it was now proposed that the Council should have the right to acquire the projected extensions at a superimposed cost, although they were already included in the original arrangement that the Council should

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acquire the whole undertaking for £258,000, less 25 per cent. for depreciation. At a Board of Trade inquiry held before the passing of the Council's 1902 Bill, Mr. Pollock, on behalf of the Board of Trade, said the Council could not calculate upon funding the rent received at a higher rate than 3¼ per cent., which would produce £196,000 to cover the £193,875, the value after deducting 25 per cent. Mr. Lloyd went on to say that the 1902 Act intended that the capital should not exceed £258,000, as otherwise the funded rent and interest would not be sufficient to wipe off the capital minus 25 per cent., and that the Council should have the option of buying at tramway price, under sec. 43 of the Tramways Act, and that such price should not exceed the funded rental. There was no case shown for departing from that principle. The company had made 6 per cent. in their first year because of the novelty traffic and the absence of provision for depreciation, but it would be different when they had to face renewals. Much traffic had gone from the Taff Vale Co. to the tramways. He still objected firstly to the construction of the extensions, and secondly to the superimposed bargain with regard to the extensions.

Mr. O. Beasley, general manager of the Taff Vale Railway Co., said his company had spent nearly a million on accommodating the traffic in the Rhondda Valleys. The tramways had carried nearly nine million people, and they had seriously crippled the Taff Vale Railway's passenger traffic. The railway paid 4 per cent., but if the original capital and original shareholders existed it would be 10 per cent.

The Chairman announced that the Committee had unanimously come to the decision to give the powers to make the tramways and to assent to the terms of the agreement between the Council and the Company.

LEGAL INTELLIGENCE.

B. Spencer v. London United Tramways (Ltd.)

In the Divisional Court on Saturday Mr. Justice Phillimore and Mr. Justice Bucknill heard an appeal against judgment and verdict in this action brought by plaintiff for damages for personal injury. At Brentford County Court the jury returned a verdict for plaintiff for £15. Against this the Tramway Co. appealed, on the ground of misdirection and that the verdict was against the weight of evidence.

Mr. Glasgow (for the company) said the complaint of appellant was that the judge was wrong in law in holding that there was evidence of negligence on the part of defendants' servants, and should not have allowed the case to go to the jury. The circumstances disclosed were that while plaintiff was in the act of boarding one of defendants tramcars the car increased its speed and defendant was thrown into the road and injured. At the second trial evidence was given that plaintiff was standing at some little distance from the " stop if required " post, and when the car was a short distance off he, by raising his hand, signalled the driver to stop. The driver slowed down as he was approaching the stopping post, and plaintiff grasped the stanchion bar in the middle of the platform, but the car at that moment increased its speed, and the man was pulled to the ground and dragged about 40 yds. There was no evidence that the driver saw the signal to stop beyond supposition, and he asserted that he did not ; that he slowed down in case anyone should desire to get on or off the car at the " stop if required " post.

Mr. Justice Phillimore said that if the driver slowed down on approaching the stopping post it was an invitation for people to get on, and if he suddenly increased the speed without stopping it would be negligence.

Mr. Justice Bucknill said that if there was evidence that the driver saw the signal the direction of the judge in the Court below was right.

Mr. Justice Phillimore said the practice was for people, as the car slowed down on approaching a stopping point, to get on board. There was a bye-law which said that passengers were not to enter the car while in motion, and the judge had to say whether the passenger's negligence was the cause of the accident, or whether there was something which defendants must do to counteract such negligence. If the driver knew that it was the practice for people to board the car while in motion was he not negligent if, when he saw someone coming, he did not see that the person was on board before he increased the speed again ? Whether he saw the passenger or not, if he had once slowed down in that way, he took the risk if he increased the speed before he reached the stopping place, without being sure that no one was getting on or off. If he did not take that precaution was he not guilty of negligence ?

Mr. Glasgow submitted that he was not. The driver invited the man to get on only when he had stopped the car. In this case he had simply slowed down in case it was necessary to stop. He did not see the man, and unless he did see him he had a perfect right to do what he had done.

Mr. Justice Phillimore, without calling upon the other side, said there was nothing in the judge's summing up of which the applicants could complain. The jury were directed that they could only find for plaintiff if they believed the driver saw him, and that was quite right. If a driver knew that a man was approaching to board a car as it was approaching a stopping place, and begins to slow down the man knew that the driver was responding to his signal, and took the slowing down as an invitation to board. And although it might be that the man was negligent in trying to board before the car stopped the driver was negligent in not completing the process of stopping, and in going on at a faster pace without being convinced either that the passenger was on board or had given up his intention of boarding the car. The jury had been properly directed, and there only remained the question as to the evidence upon which they could find that the driver saw plaintiff. On that the evidence was certainly very slight, but it was enough for the jury, and the appea must be dismissed.

Mr. Justice Bucknill concurred.

The appeal was dismissed, with costs.

Electrical Co. (Ltd.) v. Thomas, Son & Co.

This action was continued before the Official Referee (Mr. Pollock) this week.

Mr. Wales was called for the defence and said that a month would have been a fair and reasonable time to unwater the mine after the installation of the plant. He estimated the amount to which defendants were entitled, in respect of damages, at £27,900.

Rebutting evidence was called by plaintiffs, and Mr. F. B. Johnson, electrical engineer, said he erected the plant for plaintiffs in defendants' mine. The machinery, he declared, was allowed to get into such a dirty condition by defendants' men that it would not work properly, and the generating plant would not produce the required amount of current. The sump of the Allen pump was allowed to get into a very bad state, and the water was very dirty and thick with clots of grass floating in it. Witness mentioned occasions when the pump was not allowed to work in a sufficient depth of water, with the result that it drew air, and it would have to be stopped. If it were allowed to run on it would heat up the pump machinery and bearings.

G.E. Railway Co. v. Leyton Urban Council.

On Tuesday Mr. Justice Phillimore heard a special case stated by the arbitrator in the matter of the G.E. Railway Co. and Leyton Urban Council. The question at issue was whether, on the conversion of tramways from horse to mechanical traction, involving an increase in the weight of the tramcars, the owners of the cars became responsible for any payment in respect of the further repair and strengthening of the structure of bridges over railways rendered necessary by the additional weight and vibration they had to bear in consequence of the increased weight and speed of the tramcars. The particular question was in regard to the Lea Bridge, which the G.E. Co. had been compelled to strengthen and partly to reconstruct on account, as they alleged, of the conversion of Leyton Council's trams from horse to electric traction.

Mr. Eldon Bankes, K.C., for the G.E. Railway Co., argued that under sec. 55 of the Urban Council's Act of 1904 provision was made for remuneration to the company by the Council if the conversion of the trams to electric or any other mechanical traction led to increased vibration and strain on the structure of the bridge.

Mr. C. A. Russell, K.C., for the Council, contended that the facts disclosed did not bring the case within the section cited.

Mr. Justice Phillimore said the section might have been more clearly expressed, but he was of opinion that the construction contended for by the railway company was right. The reconstruction of the bridge was rendered necessary by the increased weight of mechanically-driven cars. It was possible to provide cars of no greater weight than the horse cars, but that would not have been an economical practice, nor in accordance with the custom of this country, which was that mechanically-driven cars, particularly in a district like Leyton, where there was a great number of passengers, should be heavier and give greater accommodation than would be possible with the lighter cars. He therefore gave judgment for the railway company, with costs.

Assessment Appeal.

At the Liverpool County Sessions on Tuesday the Liverpool District Lighting Co. appealed against their assessment in three different townships by the Assessment committee of the West Derby Union.

Mr. Rigby Swift (for respondents) said the appeals were in respect of the company's generating station at Waterloo, whose mains ran through the townships of Waterloo, Crosby and Seaforth, and of " free " wiring in the houses of electricity consumers. At present the whole undertaking was rated at £740 net, and if the contention of appellants was right that the expenditure of £7,510 in respect of the installation of " free " wiring must be regarded as tenants' capital, it had been agreed that the amount must be reduced to £350 net.

Mr. F. A. Greer (for appellants) argued that the outlay on " free " wiring was that of a tenant undertaken for increasing his business, and ought not to be taken into account in estimating the ratable value of hereditament.

Sir William Forwood said that in the opinion of the court some deduction ought to have been allowed in the valuation in respect of the tenants' capital employed in wiring the houses. Having come to that conclusion, they were bound by the agreement that had been made to fix the ratable value at £350. They, therefore, allowed the appeals, with costs. He must, however, say that the figure was not one which the court would have fixed had it been left to them.

On the application of Mr. Swift the bench agreed to state a case for the Higher Court.

J. E. Cutler v. London United Tramways (Ltd.)

On Tuesday, before Mr. Justice Scrutton, plaintiff was awarded £350 damages for personal injuries received whilst riding on the top of one of defendants' cars. Plaintiff said that the car jerked so violently whilst running from the main track on to a loop line at Southall that he was thrown from his seat, and his head striking the seat opposite so seriously injured his left eye that he had to have it removed.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An inspector of telephones is required by the Government of Ceylon for an engagement of three years. Salary £200, and an allowance of R.6 per day to cover cost of subsistence when away from headquarters. Applications to Messrs. Preece & Cardew, 8, Queen Anne's-gate, London, S.W., by 30th inst. See an advertisement.

A leading draughtsman is required by a first-class electrical firm, to take charge of drawing office; must be used to h. and l.-t. switchgear. See advertisement.

A draughtsman is wanted for switchgear design, both h. and l.-t. See advertisement.

There is a vacancy for a premium pupil at Watford electricity works. Applications to the Chief Engineer. See an advertisement.

A man is required to take charge of suction gas electric plant, accumulators, &c., on an estate in Herts. Applications to Estate Offices, Erpingham, Norwich. See advertisement.

The Committee of Visitors of the Essex and Colchester Lunatic Asylums require an engineering clerk of works, under the direction of their architects and consulting engineers, during the installation of electric lighting machinery, mains, wiring, telephones and heating apparatus, &c., at their new Asylum, Mile End, Colchester. Applicants must be capable of taking charge of the installation when completed. Salary as Clerk of Works £4 per week. Application forms from the clerk to the Committee of Visitors (Mr. Walter Payne Gepp), Essex and Colchester Lunatic Asylums, Chelmsford, to whom applications by April 28.

An assistant is required in the engineer-in-chief's department of the Westminster Electric Supply Corpn., to calibrate and keep in order all instruments and telephones in the company's generating stations. Commencing salary £120 per annum. Applications by the 25th inst. to the Engineer-in-Chief, Eccleston-place, London, S.W.

Mr. T. M. Colson, who has been resident engineer at Hamilton since 1902, has been appointed resident engineer at Surbiton. Mr. G. Salter (Leamington) has been appointed to succeed Mr. Colson.

The Executive committee of the National Physical Laboratory have appointed Mr. J. E. Sears, M.A., to take charge of the work of the metrology division of the laboratory in the place of Mr. H. Homan Jeffcott, who has recently been nominated to the professorship of engineering in the Royal College of Science, Dublin. Mr. Sears, who was formerly at St. John's College, Cambridge, graduated with first-class honours in mathematics and engineering, and is an associate member of the Institution of Civil Engineers.

Mr. E. F. Fleet, assistant signalling engineer, N.E. Railway (Southern Division, York) has been appointed signalling superintendent for the Northern Division at Newcastle, vice Mr. J. Simpkins, resigned.

EDUCATIONAL NOTICES.

Summer School Lectures.—Glamorgan Education committee have arranged short summer courses of lectures during August, as follows: (1) Practical surveying course at Penarth; (2) Engineering course; Mining, mechanical and electrical engineering (laboratory work) and practical mathematics; (3) Metallurgy course: Metallurgy, chemistry and practical mathematics; (4) Teachers' course: Geology (lectures and field work), physics and chemistry (this course has been arranged to meet the requirements of teachers engaged in or preparing for technical work at evening schools or technical schools); (5) Evening lectures for colliery firemen on explosives and shot-firing; (6) Evening lectures on electricity in mines. Courses 2, 3, 4, 5 and 6 will be held at University College, Cardiff, the other courses at the County School, Penarth. Certificates will be issued to successful candidates. Particulars and admission forms from 35, Park-place, Cardiff.

Crystal Palace School of Practical Engineering.—The new courses will commence on 27th inst. New students should attend at the school on the previous day for examination. Prospectus from the Registrar, School of Engineering, Crystal Palace, London, S.E.

Argentina.—Mr. Edwd. Richards has obtained a 30 years' concession for a telephone system to extend from Ultima Esperanza (Santa Cruz Province) to the 30th section in the southern zone of Santa Cruz, with a branch to the Gallegos Punta Arenas telephone line.

Ashton-under-Lyne.—An inquiry was held here last week into the application of the Corporation for permission to borrow £48,424 for extension of the electricity undertaking. It was stated that the loan was required owing to the increasing demand for electrical energy for power by local manufacturers, and the Corporation desire to do everything possible to meet all demands.

Association of Municipal Corporations.—The president (Mr. J. S. Harmood-Banner, M.P.) presided at the annual meeting on Wednesday, and in moving the adoption of the annual report, said that one of the features of legislation, not only in 1909, but for several years past, had been the increasing desire on the part of Government departments to obtain more or less absolute control over local authorities. That was one of the greatest dangers threatening municipal life at the present time, and unless it was faced it would go far towards depriving municipalities of that reasonable degree of independence which they had enjoyed in the past.

Mr. HARMOOD-BANNER said that, while they did not object to reasonable control in such matters as the making of new by-laws and the borrowing of money, the action of Government departments was, according to modern practice, going much too far in that they sought to interfere in matters of administration frequently of a comparatively trivial character, which ought to be left to the persons elected for the purpose, and in that they sought to take the initiative and to force local authorities into action against their wishes. If that policy of centralisation was continued one of the results would inevitably be that sooner or later the men most able and suitable to administer local affairs would cease to become members of councils. They did not hear so much now on the subject of municipal trading from their critics. Most reasonable persons had been convinced by the action of municipalities that, in providing such important public services as the supply of water, electricity and gas, tramways, &c., they had met the public requirements both efficiently and economically.

Australasia.—The "Australian Mining and Engineering Review" contains correspondence in reference to the contract, for which the N.S.W. Government recently invited tenders, for the electrical equipment of a small arms factory at Lithgow (N.S.W.), and for which the tender of the N.S.W. State Dockyard department was accepted.

Mr. G. W. Fuller, Minister for Home Affairs, states that seven tenders were received, and the Fitzroy Dock tender was the lowest. Mr. Cutler, manager of the State Dockyard, is reported to have informed a representative of the "Sydney Morning Herald" that practically all the required machines would be made at the Fitzroy engineering establishment.

The Hon. C. G. Wade, Premier of N.S.W., says it was understood that no N.S.W. firms were likely to tender, and that the Fitzroy Dock tender was the lowest.

Mr. E. J. Erskine, representative of Crompton & Co., and president of the N.S.W. Electrical Employers' Association, asks whether it is not a fact that the boilers and the whole of the electrical plant are to be imported, and states that the contractors who tendered would have quoted lower prices if they had been asked to tender as sub-contractors under the Dock authorities.

Messrs. Haes & Eggers state that they have now before them a tender from a reputable firm of English manufacturers, which is in every way formal, was lodged according to the requirements of the Federal Government in England at the correct time, and is several hundred pounds below that of the Fitzroy Dock tender.

Geelong Council has sealed the agreement with the Melbourne Electric Supply Co. for the construction of electric tramways by the company.

Gisborne, Wairoa, Hastings and Napier (N.Z.) Councils recently appointed a joint committee to report on the question of establishing a joint hydro-electric station at Waikaremoana.

Mr. Forbes-Mackay, Sydney City electrical engineer, reports that the year's income was £118,275 and the net profit £17,898. Mr. Forbes-Mackay recommends the abolition of all meter and demand indicator rents.

The price of 6¾d. quoted by Messrs. Drew & Poole for the supply of 100,000 porcelain insulators of Australian manufacture to the Commonwealth Postmaster-General is stated to be 15 per cent. above the average price paid for imported insulators during the past two years. The material will be Australian, and Messrs. Drew & Poole are about to establish a factory for making insulators.

Barking.—During the year ended March 31 the electricity supply department generated 1,622,485 units, increase 38,772; and 1,374,960 units were sold, increase 37,616. The units used for traction were 293,712, decrease 35,198.

On the light railways the passengers carried numbered 1,292,146, against 1,280,420. Receipts amounted to £3,099, against £3,130. The working expenses have been reduced by about £130, and electricity cost £250 less.

Barnes.—The electrical engineer (Mr. C. S. Davidson) is to invite prices for the supply of 1 mile of distributing cable. The Council have instructed Mr. Davidson to visit the Glasgow electricity works with a view of obtaining information for improving the Barnes electricity undertaking.

Belfast.—The revenue of the tramways department for the year ended 31st March was £203,874, an increase of £8,831; working expenses were £107,574, a decrease of £1,306. The working profit was over £96,000, and the next profit £46,056. The manager (Mr. A. Nance) recommends that this be applied to sinking, depreciation and

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reserve funds, and to paying off the cost of the Act of 1904, and the debit balance of the net revenue account.

Bethnal Green (London).—The Electricity committee have had again under consideration the question of electricity supply in the borough.

Every authorised undertaker was communicated with, and the Councils of Shoreditch, Hackney, Poplar and Stepney were again invited to submit fresh offers. No company has made any proposal; Poplar and Hackney adhered to their previous offers, and Stepney and Shoreditch Councils made slight modifications in their previous offers. The committee are of opinion that the Council should enter into a contract with Shoreditch for seven years upon the basis of their alternative flat rate scheme.

Birmingham.—The Tramways committee recommend the City Council to extend the tramways system to Harborne and Quinton.

The new station of the G.W. Railway will be electrically lighted throughout.

Bootle.—The Council have decided to adopt electricity for pumping at the waterworks.

Canada.—H.M. Trade Commissioner for Canada (Mr. R. Grigg) states that the Master Builders' Association of Montreal established a permanent exhibition of building materials in that city last year. There are sections for electric light fittings, bells, &c., and for artistic metal work, and it is suggested that this might afford an opportunity for British manufacturers to exhibit their goods and catalogues. Communications to H.M. Trade Commissioner, 120, Board of Trade Building, Montreal, or the Secretary, Department of Permanent Exhibits, Builders' Exchange, Montreal.

Canadian Cable Rates.—It is reported that the Canadian Senate has sent Mr. Lemieux's bill, placing the control of submarine cable rates in the hands of the State, to the Railway Committee. This will ensure the cable companies being in a position to present their case against the threatened interference with their business.

Colchester.—The borough electrical engineer (Mr. A. R. Sillar) has tendered his resignation, and the chief assistant engineer (Mr. Wm. Frisby) has been instructed to undertake control of the department until a fresh appointment is made, and Mr. Frisby and the second assistant (Mr. Buzza) are to act jointly in the working of the station.

Croydon.—The Council have decided to dispose of two dry back marine boilers (now out of use), and to instal two new water tubes boilers, at an estimated cost of £4,500.

Darlington.—The electrical engineer and manager Mr. J. R. P. Lunn has reported to the Electricity committee that it will be necessary to provide additional condensing plant at the electricity works.

Devonport.—The Council have applied for sanction to a loan of £7, 061 for extending the electricity mains in the Pennycomequick district.

A number of the electrical staff have been granted increased salaries and wages, including Mr. W. F. Stamp, assistant electrical engineer, whose salary has been increased to £180.

Dunfermline.—The Queen Anne United Free Church is to be wired.

Electric Carriages in Hyde Park.—Licences and badges will be issued by the Commissioners of Works and Public Buildings for the admission of electric carriages to Hyde Park between 4 p.m. and 7 p.m. in the months of May, June and July.

Electric Plant for Oil Cleaning.—At the meeting of the Pacific Oilfields (Ltd.) on Friday, the chairman (Mr. A. B. Williamson) said that

Under a contract the company had been delivering oil from one of their properties to buyers who had laid their pipe-line to their tanks. These buyers had at first expressed entire satisfaction in regard to its quality and freedom from impurities, but later objection was taken on the score of an excessive percentage of water in the oil. Finally, it was intimated that they could not accept further deliveries in that condition. The presence of water in microscopic globules was suddenly discovered in their oils and in other wells in the neighbourhood, and it was possible it might as suddenly disappear. Local experts apparently believed that it had been forced into the oil by gas and other pressures and that it was not the result of ineffective shutting off of water in the wells. Their buyers, however, had signified their willingness to accept again if they could reduce the water to a moderate percentage. Unable to do anything in that regard at short notice, and their tanks soon being filled with oil which they could not deliver, the management had to shut down the wells just as the fourth well was completed, so it had not been pumped yet. Under those circumstances, it was decided to instal an electrical cleaning plant. Their agents and field manager had made careful investigation and had seen the proposed plant in satisfactory operation in other fields, where it had met with entire success in clearing the oil of that form of water. The water was found in such microscopic globules that it would not collect and free itself by the usual gravitation process. The electrical plant was now being constructed, and it was expected to be completed in April current. It would serve other useful purposes, such as lighting the camp, supplying power for drilling the wells, and operating a lathe and pipe threader, which would always be an economy of time and money.

Exhibition.—The Brussels International Exhibition will be opened to-morrow (Saturday).

Fatality.—On Wednesday Harry Calladine was killed while working an electric coal-cutting machine at South Wingfield Colliery, Alfreton.

Felixstowe.—An inquiry was held on Tuesday into the application of the Council for permission to borrow £4,500 for additional plant for the electricity works.

Fire.—A fire in the electrical engineering works of Mr. Edwd. Dewhurst, at Preston, occurred last week, and although it was quickly subdued, the damage is estimated at about £400. The fire began with the ignition of wood by an emery wheel.

Gillingham.—At the inquiry held last week into the Council's application for sanction to borrow £3,000 for a Diesel oil-driven set, &c., the inspector (Mr. H. Ross Hooper) pointed out that separate ledger accounts must be kept for each loan. He must have the accounts put in order from March, 1908, and, therefore, the inquiry was adjourned.

Grimsby.—The borough electrical engineer (Mr. W. A. Vignoles) reported to the Lighting committee on Monday that during the past quarter there had been an increased consumption of 86,492 units of electric current compared with the previous quarter.

Mr. Vignoles submitted a scheme for stimulating the use of arc lamps by tradesmen. He stated that the initial cost and short life of arc lamps deterred many traders who would like this system of exterior lighting from embarking upon it, and he suggested that the committee should supply arc lamps on the hire purchase system, or by simple rental. The committee decided to adopt the scheme.

Hammersmith (London).—The existing 100 c.p. lamps in Woodlane are to be replaced by 200 c.p. lamps.

Holborn (London).—The Metropolitan Electric Supply Co. has reduced the charge for electric energy in connection with the lift and fans at the Council's offices from 3d. to 2d. per unit. The concession is to date from Jan. 1 last and is also to apply to power used in the stone yard.

Hornsey (London).—There are over 1,720 consumers of the electricity department and the equivalent of over 91,000 30-watt lamps is connected to the mains.

India.—It is stated that the Calcutta Electric Supply Corpn. intend to transmit current at 6,000 volts pressure from their Ultadanga station in the north of Calcutta to the riverside warehouses and presses.

The report of the Irrigation Branch of the Punjab Public Works Department for 1908-9 states that a new machine shop 200 ft. by 80 ft. is under construction at the Upper Bari Doab Canal Central workshops, that the whole of the machinery therein will be driven electrically, a 10 ton electric travelling crane will span the central bay, and that a new power house has been erected.

Inquest.—An inquest was held on Saturday into the death of Llewellyn Evans, electrical engineer, which occurred at the Birmingham Tame and Rea District Drainage Board's sewage disposal works, Bromford, on 13th inst.

Dr. F. W. CLARK, who was called to the works immediately after the accident, said he found the mark of a burn on the toe of the left foot and a corresponding mark on the left boot. He was informed that Evans had received an electric shock, and he ascribed death to the shock, which had arrested the heart's action.

LOUIS MOUNTFORT, electrical engineer in the service of the Drainage Board, said Evans had been employed at the Bromford works as chief operating electrical engineer for 2½ years. On April 13 he and two other electricians were testing a newly-installed motor. At the time of the accident the machinery had been under test at full load for six hours. One of the principal objects of the test was the fixing of a measuring instrument to gauge the quantity of current, and it was on this work chiefly that Evans was engaged. Evans expressed the opinion that the voltage (6,000) being employed would damage the instrument. A consultation on that point was held, and resulted in a determination to allow the current to pass through the instrument. Evans left his (witness's) sight at that point, and a moment later he heard an exclamation, and Evans was found lying unconscious near the instrument. Artificial respiration was tried, but without avail. He conjectured that Evans went to make the alteration in the current he and his colleagues had decided upon, and, forgetting that the current was on, touched the live wire.

The CORONER: Did you know that the switches were not disconnected and that the current was on?—Yes. And Evans knew a few minutes before. His going to the instrument instead of to the switch indicated that he must have forgotten the main switches were closed. He was wearing a rubber glove, but that would be no protection against 6,000 volts. No one actually saw Evans killed, because he went behind the switchboard, apparently to the instrument. I consider that momentarily he forgot the switches had been put in, and that he went straight back to his instrument without seeing whether they were in or out.

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There is no suggestion that any part of the machinery was out of order?—Not in the least. Nor was there any neglect to provide protective appliances to make everything safe.

Replying to a question, witness agreed that an insulated floor might produce a false sense of security. It is better that a man should realise fully the danger of approaching a live wire carrying 6,000 volts, and there should be no degree of safety in the presence of it.

Mr. H. Kemp (Mr. Evans's assistant) and Mr. H. W. Fisher, engineer in the employ of Messrs. Crompton & Co. (who supplied the motor) agreed with Mr. Mountfort.

The jury returned a verdict of accidental death.

Japan-British Exhibition.—The President (the Duke of Norfolk) asks us to impress upon all participating in the British section of this Exhibition the necessity of taking advantage of the facilities afforded by the administration in order to have their exhibits completely installed in ample time before the opening early in May. The Japanese have already made great progress.

The Prince of Wales has consented to perform the opening ceremony.

Leeds.—At the meeting of the Tramways and Electricity committee on Monday it was reported that during the year ended March 31 there had been an increased revenue. A surplus of £46,000 had been estimated, but this had been exceeded by about £9,000. There will be about £55,000 for relief of rates after paying £18,528 for rates and taxes, &c.

The general manager of the city tramways (Mr. J. B. Hamilton) reported that the past year had been more prosperous than anticipated, and the amount of the profit was £55,000.

Litherland (Lancs.)—The electric lighting order has been extended for a year.

London County Council.—On Tuesday sanction was given to Stepney Council to borrow £7,150 and £33,500 for the electricity supply.

Special Car.—The Highways committee reported having constructed by direct labour the body of a specimen electric tramcar of special pattern for use on steep gradients. The Board of Trade had now agreed to the use on the Highate-hill tramways of double-deck cars with or without roof covers, when fitted with a special slot-brake. They had arranged for a roof cover to be fitted on the special car and also for certain modifications to be made to the underframe of the car in connection with the braking arrangements.

Purchase of Electric Lighting Undertakings.—The Highways committee stated that they reported in October, 1909, with reference to agreements proposed to be entered into, under the London Electric Supply Act, 1908, between the London Electric Supply Corpn. and the St. James' & Pall Mall Electric Light Co., and between the London Electric Supply and the Westminster Electric Supply Corpns., and the Council decided to ask the Board of Trade, in the event of their deciding to approve the agreements, to arrange for the following amendments to be made: (i.) The insertion of a clause to provide for the termination of the agreements in 1915, unless in the meantime legislation shall be passed constituting the Council the purchasing authority of the undertakings of the Westminster Electric Supply Corpn. and the St. James' & Pall Mall Electric Light Co. (ii.) The insertion of such a clause as may be considered necessary to ensure that the interests of the consumers in the areas affected by the agreements shall be fully safeguarded.

The Board of Trade have now forwarded the draft of the agreement proposed to be entered into between the London Electric Supply and the Westminster Electric Supply Corpns., amended with a view to meeting certain of the points raised by the Council, but with reference to the Council's suggestion that the agreement should be terminated in 1915 the Board stated that it was not prepared to introduce such a clause, because it would destroy the whole basis of the agreement, and it was further pointed out that the Board had introduced a bill into Parliament in the present session for transferring the power of purchase to the Council. The agreement dealt with one undertaking (the London Electric Supply Corpn.) which was purchasable under the 1908 Act, while the undertaking of the Westminster Electric Supply Corpn. was not yet purchasable. The assurance of the Board as to the introduction of legislation did not, the committee thought, quite meet the Council's views, and the committee are of opinion that the Council should press for the insertion in the agreement of the provision desired.—It was agreed to communicate to the Board of Trade in the terms of the report.

Manchester.—On Tuesday the Tramways committee approved the estimates for the current year, and provision is made for the payment of £60,000 in relief of rates, against £75,000 last year. The decrease is due to the fact that the committee have to meet additional expenses, including payment of half-wages to sick workmen, higher rates, &c.

The Electricity committee have had before them the accounts for the year ended March 31. The net surplus is £35,220, of which £12,000 had already been paid over in aid of rates, and the balance of £23,220 was now placed to renewals account. It was reported that the sales had exceeded all previous records, notwithstanding the fact that there had been a reduction of more than 1,000,000 units in the consumption for traction. On electric lighting there was only an increase of about 500,000 units, but the power and heating sales showed an increase of 5,000,000 units.

Marylebone (London).—The Electricity committee, in submitting the annual estimates, report that as far as can at present be ascertained, the total sales to private consumers for the year ended March 31 last will amount to 10,316,000 units (an increase of 16 per cent.) and the average price to 3·63d. (a decrease of 9 per cent.).

For the current year the increase in units has been put at half last year's increase (8 per cent.), and there will probably be a further diminution of prices to the extent of 0·28d. per unit, or 8 per cent. This gives an estimated increase of 825,000 units, compared with nearly 1,500,000. A substantial increase has taken place in public lighting owing to the three schemes for converting to electricity the whole of the gas lamps in the borough. It is calculated that the increased units for street lighting will amount to 440,000. In estimating cost of generation, distribution, management, &c., the balance costs for the half-year to December have been taken as a basis and it has been assumed that all additional sales during the year will not exceed a total cost of 0·5d. per unit. The general manager (Mr. A. Hugh Seabrook) is of opinion that the sales department will pay its way after debiting all expenditure properly chargeable against it. After reducing the capital liabilities by £37,915 the committee estimate that there will be a surplus on the year's working of £8,602.

Mold.—The Lighting committee are to consider an electric lighting scheme submitted by a Leeds firm.

New Malden and Coombe.—The Council have informed Kingston Corporation that they are prepared to consider proposals with reference to the supply of electricity to residents in Coombe.

Obituary.—We regret to record the death of Mr. Augustin Gifford Palgrave, M.A., electrical engineer (son of the late Sir Reginald Palgrave, K.C.B., for many years clerk to the House of Commons). Mr. Palgrave (who was under 40 years of age) was born within the precincts of the Houses of Parliament and educated at Marlborough and at Merton College, Oxford. Deceased, who leaves a widow and two children, resided at Withington, Manchester, until recently, when he moved to Newcastle-under-Lyme.

We regret also to record the death of Sir Samuel Black who was town clerk of Belfast for over 30 years. During his tenure of office Belfast Corporation established electricity works, municipalised the tramways, and carried out many other extensive improvements.

Oswaldtwistle.—The Council have resolved to apply for an electric lighting order.

Penzance.—The Council have instructed the Electric Lighting committee to report upon a communication received from Mr. W. T. Pressland who is acting for the Cornwall Electric Power Co., and has offered to take a transfer of the Penzance Electric Lighting Order.

Presentations.—Fleetwood electricity staff have presented a smokers' cabinet to Mr. W. Smith, who is leaving for Liverpool.

Mr. T. M. Colson, resident electrical engineer at Hamilton, has been presented by officials of the Hamilton Corporation with an inlaid Sheraton clock, and an aneroid barometer, on his leaving to take up a similar position at Surbiton.

Saltwood (Kent).—Elham (Kent) Rural Council have consented to electric current being supplied to consumers at Saltwood by the Folkestone Electricity Supply Co.

Shoreditch (London).—Mains extensions are to be made at a cost of £497, and £400 is to be spent in providing a further stock of meters and indicators.

Smoke Nuisance.—Before the Oldham magistrates on Wednesday the Electricity Department were summoned by the Health Department of Oldham Corporation for alleged nuisance by allowing black smoke to issue on two occasions from the local electricity works.

It was stated that experiments were being carried out with a view to doing away with the nuisance. This was expected to cost about £2,500. A fine of £1 and costs was inflicted in each case.

Southampton.—The tramways manager has been authorised to purchase controller regulators at a cost of £137. 10s., so as to make it impossible for a motorman to rush his car at starting.

Stepney (London).—In connection with experiments to reduce the smoke emitted from the chimney at the Whitechapel generating station, arrangements were made some time ago with the Crosthwaite Fire Bar Synd. to fix on trial for three months the Crosthwaite furnace to one of the hand-fired boilers. The engineer and manager (Mr. W. C. P. Tapper) now reports that the result of the experiment has been quite satisfactory, and the apparatus is to be purchased at £145.

Street Boxes and District Surveyors' Fees.—Southwark (London) Council having recently raised the question of district surveyors' fees, and Islington has written expressing the opinion that the exemption of street boxes from the operation of the London Building Act should be brought under the notice of the L.C.C.

Whitehaven.—The Board of Trade are to be asked to grant an order to supply electricity in the parish of Hensingham.

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Wireless Telegraph Notes.—Marconi's Wireless Telegraph Co. announce that their trans-Atlantic service between Europe and America will be re-opened to-morrow (Saturday), and that from that date the company will maintain a 24-hour telegraphic service for commercial and other purposes. The company's offices are Watergate House, York-buildings, Adelphi, London, W.C.

The expert committee appointed to consider the tenders received for the erection of high power wireless telegraph stations at Sydney and Fremantle have reported to the Commonwealth Postmaster-General (Sir John Quick), who has decided that the tenders (with one exception) have complied with all the requirements of the specification. The successful tenderers have to erect the plant on sites in or near Fremantle or Sydney to be determined by the Government, and have also to provide supervision in working the plants for three months after erection, and the maintenance of the works for 12 months in working order. The Advisory Board recommend the acceptance of the lowest tender, subject to certain conditions, and Sir John Quick has adopted this advice, conditioning that there shall be some undertaking as to the nature of the labour to be employed during the probationary period of supervision and maintenance.

An Institute of Wireless Telegraphy is reported to have been formed in Sydney, N.S.W., with a view to facilitating conferences between investigators and inventors, and protecting legitimate experimenters.

A report from Eureka, California, states that the North Pacific Co.'s steamer "Santa Clara" sank four miles from that place on April 12. A wireless message brought a tug which rescued the whole of the 95 souls on board the steamer, which ultimately went down.

Yarmouth.—Application is to be made for sanction to borrow £500 for h.t. and £3,000 for l.t. mains.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

NEWPORT (Mon.) Electricity committee invite tenders for supply and erection of a 1,000 kw. double-current turbo-generator or, alternatively, a 1,000 kw. or 1,500 kw. turbo-alternator, together with surface condenser. Specifications, general conditions and forms of tender from the borough electrical engineer and tramways manager (Mr. H. Collings Bishop). Tenders, addressed to the Town Clerk, by first post, Monday, May 2. See also an advertisement.

LEEDS City Council invite tenders for supply of 5¼ miles of 0.15 sq. in. three-core cable, suitable for working pressure of 6,600 volts. Tenders to the town clerk (Mr. Robt. E. Fox), by 10 a.m. Monday, May 9. Specifications and conditions from the manager of the electric lighting department (Mr. H. Dickinson), 1, Whitehall-road, Leeds. See also an advertisement.

Tenders are invited up to June 1, for the supply of eight sections of common battery switchboard to the Postmaster-General's Department, NEW SOUTH WALES. Tender forms, specifications, and general conditions may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W. See also advertisement.

Tenders are invited up to June 8 for the supply of protectors, switchboards (small) and common battery telephones to the Postmaster-General's Department, QUEENSLAND. Tender forms, specifications and general conditions may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W. See also advertisement.

Tenders are invited (up to May 17) for supply to the Postmaster-General's Department, VICTORIA, of 50 coin attachments. Tender forms and specifications from the High Commissioner's Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are required by June 8, 1910, for the supply of six sections of common battery switchboard and equipment jumper wire and cable to the Postmaster-General's department in QUEENSLAND. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W.

Tenders are invited, up to May 18, for the supply of paper insulated lead-covered and brass ribbon taped cable to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

The Deputy Postmaster-General, MELBOURNE, will receive tenders until 3 p.m. May 17 for supply of 1,010 reinforced concrete telegraph poles, preferably of Australian cement. Local representation necessary. Specification from Commonwealth office, London.

LITTLEBOROUGH Urban District Council invite tenders for the supply and laying of h.t. feeder cables, l.t. distributors, roadwork, &c., for private lighting, and transformer kiosk, with transformers and equipment and switchgear in substation. Copies of specification, forms of tender, &c., may be obtained from the clerk to the Council, Mr. Geo. H. Wild. The works are to be carried out in accordance with plans and specifications, which may be seen at, but not obtained from, the offices of the consulting engineers, Messrs. Hawtayne & Zeden, 9, Queen-street-place, London, E.C., from whom further information can be obtained. Tenders to the Clerk to the Council, Council Offices, Littleborough, near Manchester, by May 2.

WHITWOOD Urban Council invite tenders for copper cables, steel and wooden poles, supports, arms, insulators, &c., watertight street light fittings, meters, switchboard, instruments, &c. Specifications from Mr. H. Marsden, Electricity Works, Honley, and tenders to Mr. V. Hulme, County Chambers, Castleford, Yorks., by April 28.

WEST BROMWICH Electricity committee invite tenders for supply, delivery and erection of a 750 kw. d.-c. turbo-generator and surface condenser. Specification, general conditions, forms of tender, &c., from the borough electrical engineer (Mr. W. A. Jackson), Electricity Works, West Bromwich. Tenders to the Chairman of the Electricity committee, Town Hall, West Bromwich, by May 2.

The SECRETARY OF STATE FOR WAR invites tenders for the supply of two plants for the production of hydrogen and oxygen by the electrolysis of water at the Balloon Factory, South Farnborough, Hants. Forms of tender from the Director of Army Contracts, War Office, Whitehall, London, S.W., where tenders are to be delivered by noon of May 4.

HESTON and ISLEWORTH Council want tenders by noon May 11 for extension of engine room, and for supply of 250 kw. generating set (high-speed engine direct coupled to c.c. 500-600 volt generator), piping, ejector condenser, machine tools, &c. Specifications, &c., from the Engineer, Electricity Works, Bridge-road, Hounslow.

LAUNCESTON (Tasmania) Council want tenders by 4 p.m. June 13 for overhead electric equipment for tramways, and by 4 p.m. June 27 for synchronous motor-generators, &c., and battery, reversible booster, &c. Specifications, &c., from the Town Clerk.

BRISTOL Docks committee want tenders by noon April 30 for one year's supply of stores, including arc lamp carbons, incandescent electric lamps, metals, oils, &c. Forms of tender from the Engineer, Cumberland Basin, Bristol.

IPSWICH electric supply department want tenders by April 27 for supply of about ¾ mile 0·3 sq. in. concentric feeder and about the same quantity of multicore cable. Specifications, &c., from the Borough Electrical Engineer.

LONDON County Council want tenders by 11 a.m. May 3 for roadwork and platelaying required for reconstruction on the conduit system of tramways in Bermondsey and Deptford. Specifications, &c., from the Chief Engineer.

LONDON County Council require tenders by 11 a.m. May 3 for supply of 4,800 steel tyres for driving wheels, and 1,600 for pony wheels of tramcars. Forms from 62, Finsbury-pavement, E.C.

LONDON County Council also require tenders by 11 a.m. May 4 for the electric lighting of Fairclough-street and Amberley-road schools. Specifications, &c., from the Chief Engineer, Spring Gardens, S.W.

Tenders are wanted for the electric lighting of St. John's Church, ROUGHTOWN, near Manchester. Tenders to the Vicar and Churchwardens, Roughtown Vicarage, Mossley, by May 2.

SHIPLEY Council want tenders by 10 a.m. May 3 for supply of steel girder tram rails and fish plates. Specifications, &c., from Mr. W. H. Dawson, Shipley.

HENDON Council want tenders by 5 p.m. April 25 for the electric lighting of the Council Offices, The Burroughs, Hendon. Specification may be seen at the Council Offices.

The Consejo de Administracion del Puerto de MONTEVIDEO (Uruguay) require tenders by 3 p.m. July 4 for supply of 20 electric cranes.

VASLUI (Roumania) Municipality require tenders by May 25 for erection and equipment of electricity works.

The Turkish Ministry of Commerce and Public Works require tenders by May 28 for a concession for electricity supply works at CONSTANTINOPLE. Deposit of £9,000 required with tender. Local representation necessary. Specification (in French) may be seen at 73, Basinghall-street, London, E.C.

ANTWERP Council want tenders by May 9 for supply of electrical appliances for the town workshops at the new North Docks. Conditions, &c. (price 5d.) from the Hotel de Ville.

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The SPANISH GOVERNMENT require tenders by Nov. 7 next for construction of a single-track electric or steam strategic railway from Badajoz to San Vicente de Alcantara, and, by Feb. 6, 1911, for a similar line from Badajoz to Fregenal. The contracts are open to Spanish firms only, but material may have to be purchased from abroad.

SALAMANCA (Spain) Municipal Council want tenders by 1 p.m. May 13 for the provision of electricity supply works. Local representation is necessary.

TENDERS RECEIVED AND ACCEPTED.

Blackburn Council have accepted the following tenders :—

L. Andrews & Co., armature insulating varnish; Boardman Bros., cotton waste; Baxter & Caunter, screwed tubes for inside wiring; P. W. Blackwell & Co., P. and B. insulating tape; British Insulated & Helsby Cables, house service fuse boxes; British Westinghouse Co., linen tape, shellac, motor starting switches; Burrows & Garland, metallic joint-rings and ironware; Cresswell's Asbestos Co., packing, asbestos sheet, asbestos millboard and abestos string; Eckstein, Heap & Co., ceiling roses, switches (10 amperes); Jas. Ferguson, machine screws; General Electric Co., ebonite sheet and rod; W. T. Glover & Co., diatrine tape; W. T. Henley's Telegraph Works Co., waterproof tape; India Rubber, Gutta Percha & Telegraph Works Co., indiarubber solution, self-adhesive compound tape; John Lang, iron castings, fire-bars, pipes, &c.; Mercer Bros., fish-glue, nails, hammers, &c.; Micanite & Insulators Co., micanite plate; Siemens Bros. & Co., ozokerit tape, non-hygroscopic tape, porcelain fuses, &c.; Spicer Bros. (Ltd.), red fibre sheet and press-spahn sheet; Wm. Stones & Sons, teak boards, baywood and pine; J. H. Tucker & Co., tumbler switches and lampholders; Watlington & Co., P. & B. insulating paint; Booth & Openshaw, resin, wax, paints, asbestos paint, turpentine, &c.; and Vacuum Oil Co., oils.

The following tenders have been accepted by London County Council :—

Hurst, Nelson & Co. (lowest tender), for brass fittings for tramcars, £186. 11s. 11d. (nine tenders received, highest £305. 17s. 7d. Chief officer's estimate, £230.)

Hurst, Nelson & Co. (lowest tender), for 90 sets of operating gear for car windows, £668. 7s. 6d. £7. 12s. 6d. per set for bogie cars and £6 per set for single-truck cars. (Eight tenders; highest £28. 10s and £23. 10s. per set. Chief officer's estimate, £1,125.)

Wm. McGeoch & Co. (lowest tender), for 545 roof light fittings for 90 cars, 5s. 5d. each, less 2½ per cent. (nine tenders; highest 9s. 7d. Chief officer's estimate £150.)

Deptford Engineering Co. (lowest), for six conduit cleaning trucks, £152. 9s. (Six tenders; highest £357. 7s. 7d. Chief officer's estimate £250.)

J. G. Ingram & Son (lowest), for 500 moulded rubber plough bases and 916 plough leads, 37s. 6d. each for bases and 3s. 3d. each for leads. (Four tenders; highest for bases £4. 15s. each and for leads 11s. 2d. each. Chief officer's estimate, £1,280.)

The following tenders have been accepted by Southampton Council in connection with the tramways :—

John Douglas, construction of tramways from Clock Tower and Northam Toll Bridge, £2,816. 11s. 8d.; ; Walter Scott (Ltd.), 400 tons tramway rails, £7 per ton; Imeson, Finch & Co., 130 steel poles, £3. 19s. 9d. each and 130 c.-i. pole bases and 150 finials, £111. 17s. 6d.; Edgar Allen & Co., 10 pairs points, £34 per pair, 10 sets crossings, £13 each, and 10 tons rails for curves, £43 per ton.

The tender of the British Thomson-Houston Co. has been accepted by Southampton Council for annual supply of lamps at £60; and the tenders of the following for annual supplies of stores have also been accepted: Lankester & Son, Cammel, Laird & Co., McWhirter, Roberts & Co., Armstrong, Stevens & Son, Wm. Dibben, Flack, Ellis & Co., Summers & Payne, Shalders & Davis, Jas. Freemantle & Son, and A. Duckham & Co.

Marylebone (London) Council have accepted the following tenders:

W. T. Henley's Telegraph Works Co., rubber tubing; Pryke & Palmer, Chatterton compound, Para rubber strip, fire resisting tape, &c.; Siemens Bros. & Co., black adhesive tape, rubber gloves and plain rubber mats; Pooley & Austin, white silesian tape; Anti-Attrition Metal Co., gun-metal, copper and brass; H. W. Gilbart, casing and capping, match-lining and creosoted troughing; General Electric Co., capping; C. Jennings & Co., casing and capping, meter boards and battens; Howard Bros. & Co., match-lining and American white wood.

Hammersmith (London) Council have accepted the following tenders for annual supplies: Sloan Electrical Co., Conradty carbons, H. G. Mayer & Co., Stella, (enclosed type) carbons; Edison & Swan, electrical goods (£36. 7s. 5d.); Hobdell, Way & Co., boiler covering, &c. (£66. 6s.); Bruce Peebles & Co., brushgear for two 400 kw. motor generators (£21. 12s. for two sets).

Gravesend Council have accepted the following tenders:

Chloride Electrical Storage Co., overhauling and repairing traction storage battery, £374. 14s.; British Thomson-Houston Co., lamp stores; Sutton & Co., cable troughing; Bastian Meter Co., Electrical Co., Ferranti (Ltd.), and British Thomson-Houston Co., meters.

Stalybridge, Mossley, Hyde and Dukinfield Tramways and Electricity Board have accepted the tender of Ed. Bennis & Co. for two mechanical stokers, and that of Graham, Morton & Co. for a coal conveyor and bunkers.

Grimsby Corporation have accepted the tender of the Jandus Arc Lamp Co. for supply of 80 flame arc lamps with line switches and resistances for £662. The lowest tender submitted was £307, the highest £789.

Chichester Council have accepted the tender of the local electric lighting company for lighting the city for five years at £3. 5s. per lamp per annum. Gas lighting has been displaced.

Whitehaven Council have accepted the tender of Babcock & Wilcox for a boiler and that of the Phœnix Dynamo Mfg. Co. for a 2 H.P. motor for driving the mechanical stokers.

Bootle Council have accepted the tender of the Northern Electric Co. for wiring the girls' secondary school at £89. 10s.

Southwark Council has accepted the tender of the Electrical Co. for a 10 H.P. motor at £36. 8s. 2d.

Barking Council have accepted the tender of the Union Cable Co. for cable at £47. 8s.

Lowestoft Council have accepted the tender of W. G. Murrin for "free" wiring up to a total of 200 lamps at 8s. 8d. per point.

Aberdare Council have accepted the tender of D. T. Davies for the erection of electricity station buildings at £562.

"Lea" Recorders.—The "Lea" Recorder Co., 28, Deansgate, Manchester, have recently received a number of orders for "Lea" recorders (for home use and export), including the following amongst many others :—

Glasgow Corporation Electricity Works, Stockport Corporation Sewage Works, Brighton Corporation Electricity Works, General Post Office, London (three sets), J. G. White & Co., Cardiff Corporation Electricity Works, Ryde pumping station (Australia), London Hydraulic Power Co., Halifax Corporation Electricity Works, Adelaide (Australia) Municipal Tramways, West Bromwich Corporation Electricity Works, Broken Hill South Silver Mines, Australia, Sydney (Australia) City Council, Cheltenham Sewage Works, Cheltenham, E. Hulton & Co., Manchester, Electricité de Paris, &c.

Government Contracts.—The following tenders have been accepted by Government Departments :—

War Office :—Barton & Sons, Credenda Conduits Co., General Electric Co., Nettlefold & Sons and Perfecta Seamless Steel Tube & Conduit Co., conduit fittings; Lancashire Dynamo & Motor Co., motors; Electric Construction Co., motor-generators and switchgear. *India Office* :—Bullers (Ltd.), insulators; Siemens Bros. & Co., manganese blocks. *General Post Office* :—Western Electric Co., indiarubber and cotton core cable; Johnson & Phillips, Western Electric Co. and British Insulated & Helsby Cables, paper core cable; India Rubber, Gutta Percha & Telegraph Works Co., submarine cable; Western Electric Co., loading coils; British Insulated & Helsby Cables, flexible cords and copper wire; T. Bolton & Sons, Elliott's Metal Co., R. Johnson & Nephew, Shropshire Iron Co., F. Smith & Co., and Wilkes, Son & Mapplebeck, copper wire; Stanley Bros., earthenware ducts; Colley's Patents (Ltd.) and Waterlow & Sons, telegraph paper; British L. M. Ericsson Mfg. Co., telephones; A. & P. Stevens, four electric lifts at Newcastle-on-Tyne, Western Electric Co., local telephone exchange equipment installation at Kirkintilloch.

Commonwealth Tenders.—The Australian Postmaster-General has accepted the following :—

The tender of Drew & Poole for 100,000 porcelain insulators of Australian manufacture at 6¾d. each; Davies, Shephard & Co., for fuses, plugs, terminals, glass cells, porous pots, sal ammoniac and Leclanché zincs; Standard Cable Mfg. Co. for wire; and Scheele & Gibbes for glass cells, sal ammoniac and Leclanché porous pots and zincs.

The following tenders have also been accepted by the Postmaster-General's department :—

Victoria.—J. Bartram & Son, g.-i. wire; R. Johnson, Clapham & Morris, g.-i. and h.-d. copper wire; British & Foreign Indent Co., 5,500 porcelain insulators.

N.S.W.—W. T. Henley's Telegraph Works Co. for submarine telephone cable; Jones Bros., coal; Jas. Paton & Co., table magnets, telephone sets and protectors; Lawrence & Hanson, common battery wall telephones; British Insulated & Helsby Cables, common battery table telephones.

Queensland.—Jas. Paton & Co., plugs; Western Electric Co., lamp signalling switchboard for Toowoomba Post Office, relays and rheostats; Siemens Bros. Dynamo Works, lead-covered cable; G. Wills & Co., 60,000 porcelain insulators; Brabant & Co., jointing sleeves and g.-i. wire; British Insulated & Helsby Cables, copper tapes and binders, phosphor bronze, copper v.i.r. lead-sheathed and tinned copper wire, D.P.B. receivers and cords, and condensers; India Rubber, Gutta Percha & Telegraph Works Co., phonopores and phonopore carriers and detectors; Brisbane Electrical Co., Morse keys and trembling bells; Perry Bros., solder, staples and washers; Rich & Co., g.-i. wire; Webster & Co., gal. steel wire; Lawrence & Hanson, ammeter and chronoscopes; Jas. Paton & Co., fuses in glass tubes; Hippisley & Waddell, coin attachments.

Western Australia.—J. M. Ferguson, table telephone sets.

Tasmania.—British Insulated & Helsby Cables, paper-insulated cable, bronze and v.i.r. copper wire, Morse sounders and cords; Western Electric Co., lead-covered, silk and cotton-insulated cable; W. T. Henley's Telegraph Works Co., webbing; India Rubber, Gutta Percha

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& Telegraph Works Co., terminal screws, &c.; Siemens Bros. & Co., Morse keys and relays; International Electric Co., switches and switchboards; H. K. Fysh & Co., dry cells; Scheele & Gibbs, porcelain tubes; Shiner & Co., c.-i. brackets; Ringdahl & Co., coin attachments.

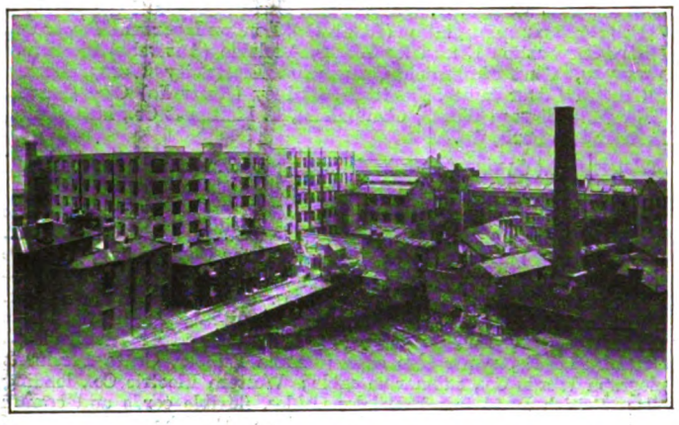
Sale by Auction.—Messrs. Fuller, Horsey, Sons & Cassell have been instructed to sell by auction at H.M. Dockyard, Chatham, on Tuesday, May 10 and following days some old and surplus stores, including 3,000 tons mild steel and steel and iron scrap, also quantities of wire rope, steel tubes, lead and zinc ashes, brass borings and scrap metal, electric cable and electrical gear and stores, boilers, machine tools, &c. May be viewed three working days prior to and on morning of sale. Catalogues (6d. each) at the Dockyard, or of Messrs. Fuller, Horsey, Sons & Cassell, 11, Billiter-square, London, E.C. See also an advertisement.

For Sale.—In another column an electric light and power undertaking is advertised for sale as a going concern.

Machine Tools for Sale.—Messrs. Price & Belsham, 52, Queen Victoria-street, London, E.C., advertise some lathes for sale.

Factory Premises for Sale.—Mr. F. Warman, 52, Chancery-lane, London, W.C., has for sale some well-equipped factory premises in Reading. See an advertisement.

Osram Lamp Development.—The development of the Osram lamp is well shown in a letter the General Electric Co. have received from Messrs. Bull & Barton in regard to the present pay roll at the Osram lamp works. On March 13, 1910, it appears that the number of persons employed in manufacturing Osram lamps at Hammersmith (including the staff and managers) was 946. The Works, in which nearly 1,000 people are employed, are shown in the accompanying illustration.



THE OSRAM LAMP WORKS, HAMMERSMITH.

"Tantalum" Lamps on a Merry-go-round.—Tantalum lamps, as we have many times shown, are used in a variety of places. This week we illustrate Tantalums on a merry-go-round (at St. Kilda Beach, Melbourne, Australia), showing the effect of Tantalum illumination at night time, and at the same time demonstrating that they will withstand severe vibration. Residents in provincial towns are familiar at certain seasons of the year with the ear-splitting noises of these delights of gay and giddy youth, and all will agree that the din and vibration is "heavy." Tantalums seem to thrive in these surroundings.

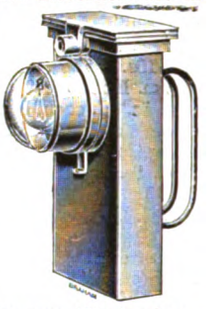
Garcke's Manual of Electrical Undertakings.—We have received a copy of the 14th edition of this "Manual" which appears to have been carefully revised. All the well-known features of the publication have been retained, and complete financial and other particulars relating to about 3,000 electrical undertakings are given, their classification being the same as in previous years, as follows: (I.) Electric Lighting, Power and Traction, (II.) Telegraphs and Telephones, (III.) Manufacturing and Miscellaneous, (IV.) Colonial and British Possessions, (V.) Directories of Officials, including Chairmen, Managers and Secretaries, members of Electric Lighting and Tramway committees, and Electrical Contractors, and (VI.) Index of Undertakings and list of other Electrical Undertakings registered since 1896. The "Progress of the Year" section contains a general survey of the year's work, but the main portion of the book is made up of particulars relating to all joint-stock electrical companies and municipal electrical undertakings. These particulars include the latest accounts in full, comparative tables of progress and other statistical data, information about the constitution of the undertaking, &c., also dividends paid and Stock Exchange quotations, and names of directors, members of committees and other officials. The "Manual" is published by the Electrical Press (Ltd.), 57 and 58, Strand, London, W.C., at 21s. nett.

CATALOGUES, &c.

ALUMINIUM 'BUS BARS.—We have received from the British Aluminium Co. a copy of a pamphlet containing a great deal of interesting information regarding the use of aluminium for 'bus-bars, machine and feeder connections.

ARCTIC VENTILATING FANS.—The Wilson-Wolf Engineering Co., of Bradford, send us a section of their new catalogue dealing with Arctic ventilating fans for direct current. Illustrations and details are given of the complete range of fans up to 72 in. in diameter, together with suitable regulators and other accessories.

LEA RECORDER.—The Lea Recorder Co., of Manchester, forward a leaflet illustrating their well-known recorders, and giving some details of the work carried out by the Company. An interesting list on the back of the pamphlet shows where Lea Recorders are in use. We can advise station engineers to take the first opportunity of becoming acquainted with this useful piece of apparatus.



ELECTRIC SAFETY LAMP.—A new type of electric safety lamp has recently been put on the market by the Bristol Electric Safety Lamp Works, of Westminster, London. The lamp is shown in the illustration herewith, and is provided with a 4-volt accumulator in a celluloid case of the non-spilling type. Its storage capacity gives a good light for about 10 hours.

ONEWATT LAMP.—Messrs. Siemens Bros. Dynamo Works have ready a leaflet dealing with their new "Onewatt" lamp, which contains, on what may be called the obverse side, an illustration of the lamp, and details of its efficiencies and dimensions and price. On the reverse side are set out in prominent form a number of the distinctive features of the lamp. These leaflets will be supplied to contractors overprinted with their own names on application.

LIGHT ACCESSORIES.—Messrs. D. H. Bonnella & Son, of Mortimer-street, London, W., have issued a section of their catalogue dealing more especially with wall and floor sockets and pressel switches. These various lines are illustrated and seem to be all that can be desired from the point of view of sturdiness of the work they are designed to carry out.

BANKRUPTCIES, LIQUIDATIONS, &c.

The public examination of Alfred Ernest Felgate and Wm. Storey, electrical engineers, 10, Queen Victoria-street, Reading, took place last week.

Gross liabilities were returned at £3,012. 8s. 3d., of which £2,412. 2s. 9d. was expected to rank; and assets estimated to produce £863. 7s. 9d., leaving a deficiency of £1,753. 15s. The Official Receiver questioned Felgate as to the causes of his failure, and he admitted that, considering he had been carrying on business with borrowed money, he had not been solvent practically from the start. Trade had been bad in Reading during the last few years, and there was a heavy loss on realisation of stock. Examination was adjourned.

Wm. H. Palmer, electrician, 10, Gt. Castle-street (lately trading at 7, Gt. Castle-street), Oxford-street, London, W., has been adjudicated bankrupt.

The public examination of Hy. K. P. Barham (trading as the South of England Electrical Engineering Co.), 60, Fratton-road, Portsmouth, will take place on April 25 at the Court House, St. Thomas-street, Portsmouth.

Claims against the Contraflo Condenser Co. (Ltd.) and the Contraflo Continental Patents Co. (Ltd.), whose undertakings are to be transferred to the Contraflo Condenser & Kinetic Air Pump Co.

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(Ltd.), by May 7 to Mr. W. S. Gregg, 3 and 5, Crown-court, Old Broad-street, London, E.C., at which address meetings of creditors will be held on April 21.

A meeting to receive an account of the winding-up of Amalgamated Dry Batteries (Ltd.) will be held on May 26 at 394, Moorgate Station-chambers, London, E.C.

A meeting to receive an account of the winding-up of the City of Wellington Electric Light & Power Co. (Ltd.) will be held on May 23 at 180, Dashwood House, New Broad-street, London, E.C.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

*NOTE.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

February 7, 1910.

2,981 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Electric switches.*
2,983 WESTINGHOUSE METALLFADEN GLUHLAMPENFABRIK G.M.B.H. Decarbonising metallic filaments for incandescent electric lamps. (Date applied for, 19/2/09.)*†
3,007 SUCKLING. Shade carriers for electric lamp-holders.
3,011 B.T.-H. CO. (G.E. Co., U.S.) Electric braking.
3,012 PHŒNIX DYNAMO MFG. CO. & POHL. Dynamo-electric machines.
3,013 WINSBOROUGH. Safety apparatus for use with electrical installations.
3,015 DANIEL. Arc lamp.*
3,019 LAMKIN & HUNTER. Electric telegraphy.

February 8, 1910.

3,052 BUCKLEY. Cleaning and disinfecting telephone receivers.
3,068 POOLEY. Motor-starting switches.
3,098 CHILDS & HILL. Electric controllers.
3,114 B.T.-H. CO. (G.E. Co., U.S.) Alternating-current motors of the commutator type.
3,117 SIEMENS-SCHUCKERTWERKE G.M.B.H. Transmitting power by means of polyphase alternating electric currents. (Date applied for, 27/2/09.)*†
3,118 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchanges.*

February 9, 1910.

3,125 PARSONS. Driving gear for ignition magnetos and similar devices.
3,137 RIDER. Mechanical ears, crossings, switches, frogs and section insulators for supporting the overhead wires for electric tramways.
3,153 KIDD. Morse signalling apparatus.
3,160 CHURTON & SMITH. Alternating-current induction motors.
3,163 ABBOTT. Cooking and the like by electricity or otherwise.
3,174 HOOKHAM. Electricity motor meters.
3,185 JOEL. Portable electric lamps.
3,186 QUAIN, TRUE & WADE-BROWNE. Electric lamps.
3,199 COMPAGNIE DE SIGNAUX ELECTRIQUES POUR CHEMINS DE FER. Controlling railway points and signals. (Date applied for, 11/2/09.)*†
3,208 CADDY. Flexible electric wires or cables.
3,209 BIGGE & BUTT. Induction coils and transformer apparatus.

February 10, 1910.

3,250 SPRAGUE & CHAMBERLAIN & HOOKHAM. Prepayment electricity meters.*
3,260 ELLIS. Expansion device for a gasolier, electrolier or the like.
3,294 HANDCOCK & DYKES. Electric meter systems.
3,307 DREIER. Electric chisels.
3,310 ETABLISSEMENTS DE DION BOUTON (SOC. ANON.). Electric ignition devices for internal combustion engines. (Date applied for, 11/2/09.)*†
3,314 STACHOW. Magnetic ore separators. (Date applied for, 19/2/09.)*†
3,318 HAWKER & MARKT. Electric switch for electric lamp-holders, wall switches and the like.
3,328 LEITNER. Induction spark arrester for direct-current apparatus.
3,329 ADAM. Protecting electric conductors.
3,336 B.T.-H. CO. (G.E. Co., U.S.) Brushes for dynamo-electric machines.
3,340 HEALING & CO. (Juzo Kajiura, Japan.) Electric telegraphy.

February 11, 1910.

3,380 PAPE. Grid for electric storage batteries.
3,381 PAPE. Storage batteries.
3,383 WINTERS. Combined trolley-wire hangers and automatic circuit-breakers.*
3,400 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchanges.*
3,410 MURPHY. Electric valves. (Date applied for, 19/8/09. Comprised in application No. 19,090, dated 19/8/09.)*
3,411 PERRY & BROWN. Systems for telegraphy and telephony.
3,421 SOCIETE ANONYME ELECTRO-METALLURGIQUE (PROCEDES PAUL GIROD). Supplying electric furnaces with polyphase currents. (Date applied for, 26/8/09.)*†
3,435 LEITNER. Electric lighting of trains.

February 12, 1910.

3,462 STOTHERT & PITT & PITT. Cranes and winches operated by electric motors.
3,475 SMITH. Portable electric lamps.
3,518 ASHTON. Reduction of voltage at terminals of electric lamps working on alternate-current circuits.

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

2,285 MASCORD, LANGE & CHITTY. Motors and transmission gear.
2,311 DAWBARN. Contact-making devices.
2,383 READ. Starting and controlling electric motors.
2,520 HEYLAND. Regulating system for alternate-current installations. (Date applied for, 3/2/08.)
2,715 BAERLOCKER. Controllers for electric motors.
2,749 GARDE & ADAMS. Electrodes of scondary batteries (accumulators). (Date applied for, 2/4/08.)
2,754 RORKE & RORKE. Switches for electrical purposes.
2,755 SCHULZ. Unipolar turbo-dynamo with the blade wheels running in opposite directions.
2,779 JOHNSTONE. Plug fuses and fuse boxes.
2,943 THOMAS. Electrical controllers.
3,046 PECK, FAYE-HANSEN & LUSTGARTEN. Alternating electric current distribution systems.
3,105 SIMPLEX CONDUITS & ELLIOTT. Switches and adapters for controlling lamps.
3,176 DANNATT. Electric switches, electricity meters and similar apparatus. (Cognate application, 18,268/09.)
3,191 CURTIS & ADAMS MFG. CO. Electrical resistances.
3,192 B.T.-H. CO. & WEDMORE. Protective devices for power transmission systems.
3,371 HOLMAN. Arc lamps. (Addition to No. 27,536/08.)
3,533 PECK. Control systems for electric motors.
3,554 FENNELL & PERRY. Electric radiators and other apparatus.

COMPANIES' MEETINGS AND REPORTS.

AIRDRIE & COATBRIDGE TRAMWAYS CO.—The capital expended during 1909 was £104.7s. 1d., making the total expenditure £67,304.16s.4d. The revenue for the year amounted to £11,666. 0s. 2d. compared with £11,808. 8s. 2d. for 1908. After deducting all expenses (including repairs and maintenance, interest and provision for permanent way renewals) the profit was £1,700. 10s. 1d., which, added to £282. 17s. 1d. brought forward, makes £1,983. 7s. 2d. £200 has been placed to sinking fund for loan redemption and £250 to depreciation reserve. A dividend at the rate of 3 per cent. per annum on the ordinary shares (£1,350) is recommended, leaving £183. 7s. 2d. to be carried forward.

ARBROATH ELECTRIC LIGHT & POWER CO. (LTD.)—At the meeting on Tuesday the Chairman, Mr. G. Balfour, stated, in the moving the adoption of the annual report, that there had been a satisfactory increase in the business of the company during the past year, and that it was advisable to extend the plant at the power station. The net profit was £426. 16s. 6d., and a total of £503. 9s. 6d. was being carried forward.

BELL'S ASBESTOS CO. (LTD.)—The directors' report for 1909 states that the net profit was £13,902, and with amount forward (£15,266) made £29,168. The absorption of the United Asbestos Co. has been effected. A dividend is recommended of 1s. 6d. per share (tax free) (making 12½ per cent. for the year), carrying forward £14,168.

CUBA SUBMARINE TELEGRAPH CO. (LTD.)—The report of the directors for the half-year ended Dec. 31 last shows that the total receipts of the six months were £16,376. 15s. 3d. and expenses £6,415. 1s. 7d., leaving a balance of £9,961. 13s. 8d., to which has to be added £7,059. 5s. 5d. brought forward, making £17,020. 19s. 1d. £2,000 has been added to reserve, which now stands at £116,000. The preference dividend absorbs £3,000, leaving £12,020. 19s. 1d., and the directors recommend payment of a dividend at the rate of 6 per cent. on the ordinary shares, tax free. £7,220. 19s. 1d. is carried forward. The company's cables continue in good working order.

CRAIGPARK ELECTRIC CABLE CO. (LTD.)—The nett profit for the year ended March 31 was £6,243. 14s., which, with £477. 6s. 2d. brought forward, makes £6,721. 0s. 2d. The directors recommend that £500 be applied towards depreciation of buildings and machinery, that £500 be placed to reserve and that dividends of 6 per cent. per annum be paid on the preference and ordinary shares, leaving £1,221. 0s. 2d. to be carried forward. During the year the company's business has continued to extend. The result, however, has not been so satisfactory as could be desired, and is entirely due to the great increase in the price of raw rubber. The directors have appointed Mr. Peter Rintoul, C.A., to the vacancy on the board caused by the death of Mr. W. R. Dick.

DEUTSCH-ATLANTISCHE TELEGRAPHENGESELLSCHAFT (COLOGNE)—The report of the directors of this company for the year ended December, 1909, states that the receipts from the Atlantic and the Vigo cables exceeded those of 1908. The Norddeutsche Seekabelwerke A.G. (Nordenham) have been engaged upon the laying of the first portion of the cable to South America, and will probably be fully employed during 1910. The net profit was M.2,520,890 (£126,045), compared with M.2,154,407 (£107,720) in the previous year. M.126,044 (£6,302) has been placed to reserve and M.500,000 (£25,000) to special reserve and repairs funds; dividend of 7 per cent. (as in 1908) requires M.1,680,000 (£84,000) and M.475,549 (£23,777) is carried forward, compared with £22,271 last year.

ISLE OF WIGHT ELECTRIC LIGHT & POWER CO. (LTD.)—At the recent meeting of this company the chairman (Mr. F. E. Gripper) stated that they had added the equivalent of 4,000 8 c.p. lamps to their system, and the revenue had increased by £450. The year's trading showed an increased profit of £145.

LA PLATA ELECTRIC TRAMWAYS CO. (LTD.)—At the meeting on Tuesday the chairman (Mr. W. Hamilton) said the electrification of the first section of the tramways, comprising over 3 miles of single track, was opened for traffic at the beginning of January, and a second section (comprising 5 miles of single track) was opened on 3rd inst. Those two sections included most of the principal lines of the city. The results of working by electricity were satisfactory.

LISBON ELECTRIC TRAMWAYS (LTD.)—The result of the operations for the past year, after deducting interest, London office expenses, &c., shows a net profit of £103,766. 1s. 9d., added to £3,380. 4s. 2d. brought forward, making £107,146. 5s. 11d. £35,000 has been placed to depreciation reserve, £5,000 to credit of exchange reserve, and £5,000 as a nucleus for the future establishment of an employés pension fund. Investments have been written down to market value. After providing for these charges the available balance is £62,146. 5s. 11d., and preference dividend (£25,533. 3s. 8d.) has been paid. An interim dividend of 2½ per cent. has been paid on the ordinary shares (£15,850. 13s.) and payment of a final dividend of 3 per cent. (£19,020. 15s. 7d.) is now recommended, making 5½ per cent. for 1909. The balance (£1,741. 13s. 8d.) is carried forward. Traffics continue satisfactory, and show a steady increase over 1908.

LONDON UNITED TRAMWAYS (LTD.)—For the year ended Dec. 31, last the gross receipts were £318,226. 6s. 3d., and working and general expenses, maintenance and repairs £226,566. 15s. 8d., leaving, with balance forward, net revenue £91,986. 8s. 3d. After payment of interest, &c., there remains £21,950. 5s. 7d. £21,000 is put to reserve for renewals

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and £950. 5s. 7d. carried forward. Gross receipts show a decrease of £30,163. 18s. 7d. and working expenses an increase of £6,334. 11s. 6d. compared with 1908. The directors have carefully considered the condition of the permanent way and rolling stock, and they deem it advisable, from the standpoints of both economy and efficiency, that certain repairs which have become necessary should be undertaken immediately. They therefore propose to forego payment of any preference dividend for the past year, and to utilise the reserve funds for these repairs. The directors have deposited a bill to extend the period for the reconstruction for electric traction of the tramway along the Kew-road, Richmond. Sir Clifton Robinson having resigned the position of managing director and engineer, Mr. A. H. Stanley has been appointed to succeed him as managing director and Mr. Jas. R. Chapman, having returned to the United States, has resigned his seat on the board.

METROPOLITAN ELECTRIC TRAMWAYS (LTD.)—At the meeting last week the chairman (Mr. E. Garcke) said the tribulations of most tramway companies in this country were so great and so well known that the shareholders of the company had some difficulty in believing that their position was satisfactory, that the prospects were good, and that the payment of a dividend at the rate of 5 per cent. on the ordinary shares was compatible with the maintenance of the property and the adequate provision for depreciation. Nevertheless, such were the facts. The primary reason of that contentment and the absence of anxiety was undoubtedly the arrangement which they were able to make with the local authorities. This enabled them to maintain a contented and efficient staff of officials who were able to devote the whole of their energies to the development of the business. With the extensions opened during the past year they had practically completed that important system of tramways and light railways in the North Metropolitan area. Their network was fed and tapped by no less than five terminal stations of tube railways. That would at once indicate the enormous scope there was for the development of tramways in the area. Those tube railways were a great advantage to them, but he was quite justified in saying that the advantage to the tubes was also great. They had powers for a small tramway at Watford, which was still under consideration, and there were one or two small lines to be completed. There was a small connecting tramway line from Enfield to Ponder's End, and a small extension at Harrow-road. With those exceptions, the system was practically complete, and they might, at any rate for the immediate future, consider the capital account of the company as closed. With regard to the North Metropolitan Power Co., the increase in power consumers was quite satisfactory, amounting to something like 70 per cent. in the past year, and as the districts developed by means of the travelling facilities now completed, and the general favourable situation of the area in regard to manufacturers, &c., he had no doubt that the business of the Power Company would steadily increase. The dividend on their shares in that company this year was 6 per cent., against 5 per cent. in the preceding year. They were now free to devote their energies to the development of the Power Company, which was capable of very considerable extension, and upon the working up of their traffic on the tramways and light railways.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—Including £5,263. 4s brought forward, deducting the interim dividends of 3 per cent. on both the preference and ordinary shares, and making provision for redemption of debenture stock, and other charges, the amount to be dealt with for the year to Dec. 31 is £28,994. 5s. The directors recommend payment of the final preference dividend (£1,500) and a final dividend of 5 per cent., tax free, on the ordinary shares (making 8 per cent. for the year) (£8,965. 13s.), the transfer to reserve of £7,500 and of £500 for contemplated pension scheme, leaving £10,528. 12s. to be carried forward. The exchanges worked by the company continue to show improving revenues. In Mauritius negotiations are still proceeding with the Government with a view to enlarge the field of operations. The Indian local companies report a continued accession of subscribers. The Bengal Telephone Co. has declared the same dividend as for 1908 (5 per cent.) and the Bombay Telephone Co. 7 per cent. (against 6 per cent. for 1908). The Telephone Co. of Egypt has also shown further increases of business during 1909, and has again declared a dividend of 10 per cent. for the year on both preferred and deferred shares. The China & Japan Telephone & Electric Co. also made good progress, and dividends of 5 per cent. for 1908 and 1909 have been declared.

ROTHESAY TRAMWAYS CO. (LTD.)—The total revenue for 1909 was £10,565. 16s. compared with £10,431. 17s. 2d. for 1908. The working expenses (£5,689. 16s. 7d.) showed a decrease of £297. 18s. 8d. After deducting expenses and providing £400 for renewals, the balance is £1,306. 18s. 4d. making, with £82. 10s. 5d. brought forward, £1,389. 8s. 9d. The directors recommend that £400 be applied to sinking fund for loan redemption, and £100 to depreciation and reserve, and that a dividend at the rate of 1 per cent. on the ordinary shares (£638. 15s.) be paid, leaving £250. 13s. 9d. to be carried forward.

SOUTHPORT TRAMWAYS CO. (LTD.)—At the meeting on Monday the directors' report stated that the decrease in traffic receipts was mainly due to unfavourable weather and trade depression, but the competition of the electrified section of the Lancashire & Yorkshire Railway and of the Southport Corporation tramways had not been without its effect on the receipts. After paying £5,573. 8s. 4d. to the local authorities under various agreements and other sums, the accounts showed a debit balance of £818. 14s., which, reduced by £126. 18s. 8d. brought forward, left a debit balance of £691. 15s. 4d.

NEW COMPANIES.

BRITISH ALUMINIUM CO. (LTD.) (108,758)—Reg. April 12, capital £1,000,000 in £1 shares (300,000 preferred), to acquire any minerals, claysor other substances suitable for the production or manufacture of aluminium, sodium, iron or other metals, to carry on the business of miners, manufacturers of and dealers in aluminium and its alloys, &c., to acquire and deal in any manner with all or part of the undertaking and assets of the Loch Leven Water & Electric Power Co., and to adopt an agreement with the British Aluminium Co. (Ltd.) (in liquidation).

BRITISH ARC WELDING CO. (LTD.) (108,759)—Reg. April 11, capital £15,000 in £10 shares, to carry on the business of welders, electrical, civil and mechanical engineers, electricians, &c. Private company. First directors, R. S. Kennedy and J. Kennedy. Reg. office, Suffolk House, Laurence Pountney-hill, London, E.C.

ELECTRICAL TRUST (LTD.) (108,846)—Reg. April 14, capital £2,500 in 2,000 ordinary shares of £1 each and 10,000 founders' shares of 1s. each, to carry on the business of electrical, telegraph, telephone and mechanical engineers, cable makers, dealers in electrical and other motors, generators and accumulators, &c. Private company. First directors, J. Metcalfe and A. C. Vincent. Reg. office, 9 & 10, Pancras-lane, London, E.C.

HILL, HARDING & CO. (LTD.)—Reg. April 16, capital £1,000 in 950 preferred ordinary shares of £1 each and 1,000 deferred shares of 1s. each, to carry on the business of electrical and surgical instrument manufacturers carried on as Hills, Harding & Co., together with a certain invention for an improved device for controlling an auxiliary electric circuit requiring a voltage which is lower than that of the source of electrical supply. Private company. First directors, H. W. Hill (life director), H. W. Chapman and W. G. Harding. Reg. office, Shandon-road, London, S.W.

NU-ADS (LTD.) (108,858)—Reg. April 14, capital £2,000 in £1 shares, to take over certain patent rights from F. J. Blaxley, C. C. Chapman, A. C. Harris and F. H. Blaxley, to carry on the business of manufacturers of and dealers in electric advertising signs, &c. Private company. First directors, F. J. Blaxley (managing director) and A. C. Harris.

RAILOPHONES (LTD.) (103,940)—Reg. April 16, capital £500 in £1 shares, to carry on the business of electricians, telegraph and telephone instrument makers, engineers, wire drawers, &c. Private company. Reg. office, 21, Wood End-road, Erdington, Warwick.

A. WARD & CO. (LTD.) (108,793)—Reg. April 13, capital £3,000 in £1 shares, to carry on the business of electrical, automobile, mechanical and general engineers, founders, boiler makers, &c. Private company. First directors, A. V. Ward and G. L. Kirkpatrick. Reg. office, 85, Shaftesbury-avenue, London, W.

CITY NOTES.

MEMORANDA (April 21).—**Bank rate 4 per cent.** (since March 17, 1910). **Price of silver,** 24⅛d. per oz. Consols 80¾—81⅛ for money and 81—81¼ for account. Consols Pay Day, May 5; Stock and Shares Continuation Days, April 27 and May 10; Ticket Days, April 28 and May 11; Pay Days, April 29 and May 12; Mining Shares Carry Over Day, April 26.

PRICES OF METALS (London).—*Copper*, cash, 55⅛; three months, 57⅛. *Lead*, English, 12⅞—13¼; foreign, cash, 12⅜; three months, 12⅝. *Spelter*, foreign, 22⅜. *Tin*, English, 149—151; foreign, cash, 150¼; three months, 151¾. *Iron*, Cleveland, cash, 50/7, and three months, 51/7.

BRITISH COLUMBIA ELECTRIC RAILWAY CO. (LTD.)—An interim dividend at the rate of 8 per cent. has been declared on the deferred ordinary stock for the half-year to Dec. 31 last.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD).—The transfer books and register of holders of the second debenture stock are closed from 18th to 30th inst., inclusive, preparatory to payment of interest due May 1.

COVENTRY ELECTRIC TRAMWAYS (LTD.)—Gross receipts during the past year were £28,350, expenses £18,729 and net earnings £9,621. Net profit was £6,939. The directors recommend a dividend of 3½ per cent.

EASTERN TELEGRAPH CO. (LTD.)—The company announce payment by warrants on May 2 of interest for the half-year ending 30th inst. on their 4 per cent. mortgage debenture stock. The transfer books of the debenture stock will be closed from 27th to 30th inst. inclusive.

EASTERN & SOUTH AFRICAN TELEGRAPH CO. (LTD.)—This company announce payment by warrants on May 2 of interest for the half-year ending April 30 on their 4 per cent. Mauritius subsidy debentures. The transfer books will be closed from 27th to 30th inst. inclusive.

MONTE VIDEO TELEPHONE CO. (LTD.)—The directors have declared an interim dividend for the half-year ended Jan. 31 at the rate of 6 per cent. per annum on the ordinary shares.

MONTREAL LIGHT, HEAT & POWER CO.—A dividend of 1¾ per cent. for the quarter ended April 30 has been declared.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have granted a quotation to a further issue of £350,000 5 per cent. 50 year mortgage bonds of the *Rio de Janeiro Tramway, Light & Power Co.* (*Ltd.*)

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdire	April 8	206	..	14	3,017	+ 101
Anglo-Argentine	,, 15	46.528	+ 6,764	15	650.556	+ 54,909
Ayr Corporation	,, 16	206	— 80	48	13.387	— 76
Baker St. & Waterloo Ry.	,, 16	3,360	+ 120	15	51.435	+ 705
Barnsley	,, 8	148	— 39	14	2,388	+ 148
Barrow	,, 8	200	— 64	14	3,169	+ 376
Bath Electric Trams, Ltd.	,, 13	723	— 331	15	10.491	+ 1,183
Birmingham Corporation	,, 16	6,643	— 452	2	15,093	— 1,779
Birmingham & Midland	,, 1	1.043	+ 243	13	10.560	+ 544
Blackburn Corporation	,, 13	964	— 1,078	‡3	3,164	— 514
Blackpool and Fleetwood	..	..	..	..	..	..
Blackp'l St. Anne's & Lytham	..	..	..	..	..	..
Bolton Corporation	,, 17	2.343	+ 46	3	5.438	— 1,459
Bombay	Mar. 18	2,801	+ 127	11	29.786	+ 1,978
Bournemouth Corporation	April 13	1.511	— 991	‖2	2.816	— 1,115
Bradford Corporation	,, 16	4.727	— 983	3	10.849	— 2,047
Brighton Corporation	,, 17	834	— 177	§2	1.990	— 584
Bristol Trams & Carriage	,, 15	5,536	— 999	48	275.232	+ 21,626
Burnley Corporation	,, 16	1,196	+ 12	15	19,110	+ 656
Burton Corporation	,, 17	254	— 27	§2	604	— 60
Bury Corporation	,, 17	1.158	+ 33	§2	2.715	— 729
Calcutta Tramways Co.	,, 16	₹51,935	+ ₹7,059	15	₹786.200	+ ₹19,990
Camborne–Redruth	,, 16	112	— 36	15	1.764	— 53
Cardiff Corporation	,, 16	2,097	— 240	3	4.751	— 837
Cavehill	,, 8	62	— 3	14	1.017	+ 258
Central London Railway	,, 16	5.520	+ 791	15	82.558	+ 126
Charing C., Euston & H'stead	,, 16	3.710	— 360	15	57.405	— 140
Chatham & Dist. Lt. Rys.	,, 14	752	— 436	15	11.423	+ 668
City & South London Rly.	,, 17	3.090	— 37	15	49.506	— 574
City of Birmingham	,, 8	2.589	— 316	14	39.408	+ 2,957
Colchester Corporation	,, 13	162	— 74	15	2.407	+ 424
Cork Electric Trams Co.	,, 14	471	— 57	15	6.517	+ 255
Croydon Corporation	,, 8	1.512	— 74	14	1.702	— 256
Devonport & Dist. Trams	,, 8	409	— 3	14	5.646	+ 597
Dover Corporation	,, 16	190	— 30	2	432	— 97
Dublin & Lucan Railway	,, 15	125	— 48	15	1.704	+ 22
Dublin United	,, 15	5,264	— 544	15	75.554	+ 3,178
Dudley–Stourbridge	,, 8	641	— 142	14	9.828	+ 42
Dundee Corporation	,, 13	1.190	— 76	†48	55.940	— 573
East Ham Council	,, 16	965	— 107	¶2	2.247	— 125
Exeter Corporation	,, 15	305	— 111	2	629	— 181
Gateshead & Dist. Trams	,, 8	927	— 118	14	13.354	— 48
Glasgow Corporation	,, 16	17,508	— 102	‡46	776.584	+ 2,224
Glossop Trams	,, 16	107	— 13	15	1,637	— 82
Gloucester Corpn.	,, 13	261	..	2	506	..
Gravesend–Northfleet	,, 8	181	— 24	14	2.641	+ 219
Great Northern & City Rly.	,, 16	1,451	+ 55	15	22.740	— 570
Gt. Northern, Piccadilly, &c.	,, 16	5,935	+ 560	15	90,905	+ 3,750
Greenock & Port Glasgow	,, 8	597	+ 31	14	7.282	+ 1,119
Hartlepool Tramways	,, 8	197	— 42	14	2.881	+ 167
Hastings Elec. Trams Co.	,, 14	842	— 793	15	12.001	+ 642
Hong Kong	,, 16	$2,504	+ $865	15	$126.976	+ $11,595
Huddersfield Corpn.	,, 16	1.741	— 291	2	3.316	— 455
Hull Corporation	,, 16	2,621	— 2	2	6,065	— 438
Ilford District Council	,, 16	486	— 75	¶2	1.120	— 175
Ilkeston District Council	,, 13	109	— 68	2	213	— 87
Ipswich Corporation	,, 16	366	— 59	2	813	— 121
Isle of Thanet Co.	,, 16	355	— 282	¶28	8,480	+ 349
Jarrow	,, 8	110	— 22	14	1,553	+ 124
Keighley Corporation	,, 14	163	— 62	2	313	— 63
Kidderminster & District	,, 8	75	— 19	14	1.212	+ 113
Kilmarnock Corporation	,, 16	140	— 8	48	6.941	— 196
Lanarkshire Trams Co.	,, 14	1,349	+ 36	15	19.842	+ 2,117
Lancashire United	,, 13	1,172	— 1,114	15	18.287	— 67
*Leamington	,, 8	170	+ 7	14	2.032	+ 80
Leeds Corporation	,, 16	6,706	— 565	2	15.329	— 548
Leicester Corporation	,, 16	2,188	— 314	14	32,403	+ 2,433
Leith Corporation	,, 16	557	+ 48	48	28,288	+ 3,402
Lincoln Corporation	,, 16	115	— 9	3	358	— 10
Liverpool Corporation	,, 9	10,387	— 713	14	149.824	+ 4,177
Liverpool Overhead Rly.	,, 17	1,314	— 109	16	20,734	+ 68
Llandudno&ColwynBayRy.	,, 15	162	— 262	§19	2,709	+ 200
*London County Council	,, 2	41,885	+ 7,891	¶52	1,979,888	+ 167 498
London United	,, 16	5,715	— 1,076	§52	84,746	+ 7,039
Lowestoft	,, 16	143	— 20	29	4,316	+ 314
Maidstone Corporation	..	..	..	..	..	..
Manchester Corporation	,, 16	14,794	— 195	2	33,413	— 2,591
Mersey Railway	,, 16	1,954	— 67	15	29.948	+ 540
Merthyr	,, 8	176	— 61	14	2,681	— 53
Metropolitan Dist. Railway	,, 16	10 949	+ 1,623	15	162.117	+ 16,239
Metropolitan Elec. Trams	,, 8	6,864	— 191	14	94.578	+ 20.832
Middleton	,, 8	255	— 183	14	3.895	— 168
Newcastle-on-Tyne Corp.	,, 16	3,739	— 760	¶2	8,567	— 1,757
Newport (Mon.)	,, 16	622	— 83	3	1,984	— 67
Northampton Corporation	,, 15	442	— 152	2	917	— 230
Oldham, Ashton & Hyde	,, 8	479	— 227	14	7,409	+ 114
Oldham Corporation	,, 17	1,748	— 278	‡3	6,416	— 796
Perth (N.B.) Corporation	..	..	..	..	..	..
Perth (W.A.) Elec. Trams	,, 15	1,636	+ 52	15	23.954	+ 1,700
Peterborough	,, 8	91	— 53	14	1,384	+ 42
Portsmouth Corporation	,, 16	1,800	— 547	2	4,185	— 1,212
Potteries	,, 8	1,577	— 267	14	23,710	— 238
Preston Corporation	,, 13	663	— 226	15	10,597	+ 95
Rotherham Corporation	,, 14	592	— 174	2	1,143	— 271
Rothesay	,, 8	108	+ 4	14	973	+ 316
Salford Corporation	,, 18	4,496	+ 56	†3	11,170	— 1,234
Sheerness	,, 8	44	— 4	14	591	+ 8
§Sheffield Corporation	,, 17	5,833	— 11	¶3	19,713	+ 337
Singapore Trams	,, 16	$10,540	+ $1,100	15	$148,656	+ $1,890
South Metropolitan	,, 8	693	— 237	14	10.198	+ 1,081
South Staffs	,, 8	731	— 121	14	11,195	+ 216
Southend Corporation	,, 13	417	— 252	2	780	— 226
Southport Tramways	,, 8	238	— 52	14	3,363	+ 327
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 16	637	— 133	2	1,432	— 863
Sunderland Corporation	,, 17	1,020	— 177	3	2,446	— 571
Sunderland District	,, 13	348	— 342	24	9,739	— 861
Swansea Trams	,, 8	926	— 26	14	13,574	+ 1,668
Swindon Corporation	,, 13	125	— 48	..	..	..
Taunton	,, 8	39	+ 4	14	554	+ 97
Tynemouth and District	,, 8	165	— 41	14	2,169	+ 338
Tyneside Trams Co.	,, 13	365	— 468	15	5,713	— 295
Wallasey District Council	,, 16	864	— 155	§2	1,936	— 454
Walsall Corporation	,, 16	510	— 115	15	7,936	+ 401
Warrington Corporation	,, 14	365	— 53	2	718	— 71
West Ham Corporation	,, 7	2,253	+ 19	1	2,253	+ 19
Weston-super-Mare	,, 8	59	— 8	14	547	+ 170
Wolverhampton Co.	,, 8	349	— 52	14	5,630	+ 320
Wolverhampton Corpn.	,, 13	812	— 230	2	1,668	— 116
*Worcester	,, 8	244	— 49	14	3,377	+ 192
Wrexham	,, 8	90	— 30	14	1,265	+ 31
Yorkshire W.R. Trams	..	..	..	..	..	..
Yorkshire Woollen District	,, 8	900	+ 10	14	13,045	+ 1,587

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Shre	Last Dividend	NAME.	Price Wed. April 20	Rate per cent. Yielded.	Dividend Due.	Business Week to April 20. High est.	Business Week to April 20. Low est.
		Electricity Supply.		£ s. d.			
10	6/0	†Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	19	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½—9¾	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	9½—10½	5 17 0	Feb, Aug	10⅛	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
5	2/0	Bromley (Kent) El. Lt. & Power Shares	4½—4¾	5 15 9	April, Oct.	..	..
St.	4½%	Do Do. 1st Debs.	91 —94	4 15 9	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅜—7½	6 7 0	March	7⅜	..
5	3/6	Do. 7 per Cent. Pref.	7 —7¼	4 13 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 9	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 —4¼	5 11 0	Feb, Aug	2⅛	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4¾	4 17 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —100	4 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	..	101⅛	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅞—4⅛	5 3 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅞—4⅛	5 9 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	101⅛	..
10	9/0	City of London Electric Lighting Ord.	11½—12	5 16 6	Feb, Aug	11⅝	11⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	..	..
10	6/0	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	..	..
St.	5%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99 —102	4 8 0	Jan, July	..	..
5	5%	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per cent. non Cum. Pref.	2¾—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7⅝—8⅛	6 1 6	Feb, Aug	8⅛	7⅞
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞—11¼	5 6 6	Mar, Sept	10⅞	10⅝
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103—106	4 5 0	Jan, July	104½	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 0	May, Nov	102½	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4½	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5⅛	4 15 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	93 —96	4 14 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7⅛	5 6 8	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅞—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94½—96½	4 3 6	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —97	4 1 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1½—2	4 10 0	Mar, Sept	1⅛	..
5	3/0	Do. 6 per Cent. Pref.	4¼—5¼	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	92 —94	4 4 0	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	4 —4½	5 0 0	April, Oct	4⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅝—5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	96½—98½	4 11 6	June, Dec	..	..
100	4½%	Newcastle & Dist. Elec. Ltg. 4½ per Cent. Deb.	82 —86	5 2 6	Jan, July	..	..
5	4/0	Newcastle Elec. Supply Ord.	4¼—4½	4 5 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅞—4⅞	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	..	..
100	5%	†North Metro. Elec. Power Sup. 5 Morts.	97 —99	4 18 0	..	..	..
10	9/0	Notting Hill Electric Ord.	11⅞—12⅛	5 17 6	March	..	..
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 —97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8½—9	5 11 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7⅛	4 16 9	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84—88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1⅝—2¼	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3⅛	6 11 0	April	..	..
St.	5%	Do. 5 % 1st Mort. Stock (red.)	100 —103	4 17 6	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅞—⅞	4 14 0	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	1⅛	..
5	2/6	Urban Electric Supply Ord.	¾—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	1½—2	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	79	..
5	5/0	Westminster Elec. Sup. Ord.	8½—9	5 10 0	Mar, Sept	8⅛	8⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	5⅜	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97⅛	..
1	..	Bath Elec. Trams Pref. Ord.	¼—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—½	7 4 0	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	83 —86	5 5 6	Jan, July	85¼	84½
10	6%	Bristol Tramways & Carriage Ord.	7¼—7½	7 15 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7¾—8¼	4 17 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	1 —1⅛	..	June, Dec	1⅛	..
10	3%	Do. 6 per Cent. Cum. Pref.	3¾—4⅛	6 17 0	Feb, Aug	4⅛	4
St.	5%	†Do. 5 Cent. Perpetual Debs.	90 —93	5 7 6	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 —72	6 5 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	70 —72	5 4 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	86⅛	..
St.	2%	Do. Deferred Stock	53 —55	3 12 0	Feb.	53⅛	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	101⅛	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	96 —99	4 2 0	Jan, July	97⅛	97
5	2/6	†City of Birmingham Trams, 5 % Cum. Pref.	4½—5	5 0 0	April, Oct	..	..
100	4%	†Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	36 —37	4 6 9	Feb, Aug	36⅛	35
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	106 —108	4 12 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —105	4 15 0	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	102⅛	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 —102	3 18 0	May, Nov	102	100⅛
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 —93	4 2 0	Jan, July	97⅛	96½
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	70 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅝—1⅞	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅞—10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan, July	..	..
10	..	London United Trams, 5% Cum. Pref.	2¾—3¼	..	Jan, July	3⅜	3⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	70 —73	5 10 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	†Metropolitan Elec. Tramways Ord.	⅝—¾	..	..	⅞	..
1	..	Do. Deferred	⅛—¼	..	April	⅛	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	5 12 9	Feb, Aug	⅞	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 —100	5 0 0	Jan, July	99	97½
St.	1%	Metropolitan Railway Consolidated	44 —44½	2 5 0	Feb, Aug	45⅜	44½
St.	2½%	Do. Surplus Lands Stocks	67 —69	3 19 6	Feb, Aug	68½	67
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	89⅜	..
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	87⅛	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	93⅛	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., April 20	Rate per cent. Yielded.	Dividend Due.	Business Week to April 20. Highest.	Lowest.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 0	Jan, July	92½	..
St.	..	Metropolitan District Railway Ord.	23 —23¼	..	Feb, Aug	23½	22⅝
St.	..	Do. Extension Pref. (5 per Cent.)	69 —71	..	Feb, Aug	70½	69¼
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	72½	71⅛
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	76½	76
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	102⅜	102
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	143 —145	4 2 9⅛	Jan, July	144⅛	..
St.	4%	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¼—¼	..	May	..	..
1	..	Potteries Electric Traction Ord.	⅛—⅛	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅛	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	84 —87	5 2 6	May, Nov	..	..
1	..	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—⅝	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	67 —71	5 12 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	62 —67	7 5 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. with coups	38 —40	..	June, Dec	38⅜	..
..	5%	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103½	..
..	4½%	Do. 4½% Bonds with coup. 5	89 —91	4 19 0	..	90½	90¼
..	4%	Do. 4 per Cent. 1st Power Ho. Dbs.	97 —99	4 1 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—¾	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—2½	..	..	3½	3⅜
St.	4½	Do. 4½ per Cent. 1st Debs.	78 —81	5 11 0	Jan, July	79	78½
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101 —103	4 7 0	..	..	..
1	..	Aron Electricity Meter Ord.	7/16—9/16	..	..	..	..
1	7½d.	Do. 6% Cum. Pf.	⅝—¾	6 8 0	April, Oct	..	..
1	1/7½	Babcock & Wilcox Ord.	5⅛—5⅜	3 14 3	April, Oct	5⅛	5⅛
1	0/7½	Do. Pref.	1 7/16—1 9/16	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7½	6 18 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	6 —6½	4 10 9	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	91 —95	4 14 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅜—⅝	..	Feb, Aug	⅜	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	97 —99	6 1 0	..	98½	97½
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	47 —51	7 16 0	Jan, July	47	..
St.	4½%	BrushE. Eng. Co. 4½% Perp. 1st Deb. Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	25 —29	15 10 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.	10 —10⅜	6 3 0	Jan, July	10⅛	10
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 11 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	102½—104½	4 6 0	Nov, May	..	..
1	1/9½	Castner-Kellner Alkali Co.	2⅛—2⅜	5 4 3	May, Nov	2⅛	2⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	104 —107	4 4 0	Feb, Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
..	0/7½	Do 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/7½	Consolidated Electrical Co.	⅜—½	7 0 0	August ..	⅜	..
1	0/6	†Consolidated Signal Co.	⅛—1⅛	6 12 0	April, Oct	..	..
1	0/7½	†Do. 6 per cent. Cum. Pref.	⅜—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	⅜—½	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	⅞—1	6 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜—1½	5 5 3	Sept	1⅜	1⅛
St.	4½%	Do. 4½ per Cent. Deb. Stock	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅞—1	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	3/16—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1⅜	..	May, Nov	1⅜	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	72 —75	6 0 0	Jan, July	74	..
2	..	Electric Construction Co.	¼—⅜	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1 3/16—1 5/16	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	61 —66	6 1 0	Jan, July	..	..
St.	5%	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	61 —66	7 11 6	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—8½	6 1 6	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	12⅜—13⅜	5 17 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5⅛	4 3 9	Feb, Aug	5⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 3 6	Mar, Sept	15⅜	15¼
10	15/0	India Rubber, Gut. Per., &c., Works	15½—16	6 5 0	Feb, Aug	15⅜	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10⅜—11	4 11 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97½—99½	4 0 6	April, Oct	97½	..
1	..	National Elec. Construction Co.	¼—½	..	April ..	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—⅝	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	9/16—⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5⅛	..	..	..	..
12	30/0	Telegraph Construction & Maintenance	34 —35½	5 16 0	Mar, July	34	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2¼	4 9 0	..	2⅞	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference	1 7/16—1 9/16	4 4 3	..	1⅜	1⅜
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 11 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 16 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —106	4 5 0	June, Dec	105	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip	106 —108	4 12 6	..	107½	106½
10	8%	J. G. White & Co. 6% Cum. Pref	9½—10½	7 12 0	..	..	..
1	..	Willans & Robinson Ord.	¼—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1⅞—2⅛	9 0 0	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	68 —73	5 9 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3¾	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100 —102	4 18 0	June, Dec	..	..
St.	15/0	†Anglo-American	59 —61	5 19 0	F,My,Ag,N	60½	..
St.	30/0	†Do. Preferred	101 —102	5 18 0	F,My,Ag,N	103½	101½
St.	25/0	Do. Deferred	18½—19½	6 10 0	F,My,Ag,N	19	18⅜
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	87 —89	4 10 0	Jn,Ap,Jy,O	..	..
10	6/0	Cuba Submarine Ord.	8½—9½	6 6 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17½—18½	5 10 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3¼—3½	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7 15/16—8¼	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	102	101½
20	4/0	†Direct United States Cable	13½—14	6 1 0	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 18 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	136 —139	5 1 0	Ja,My,Jy,O	138½	136
St.	17/6	Do. 3½ per Cent. Pref. Stock	86 —88	4 0 6	Ja,My,Jy,O	87½	86½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 15 6	May, Nov	..	..
St.	2/6	Eastern Extension	12⅝—13⅜	5 7 6	Ja, Ap, Jy, O	12⅜	12¼
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub. Debs	101 —103	3 17 6	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 78	31½—32½	5 15 6	Jan, July	31½	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 8 0	June, Dec	..	..
..	12/6	Indo-European	54½—56½	5 15 9	May, Nov	..	..
100	$1½	Mackay Companies Common	92 —94	4 15 9	Ja,Ap,Jy,O	..	..
100	$1	Do. Preference	78 —82	4 17 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	1/32—1/16	..	April	3/32	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	98 —100	4 0 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅜—1⅝	3 14 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	15/16—1 1/16	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9½	6 10 0	May, Nov	..	..
0	20/0	Do. 6% 2nd Pref.	8½—9½	6 10 0	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	100½—102½	4 17 6	Jan, July	102	..
10	3/0	Western Telegraph	13⅜—14½	5 0 6	Mr,Jn,O,D	13⅜	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	..	..
..	4%	†Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	..	..	..

Share	Last Dividend	Name	Price Wed., April 20	Rate per cent. Yielded.	Dividend Due.	Business Week to April 20. Highest.	Lowest.
		Telephones.		£ s. d.			
		Amer. Telephn. & Telegh. Cap. St.	140 —142	5 12 6	..	..	..
		Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	93½	..
		Do. 4% Cons. Bonds 1936	104 —106	3 15 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99½—101½	4 18 6	Mar, Sept	..	..
		Chili Telephone	8⅛—8⅜	4 15 3	August ..	..	..
		Monte Video Telephone Ord.	⅛—¼	7 0 0	Nov	..	..
		Do. 5 per Cent. Pref.	⅛—¼	5 14 6	May, Nov	..	..
St.	6%	National Co. Pref. Stock	104 —105½	5 15 6	Feb, Aug	104½	103½
St.	6%	Do. Def. Stock	124 —126	4 16 6	Feb, Aug	125½	123½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—10¾	5 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —10½	5 10 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5⅜	4 9 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	97½—99½	3 10 6	June, Dec	98	97½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99 —101	3 19 0	Jan, July	98½	..
		New York Telephone Co. 30 yr. Bnds. Scrip	100½—101¼	4 8 9	..	101	100½
		Oriental	1⅛—1½	5 6 9	April, Oct	1⅞	1⅛
		Do. 6 per Cent. Cum. Pref.	1⅜—1⅝	4 11 0	April, Oct	..	..
		Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	..	..
St.	4%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	100 —102	4 8 0	Jan, July	100½	..
St.	4½	United River Plate	7½—7¾	5 9 0	July	7⅞	..
5	3/0	Do. 5 per Cent. Cum. Pref.	5⅜—5⅝	4 9 0	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.	103 —105	4 5 6	Jan, July	..	..
		Financial, Investment, &c.					
		Elec. & Gen. Investment 6% Cum. Pref.	2⅞—3⅛	8 18 0	Jan, July	2⅞	..
		Globe Telegraph & Trust	10½—11	5 9 0	Sp,DcMr Ju	10⅜	10¼
		Do. 6 per Cent. Pref.	13½—13⅞	4 8 0	Sp,DcMr Ju	..	..
		†Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4 7/16—4 9/16	5 7 0	April, Oct	4 9/16	4 7/16
		Do. 5% Cum. 2nd Pref.	4 7/16—4 9/16	5 5 6	Jan, July	4⅞	..
		Do. 4% Deb. Stock	90½—92	4 7 0	June, Dec	91½	91
		Do. 4½% Deb. Stock	96 —98	4 12 0	..	98	97
		Auckland Elec. Trams. 5% Deb. (red.)	105 —107	4 13 6	Jan, July	..	..
		Brisbane Electric Trams. Invest. Ord	7 —7½	4 2 0	May	7⅛	..
		Do. 5 per Cent. Cum. Pref.	5½—5¾	4 3 6	May, Nov	..	..
		Do. 4½ per Cent. Db. Prov. Certs.	101 —104	4 6 6	Jan, July	104	..
		British Columbia El.. Rly. Df. Ord.	145 —150	5 8 0	Mar, Sept	..	..
		Do. Pref. Ord. Stock	121 —125‡	4 16 0	May, Nov	123	121
		Do. 5% Cum. Perp. Pref. Stock	109½—111½	4 9 6	Jan, July	111½	110½
		†Do. 4½ per Cent. 1st Mort. Debs.	101 —103	4 7 6	April, Oct	104½	104½
		Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	104½	102½
		†Do. 4½% Perp. Con. Deb. St.	101½—103½	4 1 6	..	103⅜	102½
		Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	..	..
		Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	92 —95	6 4 6	Feb, Aug	..	..
		Calcutta Tramways (1 to 137,610)	4⅜—4½	4 2 6	Mar, Sept	..	..
		Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	Jan, July	..	..
		Do. 4½% 1st Deb. Stock (red)	99 —102	4 8 0	Jan, July	..	..
		Cape Electric Tram Shares	⅛—¼	..	..	..	..
		City of Buenos Ayres Trams Co. (1904) Sh.	5⅜—5½	4 8 3	F,My,A,N	5⅜	..
		Do. 4 per Cent. Deb. Stock	97 —100	4 0 0	June, Dec	..	..
		Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 —99	5 1 0	May, Nov	..	..
		Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	81½	80½
		Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94½—97½	5 2 6	Feb, Aug	..	..
		Kalgoorlie Elec. Trams Sh.	7/16—½	..	..	..	..
		Do. 5 per Cent. "A" Deb. Stock	96 —98	5 2 0	Jan, July	..	..
		Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	..	..
		Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
		Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
		Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
		Manila Elec. Ry. $1,000 Gold Bonds	95 —97	5 2 6	Feb, Aug	..	..
		†Mexico Trams Co. Com. St.	130½—132½	4 13 0	..	..	..
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	95 —96	5 3 6	..	95½	95½
		Do. 6% 50 yr. Mort. Bds.	98½—99½	6 0 3	..	99½	98½
		Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	102	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..	..	..
		Perth Elec. Trams Ord.	⅜—⅞	5 14 0	May	..	..
		Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
		Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅜—5⅝	5 2 6	..	..	..
		Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	..	..
		†Ric Janeiro Tram, Lt. & P. Co.	96 —98	4 2 0	..	98½	96¾
		Do. 30 yr. Gold Bnds.	97½—98½	5 1 9	..	98	97½
		Do. 50 yr. Mt. Bnds	86 —87	5 15 0	..	87⅜	86⅛
		Sao Paulo Tramway, Light & Power Co. $100 Stock	150 —152	5 6 0	..	..	..
		Do. 5 per Cent. 1st Mt. $500 Db.	103 —105	4 15 0	June, Dec	104½	103
		Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	100½	..
		Colonial and Foreign Electricity Supply, &c.					
		Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅜—5⅝	5 2 0	Mar, Sept	..	..
		Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 9 0	..	..	..
		Do. 4½ per Cent. Deb. Stk. (red)	95 —97	4 12 6	Jan, July	96	..
		Do. 5 per Cent. 2nd Mort. Deb. Stock	96 —98	4 18 0	..	96½	..
		Calcutta Elec. Supply Ord.	6¼—6⅝	5 18 9	April, Oct	6⅜	..
		Canadian Gen. Elec. Co. Com. St.	115 —118	6 2 0	..	117	116½
		Do. 7% Cm. Pf. Stock	117 —120	6 0 0	..	..	..
		Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
		Elect. Development Co. of Ontario	83 —85	5 16 0	..	..	..
		Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
		Indian Elec. Sup. & Trac. Co.	1⅜—1⅝	..	..	..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	⅛	..
		†Do. 6 per Cent. Cum. Pref.	⅜—½	8 0 0	April, Oct	½	½
		Madras E. S. Corp. Ord.	2⅜—2⅝	..	..	..	..
		Melbourne E. S. Co. 6% Cum. Pref.	33 —38	..	..	..	..
		Do. 5% 1st Mortg. Deb. Stock	92 —94	5 6 9	..	93½	..
		Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84½—85½%	5 16 6	..	84½	84½
		†Mexican Lt. & Power Co. Com. St.	80 —82	4 17 0	..	81	80
		Do. 5% 1st Mort. Gold Bnds.	89½—90½	5 9 0	..	90½	89½
		Montreal Lt. Ht. & Power Co. Cap. St.	137 —141	4 15 0	F,My,A,N	..	..
		River Plate Electricity Co. Ord.	1⅝—2	4 0 0	April	1⅝	..
		Do. 6 per Cent. non-Cum. Pref.	1⅞—2⅛	4 18 0	May	..	..
		Do. 5 per Cent. Deb. Stock	103 —106	4 14 6	Jan, July	..	..
		Rosario Ele. Co. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
		Do 2nd Pref.	8⅜—8¾	6 14 6	..	..	..
		†Shawinigan, Water & Power Co. Ca.	101½—103½	4 7 0	..	103½	..
		Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	108½	..
		Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102½	102½
		Toronto Power Co. 4½% Db. St.	101 —103	4 7 6	..	102⅝	101½
		Victoria Falls Power Co. Pref. (1 to 808,000)	5⅛—5⅜	5 14 0	Jan, July	‡	..
		Do. (803,081 to 1,700,000)	⅜—½	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,667. [No. 3. Vol. LXV.] FRIDAY, APRIL 29, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90s., or 80m.

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NOTES.

The Institution of Electrical Engineers.

AT the meeting of the Institution last week, when the nominations were announced for the new Council, some surprise was caused by Mr. W. A. CHAMEN proposing (in accordance with the Articles of Association) Mr. H. FARADAY PROCTOR as a further nomination. This proposal was seconded by Mr. W. W. LACKIE, and supported by Messrs. H. COLLINGS BISHOP, A. ELLIS, H. D. MUNRO, E. G. OKELL, H. T. SULLY, C. A. L. PRUSMANN, W. J. BACHE, R. A. CHATTOCK, T. O. CALLENDER, D. E. ROBERTS, T. SCHONTHEIL, and A. J. HODGSON. Mr. CHAMEN, in putting forward the nomination, remarked that he did not do so in any antagonistic spirit. This we can quite believe, as we think it may very well be said that the nominations this year are more acceptable to the general body of members than has often been the case. It is really just as well that the innovation of outside nominations should come when there is not any marked dissatisfaction. Undoubtedly, the present practice is not satisfactory, as nominations by the Council alone are always liable to lead to undesirable results for very obvious reasons. We hope, therefore, that nominations will come in future from the general body of members as a matter of course, and we are glad to see that the President welcomed Mr. CHAMEN'S action. The only objection that we can see is that members may possibly be disinclined to have their names put down for a ballot which may lead to their rejection, as such must inevitably be the fate of some of the candidates if more are nominated than there are vacancies to be filled.

The Westminster Street Lighting Contracts.

IN our last issue we commented upon the Westminster street lighting contract, and referred to Mr. JACQUES ABADY, the chairman of the Works Committee, as an "out-and-out supporter of gas." We are glad to find that in this statement we were mistaken, and that Mr. ABADY is equally well disposed to electric lighting as to gas lighting so long as it is a case of equal light for the same money. It is highly important that a chairman should be impartial in such matters, for municipal government has often suffered seriously by the neglect of the simple principle that the ratepayers' pocket and interests are what should be kept in view before anything else. We also referred to Mr. ABADY'S views as being "somewhat biased." We came to this conclusion because, in the account of the proceedings, he seemed to lack sympathy with the deputation of shopkeepers who desired electric light to be retained in Regent-street and the decision of the Council to be postponed for further consideration. It appears, however, that there were objections (which were not apparent in his remarks) to the adoption of such a course, and had we been aware of these the expression would not have been used. The essential fact remains that the price quoted by the gas company was much lower than that by the electric light companies for the same light units, and so long as that is the case, and the guarantees are considered satisfactory, a Committee have very little option but to recommend acceptance of the lower tender. It is interesting, however, to enquire why there should be such a disparity in the prices tendered.

DURING the last week the situation has become more clear, as it has been possible to unravel to some extent the basis on which the tenders stand. This remark, however, does not apply to the gas tenders, for the Gas Light & Coke Co. are particularly reticent about the matter. Perhaps this attitude is only to be expected. We understand

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however, that the Gas Company are about to use for the 90 c.p. units a new type of lamp with inverted mantle, the maintenance of which is expected to be much lower than that of the older form of lamp hitherto used. Even so it is pretty clear that the gas is being supplied at a price very much lower than is usually charged. The prices are said to be the result partly of the Gas Company's confidence in recent improvements and partly due to the necessity for regarding street lighting as an advertisement.

In regard to street lighting by electricity the present situation is so important that we offer no apology for dealing with it at some length. Taking into account the great disparity between the tenders of the competing illuminants the question arises whether the electricity supply companies could not have quoted lower prices. During the past week we have taken the opportunity of going into this matter, and through the kindness of the various engineers, we are now able to give, in some detail, the figures on which the contract prices were based. Before doing so, however, it may be as well to point out that the prices for maintenance given in Table III. of the article on p. 66 of our last issue include, in the case of the electricity supply companies, a proportion of the capital charges necessary in connection with the new work—*i.e.*, for laying the mains and services required. The outlay is, in some cases, very large, since some of the districts to be lighted, especially in the area of the Westminster Electric Supply Corpn., are only provided with mains to a small extent, and it would also have been necessary to lay special arc lamp services. For instance, in the case of one particular district in Westminster, in which electric light is fairly generally used, it may be mentioned that over £8,000 would have to be so expended, while in the Pimlico district, where electric lighting is not nearly so general, it would be nearer £18,000.

In turning to the actual cost to the electricity supply companies, it may be well to take as an example the district served by the St. James' & Pall Mall Electric Light Co. This includes not only the lighting of Regent-street, which has loomed large in the discussion on this question, but also a number of side streets where electric lighting is not at present employed to any great extent. Under the conditions of the contract the Company were not able to tender for only a part of the district, and therefore, while they could have maintained lamps in Regent-street itself at a comparatively low cost, this advantage was offset by the high capital expenditure necessary in the rest of the district, so that the average annual charge over the whole area for a 3,000 c.p. unit worked out at £28 on the five-year basis. This figure was arrived at as follows:—£7. 6s. per annum for carbons, £2. 10s. per annum for trimming, and £1. 14s. per annum for repairs. These are actual working costs and are higher than those commonly found in arc lighting, because not only is the required candle-power high but there is a considerable margin, a figure of 3,575 c.p. being obtained on the photometer at ground level. To these costs had to be added that of the current, and a figure on account of the capital expenditure necessary to instal the new system. It was decided to supply energy at ¾d. per unit, but to include the capital charges in the energy charge, which then worked out at 1½d. per unit on the five years, 1¼d. on the 10 years, and 1d. on the 15 years' contract. It will thus be seen that an attempt was made to pay off such capital expenditure as could be charged against the arc lighting within the term of the contract. In the case of the incandescent lighting the same policy was followed, and as the capital charges for mains are, in this case, large compared with the cost of energy, the price per lamp per annum becomes what seems, at first sight, unduly high. On a 15 years' contract the price is naturally much lower than on a 5 years' contract, because the capital charges are spread over a longer period.

From the result of the tenders it is quite apparent that the electricity companies must reduce their costs if they desire to obtain street lighting under the present conditions of competition in London. It will be admitted that the price included for energy was not high, but whether capital charges should be included on the basis considered above is a question that is open to some doubt. We are inclined to think such a policy is not expedient, and that the companies must take the same risks in street lighting as with private consumers, unless they are prepared to drop the former. Tendering was, no doubt, rendered difficult by the fact that in some areas there are mains already in existence, whilst in others there are none. Obviously the price desired would vary with the locality, but an average price has been given to cover the possibility of lamps being required where there are at present no mains. Thus it happens that the price for arc lighting in Regent-street would be raised by the new tenders above the price at present paid. This seems illogical, or at least very undesirable. It is important that the electricity companies should retain the street lighting they at present have, and with this object in view it would seem better to have quoted prices at least not higher than those hitherto obtained, and preferably lower. This course would certainly have involved a risk as to capital charges, but if necessary we think that this risk should be met by co-operation as mentioned in our last issue. The question should be viewed as a whole, and the damaging effect of the return of such thoroughfares as Regent-street to gas lighting must be borne in mind. We repeat that it is a question of advertisement, and as such it may be worth while to adopt a broad policy and even to supply at some loss. We also think that the specification might very well have been drawn so as to allow separate prices to be tendered for the continuance of existing lighting. The letter of the St. James' & Pall Mall Electric Light Co. in another column is of interest and serves to emphasise this point very clearly.

Tramway Reserve Funds.

To have to report decreased revenue is at all times a thankless task for a chairman of any business concern, but when such decrease takes place in spite of the growth of an undertaking, the task becomes increasingly unpleasant. This is, however, the unfortunate position of the London

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United Tramways. In 1906 there were 45 miles of route in operation and the traffic brought in £325,000, whilst, in 1909, with 55¼ miles of route, the revenue only amounted to £317,000, a decrease of £29,000 on that of the previous year. For this unsatisfactory progress, or, to be more correct, lack of progress, two reasons were assigned by the Chairman at the meeting last week—namely, the unfavourable weather (from the traffic point of view) during the past three years, and the competition of railways and omnibuses. During recent years there have undoubtedly been extensive changes in the means of locomotion in the London area, and as the effects could scarcely have been foreseen a few years ago, it is not surprising that the estimates of the directors of the London United Tramways as to the expansion of the undertaking have not been realised. To increase the troubles of the Company the question of renewals is now becoming increasingly important; in fact, it has been found necessary on the present occasion to pass over the dividend on the preference shares and to devote the whole of the profits to the maintenance of the undertaking. The rapid increase in the cost of maintaining the track and equipment, with the possibility of a decline in the revenue due to extraneous causes, render it most important that an adequate reserve fund should be provided in the early days of a tramway undertaking without postponing such steps until the undertaking shall have developed.

In this connection it may be mentioned that the reserve fund of the London County Council tramways has also been brought into prominence during the last few days by the estimates of the Finance Committee of the Council for the current year. These were presented at the meeting of the Council on Tuesday last, when Mr. Hayes Fisher, Chairman of the Finance Committee, announced that a surplus, estimated at £244,132, would be shown by the Council's tramway undertaking on the present year's working. It is proposed to allocate the whole of this sum to the renewals and general reserve funds, which on this basis will together amount by March, 1911, to about £700,000. It is interesting to notice that Mr. Fisher advised the Council to dismiss for the present from their calculations any suggestion of relieving the rates by means of profits obtained from the tramway undertaking. In so doing, however, he did not wish to give the impression that the tramway undertaking was not in a flourishing condition; in fact, he believed its financial position was very satisfactory. In view of the developments which have taken place in the London traffic problem during recent years and the vicissitudes of tramways and other forms of locomotion, we think the Council will be well advised to follow the Financial Committee's recommendation as regards the provision of an adequate reserve fund.

Cable Interruptions.

	Date of Interruption.
Assab—Perim	July 8, 1909
Balik Papan—Kwandang	Nov. 1, 1909
Para—Maranham	Mar. 16, 1910
Malta—Tripoli	April 20, 1910
Para—Pernambuco	April 25, 1910

International Conference of Government Telegraph and Telephone Engineers.—The first conference was held at Budapest in September, 1908, and in The Electrician for February 25th last we gave particulars relating to the next Conference, with a list of the subjects to be discussed. We now learn that the coming Conference will be held from 4th to 11th September inclusive. The French Administration is disposed to hold from 4th to 18th September, in Paris (if a sufficient number of exhibits are entered), a public exhibition of existing automatic telephone systems. It is considered that this exhibition will greatly facilitate the study of one of the principal questions submitted to the Conference. The Administration will, if the suggestion is carried through, provide free space and lighting and will be responsible for the safety of the exhibits, which should include apparatus for at least 100 subscribers and should, as far as possible, represent inter-communication stations. Particulars as to space required must be sent as soon as possible, but not later than May 20th, to M. le Ministre des Travaux Publics des Postes et des Télégraphes de France (Direction de l'Exploitation Téléphonique, 103, rue de Grenelle, Paris).

Systems of Charging for Electric Light.—We have received from Mr. A. H. Seabrook a copy of a pamphlet with this title, which has been issued by the St. Marylebone electricity department for the benefit of consumers and prospective consumers of electrical energy in the borough. The pamphlet contains a brief explanation, in as non-technical language as possible, of the "maximum-demand" and "telephone" systems of charging. After describing the principle of the maximum-demand indicator and the basis on which the consumer's bill is made out on this system, it is shown how much simpler is the "telephone" system of charging, all that is necessary being that the consumer must fill up a form (or let the electricity department's representative do this) stating the particulars of the lamps installed. From the number and candle-power of these lamps the annual fixed charge is determined, and for all energy consumed a further charge of 1d. per unit is made. In addition to simplicity, other advantages of this system are: (1) The consumer knows within about 10 per cent. what his annual bill will be; (2) no special wiring or meter is necessary if electrical apparatus such as irons, kettles, stoves, fans, &c., are installed. It should be noted that a small annual charge is made for each piece of apparatus installed; thus, for an electric iron the annual charge (payable in advance) is 5s., whilst for a four-lamp radiator the consumer would be required to pay £1, the energy consumed, of course, passing through the lighting meter and being paid for at 1d. per unit. An annual sum of £2. 2s., however, allows a consumer to instal as much heating and other electrical apparatus (apart, of course, from lighting) as he wishes. It should be noted that the "telephone" system can only be applied to premises where electricity is used throughout for lighting purposes. It is, however, a distinct advance in methods of charging, and should do much to popularise still further the use of electric lighting and all forms of electrical apparatus. The fact that £7,000 has been received in St. Marylebone in annual charges payable in advance since this system came into use is an excellent testimonial to its value. Systems of charging, especially the maximum-demand system, are a stumbling block to the lay mind, and we do not doubt that this pamphlet will do something to clear up such difficulties.

Grants to University Colleges.—There was issued last week the report of the Advisory Committee who have been considering the disposal of the unallocated balance of the Treasury grant for 1909-10, after payment of the general grants to recognised colleges. With a view to the approaching reallocation of grants for the quinquennium beginning with the financial year 1910-11, the Committee have had under consideration the question whether any new colleges should be added to the list of those which participate in the Treasury grants. The following colleges have therefore been inspected: Royal Albert Memorial College (Exeter), East London College,

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Birkbeck College and Hartley College (Southampton), the last-mentioned college being in receipt of a temporary grant.

The Committee first draw attention to some general considerations. They state that "Besides some institutions in London, there are several in various provincial centres of population which offer facilities for study and instruction of a university standard, both in pure science and in literary subjects, and that students attending them do, as a matter of fact, obtain the instruction they require in preparation for intermediate and final university examinations. Some of these institutions are in more or less intimate connection with the local university; others at present depend upon the external examinations of the University of London. These institutions do not in all respects satisfy the conditions which have been laid down as required to justify inclusion in the list for university college grants, but they are practically local colleges, performing a useful function as centres of literary culture as well as of technical or professional education. They deserve direct encouragement in this work, but it would be a misfortune to offer that encouragement in a way or on grounds which would tend to lead them out of their proper line of development as local colleges under distinctly municipal management. Such a policy, if carried out in advance of any real demand, is likely, instead of raising the general standard of the institutions as a whole and widening the range of learning and intellectual interest in the centres which they serve, to result in the provision of inferior university courses—inferior, that is, to those which exist in an institution where experience has shown that real university work can be carried on as the centre of intellectual life over a wide area. The growth of a true university institution is a slow business, is likely to be hindered rather than promoted by attempts at hasty development, and is certain to fail if such higher instruction as the neighbourhood is ready and anxious to receive is not made the basis of its development." On these considerations the Committee are unable to advise that the Hartley College, Southampton, should remain permanently on the list of university colleges in receipt of a Treasury grant. In order that the work of the college may not suffer during a transitional period they recommend that the grant, reduced to £1,500, be continued for the year ending March 31, 1911, but no longer. The Committee are also unable to recommend that the Royal Albert Memorial College, Exeter, and the Birkbeck College should be added to the list of university colleges receiving Treasury grants; but they recommend that the East London College should be awarded a grant, provided: (1) The college continue to be recognised as a school of the University of London; (2) that it be incorporated as a public educational institution; (3) that after such change by scheme in its standing and constitution as may be required, the resources of the college be sufficient for its support as a university college in accordance with the conditions prescribed by Section A of the Treasury Minute of June 3, 1909. The recommendations of the Committee have been approved.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. J. Rezelman contributes an article on "Leakage Reactance."

At the Institution of Electrical Engineers yesterday evening a Paper was read by Mr. W. W. Wood on "Earthed *versus* Insulated Neutral in Colliery Installations."

Last week the Friday evening discourse at the Royal Institution was delivered by Mr. T. Thorne-Baker, the subject being "The Telegraphy of Photographs, Wireless and by Wire."

Baku (Russia) municipality has recently raised a loan of 27 million roubles for electricity supply, electric tramways, &c.

It has been decided to convert the Northern Leopoldina (Brazil) Railway to electric traction.

The Southern Nigeria Railway Co. are about to raise a loan for an electric power station, for the construction of electric tramways at Dairen, &c.

Leicester Corporation have decided to put down additional generating plant at the tramways power station, at an estimated cost of £19,190.

London County Council recently communicated with Hackney Borough Council on the period of the loans sanctioned for the electricity undertaking, and suggested that instead of building up a large reserve fund it would be advisable to reduce the period of the current loans to periods equivalent to the terms now allowed by the County Council.

At the annual dinner of the Midland branch of the Electrical Contractors' Association last week the secretary, Mr. L. G. Tate, announced that his Association was in negotiation with the Association of Municipal Corporations to see if some understanding could be arrived at.

Hampstead (London) have decided to dispose of some of the existing plant at the electricity works and to obtain tenders for new plant at a total cost of about £18,000.

Legal.—The proceedings before Mr. Justice Parker, on a motion by the Corporation of London to prevent the County of London Electric Supply Co. from opening up London Bridge for the purpose of laying mains to link up the Company's southern and northern generating stations, were interesting from the fact that they show how London Bridge, although an important public thoroughfare, is held by the City Corporation to be outside any possible area of electricity supply at present constituted—that is to say, until certain very primitive formalities have been gone through, London Bridge can offer successful opposition to the connection of the north and south of London electrically.

INSTITUTIONS AND SOCIETIES.

Institution of Civil Engineers.—At the annual general meeting last Tuesday the result of the ballot for the election of officers was declared as follows: *President*, Mr. Alex. Siemens; *Vice-presidents*, Dr. W. C. Unwin and Messrs. R. Elliott-Cooper, A. G. Lyster and C. A. Brereton; *Members of Council*, Mr. J. A. F. Aspinall, Mr. B. H. Blyth, Mr. J. A. Brodie, Mr. W. B. Bryan, Col. R. E. B. Crompton, Mr. W. Davidson, Mr. E. B. Ellington, Mr. M. Fitzmaurice, Mr. J. P. Griffith, Sir A. Hadfield, Dr. C. A. Harrison, Mr. W. Hunter, Mr. G. R. Jebb, Mr. H. E. Jones, Sir W. T. Lewis, Mr. H. D. Lumsden, Sir T. Matthews, the Hon. C. A. Parsons, C.B., Mr. Alex. Ross, Mr. J. W. Shores, Mr. F. J. E. Spring, Mr. J. Strain, Sir F. R. Upcott, Sir P. Watts, Mr. W. B. Worthington and Mr. A. F. Yarrow.

It is announced that the 18th "James Forrest" Lecture will be delivered at The Institution on Wednesday, June 22nd, at 8 p.m., by Sir John Gavey, C.B., his subject being "Recent Developments of Telegraphy and Telephony."

Glasgow Section of the Institution of Electrical Engineers. At the meeting of this section, held on Tuesday, April 12th, the following nominations for the committee of the section for the session 1910-11 were made: *Chairman*, Mr. Sam Mavor; *Vice-Chairman*, Mr. J. A. Robertson; *Hon. Secretary and Treasurer*, Mr. J. E. Sayers; *Committee*, Messrs. W. McWhirter, T. B. Murray, T. C. Parsons and J. Ferguson.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, April 29th (to-day).

Students' Section of the Institution of Civil Engineers.

Visit to Southampton Docks, and to Messrs. Harland & Wolff's Engineering Shops.

TUESDAY, May 3rd.

Electro-Harmonic Society.

4:30 p.m. Annual General Meeting at the Institution of Electrical Engineers, 92, Victoria-street.

WEDNESDAY, May 4th.

Students' Section of the Institution of Electrical Engineers.

7:45 p.m. Annual General Meeting at 92, Victoria-street, S.W. The Paper announced to be read at this Meeting has been cancelled.

THURSDAY, May 5th.

Institution of Electrical Engineers.

8 p.m. Meeting at the Royal Society of Arts, John-street, Adelphi. Paper on "A Telephone Relay," by Mr. S. G. Brown.

Röntgen Society.

8:15 p.m. Meeting at 20, Hanover-square. Paper on "Quantitative Measurements of the Conversion of Cathode Rays into Röntgen Rays by Anticathodes of different Metals," by Mr. J. H. Gardiner.

IRON AND STEEL INSTITUTE.

Wednesday and Thursday, May 4th and 5th.

10 a.m. Meetings at the Institution of Civil Engineers, Great George-street. Among the Papers to be read are the following: "On the Girod Furnace and the Electric Smelting Works of the Paul Girod System," by Prof. W. Borchers; "On the Progress of Electric Smelting," by Mr. D. F. Campbell, and "On Developments in the Production of Electric Power; Its Application and Bearing upon the Iron and Steel Industries," by Mr. D. Selby Bigge.

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, May 2nd, "A" Company.—Recruits Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 9:30 p.m.

Tuesday, May 3rd, "B" Company.—Company Drill, 7 to 9:30 p.m.

Wednesday, May 4th.—Gymnasium, 6 to 9:30 p.m.

Thursday, May 5th, "C" Company.—Recruits Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 8 p.m. Technical Drill, 8 to 9:30 p.m.

Friday, May 6th, "D" Company.—Company Drill, 7 to 8:30 p.m. Technical Drill, 8:45 to 9:45 p.m.

Saturday, May 7th, "D" Company.—Company Drill, 3:15 to 4:15 p.m.

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EARTHED *VERSUS* INSULATED NEUTRALS IN COLLIERY INSTALLATIONS.*

BY W. WELLESLEY WOOD.

Summary.—The author discusses in detail the advantages and disadvantages of working in a three-phase colliery installation with an earthed as against an unearthed neutral. Although a hard and fast rule cannot be laid down, he concludes that generally an insulated neutral is better where permanent plant is at work and the cables are not liable to injury. Where portable machines are used or cables are liable to damage, automatic devices may be installed. A separate transformer with earthed neutral might be used to supply this plant.

A great deal of attention has recently been attracted to the question whether a three-phase colliery installation should work with an earthed or insulated neutral, and not only are there a number of supporters of both systems, but also a number of long-standing examples of each at work both on high and medium pressures, and with current taken in some cases from a supply company and in others from their own generating plant. Conditions vary so greatly in collieries and mines that what is suitable and perhaps necessary in one case may be absolutely dangerous in another. The principal advantages of each system are as follows:—

Earthed Neutral.—(1) Maximum potential to earth of any phase limited to 58 per cent. of line voltage. (2) Leakage to earth probably results in isolation of the damaged circuit. (3) Leakage tripping devices can be used which switch off the supply when an earth occurs on one phase, reducing danger of shock and explosion.

Insulated Neutral.—(1) Danger of shock and explosion is reduced, as contact with earth and one phase does not complete the circuit. (2) An earth on one phase does not cause an interruption of supply, for the same reason. (3) Stress on insulation under normal circumstances is less, and liability to flash to metallic casings considerably less. (4) Only two-trip coils instead of three are required to protect each circuit where an automatic switch is installed.

Power Taken from a Supply Company.—As the principal consideration is the safe operation of the underground plant, it is only proposed to consider briefly how the question affects generating machinery and transmission lines. Many collieries now take their power from a supply company, and where such an installation is connected without the intervention of a transformer, advantages (1) and (2) of the insulated system are minimised, as an earth on any part of the supply company's mains (possibly in another colliery) will have the same effect as an earth on the installation, but be beyond its control. Under such circumstances, and particularly where the voltage is high, say 5,000 or over, it is probably better to earth the neutral so that a faulty installation is isolated, and the stress to earth on healthy plants kept permanently at 58 per cent. of the line volts. In a high-tension installation the factor of safety of the installation is often small, and the sudden rise of pressure produced by an earth on one part of the system may damage the insulation of another part or cause a flash-over on motors. Where the supply is transformed the colliery circuit is a separately insulated one, and the above does not apply.

Generating Plant.—As far as the generating plant is concerned (where a colliery has its own supply) the earthing or insulating of the neutral makes very little difference, as although with alternators in parallel triple-frequency currents may give trouble with an earthed neutral, this can be got over by only earthing the neutral of one generator, or by the introduction of choking coils, and this point was discussed in Mr. Rider's Paper on the London County Council tramways. The conditions, moreover, under which most colliery stations work are less strenuous than in those of a supply company, where interruption of the service affects a large number of concerns, so that the earthing of one generator at a time would probably work satisfactorily.

Transmission Lines.—As far as transmission is concerned, the question of earthed *versus* insulated neutral is a very open one indeed, especially on voltages under 20,000, and the President of the High Tension Committee of the American Institute of Electrical Engineers, in opening the discussion on this subject, puts his conclusions as follows: "That some plants earthed the neutral, and its engineers considered it safe, and would never think of running in any other way, whilst the engineers of plants which did not earth the neutral would never think of doing such a thing."

Where the neutral is earthed, it has sometimes been found possible in emergencies to keep up the supply with two lines and an earth return, while with an insulated system the supply can be maintained with an earth on one phase, if the insulation of the system has a sufficient factor of safety to withstand the full-line voltage between any part of it and earth. These points are of more importance on a supply company's system than on the average colliery installation. Before considering the underground plant it is interesting to note that under certain conditions it is possible to get the full line voltage to earth in two phases of a system even with the neutral earthed on both high and low-tension sides of the transformers, if these are connected star to star, and the generator neutral is insulated. This is due to the instability of the neutral point under such conditions. Very often the first indication of anything wrong is the arcing of the lightning arresters.

Underground Plant.—The chief considerations in the underground plant are safety as regards shock and explosion, reliability and simplicity in working, and cost both of the installation and maintenance of the same.

Danger from Shock.—Although even on a perfectly insulated system of large size, or working at high pressure, it is possible to get a severe shock from the capacity effect alone, and without any actual circuit being completed, there is no doubt that on such a system there is less danger of fatal results from accidental contact with one live phase and earth, and particularly so on medium pressure installations. It must be noted, however, that very often on these medium-pressure systems the neutral point is connected to earth through the resistance of the leakage indicator. This resistance is generally designed to pass several hundred milliamperes, which is sufficient to give a fatal shock, and while it is, of course, much safer to get a shock in series with such a resistance which limits the current, this danger can be reduced by using the same electrostatic type of indicator usually supplied for higher voltages, or by the Nalder type of instrument which only passes a few milliamperes. Considered from this point of view there is no doubt that a system with earthed neutral presents greater dangers.

Limitation of Voltage.—With an earthed system the voltage between any point and earth cannot exceed 58 per cent. of the line pressure, but as fatal accidents have occurred with voltages as low as 150, this limiting of the voltage is not of any very great advantage, particularly in a colliery where the conditions are such as to make the men specially susceptible to the effects of electric shock.

Earthing of Metal Casings.—The best protection against the danger of shock from conducting bodies does not lie either in earthing or insulating the neutral, but in properly protecting or enclosing all live parts, and in efficiently earthing to the surrounding ground all motor frames, switch cases, &c. The earth wire should be large enough safely to carry the load which will blow the fuses of the plant it protects, and it should be frequently tested for continuity. In a dry pit it is often difficult to get a good earth connection, and to meet this difficulty some engineers carry either a separate cable or core for earthing purposes only, but this method may possibly be a source of danger unless the system is also earthed underground. For example, on a three-phase system with an earthed neutral, and an earth-plate at the generating supply end, a leak takes place near the motor on one of the outers. This motor is at work in a more or less insulating stratum, so that the resistance from the ground to the earth-plate at bank (except through the earth wire) is very high. The motor makes bad contact with the ground on which it stands, and there is a very considerable difference of potential between this ground and the motor. Anyone standing on this ground and touching the motor-case will get a possibly fatal shock. If the neutral is insulated it is necessary to have a leak on one of the other phases at bank before the same conditions can apply. It may be thought that this is a rather exaggerated case, but a non-fatal shock on somewhat the same principle as outlined above, and due to variations in the resistance of the strata, occurred recently in a colliery in Scotland, and on measuring the resistance between an earth-plate at bank and an earth connection at the bottom of the shaft, this was found to be 300,000 ohms. With regard to this question of earthing, Messrs. J. G. and R. G. Cunliffe, in a very interesting Paper read before the Manchester local section, have shown that the resistance of an earth-plate is often very considerable, and that apart from the intervention of non-conducting strata the resistance between two plates each 1½ ft. square, and arranged 200 ft. apart, may be about 30 ohms, so that a leakage current of a few amperes would cause a big drop in potential. Another very important point is that nearly 50 per cent. of this drop occurs within 3 ft. of the plates. It appears all the more necessary, therefore, in earthing the metallic dead portions of any system to provide several earth-plates distributed over the installation. Also, Messrs. Cunliffe's results show that there is no great advantage in making each plate more than about 4 sq. ft. in area.

Danger of Faulty Insulation.—There is, however, a possible danger

* Paper (slightly abbreviated) read before the Institution of Electrical Engineers last night and before the Newcastle local section on Monday last.

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of shock which cannot be guarded against in this way, and that is by coming in contact with faulty insulation, such as an unarmoured damaged cable. With an earthed system shock as before is certain, with an insulated system it is likely to be less severe. Where cables are armoured or enclosed in a metallic covering this danger cannot occur as long as the armouring or cover are efficiently earthed and electrically continuous. If, however, a careless jointer leaves the armouring disconnected after a hurried repair, or the armouring is eaten away by bad water, &c., the conditions are now more dangerous than before, as an earth may cause a considerable length of armouring to be alive, any part of which will give a shock. For this reason many colliery engineers object strongly to the use of armoured cables as being likely to produce a false feeling of security.

Danger from Explosion.—It is very doubtful whether many colliery managers would instal electric plant at all in places where there is real and constant danger of inflammable gas or coal dust, as it seems fairly certain from recent experiments that an arc or flash with any moderate amount of power behind it will ignite either gas or coal dust in suspension if present in suitable proportions. With an earthed neutral failure of the insulation of one phase to earth is practically bound to produce such a flash, while with an insulated system an earth on one phase shows on the leakage indicator, and there is, at any rate, a greater chance of isolating the section before any arc occurs.

Reliability of Supply.—It is sometimes desirable to run certain plant, even although it may be in a damaged condition. The stoppage of, say, a main haulage gear will disastrously affect the day's output of coal—a matter of very great importance to the colliery manager—and very possibly if the plant can be kept going for a few hours till the end of the shift the fault can then be remedied without disorganising the working of the pit. In many such cases it may be perfectly safe and advisable to run, and as the majority of failures of colliery plant are leakages to earth, an installation with earthed neutral is likely to give more trouble than an insulated system. If leakage trips are indiscriminately used, it is probable that unnecessary interruptions from trivial causes may be sufficiently troublesome to prejudice the manager against electricity and lead him to adopt some other motive power.

Leakage Tripping Devices.—Several very interesting devices have been recently put on the market arranged to cut off current as soon as any leakage current exceeding, say, $\frac{1}{4}$ ampere flows. They are only designed for use on a system with a neutral earthed either directly or through a resistance, and the current at which they operate can be adjusted to different values on different feeders as may be required. It is claimed that by using such switches in connection with armoured cables danger from shock and explosion is largely avoided, and Mr. Wedmore, in a Paper read at Barnsley, gave the results of some very useful experiments on cables which tended to show that with such a device and armoured cables it was very unlikely that a fall of the roof could so damage the cable as to cause flashing or arcing externally. Even without the leakage trips and with only the ordinary overload devices it appeared to be generally necessary to subject the cable to "successive blows of a heavy hammer" before flame occasionally issued, and apparently also high-tension supply was safer in this respect than medium pressure. In case a cable were actually suddenly severed, it seems hardly possible that a flash of sufficient energy to ignite an explosive mixture could be avoided, whether a leakage trip was installed or not, and particularly if the point of failure was comparatively near generating plant of large capacity. It must be borne in mind, however, that many cables are run in places where there is no danger of explosion or of mechanical injury. It must be also noted that these devices depend absolutely on the continuity of the armouring or earthing being maintained, and if through carelessness or other cause this is not done they afford little protection against explosion and practically none against shock. A motor standing on concrete foundations is on a very good insulator, and if the earth connection is broken or inoperative insufficient current would flow to operate the leakage trip in case of leakage to the motor frame, which would then be raised above earth potential. We have previously seen that as long as earth connections are kept in good order there is no danger of shock from motor or switch casings or armouring, so that while there are undoubtedly many cases in which a leakage device may be of considerable use there are also many others where it would not justify the increased expenditure and would probably prove rather a nuisance. These devices, moreover, do not protect against shock from live terminals or from contact with a high-resistance leakage.

Simplicity of Installation.—In the author's opinion the simpler the installation can be made the more likely it is to be kept in good working order, and it has generally been found in the past that it is better to rely upon having good men to look after the plant and see that small details such as earthing, &c., are properly attended to than on automatic appliances.

Stress on Insulation.—As long as a system with insulated neutral is in good order the stress on the insulation is 16 per cent. less than on an earthed system, so that under equal conditions its factor of safety is greater. There is no doubt also that much greater clearances and creeping distances to all metal work must be provided where the neutral is earthed, to give the same factor of safety as on insulated systems. The advantage of the earthed system is that an earth on one phase soon isolates the faulty part, and does not increase the stress on the other parts of the system, while a similar occurrence on an insulated system doubles the stress on the other places and is likely to cause further breakdowns. This point is of greater importance on extra high voltages.

Cost of Installation.—While not necessarily the first consideration, the question of cost in all engineering problems is of very great importance and one that will not be neglected by the colliery manager, whose business it is to get the best possible financial results. Where automatic oil switches are used, three relays, one in each phase, are needed with an earthed neutral, and only two with an insulated neutral. If many switches are needed, the difference in first cost may be considerable. The cost of armoured cable is often nearly double that of unarmoured, so that if these are run in places where there is is no danger of accidental contact, damage from falls of roof or sets off the line or of explosion, armouring is an unjustifiable expense. The cost of maintenance is generally of greater importance than first cost, and it is here that the simplicity of the installation is of primary importance.

Conclusions.—No hard-and-fast rules can be laid down, and every case should be considered broadly on its merits, but it certainly seems that generally an insulated neutral is better where permanent plant is at work and the cables are not very liable to mechanical damage. Where portable machines such as coal-cutters are used, or where cables are liable to frequent hard usage, it may be worth while to use automatic devices; and in this case, if a separate transformer were used to supply this plant, its neutral could be earthed (and preferably through a resistance) without interfering with the remainder of the system. Such devices, however, will require constant inspection. There is another very important case which has not so far been considered, and that is where small lighting transformers are used. It would seem desirable to limit the secondary pressure of these to 110 volts and connect either the neutral or one side directly to earth. Finally, the author wishes to disclaim any sympathy with the present scare in regard to the use of electricity in mines. It is necessary in a Paper of this sort to consider how accidents can and may occur, but the number that actually do occur is extraordinarily small considering the present widespread use of electricity and the insufficient electrical staff employed in many collieries. The average number of deaths caused by the use of electricity in mines appears to be about 1 per cent. of all the accidental deaths in such places, and many of these cases have been due simply to pure accident or carelessness which nothing could have prevented.

TELEGRAPHY OF PHOTOGRAPHS, WIRELESS AND BY WIRE.*

BY T. THORNE BAKER.

Summary.—The lecturer first describes the telectrograph system as used by the "Daily Mirror," explaining the method of overcoming the effect of capacity in the lines. He then refers to the work of Prof. Korn with selenium cells, and finally gives particulars of the experiments in wireless transmission upon which he (the lecturer) has recently been engaged.

It frequently happens that when two alternate processes are available for certain work, and one of them is considerably less practical than the other, that the less practical one is possessed of much higher scientific interest. This may certainly be said of the telegraphy of pictures and photographs. The whole of the methods of transmission can be classed as either purely mechanical, or dependent on the physical properties of some substance which like selenium, is sensitive to light. The latter methods are of no little scientific interest, and, although very delicate and for the moment obsolete, there is every likelihood of their coming into more extended use later on.

I propose to deal with the practical more system first. The telectrograph system has been employed by the "Daily Mirror" for

* Abstract of a lecture delivered at the Royal Institution last Friday evening.

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the transmission of photographs since July, 1909, and has been worked very regularly between Paris and London, and Manchester and London. The method of telegraphing photographs that has been employed on a large scale by the "Daily Mirror" may be called a practical modification of several early attempts. The effect of an electric current to discolour certain suitable electrolytes or to set free an element or ion that can be used to form with a second substance a coloured product was employed in many early forms of instruments for telegraphing writing, &c. If we break up a photographic image into lines which interrupt the current for periods depending on their width, these interrupted currents can be used at the receiving station to form coloured marks which join up *en masse* to form a new image. My telectrographic process is thus briefly as follows :—

At the sending station we have a metal drum revolving under an iridium stylus, to the drum being attached a half-tone photograph printed on lead foil. Current flows through the photographic image to the line and thence to the receiver. The receiver consists of a similar revolving metal drum over which a platinum stylus traces. Every time the transmitter stylus comes in contact with a clear part of the metal foil current flows to the receiver, and a black or coloured dot or mark appears on the chemical paper. But you will readily understand that if our reproduction—built up of these little marks, which have to be made at the rate of some 200 per sec.—is to be accurate, each mark must be only exactly as long, in proportion, as the clear metal space traversed by the stylus.

It will be easier to explain the system by means of the rough diagram shown in Fig. 1. A metal drum is revolved by a motor, one revolution every two seconds ; over this a metal stylus or needle traces a spiral path in the same way as a phonograph. On the drum is fixed a half-tone photograph broken up into lines, and printed in fish glue upon a sheet of lead foil (in these line photographs the light and shade of the picture is made up of masses of thinner or thicker lines, with clear spaces in between). As the stylus traces over such a photograph, its contact with the metal base is interrupted every

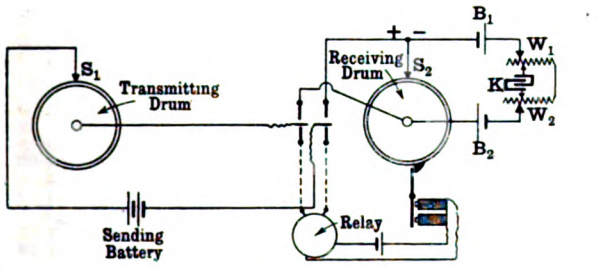

FIG. 1.

time one of these fish-glue lines comes beneath it, and for such a time as depends, of course, on the width of the line. The transmitting instrument thus sends into the telegraph lines a series of electric currents whose periods of duration are determined by the width of the lines composing the photograph. A similar stylus S_2 traces an exactly similar path over a revolving drum in the receiving instrument, but round this drum is wrapped a piece of absorbent paper impregnated with a colourless solution, which turns black or brown when decomposed by an electric current. What happens then is that every brief current which passes through the paper causes a mark to appear on it. The width of the mark depends on the duration of the current—or should do—so that these marks gradually combine to recompose the photographic image.

This method is all very well in the laboratory, but when we come to try it over a long distance the capacity of the line at once causes serious interference. If the circuit be closed by means of a Morse key, the time of contact at the key being $\frac{1}{6}$ sec.,—a common time of duration of a short tap—the discharge of current from the cable would be considerably longer than $\frac{1}{6}$ sec. When, therefore, we are sending signals through the line at the rate of 175 per sec., it is not difficult to see that every signal will run into the next dozen or so at the receiving apparatus, and the result will be a hopelessly confused mass of overlapping marks. The use at the receiver of what I have termed a line balancer, a modified form of shunt apparatus embodying the principles of *wiping out* residuary currents from the cable in the way frequently made use of in duplex telegraphy, has rendered commercial the old ideas of telegraphing by the electrolytic method, and as many as 300 sharply defined chemical marks can be recorded in 1 sec. by its means. The method of application will be seen from Fig. 1, here shunted on to the line (which is closed by the stylus S_2 and the metal drum) is a circuit containing two batteries B_1 and B_2 and the two sections of a divided 1,000 ohms resistance, W_1 and W_2. Shunted across the variable contacts of the resistances is a variable condenser K. By varying the resistances W_1 and W_2 we can vary the power of the current used to sweep out the residuary charges in the line ; the current can, of course, flow through the chemical paper on the drum, but the pole of the battery B, connected to the stylus is of opposite sign to that of the line unit connected to it. When the leakance on the line is great and evenly distributed, less reverse current from the balancer is necessary, this being quite in accordance with Heaviside's formulæ for telephony over lines with capacity and inductance. It is interesting to note, also, that by increasing the voltage of the reverse batteries, B_1 and B_2, considerably greater contrast can be obtained in the pictures ; the finer the half-tone screen employed in splitting up the photographs into lines, the higher, again, must the voltage of B_1 and B_2 be made.

The lecturer here again referred to the actual utility of photo-telegraphy. News is telegraphed in order to expedite its publication, and photographs illustrating this news can therefore be telegraphed advantageously. But where a large installation and establishment with accumulators, a large instrument and an operator to work it are required, the cost of telegraphing every individual picture becomes quite out of proportion to its value. The lecturer therefore called especial attention to portable instruments, the first one of which was shown. A photographer going to obtain pictures of some important function or interesting event can take this machine with him, prepare his pictures and telegraph them to his head office, and when the event is over return with the apparatus. For criminal investigations the portable instrument should become of considerable value. Through the continued courtesy shown by the Postmaster-General and Major O'Meara every facility has been given for developing the work, and the uses of the portable instrument should before long have been amply demonstrated.

If a picture revolving beneath a tracer has to redraw itself, as it were, on a piece of paper perhaps hundreds of miles away, it is obvious that each mark redrawn must occupy a precisely similar spot on the new paper as it does in the original picture. As cylinders or drums are used in picture telegraphy, this means that they must revolve in perfect unison. The method of synchronising used by

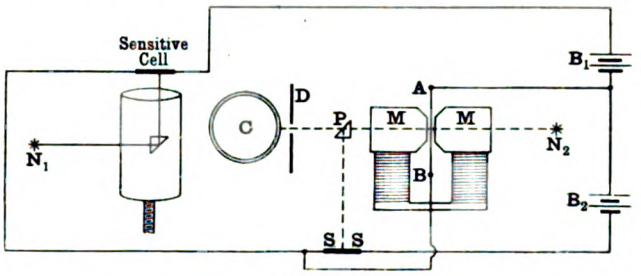

FIG. 2.

Prof. Korn has proved very satisfactory, and has been adopted in practically all systems of phototelegraphy. The motors which drive each drum are run at about 3,000 revs. per min., and geared down very considerably, so that the drums themselves revolve, perhaps, at 30 revs. per min. ; the motors are run from secondary batteries and should be run for a sufficient time before beginning a transmission to allow of their warming up. The speed of each motor is controlled by a regulating resistance in series with the field magnets, and the speed is ascertained by means of a frequency meter.

The receiving drum is revolved a little quicker than the transmitting drum. It consequently completes its revolution before the transmitter. It is then stopped by a steel check, and is obliged to wait until the other drum has caught it up. When the transmitting drum has completed its turn, a fleeting contact comes into play, a reverse current is sent to the receiving instrument, this is led into a polarised relay which actuates an electromagnet, and this magnet removes the check. Thus both drums must always start off in unison for each new revolution. I have found that where each operator endeavours to keep his motor running uniformly by regulating the resistance according to the fluctuations recorded by the frequency meter, the personal element makes itself visible in the results ; straight lines appear wavy, and the synchronism is not at all good. I therefore tried very carefully calibrating the motors by timing first, and then arranged that, once started, the motors should not be touched ; the gain in speed of each is approximately the same if both motors are run from secondary batteries of the same ampere-hour capacity, and in this way we have obtained the most perfect results as regards synchronisation.

The great advantage of this process is that the whole operation is in full view, whereas with systems in which the received picture is obtained on a photographic film one has to develop such film before it is possible to discover whether anything is wrong. With the receiver described, the operator keeps his hand on the sliding contact of the resistances, and merely adjusts their position during the first two or three seconds according to the condition of the

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electrolytic marks—*i.e.*, whether crisp and concise or not. The transmitting cylinder can be used as the receiving cylinder, and the apparatus is thus reduced to the limits of simplicity.

Towards the end of last year I designed a portable machine, two of which Mr. Sanger-Shepherd has just completed, embodying in them a number of improvements of his own, and these machines, which have worked successfully on their trials, are shown. They are suitable for line or wireless work, and will, I believe, prove of great value in naval and military operations.

The "Daily Mirror" inaugurated the Paris-London photographic service in November, 1907, with Prof. Korn's selenium instruments. In this system use is made of the fact that the electrical resistance of the metal selenium varies according to the strength of illumination to which it is subjected, a beam of light passed through the light and dark parts of a photograph in succession being used to vary the strength of an electric current sent to the receiving apparatus. The transmitter light is concentrated from a Nernst lamp to pass through a revolving glass cylinder, round which a transparent photograph (printed on celluloid) is fixed, the beam traversing the film at its brightest part, where the rays come to a focus. The light which passes through the picture is reflected by a prism inside the cylinder on to the selenium cell, through which the current passes. Across the circuit is shunted a galvanometer of the Einthoven pattern, containing two fine silver strings free to move laterally in a strong magnetic field. These are represented by AB, the magnet poles being MM. When a bright part of the photograph admits of light falling on the sensitive cell current passes through AB, and it shifts aside, allowing light from a Nernst lamp N_2 to enter the prism P, whence it is reflected on to a second cell SS. The telephone lines connecting the two instruments go direct to the wires of a similar galvanometer, which is in series with the galvanometer of the transmitting instrument. If we imagine MM to be the receiving galvanometer, then we remove the prism P, and the light acts on a sensitive photographic film attached to the drum C, which revolves synchronously with the glass cylinder of the sending instrument.

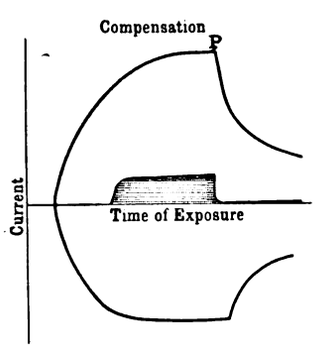

FIG. 3.

The inertia of selenium once overcome, the metal immediately becomes of great use for many purposes. Prof. Korn's method of compensation is to let the light fall at the same time on two cells of opposite characteristics; one has great inertia and small sensitiveness, the other low inertia and great sensitiveness. By using the two cells on opposite sides of a Wheatstone bridge, dividing the battery into two parts for the other sides, the deflection in the galvanometer is very rapid. The effect is shown in Fig. 3. The curve above the axis along which exposure is measured relates to the sensitive cell, that below this axis, to the cell of low sensitiveness. Clearly the current passed through the galvanometer is that obtained by joining the sums of the ordinates. This gives the small curve shown as the shaded portion. When the illumination is thrown on the cell the current rises very rapidly instead of gradually, whilst when it is suddenly shut off (at P in the upper curve) it drops to zero almost instantly instead of falling gradually. This enables the cells to be used for the purposes of photo-telegraphy, where at least half a dozen changes per second are required to be recorded abruptly, even in transmitting the simple portraits to which the selenium process is limited.

This compensated arrangement of selenium cells at once renders their use of practical value for various physical and optical measurements. Prof. Korn has found that for an increase in the illumination δI, the current obtained is given by the equation $y = a \cdot \delta I \cdot e^{-\beta t^{-\frac{1}{m}}}$, where y is the current, a the sensitiveness of the cell, β and m its inertia constants, and e the base of Naperian logarithms. For two cells to be combined to the greatest advantage we must have them such that if their equations are respectively

$$y_1 = a_1 \delta I \cdot e^{-\beta_1 m^{-\frac{1}{t}}} \text{ and } y_2 = a_2 \delta I \cdot e^{-\beta_2 n^{-\frac{1}{t}}}, \text{ then } \frac{d(y_1 - y_2)}{dt} = 0.$$

This makes the condition for good compensation that $a_1 \beta_1 = a_2 \beta_2$; m is usually almost constant, and with suitable Giltay cells is about 2·3. In practical language, the condition for compensation is that the principal cell should have great sensitiveness and a small inertia constant, the compensation cell low sensitiveness and a high inertia constant, the product of sensitiveness and inertia constant being the same in the case of both cells.

The physical properties of selenium are of such importance that I feel I may be allowed to digress for a few moments to show one way in which they may be utilised to solve a problem that has long occupied many investigators—viz., the satisfactory measurement of the beam of heterogeneous rays from an X-ray tube. If the X-rays fall on a fluorescent screen of barium platino-cyanide, the screen absorbs them and emits yellowish-green visible rays; this transformed energy is capable of affecting a very sensitive selenium cell when placed in contact with the screen, the resistance becoming less the greater the fluorescence. I will take a selenium cell of approximately 395,000 ohms resistance, over which is placed a small fluorescent screen of the same size; the cell is put in series with a battery of 100 volts pressure, and a milliampere meter, the divisions of which may be made to correspond to some arbitrary scale, or to the time necessary for the exposure of a given make of photographic plate. The dividing of the scale depends on two things: first, the characteristic curve of the selenium cell connecting its resistance with the strength of illumination, the linear distance of the source from the cell being in this case the most convenient to employ. Secondly, this characteristic curve must be modified to meet the case of illumination by the rays from the anti-cathode, which do not necessarily diminish in their power to make the screen fluoresce as the square of the distance from it. Fig. 4 shows the characteristic curve of a selected selenium cell for feeble illumination, the maximum being of about the same wave-length as that of the fluorescence, showing the relation between the current and distance separating the source of illumination and the cell; and Fig. 5 the modified curve showing a similar relation between the current and distance between anti-cathode and cell, with the screen in contact. The portion of the first curve most nearly asymptotic is best to employ for the work, and from the second curve the scale of the meter can be easily calibrated. The actual instrument is provided with a scale divided so as to show

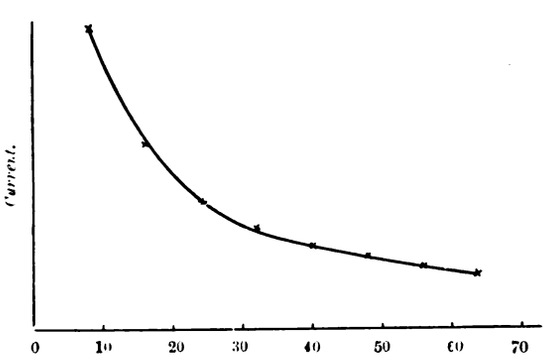

FIG. 4.—CURVE SHOWING EFFECT OF FEEBLE ILLUMINATION ON THE RESISTANCE OF SELENIUM. Giltay Cell.

Resistance of Unilluminated Cell, 395,000 ohms.

comparative times of exposure, and by its use radiographic work can be greatly facilitated.

It is interesting to note that the effect of the rays on the fluorescent screen, as estimated by the selenium cell, differs less with increasing distance, the further the anti-cathode is from it:—

Distance of anti-cathode from apparatus.	Current recorded in milliamperes.	Difference.
Inches.		
6	0·33	...
8	0·27	0·06
10	0·22	0·05
12	0·20	0·02
14	0·18	0·02
16	0·16	0·02

The lecturer next showed some of the photographic results with the selenium apparatus of the "Daily Mirror" installation.

Late in 1908 Prof. Korn introduced his telautograph, in which a Caselli transmitter, such as already described for the telectrograph is used, and a line sketch or half-tone photograph is attached to the drum. The receiver is similar to that used in the selenium machines, a spot of light cast on a revolving sensitive film being shut off every time current flows through the wire of the galvanometer and displaces it; when displaced the shadow of the wire falls over a fine slit placed in front of the film, and so prevents the light from passing through to it. The methods of synchronising the sending and receiving cylinders is the same as that used in the telectrograph, but Prof. Korn's work was done prior to mine, and his arrangements were therefore copied by me. Similar methods have been adopted for many years, however, in certain systems of ordinary telegraphy.

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Wireless Transmission.

The wireless apparatus I have used for transmitting sketches, writing, or simple photographic images over distances up to about 50 miles may perhaps be looked upon as rather rudimentary, but it is at any rate practicable. The following experiment illustrates clearly how easy it really is to transmit a photograph by wireless under ideal conditions. I have here a small electric lamp, coupled up with the local side of a relay and battery, the relay being actuated by means of a coherer detector. At the other side of the platform there is a Morse key, which, when depressed, closes the primary circuit of an induction coil, the secondary being coupled up in the usual way to give oscillations. When I press the key, and thereby send a signal, you see that the lamp at once lights up. If the coherer be tapped the lamp is extinguished, and another tap of the Morse key causes it to light again. Now suppose that the taps of the Morse key were controlled by the lines in a photograph or sketch, and that the light from the lamp were concentrated on a revolving photographic film, and you will see at once how a photograph could be transmitted by wireless telegraphy.

Such a process would be utterly impracticable commercially, but my telectrographic system can be used with success in its place. A line picture is attached to the drum of the transmitter, and the intermittent current which is ordinarily passed into the telephone line goes into an electromagnet (M in Fig. 6), which then attracts a soft iron diaphragm attached to brass springs, which are fixed to two rigid supports. Every time current flows through the magnet coils this diaphragm is attracted to it, and the platinum contacts PQ are brought together; when the current flows, and PQ are in contact, the primary circuit of a transformer is closed, and the secondary having a spark gap and being inductively coupled to the aerial and earth, a signal is transmitted into space. Thus, in the wireless transmitter the only difference from ordinary telegraphy lies in the fact that the length of the signals and their distance apart is regulated by the lines composing the sketch or photograph.

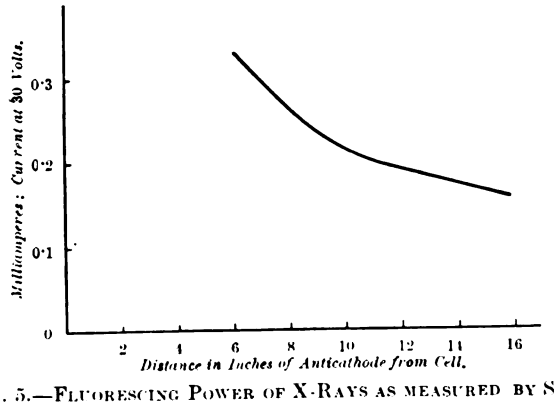

Fig. 5.—Fluorescing Power of X-Rays as measured by Selenium.

When working with high voltages in the primary, such as 110, arcing is liable to take place, and hence the distance between P and Q when not attracted must be considerable. This means that the distance between the diaphragm clamps must be short, and the German-silver spring of which the diaphragm is made must be thick, these two conditions making the natural period of vibration very short. I have, however, found that by interposing a mercury motor-interrupter in the primary circuit, arcing is almost entirely avoided.

The receiving apparatus is very simple, and depends, for short-distance work, upon a coherer cymoscope, the decohering apparatus being of a particular character. Every time an oscillation passes to the antenna, the coherer becomes conductive in the ordinary way, and a relay is actuated; this relay is usually made to start a hammer vibrating, the hammer hitting the coherer, and thus causing it to lose its conductive power. But a vibrating hammer is useless for the photo-telegraphic receiver, and it is essential to have one strike only on the coherer for each signal detected.

The form of apparatus I have employed for this purpose is seen diagrammatically in Fig. 7. EE is the magnet which is actuated by the relay R. It then attracts an armature MN, which moves towards the magnet poles and brings a resilient hammer, H, fitted with a platinum contact, P, against the coherer. The coherer AB is also fitted with a collar, F, and contact pin, so that in the act of striking the coherer the hammer closes a local circuit, and so causes a black mark to appear on the chemical paper. Successive distinct marks can be obtained in 0·017 sec. in this way, which is considerably more rapid, I believe, than a decoherer was given credit for.

Only sketches of the simplest character are at present being transmitted, but as you will see from the result thrown on the screen—a simple portrait of His Majesty the King—the images are recognisable, and merely require slightly more detail to make them quite comparable with the early results in line obtained by Prof. Korn's tel-autograph. Another result showed a plan transmitted by wireless. Such plans could be drawn direct in shellac ink on a slip of metallic foil, placed upon a portable machine coupled to a portable military wireless set, and communicated from one section of an army to another. The small portable machines I have already shown are used for the wireless transmissions, and they possess the advantage that "tapping" of the communications would be quite impossible. It is for this reason that I think the method would be of such value for military and naval purposes; even supposing that anyone wishing to intercept a plan or written message were to have an exactly similar instrument, with the same dimensions, by merely altering the rate of running by 5 or 10 per cent., according to prearranged signals, the picture as received by the intercepting party would be quite unintelligible and confused.

When dealing with wireless work the question of synchronism becomes more serious. I have employed two methods, each of which

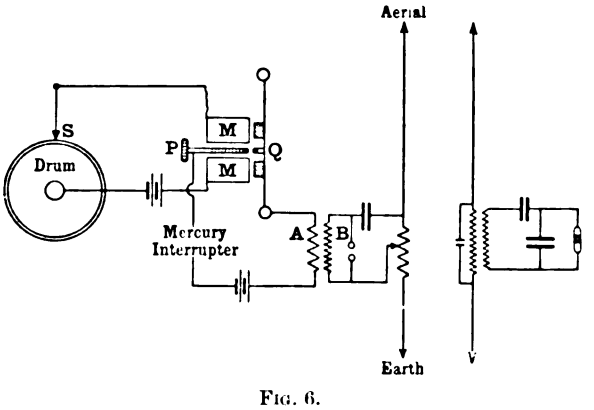

Fig. 6.

appears to answer satisfactorily. The first method secures accurate synchronism independently of any wireless communication. You have already seen how, in the ordinary telegraphic work, the receiving cylinder is driven rather faster than the sending one, and when it finishes up a complete turn too soon it is arrested until the sending cylinder has caught it up, when the latter sends a reverse current which is responsible for its release. In the wireless apparatus both sending and receiving cylinders are driven too fast, so to speak—that is, they are made to revolve in 4¾ secs. instead of a nominal 5. A check comes into play at the end of the revolution, and the cylinder is stopped until the 5 secs. are completed, the motor working against a friction clutch in the ordinary way during the stop. At the end of ½ sec. each cylinder is automatically released by chronometric means, as shown in Fig. 8. A special form of clock is used, with a centre seconds hand which projects beyond the face by about 1 in., and to the end of it is attached a brush of exceedingly fine silver wires. At every $\frac{1}{12}$ part of the circumference of the clock dial is fixed a platinum pin, and consequently every 5 sec. the little brush wipes against the convex surface of one of them. Each of these pins is connected with one terminal of a battery, the other

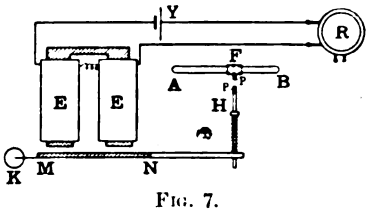

Fig. 7.

side of the battery leading to the relay, as does also the centre seconds hand. Therefore each time the brush wipes against a pin the circuit is closed, and the relay throws into action the local circuit connected up with its terminals. This circuit excites an electromagnet, which attracts an armature and pulls away the check which is holding back the cylinder. At the end of each 5 sec. the cylinders consequently recommence turning. Well calibrated clocks of the pattern used will keep good time for the period taken to transmit a picture, one gaining on the other quite an inappreciable amount, depending on the friction of the brush against the pins.

The other method of synchronising is controlled by electromagnetic oscillations. Let us suppose that a coherer is being used as cymoscope, the transmitting cylinder is kept running without any interruption, but by means of a fleeting contact it sends out a wave at the conclusion of its turn, a bare space in the picture being necessary about ½ sec. beforehand, so that no waves are sent out for the

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½ sec. previously. The receiving cylinder is driven too quickly and checked at the end of the revolution. It then, by means of a cam pressing down a spring lever, throws out of circuit the marking current and brings into circuit the relay which actuates the electromagnetic release. Consequently, when the synchronising wave is received, the coherer causes the relay to work, the release is effected, and the receiving cylinder starts a new revolution in unison with the transmitter. This means of synchronising is only possible in cases where a cymoscope is employed that is capable of actuating a relay, and you will therefore see that it is out of the question except for short distances. I am therefore using the chronometric system already described in the apparatus, and it is being embodied in the quartz fibre apparatus described below. I must first remark that the wireless work has been greatly facilitated by the courteous assistance so readily given by the Marconi Company.

The general form of the Einthoven galvanometer is well known, and the modified type of it used by Prof. Korn for photo-telegraphic purposes has been shown. If, now, we make the magnetic field very much more intense by building the field magnets heavier, and using a large number of ampere-turns in the winding, and also employ a "string," which is very much more elastic than the silver ribbon, the displacement of the string will be correspondingly greater. The silvered quartz fibre used by Duddell for this purpose gives an extremely sensitive instrument, and very appreciable displacement is obtained with the current from one dry cell passing through 35 to 90 megohms resistance. It is not long since Prof. Fleming explained at this Institution the valve receiver for detecting wireless oscillations; in ordinary wireless telegraphy the minute alternating currents are rectified, and sounds are heard in the telephone in circuit owing to small uni-directional currents. If these currents be passed through the silvered quartz string of the galvanometer the string is shifted. If, therefore, we cause a shadow of the string to lie over a fine slit, any displacement will cause the slit to be opened, as it were;

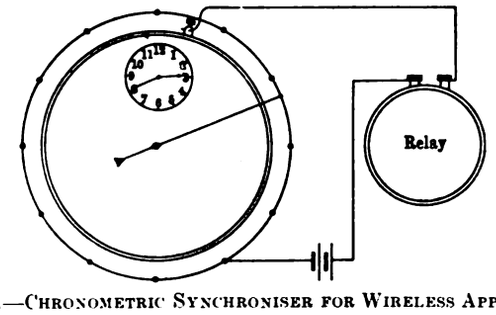

Fig. 8.—Chronometric Synchroniser for Wireless Apparatus.

the shadow will be shifted off the slit, and light will be free to pass through it. Oscillations corresponding to the lines in a photograph or sketch could therefore be utilised to cause shifting of the shutter in the manner I have already described for Korn's telautograph, and a sensitive photographic film could be revolved on a drum behind the slit to receive the picture. Such an apparatus is now in course of preparation, but the amount of light that passes through the slit is extremely small, owing to the fineness of the fibre. Mr. Sanger-Shepherd has therefore attached a minute shutter to the fibre, crossing the optic axis; this enables me to use a very much wider slit, and also to adopt the alternative procedure for reception. The oscillation is passed into the valve detector, and thence to the quartz fibre, which is stretched across the field of the magnets, whose poles are bored with a tunnel through which the beam of light is directed. When the fibre is displaced light is enabled to pass through a fine slit, and so act on the photographic film. Where, however, the shutter is attached to the fibre a much wider slit can be used, and then a pair of narrow compensated selenium cells are placed behind the slit, a positive lens being interposed. When a signal corresponding to a dot in the photograph—*i.e.*, the traversal of a line by the stylus—is received, the fibre shifts, light falls on the cells, and their resistance is decreased sufficiently to enable the battery to actuate the relay. This closes a local circuit, in which the telectrograph receiver is included, and a mark appears on the paper. In this way a visible record is obtained, which greatly facilitates the process.

Wireless photo-telegraphy may eventually prove of more utility than the closed-circuit methods, because it would bring America within reach of this country, and would enable communication to be made where telephone or telegraph lines did not exist. It is not limited to photographs—banking signatures, sketches, maps, plans and writing could be transmitted. But I would point out most particularly that the work is as yet in the very earliest stages, and that in giving you some account of it to-night I may be bringing before your notice methods and systems on which a few years' hence you will look back with a smile—as curious merely from a historical point of view.

LEAKAGE REACTANCE.

BY J. REZELMAN.

Summary.—The author supplements his recent article on "Leakage Reactance" with the test results of the reactance of a four-pole stator winding with special end connections. The results confirm his conclusions on the mutual induction between phases.

The Mutual Induction between Phases.

The author has thought it useful to describe experiments carried out on a new machine with special arrangement of the end connections; these experiments complete his previous

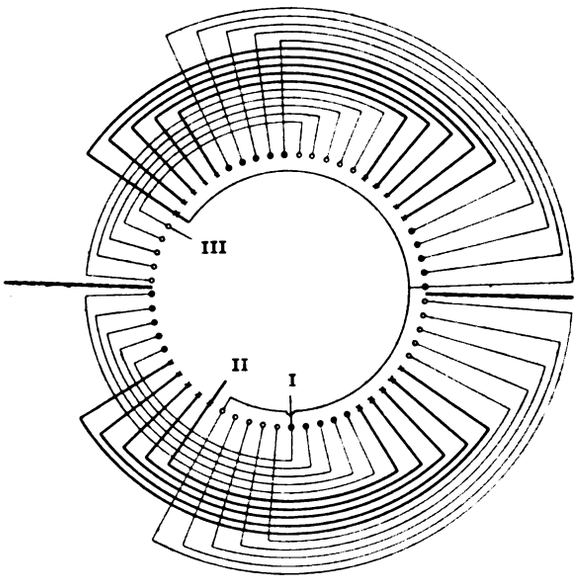

Fig. 1A.—Special Consequent Pole Winding in Three Planes.

study of leakage reactance,* and at the same time confirm the results already obtained on the mutual inductance between the phases.

Stator of a Three-phase Turbo-alternator 4,000 k.v.a., 4 poles, 50 ~ per second, 1,500 revs. per min. 6,600 volts between phases, the rotor being out.

Dimensions.—$\phi_i = 1{,}034$ mm., $\tau = 812$ mm., $l = 1{,}050 - 26 \times 7{\cdot}5$ mm., $l_i = 950$ mm., 60 slots, open type (22×73), $t_1 = 54{\cdot}2$ mm, $s_n = 5$, $p = 2$, $q = 5$.

The stator is wound with consequent poles, that is to say, there are two coils per phase for the four poles; the end connections of the five slots thus form one coil, only, since the

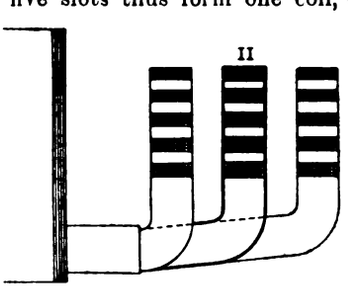

Fig. 1B.—Special Consequent Pole Winding in Three Planes.

frame of this alternator is in two pieces, it was necessary to arrange the end connections *un*symmetrically, and in three planes, in order that each half could be completely wound before assembling. The end connections of phase I. and III. are arranged just as is customary in the case of a consequent pole winding, whilst those of the remaining phase (II), instead of crossing over the joint, are bent back in the *opposite* direction. Figs. 1A and 2.

Fig. 3 shows the direction of the current in phases I. and III. when connected in series; we see then that the parts *a* are traversed by currents in opposite directions, there is, therefore a *negative* mutual induction; the parts *c* are traversed by currents in the same direction which produce a *positive* mutual

* *See* The Electrician, August 20 and 27, 1909.

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induction. The mutual induction of the part c is thus in opposition to that of the part a, and they counteract one another to a great extent.

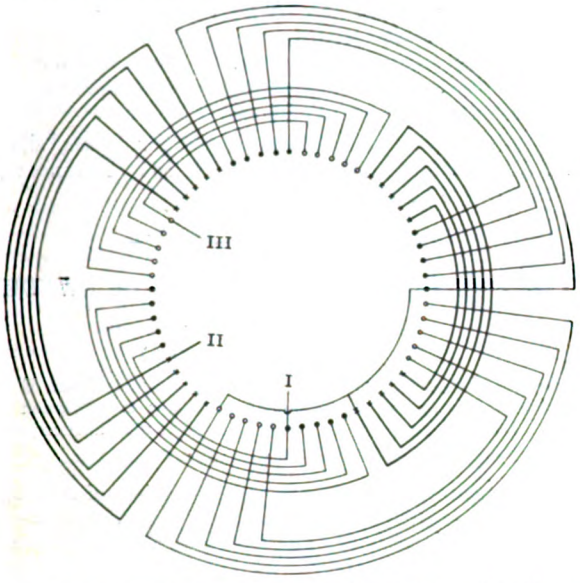

Fig. 2.—Ordinary Consequent Pole Winding in Two Planes.

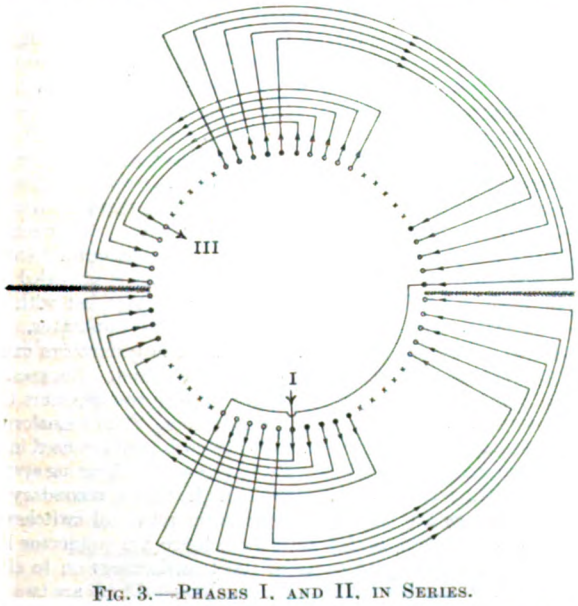

Fig. 3.—Phases I. and II. in Series.

With phases I.—II. and II.—III. connected in series this is not the case (Fig. 4); the parts a and c are now traversed by urrents in the *same* direction, there is thus a *positive* mutual in-

Table of Experiments, No. 1.

—		$e_{0\text{-}1}$.	$e_{0\text{-}2}$.	$e_{0\text{-}3}$.	Current. I.	Frequency c.
Reading with a current of 30 amps. in phase	I.	*52*	16·8	7	30	51
	II.	17	*52*	17	30	51
	III.	7	17	*52*	30	51

Table of Experiments, No. 2.

—		e between phases.	$e_{0\text{-}1}$.	$e_{0\text{-}2}$.	$e_{0\text{-}3}$.	Current. I.	Frequency c
Reading with a current of 30 amps. in 2 phases in series	I.– II.	*137*	69	68·3	0	30	51
	II.–III.	*136*	0	69	67·5	30	51
	III.– I.	*118*	59	0	59·5	30	51

Table of Experiments, No. 3.

—		e between phases.	$e_{0\text{-}1}$.	$e_{0\text{-}2}$.	$e_{0\text{-}3}$.	Current. I.	Frequency c
Reading on measuring a current of 30 amps. in phase ...	I.	105	*60*	...	...	30	51
	II.	123	...	*68*	...	30	51
	III.	108	...	...	60·5	30	51

duction in both cases, and, moreover, for a *considerable* length of end connections. The external length of the coils is the same for the two coils of phase II: $l_s = 1{,}860$ mm.; with the

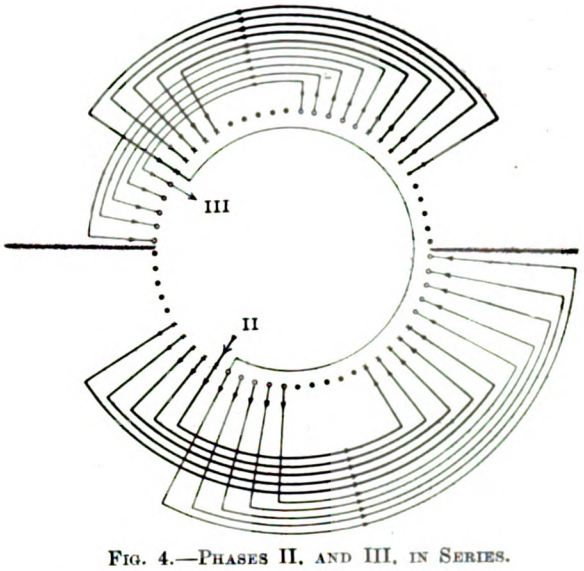

Fig. 4.—Phases II. and III. in Series.

two other phases there is in each case a short coil near to the core and a long coil away from the core. Their *mean* length, however, is *equal* to that of phase II.

The length l_s may be divided into l_{s_a} and l_{s_c}, and we have $l_{s_a} = 1{,}060$ mm., $U_{s_a} = 440$ mm., $l_{s_c} = 800$ mm., $U_{s_c} = 650$ mm.

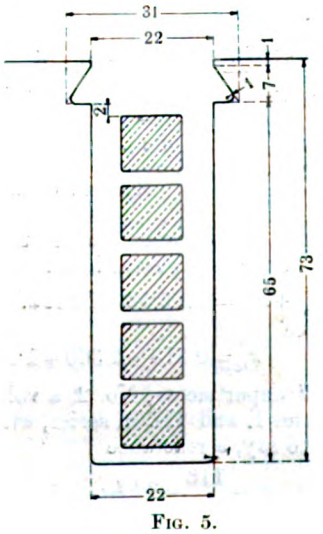

Fig. 5.

Experiments.—Measurements were taken on *each* phase with end shields removed.

1. Single-phase per phase.
2. Single-phase two phases in series.
3. Three-phase.

Separation of the Voltages.

1. *Single phase per phase.*—The machine has *open* slots (Fig. 5). We have then

$$\lambda_s = 1{\cdot}25\left(\frac{63}{66} + \frac{2}{22} + \frac{2\times 7}{31+22} + \frac{1}{22}\right) = 1{\cdot}695$$

for a length $l_s = l_i = 95$; whence

$$x_{s_a} = \frac{12.5 \times 51 \times 50^2}{2\times 5\times 10^8} \times 95 \times 1{\cdot}695 = 0{\cdot}257\omega.$$

For five slots per pole and phase,

$$\lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi \times z_1}{r_1}\right) + 2{\cdot}1 + 5\log\left(\frac{\tau}{4t_1}\times\frac{p+1}{p}\right)\right\}$$

$p=2$, $q=5$.

$$= 0{\cdot}92\left\{\log\left(\frac{\pi\times 32{\cdot}2}{22}\right) + 2{\cdot}1 + 5\log\left(\frac{812}{4\times 54{\cdot}2} + \frac{2+1}{2}\right)\right\}$$

$$= 6 \text{ for a length } l_k = l_i = 95.$$

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Whence $x_{s_K} = \frac{12{\cdot}5 \times 51 \times 50^2}{2 \times 5 \times 10^8} \times 95 \times 6 = 0{\cdot}908\omega$,

we have

$$\lambda_{s_a} = 0{\cdot}46 q_s \left(\log \frac{2 \times l_s}{U_{s_a}} + A \right) = 0{\cdot}46 \times 5 \left(\log \frac{2 \times 1860}{440} + 0 \right)$$

$= 2{\cdot}13$ for a length $l_{s_a} = 1060$

and $\lambda_{s_c} = 0{\cdot}46 \times q_s \left(\log \frac{2 \times l_s}{U_{s_c}} + A \right) = 0{\cdot}46 \times 5 \left(\log \frac{2 \times 1860}{650} + 0 \right)$

$= 1{\cdot}74$ for a length $l_{s_c} = 800$; $A \simeq 0$ for a consequent pole—hemitropic winding.

$$x_{s_a} = \frac{12{\cdot}5 \times 51 \times 50^2}{2 \times 5 \times 10^8} \times 106 \times 2{\cdot}13 = 0{\cdot}36\omega,$$

$$x_{s_c} = \frac{12{\cdot}5 \times 51 \times 50^2}{2 \times 5 \times 10^8} \times 80 \times 1{\cdot}74 = 0{\cdot}22\omega.$$

$$x_{s_a} + x_{s_c} = 0{\cdot}58\omega.$$

The *total* reactance then becomes

$$x_{s_1} = 0{\cdot}257 + 0{\cdot}908 + 0{\cdot}580 = 1{\cdot}745.$$

The table of experiments, No. *1*, gives 52 volts for 30 amperes, which corresponds to a reactance

$$x_{s_1} = \frac{52}{30} = 1{\cdot}735\omega.$$

2. *Single Phase.—Two Phases in Series.*—The permeance λ_u still has the value of 1·695, whence

$$x_{s_u} = \frac{12{\cdot}5 \times 51 \times 100^2}{2 \times 10 \times 10^8} \times 95 \times 1{\cdot}695 = 0{\cdot}513\omega.$$

For 10 slots per pole and phase;

$$\lambda_i = 0{\cdot}92 \left\{ \log \left(\frac{\pi z_1}{r_1} \right) + 5{\cdot}6 + 10 \log \left(\frac{\tau}{9t_1} \times B \right) \right\}$$

$p = 2$, $q = 10$.

$$= 0{\cdot}92 \left\{ \log \left(\frac{\pi \times 32{\cdot}2}{22} \right) + 5{\cdot}6 + 10 \log \left(\frac{812}{9 \times 54{\cdot}2} \times 1 \right) \right\}$$

$= 7{\cdot}8$ for a length $l_k = l_i = 95$; $B \sim 1$ for a winding covering two-thirds of the pole pitch.

$$x_{s_k} = \frac{12{\cdot}5 \times 51 \times 100^2}{2 \times 10 \times 10^8} \times 95 \times 7{\cdot}8 = 2{\cdot}360\omega.$$

With *no* mutual induction between phases the reactance of the end connections of the two phases in series would be:

$$2(x_{s_a} + x_{s_c}) = 2 \times 0{\cdot}58 = 1{\cdot}160\omega.$$

and the *total* reactance

$$x_{s_2} = 0{\cdot}513 + 2{\cdot}360 + 1{\cdot}160 = 4{\cdot}033\omega.$$

From the table of experiments, No. 2, a voltage of *118* is obtained for the phases I. and III. in series, with a current of 30 amperes, that is to say, a reactance

$$x_{s_2} = \frac{118}{30} = 3{\cdot}94\omega.$$

from which it follows that the mutual induction between the phases is *in reality* negligible.

For phases I. and II. or II. and III. the voltage is increased to *137* volts for *30* amperes: the total reactance is then

$$x'_{s_2} = \frac{137}{30} = 4{\cdot}56\omega \text{ instead of } 4{\cdot}033\omega.$$

This augmentation of $4{\cdot}56 - 4{\cdot}033w = 0{\cdot}527\omega$, is due to the mutual induction between the end connections of these phases; the reactance of $1{\cdot}16\omega$ then becomes $1{\cdot}16 + 0{\cdot}527 = 1{\cdot}687\omega$, which corresponds to an augmentation of $\frac{1{\cdot}687}{1{\cdot}16} = 1{\cdot}45$. It is to be still further noticed that there is no magnetic attraction between the end connections of phases I. and III., but there is a considerable attraction between the coils of phase II. and those of the two other phases.

In addition, on three phase, the phases are no longer perfectly balanced on load; for a constant exciting current of 10 amperes the short-circuit current has been found to have the values given below.

1. *Three-phase.*
   Phase I.: $I_k = 35{\cdot}8$ amperes.
   Phase II.: $I_k = 31{\cdot}5$ amperes.
   Phase III.: $I_k = 36{\cdot}8$ amperes.

2. *Single-phase.—Two-phase in Series.*
   Phase I.–II: $I_k = 51{\cdot}25$ amperes.
   Phase II.–III.: $I_k = 51{\cdot}2$ amperes.
   Phase III.–I.: $I_k = 53{\cdot}5$ amperes.

3. *Single-phase—Per phase.*
   Phase I.: $I_k = 89{\cdot}5$ amperes.
   Phase II.: $I_k = 90{\cdot}5$ amperes.
   Phase III.: $I_k = 89{\cdot}5$ amperes.

The short-circuit test, single phase *per phase*, shows, as before, that without mutual induction the reactances of the three phases are perfectly *equal*.

HYDRO-ELECTRIC INSTALLATIONS OF SWEDEN.*

BY A. V. CLAYTON.

(*Concluded from page 54.*)

Summary.—After drawing attention to the characteristics of Sweden the author refers to the development of power transmission in that country. He then proceeds to describe typical installations, mentioning the features of particular interest.

Having digressed to describe briefly the subject of generators we will now return to Graninge. The current from the generators is led to the 5,000-volt 'bus-bar room for distribution to the outgoing lines of the 5,000-volt transmission and the primaries of the step-up transformers. This room is on the ground floor level, and in it are situated all the necessary transformers for the measuring instruments, the oil switches and connectors. All 'bus bars are laid in closed tunnels, and the only openings in these tunnels are at junctions to the 'bus bars. Further, it has also been arranged that the only insulators supporting the 'bus-bars are placed at these openings, so that they are easy of access for inspection, &c. The distance from the conductors to the walls of these tunnels is 6 in. for the 5,000-volt leads and 12 in. for the 40,000-volt. All the 'bus-bar connectors, instrument transformers, &c., are isolated and placed in respective fireproof cells. The switching apparatus is very simple: no fuses are used, oil switches with maximum relays taking their place. Between the generators and 5,000-volt 'bus bars there are maximum relay oil switches, and likewise the 5,000-volt outgoing line is provided with maximum relay oil switch. Each generator is provided with ammeter, voltmeter, wattmeter and synchronising apparatus. The 5,000-volt 'bus bars are in sections, so that the generators can be worked on separate sections or in parallel as required. Between the 5,000-volt 'bus bars and primaries of the step-up transformers there are no oil switches, but simply link connectors. The transformers are of single-phase type, of 720 kw. capacity each, and are used in sets of three to form complete 2,160 kw. three-phase transforming systems for each of the three generators. On the high-tension secondary side of the transformers are three-pole maximum relay oil switches for each set of transformers, and beside these there are connector links which permit of coupling any one of the transformers on to either of two sets of high-tension 40,000-volt 'bus bars. There are two outgoing transmission lines, each having its maximum relay oil switch, and they can be fed from either of these duplicate sets of 40,000-volt 'bus bars by means of connectors.

As is well known, great precautions must be taken against the effects of lightning discharges or over-tension due to other causes on aerial transmission lines of this kind, and the difficulties increase enormously when the transmission voltages get into high figures. Moreover, the very severe climatic conditions obtaining in Sweden, especially so far north as this power station is situated, call for special attention to this point. In the present case zinc roller tension limiters and horn lightning arresters are used, while powerful impedance coils are placed between these protective devices and the 40,000-volt 'bus bars. On each phase of the outgoing lines there are two horn arresters in series, one of which is connected in parallel with a water resistance. The water resistances consist of very large glazed earthenware bent pipes filled with water. The up-bent open ends of the pipes are covered with loose brass covers through which are brought conductors terminating in spiral wire ends immersed in the water. The horns and resistances of each phase are placed in separate chambers. It has been found that a gap of 32 mm. for the first horn and one of 40 mm. for the second horn, which is in parallel with the resistance, give the best results. Another means of preventing over-tension on transmission lines, and one which has proved exceedingly effective, is to make connections from the lines to earth through fixed resistances. The resistances are adjusted so as to allow a very small current constantly to flow to earth, and these connections to earth

* Abstract of a Paper read before the Institution of Electrical Engineers.

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lead off the small static charges which would otherwise accumulate on the line. Experiments have been made with carbon and other classes of resistances for this purpose, but a circulating water resistance has proved the best.

Now as to the switchboard itself, which is placed on the first story over the 5,000-volt 'bus bar room. It is in the form of a circular sloping-top desk, while behind this desk are a number of cast-iron pillars on which are mounted the instruments corresponding to the switches on the panels of the desk switchboard. All the switches situated in different parts of the building are electrically controlled from the switchboard, as well as all rheostats and also the turbine gates, so that from this point the entire station is controlled. Signal lamps show whether the switches are closed or open. The board being of circular form permits an operator standing opposite to it to see all the instruments at once without running from one to the other, and, moreover, he has a full view of the entire station and the transformer cells, as there is a clear space to the machine house at the back of the instrument pillars. Each transformer is placed in its own little fireproof cell, the cells being in a row on the first story of the 40,000-volt building, on a level with and immediately opposite the

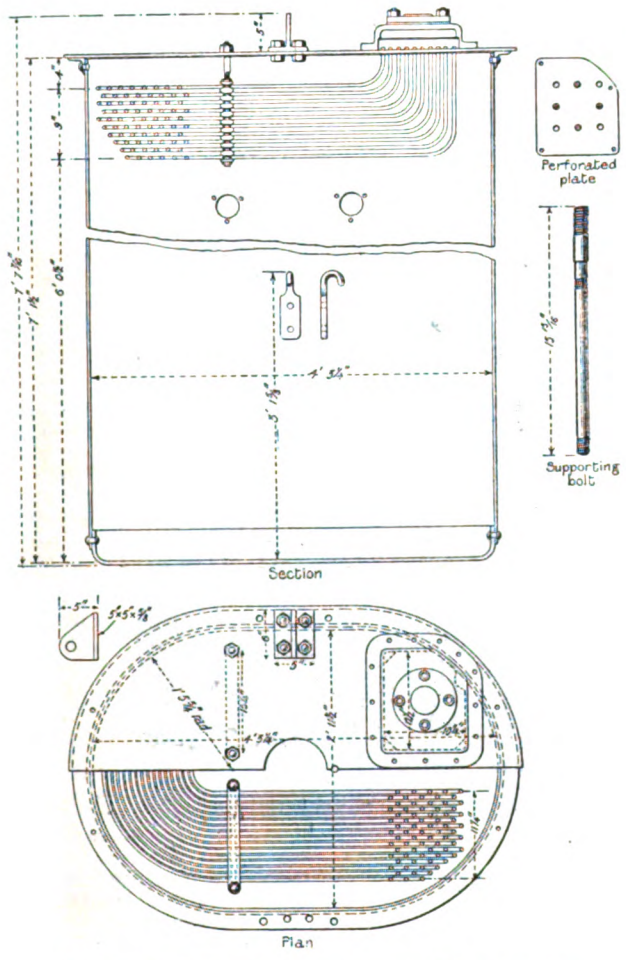

Fig. 5.—Box for Graninge 720 kw. Transformers.

switchboard alcove. The cells have fireproof iron doors front and back, the doors on one side opening to the machine hall and on the other to a long gallery having rails leading to a repair shop. The transformers stand on little trucks, so that any transformer can with the greatest ease be removed and replaced. The doors of the transformer cells on the machine hall side usually stand open, mainly with the object of seeing if the circulating water for the cooling coils is running properly. This can be observed from the machine hall and the switchboard alcove. There are signals to show if the temperature of any transformer rises too high, and in case of fire the iron doors of the cells can be instantly closed by operating a lever.

The cooling coils of the transformers may present some novelty, in that instead of having one or a few circulating pipes of large diameter, or a water jacket, they consist of a number of small diameter copper tubes placed in parallel, like a little water-tube boiler. Fig. 5 shows the box and cooling coils. In this construction the tubes are expanded or sweated into headers which form one side of distribution boxes for the inlet and discharge of the circulating water. The entire system of cooling tubes is placed at the top of the transformer box over the transformer itself, and is attached to the transformer box lid, so that when the lid is removed the coils are removed with it. By employing this construction an enormous cooling area can be got into a very small space, practically the only limit to the room required for the cooling coils being the amount of space which must of necessity be left between the tubes in order to obtain good circulation of the oil. Moreover, the cooling coils are at the top of the box, where the oil is hottest, and hence in the most effective and best position. A very complete arrangement is provided for tapping out the oil, boiling and refilling. It consists of a system of pipes to and from the transformers connected with oil-boiling tanks.

The use of oil-cooled transformers has only of recent years become general in Sweden. On account of the larger units now employed and the high voltages used for transmission, the use of oil-cooled transformers has become general. In the water-driven power stations it is, of course, easy to get water for cooling purposes, but in most sub-stations it would be a very troublesome job to have to arrange for circulating water, and hence in them oil-insulated transformers with ordinary air cooling must be used. As the sizes increased, extra radiation surface was obtained by casting ribs on to the outside of the boxes. As demands arose for still larger sizes, it was found that the oil would not transmit its heat quickly enough to the smooth inside circular box in order to get the full advantage of the increased area of the outside ribs. The suggestion of casting radiation ribs on the inside was a failure, the difficulties in casting being too great; and, in fact, even with ribs on the outside alone, the percentage of wasters in casting was very high. Therefore the next step was to make the walls or sides of the boxes with a very deeply corrugated section, in which case the area exposed to the oil inside and the air outside was practically the same. Even these boxes, when of great depth, were difficult to form and cast, and, therefore, they were cast in sections 20 in. deep and bolted together with a lead packing between. These sections were of fixed diameter and represented roughly the losses of a given size of transformer, so that with increased size a greater number of sections were added. Thus, for instance, a two-section box with top and bottom would be for a 100 kw. transformer, a three-section box for a 150 kw. transformer, and so on. These boxes, however, became very heavy and costly in larger sizes, and were abandoned in favour of boxes of wrought iron having similar deep corrugations. As in the case of the previously described water-cooled transformer boxes, the idea of keeping the radiation surface concentrated towards the top of the box where the oil is hottest has been carried out in these air-cooled boxes also. The small cistern seen in the illustration on the top of the box is provided to allow the extra space required by the oil when hot, on account of its expansion, and to keep a constant head of oil pressure against the lid of the box. This is necessary to prevent moisture condensing on the under side of the lid in cold weather, which happens if an air space be left between the top of the oil and the lid of the box. Such drops of moisture will fall through the oil on to the transformer, and may cause serious damage. The oil in this little cistern is connected to the main body of oil in the transformer box by a small tube, the upper end of which is some inches above the bottom of the little cistern, so that any moisture that may condense on the under side of the lid of the little cistern will not be drawn into the transformer box, but will lie at the bottom of the little cistern, and can periodically be drawn off from this through a pet-cock. The bottom of these boxes is circular and is of ¼ in. boiler plate, and the top part is corrugated and of 14 gauge sheets. Another idea of the heavy circular bottom is that it will stand pinching with crowbars and other rough handling in transport in places where proper lifting devices are lacking. In order to stop small leaks the whole box is galvanised after it is riveted and complete. The eventual successful commercial evolution of these boxes is in a large measure due to Mr. Alfred Fraser, of Messrs. John Fraser & Sons, Millwall, the makers of the boxes. It is remarkable what a difference there is in the radiation properties of cast-iron and wrought-iron surfaces.

As to the transmission line at Graninge, the greatest distance of transmission is about 40 English miles. There are, of course, much longer transmissions than this in service in Sweden—for instance, Hemsjo, 96 km., Yngredsfors-Varberg 90 km. It has even been suggested by the State engineer of the Trollhättan Falls to transmit power from there to Copenhagen, a distance of about 350 km., including 8 km. across the sea between Sweden and Denmark. The Graninge line consists of three single wires of 4·5 mm., about 0·18 in. diameter, carried on wooden poles. The pin of the top insulator is mounted on the wooden pole directly, while the two lower insulators are supported on an iron cross-bar. The insulators are of triple petticoat type, made in two pieces cemented together and supported on iron pins fixed to them by a tight packing of oakum between the pin and the inside of the insulator. Formerly it was customary to cement the insulator caps to the pins, the cement used

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being mostly the litharge and glycerine mixture, but with this cementing it was found that the insulators split, owing to unequal expansion with the extremes of heat and cold pertaining to the Swedish climate. The wires are suspended in positions corresponding to the tips of an equilateral triangle, the distances between wires being 50 in. The distance of span between the poles is about 45 yds. generally, but at river crossings there are two spans of about 140 yds. each, and one at the estuary of nearly 400 yds. In the case of this latter span the conductors and their insulators are supported on triangular frames which are suspended from a steel hawser. The steel hawser passes over rollers on towers 120 ft. high, situated on the opposite shores, and is anchored to rocks at each end. Where transmission lines cross public highways or railways the law requires that such crossings shall be protected so that in the event of a conductor breaking the free end cannot fall down and thus be dangerous. This is effected by enclosing the transmission lines at these points inside a casing of iron lattice work supported on iron lattice poles situated each side of the crossing.

All the preceding power stations described are built with horizontal shaft turbines, and are typical of the most general run of power stations. In many cases, however, vertical shaft turbines and generators of the umbrella type are employed, principally on very low falls, where this type offers advantages. In these cases the turbines are placed in ordinary open flumes, over the top of which is the floor of the generating room, and the advantages are chiefly as regards variable levels of backwater in the tail race as well as cost. Fig. 6 shows the interior of a typical power station of this class. In the attempts made to get up high speeds on low falls quite freakish designs are sometimes met with. It may be remarked here that the Swedish practice in this respect is quite different from the American custom of employing gearing to increase the speed of generators driven from slow-speed turbines, in Sweden direct coupling being the rule.

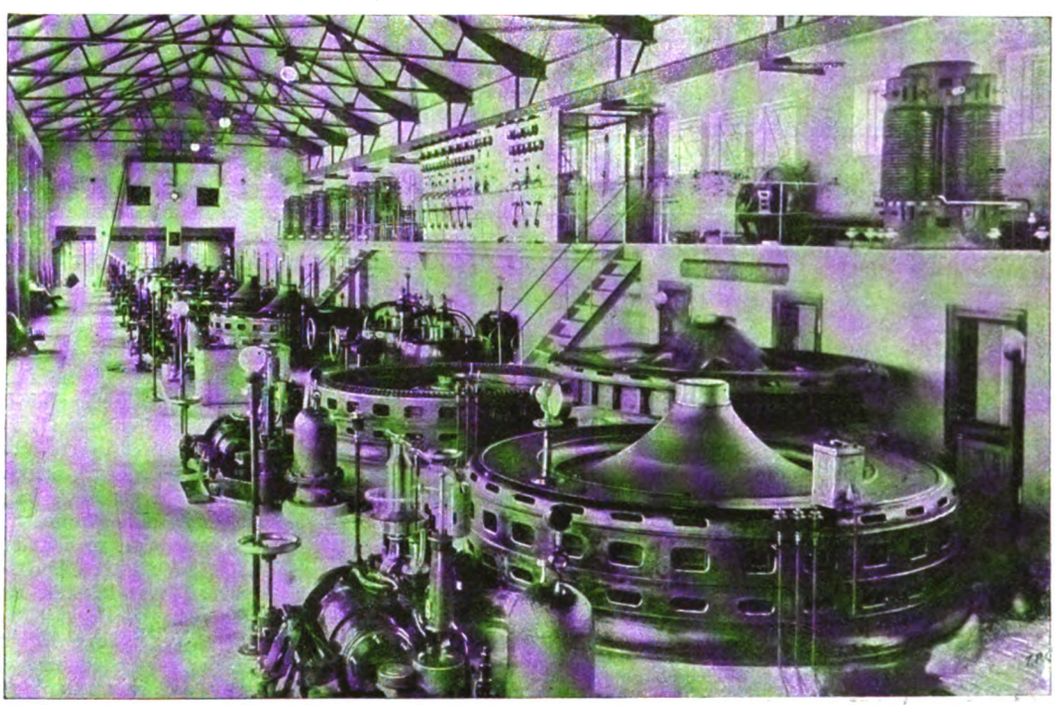

Fig. 6.—Interior of Power Station at Näs, Horndal, typical of the Vertical Shaft Turbine and Umbrella Type of Generator.

Another class of turbine generator set which is very interesting, and for which Mr. Böving has obtained patents, consists of two wheels running in opposite directions, the shaft of one being hollow and having inside it the shaft of the oppositely rotating turbine. To these two shafts are attached respectively the field and the inductor of the generator, both of which rotate, but in opposite directions. The result is that, for a given frequency and speed, the generator has only half the number of poles that would be required if the field alone rotated; in other words, it is equivalent to doubling the speed of the generator. Several of these have been at work at Hellefors for many years past, and are quite satisfactory. In vertical shaft turbines the rotating parts have, of course, to be suspended, and with the generator rotating field, the long and heavy vertical shaft, and the turbine wheels themselves, it will be seen that the weight to be supported is often very great. Many unsuccessful attempts were made to take up this weight on ball bearings, but now it is almost general to use hydraulic bearings, which float the entire system where the weight to be supported is too great to be taken up on the ordinary lignum vitæ turbine footstep. In a power station at Korsnäs no less than four pairs of turbines—that is, eight wheels—are used on one shaft. The fall in this case is only 6 ft., and despite the use of eight wheels, the speed is only 107 revs. per min., while the power is only 420 H.P. Installations with such very low falls utilising enormous quantities of water per horse-power developed are, of course, excessively costly compared with their power output. Twin wheels are, of course, the ideal; but in many cases quadruple wheels must be used to enable the use of large-size electrical generators at reasonably high speeds. Of course, on high falls the obverse obtains, and in such cases single wheels having high peripheral velocity are used in order to get reasonable speeds for the generators. A single-wheel turbine of this class, with an output of 3,300 H.P., is in operation on a 290 ft. fall at the works of the British Aluminium Co., at Stangfjorden, Norway. Even with this single wheel of large horse-power capacity the speed is 300 revs. per min., and at this speed the generators, which are of continuous-current type, had to be divided into two units of 1,100 kw. each.

On high falls, and even on only moderately high falls where pipe-lines are used, very great precautions must be taken against the dangers of water-hammer arising from the operation of the turbine gates with sudden variations of load. To protect against these, relief automatic by-pass valves are used. On still higher falls Pelton or impulse-type wheels must be used, but I do not know of anywhere in Sweden where wheels of this type are at work. There are, however, two installations being carried out in Norway where Pelton wheels are being used. One of these is at Tya, where a head of about 3,300 ft., probably the highest in the world, is utilised to develop about 70,000 H.P.; the other Pelton wheel power station is at Rjukanfos, also in Norway, where the head is about 1,000 ft. The units at the latter station will be of 14,500 H.P. each. It is interesting to note the low capitalisation cost of these latter big schemes. From calculations made by the Hydraulic Association of Scandinavia, the installation at Tya is estimated to cost about £525,000, or £7. 10s. per electrical horse-power developed. Where open intake water canals cannot be built—such, for instance, as on sloping ground—wooden pipe-lines are often used for the sake of cheapness. They are made of wooden planking about 3 in. or 4 in. thick, and bound at frequent intervals with strong iron hoops, the spacing between the hoops being dependent upon the pressure due to head of water in the pipes. These wooden pipe-lines cannot, of course, be used with advantage on anything but moderate heads, and they are often used for the first portion of a long, sloping pipe-line until the head gets too great.

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DISCUSSION.

Mr. J. F. C. SNELL said he was very glad that such a Paper had been read, because they were an Institution of Electrical Engineers and not electricians, and therefore the adaptation of the great forces of Nature by means of hydro-electric plants, while not applicable in England to any great extent, must appeal to those who had to carry out work abroad. The author had given the price per electrical horse-power of some completed hydro-electric stations as £7. 10s.; that was practically £10 per kilowatt installed. He asked the author to amplify that figure and give the price that obtained in Scandinavia per horse-power-year or per kilowatt-year. The author had also stated that there were many cases in Sweden where the price of imported coal was so low as not to warrant the use of hydro-electric plant. The speaker thought it would be a very difficult matter for a steam-driven station to compete with a hydro-electric station installed at so low a capital outlay as £7. 10s. per horse-power, unless, of course, the added cost of transmission was unnecessarily high. He asked the author whether the 8 million horse-power which Sweden and Norway had between them was the horse-power calculated upon the drought rating, or whether it was taken upon the average rainfall for the year.

Mr. G. STJERNBERG said that although Sweden and Norway were lacking in coal they certainly made up for it in water power. He thought the author's figures for inherent regulation were very low and asked if the short-circuit current had been measured. He also questioned whether it was altogether a desirable thing with generators working on overhead lines to keep the regulation so low. With greater regulation the effect of short-circuits would certainly be much less severe. As to the statement in the Paper that no short-circuit troubles had been experienced in the Swedish power plants, he was told when travelling through the country that they had found it necessary in places to take special precautions against these troubles, choking coils without iron sometimes being inserted in the dynamo circuit. It was to be expected that some trouble of this sort would occur with machines of such high capacity. Referring to the transformer, he thought that the arrangement of the cooling ribs at the top of the transformer would probably give a good cooling effect, but one would think that such an arrangement would not tend to produce a good circulation of the oil in the transformer case. With such thin riveted wrought-iron sheets he thought it would hardly be possible to get the cases completely oil-tight.

Mr. H. BRAZIL asked the author whether the neutral point of the Graninge system was earthed.

Mr. CLAYTON stated that he believed it was not earthed.

Mr. BRAZIL, continuing, pointed out that that being the case the arrangement of the arrester horns described in the Paper was not very satisfactory, in that it required double the pressure to cause the horns to spark when the system was entirely insulated that it would when one pole was earthed. This was clear from the fact that when one pole was earthed only one horn was in circuit, but when all poles were insulated two horns were in series. Assuming that the horns were set for 50 per cent. rise, this would mean that each horn would spark across at 60,000 volts and that two in series would require approximately 120,000 volts, which was three times the normal pressure. With regard to the resistances used in connection with lightning arresters, these were very important, and it was generally agreed that a very large proportion of the troubles experienced with lightning arrester apparatus had been due to the resistance not being of sufficient capacity to withstand the heavy load thrown on them when a discharge occurred. The problem of designing a suitable resistance for the purpose was a peculiar one, in that it was required to have a very high ohmic value, and at the same time the capacity for absorbing very heavy loads for a short period. Having had considerable experience with the water and carbon type of resistance, he ventured to disagree with the author's conclusion that a water resistance was the best. He was quite prepared to agree with the author, if by carbon resistances he meant only the carbon rod or other compressed carbon type, but suggested that there were other types of carbon resistance, which were much to be preferred to the water type. The failures with the carbon rod type were nearly always due to the fact that it was very difficult to get the resistance per unit length anything like uniform, and when a number were in series it was more than likely that one of them had a high resistance point or crack in it. When a discharge occurred a very large proportion of the available potential was concentrated at this point; the rod got hot and broke and the whole resistance was useless. The remedy he suggested would appear to be rather paradoxical. It was to take the carbon rods and to break them into thousands of pieces, distributing these pieces in a suitably shaped groove. A resistance consisting mainly of bad contacts resulted. In this connection Mr. Brazil showed a resistance unit consisting of a fire clay slab 12 in. square by 1½ in. thick, with a zigzag groove ¾ in. deep and ⅝ in. wide moulded in it. In this groove was placed a special kind of carbon powder. The grooves were not parallel to one another, and a thickness of insulation at each point was provided which bore some relation to the potential between one leg and another at that point. As to the capabilities of this resistance, with the voltage of 6,000 across the terminals the current rose to a maximum of 1·9 amperes in just over two minutes and then slowly decreased to 1·35 amperes, at which figure it remained, even after eight minutes had elapsed. The maximum power absorbed in this case was 11·4 kw., and when steady 8·1 kw. With 10,000 volts across the terminals, the current rose to a maximum of 2·4 amperes, and then decreased to 1·8 amperes at the end of one minute when the resistance was switched off. The maximum load in this case was 24·2 kw. The above tests were, of course, very severe, and it was highly improbable that the resistance would be subjected to them in practice. The object in giving these figures was to show that even under the worst conditions the resistance would keep the current within safe limits. His objections to water resistances were: (1) They introduced moisture into the extra high-tension chamber; (2) they varied in resistance to a very great extent with the ordinary temperatures obtaining in sub-stations; (3) the possible range of temperature and therefore the capability of absorbing power for any length of time was very limited; (4) a very small quantity of impurity getting into the water would alter the resistance value to an enormous extent; (5) if subjected to severe cold they would freeze. Turning to the permanent leak arrester, he agreed with the author that this was a very valuable piece of apparatus, but imagined that it would require a good deal of attention, as the value of the resistance varied considerably, especially if anything got into the water. He believed that all engineers, if they could obtain a dry resistance which cost no more and was as efficient, would instal it in preference to the water type, and he suggested such a resistance similar to the one he had described. This resistance consisted of a number of insulating slabs made of material resembling porcelain with grooves about ¼ in. wide. These grooves were filled with a very high resistance powder, and the slabs were stacked one on top of the other and connected in series.

Mr. W. H. PATCHELL mentioned that it was unnecessary to go to Scandinavia to see the early forms of machinery and transmission apparatus mentioned in the Paper, as tilt hammers were used in this country, and flat-rod transmissions with wooden rods and also ropes were to be found working among the mines of Cornwall. The width at which the flat rods were kept apart depended simply upon the width of the water-wheel cranks. The author did not mention whether the water-jet earth resistances were turned on when a thunderstorm was seen approaching, or whether they were left on all the year round. Mr. Stjernberg had mentioned that the design of tank shown did not lead one to believe that the best circulation was obtained. If we had to go to Sweden to learn how to make transformers, it was gratifying to see that they had to come to England to see how to make the cases. He noticed the author mentioned that in the dynamos the pole-ring and the arms and boss were all cast in one piece, and the boss was not divided. He, the speaker, thought that it would be very difficult to get such a casting without the arms cracking.

Mr. A. V. CLAYTON, in reply, said that the £7. 10s. per horse-power referred to by Mr. Snell was not the electrical horse-power, but was the turbine horse-power. The price per horse-power-year obtained in Sweden was a very variable quantity. In some cases it was as low as 27s. 6d. per horse-power and in others amounted to as much as £6. 10s. On might take a fair average as 55s. per horse-power-year. In contracts which were made for a number of years at £6. 10s., the supply of the full power demanded was guaranteed; but where the supply was not guaranteed the price was at a lower rate. Mr. Snell accused him of making a statement that in many cases in Sweden the cost of imported coal was such that the cost of the hydro-power was unnecessarily high. He, the author, did not state in Sweden, or, at least, did not intend to. The 8 million horse-power available in Sweden and Norway had been arrived at on the average rainfall rating. In regard to Mr. Stjernberg's remark that the figures for the inherent regulation were very low, he had stated in the Paper that the figures were exceptional. In regard to introducing choking coils to check the flow of current on short-circuits, he thought that Mr. Stjernberg had been misinformed. Mr. Stjernberg had probably come across some isolated case, but it must not therefore be inferred that the practice was general. He might say he knew most of the power stations in Sweden, but he did not know of one where they had put in choking coils for that purpose. The circulation of the oil in the oil cooling boxes was a troublesome thing, but was overcome by the use of thin oils. Thin oils also gave better insulation resistance than thick oils. He agreed with Mr. Brazil's remarks re earthing. Of course, any dry resistance would be very much better than the water jets. Much experimenting had taken place, and carbon resistances had been discarded because of their inequalities. The protective devices were used in the summer when the lightning was about, and taken off during the winter. As to using a carbon resistance of that kind for an earthing device, that had also been tried, but the trouble was that damp sometimes got into the carbons and they cracked, and also the inequalities above referred to prevented their use. No doubt Mr. Brazil's broken carbon resistances were better than rod carbons. As to the question of casting the arms and the ring all in one piece, one would, of course, not attempt to do such a thing with iron. When steel was first cast it was exceedingly brittle, but in annealing the stresses were all removed. As to cradles at railway crossings, there was a feeling in Sweden that these were unnecessarily costly.

PATENTS IN 1909.

We give below an abstract of the twenty-seventh report of Mr. W. Temple-Franks, the Comptroller-General of Patents, which has been issued during the past few days. In the report it is mentioned that at the end of February, 1909, the Patent Office sustained a serious loss in the retirement from active service of the late Comptroller-General, Sir Cornelius Neale Dalton, K.C.M.G., C.B., who had held office since 1897.

After a brief survey of the history of legislation in regard to patents and designs and a discussion of the revocation of patents, the report proceeds to state that one of the outstanding features of the year 1909 was the enormous

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development in aeronautics, the number of applications relating to this subject being more than three times the number received during the preceding year. The subject of locomotion in general, though continuing the slight falling-off noticeable during the past few years, still occupies the most prominent position in the field of inventive activity. The construction of motor-road vehicles has become so far standardised that the present tendency of inventors is to concentrate their attention mainly on the perfection of details. Applications dealing with wheels have slightly diminished, but this has been counterbalanced by the number of inventions relating to speed indicators and signals, due, no doubt, to the possibility that motor vehicles will in the future be required to give audible or visible warning of excessive speed. The interest shown by inventors in the development of the internal-combustion engine has been more than maintained. Following the tendency of last year, applications in connection with horse-drawn and railway vehicles show a slight decrease. Considerable attention has, however, been given to electric railway signalling systems in which the track rails are electrically continuous and are used for both the signalling and the power circuits. Inventions dealing with the mechanical handling of materials by conveyors and transporters are much in evidence, particularly in connection with the carrying of coal and ores from the working face to the bottom of the mine shaft. Problems relating to lighting have been a prolific source of invention, especially with regard to vapour or self-generating gas lamps and to means for automatically lighting and extinguishing street lamps.

The number of applications for patents during the year was 30,603, compared with 28,598 in 1908, and 28,915 in 1907. The number of specifications, provisional and absolute, shows an increase compared with those in 1908—viz., 21,553 and 18,705 in 1909, as against 19,495 and 17,746 respectively in 1908; but the number of patents sealed was only 15,065 compared with 16,284 in the previous year and 16,272 in 1907. The number of designs registered was the maximum recorded, viz., 25,754, compared with 24,389 in 1908, which latter was also a maximum figure. The number of trade marks registered was 6,112, compared with 5,965 last year and 6,255 in 1907.

The receipts from patents fees were £267,985, as compared with £262,890 in 1908, an increase of £5,095; from designs fees £5,578, as compared with £5,189, an increase of £389; and from trade marks fees £17,247, as compared with £17,358, a decrease of £111. The receipts from the sale of Patent Office publications were £12,029, as compared with £11,898, an increase of £131. The total receipts were £302,839, as compared with £297,335, an increase of £5,504. The total expenditure on behalf of the Office was £208,536, as compared with £179,531, an increase of £29,005. This increase is principally due to a payment of £30,000 in connection with the purchase of site for the new office buildings. The amount paid for salaries increased by £5,242, and the expenditure upon stationery, &c., decreased by £6,075. The total number of persons employed in the Office was increased during the year from 648 to 664. The number of readers who made use of the library was 157,235, as compared with 152,221 in 1908, an increase of 5,014 or 3·3 per cent., and the largest number recorded in any one year. The number of volumes added to the library was 5,858, of which 1,149 were volumes of patent specifications or journals (English and foreign) and 115 were trade catalogues. The remaining 4,594 volumes were text-books or periodical publications relating to scientific and technical subjects, and of these 3,384 were obtained by purchase and 1,210 by donation. The number of works in the library at the end of the year was 39,658, and the approximate number of volumes (exclusive of duplicates) was 124,000. A supplement to the author catalogue for the period 1898–1908 will be published early in the current year, with an appendix completing the work to December 31, 1909. It is proposed to print future supplements at much shorter intervals, thus making it possible to maintain a consolidated catalogue of the library in book form practically up to date. These supplements will be printed in an edition sufficient only for the library requirements, and will not be placed on sale or be available for public distribution. The new "relative" system of shelf classification of the library has been extended from B K to C R.

Through the courtesy of the heads of the Patent Offices in Germany and the United States, who have supplied for the purpose a duplicate set of their specifications, the systems of patent classification adopted in those countries are made as far as possible accessible to the readers in our library. The German classification comprises 89 classes, 480 sub-classes and 7,950 groups, and a list has been issued indicating the allotment under this system of all patents granted in Germany since 1877. One set of German specifications in the library is now being arranged in accordance with this classification, and 24 classes, comprising 2,547 groups, are already completed. A revision and extension of the United States classification has been in progress since 1905, and 90 classes and 7,863 sub-classes have been dealt with. Lists showing the allotment of specifications under this system are supplied by the American Patent Office and may be seen at the library.

The use of deposit accounts at the sale branch for the purchase of Patent Office publications continues to increase. During the year 32 new accounts were opened, and the total number of depositors is now 340, of whom 33 live in London, 115 in other parts of the United Kingdom and 192 abroad.

Patents.

The sum received from renewal fees was £154,777, as compared with £154,388 in 1908, an increase of £389; and that from sealing fees £15,220, as compared with £15,912, a decrease of £692.

The applications accompanied by provisional specifications, which fell off seriously in 1907 and slightly in 1908, increased by 2,058 in 1909. This increase brings the provisional specifications back to a higher point than they have attained since 1904. On the other hand, the applications accompanied by complete specifications, which decreased in 1908 by 244, decreased again, but only by 53. The falling off in these applications, which has never occurred before except in 1898, appears now to be checked, the number filed during the last six months being very considerably in excess of those filed in the corresponding months a year ago. The applications received from women inventors numbered 648, as compared with 572 in 1908.

There were 1,509 applications made by way of communication from abroad; of which 731 came from the United States of America, 431 from Germany, 54 from France, 42 from Canada, 30 from Switzerland and 28 from Austria-Hungary. An appendix shows the number of applications made in this country under the provisions of the International Convention for the Protection of Industrial Property by the various States of the Union during each of the last five years. The total number of such applications in 1909 was 2,303.

The cases where a complete specification is reported as wholly anticipated or not anticipated at all are decreasing in number year by year, while those where it is reported as partially anticipated are increasing. It also appears that there is a growing tendency to meet the reported anticipation by an amendment of the specification, and a consequent decline in the number of cases in which a reference to a previous specification is inserted. The number of such references inserted in the specifications of 1908 was only 310, as against 426 and 523 in those of 1907 and 1906 respectively. There was a large increase in the number of applications received in 1909 from England and Wales, a slight increase in those from Scotland, and a decrease in those from Ireland. The applications from most of the British Colonies are about equal in number to those made in 1908, but those from Canada show a large increase. There is a decrease in the number of applications received from Austria, Belgium, Denmark, France, Germany, Holland, Italy and Spain; and an increase in those from Russia and the United States.

An appendix shows the number of patents granted in 1908 in the United Kingdom, the United States, Germany, Austria-Hungary and Switzerland to persons resident within and outside the country. The percentage of patents granted to persons resident outside the country was: For the United Kingdom 46·2, United States 10·1, Germany 32·4, Austria-Hungary 71·2 and Switzerland 64·0. The number of applications made for the restoration of patents which had lapsed in consequence of the non-payment of renewal fees was 31, of which 3 were subsequently withdrawn and 7 are still pending. There were 22 hearings in connection with these applications, and in 21 cases the patent was restored.

Under the provisions of sec. 26, which empowers the Comptroller to revoke a patent upon the application, within two years from the date of the patent, of any person who would have been entitled to oppose its grant there were 9 applications, but 1 of these was subsequently withdrawn and 3 are still pending. In 2 of the 5 decided cases the patent was revoked, in 2 an amendment of the specification was required, and in 1 the application was dismissed. There were 2 cases in which patentees availed themselves of the provisions of sec. 26 (3) and offered to surrender their patents. In 1 of these cases the patent was revoked and the other case was not proceeded with. The number of applications made for the revocation of patents worked exclusively or mainly outside the United Kingdom was 55, but 27 of these were subsequently abandoned. In 11 of the remaining cases the patent was revoked, in 5 the application was dismissed, in 1 the patent expired after proceedings had been begun, and 11 cases are still pending.

During the last 10 years the number of hearings upon oppositions to the grant of patents was 1,304, and the number of appeals to the law officer in these oppositions 254, of which 43 were withdrawn or abandoned and 32 are still outstanding, while in 1 case the application for the patent was abandoned. The number of appeals heard by the law officer in these cases was, therefore, 178. In 103 of these appeals the decision of the Comptroller was supported, in 52 varied and in 23 reversed.

Nine petitions, 5 relating to patents of the year 1896, 3 to patents of the year 1895 and 1 to a patent of the year 1888, which had previously been extended for seven years, were lodged during 1909. Of these, 5 were abandoned and 2 dismissed and 2 cases are still undecided. There are now 4 patents in force which have been prolonged beyond the normal period of 14 years, viz., Nos. 8,700 of 1892, 10,274 of 1894, 1,272 of 1894 and 17,112 of 1894.

The names of 9 patent agents were added to the register during the year, the total number on the register on December 31st being 265.

Designs.

The number of designs applied for during the year was 24,816, exclusive of 1,596 sets of designs, as compared with 23,867 single designs and 1,040 sets in 1918. The number of designs refused registration, on account of their similarity to designs already registered, was 821. During the year 1,050 applications for registration of designs (including the above-mentioned 821) were objected to by the Comptroller. The objections, other than those on account of similarity to designs already registered, were chiefly on account of want of subject matter or want of substantial novelty. The number of applications made for the cancellation of registration on the ground that the design was used for manufacture exclusively or mainly outside the United Kingdom was 25, and in 24 cases the registration was cancelled, 1 being abandoned. The number of designs of which the copyright was extended at the end of five years for a further period of five years was 877, or 3·9 per cent., as compared with 938, or 4·6 per cent. in 1908.

Trade Marks.

The number of applications in 1909 for the registration of trade marks (including 173 applications made to the Cutlers' Company of Sheffield)

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was 10,880, as compared with 10,645 in 1908. The receipts from various sources on account of trade marks amounted to £17,246. 11s. 4d., including the sum of £2,546. 15s. for renewal fees. The notices of opposition to the registration of trade marks numbered 254, and the cases of opposition heard under sec. 14 of the Act 44.

A number of appendices are attached to the report, and give in tabular form the particulars referred to in the report.

METHOD OF TESTING THE MECHANICAL STRENGTH OF METALLIC FILAMENTS.*

BY T. MÜLLER.

Lamps intended for use in trains and in places where they are exposed to unusual vibration require to be capable of resisting considerable shocks. A method of testing lamps for this property has been in use for the last six months in the laboratory of the telegraph department of the Swiss railways at Berne, and a description is given in the present article of the system employed.

The shocks to which the lamps are exposed are produced by a rubber ball, filled with lead, which is allowed to roll down an inclined plane and to impinge on the bulb of the lamp at the bottom. The ball weighs 120 grammes—*i.e.*, rather more than 4 oz. The inclined plane is graduated in centimetres throughout its length, and has an inclination of 10 per cent. The lamp under test is suspended by flexible cord at the bottom of the inclined plane. The ball is first started from a distance of 20 cm. from the lamp. If this shock is successfully resisted, the distance is increased by steps of 5 cm. until the filament breaks. The distance traversed by the ball when breakage occurs is taken as a measure of the power of the filament to resist shock and vibration.

The figures obtained under test are given in the following table, the different letters denoting the various makes.

Maker's reference number.	Volts and c.p. frosted on bulb.	Actual Hefner c.p.	Watts per Hefner c.p.	Length of path in cm.
A	125 25	25·5	1·18	30
	125/25	25·0	1·21	40
	125/32	34·0	1·18	50
	130/25	25·7	1·22	25
	130,25	25·7	1·22	25
	130/32	32·6	1·20	20
			Average=1·20	36
B	125/25	24·3	1·39	40
	125/32	30·7	1·26	35
	130,25	25·0	1·35	35
	130,32	31·5	1·30	35
			Average=13·2	36
C	125/25	26·4	1·17	35
	125/32	31·0	1·13	30
	130/25	22·0	1·30	45
	130/32	31·8	1·15	40
			Average=1·19	37·5
D	125/25	25·2	1·31	40
	125/32	31·8	1·19	40
	130/25	26·4	1·23	45
	130/32	32·4	1·20	40
			Average=1·23	41
E	125/25	...	...	80
	125/25	...	...	45
	125/32	...	...	35
	125/32	...	...	30
	130/25	...	...	40
	130/32	...	...	25
			Average=1·20	42·5

Other results given include a group by one maker giving 53 as an average, and five groups by another maker giving averages of 57, 90, 47·5, 32·5 and 25, the last being for two 155 volt-32 c.p. lamps.

The following general conclusions may be drawn: (1) The figure denoting the mechanical strength varies considerably with the different makes. (2) There is no traceable connection between mechanical strength and electrical efficiency. (3) For a given voltage the strength appears to be greater the lower the candle-power, and for lamps of a given candle-power the strength is greater the lower the voltage. (4) The filament itself is not always the most fragile part seeing that several of the breakages took place in the supporting glass rod or at the hooks or contacts.

The length of the turns composing the filament has a direct bearing on the results, which might in some cases be better if the length composing one turn were reduced. Curiously enough, those lamps which had the highest efficiency had also the greatest mechanical strength on an average. Blows caused by allowing the ball to traverse a distance of 80 cm. are very heavy, and lamps which survive till this stage may be considered to be thoroughly well made. When the lamps are alight it is not at all easy to break them. A succession of heavy blows tends to knock the filament out of shape and to bring the convolutions in contact with one another. Probably it would be a good plan to clean the lamps, shades, &c., while the lamps are alight.

* Translated (and slightly abbreviated) from the "Elektrotechnische Zeitschrift."

THE ELECTRIC COMMERCIAL VEHICLE AT THE CLOSE OF 1909.*

BY J. H. VAIL.

In the business progress of electric vehicles, the year 1909 has witnessed a distinct advance. The more progressive central stations recognise the growing value of this new field for selling energy, the importance of which was previously unsuspected.

At the close of 1908 there were five central stations using electric vehicles in their daily operations. Compared with this we find, at the close of 1909, central stations in the following cities have adopted these vehicles: New York, Brooklyn, Philadelphia, Boston, Rochester, Buffalo, Cleveland, Atlantic City, Chicago, Des Moines, New Bedford, Cedar Rapids, Davenport, St. Louis, Rio Janeiro. There can be no doubt of the awakened interest on the part of progressive business concerns in those cities where the electric light company takes the lead. The annual income to electric lighting companies from charging electric vehicles now ranges from £100 to £10,000 per year. The kilowatt-hours of electrical energy sold by meter for charging electric vehicles by one company active in this field of enterprise, in a city of less than 300,000 population, were as follows: In 1906 the average monthly consumption was 23,828 kw.-hours, and in 1909 the average monthly consumption was 46,720 kw.-hours, exclusive of energy used for the company's own vehicle service.

It is an important fact recognised by all that this revenue is profitable in a larger degree than any other service supplied, for two leading reasons. First, the income is derived during hours of minimum demand that were hitherto unprofitable. Second, no company has been obliged to invest any new money in station equipment to serve this class of business.

Of the total number of commercial electric vehicles in use, the General Vehicle Co. has manufactured upwards of 1,600. The salient points of the vehicles made by this company are the one-motor drive, roller bearings, enlarged battery capacity and a conservative rating.

It is recognised that the large adoption of the electric commercial vehicle must come through the education of the central station manager up to the value of the vehicle as a revenue producer, and of the business men up to the advantages in reliability, economy and utility. The whole matter is not one of sentiment, but a proposition of dollars earned by enterprising progress. The following are examples of what is being done in America. The Whites Express Co., of Brooklyn, operates four 2-ton trucks, and six 3½ ton trucks. These make as high as 250 delivery stops per truck in daily trips of from 35 to 50 miles. The estimated supply of electrical energy is from 85,000 to 100,000 kw. hours per year. The Motor Delivery Co., as mail contractors in New York City, operates 16 electric wagons of 1,000 lb., 2,000 lb., 4,000 lb. and 7,000 lb. load capacity, and quite recently at holiday times several extra machines were impressed into service. The quantity of mail hauled, the promptness of delivery, and the aggregate excellence of the electric mail service exceeded all previous experience of the New York City post office.

Department stores and others find they can rely on making from 100 to 200 delivery stops per wagon in circuits of 40 to 50 miles, on a single charge of battery. The amount of energy for a full battery charge for a 1,000 lb. wagon is 19 kw.-hours, and for a 2,000 lb. wagon, 23 kw.-hours. Many prominent brewers have demonstrated the economic advantages of electric delivery service. Early orders of 1902 and 1903 have been followed by repeat orders from year to year, so that many of the brewery equipments comprise the early and also the most recent types of vehicles. The 3½ ton and 5½ ton trucks are used for a great variety of heavy trucking. The amount of energy for a full battery charge for the 3½ ton truck is 39 kw.-hours, and for the 5-ton truck 47 kw.-hours.

* Abstract of an article in the "Electrical World."

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PATENTS DURING 1909.

The chief interest of the Annual Report of the Comptroller of the Patent Office at the present time is the view it affords of the effect produced by the Patents Act of 1907. The result of such a measure takes some time to be fully apparent, and we must be content to wait, probably for another three or four years, before the merits or demerits of this Act can be judged at their full value. In this connection we refer more particularly to the question of revocation, which was the most drastic of the alterations then introduced, though, as pointed out by the Comptroller, the principle involved was not really novel. Up to 1907 it appears that the form of Letters Patent granted by the Crown contained a clause providing that the patent should be void if it should be made to appear to the King, or to any six or more members of the Privy Council, that the grant was prejudicial or inconvenient to the King's subjects. Under this clause Letters Patent might always have been determined or declared void, and by the Act of 1902 power was expressly given to the Judicial Committee of the Privy Council to revoke a patent worked mainly or exclusively abroad if the reasonable requirements of the public in the invention were not satisfied in this country. The Comptroller points out that the provisions of this section of the new Act are not so stringent as those in force in many countries, as for example, Germany and Canada. In

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both these countries the obligation to work a patent after a definite period is directly enforced, and the jurisdiction of the Court is not dependent, as in this country, on proof of the fact that the patented article is manufactured, or the process carried on, mainly or exclusively outside the United Kingdom.

It is now becoming more clear what may be expected in regard to the revocation of patents in this country; and the requirements are becoming more defined. The applicant for a revocation must give some *prima facie* evidence that the article is mainly or exclusively manufactured abroad. For this purpose the whole foreign manufacture is considered, and something more than a mere percentage below one-half of the total manufacture must be shown. The tribunal has to decide whether the working is adequate under the circumstances, and whether the article is manufactured in the United Kingdom to as great an extent as can reasonably be expected, having regard to the industrial developments in other countries. It appears that the main point to be decided is whether there has been a reasonably honest effort on the part of the patentee to manufacture in this country or to grant licences on reasonable terms; or whether, on the contrary, the patentee has abused the privileges and the monopoly granted to him, either by showing an undue and unjust preference to foreign countries, or by the imposition of unreasonable prices or unreasonable terms, or by wholly neglecting this country in his efforts to develop foreign trade. Evidently there is much to be taken into account in arriving at a decision, for there are many circumstances—such as date of the patent, the need of the invention, the demand for the article or process, the state of the art, and the stage of progress at which the invention has arrived—that all have a bearing on each particular case.

It will be admitted that revocation is a serious step, and that it materially affects the value of the protection afforded by patents in this country unless such revocation is obtainable only on very adequate grounds. We think it will be allowed that every care is being taken. From the records so far available it appears that revocation has not been made too easy; and, no doubt, this is the correct attitude for an institution such as our Patent Office to maintain. Up to December 31st last there have been 73 applications, but only 17 of these have been successful.

As to the indirect effects of the Act, it is also a little difficult to judge. It has become apparent that, if the patentee does not himself manufacture, orders have been given to British firms and licences have been offered for the manufacture of the article or carrying on the process in order to meet the requirements of the Act. There cannot be much doubt, therefore, that the existence of the section and of the power to revoke a patent has brought about the establishment of factories in this country and has led to the increased employment of British labour. There has been some fear that the Act might have a bad effect on the applications for patents from abroad. Possibly there may be a slight falling off, but we doubt if the effect of the Act can be traced in this way at present, as comparatively large fluctuations occur from year to year. All that can be said with certainty is that the number of applications during the past year was the highest number but one on record.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Anlasser und Regler für Elektrische Motoren und Generatoren. By RUDOLF KRAUSE. 2nd edition. (Berlin: Julius Springer.) Pp. xi. + 149. M.5.

The theory, construction and methods of connection of motor starting and regulating rheostats and dynamo field regulators are ably expounded in the present volume. The subject is an important one. The author deals with it authoritatively and clearly, and has included a vast amount of useful information in the 15 chapters comprising the work. The present edition has been improved; not only has it been enlarged, revised and brought up-to-date, but it has been partially rearranged, and a special chapter has been added containing fully worked out numerical examples, which readily show the practical application of the mathematical formulæ involved. This chapter adds considerably to the merit of the book, which contains a large number of excellent diagrams.

Starting with a few introductory notes on the functions of starting and regulating rheostats and on the different types, the method of determining the size of the resistance material for transient and permanent working is given in Chapter I. Chapter II. contains some brief remarks on the permissible loading of switch contacts, and on spark prevention (magnetic blow outs, &c.). The method of arranging the resistance material is discussed in Chapter III., and in Chapter IV. the fundamental connections of hand-operated starters are explained for series, shunt, compound-wound and three-phase motors, and for reversing motor switches. Various designs of hand-operated starters with special devices to protect them from overload, loss of voltage, too rapid starting, &c., are given in Chapter V., and automatic self-starting rheostats are considered in some detail in the following chapter.

The speed regulation of motors is explained in Chapter VII., which is followed by a short one on motor braking by the aid of starters and resistances. Controllers are very well dealt with in Chapter IX., and the general characteristics of dynamo field regulators for direct and alternating current are set forth in Chapter X.

The mathematical formulæ for calculating the grading of motor starters and regulators are deduced in Chapters XI. and XIII., respectively, their graphical determination being given in Chapter XII. The mathematical and graphical methods applicable to generator field regulators are similarly given in Chapter XIV. These chapters are excellent and are deserving of close study. The graphical solutions are especially noteworthy. Finally the practical application of the preceding methods is explained by the aid of no fewer than eight complete examples in Chapter XV.

Elementary Treatise on Electricity and Magnetism. By G. CAREY FOSTER and ALFRED W. PORTER. 3rd edition. (London: Longmans, Green & Co.) Pp. xix. + 623. 10s. 6d. nett.

This third edition of a work which must now be known to the majority of serious students of electricity shows the sound knowledge and the progressive spirit that are to be expected from the authors responsible for its present form. The treatise under review is, in a sense, elementary; but the majority of students would rightly consider their knowledge to be of an advanced character if they had assimilated all its contents.

The book occupies an almost unique position in the fact that there is no lack of continuity or completeness in the theory; and yet scattered through the work there are numerous references to apparatus and experiments, well illustrated with diagrams. These references are not such as appeal specially to the electrical engineer; but are such as give life and body to the theory. Students who are familiar with the previous edition will be glad to know that the numbering of the old articles has been unaltered, and that where new articles have been added their presence has been indicated by asterisks. Thus a glance through the table of contents shows what new matter has been added. In the chapter on electrical capacity and condensers there are new articles on Kerr's electro-optic

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effect, and on pyro-electricity. In the chapter on thermo-electricity there is a new article which contains a neat treatment of a circuit of three metals in series. In one of the chapters on electromagnetic induction there are new articles on the magnetic field associated with electric convection, and on the energy of a moving charge; and the way is prepared for the very interesting last chapter on *recent developments*. Students who have attempted to follow modern work will be delighted with the last chapter, which deals with phenomena which have either been recently discovered or have recently come into prominence. This chapter is only 30 pages in length, and yet it manages to cover an enormous area with considerable success. There are articles on cathode rays, which the authors very properly prefer to call cathode streams; these articles enable the reader to be introduced to the notion of streams of negatively charged particles. A consideration of Röntgen rays caused by the impact of the streams against an obstacle naturally follows. Becquerel rays are next described, and they prepare the way for the study of radio-activity. Succeeding articles deal with the Zeeman effect, canal rays, and electrons. The chapter concludes with applications of the electronic theory to explanations of the electrical and thermal conductivity of metals, of thermo-electricity, and of certain magnetic effects.

At the end of the book there are some tables which were not in the second edition; and, altogether, the current edition contains about seventy pages more than its predecessor.

Storage Batteries: Their Theory, Construction and Use. By A. E. Watson. (Lynn, U.S.A.: Buliver Publishing Co.) Pp. vi. —135.

This is an excellent little book, written almost entirely from the purely practical point of view; indeed, it may be said that the "theory" extends very little beyond the title. After describing the general action and construction of batteries, detailed instructions are given for making a battery, the information given being eminently suitable for the amateur. The book concludes with a description of commercial cells used in America, and typical installations. Switchboard diagrams and brief particulars of boosters are also included.

Making Wireless Outfits. By Newton Harrison. (London: E. & F. N. Spon.) Pp. 61. 1s. 6d. net.

Wireless Telephone Construction. By Newton Harrison. (London: E. & F. N. Spon.) Pp. 41. 1s. 6d. net.

These two little books have been written for the benefit of those amateurs who wish to build up their own apparatus. Careful directions are given, in comparatively non-technical language, for the construction and erection of small wireless outfits, which, if followed, should lead to successful results; at any rate so far as spark telegraphy is concerned. With wireless telephony the difficulties are much greater; the arc is very troublesome, and the novice must be prepared for many failures.

CALCULATION OF THE OVERHANG LEAKAGE IN THREE-PHASE MOTORS.*

BY DR. M. KLOSS.

Summary.—In the present article it is shown how the leakage of the coil ends of an induction motor or alternator can be found in a simple manner.

For determining the circle diagram of a three-phase induction motor two quantities are required—the magnetising current i_μ and the ideal short-circuit current i_k. The magnetising current produces the ampere-turns in the stator winding necessary to drive the normal flux along the main magnetic circuit. The short-circuit current produces the ampere-turns required to drive the normal flux (assuming constant applied E.M.F.) along the leakage path. The relation between the flux and the ampere-turns is given by

$$\Phi = 0{\cdot}4\pi \,.\, AT \,.\, \Delta, \quad \ldots\ldots\ldots \quad (1)$$

where Δ denotes the permeance of the path of the flux produced by AT. At short-circuit, with q slots per pole and phase and z conductors in series per slot, this becomes

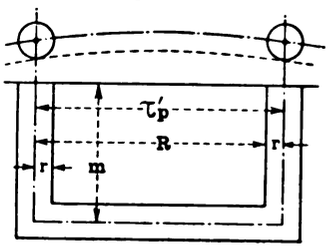
$$\Phi = 0{\cdot}4\pi q z i_k \sqrt{2}\cdot 2(\Delta_n + \Delta_z + \Delta_e), \quad \ldots\ldots \quad (2)$$

where Δ_n = permeance of slot leakage path,
Δ_z = permeance of zig-zag leakage path,
Δ_e = permeance of overhang or coil-end leakage path,
all with respect to one coil side.

The first two quantities are easily calculated according to well-known formulæ (*e.g.*, those due to Arnold). The last is not so simple and forms the subject of the present article.

When the overhang of a three-phase motor is considered, with its various shaped bent and straight coils, and an attempt is made to depict the field due to the action of the three phases, it would at first appear that the problem is insoluble. To simplify the procedure, therefore, various assumptions are necessary, but in making these we must keep quite clear the way in which these assumptions affect the result, and in any case we must avoid too large an estimation of the short-circuit current; in other words, the leakage must not be underrated.

Assumptions for Simplifying the Calculation.—Consider first a straight coil made up of three slots per pole and phase ($q = 3$), without regarding the action of the other phases. We first assume that these q coils are all combined in one circular coil whose section equals the sum of the q individual sections. Further, we shall assume the corners to be rectangular and not round as in practice. The lines of force are also taken as circular. The equivalent rectangular coil-end is shown in Fig. 1.



Coil Head and the Equivalent Right Angle.

Permeability for a Circular Section carrying Current.—There are two parts to be considered—the internal and the external. For the internal it is shown that the specific permeance (*i.e.*, the permeance per centimetre length) is

$$\lambda_i = 0{\cdot}04. \quad \ldots\ldots\ldots \quad (3)$$

For the part outside the circular section of conductors we get per centimetre length

$$\lambda_a = 0{\cdot}367 \log \frac{R}{r}. \quad \ldots\ldots\ldots \quad (4)$$

Hence the permeance of a coil-end—neglecting the effect of the other phases—will be

$$\Delta = \left(0{\cdot}04 + 0{\cdot}367 \log \frac{R}{r}\right) 2m + \left(0{\cdot}04 + 0{\cdot}367 \log \frac{m}{r}\right) \tau'_p. \quad (5)$$

The Permeance of the Overhang of a Normal Three-phase Winding.—Before simplifying the above formula the effect of the other phases will be considered. Instead of $\log R/r$ in equation (4) there will be a summation corresponding to $\Phi_I + \Phi_{II} + \Phi_{III}$, and we get for the *axial* part

$$\lambda_a = 0{\cdot}367 \left\{ \log \frac{R}{r} + \tfrac{1}{2} \log \frac{2\frac{R}{r} - 1}{\frac{R}{r} - 2} + \tfrac{1}{2} \log \frac{3\frac{R}{r}}{\frac{R}{r} + 4} \right\} \quad \ldots \quad (6)$$

To take the *tangential* part into account, the term for this has to be multiplied by 0·94.

Hence, instead of equation (5), the following expression is obtained:—

$$\Delta_e = \left\{ 0{\cdot}04 + 0{\cdot}367 \left(\log \frac{R}{r} + \tfrac{1}{2} \log \frac{2\frac{R}{r} - 1}{\frac{R}{r} - 2} + \tfrac{1}{2} \log \frac{3\frac{R}{r}}{\frac{R}{r} + 4} \right) \right\} 2m$$
$$+ 0{\cdot}94 \left(0{\cdot}04 + 0{\cdot}367 \log \frac{m}{r}\right) \tau'_p. \quad \ldots \quad (7)$$

To simplify this formula we must see what values r and R/r assume in practice. From a large number of actual motors it was found that, with close approximation,

$$r = 0{\cdot}5\,\text{cm.} + 0{\cdot}052\tau'_p \quad \ldots\ldots\ldots \quad (8)$$

and

$$\frac{R}{r} = 10 + 0{\cdot}1\tau'_p \quad \ldots\ldots\ldots \quad (9)$$

* Abstract of an article in the "Electrotechnik und Maschinenbau."

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Substituting in equation (7) we then get

$$\Delta_s = \left\{0{\cdot}04 + 0{\cdot}367\left[\log(10 + 0{\cdot}1\tau'_p) + \tfrac{1}{2}\log\frac{19 + 0{\cdot}2\tau'_p}{8 + 0{\cdot}1\tau'_p} + \tfrac{1}{2}\log\frac{30 + 0{\cdot}3\tau'_p}{14 + 0{\cdot}1\tau'_p}\right]\right\} 2m + \left\{0{\cdot}038 + 0{\cdot}345\log\frac{m}{0{\cdot}5 + 0{\cdot}052\tau'_p}\right\}\tau'_p \quad . \quad . \quad . \quad . \quad . \quad (10)$$

which gives us Δ_s in terms of m and τ'_p. Curves were then drawn giving Δ_s as a function of τ'_p for different values of m, such as occur in practice. From these curves—which were practically straight lines—it was possible to replace equation 10 by the much simpler form

$$\Delta_s = 1{\cdot}41(m-1) + 0{\cdot}24\tau'_p. \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Taking now the usual method of expressing the length of a mean turn, viz., $lm = 2(L + \tau'_p + A)$, where L = active core length, τ'_p the pole-pitch at centre of slots and A an increment chiefly dependent on the pressure, we have the following simple empirical relation:—

$$m = 1{\cdot}0 + 0{\cdot}05A + 0{\cdot}04\tau'_p$$

which, inserted in equation (11), gives

$$\begin{aligned}\Delta_s &= 1{\cdot}41(0{\cdot}5A + 0{\cdot}04\tau'_p) + 0{\cdot}24\tau'_p \\ &= 0{\cdot}705A + 0{\cdot}296\tau'_p \\ &\simeq 0{\cdot}7A + 0{\cdot}3\tau'_p, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)\end{aligned}$$

or, if l_s = mean length of overhang, we can write

$$\Delta_s = 0{\cdot}7l_s - 0{\cdot}4\tau'_p, \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Split-phase Winding.—For a split-phase winding (overhang in three planes) this formula becomes

$$\Delta_s = 0{\cdot}65A + 0{\cdot}2\tau'_p \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

or,

$$= 0{\cdot}65l_s - 0{\cdot}24\tau'_p, \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

where $A = l_s - \frac{4}{8}\tau'_p$.

The above formulæ hold for motors with slip-ring armatures and for short-circuited armatures where the rings are close to the core, for in these cases the effect of the rotor overhang on the leakage can be neglected.

In squirrel-cage rotors, where the rings lie some distance away from the rotor, or in wound rotors where the rotor winding is very close to that of the stator, the coefficients in the above formulæ must be reduced by some 10 to 20 per cent.

Having determined the overhang leakage in the above manner and also the slot and zig-zag leakage, the ideal short-circuit current can be found at once from the expression

$$i_k = \frac{\Phi}{0{\cdot}4\pi q z \sqrt{2}(\Delta_s + \Delta_z + \Delta_s)},$$

where Φ is the main flux of the motor.

It only remains to mention in what way the calculation of the overhang leakage is affected by the assumptions introduced at the commencement. First, with respect to taking all the conductors in the overhang as forming one circular bar, this gives the leakage on the high side, for it assumes all conductors to be equally effective, which is not the case actually. Then, again, no distinction has been made between bent and straight coils. Now the surface enclosed by one of the former is larger than that enclosed by one of the latter, hence calculating the leakage for a straight coil also tends to make it too large. A partial offset to the above is due to the effect of the contiguity of the shield bearing, which tends to increase the leakage path. In practice, however, the above simple formula—free from all logarithmic terms—is found quite near enough.

SWITCH AND TRANSFORMER OILS.

The following is an abstract of the discussion which took place at the meeting of the Manchester local section of the Institution of Electrical Engineers when Messrs. W. Pollard Digby and D. B. Mellis read their Paper on this subject. An abstract of this Paper appeared in our issue of April 1st.

DISCUSSION.

Mr. C. J. Beaver (Messrs. W. T. Glover & Co.) referred to several points. The first was the general character of the oils which had been taken by the authors as typical samples of switch and transformer oils. If the oils were arranged in order of merit so far as the electrical and chemical properties were concerned, and in order of magnitude so far as the physical figures were concerned, several features became noticeable. For instance, there was a rough relation between the specific resistances and breakdown voltages and between breakdown voltages and alkalinity or acidity, though not between breakdown voltages and resinoid contents. It was also noticeable that no relation existed between the physical and electrical properties, H3 and H being the best of the series and almost equally good electrically, but being comparatively wide apart physically. While some relation was to be expected between specific resistance and dielectric strength, and also between dielectric strength and purity, he did not think the impurities indicated in the table accounted for the wide difference between the various oils in specific resistance and dielectric strength. His experience was that alkaline, acid and resinoid substances were not the most usual kinds of impurity met with in mineral oil, but that moisture was by far the most predominant source of variation in electrical properties. It was practically impossible to dry an oil perfectly by the application of heat, and it was certain that the elimination of the last traces of moisture from an oil would make far more difference to its electrical properties than would alkaline, acid or resinous substances, such as were referred to in the table. In connection with the question of moisture, he thought its elimination to the utmost practical extent should not be one for the oil refiner or producer, but rather for the transformer or switch maker. There were such wide possibilities for the taking up of moisture in handling, packing and transit that the variations in one consignment referred to by the authors were not surprising. Physical and chemical properties which fixed the general character of the oil could be so easily adhered to by the oil manufacturer on the one hand, and the elimination of the moisture, on the other hand, could be so easily ensured to a practically efficient extent by, say, filteration through beds of calcium chloride, that it seemed reasonable to think that the oil user was in a better position to take care of the electrical properties than the refiner. He did not suggest that the question of moisture had been overlooked by the authors, but he thought that it had hardly been given sufficient prominence where, in his opinoin and experience, it was deserving. He had already referred to the fact that alkalinity or acidity in mineral oils was of rare occurrence, and in view of this, it would be interesting to know whether the authors had any theory as to the changes which they observed in studying the effect of disruptive tests on the chemical and physical properties of oils, where they found changes not only in degree of alkalinity, after baking and testing, but also changes from slight acidity to marked alkalinity. One of the most interesting sections of the Paper was that dealing with the experiments on the relation between dielectric strength and temperature. The general trend of the curves obtained for solid insulating materials was rather in the opposite direction to those shown for the various oils. He was inclined to think that this striking difference between solid and liquid insulating materials was due to the much better dissipation of heat in the path of stress in oils. Reference to the viscosity figures for these oils gave support to this view, and parallel cases would be familiar to those experienced in the testing of insulating materials. For the reasons just stated, he could not agree with the authors in stating that makers of oil-cooled transformers were wrong or misguided in applying lower test pressures to transformers when they were heated up at the end of a test run, than after being allowed to cool. The dielectric which the transformer maker tested was not the oil, but various solid or laminated dielectric materials which had, to some extent at least, reverse electrical characteristics to those of oils at high temperatures. The relation of viscosity to temperature was a portion of the subject on which a great deal of work had already been done, although almost entirely in connection with lubrication. The relation between fall of viscosity with temperature and electrical properties should prove exceedingly interesting, because the general order of percentage decrease of viscosity with increase of temperature bore some relation to the surface tension of the oil, and the surface tension of the oil might be quite different in cases where oils of different origin gave identical results under physical tests at the usual testing temperatures. The authors would find some remarkable results in this direction when they made further investigations in connection with this part of their subject. Referring to the chemical side of the Paper, Mr. Beaver said, with regard to the detection of moisture, although the exsiccated cupric sulphate was very sensitive to the action of water, oil might be chemically dried, and improved electrically by such drying, beyond the point when this test ceased to be sensitive. Without doubt, the most delicate test was the stream of hydrogen bubbles given off from a small piece of sodium immersed in the oil, and as the nitro-prusside test for the detection of sulphur entailed the use of metallic sodium, there would appear to be little use for the dehydrated cupric sulphate. In regard to indicators, he found no necessity for testing the aqueous extract while hot, and personally did not prefer tincture of cochineal to the more usual phenol-phthalein and methyl-orange. He had always found phenol-phthalein reliable and did not understand the statement that it was not affected by the soaps of alkaline metals. He had some doubt as to the identity of the resinous bodies to which the authors frequently referred in connection with their samples, and wished to know whether they had been isolated as such or identified by such a test as the Liebermann-Storch test.

Mr. J. S. Peck (British Westinghouse Co.) remarked that from a practical point of view there were three necessary qualities in oil used for transformers: (*a*) High fire test, (*b*) high dielectric strength, (*c*) freedom from deposit under working conditions. The authors had dealt with (*a*) and (*b*), but had not touched upon the question of deposit at all. He hoped their investigations would extend to cover this question, for although there were oils on the market which were unsatisfactory as regards the fire tests and dielectric strength, it was very difficult to obtain an oil which would not throw down a deposit when worked at a comparatively high temperature. High dielectric strength was largely a matter of purity, while the method of obtaining a high flash point was well understood. Regarding the question of deposit, however, very little appeared to be known beyond the fact that some oils exhibited this defect to a marked degree, whilst others were practically free from it. This might

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be said to be the most important question now confronting manufacturers and users of oil for insulating purposes. There was no advantage in purchasing expensive oil of great purity unless precautions were taken to maintain the purity of the oil during shipment. Oil would absorb a certain amount of moisture if exposed to a damp atmosphere, and when shipped in wooden barrels there was always a risk, especially when stored out of doors, that water would work in through the heads of the barrels. On this account the use of wooden barrels for shipping and storing had been largely done away with. The authors had devoted considerable space to the question of the specific resistance of oil, but in his opinion this was not of practical importance, unless this formed some identification of the dielectric strength of the oil. From the results this was apparently not the case. He agreed with Mr. Beaver, and therefore disagreed with the authors, in regard to the statement that a transformer should not be tested with a higher voltage when cold than when hot, because the oil had little to do with the insulation strength except in preventing surface discharges. Breakdowns usually occurred through the solid dielectric, and there was no doubt that this was weaker when hot than when cold. He thought it would be interesting to compare the effect of the alternating-current arc with that of the direct-current arc, as experience indicated that the carbonising effect was much greater with direct than with alternating current.

Mr. J. E. Southcombe (Henry Wells & Co.) said, speaking as a chemist with experience of oil investigation, he could not quite agree with some points raised by the authors as to the purity of the samples. In the first place, an examination of many samples of transformer and switch oils had not revealed the universal presence of alkali which the authors appeared to have observed. It was, in fact, an extremely rare thing nowadays to find alkali in oils of this type, and he could only say that if an oil submitted to him for adjudication contained any traces of this substance he would reject it at once as totally unworthy of any further consideration. The authors had apparently had somewhat abnormal samples under consideration. With regard to the question of moisture, the authors stated that they found oils containing as much as 0·57 per cent. of moisture, but it would appear that they had estimated this by drying at 100°C. and noting the loss. This would not give any measure of moisture content whatever, since the losses from volatilisation of the oil would always be an unknown quantity, and would totally vitiate the figures. There appeared to be a most unfortunate haziness with regard to the question of how much water there was in oils. He had conducted a long series of experiments on this matter from several points of view. Oil and water were immiscible, and if an oil contained water at all it was present in fine globules distributed throughout the mass. Now if the globules were big the water would quickly settle out of the oil, while if they were very fine indeed they might be retained for long periods, since the mixture would partake of the properties of an emulsion. Now if the globules were very minute there would have to be an immense number of them present to have anything like 0·57 per cent. of water in the oil; consequently, the water surfaces would be great, causing considerable thickening, and the oil would be very turbid. It was inconceivable that any self-respecting oil manufacturer would submit such an emulsion for transformers. Such cases did not need discussing, but what was a burning question was the influence of very minute traces of moisture on insulating properties. An oil might be quite bright and yet contain absorbed moisture, but such moisture was present only to the extent of about 0·1 per cent. or less. The quantitative estimation of such minute traces chemically was almost impossible, but he could say that the dielectric strength was a very delicate test. In his opinion variations in dielectric strength could be correlated very largely with these exceedingly minute traces of moisture, which had a far greater influence on the electrical properties than any so-called chemical impurity in well-refined oil of standard quality. There was very little evidence to show that disruptive discharge proceeded more readily in the presence of resins, &c. In fact, resin oils were admirable insulators. A study of the figures given in the authors' Paper showed that what they called resinoid content did not explain the variations in dielectric strength. He emphasised again the fact that in his opinion it was not chemical impurities but exceedingly minute traces of moisture that would explain many discrepancies in dielectric strength. The problem of how to get rid of this moisture resolved itself very much into a commercial question. Was it to be done by the oil manufacturer or by the transformer builder? There was no doubt that the oil man could supply a perfectly anhydrous fluid, but it could not be done if the electrician was going to ask for an oil at a price which his better sense must tell him would make it impossible to devote much attention to these minute but important details. Considerable success had attended drying the oil by electrical resistances immersed in the oil, but it would appear to him a better investment to pay the experienced oil manufacturer his price and demand from him an anhydrous oil. Although the question of chemical impurities did not appear so important as moisture in lowering the dielectric strength, yet it was absolutely imperative that an oil should be of the highest possible purity, since the influence of acids, and more particularly alkalis, on the windings was disastrous, while at the same time any tendency for the oil to resinify or oxidise on heating would materially affect its heat disseminating powers. It was unfortunate that the authors had not gone into this question more fully. In addition to the points they drew attention to, no specification would be complete which did not demand tests as to the durability of the oil on successive heating and cooling. On the electrical tests he could not speak with authority, but some experiments made by Mr. Lustgarten at the Manchester School of Technology, and the conclusions of Russell, did not confirm the authors' results at such short distances. Further the carbon produced by the passage of the arc required some considerable time to settle, and a sufficient interval must elapse before making a second puncture. The carbon produced was disseminated throughout the oil in a kind of semi-colloidal suspension of charged particles, which settled at varying rates in different oils. The speaker was at present investigating this phenomenon, and had obtained some most interesting results which appeared to be of supreme importance in the choice of a switch oil.

Mr. J. Lustgarten (Manchester School of Technology) said that of the properties mentioned in the Paper as requisite in a mineral oil one might add that evaporation must be small, and that no trace of sediment after repeated heating and cooling should occur. The authors mentioned that resinoid matters contaminated oil when stored in wooden barrels. He wished to ask the authors if the wooden barrels which were sent into this country from America were made of oak, because, if so, he hardly saw that resinoid matters would be likely to get into the oils with such construction of the barrels. As the authors recommended standardised methods of testing, and though they deprecated criticism of methods of taking the dielectric tests, it should be stated that the sparking voltage depended on many factors which the authors had not mentioned. These factors were: (*a*) The width of the glass vessel in relation to the spark distance and the size of the electrodes; (*b*) the position (depth) of the spark-gap in the oil; (*c*) the amplitude factor of the machine used; (*d*) the rate of growth of the testing pressure; (*e*) whether the electrodes were insulated or one was earthed; and (*f*) the shape of the electrodes. The amplitude factor was important, because if the machine had a peaky wave, the oil would break down very much earlier. Earthing one electrode altered the maximum potential gradient on the insulated electrode. With regard to (*d*), a modification of the method was to move the electrodes, keeping the testing pressure constant. As to the shape of electrodes, he could not see why the authors got the voltage distance curve for ¾ in. diameter spheres to lie below that of needle points, as it was shown that in the air the voltage distance curve lay above that of needle points. Speaking of his own results on oils, the larger-sized spheres gave curves lying above the smaller size, and obviously the needle point was a very small sphere, and for a given sparking distance and voltage the potential gradient was steeper with needle points. He had experimented with ½ in., ¾ in. and 1 in. spheres, and had obtained better results with large spheres than with the smaller ones, but the distances had to be greater than ⅛ in. With regard to the curves for spheres, these bent over as in the needle point curve. Dr. Russell some years ago suggested that the best way of expressing the dielectric strength of an insulating material was by the maximum potential gradient at breakdown. This for the parallel plate electrodes immersed in the dielectric would be V/X, and for spheres V/X*f*, where V = maximum voltage, X = spark-gap distance, and *f* a factor depending on X and the diameter of the sphere. The dielectric strength of the best oils was about 160 kv. per centimetre, and for medium oils about 100. The potential gradient for the oil in the curves on p. 13 of the Paper was rather low, 80 kv. per centimetre. The authors remarked that the dielectric strength improved with flashing over, and was due to traces of moisture and impurities being burnt out. This was particularly apparent in an oil submitted to the speaker to test. The breakdown voltage went up from 42 kv. to 80 kv. (R.M.S.) in 20 days with a test taken once every 24 hours, but after repeated breakdowns the strength diminished, 80 kv., 71·2 kv. and 63·6 kv. being readings taken on three consecutive days. In testing oil sufficient time should be given to allow air bubbles to rise and finely-divided floating or colloidal matter to settle, as they would seriously affect the results, especially at the small sparking distances. In a particular case the breakdown voltage a few minutes after pouring in was 10 kv., half an hour afterwards 17 kv. and 24 hours later 48 kv. (in the latter test traces of moisture must also have been removed). The authors found that the dielectric strength of the oils increased with temperature. This result seemed the reverse of what might be expected. In solids it was the reverse. Did the authors find this to hold after repeated heating and cooling of one specimen in order to eliminate traces of moisture and impurities before conducting the test? For drying oils he found that hot air and sodium answered very well. In one case a transformer oil treated with sodium increased in strength from 107 kv. to 122 kv. per centimetre.

Mr. D. B. Mellis, in reply, said in connection with Mr. Beaver's remarks, the purpose of putting down along with the observed physical behaviour of the oils examined the result of their chemical examination also was not to infer that the physical properties found were due to chemical impurities. Although had no chemical examination of the oils been made it would always have been open for anyone to say that variations in the behaviour of the oils under discussion were due to variations in their degree of purity. With regard to the slight variations in the reaction of oils observed after testing for dielectric strength, these might be due to several causes. For instance, electrolytic action might change some of the impurities contained in the oil from acid to alkali and *vice versa*. Or again, owing to the high voltages used, the air surrounding the testing vessel and in contact with the oil became ozonised, and nitrous oxide was also formed. These substances might easily affect the reaction of so nearly neutral a liquid as the oil usually was. Mr. Beaver seemed to think that it was asking too much of the oil people to expect them to supply oil to a standard of specific resistance. The authors did not agree with him in this matter, as the specific resistance test was really a very delicate test for the chemical purity of the oil in question. In fact, the importance of the specific resistance test was that no oil having a relatively large amount of water or other harmful impurity would have a high resistance. If copper refiners could work to a specification of specific resistance it was not unreasonable to ask oil suppliers to work to a similar one. Mr. Beaver remarked that the authors did not attach sufficient importance to the presence or absence of water. This was unintentional. They did not labour the point as they thought it fairly self-

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evident. They considered it of the utmost importance for the refiner to supply absolutely dry oil, but it was of no use his doing so unless the necessary care were taken to keep it dry. When the user had to dry his own oil they would suggest warming it up in a vacuum oven to a moderate temperature. Too high a temperature must not be employed or the nature of the oil might be changed. If possible, when in the vacuum oven, dry air should be allowed to bubble through the oil, so as to stir it up and help the evaporation, and by "dry air" they did not simply mean "hot air," but air which had been freed from moisture by passing it over calcium chloride or, better still, phosphorus pentoxide. The method suggested by Mr. Southcombe of stirring the oil with a cage containing metallic sodium would appear to have the disadvantage that caustic soda would tend to replace the water, and would afterwards attract to itself much more water, unless the vessel were hermatically sealed after treatment of the oil. Mr. Beaver remarked that the other physical properties such as viscosity and flash point did not appear to have any relation to the electrical properties of an oil; in this connection the authors would like to remark that a sample of ordinary illuminating paraffin oil bought at a very cheap rate gave a curve of dielectric strength at least twice as good as the best transformer oil, and needless to say both its viscosity and flash point were very low, far lower than those of any transformer oil. It was also interesting to note that the dielectric strength of any transformer oil increased with rise in temperature, while its viscosity fell. This relation between viscosity and dielectric strength might be accidental, both being due to some molecular condition. Mr. Pollard quite agreed with Mr. Beaver that variations in electrical properties might be caused to a very great extent by very small proportions of moisture, but the question of alkalinity was of importance because a very slight trace of alkali caused absorption of moisture. He was not in favour of filtration through calcium chloride for drying oils, but preferred Mr. Peck's vacuum oven process. Another good method of eliminating moisture was by blowing hot dry air through the oil. Whilst endorsing Mr. Beaver's remarks as to the sodium test, he found that the exsiccated cupric sulphate test was sufficiently sensitive when suitably applied. With regard to indicators, he had no intention of advising the testing of the aqueous extract whilst hot, but cochineal had the advantage that it could be used for hot liquids, whilst methyl orange could not, and, moreover, the colour change of methyl orange, with traces of alkali, was not easily observed, unless the indicator were first made feebly acid and then carefully neutralised. It seemed to be generally taken for granted that the alkali in oil invariably existed as hydroxide. This was very far from being the case, and consequently, when phenol-phthalein was used as an indicator, considerable traces of alkali escaped detection. The neutrality of phenol-phthalein to soaps permitted its use in soap analyses for the estimation of free caustic alkali, whilst the subsequent volume of acid required to give neutrality with methyl orange was a measure of the alkali combined with fatty acids, &c., or existing as carbonates, borates, &c. However, soaps of the alkali metals were very seldom found in mineral oils of the type under consideration, although aluminium soap was by no means infrequently met with. The exact nature of the "resinoid" matter was not determined. In most cases it appeared to be tolerably pure resin, but in several instances examination revealed admixture of other substances, hence the employment of the term "resinoid matter" instead of "resin." With regard to Mr. Southcombe's statement that it was an extremely rare thing nowadays to find alkali in oil of this type, out of considerably more than 100 samples examined during the last 18 months or so, at least 80 per cent. had been found to contain alkali, sometimes in slight, sometimes in very distinct traces, but had phenol-phthalein been used as an indicator, no doubt practically the whole of these would have been returned as neutral. Comparative tests had demonstrated that cochineal and methyl orange were more than ten times as sensitive to alkaline carbonate than was phenol-phthalein. All the samples were obtained from well-known makers of transformer oil. They could not, therefore, be considered to be abnormal samples, as Mr. Southcombe suggested. Of all the oils discussed in this Paper only one of them showed an acid reaction—viz., H_5—all the others being neutral or alkaline. With reference to Mr. Southcombe's criticism of the authors' method of making tests for dielectric strength, in which he quoted Russell as saying that such determinations were not reliable when tests were made over short distances, and that consequently high voltages must be employed, the authors would point out that when Russell made this statement he was discussing the experiments of Hobbs, who tested over microscopic distances down to 3×10^{-7} cm., and he went on to say that it was not safe to calculate dielectric strengths from the observed disruptive voltages when the electrodes were less than 1 mm. apart, and suggested that for accurate work at least 0·5 cm. should be tested over. Now, as the authors' distances range from about 0·5 mm. to over 1 cm., they did not suppose that Russell would take exception to the lowness of the voltages used. Their results were in accordance with Russell's statement, in that the more consistent readings were generally obtained with the higher voltages than with the lower ones. Mr. Southcombe's tests were apparently mostly made using balls as the electrodes, and in his case air bubbles would be more likely to give trouble than in the authors' case. In connection with Mr. Peck's remarks on deposit, one usual explanation offered was that varnish, supposed to be oil-resisting and used in transformer insulation, was not actually so, and that it dissolved out, or partially dissolved out, forming a more or less gelatinous solution, which, by electrostatic attraction, clung to the windings and impeded the free circulation of the oil. This, however, did not appear to cover every case observed, and they were forced to suppose that the thickening, in some cases at least, was due to polymerisation of some of the hydro-carbon of which the oil consisted, or even to chemical change brought about by repeated heatings and cooling. This was a question for chemists rather than electrical engineers to investigate. The authors fully agreed with Mr. Peck in his remarks about carelessness in handling oils sent out in casks, and considered that, for electrical work, nothing but hermetically sealed metallic drums should be permitted. While agreeing with Mr. Peck that high dielectric strength was a most important feature, they did not agree that a high resistance was not of much use, as the latter was only obtained with very pure oils and might be taken as a measure of their chemical purity. With regard to the authors' suggestion as to testing transformers with a higher voltage when hot than when cold, Mr. Peck disagreed on the ground that oil was not the principal insulating medium. This criticism, of course, would not hold good in the case of a transformer so designed that the oil was the principal insulator. Referring to the much greater relative amount of carbonisation which took place in the oil tanks of direct-current controllers or switches than with alternating current, the fact of the alternating current passing through zero twice a cycle gave the oil a very much better opportunity of extinguishing the arc in the latter than in the former case, and also no highly inductive arcs had to be quenched, which was not the case with direct currents. Replying to Mr. Lustgarten, when American oil was shipped in barrels these were usually made of oak, but in the case of Russian oil steel drums were generally used. The glass containing vessel of the apparatus illustrated was about 2 in. diameter, and as the electrodes were placed axially it was obvious that the distortion of the electrostatic field, due to the high specific inductive capacity of the neighbouring glass, would have no effect on the field between the two electrodes, which were never separated by more than 0·4 in. The curve of voltage of the alternator used did not differ very much from a true sine curve. The value in kilovolts given on the curves of dielectric strength was expressed in virtual volts. Besides the maximum voltage the length of time during which the voltage was applied decided the limiting sparking distance. From this they would conclude that higher dielectric strength would be obtained with a higher frequency. Neither of the electrodes was earthed, but as everything was very well insulated and the voltages used were never higher than about 25,000, earthing should not have made much difference. In reply to Mr. Lustgarten, it was not safe to argue as to the phenomena of breakdown in liquids from experimental results obtained in air. J. J. Thomson showed that when ions were present the electrostatic field was distorted, and could not be calculated from the geometry of the electrodes only. It was obvious, therefore, that if in the one case the ions could freely move about and in the other they were relatively stationary the distribution of the electrostatic field would be different in the two cases. Another suggestion they would offer was that, when testing with one or both the electrodes pointed, only a very small volume of the oil was subjected to intense dielectric stress, whereas when testing between balls a very much greater volume of oil would be stressed. Owing to the fact that the oil was probably far from homogeneous there would be a much greater likelihood of a weak part being stressed and broken down in the latter than in the former case. In a similar way it would not be safe to estimate the dielectric strength of a mile of cable as equal to the value experimentally found for a yard length. The only apparent advantage in testing between balls was that the absolute value of the physical constant "dielectric strength" could be more readily calculated than when points or a point and disc were used. As the authors found the latter gave the more regular results, it was the more suitable for determining the relative dielectric strengths of oils under similar conditions. Further, the authors did not state that the curve connecting sparking voltage and distance between spherical electrodes was linear. Of the oils designated by the letters H_1 to H_7 all were ordinary commercial samples, none being appreciably better nor worse in their purity than those supplied in bulk to large purchasers. At the commencement of the Paper the authors referred to the splendid curve of high dielectric strength widely circulated but rarely attained in practice, they therefore urged that in dealing with commercial oils in everyday use the present researches had tended towards practical utility.

CORRESPONDENCE.

ON THE EFFECT OF SHUNTING INDUCTIVE COILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In his interesting article on the effect of shunting a choking coil with a non-inductive resistance, Mr. Howe points out that the *impedence* is not increased by the addition of such a shunt. If, however, he had drawn his vector diagrams to illustrate the effect of shunting a highly inductive coil when the latter has *in series with it* a non-inductive resistance, he would have found that the total impedence of such a circuit may be increased by connecting a non-inductive shunt across the choking coil. This effect was explained by the writer in his book on Alternating Currents (published in 1898), and it is not unlikely that both Mr. H. E. Harrison and Mr. A. Campbell may have had such a circuit in mind when referring to the increased impedence.

Given a non-inductive resistance connected in series with a choking coil across an alternating supply of constant voltage, it is an undeniable fact that the current flowing in such a circuit can actually be *reduced* by connecting a non-inductive shunt across the choking coil.—Yours, &c.,

Springfield-lane, Salford, April 28. ALFRED STILL.

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THE WESTMINSTER STREET LIGHTING CONTRACTS.

The following letter has been sent by the St. James' & Pall Mall Electric Light Co. to the Town Clerk of the Westminster City Council, and copies have also been forwarded to all members of the Council:—

DEAR SIR: I am in receipt of your letter of the 15th inst., informing me that the City Council have not seen their way to accept the tender of this Company, dated the 14th March last, for public lighting in District D of the City, and reminding me that the existing contracts of the Company with the Council for this purpose will expire on the 10th November next.

With regard to this matter and more especially to this notice that the existing contracts will be terminated at that date, I would respectfully point out that this Company has been placed at a great disadvantage by the form of the recent specification and tender to which strict adherence is enjoined. For instance, Clause 2 of the General Conditions of Contract stipulates that the contractor may tender for the lighting of all or any of the districts A, B, C and D mentioned in the form of tender, treating each district as a separate unit, and that the Council *inter alia* may accept any such tender in respect of any part of any district to the exclusion of the remainder of the same district, and for this purpose may sub-divide any district, but the contractor is not permitted to tender for the lighting of any part of a district or even to submit a different price for that part which the special circumstances of the case may justify.

Under the existing contracts this Company maintains at the uniform charge of £17 per lamp per annum a total of 66 arc lamps consisting of 16 660-watt flame arc lamps in Regent-street which give an illumination according to the tests of the City Engineer of 3,575 c.p.; four 440-watt flame arc lamps in St. James's-street which give an illumination of 1,800 c.p.; and 46 660-watt white arc lamps in Piccadilly, St. James's-street, Pall Mall, &c., which give an illumination of 900 c.p. In addition to these there are five white arc lamps in Piccadilly-circus which are maintained at the rate of £2. 10s. per lamp per annum, and a charge of 2½d. per unit for electricity consumed by meter, but this small circuit need not be included as part of the above.

For the above total of 66 lamps a special circuit of mains has been laid down in connection with a complete generating and accumulator plant, the system being controlled direct from the works of the Company. To extend this system for the whole of District D, for which the Company had to tender, involved a capital outlay for additional mains and plant, which rendered the cost on a five year contract practically prohibitive. Competition with the tender of the Gas Company had therefore under the circumstances to be directed to the longer period of a 15 year contract, and on this basis the charges of this Company for the 3,000 and 1,800 c.p. lamps are entered at £22 and £17. 10s., as compared with those of the Gas Company at £20. 5s. and £14. 5s.

But with regard to the above circuit of 66 arc lamps the circumstances are different. This Company would have to incur no additional capital expenditure, except that of providing the new flame arc lamps in place of the existing white arc lamps, and had the form of tender permitted, these matters would have been fully taken into account and a special price submitted. This, on the basis of the estimates prepared for the original tender, would be:—

For a five year contract with the option to the Council to renew for the 10 or 15 year period the maintenance of the existing 16 flame arc lamps in Regent-street to the 3,000 c.p. standard and the installation and maintenance of the other 50 lamps in Piccadilly, St. James's-street, Pall Mall, &c., with new flame arc lamps to the 1,800 c.p. standard for the inclusive price of £1,122 per annum, representing an average charge of £17 per lamp per annum for both sizes. No charge would be made for any installation costs in connection with the above, and the Company would undertake to have the whole of the alterations completed and in full working order by November next.

The efficiency of the flame arc lamps in Regent-street is an established fact, and as the carbons are renewed each day and the current of electricity maintained at a constant quantity there can be no deterioration of the illumination. On the other hand, no gas lamp of equivalent illuminating power and effect has yet been exhibited, and on account of the deterioration of the gas mantles employed the resultant light must be subject to considerable degeneration when in regular use.

By the arrangement proposed by this Company a total of 138,000 c.p. is provided at an inclusive cost of £1,122 per annum as compared with the cost of £1,127 per annum for the equivalent candle-power derived from gas lighting, to which must be added the further cost of installation of £140 per annum, for which no charge is proposed by this Company. Further, the maintenance of the electric light circuit involves no further opening of the roadway of these important thoroughfares, whereas the installation of a high-pressure gas service in this case will surely necessitate the opening of the whole length of these streets.

In view of all the circumstances which are set out in this letter, my Directors ask that it may be read at the next meeting of your Council, in the hope that a modification of their recent resolutions may be made which will provide for the continued supply by this Company of 66 arc lamps of the improved type at the same inclusive cost as heretofore.

They take the liberty of urging this course upon your Council from the point of view of the public benefit, having regard to such matters as the satisfactory illumination which has been demonstrated in Regent-street, the actual cost of this method of lighting, and the important fact that no disturbance whatever of the roadways of these important thoroughfares is involved therewith, and in this connection they desire to call attention to the reiterated assurance given by Mr. Abady to your Mayor that your Council have the right to omit the lighting of Regent-street and Piccadilly from the contract should they think fit to do so.

I shall be glad to hold myself at your disposition for any information that you may require, or to consider carefully any modification of the above arrangement that the Council may suggest.—I am, dear Sir, yours faithfully,

(Signed) F. J. WALKER,
General Manager and Secretary.

STREET LIGHTING IN WESTMINSTER.

Westminster City Council yesterday discussed a section of the Works Committee's report in regard to the distribution and cost of the lighting, under the Gas Light & Coke Co.'s recent tender, which had been accepted at the previous meeting for the street lighting of several districts, including Regent-street and Piccadilly, at present lighted by the St. James' & Pall Mall Electric Light Co.

Councillor PULLMAN said he had been so pertinaciously approached by ratepayers of his ward that he raised once more the question of the removal of the arc lamps. It had been pointed out to him that the electric lighting of Pall Mall, part of Piccadilly, Piccadilly Circus, Regent-street and St. James'-street would cost only £250 more than gas lighting. Although he, personally, was satisfied that the new light would be equally satisfactory, he moved, in order that the matter should be ventilated, that they disagree with the Works Committee's report so far as the streets he had named were concerned.

Councillor GATTI said there would be a distinct advantage in continuing the lighting by arc lamps, which at present existed in Regent-street. The arc lamps were there, and they would save the trouble and interference with traffic, and there would be also an actual reduction in the cost of the lighting. They had a perfect right to reconsider the matter.

Councillor ABADY (Chairman of the Works Committee) said the standing orders barred the Electric Light Co. from having their tender reconsidered on the ground that contractors were prohibited from canvassing members or officials of the Council, and the letter that had been sent by the company amounted to canvassing. Their specifications were clear, and if the Council allowed that Dutch auction sort of business they should also give the Gas Co. another chance of having a shot at the electric light prices. The St. James' Co.'s letter which had been sent to the Town Clerk stated that the contractors were not allowed to submit a different price for a district in which special circumstances applied, but the conditions of contract stated that the contractor could make different charges for different districts.

Mr. PULLMAN said he would withdraw his motion as he was satisfied with Mr. Abady's explanation.

Capt. JESSEL congratulated the Chairman of the Works Committee, but he did not think there was anything improper in the letter of the St. James' Co. It was customary when a company had a case to defend or to put forward. He remembered that the same thing was done by the Gas Light & Coke Co. many years ago.

Councillor GATTI said the tables which had been put before the Council at the last meeting referred to an average for 10 years, but he could not see how any average could be taken. There had been a tendency to make things difficult for the Electric Light Co. Conditions were imposed which he did not think could be of any benefit to the Council, but which might have been a great burden to the contractor. He quoted as an instance a condition that if a lamp were out for five minutes you got the light free for about two months. Mr. Abady had, all through, for the purpose of comparison, taken the five year period, and when a contractor had to spend a certain sum of money, and only had five years to recoup himself, that made it necessary to make a correspondingly high charge for the light. On the 15 year period the prices would have been much nearer.

Councillor BINGHAM did not agree with Mr. Abady that the Electric Light Co. were not prevented from tendering for certain portions at different prices. Looking at it from a lawyer's point of view it might not mean that, but the Company had not come for an explanation, and he thought they must suffer for it. He was afraid the removal of the electric light would do away with competition. He went on to say that the 3,000 nominal candle-power electric lamps at present in use gave 3,500 c.p., whereas the only 3,000 nominal candle-power gas lamp of which he knew (that outside the Mansion House) only gave 2,500 c.p. The Regent-street arc lamps gave a magnificent light.

Councillor ABADY said the reason they took the five years' period in making a comparison was that the Committee would not consider a contract for more than five years at the outset, but wished to reserve the right to enter into an additional five years' contract at the end of the first five years, at the 10 years' prices.

The Committee's report was ultimately adopted, without exception.

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OERLIKON VARIABLE-SPEED THREE-PHASE MOTORS.

The use of centrifugal and turbine pumps, and particularly of ram pumps, has hitherto been considerably limited in places where a three-phase current supply is available, as speed regulation with three-phase motors entails reduced efficiencies when resistances are used in the rotor circuits.

The Oerlikon variable-speed three-phase motor of the induction type, which has been used for many years past and which is particularly well known on the Continent, has provided a solution of this difficulty. Until recently it has only been possible to build such motors of the two and four-speed step type, but of late, say, for the last two years, the Oerlikon works have succeeded in making machines with five and six-speed steps, thereby widening the range of utility of this class of machine very considerably, and making it particularly adaptable to mining work for the driving of haulage gears, main fans, pumps, &c.

In the case of a 100 B.H.P. Oerlikon variable-speed induction motor driving a three-stroke ram pump in a well-known Scottish mine, the motor is built to run at 105, 360, 485, 725 and 970 revs. per min., and gives at these speeds 10, 34, 48, 70 and 100 B.H.P. respectively on the spindle shaft. It could, of course, have been designed to give any other range of output and also, for instance, a constant output of 100 B.H.P. at all speeds should this have been necessary. This motor is supplied with three-phase current at 2,200 volts between phases and a frequency of 50 cycles. The rotor diameter is 35·25 in., and the width of the active iron of both rotor and stator is 10 in., the air-gap being approximately $\frac{1}{16}$ in. The

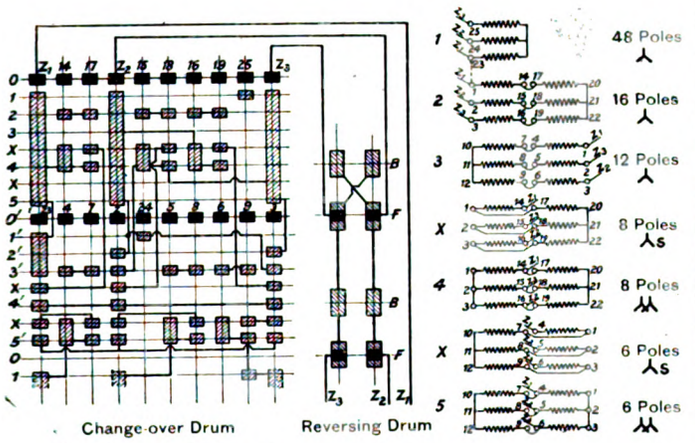

FIG. 1.—DIAGRAM OF CONNECTIONS OF OERLIKON CONTROLLER.

stator has 144 half-open slots measuring in section 0·45 × 2·55 in. The rotor has 213 half-open slots measuring 0·195 × 1·02 in. The stator is equipped with three independent sets of drum windings, equally divided in the slots. The first winding for the lowest speed has 48 poles. The two other windings are arranged for two sets of poles in the ratio 1:2, viz., 16 and 8 poles and 12 and 6 poles respectively. The first winding has per slot 55 turns, 0·043 in. diameter; the second winding has 24 turns of 0·075 in. diameter, and the third winding has 18 turns of 0·0857 in. diameter. The windings for the 16 and 8 poles are formed of eight sets of coils, and the windings of 12 and 6 poles are formed of six sets of coils, which are connected in series for the higher number of poles and in parallel for the lower number of poles, as indicated in Fig. 1.

The design of the rotor is the simplest feasible. It is provided with a squirrel cage winding of copper bars without insulation, and short-circuited at both ends by means of cast-on brass rings. The pole change-over switch is also of extremely simple design. The contact pieces are so arranged on the controller drum that no crossings of the leads beneath the individual contact pieces takes place, so that the insulation of the individual contacts against the drum and between each other is perfect. There are 20 contact fingers in number, 17 of which are required for the pole-changing device, and three for the leading-in wires (*see* Fig. 1). The contact drum is provided with a ratchet giving seven distinct positions, five of which correspond to the five different speed steps, whilst the intermediate positions are so-called "transition positions," from 12 to 8 and from 8 to 6

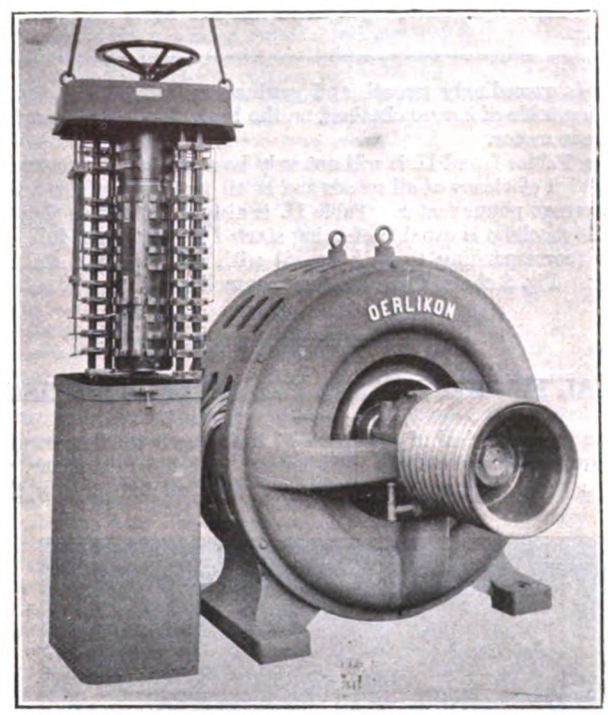

FIG. 2.—OERLIKON VARIABLE-SPEED 3-PHASE INDUCTION MOTOR.

poles. The pole change-over switch is equipped with a reversing drum, which moves freely on the shaft of the main drum, but so interlocked that it can only be operated when the main drum is in the zero position, *i.e.*, when the stator is disconnected. The whole pole change-over and reversing gear is oil-immersed. Such pole change-over drums with motors have been in operation for four and five years without having necessitated the replacing of contacts, thus showing that the life of the whole combination is very good. The starting up of the motor by means of this pole change-over

Table I.—*Tests on* 100 B.H.P. 3-*phase variable speed Oerlikon motor*, 2,200 *volts*, 50 *periods*.

Load. H.P.	Revs. per min.	Volts.	Amps.	Losses.			Input.			Efficiency per cent.	Power factor.	Stator resistance per phase.	No. of poles.
				Iron and friction losses.	Copper losses, stator	Copper losses, rotor.	Total.	K.v.a.	Kw.				
				Watts.	Watts.	Watts.						Ohms.	
0	125	2,200	4·95	1,300	1,500	0	2,800	18·8	2·8	0	0·15	...	...
5	119	2,200	5·15	1,300	1,800	180	3,280	19·5	6·98	53·0	0·355	22·75	48
10	108	2,200	6·7	1,300	3,200	480	4,980	25·5	12·36	60·0	0·485	...	...
0	375	2,200	7·0	2,000	900	0	2,900	26·6	2·9	0	0·11	...	...
17	369	2,200	8·2	2,000	1,050	200	3,250	31·0	15·75	79·5	0·51	5·2	16
34	362	2,200	10·4	2,000	1,700	1,200	4,900	39·2	29·9	84·0	0·76	...	...
0	500	2,200	7·5	2,600	600	0	3,200	28·5	3·2	0	0·112	...	...
24	492	2,200	9·7	2,600	1,000	280	3,880	37·0	21·7	81·5	0·59	3·5	12
48	484	2,200	13·8	2,600	2,000	1,130	5,730	52·5	41·13	85·5	0·79	...	...
0	750	2,200	8·0	4,200	400	0	4,600	30·5	4·6	0	0·15	1·37	8
35	738	2,200	11·3	4,200	530	420	5,150	43·0	30·85	83·5	0·72	...	...
70	724	2,200	18·5	4,200	1,400	1,800	7,400	70·0	58·9	87·5	0·84	...	...
0	,000	2,200	8·4	7,000	200	0	7,200	32·0	7·2	0	0·225	...	...
50	984	2 200	15·0	7,000	600	550	8,150	57·2	44·65	82·0	0·78	0·9	6
100	968	2,200	25·0	7,000	1,700	2,350	11,050	95·0	84·65	87·0	0·89	...	...

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Table II.—*Torque Tests.**

Position.	No. of poles.	Amps.	Volts.	Torque.
1	48	6·5	2,200	1·58 × 45 kg. (corresponding to 10·5 H.P. at 105 r.p.m.)
2	16	28·0	2,200	1·58 × 45 kg. (corresponding to 35 H.P. at 360 r.p.m.)
3	12	20·0	2,200	1·58 × 45 kg. (corresponding to 48 H.P. at 484 r.p.m.)
4	8 series	25·0	2,200	1·58 × 20 kg. (corresponding to 33 H.P. at 724 r.p.m.)
5	8 parallel	42·0	2,200	1·58 × 45 kg. (corresponding to 71 H.P. at 724 r.p.m.)
6	6 series	30·0	2,200	1·58 × 20 kg. (corresponding to 43 H.P. at 960 r.p.m.)
7	6 parallel	45·0	2,200	1·58 × 45 kg. (corresponding to 100 H.P. at 968 r.p.m.)

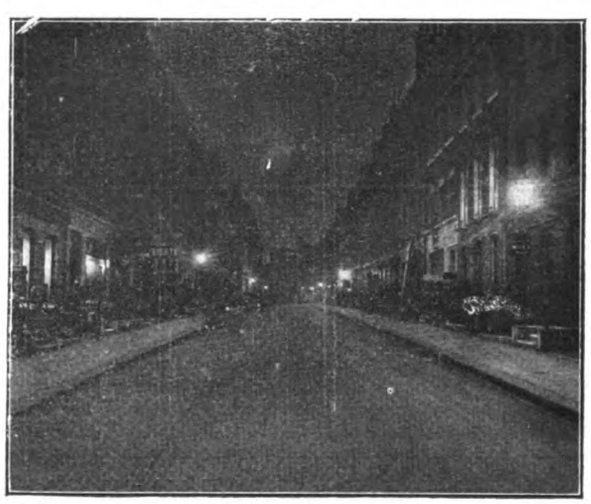
* Starting torque tested by Prony's brake. Lever 1·58 m. long; 45-50 kg.

device is exceedingly smooth and gradual, as will be seen by the adjoining table of figures obtained on the brake tests carried out with the above motor.

From Tables I. and II. it will not only be seen that the motor has a very high efficiency at all speeds and at all ouptuts, but also a very high average power factor. Table II. is also of interest as showing that the machine is capable of being started up at normal full load torque (corresponding to each speed) with a very small starting current. Fig. 2 shows the motor and controller.

METAL FILAMENT LAMPS FOR STREET LIGHTING.

There is a good deal of discussion at the present time concerning this development of electric illumination, and the future has, we think, a great deal of interest for the electrical industry in this



(Reproduced from an untouched photograph.)

A Typical Example of Osram Side-Street Lighting in the West End of London.

direction. For this reason any example of actual street lighting by this means is pertinent to the question at issue, and we give herewith a photograph which shows the illumination of a street in the West-end of London carried out by means of a combination of two 100 c.p. Osram lamps fitted in lanterns with special reflectors. It needs no expert to decide that the example is a particularly effective one.

"The Inventions of Nikola Tesla."—"The Electrician" Co. have inquiries for copies of Mr. T. C. Martin's book, published about 1894, entitled "The Inventions of Nikola Tesla." Anyone desirous of disposing of copies of this book will please address the Publisher, 1, 2 and 3, Salisbury-court, Fleet-street, London.

RADIOTELEGRAMS.

Returns have just been presented to Parliament showing:—

1. The total number of Unofficial or Non-Departmental Radiotelegrams to and from commercial ships at sea.
2. The number dealt with at each Wireless Station.
3. The number of such Radiotelegrams calling for assistance to ships disabled and for those in danger, with the names of the ships and the results of any such appeals.
4. The total number of licences held by shipowners, the number and names of ships so covered and actually fitted, and the trades in which the ships are engaged.
5. The total revenue derived by the Post Office from such Radiotelegrams.
6. The total number of Stations licensed in the United Kingdom apart from ship installations, specifically stating the number in the county of London.

Following are the particulars given:—

1. Total number of unofficial or non-departmental radiotelegrams exchanged between the shores of the United Kingdom and commercial ships at sea from March 31 to Dec. 31, 1909, 34,496.
2. These radiotelegrams have been dealt with at Bolt Head 262, Caister-on-Sea 680, Crookhaven 18,599, Heysham Harbour 123, Lizard 4,434, Malin Head 3,423, Niton 1,779, North Foreland 477, Parkeston Quay 592, Rosslare 875, Seaforth (Liverpool) 3,252.
3. No radiotelegrams embodying a general call for assistance to ships disabled or in danger were received at any of the above stations during the period in question, but in three cases vessels which were in distress communicated with their owners or agents through one or other of the stations. Names of vessels and precise results of the communications not known. In 16 cases vessels in distress were reported by certain lightships which communicate with these stations by means of wireless telegraphy.
4. Total number of licences held by shipowners on Dec. 31, 1909, in respect of ships registered in the United Kingdom, 32; number of ships covered by these licences, 116.

The names and trades of these 116 ships are given in the Return, and include five submarine cable steamers (the "Buccaneer," "Cambria," "Colonia," "Mackay-Bennett" and "Minia"), six vessels engaged in the West Indian fruit trade, 95 passenger steamers, four cargo and passenger steamers, one general cargo steamer, and four oil steamers.

5. The revenue (partly estimated) derived by the Post Office from radiotelegrams mentioned in (1) and (2) represented (*a*) coast station charges £1,120; (*b*) inland telegraph charges £1,115, total £2,235. It is noted that the Marconi stations only came into possession of the Post Office on Sept. 29 last, and the Lloyd stations on Nov. 1.
6. The total number of licensed stations in the United Kingdom on Dec. 31 (apart from ship installations) was 260, of which 241 were licensed for experimental purposes only. The total number of licensed stations in the County of London at the same date (all for experimental purposes) was 58.

ATLANTIC CABLE RATES.

The Postmaster-General's Bill providing for the control of cable rates by the Railway Commission was passed by the Railway Committee of the Canadian Senate on Tuesday.

The Bill was amended by eliminating the clause: "Any provision of any special Act inconsistent with this Act is repealed." The amendment permits the Commercial Cable Co. to retain the privileges it possesses in Canada by special legislation. The Act will only be valid so far as it is concurrent with legislation in the Imperial Parliament.

Mr. Lemieux, the Postmaster-General, expressed the opinion that the proposal to have three scales of charges for urgent (1s. a word), deferred (6d.), and Press messages (3d.) would work satisfactorily.

Mr. Dickenson, vice-president of the Commercial Cable Co., combated this idea, and said: Owing to their world-wide extent there were no idle hours on the cable lines and no deferred messages. The plan had been tried and abandoned. The companies might escape control by landing their cables at Newfoundland.

Mr. Lemieux said that Mr. Sydney Buxton, the former British Postmaster-General, promised to introduce concurrent legislation in the British Parliament.

Amendments to the Bill have been adopted which make its operation dependent on the passage of an Imperial Act.

Mr. Geo. Gray Ward, vice-president and general manager of the Commercial Cable Co., has addressed the following letter to the Speaker of the Canadian Senate:—

I understand that the bill which has recently passed the House of Commons of the Dominion of Canada, for the purpose, among others, of regulating or controlling the rates of cable companies owning trans-Atlantic cables, has been or will soon come before the Senate, and, accordingly, I take the liberty of addressing you on the subject, for the purpose of pointing out that the proposed reductions cannot be justified by business conditions or the status of the cable companies themselves. None of the Atlantic cable companies are earning more than a fair return. Some are not even earning that, because of the loss of income from disabled cables and the enormously increased charges for maintenance. To reduce rates would be to reduce income still further.

There is no reason to expect that the trans-Atlantic cables will be free from damage or breakage in the future, any more than they have been in the past. On the contrary, the

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agencies which inflict the injury are multiplying and extending the field of their operations, and the cable companies must take into account the probabilities that their repair bills and loss of traffic will increase and will not diminish. One of our cables was damaged last year about 65 miles from our cable landing at Dover Bay, Nova Scotia, and we were in consequence deprived of its use for three months. When making the repair our repairing ship found that for a distance of 2¼ miles the cable had been caught about every 10 fathoms by steam trawlers, and had been flattened, twisted and subjected to great strain. A large number of steam trawlers are now fitting out in readiness for this season's fishing, and we dread the damage which they may do us, and which we see no way to avert. The strongest, newest and best cables are not immune from the depredations and devastations of these trawlers.

The Commercial Cable Co. has had three cable ships at sea at one time repairing or replacing disrupted cables. For over six months continuously during the past year we at no time had our entire facilities working, there being some break somewhere during all that period. The expense connected with all this has been enormous, to say nothing of the loss of business on account of not having complete facilities. In fact, the menace to the business is so great that we have decided to lay still another cable in the Atlantic Ocean, although such additional cable is entirely unnecessary to our present business if we could be sure of having our present facilities uninterrupted. Then there is our competitor, the Western Union Telegraph Co. We are told that for nearly nine months both of its cables have been entirely disrupted and out of use. The Direct United States Cable Co., which has one cable in the Atlantic Ocean, has also been in trouble during the past winter. All the cable companies without exception have had these troubles, and the aggregate expenditure for interruption and repairs has been enormous.

This demand on the part of Canada for reduced rates is not justified. Canada already enjoys a much lower rate than would be possible if the rate were to be fixed for a cable service dependent on Canadian traffic alone. It is the large volume of United States traffic that renders possible the low trans-Atlantic rate for the smaller volume of Canadian traffic. The cable rates across the Atlantic are the lowest cable rates in the world. The companies, and especially this company, have shown their friendly disposition towards Canada already by making a special rate as a matter of special gratification to Canada for the traffic in which Canada herself is specially interested—namely, the traffic between Australia, Canada and Great Britain.

Mr. Ward encloses a reprint of a letter which he sent in January, 1909, to the Committee on Foreign and Insular Trade, of the New York Board of Trade and Transportation. From this letter we extract the following:—

The disposition of the cable companies to meet public requirements is conspicuously shown in their attitude towards code language. The cable companies have gradually relaxed their rules and have admitted artificial or manufactured words, which are supposed to have some resemblance to real words. These so-called words really represent 10 figures each; the 10 figures are two groups of 5 figures, and each group of 5 figures represents a separate code word, and each code word easily represents, on the average, at least 10 plain words. The net result is that each of the above so-called code words, representing at least 20 words in plain language, is transmitted at a total cost of 25c. It is almost impossible to transmit by cable these words rapidly and correctly. The result is that the carrying capacity of a cable is reduced over 25 per cent. In addition to that, many of the so-called words have to be repeated. This places upon the cables a large amount of unremunerated work, as repetitions are not charged for. It also delays a great deal of paid work. By reason of all this the earning power of a cable is very greatly reduced, while the expense for operating is increased. When it is borne in mind that 98 per cent. of the cable messages are in cipher code, and each code word, as explained above, represents at least 20 plain words, it will be seen that cablegrams in code bring the rate down to less than 2c. a word for the translated message.

The 25c. rate is a fair rate. It is no more than is necessary to pay operating expenses and to keep the plant in thorough repair and readiness to furnish the best possible service in point of regularity, accuracy and speed, and to pay a very reasonable return on the money invested. The service rendered is worth the money, and cannot be rendered for less. The only comparison to be made with it is the State-owned British Pacific cable, which in its best year compelled the taxpayers to increase their taxes to the amount of £62,362 per annum.

LEGAL INTELLIGENCE.

Corporation of London v. County of London Electric Supply Co. (Ltd.)

On Friday last Mr. Justice Parker heard a motion for an interlocutory injunction to restrain defendant company from breaking up or laying their electric mains across London Bridge without first obtaining the consent of plaintiffs (the trustees of the Bridge House Estates), and also to restrain the company from proceeding with a certain arbitration with reference to the same matter.

Mr. A. J. Walter, K.C., and Mr. C. L. Chubb were for plaintiffs; and Mr. Balfour Browne, K.C., and Mr. Tyldesley Jones for defendants.

Mr. A. J. WALTER, K.C., in opening, said that defendant company had certain areas of supply both on the north and south sides of the Thames, and the object of the London Electric Supply Act of 1908 was to enable the defendants and certain other companies scheduled to the Act to connect the various areas of supply. The preamble stated the object of Act to be to enable the companies to connect their undertakings with the undertaking of any other person or company supplying electricity in the County of London, making connections between any two or more areas which the authorised undertakers were authorised to supply or any such areas with the generating stations. It enabled the undertakers to have a generating station outside the area of supply and the County of London Electric Supply Co. in particular to connect its two areas, north and south of the Thames. In laying the electric mains for that purpose the undertakers were given powers to break up streets within their area of supply. London Bridge was not within any area which the County of London Co. was authorised to supply. They had no powers, therefore, under that section to do what they were proposing to do. For breaking up streets not within any area they were authorised to supply by a later section of the Act it was provided that they should have power, but subject to the provisions of the Electric Lighting Act of 1882. They were entitled to any powers they could get out of the Act of 1882. They had power to lay down electric mains in such positions and of such dimensions as might be agreed between the authorised undertakers and the local authority of the district, and failing agreement, to be settled by an arbitrator to be appointed by the Board of Trade. Under the Act of 1908 for powers with regard to streets not within any area of supply they were referred back to certain sections of the Electric Light Clauses Act of 1899 and the Act of 1882. The Act of 1899 was a short one and, except so far as any provisional order was concerned, it did not apply to the City of London. London Bridge was not repairable by any local authority. It was repairable by the Trustees of the Bridge House Trust, who were the plaintiffs in this action. No part of such repairs were charged in the rates. Defendants could, therefore, break up London Bridge if they were specially authorised to do so by their special order, but the company had no such powers. London Bridge was, in fact, unique in that it was not within any area of supply. London Bridge was private property dedicated to public use. There was no provision anywhere which authorised any work to be carried out by the undertakers under the Act of 1908, and therefore it was necessary for the Court to go back to the Act of 1882. There was nothing in that Act which would authorise or empower the undertakers to break up any street which was not repairable by local authorities.

His LORDSHIP: Does the Act contain any definition of a street.

Mr. WALTER: Not the Act of 1908, but in the Act of 1882 they found a street described as any street, square, court, alley or thoroughfare within the area within which the undertakers were authorised to supply electricity either by Act or licence of the Board of Trade. London Bridge was, he urged, in a very curious position. It was the only bridge in London that was not a public street and the only one that was not repairable by a local authority. It was, in fact, the private property of the Corporation, and was entirely repairable by them. The defendants therefore had no powers in respect of it without the Corporation's consent—or without a special Act. That had been recognised by all other companies. The Corporation were perfectly willing to give any consent upon reasonable terms. On Sept. 14 last year defendant company served the Corporation as the local authority with notice that they intended to lay two high-pressure mains across London Bridge, and the Corporation, as the local authority, refused their consent. The company then referred the matter to the Board of Trade, who directed that the Corporation should be served with notice, and the trustees of the Bridge House Estate were, by order of the Board of Trade, subsequently directed to be served with a similar notice, and on the footing of the bridge being a street not repairable by a local authority. The Corporation having refused their consent to the opening of the bridge for the purpose of laying these mains the company thereupon memorialised the Board of Trade asking for their consent.

Mr. Justice PARKER: Do you say that the only powers they have is with regard to streets within their area of supply.

Mr. WALTER: Yes. The only area in London that was not within some area of supply was London Bridge.

Mr. Justice PARKER: And you say that the only powers they have are derived from reference to the previous Acts and they only apply to a street repairable by a local authority.

Mr. WALTER: They have a perfect right to get special powers.

Mr. Justice PARKER: You will have to go further, and show that they have no power to break up any street outside their area.

Mr. WALTER thought that was so. It was perfectly clear that the Acts referred to streets within the area.

Mr. Justice PARKER: Is not the meaning of this Act of 1908 that the scheduled companies can exercise outside their areas the powers that they had within the areas by their previous Acts?

Mr. WALTER: But they had no powers such as they were now claiming. It may have been that the Act was clumsily framed. If they got special powers they could do it, but they had not, and what was done there must be done either by consent or by special powers.

Mr. Justice PARKER: But by the Act of 1908 they have power to connect their generating station with their area of supply by a line running outside their area. If you are right, they cannot connect their two areas at all.

Mr. WALTER said that was so, but the difficulty only arose where the road was not repairable by a local authority. Why should these people have power to break up private property? There was no objection by the City: the real question was whether the company had power to do it without the consent of the Corporation, and in order to keep matters in *statu quo* until the whole matter could be determined he asked for an interim injunction.

Mr. BALFOUR BROWNE, K.C., for the defendants, said the powers the company contended for were contained in the Act of 1882. At the time these orders confined these undertakings to particular districts that the defendant company had got under certain orders districts on the north side and districts on the south side of the Thames. They were confined to those districts, and in them they could break up streets. If London Bridge had been within their area of supply they had an absolute right to break it up, though if it was not repairable by the public the company's powers were limited. Sec. 13 provides that "Nothing in the Act should authorise the breaking up of any street not repairable by a local authority except with consent or with the dispensation of the Board of Trade." If London Bridge had been within the company's area of supply, not being a street repairable by the public at large, the company would have had to get the consent of the London Bridge authorities or a dispensation from the Board of Trade. By the passing of the Act of 1899 the undertakers, under such superintendence as was thereinafter specified, had power to open and break up all the streets and bridges within the area of their special Act. "Limits of the special Act," he contended, meant any place where they had a right to break up a street, and was not merely limited to a place where they supplied. By those provisions the company had full powers to break up for the purpose of getting from the source of supply to the area of supply. The whole object of the Act of 1908 was to enable the company, amongst other things, to break up streets that were not within their area of supply. The object of the Act was to get rid of the disability. Either London Bridge was a street repairable by a local

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authority, in which case the company had full powers to lay their mains, or if it was not the approval of the Board of Trade was required, and that had been applied for.

Mr. Justice PARKER, in delivering his judgment, said that the case raised a question as to the construction to be placed on sec. 4 of the London Electric Supply Act, 1908, an Act designed to confer further powers on London electric supply companies, of which the defendant company was one. Sec. 4 (1) of the Act provided for making (under agreement) a connection between the generating station or area of one authorised undertaking or specified company and the generating station or area of supply of another such undertaking or company. Sec. 4 (2) provided for such an undertaking or company making a connection between any two or more areas which it was authorised to supply, or between any such area and its generating station. It was obvious that under the old Acts the powers of companies were confined to their own areas. By sec. 4 (3) (*a*), as regarded electric mains, such an undertaking or company had, with respect to streets in any area which it was authorised to supply, the powers, and was subject to the provisions of the Acts and Orders relating to its powers of supply in that area. That provision was needed for the reason that the power to break up streets was for defined purposes only, and no existing undertaking had power to break up streets beyond its area of supply, and the provision extended the power to outside areas. By sec. 4 (3) (*b*) such an undertaking or company, with respect to streets, not with any area which it was authorised to supply, was to have the powers and be subject to the provisions of the Electric Lighting Act, 1882, and certain provisions of the Electric Lighting Clauses Act, 1899, and those provisions, so far as applicable, but subject to the provisions of sec. 4 of the Act of 1908, were incorporated with that Act, and were to have effect, and the authorised undertaker or specified company laying the mains was to be deemed "the undertakers." Again, that section conferred powers that were not existing before. The powers were given by reference to former Acts, and the section meant to apply the old powers to streets which were outside the area of supply. Sec. 12 of the Electric Lighting Act, 1882, incorporated certain provisions of other Acts, including provisions of the Gasworks Clauses Act, 1847, with reference to breaking up streets. But sec. 13 of the Act of 1882 placed certain limits on the exercise of those powers and provided that nothing in the Act or any incorporated Act should empower the undertakers to break up any street which was not repairable by the local authority, or any railway or tramway, without the consent of the authority, company, or person by whom such street, railway, or tramway was repairable, unless in pursuance of special powers, or with the written consent of the Board of Trade. Sec. 4 of the Act of 1908 gave power to the company to connect its northern and southern areas and to break up streets for that purpose outside its areas of supply. London Bridge was not a bridge which was repairable by any local authority, but by the Corporation (as trustees of the Bridge House Estates), and it was within sec. 13 of the Act of 1882 and a provision of the Act of 1899, and the company could not lay mains across it, except by the consent of the Corporation or the written consent of the Board of Trade. His Lordship made a declaration accordingly.

Valuation of Tramways.

In the Bill Chamber, Edinburgh, on Monday, before Lord Dundas, legal arguments were delivered upon an appeal of Glasgow Corporation against the valuation for 1910-11 of their tramways undertaking by the Assessor of Railways and Canals. The yearly rent or value of the undertaking has been fixed by the assessor at £278,070, and the Corporation asked that the valuation be fixed at £230,573. Hitherto the assessor, in making up the valuation (which he does on the "revenue" principle), has, in applying to the tramway undertaking sec. 3 of the Valuation of Lands (Scotland) Amendment Act, 1867, allowed as a deduction from the gross revenue not only one-half of the cost of maintenance of the permanent way and electrical equipment of the line, but also one-half of the sum annually set aside for renewal thereof. He now proposes to allow no deduction whatever in respect of renewal, but to continue to allow one-half of the cost of repairs. One-half of the sum set aside for renewal amounted last year to over £57,000, and appellants contend that the position now taken up by the assessor is unjustifiable. They urge that they are at least entitled to a deduction of one-half the expenses incurred in maintaining or repairing their permanent way, and charged to revenue in their published accounts, and that the practice initiated in 1873 should continue. On this basis the valuation would be £258,838. In the event of its being held that sec. 3 of the Valuation Amendment Act, 1867, does not apply to tramways, appellants submit that, looking to the nature of the undertaking, the whole expense of maintenance and repair is one which should fall not upon the landlord, but upon the hypothetical tenant, and as such should be a deduction before the valuation is struck. The deduction is in respect of repairs on (1) the causeway, (2) the rails, and (3) the overhead plant, &c. On this basis the valuation would be £230,573. In the event of a distinction being drawn between the larger and smaller repairs, appellants submit that they are entitled to the whole cost of the smaller repairs as a deduction before the valuation is struck, instead of only one-half of such smaller repairs as proposed to be allowed by the assessor. The valuation on this basis would be £269,059.

Mr. SPENS, for appellants, contended that with regard to the principle involved in undertakings such as that, which were profit-earning, it had been laid down in a series of decisions that appellants were entitled to a deduction in name of all expenses appropriately falling upon the tenant. His submission was that all such expenses—call them repairs or renewals—were expenses which appropriately fell upon the hypothetical tenant, and not upon the landlord. With regard to the statute, Mr. Spens submitted that, under the Valuation of Lands Act, 1867, the tramway undertaking must be held to be a railway, in which case appellants were entitled to deduction of half of the expenses referred to, because it had been laid down by the House of Lords that an exactly identical undertaking was a railway. Mr. Spens said that his Lordship and Lord Low had repeatedly laid it down in the Valuation Appeal Court that where no injustice followed in those cases they would not interfere with established practice. Since 1873 the practice contended for by appellants had been acted upon not only in Glasgow, but all over the country, and he submitted that there was no reason why it should now be disturbed.

Mr. GENTLES, for the assessor, said that renewals were properly landlord's burdens and not tenants', and, therefore, no deduction should be made in respect of them. He was applying to these charges the recognised principle that the obligation to maintain and to renew lay upon the landlord. There would always be the difficulty of deciding what were repairs and what were renewals, but he was prepared to admit that for the purposes of that case the entry contained in appellants' books under the head of repairs had been accepted by the railway assessor as representing repairs. He contended that inso far as those charges represented renewals the burden fell upon the landlord and not upon the tenant. So far as they were repairs the assessor had allowed one half of them on the ground that the tenants ought not to bear the cost of repairs due to traffic other than their own running. He knew of no case in which renewals as such had been recognised as a tenant's burden. The life of an average rail was between 12 and 14 years, but he differed from the argument that because the rails might perish, therefore the obligation to renew was a tenant's and not a landlord's burden. In such leases the tenant voluntarily subjected himself to the obligation to repair, renew and maintain. The reason for the insertion of such an obligation in the lease was that if it were not provided for in the lease, the tenant would not be under the obligation, because there was no such common law obligation upon the tenant, and there being no such common law obligation, that was why in valuations the Court had always applied the principle that renewal was a landlord's obligation. He argued from the fact that the obligation to renew was upon the tenant in the lease, that they were not, therefore, entitled to change the principle of valuation. All that was to be done was to take the obligation of the tenant into account as being a consideration other than rent. In the case of the Edinburgh tramways, which were at present under lease, the railway assessor did not take the rent stipulated in the lease as being the actual rent. He dealt with them very much as he dealt with the Glasgow tramways. He submitted that appellants' undertaking was tramway and not railway, and as such did not come within the scope of sec. 3 of the Valuation Act 1867.

Lord DUNDAS said he had formed an impression about the case, but in view of the importance of the questions raised and the amount of money involved, he would take a few days to consider his decision.

Electrical Co. v. Thomas, Son & Co.

The hearing of the above action was continued before the Official Referee (Mr. Pollock) during the week.

Mr. FRANCIS B. JOHNSON said that in Feb., 1906, he went to the Llynwi Valley mine on plaintiffs' behalf. He found the engine room was in an incomplete state, although parts of the machinery had arrived waiting to be installed there. He experienced difficulty in procuring labour. Witness explained how he erected the electrical plant. Common grease would be injurious to machinery of that sort running at such a high rate of speed—about 3,000 revs. per min. The oil supplied by defendants was dirty, thick oil which they were using on their old steam pump, and was not suitable for electrical machinery. On later occasions when witness visited the colliery, after defendants had been running the machinery, he examined the coils of the motor and found them in a very dirty condition and covered with oil. There was also a "short" on the motor owing to the windings having been burnt. The starter had also been broken, and the cable had been brought straight to the motor instead of through the starter. The short circuit was due to dirt, oil and dampness. The pump was not placed at a proper level and the trolley used for lowering it was not a proper one. The oil from the bearings ran down into the coils of the motor. Witness proceeded to rectify that state of things, and got the motor running by cutting out two of the coils which were burnt. It took him some two or three days to dry the motor out. Owing to the bad state of the brushes he was unable to get the exciter to work. When, however, he had cleaned them and put proper brushes on the motor he experienced no difficulty in getting the exciter to start. If the engine ran slowly it might prevent the exciter from exciting, but beyond that he could not think of anything which would account for its failure, except the negligence to the brushes, commutator, &c. When witness, in company with Mr. Blake, examined the exciter on June 17 they found it in a very dirty state, but having cleaned it they coupled up the machine in series and in parallel, and on both occasions they made it run satisfactorily. Witness further declared that the sump for the pump was not properly made, and that of itself did not give the electrical machinery a chance of life.

Mr. WM. A. SCOTT, electrical engineer, said he visited the mine and examined the plant. It was quite suitable for the purpose, but sufficient storage or sump room had not been allowed. The condition under which the plant was working, however, was the worst he had ever seen. The pipes too, were a poor lot, and so cramped was the room that the exhaust from the steam pump which was working at the time was blowing right on to the motor, and witness certainly would not have liked to have been responsible for running the motor afterwards. It was very necessary to have a man in charge of the plant who understood it.

The case had not concluded when we went to Press.

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PARLIAMENTARY INTELLIGENCE.

BRADFORD CORPORATION BILL.

The tramway proposals included in this Bill, except the Laisterdyke route, which has already been sanctioned for the railless trolley system, have now been approved by Section B of the Local Legislation Committee of the House of Commons. In regard to the parcels clauses, the Chairman (Mr. C. N. Nicholson) said that they did not wish to limit the powers Bradford already had, and it appeared the Corporation already had the right to carry heavy goods and parcels over certain tramways. It was no part of the intention of the Committee to limit those powers. The Committee desired him to say that their previous decision was entirely based on certain parts of the official shorthand writer's notes, and in giving that decision they were under the belief that they were satisfying exactly what the Corporation were really asking for. The only question was whether it ought to be put right then or in the other House. He thought it best to make it there. "We make it perfectly clear, he added, "that the Committee were rather misled by the evidence given, and that under the circumstances they are prepared to give the Corporation powers to carry parcels over the whole of their tramway undertaking in the same way as is allowed in Manchester."

In regard to a clause dealing with the laying of electric cables and water mains along private streets, the Chairman intimated that the clause would be similar to the clause in the Oldham Act of 1909.

Electric Lighting Provisional Orders (No. 2) Confirmation Bill.—This Bill was read a first time in the House of Commons on Tuesday. The Bill incorporates provisional electric lighting orders relating to Ardrossan, Saltcoats and district; Cambuslang (extension); Cowdenbeath, Lochgelly and district; and Skelmorlie.

Middlesbrough Corporation Bill.—The clauses in this Bill relating to the gas and electricity undertakings were approved by Section A of the Local Legislation Committee of the House of Commons on Wednesday.

L.C.C. Tramways and Improvements Bill.—The Standing Orders Committee of the House of Commons have authorised the London County Council to insert an additional provision in this Bill to erect at the City end of the Victoria Embankment a weather shelter for tramway passengers.

All-Night Telephone Service.—The Postmaster-General (Mr. H. Samuel) informed Mr. J. Wood, in the House of Commons on Wednesday that the day and night service at present existing throughout the National Telephone Co.'s exchanges would be continued when the service was taken over by the Post Office.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Electricity committee of Salford Corporation invite applications from thoroughly experienced men, with first-class technical training, for the position of superintendent of the hired meter and testing department. Commencing salary £120, rising to £180. Particulars from the borough electrical engineer, Mr. Victor A. H. McCowen, Electricity Works, Frederick-road, Pendleton, Salford. Applications to the town clerk, Mr. L. C. Evans, by mid-day Monday, May 9. See also an advertisement.

A man is required to take charge of suction gas electric plant, accumulators, &c., on an estate in Herts. Applications to Estate Offices, Erpingham, Norwich. See advertisement.

A junior assistant engineer is wanted for an electric supply station near London. Salary 25s. per week. See advertisement.

A junior designer is wanted, with first-class college training and some years' practical experience in the design of d.c. and a.c. motors. See an advertisement.

There is a vacancy for a premium pupil at Watford electricity works. Applications to the Chief Engineer. See an advertisement.

The National Telewriter Co. (Ltd.), 30 and 34, Tabernacle-street, London, E.C., require telewriter instrument maintenance men for the provinces. See an advertisement.

An engineer, with good experience in the lay out and erection of electric winding engines, is required. See advertisement.

An inspector of telephones is required by the Government of Ceylon for an engagement of three years. Salary £200, and an allowance of R.6 per day to cover cost of subsistence when away from headquarters. Applications to Messrs. Preece & Cardew, 8, Queen Anne's-gate, London, S.W., by 30th inst.

A junior lecturer and demonstrator in physics is required at the University of Sheffield. Salary £150 per annum. Applications to the Registrar by June 1.

The following appointments have been made in connection with the West Ham electricity undertaking:—

Mr. F. J. Delves, motor superintendent, at £2. 10s. per week and commission at usual rates, in place of Mr. T. O. Wilton, resigned; Mr. J. Inglis, assistant motor superintendent, at £2 per week and commission, in place of Mr. W. L. Wreford, resigned; Mr. J. Turtle, lighting superintendent, at £2 per week and commission, vice Mr. A. S. Tong, resigned; Mr. E. E. Smith, as canvasser, at £1. 10s. per week and commission, in place of Mr. E. A. Broom, resigned.

The Tramways committee have appointed Mr. C. I. Baker (at present in the Newcastle-upon-Tyne tramways department) traffic superintendent of the Blackpool Corporation tramways.

Aberdare.—Sanction has been received to a loan of £16,797 for electricity supply, and last week the Council accepted tenders for generating plant, cables, &c., at £13,521.

Accidents in Mines.—On Monday a deputation representing the Parliamentary committee of the Trade Unions Congress, the Miners' Federation, Durham and Northumberland deputies, and the Enginemen and Wind Enginemen's Federation waited upon the Home Secretary (Mr. W. Churchill) to urge him to embody in a bill some of the recommendations suggested by the Royal Commission on Accidents in Mines.

Mr. James Rowe, of the Electrical Engineers' Society (Manchester), suggested the appointment of additional electrical inspectors, with practical working experience, and Mr. Enoch Edwards, M.P., urged the appointment of a new class of inspector, who would practically live in the pit.

Mr. Churchill, in reply, said he would give his best attention to the points raised. As they knew, a great bulk of the recommendations of the Royal Commission required legislation to give effect to them. In addition, the Commission had not finished its labours, and it would be much better that the bill for regulating the work of coal mines should be complete and comprehensive and should cover the whole ground. He was strongly of opinion that the inspectors should be strengthened, and if he remained responsible for the direction of the Home Office he should certainly make a request to that effect. He hoped it might be possible, in strengthening the inspectors, to do so with a proportion of men who had had practical experience in mines and who were possibly in some way in touch with the men. They were to have a conference with mine owners at the end of May, with a view to ascertaining how best to improve and systematise all rescue apparatus and work.

Asylum Lighting.—It has been decided to organise a bazaar to defray the cost of the proposed electric lighting installation at the County of Antrim Infirmary, Lisburn. The estimated cost of a complete lighting and power installation is put at about £1,000.

Australasia.—A firm in Wellington wish to get into touch with British makers of metal filament lamps and arc lamps of the latest pattern. Communications to H.M. Trade Commissioner, 9, Grey-street, Wellington (N.Z.).

On Feb. 28 the proposals with regard to subaqueous tunnels to connect the north and south sides of Sydney Harbour came before the Public Works committee, Sydney. The Royal Commission appointed in 1908 to deal with the subject recommended various schemes. Mr. Hutchinson, chief engineer of railway construction, has worked out an underground city railway scheme communicating with North Sydney, and the railway subway as described by Mr. Hutchinson will be a twin tunnel, each tube being a cast-iron shell of 18 ft. 8 in. internal diameter, 2 in. thick, and lined throughout with 1 ft. 1½ in. of concrete. The Commission proposes that this work should be first undertaken, and that electricity be used. Electrification of the North Shore railway is therefore involved, and the building of a power house. If this is done, it is probable that a city underground railway system proposed by Mr. Hutchinson would also be electrical. That is estimated to cost another £1,630,000. The chief railway commissioner reported that the chief engineer's estimate of £753,000 for the railway scheme was exclusive of electric power, rolling stock, &c.

A 1,500 kw. d.c. generator, supplied by Messrs. W. H. Allen, Son & Co. (consisting of Allen high-speed engine and General Electric dynamo) has been ordered by Melbourne Corporation. Condensing plant and an Edwards motor-driven air pump have also been ordered, and a new 15-ton overhead Chatteris crane is being put in to facilitate the erection of the plant. The new set is stated to be the largest of its kind in Australia. The demands upon the Corporation's electricity department are still increasing rapidly. 4,500 H.P. of motors (including 1,000 H.P. for new customers) are connected.

Bath.—The Council have adopted a recommendation of the Electric Light committee for substituting incandescent electric lighting for the present lighting in Pulteney-street and other districts.

108 metal filament lamps of 100 c.p. each are to be substituted for 10 arc lamps and for 54 gas lamps at a total annual charge of £522. 16s. 6d. (the amount now paid for lighting), and a capital outlay of about £200 for columns.

Battersea (London).—Mains are to be extended at an estimated cost of £125. Ten 200 c.p. metal filament lamps are to be provided and fixed for lighting Clapham Common (West Side).

Belfast.—The Harbour Commissioners have adopted a report recommending the execution of certain works for lighting the new graving dock by electricity and for the renewal of 15 lamps on Queen's Quay, Abercorn Basin, and Hamilton Graving Dock, at an estimated cost of £2,115. This is, however, subject to electric current being supplied by the Corporation at a cost not exceeding 1d. per unit.

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Blackburn.—It is announced that there was a profit of about £1,000 on the electricity department for the past year and about the same amount on the tramways.

Brazil.—The electrification of the northern line of the Leopoldina Railway (from Rio de Janeiro to Petropolis) has been authorised.

East Ham.—An estimate of £2,674 for the duplication of the tramway track across Wanstead Flats has been passed by the Council.

Electrical Contractors' Association.—At the annual dinner of the Birmingham centre of the Electrical Contractors' Association on Friday

Mr. W. FINLAY (president), in proposing the toast of the Association, congratulated the members on the formation of the Midland section, which he understood was going strong and was doing good work for the trade. They had many interests to uphold and they needed co-operation for they had many battles to fight which necessitated combination. They desired to join with the manufacturers' associations, and to be dealt with in the same businesslike manner as they, as contractors, desired to treat their customers.

Mr. L. G. TATE, general secretary, responded, and referred to the general growth of the Association. During the past year something like 80 new firms had joined the association. That showed that they were growing, not in numbers alone, but in power. The central board was in negotiation with the Association of Municipal Corporations in order to see if they could arrive at an understanding in the matter of limiting the trading of municipalities to their proper functions. Let the municipalities have power to supply motors and electric apparatus on hire, but only on the understanding that the work should be done through the trade.

Fleetwood (Lancs.)—At the Council meeting last week the chairman (Mr. A. Swarbrick) said that, in regard to the electric lighting undertaking which the Council took over in September, everything in connection with it had been paid for, and the result of the six months' working to March was very satisfactory.

The revenue during the six months was £3,633 and the working expenditure £1,469. The gross profit was £2,164, interest on loans amounted to £382, and the sums to be charged out of revenue amounted to £766, making a total of £1,148. On the first six months' working, therefore, they had a profit of £1,000.

Fulham (London).—Experiments recently made by the borough electrical engineer (Mr. A. J. Fuller) near Avonmore-road with a new type of bracket lantern and grouped metal filament lamps have been successful and offer a very satisfactory and economical improvement upon the existing system of public lighting. It has, therefore, been decided that the whole of the lamps in that district shall be similarly fitted, and the alterations in those lamps already altered shall be made permanent at a cost of £32. 12s.

Hackney (London).—Electric supply mains are to be extended at an estimated cost of £554. 10s.

A communication has been received from London County Council in reference to the question of the period of electricity loans. The County Council note that the Borough Council has been able to set aside a reserve fund, of which the balance at March 31 last was £16,873, and observe that the Borough Council is repaying about 75 per cent. of its electricity loans on the system of equal instalments of principal, whereby the charge for interest diminishes each year, and it would, therefore, seem probable that the Borough Council would be able to transfer larger sums to reserve in the future. The County Council are convinced of the necessity of accumulating such a fund to a substantial extent when loans are running for 42 years, seeing that this period is admittedly much in excess of the useful life of the plant and machinery which represents a considerable part of the original outlay of electricity undertakings. It is suggested, however, that the Borough Council would be well advised, as an alternative to accumulating so large a reserve for renewals as is requisite to enable them to comply with the conditions on which the period of 42 years was sanctioned, to take steps to reduce, by agreement with the County Council, the period of the loans now running for 42 years to periods equivalent to the terms now allowed, had such periods been in operation since the commencement of the Borough Council's undertaking. It would then only be necessary for the Borough Council to accumulate a reserve fund to meet any extraordinary expenditure or to provide for such renewal of plant, &c., as might become necessary by reason of obsolescence before the expiration of the periods representing the probable life thereof. The Borough Council might consider, as a first step, whether they can arrange for the reduction of the period of loans sanctioned for plant and machinery for 42 years.

The Finance committee of the Borough Council, having consulted the Electricity committee, are of opinion that it would be inadvisable to reopen the question of loans the periods of which were sanctioned by the County Council.

The Electricity committee report having examined 11 tenders for 80,000 yellow flame arc lamp carbons, and the prices ranged from £5. 15s. to £4. 5s. per 1,000 pairs. The highest price in the past has been £3.12s.6d per 1,000. This rise means an increase of £50 per annum, or practically 10s. per lamp per annum. The committee decided for the present to instruct the Borough Electrical Engineer to buy in the open market from time to time to meet requirements.

Hampstead (London).—The Lighting committee have considered a report of Sir Alex. W. Kennedy on the financial and technical aspects of the electricity undertaking.

The committee are unanimously of opinion that the scheme recommended by Sir Alex. Kennedy should be carried out. At present they recommend that some of the existing plant be disposed of and that new plant be installed at an estimated cost of £8,515. The total expenditure would be £18,000 and an annual saving would be effected of £4,000. The money required would be borrowed from the reserve fund which now amounted to £45,000. The recommendation has been adopted by the Council and a number of tenders for the supply of the new plant have been referred to the committee.

Mr. Holtzapffel said that the committee had under consideration an amended offer from the Gas Light & Coke Co. for the improvement of the street lighting, but a motion that the work of transforming the gas lamps into electric lamps (already decided upon) be deferred until the amended offer be considered was negatived.

Holland.—Consul Turing (Rotterdam) states that the Peel Central Company has been formed at The Hague to erect works for supply of electrical energy for light and power in the provinces of North Brabant and Limburg. Turbo-dynamos will be employed, and turf will be used as fuel to commence with "and later gas refuse from a factory to be erected near the central station." It is calculated that electric light will be supplied at 40 per cent. less than in the large towns, and that electric lighting will be as cheap as petroleum lighting.

India.—"Indian Engineering" says 200 additional electric fans for the general offices of the N.W. State Railway at Lahore were purchased in India. Power for driving these will be supplied from the Lahore loco. shops.

A scheme for the general electrification of the Indian Midland Railway loco. and carriage shops at Jhansi has been sanctioned.

The administration of the Eastern Bengal State Railway are maturing a scheme for the electrification of the broad gauge workshops at Kanchrapara and the metre gauge shop at Saidpur.

Inquests.—An inquest was held on Saturday into the death of Henry Thomas Calladine, who was killed at Wingfield Manor Colliery on 20th inst.

Deceased's brother said he and deceased worked an electric coal-cutting machine. Witness felt an electric current pass through his body. He ran back from the machine, and at the same time heard his brother cry out. Witness stopped the machine, and, going towards his brother found him apparently lifeless, his head lying across the haulage rope. He obtained assistance, and resorted to artificial respiration until the arrival of Dr. Bingham, who pronounced life to be extinct.

By Mr. WALKER (Inspector of Mines): Witness did not examine the trailing rope of the coal-cutter before he started to work it. It was usual for the electrician to examine the cable and other electrical appliances. He did not know that by the rules the person in charge of the machine had to examine the trailing rope.

PERCY SMITH, assistant electrician, said he had examined the electrica parts during the shift, and they were all right. Since the accident he had made another examination, and he found a breakage in the trailing cable near where it was connected with the main cable. Perhaps the breakage was caused by a fall of roof. The result of that breakage was that the outer covering of the coal-cutter became alive. The system in operation at the colliery was quite safe, but it could be improved by the adoption of the plug system. The present system had not a very good earth. He found traces of fusing of the wires. His theory of the accident was that Calladine touched the haulage rope, which was in touch with the outer covering of the coal-cutting machine, which was alive.

H.M. Electrical Inspector of Mines (Mr. R. NELSON) said the trailing cable had become severed, with the result that the iron work of the machine had become alive. He believed that the cable strands had become broken by sawing movements. He suggested the plug system, which would be an improved connection for the trailing and the main cables, and with ordinary care fatalities of that kind would be very unlikely. Otherwise the system in operation was a good one.

The jury returned a verdict of accidental death.

An inquest was held last week on the body of Walter P. Liddell, who was killed at the power station of the Durham Collieries Electric Power Co., Philadelphia, on 15th inst.

Deceased was a joiner in the employ of G. Wardropper & Son, contractors, Penshaw, and was at the time of the accident engaged in doing some joinery work in the switchboard chamber of the power station when he came in contact with a live wire.

PERCIVAL H. ARCHBOLD, junior electrical engineer at the station, said he was in the switch chamber putting in a wood bush. Deceased was working in the chamber boxing part in with wood. Deceased was on the floor of the chamber and made a wooden wedge for witness, but this being too big he asked deceased to lessen the wedge, when witness then put it into its place with the bush. Just then there was a flash, which caused witness to drop from the switch on to the floor to get out of the way. Deceased dropped on to the top of a small wooden box from the metal casing, upon which he had been either standing or sitting. Mr. Wade, who was also there, caught deceased in his arms as he fell off the switchboard platform. They then carried deceased outside, and at that time he was alive. The chief engineer was informed, and meanwhile artificial respiration was being tried, and was continued until the

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doctor arrived, about a quarter of an hour afterwards. Witness did not see deceased touch anything, and he could not explain how the accident happened, the putting in of the wedge having nothing to do with it. He knew there was danger in spite of the fact that the conductors were supposed to be insulated. The charge engineer (Mr. Pyle) warned deceased that there was danger. Current at 5,750 volts was passing through the conductors. The conductors were quite distinguishable from the surroundings. Witness was told to keep an eye on deceased because there was danger there of which deceased had not expert knowledge and would not recognise it.

JOHN S. WADE, junior electrical engineer, said he walked into the switch chamber about 11:15 on the date of the accident, and saw a flash. Deceased was standing on the box leaning against the metal casing with his right arm at the back of the conductors, and was drawing his hand away when witness noticed him. There appeared to be a few sparks passed between his fingers and the conductor as he was drawing it away. Deceased sank down on the wooden box, making some exclamation of surprise, and then collapsed. Deceased got an electric shock, which he believed was caused by the breakdown in the insulation of the conductor. He thought there was some flaw in the insulation of the conductor at that particular place. Otherwise the accident would not have happened. Deceased had nothing in his right hand at the time.

FERDINAND F. PYLE, engineer-in-charge at the time of the accident, said there were three conductors in the switch chamber, side by side, insulated with a special insulation of mica wrapped around with Empire tape, which was coloured yellow. The work was done about five weeks ago by an electrical firm. The insulator would withstand a voltage of 12,000, or about double the working pressure; it was tested under pressure for that amount. He warned deceased about half-an-hour before he proceeded to the chamber not to touch the insulator, which he appeared to understand perfectly. Deceased had not been in that chamber before, but had done similar work in another exactly like it. There would be no danger in fixing the casing round the conductors. After the accident witness examined the chamber, and found signs of burnt skin upon the edge of the metal casing, and there was also a slight burn on the tape of one of the conductors, and it could be seen that the shock had been got from that point. Witness told deceased distinctly that a slip of a chisel on to a conductor would kill him, and witness had repeatedly warned him which parts not to touch—those that were coloured yellow. Dampness in the atmosphere would make all the difference to the insulation.

A verdict of accidental death was returned.

Institute of Chemistry.—A revised edition of the Register of Fellows, Associates and Students of the Institute of Chemistry of Great Britain and Ireland (30, Bloomsbury-square, London, W.C.) has just been issued, and contains, in addition to the lists of fellows, &c., an outline of the regulations for admission to the Institute, abstracts from the charter and by-laws, comittees for 1910-11, &c.

Italy.—The Soc. Elettrica Comense A. Volta have obtained a concession for the construction and working on the overhead system of a metre gauge electric railway from Como to Cernobbio.

M. Consul de Zuccato states that, so far as he is able to judge, most of the electrical equipments in mills and factories in the Venice district are of foreign manufacture, but he believes there is now an advance in the manufacture of such apparatus in Italy, and some foreign firms have opened offices and workshops in that country.

The hydro-electric works at Ponte della Serra, near Feltre, are approaching completion, and are expected to start working this year. The capacity of the plant will be 9,000 H.P., and extensions to increase the capacity to 15,000 H.P. will probably be commenced next year. The Edison, Adriatica and Cellina Companies are interested in the venture, and Signor Quarisa is the engineer responsible for the equipment.

The first part of the hydro-electric plant of the Societa Bellunese per l'Industria Elettrica, on the river Ardo, has recently been finished. The alternators at the generating station in the Vezzano valley are driven by two 300 H.P. turbines supplied by a Milan firm.

The Cellina Co. propose to utilise the water-power of the river Piave and the lake of Santa Croce (Belluno) for the generation of electric power. The scheme provides for three generating stations of an aggregate capacity of 14,000 H.P., at the foot of the Belluno Pre-Alps, at San Floriano and at Castelletto.

The hydro-electric plant erected by Signor Milani at Bassona (Verona) was completed and started working in Nov., 1909. The plant includes five turbines of an aggregate of 10,000 H.P. and Westinghouse generators. On a portion of the transmission line the voltage is 40,000.

Japan.—The South Manchuria Railway Co. are floating a loan of 40,000,000 yen (£4,083,000) of which 1,000,000 yen (£102,07) is for an electric power house at Dairen, 500,000 yen (£51,037) for an electric tramway at Dairen, and 300,000 yen (£30,622) for electric lighting plant at various places.

Lancaster.—A long discussion took place at the Council meeting on Wednesday on the question of tramway fares, and ultimately, on the recommendation of the Tramways committee, it was decided to adopt a universal penny fare.

Leek.—In future the Lighting committee will have control of the electricity and gas undertakings.

Leicester.—On Tuesday the Tramways committee reported to the Council that in their opinion immediate steps should be taken for providing additional generating plant at the tramways power station, having regard to the rapidly-increasing demand for the supply of electrical energy for power, and they recommended the installation of a 1,000 H.P. turbine engine, the enlargement of the existing engine house, the provision of two additional boilers, and further condensing plant and feed pump. The estimated cost of the proposed additions is £19,190, and application is to be made for sanction to a loan of that amount.

The committee have had under consideration the question of reducing the charges for the supply of energy for power, and they recommended that the basic charge (15s. a quarter per horse-power of the maximum power demanded by the consumer) should be reduced to 10s. a quarter per horse-power, the charge per unit to remain at ¾d., as at present. The scale of discounts allowed upon the units consumed is to be extended.

The recommendations were adopted by the Council.

London County Council.—On Tuesday Mr. Hayes Fisher, in introducing the estimates of income and expenditure for the financial year 1910–11, said that the only undertaking from which relief to rates might some day be obtained was the tramways.

According to the estimates, the financial position of that undertaking was extremely satisfactory. After providing for working expenses and debt charges, there was expected to be a surplus for the year of £244,132. Under a resolution of the Council passed in June of 1908 £125,989 of the surplus would be carried to renewals fund and £118,142 to general reserve. If the estimates were realised the balances on those two funds taken together would amount to nearly £700,000 by March 31, 1911. No doubt in the near future the renewal fund would be called upon to meet heavy expenditure on renewals, and indeed the whole of the fund must be regarded as required sooner or later for that purpose. The general reserve fund was on a different footing, and the Council would have to consider what limit might fairly be put on that fund. So far as he could see, he did not think the question of allocating money to relief of rates was likely to come up for consideration during the lifetime of the present Council. In saying that he did not wish to leave the impression that the tramway undertaking was not in a flourishing condition. On the contrary, he was convinced that its financial condition was entirely sound.

Highways Committee's Report.—The whole of the report of the Highways committee was opposed and stood over for a week. Amongst the items included was that tenders be invited for the supply of 250 electric cars; the acceptance of various tenders; and a recommendation that no objection be offered to the proposals of the St. James & Pall Mall Electric Light Co. to declare the pressure at which it supplies energy at 110 to 220 volts to those consumers with whom it has already been arranged or may arrange to supply at such pressures on the understanding that any variation shall be within the 4 per cent. on that 107 and 214 volts respectively prescribed by the regulations of the Board of Trade.

Luton.—The time for completing the unconstructed portions of the Council's tramway scheme has been extended by the Board of Trade until Aug. 11, 1912.

Marconi Trans-Atlantic Service.—The new service between Clifden and Glace Bay was opened for traffic on Saturday. It is announced that a continuous day and night service is now maintained for commercial and other purposes.

Obituary.—The death is announced of Sir Owen R. Slacke, chairman of the Kent Collieries Corpn., the Bogota Telephone Co. and other companies.

The death of Commander Reginald Freeland Yonge took place at Fursdon, near Plympton, Devon, on Monday. Deceased entered the navy as a cadet in Dec., 1863. In March, 1865, he served on the "Terrible" (under Capt. Napier, and later Capt. J. E. Commerell, V.C.), then engaged in laying the Atlantic cable in company with the "Great Eastern." Having lost the cable, the "Terrible" made a trip to Malta and then back again, laying cable with the "Great Eastern."

Personal.—Mr. J. C. D. Denison-Pender has been elected vice-chairman of the Stores and Contracts committee and a member of the Accommodation and Attendance and the Books and Apparatus sub-committees of the Education committee of London County Council.

Presentation.—On 22nd inst. Mr. Edward Marett, chief of the submarine cable department at the British School of Telegraphy, was presented by the staff and students with a travelling bag with silver fittings on his retirement to take up an appointment with the Pacific Cable Board. The manager of the school (Mr. Arthur W. Ward) made the presentation.

Radcliffe.—The Board of Trade inquiry by Mr. A. Read into the application of the Lancashire Electric Power Co. for a provisional order for supplying electricity within the area of Radcliffe Council was concluded last week, when the inspector sat specially to hear the addresses of the legal representatives of the various parties. The evidence taken at the inquiry was set out in our issue of April 15.

Rubber Boom and the Electrical Industry.—Mr. G. Basil Barham, A.I.E.E., contributed to the "Financial Times" of the 23rd inst. some notes on the effect of the rapid rise in the price of rubber on the electrical industry. Mr. Barham is, speaking generally, of opinion

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that the increase in price will not seriously affect the industry, which is in a position to adopt reliable and cheaper substitutes for the chief purposes for which rubber is used in connection with electrical operations.

Russia.—A correspondent of the "Financier" says that public works on a large scale will be started at Vladivostock during the current year, and that tramways and electric lighting are in the programme.

The British Vice-Consul at Baku (Mr. A. E. R. McDonell) states that Baku Municipality have raised a loan of 27 million roubles (about £2,848,500) for, inter alia, electricity supply, electrification of the tramways and other works. About 960 arc lamps will be required for public lighting, but the municipal authorities have not yet decided whether they will establish their own electric power station or come to an arrangement with the existing power company.

Sheffield.—The new tramwaymen's club was formally opened by the chairman of the Tramways committee, Sir Wm. Clegg, on Tuesday.

The general manager of the tramways, Mr. Fearnley, said there were now 1,050 members, and the main object of the club was to provide good meals at a low price. The Tramways committee paid the wages of all engaged in the club, to which there were benevolent and hospital funds attached.

Siam.—The report of Acting Consul Dunn on the trade of Bangkok for 1908-9 issued this month (April) states that the new telephone system in Bangkok will shortly be opened. The imports of electrical goods at Bangkok port during the year ended March, 1909, were valued at £62,300, compared with £23,513 and £8,732 in the years ended March, 1908 and 1907 respectively. Of the first-mentioned amount 37 per cent. was from the United Kingdom, 26 per cent. from Germany and 17 per cent. from Sweden.

Summer School Lectures.—Glamorgan Education committee have arranged short summer courses of lectures during August, as follows: (1) Practical surveying course at Penarth; (2) Engineering course; Mining, mechanical and electrical engineering (laboratory work) and practical mathematics; (3) Metallurgy course: Metallurgy, chemistry and practical mathematics; (4) Teachers' course: Geology (lectures and field work), physics and chemistry (this course has been arranged to meet the requirements of teachers engaged in or preparing for technical work at evening schools or technical schools); (5) Evening lectures for colliery firemen on explosives and shot-firing; (6) Evening lectures on electricity in mines. Courses 2, 3, 4, 5 and 6 will be held at University College, Cardiff, the other courses at the County School, Penarth. Certificates will be issued to successful candidates. Particulars and admission forms from 35, Park-place, Cardiff.

Switzerland.—A committee represented by Messrs. Dufour Freres, of Les Avants, have obtained an 80-year concession for an electric funicular railway from Les Avants to Sonloup.

Tramway Transfer.—Audenshaw Council give notice of intention to lease the tramways in the district to Manchester Corporation until April 1, 1924.

The rent to be paid annually for the Audenshaw-road tramway will be on a gradually descending scale from £595. 13s. 1d. as on Oct. 1, 1909, to £317. 16s. 4d. on April 1, 1924, and for the Manchester-road and Droylsden-road tramways £1,662. 17s. 11d. as on Dec. 1, 1904, and on a gradually descending scale from £646. 2s. 2d. as on June 1, 1905, to £594. 6s. 2d. on June 1, 1923, 10s. on Dec. 1, 1923, and 5s. on April 1, 1904. The lease contains provision for the electrical equipment of the tramways.

Venezuelan Telegraphs.—Mr. C. H. de Lemos, British Consul at Ciudad Bolivar, in reporting on the trade of that district for 1909, makes the following comments concerning matters telegraphic:—

Telegraphic cable communication with other parts of the world was re-established in May by the reopening of the French cable service, which had been closed for a number of years. The service is rapid and reliable. Lately, however, a regulation has been enforced by which a translation of all messages in code or cypher has to be supplied by the sender to the telegraph office, without which the cable is not forwarded. This rather vexatious regulation checks the use made of the French cable service, especially from inland towns, as senders are loth to furnish these translations, which may contain trade secrets or other confidential matter. Consequently many people and firms still prefer to send their cable messages by mail to Trinidad, to be despatched to their destination by the West India & Panama Co. without translation.

Watford.—The Council have approved terms submitted by the electrical engineer (Mr. F. W. Purse) for supplying energy to the L. & N.W. Railway, subject to an agreement being entered into providing for a minimum payment of £500 per annum for seven years.

West Ham.—A wing is to be added to the Greengate-street car depot.

The electrical engineer (Mr. Couzens) reports, in regard to the additional generating plant required, that it will be necessary to put in hand some of the work as soon as possible. The turbo-alternator is under discussion with the Westinghouse Co. and it is suggested that tenders be obtained for condensing plant to be used in conjunction. It is also advisable (Mr. Couzens considers) to proceed with the boiler and switchgear at an early date. The cables for the Stratford and Silvertown schemes are included in the existing contract with the British Insulated & Helsby Cables, and these should be put in hand as soon as convenient. Mr. Couzens has been authorised to negotiate for renting a site for a sub-station in Chapel-street, and to obtain quotations for the plant mentioned by him.

In regard to the terms for the new Rateau turbine set by the British Westinghouse Co., the engineer has had further communication with the company as to the payment to be made by them for the excess steam used by the existing turbo from the date of the tests in October to the agreed date when the new turbo is to be installed. He has agreed with the company for £250 (£100 in cash and £150 to be deducted by the Council from the first instalment due to the company).

Westminster.—The contracts for the supply of electricity to the Council's buildings expires on June 24, and the Town Clerk has been instructed to negotiate for the renewal of the contracts on the same terms as at present—viz., Metropolitan Electric Supply Co., 2½d. per unit for lighting; St. James & Pall Mall Electric Light Co. and Charing Cross, West End & City Electricity Supply Co., 2d. per unit for power.

Wireless Telegraph Notes.—British Consul Reed, discussing the subject of wireless telegraphy in the Azores, reports that the radio-telegraphic stations at San Miguel, Sta. Maria, Fayal, Flores and Corvo were completed early in 1910, and are now open for the service of the public.

An interesting example of the utility of wireless telegraphy is shown in an announcement that on Wednesday last week a message was sent from a Marconi installation of one of the Cunard liners in mid-Atlantic to the Haymarket Theatre, London, booking four stalls for the performance of "The Blue Bird."

There is another Australian aspirant for fame in connection with wireless transmission. Mr. Reginald Wilkinson, who is described as a young Australian, is reported to have discovered a process for transmitting pictures by wireless transmission, and also an improved process for the same over ordinary telegraph wires. Practical demonstrations of Mr. Wilkinson's work are stated to have appeared in the Sydney "Telegraph" of April 25.

Electro-Harmonic Society.—The annual general meeting of this society will be held on Tuesday next (May 3) at 4:30 p.m. at the Institution of Electrical Engineers, 92, Victoria-street, Westminster. During the past season 74 new members were elected, 3 members were lost by death, 42 resigned and 23 have been struck off for non-compliance with rule 11, a net gain of 6 members, bringing the total to 632. The accounts show surplus assets to date £70. 19s. 1d., against a balance forward of £63. 19s. 3d. The total receipts from subscriptions, entrance fees and extra concert tickets were £355. 12s., against an expenditure of £360. 9s. 2d. Cash in bank and in hand is £59. 2s. 1d.

The Osram Dinner.—The annual dinner of the staff of the Robertson and Osram Lamp Works at Hammersmith took place on Friday evening last. The function was as successful as is usually the case, and business was entirely put on one side. In proposing the toast of the allied firms, Mr. Wilson, who presided, drew attention to the way in which the lamp output from the Hammersmith works had increased in the last few years, and how such development was of distinct advantage to Hammersmith Corporation, as, apart from paying the rates, more than £6,000 was expended by the company on electrical energy alone. The toast was replied to by Mr. Hirst.

"Tantalum" Athletic Club Concert.—The first annual concert of the "Tantalum" Athletic Club (connected with Messrs. Siemens Bros.' Dalston works) was held on Monday evening, when an interesting programme was arranged.

The hall was illuminated by "Tantalum" and "Onewatt" lamps, which shed their brilliance on the "brilliant passages" of the artistes. Invitations were limited to employés of the firm, and there was a good muster. The talent also was entirely from the works staff, and the enjoyable items rendered proved that there was no limit in this respect. Miss Harrison (pianoforte), Messrs. McFarlane, Dennison and Hicks (baritones) and Mr. A. E. Watts (humorous) distinguishing themselves. A novel feature was a singing competition (open to all employés of the firm), for which prizes were offered, the audience acting as judges. The first prize went to Mr. Rodgers, the second to Mr. Lewis and the third to Mr. Hopper, jun. Miss Sabourin, Miss Crisp, Miss Clark, Mr. C. D. Gray, Mr. Gingell, Miss Wade (violin), Miss Topper, jun., and Miss Coutts (elocutonists) also competed. Competition proved very amusing, and brought out much latent talent, promising well for many more enjoyable evenings to come. We must not omit to say that Messrs. Jarvis and Lucken and Messrs. Collins and Pryor (the latter pair at the piano) were in good form. The proceeds go to the war chest of the newly-formed "Tantalum" Athletic Club

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TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited up to June 14 for supply of 100 party line common battery telephone wall sets, 10 party line common battery table sets, 100 switches, common battery, single extension and intercommunication, and 3,000 telephone protectors to the Postmaster-General's department in VICTORIA. Tender forms and specification at the Commonwealth office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited (up to May 17) for supply to the Postmaster-General's Department, VICTORIA, of 50 coin attachments. Tender forms and specifications from the High Commissioner's Office, 72, Victoria-street, London, S.W.

Tenders are invited up to June 7 for supply of one frame, main distributing, to the Postmaster-General's department in WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W. See also an advertisement.

The Postmaster-General of the Commonwealth of AUSTRALIA requires tenders up to May 17 for supply of 2 tons of wire, twisted pair, outside distributing, No. 16 Legal S.W. gauge. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to June 8 for the supply of protectors, switchboards (small) and common battery telephones to the Postmaster-General's Department, QUEENSLAND. Tender forms, specifications and general conditions may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W. See also advertisement.

Tenders are required by June 8, 1910, for the supply of six sections of common battery switchboard and equipment jumper wire and cable to the Postmaster-General's department in QUEENSLAND. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W.

Tenders are invited, up to May 18, for the supply of paper insulated lead-covered and brass ribbon taped cable to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to June 1, for the supply of eight sections of common battery switchboard to the Postmaster-General's Department, NEW SOUTH WALES. Tender forms, specifications, and general conditions may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W.

LITTLEBOROUGH Urban District Council invite tenders for the supply and laying of h.t. feeder cables, l.t. distributors, roadwork, &c., for private lighting, and transformer kiosk, with transformers and equipment and switchgear in substation. Copies of specification, forms of tender, &c., may be obtained from the clerk to the Council, Mr. Geo. H. Wild. The works are to be carried out in accordance with plans and specifications, which may be seen at, but not obtained from, the offices of the consulting engineers, Messrs. Hawtayne & Zeden, 9, Queen-street-place, London, E.C., from whom further information can be obtained. Tenders to the Clerk to the Council, Council Offices, Littleborough, near Manchester, by May 2

NEWPORT (Mon.) Electricity committee invite tenders for supply and erection of a 1,000 kw. double-current turbo-generator or, alternatively, a 1,000 kw. or 1,500 kw. turbo-alternator, together with surface condenser. Specifications, general conditions and forms of tender from the borough electrical engineer and tramways manager (Mr. H. Collings Bishop). Tenders to the Town Clerk by first post Monday, May 2.

LEEDS City Council invite tenders for supply of 5¼ miles of 0.15 sq. in. three-core cable, suitable for working pressure of 6,600 volts. Tenders to the town clerk (Mr. Robt. E. Fox), by 10 a.m. Monday, May 9. Specifications and conditions from the manager of the electric lighting department (Mr. H. Dickinson), 1, Whitehall-road, Leeds.

WEST BROMWICH Electricity committee invite tenders for supply, delivery and erection of a 750 kw. d.-c. turbo-generator and surface condenser. Specification, general conditions, forms of tender, &c., from the borough electrical engineer (Mr. W. A. Jackson), Electricity Works, West Bromwich. Tenders to the Chairman of the Electricity committee, Town Hall, West Bromwich, by May 2.

The SECRETARY OF STATE FOR WAR invites tenders for the supply of two plants for the production of hydrogen and oxygen by the electrolysis of water at the Balloon Factory, South Farnborough, Hants. Forms of tender from the Director of Army Contracts, War Office, Whitehall, London, S.W., where tenders are to be delivered by noon of May 4.

DUBLIN Technical Education committee want tenders by noon May 11 for wiring the technical schools, Bolton-street, Dublin. Specification from the City Electrical Engineer, Fleet-street, Dublin.

WHITEHAVEN Corporation require tenders by mid-day May 2 for supply of a Green's fuel economiser and pipework and main switchboard. Specifications from the Borough Electrical Engineer.

GLASGOW Corporation want tenders by 10 a.m. May 5 for one year's supply of coal to their electricity generating stations (about 100,000 tons). Forms of tender, &c., from the City Electrical Engineer.

The Deputy Postmaster-General, MELBOURNE, will receive tenders until 3 p.m. May 17 for supply of 1,010 reinforced concrete telegraph poles, preferably of Australian cement. Local representation necessary. Specification from Commonwealth office, London.

LAUNCESTON (Tasmania) City Council want tenders by 4 p.m. June 13 for overhead equipment for electric tramways, and by 4 p.m. June 27 for supply of synchronous motor generators and battery, reversible booster, &c. Specifications, &c., from the Town Clerk, on deposit of £1. 1s.

The Electric Light committee of PRINCE RUPERT (British Columbia) require tenders by noon May 3 for supply of boilers, engines, condenser pumps and piping, and electrical apparatus. Specifications may be seen at 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

West Ham Council have accepted the following tenders for electrical supplies:—

British Thomson-Houston Co., house service a.c. wattmeters (new type of meter); W. Lucy & Co., house service cut-out boxes; Pirelli Limited, indiarubber-covered wires and cables (six months, with option of extending for further six months); Baxter & Caunter, British Electrical Mfg. Co., Feld Bros. & Co., J. H. Tucker & Co., Falk, Stadelmann & Co., General Electric Co., Edison & Swan Co., Siemens Bros. Dynamo Works, Siemens Bros. & Co., British Westinghouse Co., E. Dewhurst, W. T. Glover & Co. and Accles & Pollock, electrical accessories.

West Ham Council have also accepted the tender of Blakeborough & Sons at £486 for circulating water piping.

London County Council have received the following tenders for supply of watt-hour meters for the central car repair depot, car sheds and sub-stations:—

Electrical Co. (*rec. for accep.*)..... £364. 9s. and	£389	12	0
Ferranti Limited	544	12	9
General Electric Co.	450	12	0
British Thomson-Houston Co.	422	19	9
Bat Meter Co.	372	5	0

East Ham Council have accepted the tender of Pollock & McNab for a motor-driven drilling machine with motor and set of twist drills at £84. 6s.; of Baxter & Caunter for supply of cable; that of the Patent Railway & General Eng. Co. to affix 100 patent manganese steel plates to the rail joints at 35s. for each joint exclusive of unskilled labour; and that of Hadfields (Ltd.) for manganese steel rails for a double curve at £280.

Belfast Harbour Commissioners have accepted the following tenders:—

Hind Bros. & Co., castings of bases for electric light masts; James Allan (sen.) & Son, tubular electric light masts; Stanley Johnston, arc lamps.

The Highways committee of London County Council recommend for acceptance the tender of Buck & Hickman for machine shop equipment of the central car repair depot at £2,949. 7s. 6d. The chief tramway officer's estimate was £3,000.

Aberdare Council have accepted the following tenders: D. T. Davies, electricity station buildings, £1,085; Lancashire Dynamo & Motor Co., generating plant, £3,312; Callender's Co., cables, £8,247.

Salford Education committee have accepted the tender of the Northern Electrical Co. for wiring the Wellington-street schools at £133. 13s.

Smethwick Education committee have accepted the tender of Best & Lloyd for the supply of electric light fittings for the technical school, and that of J. Ludlow for wiring work at £79. 15s.

For the ninth successive year the Lancashire Dynamo & Motor Co. have received the contract for high and low-speed motors (20–50 H.P.) for Salford Corporation.

The Midland Railway Co., who have decided to extend their electrical generating station at Derby, have placed an order for two 1,250 kw. Willans "impulse disc and drum" type turbines.

Woolwich (London) Council have accepted the tender of Crompton & Co. for supply of A type carbons at £54. 11s. 3d.

Faversham Council have accepted the tender of J. Smith for a Phœnix bitumen boiler.

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Bedford Council have accepted the tender of W. H. Allen, Son & Co. for a 750 kw. steam alternator at £3,706.

Slough Council have accepted the tender of the local electric light company for lighting the public hall clock.

Battersea (London) Council has accepted the tender of W. Geipel & Co. for annual supply of arc lamp carbons.

Aylesbury Council have accepted the tender of E. T. Mackrill & Sons for electrical work for a year.

BUSINESS NOTICES.

By mutual agreement Messrs. James T. Donald & Co., 35, McAlpine street, Glasgow, have relinquished their Scottish representation of the Union Cable Co. in favour of Messrs. J. C. Fisher & Co. Mr. J. C. Fisher, who has had the management of Messrs. Donald's electrical department for the past seven years, has now opened offices at York-buildings, York-street, Glasgow, where all inquiries and orders for electric wires and cables should now be sent, and where stocks will be available.

Messrs. Ronald Johnstone & Son, mining and consulting engineers, 190, West George-street, Glasgow, have opened a London office at 60, London-wall, E.C.

Plant for Sale.—Eastbourne Corporation advertise for sale a 50 kw. steam alternator. Particulars from the borough electrcial engineer, Mr. J. K. Brydges.

For Sale.—In another column an electric light and power undertaking is advertised for sale as a going concern.

Factory Premises to Let.—Messrs. Rowlandson & Co., 267, Mare-street, Hackney, London, N.E., advertise some factory premises to let

"The Journal."—Part 200 of the "Journal" of the Institution of Electrical Engineers is now ready, price 5s. Particulars of contents are given in an advertisement.

Shakespeare Festival.—The electrical engineer is interested, with the general public, in the dramatic and social events of the time. Year after year the Shakespeare festival at Stratford-on-Avon grows in importance and covers a longer period—this year from April 22 to May 14—when Stratford-on-Avon gives itself up to Shakespeare's plays. To enable lovers of the "Sweet Bard of Avon" who reside in the Metropolis to visit the scenes of many of the plays the Great Central Railway Co. have arranged a convenient service of express trains by their short route, and cheap tickets at the fare of 6s. 6d. return are issued from Marylebone several days during the week. The arrangements are specially suitable for attending the matinee performances in the Memorial Theatre on April 30, May 2, 3, 5, 7, 10, 11, 12 and 14, visitors being able to return in good time the same evening.

Technical Literature.—The Hill Publishing Co. (Ltd.), of 6, Bouverie-street, London, E.C., and of New York and Berlin, who are the sole agents for the McGraw-Hill Book Co., of New York, have ready a catalogue comprising a large number of electro-technical and other books. Copies of this catalogue can be obtained on application, and the company's publications can be consulted at the London offices.

CATALOGUES, &c.

Installation Accessories, &c.—Messrs. Siemens Bros. Dynamo Works have just issued a number of new price lists dealing with installation accessories and conduits. Consulting engineers, wiring contractors and others interested in this class of work should provide themselves with copies of these lists. Messrs. Siemens feel confident that the quality and prices of their material will bear comparison with any other on the market. Delivery can be effected immediately from stock, an advantage which should not be overlooked.

Crane Specialities.—The Witton-Kramer Electric Tool & Hoist Co. forward leaflets dealing with electric lifts and magnets, electric hoisting appliances and electric tool equipments. Complete catalogues will be ready shortly.

Precision Instruments.—Messrs. Isenthal & Co. have ready a description of an aperiodic millivolt and ammeter for continuous and alternating current which works on the Deprez-Weston principle. It is fitted with two scales, one for use with continuous current and the other for alternating current, between which, it is claimed, there is perfect accord.

"The Place of the Battery in Power Station Design."—The D.P. Battery Co. have sent us an artistically arranged pamphlet with this title. The question of the way in which the battery can be used to assist the generating plant is discussed, the costs being made out for the two cases when this class of apparatus is employed in stations having both light and power loads. This company have supplied batteries for use in connection with power work, and there is no doubt that its employment will be found equally economical for colliery plants, &c. All who are interested in battery work should obtain a copy of this booklet.

A.E.G. Steam Turbine.—The A.E.G. Electric Co. forward a pamphlet containing a complete account of the construction and operation of this turbine. This pamphlet will be of general interest. Combined turbo-generating sets are made by this firm with capacities so widely differing as 2 kw. and 15,000 kw.

BANKRUPTCIES, LIQUIDATIONS, &c.

Robt. Edwin Jay (trading as the Bristol Electrical Co.), 143, Cheltenham-road, Bristol, has been adjudicated bankrupt.

The trustee (Mr. F. Stone, 47, Full-street, Derby) in the bankruptcy of Lancelot W. de Grave, electrical engineer, 19, Queen-street, Derby, has been released.

The Grasse & Cannes Electric Tramways Synd. (Ltd.) is being wound up voluntarily. A meeting of creditors will take place on May 3 at Mr. H. R. Green's, liquidator, 37, Conduit-street, London, W.

A meeting to receive an account of the winding up of the Accumulator & Motor Construction Co. (Ltd.) (in vol. liq.) will be held on May 31 at Mr. Jesse Smith's, 79, Queen-street, London, E.C.

Bankruptcy Notice.—At the instance of S. R. Barley, 52, Castlenau-gerdens, Barnes, and H. H. Syms, 8, Kenilworth-court, Putney, a bankruptcy notice has been issued against Frank Sheppard, electrician, 4, Haslett-road, Kensington, London.

COMPANIES' MEETINGS AND REPORTS.

Indo-European Telegraph Co. (Ltd.)

The forty-third ordinary general meeting of this Company was held on Wednesday, Mr. J. Herbert Tritton in the chair.

The SECRETARY (Mr. John I. Bethell) read the notice convening the meeting and the auditors' report.

The CHAIRMAN said: Gentlemen, I am able to say that the year under review has been an uneventful one. Persia has reverted to a more or less normal condition from the telegraph point of view, and our lines over the great portions of the continents of Europe and Asia traversed by the Company's system have been subject to even less interruption than in former years. Strange to say, our troubles this year have been nearer home. The difficulty of the interruption of submarine cables owing to damage done by the trawls of the fishing fleets round the coasts of Great Britain is one that has seriously affected most of the companies having cables touching these shores. It is, of course, a serious difficulty, and one that certainly calls for solution. In these days, when the merchant entrusts the safety of his Argosies and even perhaps his commercial credit to the difference between a Morse dot and a dash over many thousands of miles of wire, telegraphic communications must be not only the best that can be given, but must be so far as possible completely secured against extraneous risks of all kinds. Both the cables across the North Sea in which the Company has leased wires were totally interrupted, the one for 79 days and the other for 66 days, of which 49 days were concurrent. The effect of this on the Company's business may well be imagined, particularly as the Postmaster-General found himself unable, owing to the requirements of his own traffic, to give us the use of relief wires except for a very small portion of the time. Under the above circumstances the Directors have been forced to look for additional cable accommodation between England and Germany, if possible in a direction removed from fishing operations, if such is to be found. Whilst tariffs show a consistent tendency to fall, traffics have, the Directors are pleased to report, shown a gratifying rise during the year. There is only one way to deal with increasing traffics, and that is the attainment and maintenance of perfect methods of transmission with the highest class of instruments and apparatus of all kinds obtainable. Well, gentlemen, we can say that we have no fear of reproach on the above grounds. Our friend, the Managing Director, is continually at work on the development and improvement of the system, but there is a limit even to his ingenuity, and we are faced with the necessity of permanently increasing our carrying capacity all through our system, with attendant expense. The Directors have set aside out of profits for the year a sum of £15,000 towards the cost of the additional land wire found necessary, and hope to provide a considerable further amount for the same purpose out of profits for the coming year. The cost of additional cable accommodation is, of course, a much heavier one, and the question is still engaging the attention of the Directors. I have often congratulated you on the financial position of this Company. Its large liquid assets enable the Directors to meet at a moment's notice commitments such as these, which might, ordinarily speaking, be almost heavy enough to necessitate the raising of fresh capital.

The Company's daily direct working between London and Karachi is of the greatest assistance in dealing rapidly and accurately with the traffic, and the Directors are constantly endeavouring to better the Company's own reputation in this respect. Yet we cannot keep pace with the demands of our customers, who expect their code words to be carried 7,000 miles to India without the failure of a single letter, the failure of one letter only having, apparently, the most disastrous results upon the sense of their telegram. This carries us back to the vexed

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question of pronounceable, or rather, unpronounceable, combinations. No improvement is visible in the construction of these codes—in fact merchants, in their endeavour to condense even a complete order into the limits of one code word, are forced into combinations of letters which practically make correct transmission a matter of the utmost difficulty. In this manipulation we think that he is defeating his own object by the abuse of the pronounceable combination system. It is sincerely to be hoped that the International committee provided for the censorship of codes submitted to it may be the means of standardising pronounceable-combination codes on a more reasonable basis. Turning to the accounts the revenue from message receipts and other sources, as shown in the revenue account, shows a satisfactory increase of £12,766. 13s. 1d. The combined commercial and maintenance expenses show an increase of £2,562. 7s. 8d. due to an item of expenditure on maintenance account of a non-recurring nature. The balance-sheet shows no variation from last year calling for remark. The Directors propose the usual final dividend, which absorbs £14,875, and bonus of 20s. per share, which accounts for a further £17,000, and have again decided to recommend a special distribution out of interest upon certain investments and advance accounts of 15s. per share, free of tax in each case. There remains a sufficient surplus to enable the Directors to propose the allocation of £15,000 towards the cost of increasing the carrying capacity of the system (which will, of course, ultimately amount to a considerably larger sum) and of a further sum of £5,000 to the trustees of the retirement trust fund, carrying forward £7,978. 1s. 11d. to the credit of 1910. This, gentlemen, finishes my review of the Company's operations for the year 1909. With regard to our prospects for 1910, traffics have, for the months up to date, been quite unprecedented, so that, provided our business is not dislocated by Channel cable interruptions, or any of those bolts from the blue to which undertakings such as ours are at all times exposed, we may hope for a prosperous outcome of the year 1910. I now move the adoption of the report and accounts, and the declaration of the dividends and bonus set out therein.

Mr. CHARLES HOLLAND seconded the motion, which was carried unanimously.

The re-election of the retiring Directors (Mr. C. Holland and Mr. George Plate) and the retiring auditors (Messrs. C. F. Kemp, Sons, & Co.) followed, and a vote of thanks to the Chairman, the Directors, and the officials for their strenuous and successful efforts on behalf of the Company brought the proceedings to a close.

Cuba Submarine Telegraph Co. (Ltd.)

The seventy-seventh ordinary general meeting was held on Wednesday, Mr. GEO. KEITH in the Chair.

The SECRETARY (Mr. James Scott) read the notice convening the meeting and the auditors' report.

The CHAIRMAN: Gentleman, the period under review from July to December is usually the lean or dull half of the year. You will be pleased to see that the half-year's traffics compare very favourably, as a whole, with those for the same period of 1908. The improvement shown may be attributed partly to the more active state of business following a good harvest, and partly to an increase in the Press and other traffic, in consequence of the exceptional storms and floods which took place in Cuba and the West Indies during the half-year. Bad weather in Cuba interferes with the working of the land lines, especially in the Western portion of the island, and leads to a larger use of our cables along the South Coast for local business. There was the hurricane in November, and as a consequence cable communication with the West Indies was entirely cut off for over a week. Fortunately our cables, as also the cables from Santiago to Jamaica and Hayti, were unaffected, and the through traffic lost during that time was more than made up by the large increase after the restoration of that communication, which accounts for the exceptionally good traffic for November, while the early commencement of the sugar harvest contributed to the increase in December. Now, turning to the revenue account, the traffic receipts of the half-year show an increase of £1,367 as compared with those of the corresponding period of 1908. Interest comes out £153 more, owing to our having made a further investment, and to the better rate received from our deposit at the bank. Taking transfer fees into account the gross revenue amounts to £16,376, or £1,518 more than it was in 1908. On the debit side the London expenses are much about the same, but expenses at stations are £287 more. Maintenance of land lines increased by £324, due principally to repairs having to be made to the Havana Batabano landline, and to the Cienfuegos Bay cables and cable huts. Income tax is also £119 more owing to the higher rate now current, and to an increase in the average of the three years upon which our return is based. Altogether the total expenses amount to £6,415, or £389 more than they were in 1908. The result of the half-year's business is a balance of profit of £9,961, which, after putting £2,000 to the reserve fund and providing the dividend of £3,000 for the preference shares, enables the Directors to recommend the payment of the usual dividend at the rate of 6 per cent. per annum on the ordinary shares free of income tax, and to increase the balance carried forward by £161 to £7,220. I think we may consider the result as very satisfactory. We have practically carried the interest earned by our investments to the reserve fund, increasing it to £116,000. So long as we are able to do this for the dull and lean half of the year, and a little better out of earnings of the business for the busy half, we are pursuing a safe and sound policy, but at the same time we have to keep in mind that we have over 1,200 miles of cable to maintain, and it is necessary to go on adding to the reserve fund so as to be able to meet the renewals and repairs which may have, in the future, from time to time, to be made, without unduly reducing its amount and taking away its recuperative power. As regards the present year, business generally is good and active. Cuba continues very prosperous under its own government; new industries are springing up in the island which all help to increase its prosperity; and works are going on in connection with railway extension, building of wharves and warehouses and making new roads and bridges, all of which when completed, will facilitate the transport and shipment of the produce of the island.

I now move the adoption of the report and accounts.

Mr. CHARLES W. PARISH seconded the motion.

Mr. GEORGE LYDDON referred to the statements made in the public journals regarding Marconi's wireless telegraphy, and said he would like to know, in the face of the suggestion that soon submarine telegraph cables will not be required, and that wireless telegraphy will be the only thing known throughout the world, whether they were to be in a state of collapse or to go on in the prosperous course they had hitherto done and were still pursuing.

The CHAIRMAN: Well, gentlemen, I know that a great deal of communication is being made on the sea by wireless telegraphy, but as regards communicating overland, as far as I know I do not think it has been very successful. In my own opinion, the drawback of wireless telegraphy is the want of the wire—(laughter)—and I do not think, so far as we are concerned, that we need fail to sleep soundly over the matter itself. Although wireless telegraphy is getting more and more important, I do not think we have much to fear. I understand they can communicate a longer distance from the land to the ship than from the ship to the land, and that the distance that can be communicated over from the ship is very limited—much more so than communication in the other direction. For instance, just now they say they are communicating across the Atlantic. Well, if they use tremendous power no doubt they can do so; but whether it will be successful or not remains to be seen.

A resolution approving the preference and ordinary dividends was then carried unanimously, and a cordial vote of thanks to the Chairman terminated the proceedings.

AUCKLAND ELECTRIC TRAMWAYS CO. (LTD.)—The directors' report for 1909 states that the total revenue was £182,594. 8s. 3d., and the traffic receipts (£180,386. 15s. 11d.) show an increase of £16,538. 14s. 2d. over 1908. Deducting expenses, including £16,454. 13s. 8d. for interest, the rental and percentage of profits payable to Auckland Council (£3,992. 10s. 11d.), and setting aside £15,000 (compared with £12,500 last year) to depreciation, the surplus was £35,124. 1s. 1d., or, with £3,920. 7s. 8d. forward, £39,044. 8s. 9d. The directors recommend that £11,500 be placed to reserve, that £3,000 be appropriated to preference dividend, and that a dividend be paid on the ordinary shares at the rate of 6 per cent. (making 6 per cent. for the year) (£21,000), leaving £3,544. 8s. 9d. to be carried forward. Capital expenditure during the year was £56,601. 7s. 4d., the largest portion being in connection with an extension of the power house plant and distributing system. An extension of 0·68 mile in the Grey Lynn district, which is now approaching completion, was commenced, and five additional cars were purchased. At the request of Auckland Council the company have agreed to construct an extension of about ¼ mile of tramway. An extension of 0·775 in another district has also been agreed to. Further suggested extensions of the system are under consideration. Eight further cars have been ordered and are under construction, bringing the total up to 100.

BABCOCK & WILCOX (LTD.)—At the meeting on Friday the chairman (Mr. John Dewrance) said the company had earned a record profit. It was proposed to pay for the six months ended Dec. 31 last, besides the accrued dividend on the preference shares, a dividend of 8 per cent. and a bonus also of 8 per cent. on the ordinary shares. In addition, the board recommended that £100,000 be placed to reserve and £25,000 to dividend equalisation fund. It was felt that the time had come to create a staff pension fund, and £10,000 had been set aside for that purpose. The amount carried forward was £63,082. The factory had been largely increased, and the plant and organisation considerably improved, and they were still further extending the works. With regard to the pension fund, it was intended to limit its benefits to the heads of departments and what was called the staff. The question of providing for the workmen must be left to the Government. It was not easy to make any provision for workmen, because they changed their employment so frequently, and their trade unions and other arrangements interposed a great number of difficulties.

DEVONPORT AND DISTRICT TRAMWAYS CO—At the meeting last week the chairman (Mr. W. G. Bond) dealt at length with the dispute between the company and Devonport Corporation. The past year had been an abnormal one (especially on the expenses side), and during 11 months the Corporation extensions were not operated. In 1908 the traffic receipts were £24,402, and in 1909 they were £19,255. Seeing that the total annual sum paid to the Corporation under the lease was only £3,900, it might be said that the company had been trying to bluff the Corporation in arguing, as it had done, that the extensions constituted such a drain upon their resources that the company was entitled either to some measure of relief or to purchase upon terms not appreciably worse than those of the 43rd section of the Tramways Act, 1870. He contended that the figures bore out the company's contention and that the company was justified in promoting the "Relief" Bill which was recently rejected by a Select Committee of the House of Commons. After sketching the proceedings before the Committee, Mr. Bond stated that the company only wanted fair play. That they had never had. Every concession and suggestion had come from the company. They

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would gladly come to terms with the Corporation upon any reasonable basis, but it had declined, and would continue to decline, to hand over its undertaking to the Corpoartion for a mere song.

GENERAL ELECTRIC CO. (U.S.A.)—The report for 1909 states that the gross earnings were $54,102,000, increase $6,945,000; net earnings $9,599,000, increase $2,556,000; balance, $6,494,000, increase of $1,691,000; and surplus to profit and loss account, $1,279,000, increase $1,691,000 over 1908.

LONDON UNITED TRAMWAYS (LTD.)—At the meeting last week, Mr. C. J. Cater Scott said that up to 1906 there had been a reasonable expansion in receipts, but since 1906 that expansion had diminished, until last year they were face to face with a very serious falling off. In 1906 they had 45 miles of route open, and their traffics were £325,000; in 1907 they had 52¼ miles open, and their receipts were £342,000; in 1908, with 55¼ miles open they had £346,000 from traffics, or nearly £4,000 more, and in 1909, with the same route mileage, their traffics were down to £317,000. Bad weather and competition were responsible for this drop in receipts. Competition was by far the most serious cause with which they had to deal. During the last four years there had been an absolute revolution in the conditions under which London passenger traffic had been carried on. During that period they had had the District and Metropolitan Railways electrified. They also had the three big tubes. There was one other factor, and it was the most important of all so far as they were concerned, and that was the motor 'bus. There were now just over 1,700 motor 'buses on the streets of London, and they were undoubtedly the most serious competition with which they had to deal. In dealing with that competition they were at a very serious disadvantage. A motor 'bus could run where it chose. During the week it could work any route in London itself and on Sunday it could be sent to those districts where their tramways were, and where, hitherto, they had had comparatively little competition. Unfortunately, with the lack of expansion of business they had concurrently had a considerable increase in maintenance expenses, and for some time to come they must certainly look for very considerable charges against revenue for maintenance. Many of their lines had been carrying a heavy traffic for a good many years past, and, naturally, they had begun to show signs of wear and tear. In 1909 they carried 55,750,807 passengers, against 59,255,919 in 1908. On traction expenses they had a saving of about £3,566, due to some reduction in car-mileage, and also chiefly to a considerable reduction in coal. In traffic expenses there was an increase of £1,099, entirely accounted for by compensation and legal expenses, which were up £1,890. There were also increases in salaries and management expenses. There was an increase of £2,252 on rolling stock and power plant, £1,572 on overhead lines and cables and £4,631 on maintenance. They had a total increase in expenditure of £6,334, and with the diminution in traffics they were £37,499 worse off than in 1908. London County Council had served them with notice to purchase the Hammersmith line. In regard to the retirement of Sir Clifton Robinson, that gentleman had been associated with the company for a great many years as managing director, and had devoted himself almost entirely to its work. But Sir Clifton Robinson had this year completed 50 years' service in connection with tramways in one part of the world or another, and thought the time had come when he was entitled to some rest. The London United Tramways was very closely associated, through the Underground Electric Railways Co. of London, with the Metropolitan District, the Piccadilly, Hampstead and Bakerloo Tubes, and it had been thought that if they could do something more with that closer association, if the London United Tramways could be brought under the same general management as those other companies, it might be of great benefit to the London United Co. Sir Clifton Robinson realised the position, and helped to carry it out; so that his retirement came as a friendly act. In his place they had elected Mr. Stanley (the general manager of the District Railway and of the three tubes mentioned) to be their managing director. Mr. Chapman, one of their directors, had left the country, and had resigned his seat.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—The chairman (Mr. B. St. John Ackers) stated at the meeting on Wednesday that satisfactory progress had been made during the past year and the prospects were encouraging. There was also a steady development in the business of the subsidiary companies. The negotiations between the Calcutta Co. and the Indian Government for taking over the telephone system were occupying the board's attention. In Egypt the progress did not equal that made during the years immediately preceding the recent crisis. The China & Japan Co. was able to report satisfactory developments at Hongkong and the progress made by their branch in Kowloon was equally marked.

UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)—At the meeting last week the chairman (Sir Edgar Speyer) said that the net revenue for the half-year not only showed a substantial improvement, but was sufficient to pay the full half-year's interest on the 4½ per cent. bonds. The good results which had been obtained were chiefly due to savings in coal consumption and other reductions in cost of working the Lot's-road power station, to providing the quickest and most efficient service that it was in their power to give, and to spreading, through a well-conceived plan of advertisement, the information regarding the many exceptional travelling facilities which their system offered. The affiliated companies carried 217,730,081 passengers in 1909, of which the three tubes carried 95,126,973, the District Railway 66,852,301 and the tramways 55,750,807. That would enable them to realise what an important contribution to the traffic problem of London they were making—in fact, to imagine London to-day without the tubes was hardly possible, although it was less than three years ago that they were completed. The scheme to amalgamate the three non-competitive tube companies was not an ordinary case of railway amalgamation, but was a measure of financial common-sense.

Their late chief engineer's (Mr. J. R. Chapman) agreement having terminated, and his task having been accomplished, he had returned to America. The company owed to Mr. Chapman's engineering skill and untiring energy, as well as to his unfailing loyalty, a deep debt of gratitude. The Chelsea power station was entirely due to his initiative, courage and ability.

The District Railway continued to make encouraging progress. The appointment of their general manager (Mr. A. H. Stanley) as managing director of the London United Tramways would mean unification of management and the spreading of their organisation over that system. They confidently expected that by that means better results would be obtained.

TYNEMOUTH & DISTRICT ELECTRIC TRACTION CO. (LTD.)—Including £315 brought forward, the profits for 1909 were £4,566. A dividend of 3½ per cent. per annum is recommended, £148 being carried forward.

URBAN ELECTRIC SUPPLY CO. (LTD.)—The gross profits for 1909 amounted to £44,872, and over £43,000 is available. Deducting £12,263 for interest and £1,971 for depreciation, there remains £23,877, which falls short by £3,622 of the amount required to meet the 5 per cent. guaranteed dividends. This deficit has been provided by Edmundsons' Electricity Corpn. under their contract.

WEMYSS & DISTRICT TRAMWAYS CO.—For the year ended Dec 31 last the traffic receipts amounted to £13,653. The total income was £13,909, and the balance at credit of profit and loss account was £2,599. The directors recommend a dividend of 6 per cent. on the ordinary shares. £302 is carried forward.

CITY NOTES.

MEMORANDA (April 28).—**Bank rate 4 per cent.** (since March 17, 1910). **Price of silver,** 24⅛d. per oz. Consols 81--81¼ for money and for account. Consols Pay Day, May 5; Stock and Shares Continuation Days, May 10 and 29; Ticket Days, May 11 and 26; Pay Days, May 12 and 27; Mining Shares Carry Over Day, May 9.

PRICES OF METALS (London).—*Copper*, cash, 5⅝; three months, 57¼. *Lead*, English, 12⅞—13⅛; foreign, cash, 12⅞—12⅞; three months, 12¼. *Spelter*, 21⅞—22⅛. *Tin*, English, 149—151; foreign cash, 150¾; three months, 151¾. *Iron*, Cleveland, cash, £0,3, and three months, 51/3.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The directors, after writing off £17,000 for depreciation and renewals, have declared a dividend at the rate of 9¼ per cent. (4s. 9d. per share) for the half-year to Dec. 31 (making 8 per cent. for the year).

CITY OF BUENOS AYRES TRAMWAYS CO.—A dividend of 1s. 3d. per share (less tax) is announced for the three months ended March 31.

COLOMBO ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—The directors recommend a dividend of 6 per cent. (12s. per share), tax free, for 1909, after allocating £7,300 to reserve and renewals and writing £5,300 off track renewal account, &c, and carrying £2,201 forward.

EASTERN TELEGRAPH CO. (LTD.)—This company announce that, subject to final audit, the accounts for the year ended Dec. 31, 1909, show that after making a contribution to general reserve, payment of interest on the 4 per cent. mortgage debenture stock, dividend on the 3½ per cent. preference stock and three interim dividends of £1. 5s. per cent. each on the ordinary stock to Sept. 30 last, there is a balance available out of which the directors recommend payment of a final dividend of £1. 5s. per cent. and a bonus of £2 per cent., both tax free, and payable on May 11, making with previous payments on account a total distribution of 7 per cent. on the ordinary stock for the year 1909. The transfer books of the ordinary stock will be closed from May 4 to 11 inclusive.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD). Subject to confirmation by the shareholders, the directors have declared a dividend for the quarter ended Dec. 31 last of 2s. 6d. per share, together with a bonus of 4s. per share (or 2 per cent.), making a total distribution of 7 per cent. for 1909. The dividend and bonus will be paid on 11th prox. The share register will be closed from 3rd to 10th prox. inclusive.

RIVER PLATE ELECTRICITY CO. (LTD.)—The directors, after placing £10,000 to reserve, have declared a dividend of 9 per cent. (less tax) on the ordinary shares for the year to Dec. 31, carrying forward £5,141.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted quotations to £170,000 £1 (7s. 6d. paid) 6 per cent. cumulative preference shares of *La Plata Electric Tramways Co. (Ltd.)* and a further issue of £200,000 £5 per cent. cumulative perpetual preference, £200,000 preferred ordinary and £100,000 deferred ordinary stock of the *British Columbia Electric Railway Co. (Ltd.)*. The committee have been asked to grant quotations to 70,000 £5 fully-paid ordinary and 14,000 £5 fully-paid 6 per cent. cumulative preference shares and £700,000 5 per cent. first debenture stock (renewed special application) of the *Para Electric Railways & Lighting Co. (Ltd.)*

WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)—The directors recommend payment of the following dividends: 6s. per share on the first preference shares (for six months to Dec. 31) and 9s. per share on the second preference shares (on account of dividends accrued to Dec. 31, 1909).

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdire	April 15	227	..	15	3,244	+ 100
Anglo-Argentine	,, 22	45.533	+ 3,942	16	696,089	+ 58,851
Ayr Corporation	,, 23	225	— 28	49	13,613	— 104
Baker St. & Waterloo Ry.	,, 23	3,445	+ 135	16	54,880	+ 840
Barnsley	,, 15	163	— 58	15	2,550	+ 81
Barrow	,, 15	222	— 26	15	3,391	+ 350
Bath Electric Trams, Ltd.	,, 20	739	..	16	11,231	+ 1,183
Birmingham Corporation	,, 23	6,673	+ 283	3	21,766	+ 1,497
Birmingham & Midland	,, 8	763	— 75	14	11,323	+ 468
Blackburn Corporation	,, 20	947	— 46	‡4	4,112	— 602
Blackpool and Fleetwood	,, 23	295	— 99	..	..	..
Bolton Corporation	,, 24	2,210	+ 1	4	7,648	— 1,458
Bombay	Mar. 25	2,846	+ 277	12	32,632	+ 2,250
Bournemouth Corporation	April 20	1,610	— 145	3	4,426	— 1,260
Bradford Corporation	,, 23	4,753	+ 124	4	15,602	— 1,923
Brighton Corporation	,, 24	782	— 100	§3	2,772	— 685
Bristol Trams & Carriage	,, 22	5,574	+ 450	49	280,806	+ 22,076
Burnley Corporation	,, 23	1,162	— 60	16	20,272	+ 596
Burton Corporation	,, 24	248	— 15	§3	852	— 75
Bury Corporation	..	..	..	..	..	..
Calcutta Tramways Co.	,, 23	₹52,476	+ ₹6,936	16	₹838,676	+ ₹26,926
Camborne-Redruth	,, 23	116	— 2	16	1,880	— 56
Cardiff Corporation	,, 23	2,095	+ 6	4	6,847	— 831
Cavehill	,, 15	80	— 111	15	1,098	+ 147
Central London Railway	,, 23	5,501	+ 174	16	88,059	+ 300
Charing C., Euston & H'stead	,, 23	3,820	— 25	16	61,225	— 165
Chatham & Dist. Lt. Rys.	,, 21	751	— 53	16	12,174	+ 615
City & South London Rly.	,, 24	3,271	+ 119	16	52,777	— 455
City of Birmingham	,, 15	2 750	— 487	15	42,158	+ 2,470
Colchester Corporation	,, 20	160	— 5	16	2,567	+ 419
Cork Electric Trams Co.	,, 21	461	— 8	16	6,978	+ 247
Croydon Corporation	,, 15	1,593	— 181	15	3,295	— 437
Devonport & Dist. Trams	,, 15	419	+ 21	15	6,066	+ 618
Dover Corporation	,, 23	176	— 1	3	609	— 98
Dublin & Lucan Railway	,, 22	133	+ 5	16	1,837	+ 27
Dublin United	,, 22	5,671	..	16	81,225	+ 3,253
Dudley-Stourbridge	,, 15	708	— 363	15	10,536	— 321
Dundee Corporation	,, 20	1,139	— 27	†49	57,080	— 609
East Ham Council	,, 23	970	— 7	¶3	3,217	— 121
Exeter Corporation	..	..	..	..	..	..
Gateshead & Dist. Trams	,, 15	919	— 182	15	14,274	— 230
Glasgow Corporation	,, 23	17,827	+ 469	‡47	794,411	+ 2,437
Glossop Trams	,, 23	108	— 12	16	1,745	— 94
Gloucester Corpn.	,, 20	257	— 19	3	763	— 19
Gravesend-Northfleet	,, 15	187	— 85	15	2,827	+ 134
Great Northern & City Rly.	,, 23	1,487	+ 48	16	24,227	— 522
Gt. Northern, Piccadilly, &c.	,, 23	6,035	+ 430	16	97,000	+ 4,180
Greenock & Port Glasgow	,, 15	635	+ 26	15	7,917	+ 1,144
Hartlepool Tramways	,, 15	204	— 62	15	3,086	+ 106
Hastings Elec. Trams Co.	,, 21	832	— 166	16	12,883	+ 476
Hong Kong	,, 23	$8,811	+ $1,305	16	$135,817	+ $12,900
Huddersfield Corpn.	,, 23	1,709	+ 135	3	5,025	— 320
Hull Corporation	,, 23	2,571	+ 135	3	8,636	— 302
Ilford District Council	,, 23	468	+ 13	3	1,587	— 164
Ilkeston District Council	,, 20	122	+ 4	3	336	— 83
Ipswich Corporation	,, 23	343	— 15	3	1,157	— 135
Isle of Thanet Co.	,, 23	361	— 60	¶29	8,841	+ 289
Jarrow	,, 15	108	— 29	15	1,661	+ 95
Keighley Corporation	,, 21	165	+ 14	3	478	— 49
Kidderminster & District	,, 15	85	— 64	15	1,297	+ 48
Kilmarnock Corporation	,, 23	141	..	49	7,033	— 196
Lanarkshire Trams Co.	,, 21	1,393	+ 50	16	21,240	+ 2,166
Lancashire United	,, 20	1,224	+ 20	16	19,514	— 45
*Leamington	,, 15	142	— 81	15	2,173	— 3
Leeds Corporation	,, 23	6,691	+ 222	3	22,020	— 48
Leicester Corporation	,, 23	2,218	+ 78	15	34,621	+ 2,511
Leith Corporation	,, 23	559	+ 37	49	28,847	+ 3,439
Lincoln Corporation	,, 23	115	— 51	4	473	— 61
Liverpool Corporation	,, 16	10,860	— 203	15	160,685	+ 3,975
Liverpool Overhead Rly.	,, 24	1,300	— 43	17	22,034	+ 25
Llandudno&ColwynBayRy.	,, 22	163	— 44	§20	2,872	+ 156
*London County Council	,, 9	39,514	+ 9,116	¶1	51,453	+ 5,142
London United	,, 23	5,836	+ 29	52	90,582	+ 7,068
Lowestoft	,, 23	126	— 12	30	4,442	+ 302
Maidstone Corporation	,, 23	158	— 10	3	509	— 123
Manchester Corporation	,, 23	14,804	+ 291	3	48,217	— 1,977
Mersey Railway	,, 23	2,007	+ 68	16	31,955	+ 608
Merthyr	,, 15	184	— 123	15	2,865	— 176
Metropolitan Dist. Railway	,, 23	11,231	+ 1,439	16	173,348	+ 17,678
Metropolitan Elec. Trams	,, 15	6,862	— 733	15	101,441	+ 20.079
Middleton	,, 15	274	— 205	15	4,169	— 373
Nelson Corporation	,, 23	133	+ 8	§3	448	— 77
Newcastle-on-Tyne Corp.	,, 23	3,643	— 5	¶3	12,210	— 1,762
Newport (Mon.)	,, 23	644	+ 29	4	2,629	— 38
Northampton Corporation	,, 22	451	+ 13	3	1,369	— 217
Oldham, Ashton & Hyde	,, 15	516	— 219	15	7,925	— 105
Oldham Corporation	,, 24	1,685	— 153	4	8,102	— 950
Perth (N.B.) Corporation	,, 20	159	+ 3	§48	7,532	+ 76
Perth (W.A.) Elec. Trams	,, 22	1,532	+ 132	16	25,486	+ 1,805
Peterborough	,, 15	100	— 61	15	1,484	— 19
Portsmouth Corporation	,, 23	1,750	— 72	3	5,936	— 1,283
Potteries	,, 15	1,748	— 214	15	25,459	— 453
Preston Corporation	,, 20	708	+ 1	3	2,026	— 244
Rotherham Corporation	,, 21	612	+ 57	3	1,755	— 152
Rothesay	,, 15	83	— 224	15	1,056	+ 92
Salford Corporation	,, 25	4,443	+ 145	¶4	15,612	— 1,096
Sheerness	,, 15	42	— 14	15	633	— 6
Sheffield Corporation	,, 24	5,759	+ 322	¶4	25,472	+ 659
Singapore Trams	,, 23	$10,368	+ $969	16	$159,024	+ $2,859
South Metropolitan	,, 15	751	— 307	15	10,949	+ 773
South Staffs	,, 15	781	— 384	15	11,976	— 167
Southend Corporation	,, 20	447	+ 19	3	1,228	— 207
Southport Tramways	,, 15	257	— 175	15	3,620	+ 152
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 23	626	— 62	3	2,058	— 925
Sunderland Corporation	,, 24	1,055	+ 13	4	4,060	— 558
Sunderland District	,, 20	389	— 51	25	10,128	— 913
Swansea Trams	,, 15	996	— 87	15	14,570	+ 1,582
Swindon Corporation	,, 20	126	+ 5	..	..	..
Taunton	,, 15	41	— 10	15	595	+ 87
Tynemouth and District	,, 15	152	— 80	15	2,320	+ 260
Tyneside Trams Co.	,, 20	377	— 3	16	6,090	— 297
Wallasey District Council	,, 23	826	— 97	§3	2,762	— 553
Walsall Corporation	,, 23	509	+ 31	16	8,445	+ 432
Warrington Corporation	..	..	..	..	..	..
West Ham Corporation	,, 14	2,285	— 643	2	4,539	— 624
Weston-super-Mare	,, 15	58	— 135	15	605	+ 35
Wolverhampton Co.	,, 15	389	— 186	15	6,019	+ 134
Wolverhampton Corpn.	,, 20	853	+ 108	3	2,521	— 8
*Worcester	,, 15	244	— 102	14	3,621	+ 89
Wrexham	,, 15	126	— 11	15	1,390	— 20
Yorkshire W.R. Trams	,, 24	1,141	— 202	17	20,412	..
Yorkshire Woollen District	,, 15	937	— 168	15	13,983	+ 1,418

(a) Those comparisons are with the corresponding period last year. * Partly electrical. Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shs	Last Dividend	NAME.	Price Wed. April 27	Rate per cent. Yielded.	Dividend Due.	Business Week to April 27. Highest.	Lowest.
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9½	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½—9¾	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	9¾—10½	5 17 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
5	2/0	Bromley (Kent) El. Lt. & Power Shares	4¼—4¾	5 15 9	April, Oct.	..	..
St.	4½%	Do Do. 1st Debs.	91 —94	4 15 9	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅞—7⅞	6 7 0	March	7⅞	7⅞
5	3/6	Do. 7 per Cent. Pref.	7 —7¼	4 13 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 9	June, Dec	..	..
5	4%	Charing Cross (W. End & City) El. Sup. Co.	4 —4¼	5 11 0	Feb, Aug	..	..
5	2/6	Do. 4½ per Cent. Pref.	4¼—4¾	4 17 6	Feb., Aug	..	..
5	2/3	Do. 4 per Cent. Deb. Stock (red.)	97 —100	4 0 0	Jan, July	..	..
St.	4%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	..	..	..
St.	4½%	Do. City Undertaking 4½% Cum. Pref.	3⅞—4⅜	5 3 0	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3⅜—4⅛	5 9 6	March	4	..
5	2/6	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	..	..
St.	4½%	City of London Electric Lighting Ord.	11½—12	5 16 6	Feb, Aug	11⅝	11⅝
10	9/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	..	..
10	6/0	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	124½	122½
St.	5%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 —103	4 7 6	Jan, July	..	..
St.	4½%	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	..	Do. 5 per Cent. non Cum. Pref.	2¾—3¼	7 14 0	April, Oct	..	..
5	5%	County of London Elec. Supply Ord.	7⅛—8	6 0 0	Feb, Aug	7⅛	7⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾—11¼	5 6 6	Mar, Sept	11¼	11¼
St.	6/0	Do. 4½ per Cent. Deb Stock (red.)	103—106	4 5 0	Jan, July	105	104½
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 0	May, Nov	..	..
5	4½%	Folkestone Electricity Supply Co. Ord.	4¼—4½	5 15 0	April, Oct	..	..
5	3/6	Do. 5 per Cent. Cum. Pref.	4¾—5¼	4 15 0	Mar, Sept	..	..
5	2/6	Do. 4½ 1st Deb. Stock (red)	93 —96	4 14 0	Feb, Aug	..	..
St.	4½%	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/6	Kensington & Knightsbridge Ord.	7 —7⅛	5 6 8	Feb, Aug	..	..
5	4/0	Do. 6 per Cent. 1st Pref	5⅞—6¼	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94½—96½	4 3 6	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —99	4 1 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅝—2	4 10 0	Mar, Sept	1⅝	..
5	3/0	Do. 6 per Cent. Pref.	4¾—5¼	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	92 —94	4 4 0	Jan, July	92½	..
5	2/6	Metropolitan Electric Sup. Ord.	4 —4¼	5 0 0	April, Oct	4¼	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅝—5	4 10 0	Jan, July	4⅝	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	96½—98½	4 11 6	June, Dec	..	..
100	4½%	Newcastle & Dist. Elec. Ltg. 4½ per Cent. Deb.	82 —86	5 2 6	Jan, July	..	..
5	4/0	Newcastle Elec. Supply Ord.	4¼—4⅜	4 5 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4¾	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	..	..
100	5%	†North Metro. Elec. Power Sup. 5 Morts.	99 —101	4 19 0	..	100	..
10	9/0	Notting Hill Electric Ord.	11¾—12¼	5 17 6	March	..	..
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 —97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8½—9	5 11 0	Feb, Aug	..	..
5	5/6	Do. 7 per Cent. Pref.	6¼—7¼	4 16 9	Feb, Aug	6⅛	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84—88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1⅝—2½	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3¼	6 11 0	April	10⅛	..
St.	5%	Do. 5 % 1st Mort. Stock (red.)	100 —103	4 17 6	..	101¼	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—¼	..	..	..	..
1	..	Do. 7 per Cent. Cum. Pref.	⅛—¼	..	..	..	..
1	0/8½	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	Feb, Aug	1⅛	..
St.	4½%	Urban Electric Supply Ord.	98 —101	4 9 0	April, Oct	1⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	¾—1	..	April, Oct	⅞	..
5	2/6	Do. 4½ per Cent. 1st Mort. Deb.	1¾—2¼	..	April, Oct	2¼	..
St.	4½%	Westminster Elec. Sup. Ord.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Do. 4½ per Cent. Cum. Pref.	8¼—9	5 10 0	Mar, Sept	8⅛	8⅛
5	2/3		5 —5½	4 2 0	Jan, July	5⅛	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	96½	96½
		Bath Elec. Trams Pref. Ord.	⅛—¼	..	April	..	..
1	..	Do. 5 per Cent. Cum. Pref.	⅜—½	6 13 6	Jan, July	..	..
1	0/6	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock	83 —86	5 5 6	Jan, July	85	83½
St.	4½%	Bristol Tramways & Carriage Ord.	7 —7½	8 0 0	Feb, Aug	..	..
10	6%	Do. Cum. Pref. (fully paid)	7¼—7½	5 3 0	..	..	..
10	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
St.	4%	British Electric Traction Ord.	1 —1⅛	..	June, Dec	1⅛	..
10	..	Do. 6 per Cent. Cum. Pref.	3½—4¼	7 5 0	Feb, Aug	3⅝	..
10	3%	†Do. 5 Cent. Perpetual Debs.	90 —93	5 7 6	April, Oct	92½	91
St.	5%	Do. 4½ per Cent. 2nd Deb. Stock	68 —72	6 5 0	May, Nov	..	..
St.	4½%	Central London Ordinary Stock	70 —72	5 4 6	Feb, Aug	..	..
St.	3%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	87½	..
St.	4%	Do. Deferred Stock	53 —55	3 12 0	Feb.	53½	..
St.	2%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	103	102½
100	4%	Charing X, Euston & Hmpstd Per. Deb Stk	96 —99	4 2 0	Jan, July	96½	96
St.	4%	†City of Birmingham Trams, 5 % Cum. Pref.	4½—5	5 0 0	April, Oct	..	..
5	2/6	†Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
100	4%	City & South London Rly. Con. Ord.	34½—35½	3 9 6	Feb, Aug	35⅛	35
St.	13%	Do. 5 per cent. Perp. Pref. (1891)	106 —108	4 12 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —105	4 15 0	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	103	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	102½	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	100 —102	3 18 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 —98	4 2 0	Jan, July	..	..
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3¾—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	70 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅜—1⅝	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅞—10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2½—3	..	Jan, July	3	2⅝
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	69 —72	5 11 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	†Metropolitan Elec. Tramways Ord.	⅝—⅞	..	..	..	..
1	..	Do. Deferred	⅛—¼	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅜	5 12 9	Feb, Aug	⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 —100	5 0 0	Jan, July	99	97½
St.	1%	Metropolitan Railway Consolidated	42½—43½	2 6 3	Feb, Aug	44½	42½
St.	2½%	Do. Surplus Lands Stocks	67 —69	3 19 6	Feb, Aug	69	67½
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90½	89½
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	87	86½
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87½	86½
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	93½	92½

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed., April 27	Rate per cent. Yielded.	Dividend Due.	Business Week to April 27. High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 0	Jan, July	93	..
St.	..	Metropolitan District Railway Ord.	22⅞—23⅛	..	Feb, Aug	23½	22⅝
St.	..	Do. Extension Pref. (5 per Cent.)	69 —71	..	Feb, Aug	..	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	72⅞	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	75⅛	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	103	102½
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	143 —145	4 2 9½	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅛—¼	..	May	..	..
1	..	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—¼	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	84 —87	5 2 6	May, Nov	..	..
1	..	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—¼	..	..	..	..
St.	4%	Dc. 4 per Cent. Deb. Stock	67 —71	5 12 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	60 —65	7 9 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoups	38 —40	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	103½	103
..	4½%	Do. 4½% Bonds with coup. 5	89 —91	4 19 0	..	99⅜	83⅜
..	4%	Do. 4 per Cent 1st Power Ho. Dbs.	97 —99	4 1 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	⅛—¼	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	78 —81	5 11 0	Jan, July	78	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101 —103	4 7 0	..	..	..
1	..	Aron Electricity Meter Ord.	⅛—¼	..	..	..	..
1	7½d.	Do. 6% Cum. Pf.	⅛—¼	6 8 0	April, Oct	..	..
1	1/7½	Babcock & Wilcox Ord.	5⅛—5⅜	3 12 9	April, Oct	5⅛	5⅛
1	0/7½	Do. Pref.	1⅞—1⅞	3 16 3	..	7⅛	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7½	6 18 0	July, Feb	..	..
5	3/0	Dc. 6 per Cent. Pref.	6 —6½	4 10 9	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —105	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	93 —96	4 13 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅜—⅝	..	Feb, Aug	98	97½
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	97 —99	6 1 0	..	48½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	47 —51	7 16 0	Jan, July	..	..
St.	4½%	BrushE. Eng. Co. 4½% Perp. 1st Deb. Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	25 —29	15 10 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.	10 —10⅛	6 3 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 11 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	102⅛—104½	4 6 0	Nov, May	2⅛	2⅛
1	1/9½	Castner-Kellner Alkali Co.	2⅛—2⅜	5 3 9	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	104 —107	4 4 0	Feb. Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
..	0/7½	Do 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	April, Oct	..	..
1	0/7½	Consolidated Electrical Co.	⅛—¼	7 0 0	August ..	..	..
1	0/6	†Consolidated Signal Co.	⅛—1	7 0 0	April, Oct	..	..
1	0/7½	†Do. 6 per cent. Cum. Pref.	⅛—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	⅛—¼	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅛—1⅛	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	⅛—1	6 0 0	Sept ..	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Sept ..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
		Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	⅛—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	..	May, Nov	1⅛	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	73 —76	5 18 0	Jan, July	..	..
2	..	Electric Construction Co.	⅛—⅜	..	Jan, July	⅛	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1⅝—1⅞	10 7 6	July ..	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	61 —66	6 1 0	Jan, July	..	..
St.	5%	Ferranti Ltd. 5 per Cent. 1st Mt. Db. St.	61 —66	7 11 6	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅞—8⅛	6 1 6	June, Dec	..	..
St.	4%	Dc 4 per Cent. 1st Mort. Debs.	82 —86	4 13 0	Mar, Sept	12⅛	12⅛
5	10/0	Henley's Telegraph Works Ord.	12⅛—13⅛	5 17 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5⅛	4 3 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107⅛	4 3 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Works	15⅛—16	6 5 0	Feb, Aug	15⅛	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10⅛—10⅞	4 12 0	..	10⅛	..
100	4%	Do. 4 per Cent. Debs. (red.)	97⅛—99⅛	4 0 6	April, Oct	97⅛	..
1	..	National Elec. Construction Co.	⅛—⅜	..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nc. ..	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—⅜	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5⅛	..	..	..	..
12	30/0	Telegraph Construction & Maintenance	33⅛—35⅛	5 16 0	Mar, July	33⅛	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	2⅜	2⅛
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	4 9 0	..	1⅜	1⅜
1	0/6	Dc 5 per Cent. non-Cum. Preference	1⅛—1⅜	4 4 3	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 11 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 16 0	June, Dec	103	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —106	4 5 0	June, Dec	104½	103
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —108	4 12 6	..	106⅜	..
10	8%	J. G. White & Co. 6% Cum. Pref	9½—10½	7 12 0	..	..	..
1	..	Willans & Robinson Ord.	⅛—¼	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1⅞—2⅛	9 0 0	Apr, Oct	1⅞	1⅞
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	68 —73	5 9 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅛—3⅞	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100 —102	4 18 0	June, Dec	..	..
St.	15/0	†Anglo-American	59 —61	5 19 0	F,My,Ag,N	..	..
St.	30/0	†Do. Preferred	101 —102	5 18 0	F,My,Ag,N	102	101
St.	25/0	Do. Deferred	18 —18½	6 15 6	F,My,Ag,N	18⅛	..
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	86 —88	4 11 0	Jn.Ap.Jy.O	88⅛	86½
10	6/0	Cuba Submarine Ord.	8⅞—9⅛	6 6 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	17⅛—18½	5 10 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3⅛—3⅜	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7⅞—8⅛	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	†Direct United States Cable	13½—14	6 1 0	Ja,Ap,Jy,O	13⅜	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 18 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	135½—138½	5 1 6	Ja,My,Jy,O	138½	136½
St.	17/6	Do. 3½ per Cent. Pref. Stock	86 —88	4 0 6	Ja,My,Jy,O	87½	86½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 15 6	May, Nov	103½	..
St.	2/6	Eastern Extension	12⅞—13⅛	5 2 6	Ja, Ap, Jy, O	13⅛	12⅞
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub. Debs	101½—103⅜	3 17 0	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 78	31⅛—32½	5 18 0	Jan, July	32½	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 8 0	June, Dec	..	..
..	12/6	Indo-European	54⅛—56⅛	5 15 9	May, Nov	56⅜	54½
100	$1½	Mackay Companies Common	92 —94	4 15 9	Ja,Ap,Jy,O	..	..
100	$1	Dc. Preference	78 —82	4 17 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛—¼	..	April	3⅜	3⅜
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	98 —100	4 0 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 14 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	⅛—¼	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8⅛—9½	6 10 0	May, Nov	..	..
0	20/0	Do. 6% 2nd Pref.	8⅛—9½	6 10 0	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	100⅛—102⅛	4 17 6	Jan, July	..	..
10	3/0	Western Telegraph	13⅛—14	5 0 0	Mr,Jn,O,D	13⅛	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	..	..
..	4%	†Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	—	..	..
		Telephones.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	138 —141	5 13 6	..	..	..
...	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	103 —105	3 15 6	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99⅛—101⅛	4 18 6	Mar, Sept	101	..
5	3/0	Chili Telephone	8⅛—8⅝	4 15 3	August ..	..	..
1	0/7½	Monte Video Telephone Ord.	⅛—¼	7 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅛—¼	5 14 6	May, Nov	..	..
St.	6%	National Co. Pref. Stock	104 —105⅛	5 15 6	Feb, Aug	105	104⅛
St.	6%	Do. Def. Stock	124 —126	4 16 6	Feb, Aug	125⅛	124
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	101 —104	5 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —10⅛	5 10 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5⅞	4 12 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	97⅛—99⅛	3 10 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	98 —100	4 0 0	Jan, July	99	98
100	5%	New York Telephone Co. 30 yr. Bnds. Scrip	100⅛—101⅛	4 8 9	..	100⅛	100⅛
..	..	Oriental	1⅛—1⅜	5 6 9	April, Oct	1⅜	1⅛
..	..	Do. 6 per Cent. Cum. Pref.	1⅜—1⅝	4 11 0	April, Oct	..	..
..	..	Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	100 —102	4 8 0	Jan, July	100	..
5	3/0	United River Plate	7⅛—7⅜	5 9 0	July	7⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 9 0	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.	103 —105	4 5 6	Jan, July	..	..
		Financial, Investment, &c.					
		Elec. & Gen. Investment 6% Cum. Pref.	2⅞—3⅛	8 18 0	Jan, July	..	..
		Globe Telegraph & Trust	10½—11	5 9 0	Sp,DcMrJu	10⅛	10⅛
		Do. 6 per Cent. Pref.	13⅛—13⅝	4 8 0	Sp,DcMrJu	13⅜	13⅛
		†Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅛	5 7 0	April, Oct	4⅛	4⅛
		Do. 5% Cum. 2nd Pref.	4⅛—4⅛	5 5 6	Jan, July	4⅛	..
		Do. 4% Deb. Stock	90½—92	4 7 0	June, Dec	91½	90½
		Do. 4½% Deb. Stock	95 —98	4 12 0	..	97	96½
		Auckland Elec. Trams. 5% Deb. (red.)	105 —107	4 13 6	Jan, July	..	..
		Brisbane Electric Trams. Invest. Ord	7 —7⅛	4 2 0	May	..	..
		Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 3 6	May, Nov	..	..
		Do. 4½ per Cent. Db. Prov. Certs.	101 —104	4 6 6	Jan, July	102⅛	..
		British Columbia El.. Rly. Df. Ord.	145 —150	5 8 0	Mar, Sept	106	106
		Do. Pref. Ord. Stock	121 —125	4 16 0	May, Nov	123⅛	121
		Do. 5% Cum. Perp. Pref. Stock	108 —110	4 11 0	Jan, July	109⅛	108½
		†Do. 4½ per Cent. 1st Mort. Debs.	101 —103	4 7 6	April, Oct	..	..
		Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
		†Do. 4½% Perp. Con. Deb. St.	101½—103½	4 1 6	..	102⅛	102
		Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	100	99⅛
		Buenos Ayres Port & City Tram, 1st Mt Deb. Stock	94 —97	6 2 6	Feb, Aug	..	..
		Calcutta Tramways (1 to 137,610)	4⅛—4⅛	4 2 6	Mar, Sept	..	..
		Do. 5 per Cent. Cum. Pref.	4⅛—5	5 0 0	Jan, July	4⅛	..
		Do. 4½% 1st Deb. Stock (red)	99 —102	4 8 0	Jan, July	100	..
		Cape Electric Tram Shares	⅛—¼	..	..	..	..
		City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅞	4 8 3	F,My,A,N	5⅛	5⅛
		Do. 4 per Cent. Deb. Stock	97 —100	4 0 0	June, Dec	..	..
		Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 —99	5 1 0	May, Nov	..	..
		Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
		Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94⅛—97⅛	5 2 6	Feb, Aug	..	..
		Kalgoorlie Elec. Trams Sh.	⅛—⅜	..	..	..	..
		Do. 5 per Cent. "A" Deb. Stock	90 —93	5 2 0	Jan, July	..	..
		Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	..	..
		Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
		Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
		Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
		Manila Elec. Ry. $1,000 Gold Bonds	95 —97	5 2 6	Feb, Aug	..	..
		†Mexico Trams Co. Com. St.	129 —131	4 15 0	..	..	..
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	94⅛—95⅛	5 3 9	..	95⅛	95
		Do. 6% 50 yr. Mort. Bds.	98⅛—99⅛	6 0 6	..	99⅛	99
		Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	102⅛	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 6	..	103⅛	..
		Perth Elec. Trams Ord.	⅛—¼	5 14 0	May	..	..
		Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
		Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅞	5 2 6	..	..	..
		Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	..	..
		†Ric Janeiro Tram, Lt. & P. Co.	95 —97	4 2 6	..	97⅛	95⅛
		Do. 30 yr. Gold Bnds.	97⅛—98⅛	5 1 0	..	98⅛	97⅛
		Do. 50 yr. Mt. Bnds	85⅛—85⅞	5 15 3	..	87⅛	86
		Sao Paulo Tramway, Light & Power Co. $100 Stock	149 —151	5 6 6	..	..	..
		Do. 5 per Cent. 1st Mt. $500 Db.	103 —105	4 5 0	June, Dec	103⅛	102⅛
		Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	100⅛	..
		Colonial and Foreign Electricity Supply, &c.					
		Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅞	5 2 0	Mar, Sept	..	..
		Bombay E.S. & T. 6% Cm. Pf.	10⅛—11	5 9 0	..	10⅛	..
		Do. 4½ per Cent. Deb. Stk. (red)	95 —97	4 12 6	Jan, July	..	..
		Do. 5 per Cent. 2nd Mort. Deb. Stock	96 —98	4 18 0	..	..	..
		Calcutta Elec. Supply Ord.	6⅛—6⅜	5 18 9	April, Oct	..	..
		Canadian Gen. Elec. Co. Com. St.	116 —119	6 1 0	..	118⅞	116⅛
		Do. 7% Cm. Pf. Stock	118 —121	5 19 0	..	120	118⅛
		Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
		Elect. Development Co. of Ontario	82 —85	5 16 0	..	83	..
		Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
		Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
		†Do. 6 per Cent. Cum. Pref.	⅛—¼	8 0 0	April, Oct	..	..
		Madras E. S. Corp. Ord.	2⅛—2⅞	..	..	..	..
		Melbourne E. S. Co. 6% Cum. Pref.	33 —38	..	..	..	..
		Do. 5% 1st Mortg. Deb. Stock	92 —94	5 6 9	..	93⅛	93
		Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	81⅛—85⅛%	5 16 6	..	85⅛	85
		†Mexican Lt. & Power Co. Com. St.	79 —81	4 18 0	..	81⅛	..
		Do. 5% 1st Mort. Gold Bnds.	89⅛—90⅞	5 9 0	..	90⅛	89⅜
		Montreal Lt. Ht. & Power Co. Cap. St.	137 —141	4 15 0	F,My,A,N	..	..
		River Plate Electricity Co. Ord.	1⅛—2⅛	3 18 6	April	2	1⅜
		Do. 6 per Cent. non-Cum. Pref.	1⅞—1⅞	4 18 0	May	..	..
		Do. 5 per Cent. Deb. Stock	103 —105	4 15 6	Jan, July	..	..
		Rosario Ele. Co. Ord.	8⅛—9	..	..	..	..
		Do. 6% Pref. (1-20,000)	6 —6⅛	4 12 0	April, Oct	..	..
		Do 2nd Pref.	8⅛—8⅞	6 14 6	..	..	..
		Shawinigan, Water & Power Co. Ca.	101⅛—103⅛	4 7 0	..	103⅛	102⅛
		Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	..	..
		Do. 4½ Per Con. Mt. Db. St.	101⅛—103⅛	4 7 0	..	102⅛	102⅛
		Toronto Power Co. 4½% Db. St.	101 —103	4 7 6	..	102	101⅛
		Victoria Falls Power Co. Pref. (1 to 808,000)	⅛—¼	5 14 0	Jan, July	⅛	..
		Do. (803,081 to 1,700,000)	⅛—¼	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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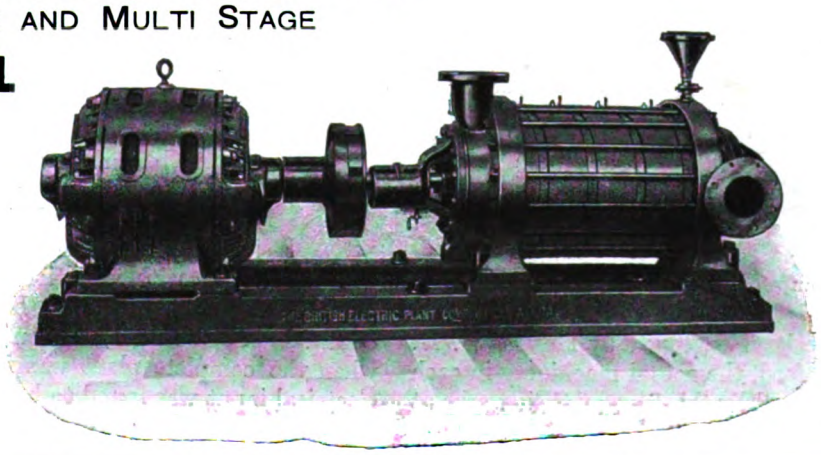

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Allen Electrically-driven Pumping Plants.

THE very varied uses to which pumps of the electrically-driven centrifugal type can be applied are well exemplified in the following instances, each of which is in its turn only typical of the large number of

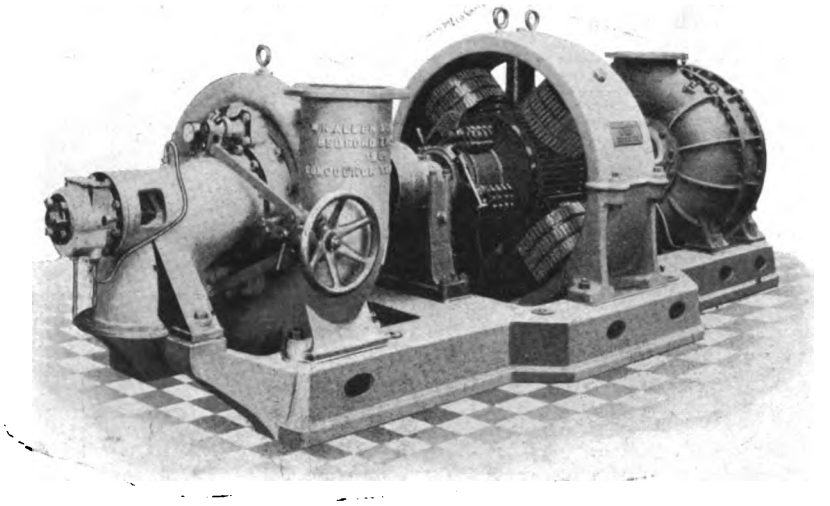

Fig. 1.—Pump for Newcastle Manor Sub-station.

installations which have been equipped by Messrs. W. H. Allen, Son & Co., of Bedford, the actual machinery in each case having been constructed by this firm at their works at Bedford. As is well known, their "Conqueror" centrifugal pumps for moderate lifts have held for many years a high reputation, and in the more recent development of turbine pumps for high lifts Messrs. Allen have devoted the results of a long experience of hydraulic machinery to the perfection of a type of high-lift pump which is, it is claimed second to none in its performance, and which, in the class of materials and workmanship employed, has few equals.

Circulating Pumps.—As an efficient and in every way suitable appliance for supplying the cooling water for condensing plant the centrifugal pump has a long-established reputation, and as the arrangements of all the various systems are now matters of common knowledge, it is unnecessary here to devote any space to them. An interesting variation, however, upon the usual plan which is applicable when the condensing plant is situated at a considerable height above the water supply level, the water returning to the original level has recently been carried out by this firm in a few instances. In such a case it is obvious that in the event of the total fall from the condenser being more than about 30 ft. the excess of potential energy of the water above this height would be entirely lost, and it is with the object of avoiding this loss that the present plant has been designed. The hydraulic plant consists of a two-stage turbine pump constructed throughout of special bronze, and coupled direct to a continuous-current motor and a water turbine of the Francis inward-flow type, also constructed throughout of bronze. This set was built for the Newcastle Corporation tramways, and is now at work in their Manor power station. The pump has to deliver 2,500 gallons per minute against a head of 120 ft. at 650 revs. per min., the plant being situated near the water supply level. The turbine receives the return water from the condenser under a head of about 100 ft., and is fitted with adjustable guide-blades to enable it to deal efficiently with variations in the quantity of water. The motor has a capacity of about 58 kw. at 500-550 volts, but on trial at the makers' works, when the complete plant was fully tested, the maximum electrical input was found to be only about 52 kw., the effi-

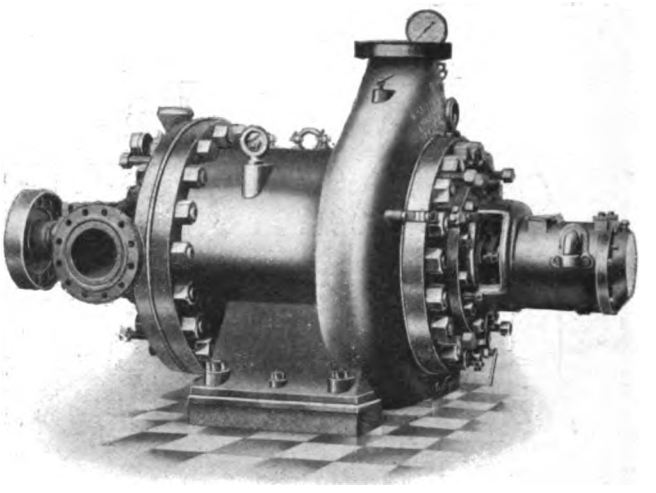

Fig. 2.—Allen Mine Pump.

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ciencies of turbine and pump being 79 per cent. and 75 per cent. respectively. The test results proved in the aggregate to be 11 per cent. better than the guarantee.

Dock Pumps.—The great advance in recent years in the application of electrical power in factories and dockyards now renders it possible for the heaviest work to be carried out by electrical power. In many cases a considerable saving in capital can be thereby effected. The problem of dry-dock pumping affords an excellent example of the application of electrical machinery in a dockyard where abundant electrical power is available. It is obvious that a large and

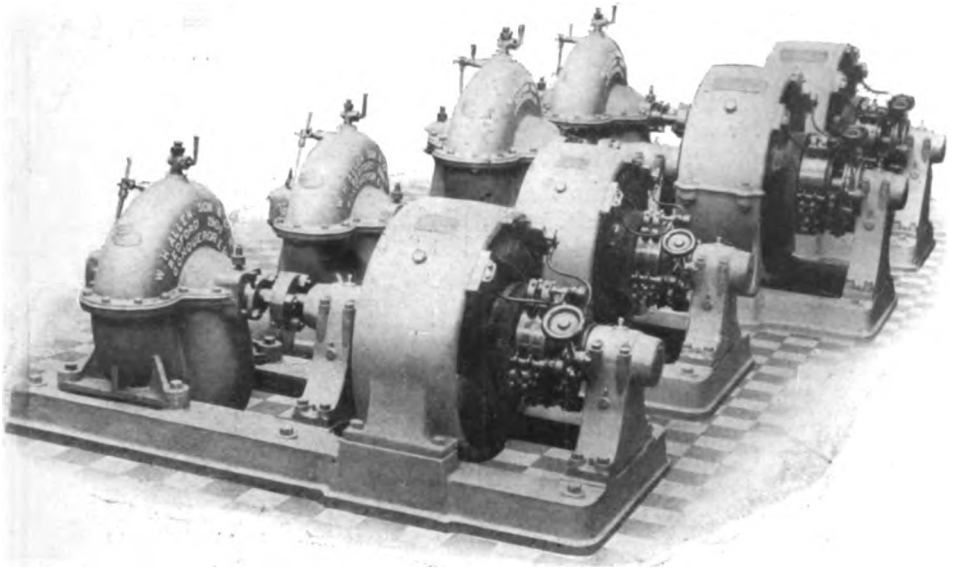

Fig. 3.—Sewage Pumps for Canterbury.

costly steam plant with all its attendant expenses of upkeep, &c., and which is only called upon to operate at very irregular intervals affords anything but an economical solution of the problem. The present instance of a powerful plant, which has been constructed and equipped by Messrs. Allen for a dockyard in the Far East, is a good example of this particular development. It consists chiefly of three of their twin-parallel centrifugal pumps, having suction and discharge branches 42 in. in diameter, and each coupled direct to a three-phase motor of 400 B.H.P. Each set is designed to discharge 24,000 tons of water per hour against a mean head of 22 ft. when running at 352-392 revs. per min. The motors are designed to develop 400 B.H.P. at the above speed when supplied with current at 60 periods and at 1,050 volts. These motors are also capable of developing an overload of 20 per cent. for one hour. In addition to these are two vertical-spindle electrically-driven drainage pumps, each having 12 in. branches and capable of delivering 2,500 gallons per minute against a 60 ft. head at 880 revs. per min. and absorbing 120 B.H.P. Priming of the main pumps is effected by a two-throw Allen-Edwards air pump, having barrels 10 in. in diameter with a stroke of 7 in. This is gear-driven by a 6 B.H.P. motor running at 1,150 revs. per min., the air-pump making 230 revs. per min. The motor works at 220 volts, receiving its current from a small oil-cooled transformer. The three main sluice-valves on the discharge branches of the main pumps are opened and closed by hydraulic pressure, which is supplied from an electrically-driven three-throw ram pump. Liquid starters are provided for the three main pumps, the drainage pumps and hydraulic pump motor. The whole plant is controlled from a switchboard having a raised platform in front and accessible by a stairway from the pump room floor.

Mining Pumps.—The easy adaptability of the turbine type of centrifugal pump to high lifts without any serious loss of efficiency, combined with its mechanical simplicity and compactness when driven direct by electrical power, as well as its great smoothness in running, renders this type

Fig. 4.—Electrically-driven Boiler Feed Pump.

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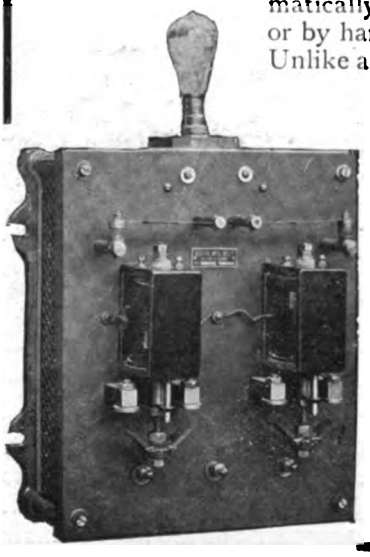
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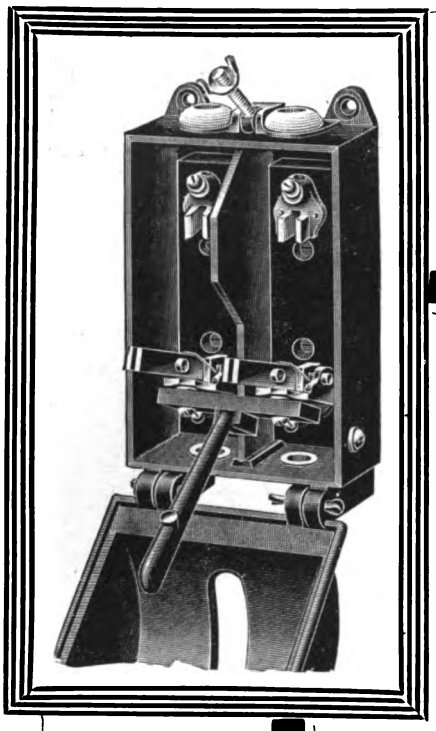

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of pump highly suitable for the work of mine pumping. One of the best examples of a thoroughly up-to-date plant of this kind is to be found in the case of two electrically-driven pumps which have recently been constructed by Messrs. Allen for a gold mining company abroad. Each pump has an output of 525 gallons per minute against a head of 1,450 ft. when running at a speed of 1,600 revs. per min. These pumps each have seven stages, and the considerable length of the pump, which is the consequence of the large number of stages combined with high speed of rotation, has necessitated special care being taken in the design of the rotary parts to ensure good balance and freedom from vibration. The casings of the pumps and the end covers, which are of cast iron, are necessarily of very substantial design to withstand the great pressure due to the head of water. The spindles are of nickel steel and are fitted with bronze liners where they pass through the glands. The discs and guide blades are also all constructed of special bronze, and the

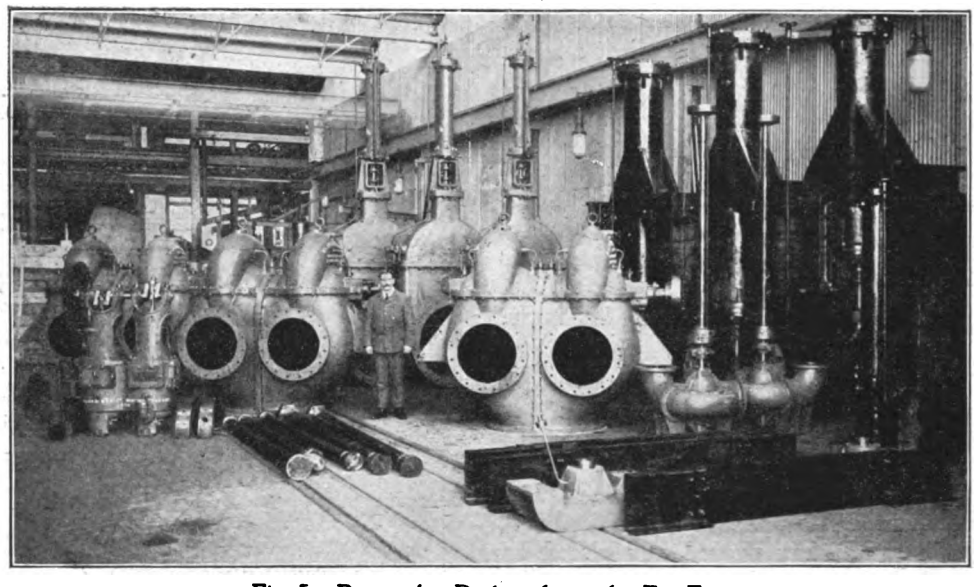

Fig. 5.—Pumps for Dockyard in the Far East.

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resultant end pressures on all the discs are automatically balanced by hydraulic pressure by means of a patented device. The motors are of the continuous-current high-speed type and are coupled direct through flexible couplings to the pump spindles. As the whole plant had to be lowered down a shaft of very limited section, the base-plates were each constructed in three pieces and bolted together on the site underground.

Boiler-feed Pumps.—As in the previous example, the suitability of the turbine pump of high efficiency for large heads has brought it into the field of boiler-feed pumping. In installations where a total quantity of 50 gallons per minute and upwards is required it is eminently suitable. Reciprocating pumps, if of the direct-driven type, consume a large amount of steam for the work done, the steam being often conveyed through a great length of small and inefficiently lagged piping, and reaching the pump more than half in the form of water. If gear-driven, plunger pumps are usually noisy in operation, expensive to instal and complicated, and special arrangements are necessary for a wide variation of speed in order to vary the quantity sufficiently, or a complicated gear for varying the stroke of the plungers becomes necessary. The turbine centrifugal pump, on the other hand, is silent in working, and delivers a continuous stream of water without any pulsations. Where floor space is limited it can be arranged with its spindle vertical, and it can run continuously with very little attention with a good efficiency over a wide range of loads. The pump illustrated is of the six-stage vertical-spindle type, and is designed to deliver 100 gallons of water per minute against a pressure of 210 lb. per square inch when running at 2,200 revs. per min. The usual automatic balancing device is employed, and the top bearing of the pump is also designed as a multi-collar thrust bearing to take the weight of the revolving parts when at rest and at very low speeds, and is fitted with automatic oil circulation. The electrical motor is situated vertically above the pump, and is coupled to it through a flexible coupling which cannot transmit any end thrusts. The weight of the electrical motor is carried on a special ball thrust bearing above the motor in a very accessible position, the remaining bearings being also of the ball pattern.

Vertical Spindle Pumps for the Dublin Graving Dock.

SOME interesting electrically-driven pumping sets have recently been built and installed by Messrs. Drysdale & Co., of Yoker, Glasgow, for the Dublin Port and Dock Board. The complete pumping installation consists of two main vertical spindle pumps having suction and delivery branches 30 in. in diameter, two vertical spindle drainage pumps having suction and delivery branches 6 in. in diameter, and one motor gear-driven vacuum pump for charging purposes. The centrifugal pumps are all of the side-cover type, and are supported on stools resting upon the stone floor of the wells. Each of the two wells contains one main pump and one drainage pump with the necessary valves, all the latter being worked from the engine room by means of spindles carried up through the floor. The bottom of each well is 28 ft. below the floor of the engine house, and thus only one 16 ft. length of intermediate shafting requires to be employed for coupling the pump to the motor. An illustration is given of one of the main pumps from which the main points of the construction can easily be gathered. The weight of the motor armature and vertical shaft is carried by the ball bearing on the top end of the motor. The vertical shaft is joined to the pump shaft by means of flexible coupling, while, to prevent any possibility of downward pressure occurring from some unforeseen cause and proving injurious to the impeller, a ball bearing is situated just above the pump. This bearing also forms one of the pump journals. The drainage pumps were arranged on the same system and have proved satisfactory in every way. Each main pump has a separate discharge pipe, but both of these pipes discharge into one main culvert which leads to the harbour basin outside the dock. The main pumps are self-charging right down to the point when the bottom of the dock is laid bare, that is, so long as the water in the sump is deep enough to cover the mouth of the suction pipe properly. As a safeguard, however, the motor gear-driven vacuum pump referred to above is installed for cases of emergency. This pump is of the single-throw plunger type and is driven through raw-hide gearing by a motor.

The electrical part of the installation was supplied by the Lancashire Dynamo & Motor Co. to Messrs. Drysdale's order. The motors for each main pump are of 300 B.H.P. capacity rating, and are of the shunt-wound semi-enclosed interpolar vertical spindle type, and are designed for working on voltages between 480 and 500, the range of speed being from 210 to 280 revs. per min. The motors for the small drainage pumps are each rated at 13 B.H.P. and are of the shunt-wound semi-enclosed vertical spindle type, having a speed range from 600 to 800 revs. per min. As before mentioned, the weight of the armature is carried by ball bearing on the top of the motor.

Each pump was guaranteed to pump out the dock in two hours, and the actual time taken on the trial run was 1 hour 35 minutes, or 25 minutes inside the guaranteed time. The pumps are of special design, such that a very large quantity of water could be discharged, the efficiency at the same time being kept at a very high point. The whole installation has been completely satisfactory in every way, and the combined efficiency of these pumping sets has been maintained at an exceptionally high standard, the plant being designed to meet the requirements of Mr. Purser Griffiths, M.Inst.C.E., the engineer of the Port and Dock Board of Dublin, under whose superintendence and to whose order the work has been carried out.

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B.E.P. Centrifugal Pumps.

AMONG the firms who have recently taken up the manufacture of centrifugal pumps, the British Electric Plant Co., of Alloa, N.B., have quickly made for themselves a prominent place, mainly due to the special system of balancing the impellers which they have developed. The device in its application is protected by a patent, and its principal claim for recognition is its simplicity, for it forms a radical departure from existing types of centrifugal and turbine pumps, permitting the entire absence of special provisions for neutralising end-thrust.

A large number of B.E.P. pumps have already been installed, and in the majority of these cases they are driven by the same firm's alternating-current or special high-speed direct-current machines. Within 6 miles of the works there are as many pumps at work, at three of the pits belonging to the Alloa Coal Co. and at each of these pits the generating plant was also supplied by the B.E.P. Co.; Fig. 1 showing one of the 475 k.v.a. 50-cycle 650-volt alternators there in use. The speed selected for the pumps was 1,450 revs. per min., squirrel-cage motors being used to drive them. At two of the pits two pumping sets in series are being used to unwater a dook, the arrangement being that one set is fixed in a permanent position, the other following the water as it recedes. As a consequence, the parts requiring to be handled when the portable set is taking up a new position are considerably lighter than they would be if the entire lift were done with one set. In one case the stationary set (Fig. 3) is capable of delivering 600 gallons per minute against a total head of 405 ft. For supplying the water to this pump, a semi-portable equipment of 500 gallons capacity is used, and is capable of dealing with a total head of 350 ft., the design being similar to that of the stationary set.

At the second of the above-mentioned pits, the quantity of water dealt with is 100 gallons per minute, the total head being 340 ft. Direct-current variable-speed B.E.P. motors, supplied from 440-volt direct-current generating plant at the surface, drive the pumps, and the sets are identical in every respect. As the pit is classed as being "fiery," the motors are of the totally-enclosed type, similar to that shown in Fig. 4, and are fitted with radiating ribs to assist cooling. Their capacity is 10 B.H.P. when running between the speeds of 1,350 and 1,450 revs. per min.

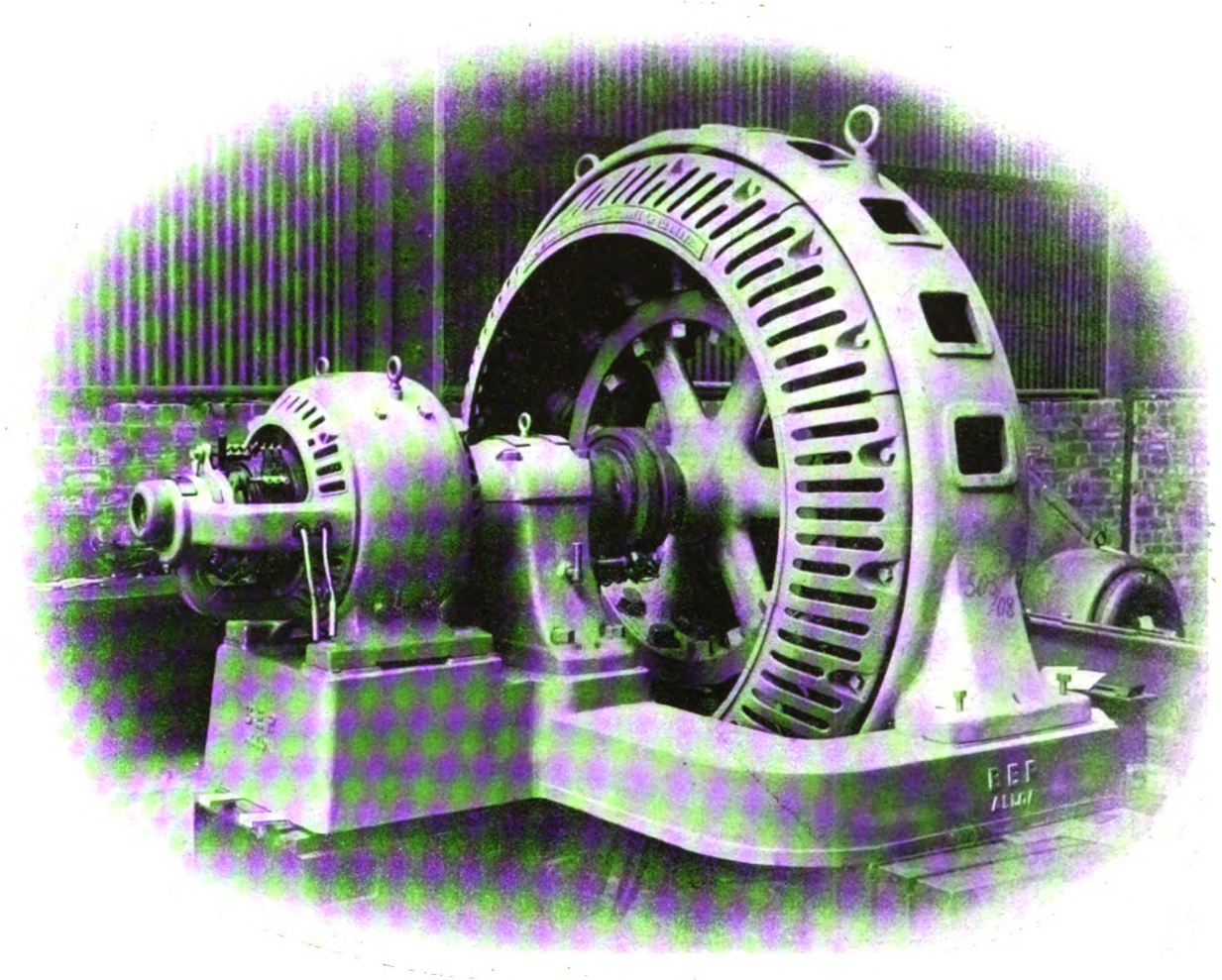

Fig. 1.—B.E.P. 475 k.v.a. Alternator.

Another interesting set recently supplied by the B.E.P. Co. is also in use for dook working, the pump again being driven by a variable-speed direct-current 45 B.H.P. motor fitted with interpoles. The pump is designed to deal with a constant quantity of 400 gallons per minute against a total head increasing from zero to a maximum of 200 ft. The units are mounted together on a channel and angle-iron bogie for operation on a gradient of 1 in 6, the entire control and starting apparatus being carried on a frame at the motor end of the set. A special point in connection with dook pumping by means of such a set is a device which the B.E.P. Co. employ when the work to be done consists of

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unwatering at a constant rate against a varying head. When the limits of the head are not too wide, the conditions can be satisfactorily met by the use of variable-speed motors when a d.c. supply is available, the speed being adjusted by means of a shunt regulator to enable the pump to discharge the desired quantity without having to throttle. When, however, the variation in the head entails an exceptionally heavy direct-current motor to give the full output at the lowest speed, or when the supply is alternating current, resort has to be made to the device already referred to, which consists in leaving out certain of the impellers and fitting so-called "dummy" chambers. By so doing the

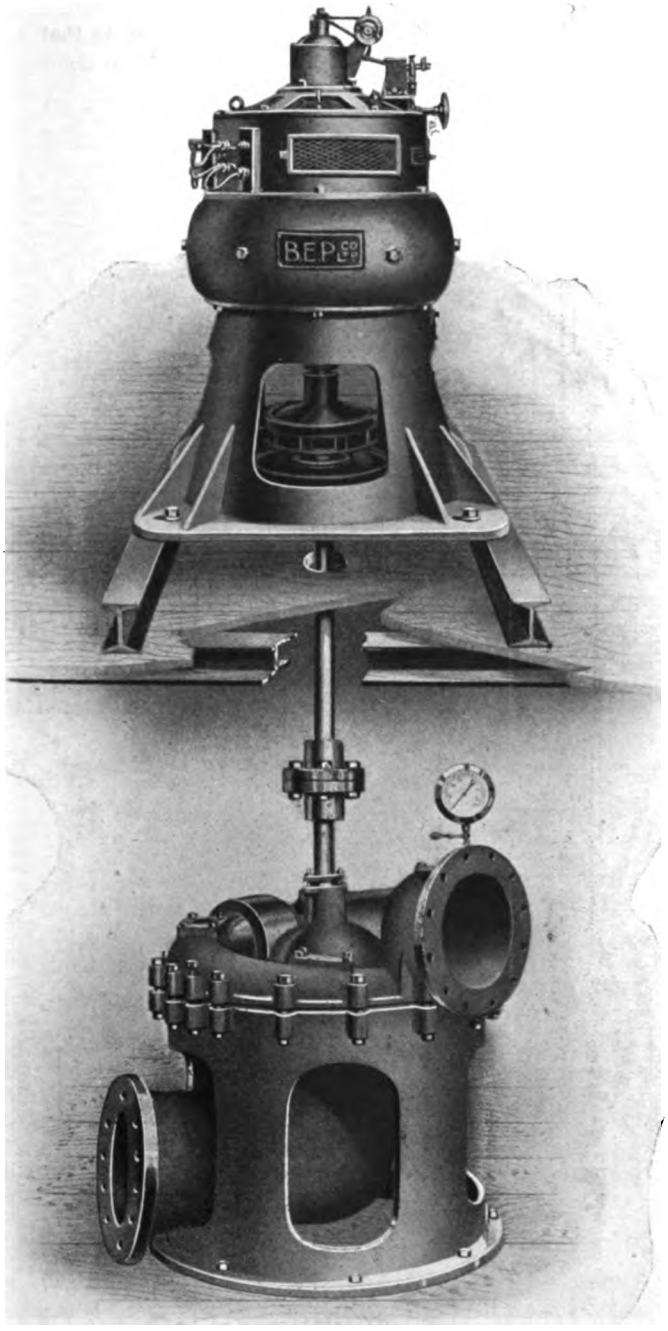

Fig. 2.—Vertical Pumping Set for use on Tideway.

total head given by the pump is reduced in the same proportion as the number of impellers removed to the original number, and as this also reduces in the same proportion the power required at normal quantity there is a considerable saving in the total expenditure of energy which would have been entailed if the pump were arranged to give a constant head, and in consequence had to be controlled by a valve to limit the discharge. Further, by this device the discharge may be considerably increased without overloading the motor, and the unwatering, when such is the operation, may

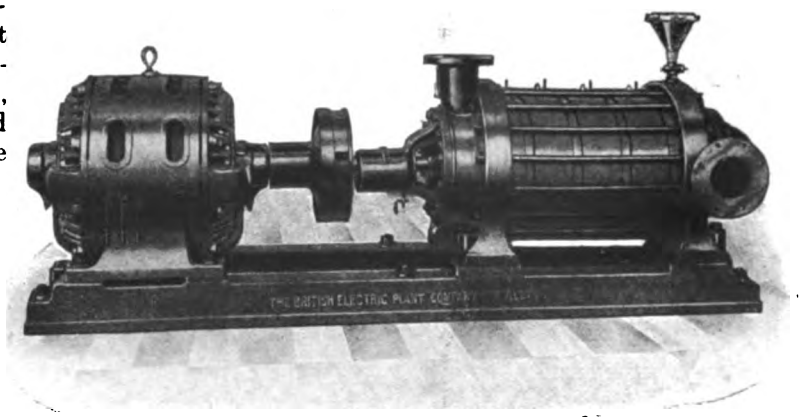

Fig. 3.—B.E.P. Stationary Pumping Set.

therefore be done in a much shorter time than would otherwise have been the case. The B.E.P. Co. have used the system with direct and alternating-current sets with complete success.

We also illustrate (Fig. 2) a vertical pumping set to which considerable interest attaches, as it is arranged to supply a constant quantity of water for condensing purposes from a tidal river, the tidal variation being 14 ft. To enable this to be done economically the speed has to be automatically adjusted by the varying water level, this being accomplished

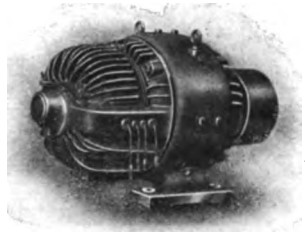

Fig. 4.—Motor for Fiery Mine.

by means of a float system gearing with the shunt regulator of the variable-speed motor. The pump duty is 5,000 gallons per minute against a total head varying from 11 ft. to 25 ft., the motor being of 58 B.H.P. capacity at speeds between 350 to 420 revs. per min.

A.C. Portable Drill.

AN interesting alternating-current portable drill is described in a recent issue of the "Electrical World." The motor is designed to work on a frequency of 60 and at a pressure of either 110 or 220 volts. An indicating control switch for starting and stopping is so placed that it can be operated by the right hand without the hold on the machine being released. Hand hole furnish an easy means of access to the commutator and brushes. The tool will take drills up to $\frac{3}{8}$ in. diameter, and weighs 21 lb. It is claimed that it will drill through soft iron plates and wood at a speed that should ensure its wide adoption in industrial work.

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ISSUED MONTHLY
"THE ELECTRICIAN"
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All communications should be addressed to the Editor, "The Electrician" Industrial Supplement, 1, 2 and 3, Salisbury Court, Fleet Street, London, E.C.

Copy for Text or Advertisement pages for next issue, publishing on **May 27th, 1910,** *should reach the above address by Tuesday,* **May 17th, 1910.**

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

The Progress of Electric Pumping.

In the INDUSTRIAL SUPPLEMENT of March 4, 1910, we pointed out how the development of the petrol-paraffin engine and the dynamo had gone hand in hand till both had reached commercially, at any rate, a state of perfection. Much the same similarity of progress is to be seen in the development of the pump and the electric motor. For while the old reciprocating pump driven by a Cornish beam engine was among the first of the applications of machinery, it was not until comparatively recent years, with the almost simultaneous introduction of the rotary pump and the motor that it began to make decided headway towards its present advanced state.

The reason for the welcome given to the newer state of things is not far to seek. The old type of pumping machinery, with its steam engine and slow moving parts, was practically confined to the ground surface and could not be introduced into the mines or other places it was desired to unwater. Further, such equipment was inefficient, owing to its slow speed and general ponderosity and took up a great deal of room.

General efforts were, therefore, made to design a pump which should better fulfil modern conditions, and this task was made easier by the increasing use of the electric motor for industrial work. The result of these endeavours was soon reflected in the output from makers' works of both rotary and reciprocating pumps, more compact, running at an increased speed, simpler in design, and, above all, suitable for direct coupling to the electric motor. Other results of this dual development are to be seen in the ease of erection, while the charge of the machinery can now be left to comparatively unskilled personnel.

The financial side of the question also showed the great advantages obtainable under the new régime. Much the same arguments can be applied with equal force in this case, and in the other directions in which the motor is being now employed. It is cheaper and more efficient to operate several pumping sets from one power station rather than to supply each pump with its own steam engines. It is easier and again more efficient to run cables down a mine shaft than a steam pipe. It is easier to run and maintain an electric-driven pumping plant in an out-of-the-way corner of a mine than to use a steam-driven set under similar conditions. It is, therefore, scarcely a matter for wonder that the development of the motor-driven plant should have been so rapid.

A point to notice in connection with electric mine pumping is that it is possible by the use of this machinery to work mines which would otherwise be unworkable. The steam-driven pump. for various reasons, could not cope with the flow of water, while the electrically-driven pump with its greater portability was able both to unwater the workings and keep them unwatered.

In the present issue of the INDUSTRIAL SUPPLEMENT we are able, through the kindness of numerous makers, to give some idea of the many ways in which the motor-driven pump is being driven at the present time. In sewage disposal works it is being extensively employed, Birmingham, Maidstone, Burslem and Salisbury being all cities where such a plant is installed, while examples of its application to the unwatering of mines, to fire service and irrigation, will be found in the columns of this issue. The last of these applications should be essentially of interest to the pumping engineer, for in many cases the motor cannot be successfully used owing to the absence of supply mains and other facilities for the supply of energy. There are cases, however, even here, where a large scheme makes the erection of a central power station and the employment of motors a commercial possibility. Examples of this class of work is to be found on the mains of the Northern Colorado Power Co., where an important load is being worked up in the pumping of water for irrigation purposes. The load thus obtained is almost ideal from the central station point of view as it is almost entirely of a summer character, and does not therefore interfere with the winter lighting peak. The motors range from 30 H.P. capacity downward, and are supplied from a 44,000 three-phase line through sub-stations, in which the pressure is stepped down to 2,300 volts for use on the motors. The various farmers concerned are taking up the question with avidity, and much good to both these classes of the population will doubtless result.

We cannot do better than recommend our readers to peruse the various articles in this SUPPLEMENT. They will learn therefrom how much work has been done in the application of the motor to pumping work, and the great strides that may be expected in the future.

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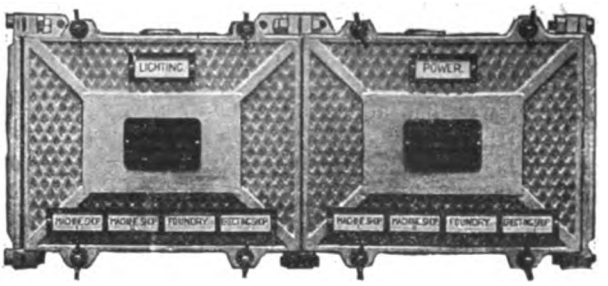

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The Electric Lighting of Small Towns.

Electric lighting in large towns such as Manchester, Liverpool and Birmingham has now made such progress that any further development will take place along well-defined lines. Flame arc lamps will be used for lighting the main streets, high candle-power metal filament lamps for the smaller streets, and a combination of these two with ordinary candle-power metal filament or carbon lamps for lighting shops, factories and private dwellings. Seeing that this is the case, and that, owing to the extended adoption of the motor car, more and more people are living, though not simultaneously, in both the country and the town, it is at first sight rather surprising to find that more has not been done towards the introduction of the benefits of the electric light into the country or country towns with, say, less than 10,000 inhabitants. Large houses have their own generating plant, as has been amply shown in the last two issues of the INDUSTRIAL SUPPLEMENT, but for the inhabitants of these districts at large there is generally nothing for it but to use, oil lamps or expensive and low quality gas, when some form of artificial light becomes necessary. This state of things is not primarily due to any lack of enterprise on the part of electrical promoters, for it is practically an impossibility to obtain any financial success when such small areas are dealt with under a Provisional Order. The order itself is expensive to obtain, and, when obtained, underground mains and other fitments unnecessary in such areas have generally to be used, to say nothing of other restrictions to cheap supply. The final result is, therefore, that small towns, with few exceptions, are not at present rejoicing in the benefits of the electric light.

Steps are, however, now being taken to remedy this state of things. A company known as the Rural Electricity Supply Co. has just come into being. This company propose to operate without Parliamentary powers, and instead to make their own arrangements with the local authorities concerned. Cheapness combined with safety will be their watchword, overhead mains will be used wherever possible, and great hopes are placed on the efficiency of the metal filament lamp. The erection of a station necessary to supply the communities that are to be dealt with by the Rural Electricity Supply Co. must be governed by economical ideas, so that it seems oil or gas engines would be the natural prime mover to employ, while as the supply would not be continuously available the advantages of this type of plant would become even more obvious.

We wish the new undertaking every success, but at the same time we pray its supporters to order their steps carefully at first, and to choose with discrimination the areas in which they open their first stations. It will be a case of going slowly for some time, but given good finance, low capital outlay, and above all sound management, there is no reason why the scheme should not be a success. There are still plenty of areas where electric lighting is at present unknown, and the new undertaking should do much towards altering a state of things which ought not in these enlightened days to exist. We shall, therefore, hope shortly to see great development in rural electricity supply.

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Electrically-driven Pumps and Water Supply.

CONSIDERABLE attention is being given at the present time to electric motor driven pumps for use in connection with the public water supply on main or domestic service, for auxiliary district service at special pressures, and for fire service. Electricity as a motive power has added advantages when operating the rotary or turbine type of pump.

In such plants attention must be called to the remarkably small space occupied and to the insignificant cost of foundations and building compared with a gas or steam reciprocating engine driven pumping station. In fact an electric pump-house becomes a "sub-station" requiring only occasional attendance. Many instances may be found where such plants are now running on both day and night service, and totally unattended except for inspection a few times a week. Frequently, such plants can be self regulated and the supply maintained independent of any adjustment of speed of the plant. On fire service such plants can almost be instantaneously available for action at any time without waiting for the boilers to be stoked up or the engines to be started, while skilled attendance is necessary. In country or small towns with steam operated pumping stations the fire brigade may get to a fire some time before the waterworks can give the requisite supply. With an electric service danger from such a delay disappears. Further, where variable speed motor operation is installed a special fire pressure on the mains can be instantly available if the mains are suitable.

With a pumping station operated from a central electric power station long hour pumping lowers both the running and the first cost of the plant, whereas with a steam or gas engine self-contained pumping station long hour pumping increases the running cost, although the hydraulic friction losses would be reduced on a long hour supply. In many cases long hour running means smaller pump horse-power hours for the same volume pumped than for short hour running.

With an electric pumping plant for water supply service such as that made by the Rees Roturbo Mfg. Co., of Wolverhampton, the electric motor, it is claimed, cannot be overloaded by the pump from variation of pressure or increase of volume, while as the public demand increases the plant adjusts itself to an increase of volume with a slight reduction in head. Owing to the patent revolving pressure drum employed in this type of pump the delivery is absolutely uniform without tremor, thus dispensing with the necessity for relief valves and avoiding water hammer shocks and consequent joint weakening.

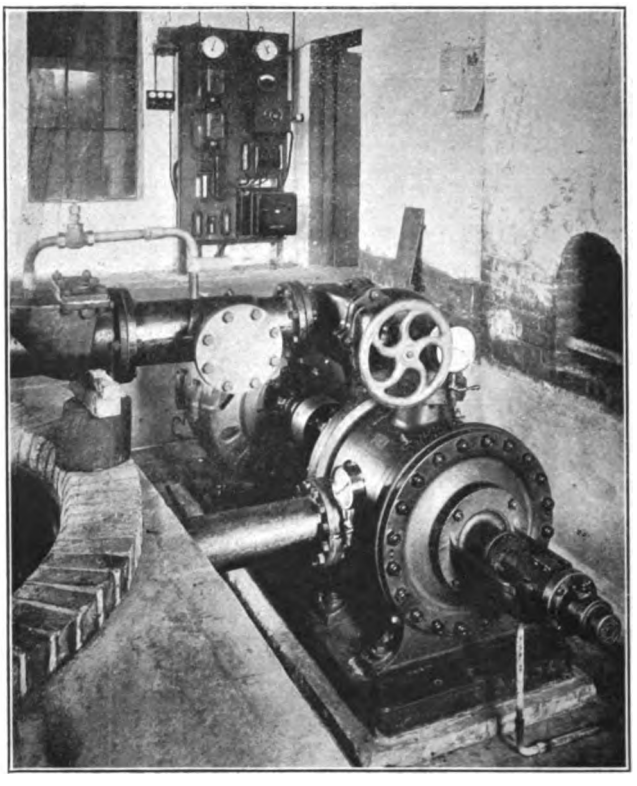

Fig. 1.—Newbury Pumping Station.

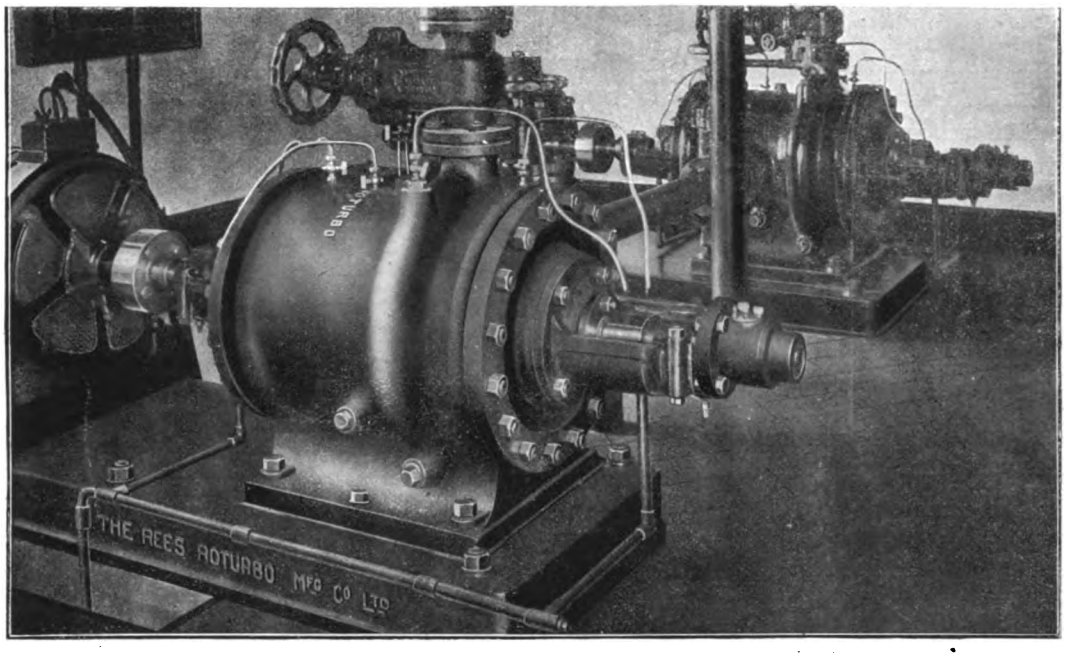

Fig. 2.—Wolverhampton Pumping Station.

A typical country town supply is that at Newbury, Berkshire (Fig. 1), where the water company at first installed one of these equipments as a standby, taking their supply from the local electric supply company. This arrangement was found advantageous from other points of view to such an extent that the town is now regularly supplied from this source. Another motor pump is also to be laid down for duty in an outlying district. The plant in question is capable of delivering 10,000 to 30,000 gallons per hour at pressures between 80 and 50 lb. per square inch. Fig. 2 shows an electrically driven pump installed by the Wolverhampton Waterworks committee to the specification of the engineer Mr. E. A. B. Woodward.

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This sub-station at Short Heath, on the outskirts of Wolverhampton, takes its energy supply from the Midland Electric Supply Corpn, the function of the pumps being to provide the requisite pressure for supplying the township of Essington, which is situated at the extreme end of the water area at an altitude which the service reservoir cannot command. The pressure on the inlet side of the pump varies from zero to 40 lb. per square inch, and from 100 to 170 lb. per square inch on the outlet side, according to the time of day and the demand. The pumps have worked day and night without a hitch since January 1909, the station being generally locked up except for an occasional inspection. The old steam plant required two attendants, one for day and one for night, with an occasional labourer for boiler cleaning. The present installation only requires an occasional visit from the local inspector to change over and see to the lubrication. Prior to this installation, the inhabitants were dissatisfied with the intermittent and insufficient supply afforded, and complaints were numerous.

Sewage Disposal Plant at Maidstone. . . . .

SOME time ago the Corporation of Maidstone decided to replace their old sewage disposal plant by an up-to-date installation with electrically-driven pumps, and entrusted Siemens Brothers Dynamo Works Limited. with the execution of the complete installation of the pumping plant. The purpose served by this plant is to pump the crude sewage from the low level at Maidstone to the filter beds. To this end the sewage first passes, on its way to the pump well, through several screens in series, which detain large matter, such as rags, pieces of wood, &c. It is then

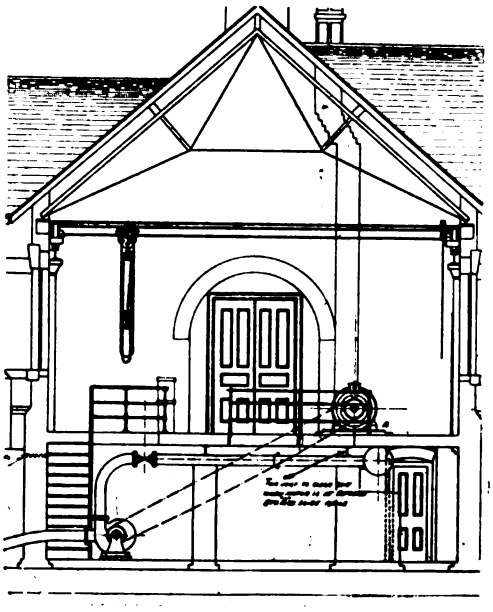

Fig. 1.—End Elevation of Maidstone Pumping Station.

raised by pumps drawing from the above well and delivered into a 24 in. pipe which carries the sewage to the filter beds situated at Aylesford, some 2½ miles below Maidstone, where it is purified, the clean water being returned to the

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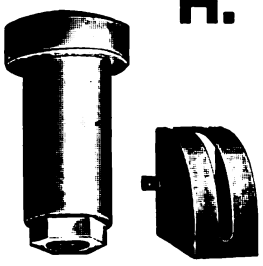

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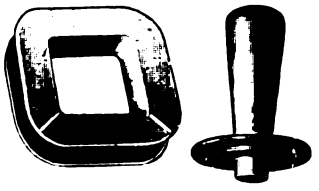

river. Ordinarily, the material treated is simply crude sewage, and this is dealt with by four 7 in. pumps, but in rainy weather the sewage is diluted with rain water, which

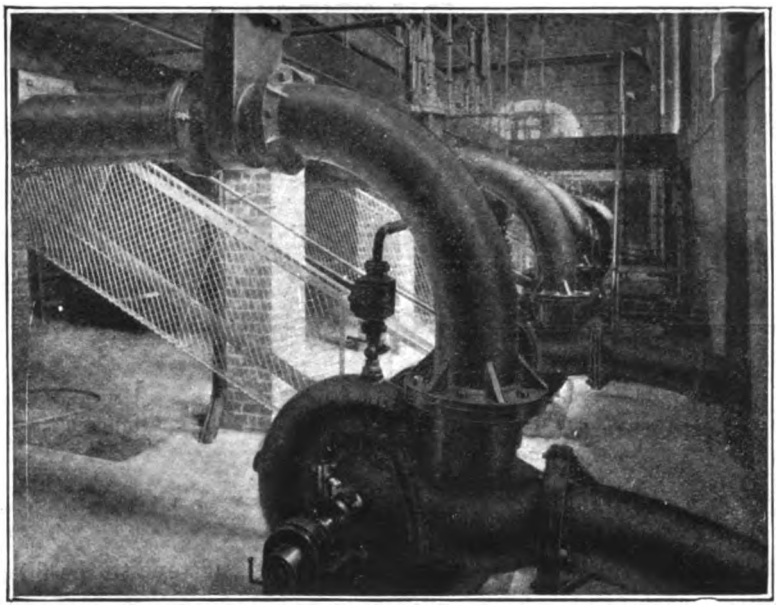

Fig. 2.—The Pumps at Maidstone.

greatly increases its volume, and the above pumps are then assisted by three larger ones of 9 in. diameter, which discharge on to the storm water filter beds situated close at hand and built on the river banks.

The screens are installed in a separate house near to the pumping station. They are lowered through openings in the floor, and each screen is provided at its lower end with a broad ledge on which the material which cannot pass through the screen is deposited. From time to time the screen is hoisted until the ledge is on a level with the floor, and the deposits removed. The raising of the screens is performed with the aid of a small travelling crane which is operated by a Siemens motor. The span of the crane is 19 ft. 9 in. between rail centres, and the lifting capacity is 2 tons. The travelling and traversing motions are operated from floor level. The lifting speed of this crane with a load of 2 tons is 20 ft. per minute.

Fig. 3 shows the general arrangement of motors and pumps, &c., in the pumping station. The motors are fixed to the concrete floor and drive the pumps in the basement by belts. The pumps are primed by two small charging sets, each consisting of a small centrifugal pump driven by a 7 B.H.P. motor running at 1,000 revs. per min. The water is circulated through an ejector by a closed system of pipes, which creates a vacuum above the sewage pumps and in consequence sewage is drawn up. After the pumps have thus been charged the main driving motors are started up. The arrangement of the piping between the two charging pumps and the sewage pumps is such as to allow either ejector to charge any of the pumps, or both ejectors to work together to shorten the time of charging. Each of the four centrifugal crude sewage pumps is capable of delivering 150 cubic ft. of sewage per minute against a total head of about 31½ ft. when running at 800 revs. per min. This total lift includes the loss of head due to friction. The three storm water pumps are capable of delivering 225 cubic ft. of sewage per minute against a total head, including friction, of about 21 ft. Each of the seven pumps is driven by a Siemens ventilated shunt motor with commutation poles, having an output of 20 B.H.P. at a normal speed of 750 revs. per min. The speed can be increased by a switchboard type field rheostat up to a maximum of 825 revs. per min. Current is obtained from the Maidstone Corporation supply mains, the voltage being 2×230 volts. The sewage pump motors are connected across the outers, while the two small charging motors mentioned above are connected between the inner and one of the outers. The motors are started up by Siemens protected type starters fitted with over-

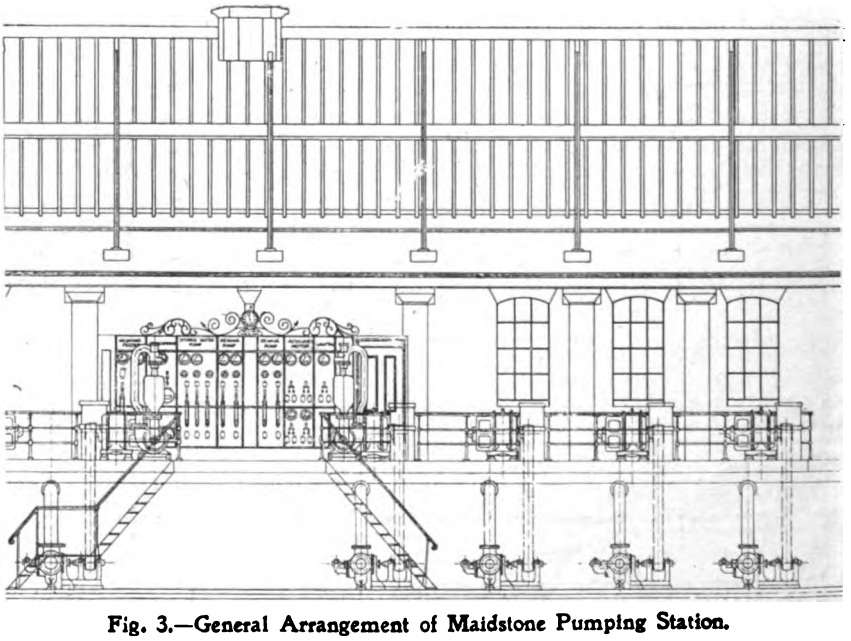

Fig. 3.—General Arrangement of Maidstone Pumping Station.

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load and no-voltage releases. They are fixed to the railings near to their respective motors, as will be seen from Fig. 4. The switchboard is of slate, and consists of the following panels: One feeder panel for two incoming feeders, one integrating panel, one storm water panel for three motors, one sewage pump panel for four motors, one panel for the small charging motors, and one lighting panel for two 230 volt lighting circuits. The panels are fitted with all necessary control and measuring instruments, including main switches, voltmeters, ammeters, watt-hour meters, &c.

Fig 4.—The Switchgear at Maidstone Pumping Station.

The hand-operated travelling crane in the pump house has a lifting capacity of 2 tons and a span of 24 ft. 10 in. between rail centres. To provide for the fire service and general water supply to the station, there is installed in the screen house a 2 in. centrifugal pump driven by a 5 B.H.P. motor. This pump has a capacity of 80 gallons per minute against a head of 62 ft. The plant has now, we understand, been running for several months with entire satisfaction.

Oerlikon Portable Electric Hand Drilling Machines.

THE Maschinenfabrik Oerlikon, whose London offices are at Oswaldestre House, 34, Norfolk-street, Strand, where the British, Irish and Colonial department is under the management of Mr. G. Wüthrich, have recently issued very complete illustrated descriptive price lists of the firm's specialities in portable electrically-driven hand drilling machines.

From the range of apparatus shown in these lists it is evident that the firm have given great attention to the requirements of the trades which use such drills. The drills are of very neat design, and the spindle of the machines is directly driven by an electric motor. The hand drilling machines (without speed reduction), when equipped with two-phase and three-phase motors, are built in two sizes, fitted with motors of $\frac{1}{16}$ H.P. and $\frac{1}{8}$ H.P. respectively, and are specially adapted for drilling holes of from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. diameter in iron, the weights of the drills being 11 lb. to 19 lb. respectively. The direct-current hand drilling machines are equipped with motors of $\frac{1}{8}$ B.H.P. and have a weight of 22 lb. They are suitable for drilling holes up to $\frac{3}{8}$ in. diameter in iron and up to $1\frac{1}{2}$ in. diameter in white or hardwood. The machines can also be equipped with single-phase motors

Hand drilling machines with a single speed reduction are specially built to drill holes, say, from $\frac{3}{8}$ in. to $\frac{3}{4}$ in. diameter in iron. The speed of the motor is reduced by means of a simple cased-in gear. The drills can either be equipped with a breast plate or with a screw and hand feed wheel; the breast plate is easily removable. The machines are equipped either with ordinary fixed handles or with tubular handles. In the machines fitted with ordinary fixed handles the current can be cut off by means of the right-hand side handle, whilst those with exchangeable tubular handles have the

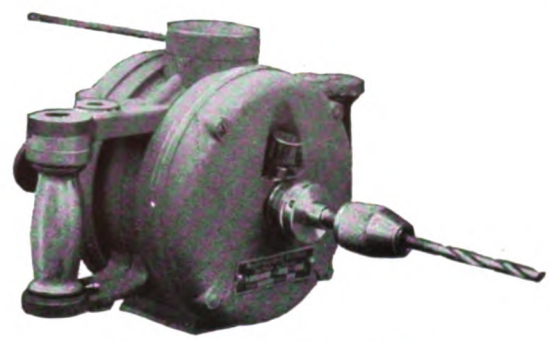

Fig. 1.—Oerlikon Electric Drill.

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Agents for Scotland: Messrs. W. B. & J. Bain, 65, Waterloo St., Glasgow.

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current circuit completed by means of a tumbler switch. The drill spindle is furnished, as a rule, with a Morse cone (No. 2), so that ordinary drills may be used. In Figs. 1 and 2 are illustrated typical Oerlikon drilling equipment.

In many industries, where a great variety of holes have to be drilled in soft or hard metal, it is necessary for the satisfactory execution of these duties to employ drills with different drill speeds, and to meet these demands the Oerlikon Co. supply their universal hand drilling machines with three different speed steps, the latter obtainable by means of three mechanical speed reduction gears cased into the shell of the machine, and operated by means of a simple lever. The machines are suitable for drilling holes from $\frac{1}{8}$ in. to $\frac{3}{4}$ in. diameter in iron, and of considerably larger diameters in softer metals or white and hardwood. The speeds of the drill spindle are as follows: With direct-current motor,

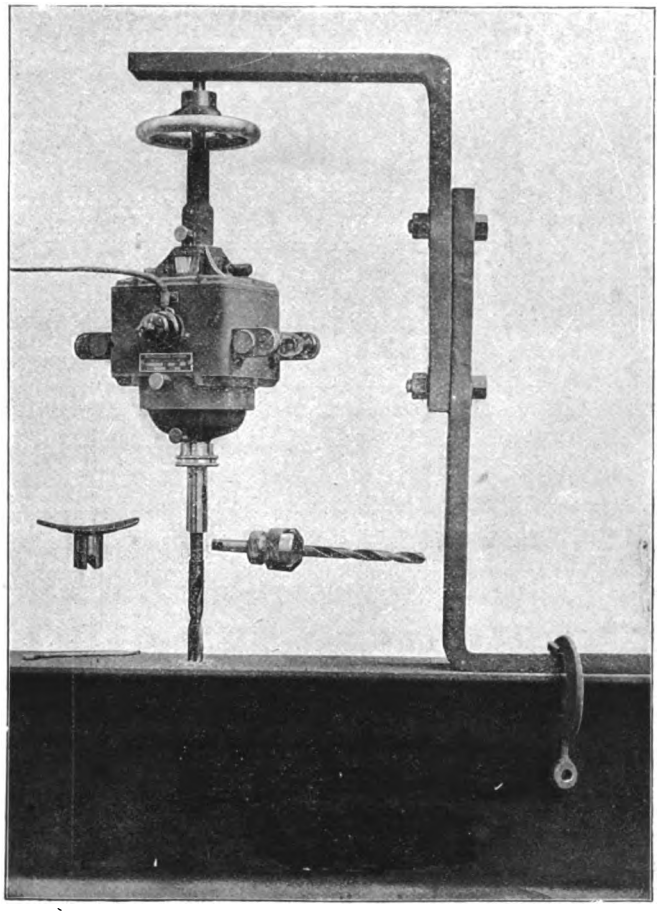

Fig. 2.—Oerlikon Drill at Work.

850, 650 and 350 revs. per min.; with two or three-phase motors, 870, 520, 330 revs. per min.

These drilling machines, with three different speed steps, are also adapted for fixing to a standard with movable work table. In this form they can be regard as portable quick drilling machines, independent of all belt driving, gearing, &c. The standard or column is made of cast steel, and is carried in a clamp bearing on the base of the work table, readily movable in all directions. The table has two T grooves for securing the work, the vertical movement of the work table being actuated by means of a rack and hand lever. The diameter of the work table is 12 in., the maximum height between head and work table $8\frac{3}{4}$ in., the maximum lift of the table 4 in., the vertical movement of the standard or column 6 in., the distance between the centre of the stand and the centre of spindle 10 in., and the weight of standard and table about 175 lb.

The "Hatfield" Pump.

A PUMP is a many-sided piece of apparatus. It can be used, considering water as the sole fluid in question, for water supply, for fire protection, for pressure augmenting, for irrigation, for spraying, for drainage and for boiler-feed purposes. If other fluids be taken into consideration its uses are just as many and varied. For certain special purposes particular types of pump are best suited, while, on the other hand, some types of pump seem specially suited for practically every kind of work. In this latter class may certainly be placed the "Hatfield" pump, made by Messrs. Merryweather & Sons, of Greenwich. It has besides the advantage to intending users of having been tried in practice under widely varying conditions, but with constant success.

The principle of the "Hatfield" pump is the following: Three pump barrels are arranged symmetrically round the motor shaft. These barrels form part of a single casting in which are also placed the valve chambers and passages. Each pump piston is of comparatively large diameter, though the stroke is short. The pump is, therefore, specially suitable for direct coupling to a motor, as it can be run at high speeds. The valves used are of indiarubber, and are of ample area though small lift. A bye-pass is fitted to facilitate starting.

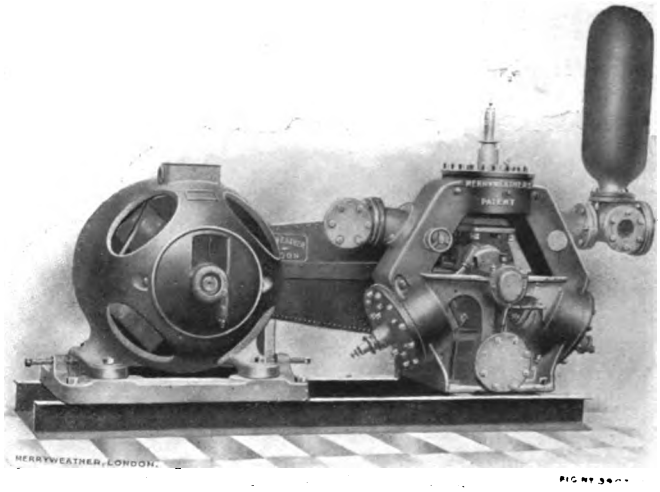

Fig 1.—Electrically-driven "Hatfield" Pump.

Turning now to the applications of such a pump, its great simplicity makes it specially suitable for use in connection with the water supply to country houses or with the fire precautionary arrangements in buildings where a skilled fitter is not employed. Fig. 3 shows such a pump direct coupled to an electric motor, the combination being exceedingly neat and compact. The particular set illustrated was supplied by Messrs. Merryweather to an estate in Leicestershire for use in connection with both the domestic water supply and the fire protection arrangements. The pump is said to be silent in working, so that it can be placed and worked in the basement without annoyance to the neighbouring householders.

This type of pump finds a useful application at Messrs. W. H. Smith & Son's premises in Kingsway, where a novel fire service was carried out by Messrs. Merryweather. A "Hatfield" pump driven by a motor is placed in the basement and connected with a fire main system which extends throughout the building, the necessary hydrants and hose being fitted on each floor. The pump can be started auto-

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matically, and all that it is necessary to do on an outbreak of fire is to run out the hose at the nearest hydrant. The pump will thus be started, and a powerful jet can be played on the flames almost immediately.

Besides directly-coupled sets Messrs. Merryweather also supply the "Hatfield" pump driven by a motor through a silent chain. A combination of this kind, which was supplied to the Great Eastern Railway Co. for use in the fire protection of Parkeston Quay, Harwich, is shown in Fig. 1. The pump is of the patent "Hatfield" type, having three plungers arranged 120 deg. apart around a common crankshaft. No barrels are fitted, the gunmetal plungers working through packed glands directly in the valve chambers. This arrangement, it is claimed, gives a minimum clearance between the plungers and the valves, thus enabling the pump to be used on a deep lift. The plungers are $7\frac{1}{2}$ in. in diameter and the stroke is $5\frac{1}{2}$ in. Each plunger is fitted with a substantial tail-rod working through a stuffing box in the valve cover; solid grease screw-down lubricators are fixed at the extremities of these rods, the tail-rods, plungers, connecting rods and crank being drilled to give thorough lubrication. The crankshaft is, as usual, run in adjustable gunmetal bearings with long wearing surfaces and oil reservoirs, and the connecting rods are coupled to the plungers with large ball and socket joints. The pump is capable of delivering 500 gallons of water per minute when running at a speed of 220 revs. per min.

The pump is driven from an electric motor by means of a silent chain, $6\frac{1}{4}$ in. wide, enclosed in a dust-proof and oil-tight case. The electric motor is shunt-wound, of 52 B.H.P., and is provided with large ironclad switch and "fool-proof" starter. The pump and motor are mounted on a channel iron frame, while the motor is on slide rails, in order to allow of the tension on the driving chain being adjusted. The machine is designed to give a maximum pressure of 100 lb. per square inch at the pump. It is fixed at the quayside, and a connection is made from the delivery to a 6 in. cast-iron main, which is laid round the quay, and upon which hydrants are fixed at suitable intervals. In addition to this there is an independent connection for hose direct on the pump, for coping with fires in the immediate neighbourhood. The suction is taken from the river through a 6 in. cast-iron pipe about 60 ft. long, the lower end of this pipe being fitted with a foot valve and strainer. The maximum lift at low water is 24 ft. As may be seen from our illustration, the installation is very compact, considering the quantity of water delivered.

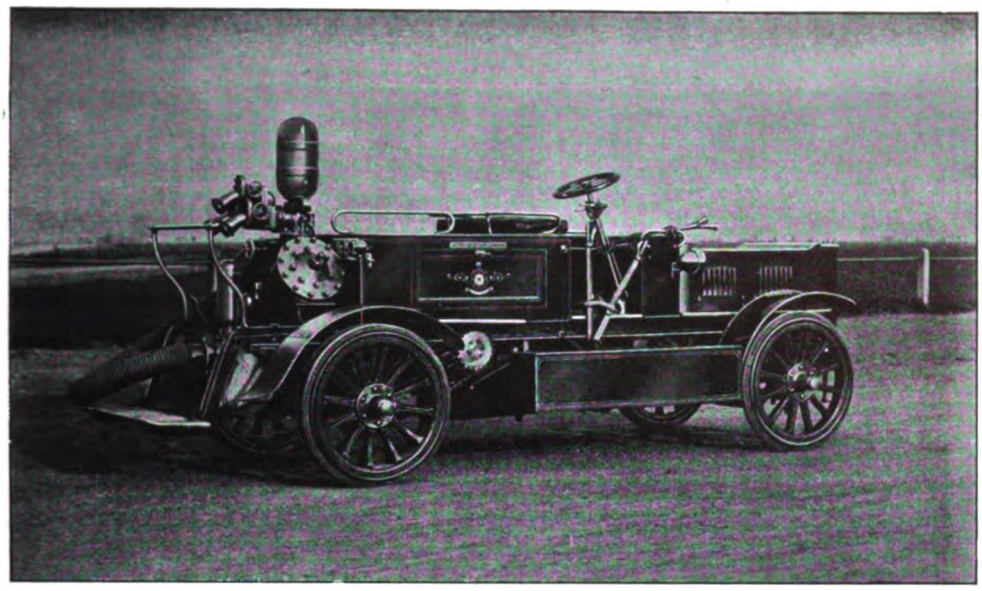

Fig. 2.—Merryweather Motor Fire Engine.

It is often rather an advantage from a domestic point of view to be able to alter the stroke of the pump. For instance, when running on short stroke a pump of this kind made by Messrs. Merryweather is capable of forcing water through long lines of pipes or to great heights, while when the stroke is made longer large quantities of water can be thrown with great force on the fire. The variation in stroke is effected by means of a sliding eccentric, provided with internal gearing for adjusting the eccentric relative to the crankshaft, thus altering the amount of stroke. A hand wheel is provided for the purpose of adjusting the stroke, which can be done gradually, thus enabling any desired quantity or pressure to be obtained.

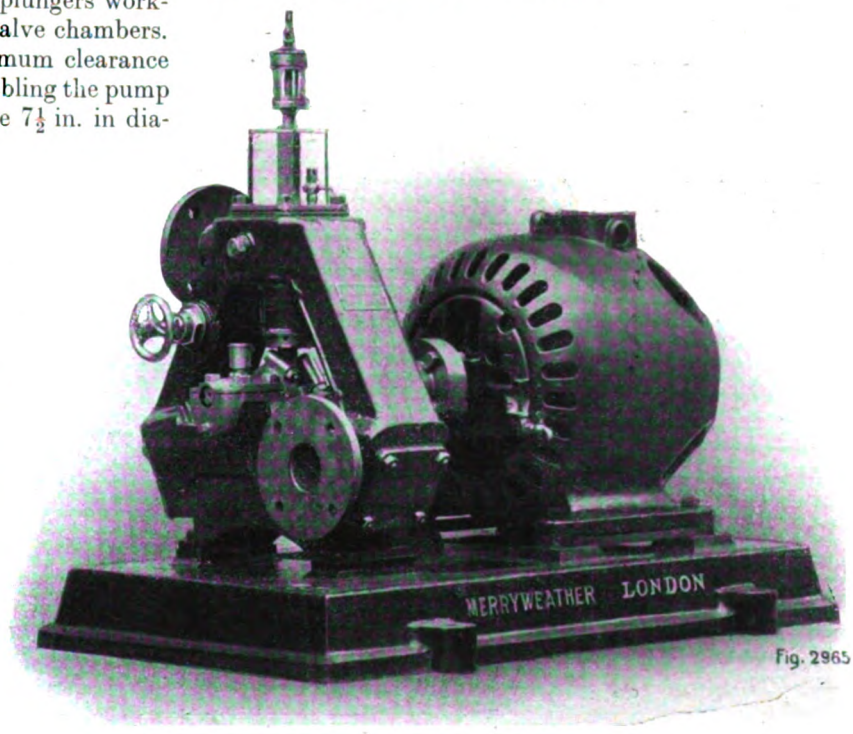

Fig. 3.—Merryweather Direct Coupled Motor Pump.

Another interesting piece of equipment is the electrically-driven pressure augmenter, of which an example is in use at Mr. Alfred de Rothschild's London house. The fire main is carried

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up to the roof, where a large tank is connected to it. This tank is filled from the waterworks' main through a ball valve, and a reflux valve is fitted to the fire-main pipe, so that when

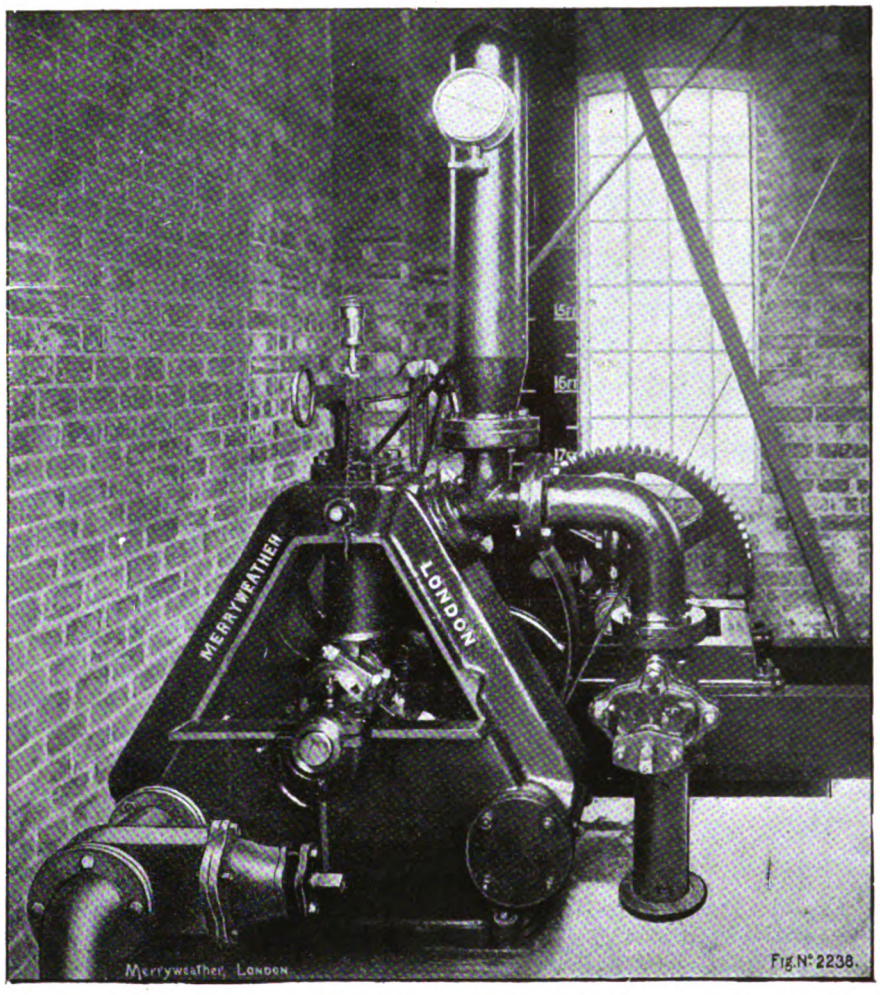

Fig. 4.—"Hatfield" Pump at Easton Lodge.

the pumping apparatus increases the pressure the water cannot return to the tank, but supplies the hydrants placed on each floor. The pump, which is of the "Hatfield" treble-barrel type, driven by an electric motor, is placed in the basement and takes suction from the roof tank. The starting switches and resistances are placed near by, and an ingenious float arrangement, working in a small tank placed over a large one on the roof, is used to operate the main switches. By this device there are no heavy cables carried through the building. When a fire occurs and the hydrant is opened the smaller tank empties into the fire main, the float falls and the pump automatically starts work. As soon as the hydrants are closed again and the tanks fill up, the float rises and the pump stops. A relief valve with the delivery into the smaller tank is provided, so that no damage will occur to the fittings between the time the hydrants are closed and the pump ceases to run.

In what is said above we have endeavoured to give some examples of the ways in which the "Hatfield" pump may be employed to provide us with what are generally known as the "benefits of civilisation"—that is, with the things we should find it very inconvenient to do without. The "Hatfield" pump can, however, also be used for deep well work and other high lifts, while besides being fixed it can be made portable, and where water power is available it can, in turn be converted into a generator and used to drive farm machinery. Among the portable sets manufactured we may mention some very useful electrically-driven bilge pumps, which should find a wide application in dockyards for keeping vessels clear of water after launching and for clearing the compartments after testing. It would not, of course, be seemly to mention the name of Merryweather without referring to their well-known fire engines whose pumps certainly come under the heading of portable. These pumps are carried on boats and road vehicles, and with the introduction of the motor car opportunity has been taken to use the petrol engine both for working the pump and driving the car. Such an equipment, which is called the "Hatfield" motor fire engine, is shown in Fig. 2. This engine was constructed by Messrs. Merryweather for the Rochdale Fire Brigade, and was the first machine of its kind to be put into service in England. It is fitted with a 50 H.P. four-cylinder petrol motor, and this engine propels the apparatus, and also drives a treble-barrel "Hatfield" pump, capable of delivering 450 gallons of water per minute. The speed on the road is from 20 to 30 miles an hour, and the pump can be brought into service instantly on arrival at a fire. At the official tests at Rochdale the pumping and road-running capabilities of the machine were effectively demonstrated. Its climbing and braking powers were tested by a trip over Blackstone Edge, and a pumping display was afterwards given on the Cattle Market ground. Motor fire engines of this pattern have also been supplied to several other leading fire brigades, including London, for which two machines are in actual service and two others nearing completion. It will therefore be seen that with their "Hatfield" pump Messrs. Merryweather cover a large field of application very satisfactorily.

Heenan & Froude Fans.

A FIRM who are justly noted for their fan work, and who may certainly be considered among the pioneers in this branch of engineering industry, are Messrs. Heenan & Froude, of Manchester. The apparatus turned out by them for ventilating and blowing include numerous types; low, medium and high-pressure fans are made, and, in fact, any operation requiring forced ventilation can be carried out by means of one at least of their fans. In this article we describe some standard equipments which have been laid down by Messrs. Heenan & Froude, and which show the class of work carried out by this firm.

The Heenan high-pressure fans are made in all sizes, from 12 in. to 28 in., and are capable of delivering from 400 to 4,000 cubic ft. of air a minute at pressures up to 24 in. water gauge. Such fans as these are specially designed for supplying air to cupolas, smiths' fires and other similar apparatus. The medium-pressure standard blast fans are turned out, varying in diameter from 9 in. to 28 in.

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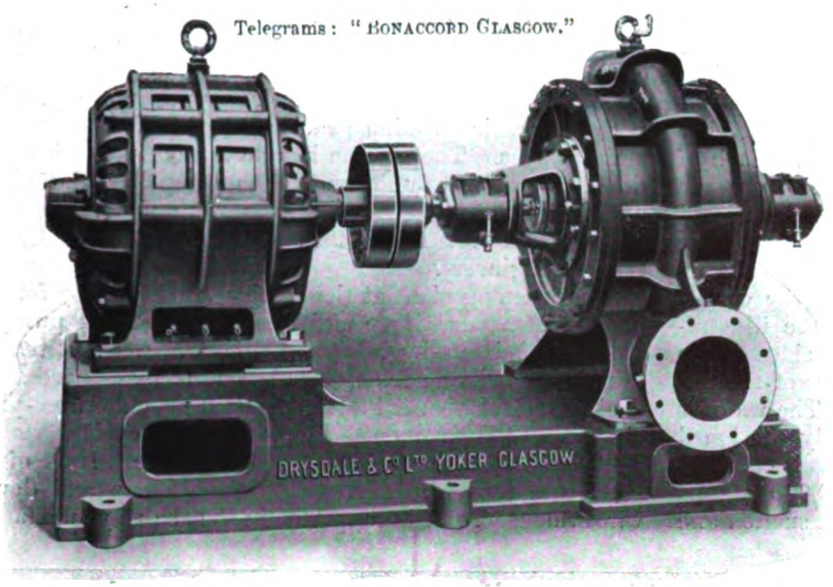

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and delivering 500 to 5,000 cubic ft. of air a minute at water gauges from 9 in. to 16 in. These fans are also specially adapted for smithy work, and as many as 40 fires can be supplied from one of them. A fan installation recently supplied to the Buxton electricity works is of interest; it is fitted in the engine room and is direct-coupled to a high-speed engine. This fan delivers 7,000 cubic ft. of air a minute. The engine which drives it is of the high-speed totally enclosed type, fitted with forced lubrication, and the destructor to which it supplies air is also Messrs. Heenan & Froude's special design. An electrically driven fan of this type, is used for supplying forced draught to another refuse destructor at the electricity works at Bury St. Edmunds. This fan supplies 5,000 cubic ft. of air a minute at a water gauge of 4 in. while another set of these fans have been supplied for ventilating the underground railways in London. Each of these fans is capable of delivering 18,000 cubic ft. of air a minute at a water gauge of 1·7 in. and is fitted in chambers in the roof of the tunnel and extract the air from the tunnel and afterwards force it through grids opening into the street above.

Some Examples of Mather and Platt Pumps.

THE adaptability of the electric motor to pumping work is, as we have endeavoured to show in another column, very great. With very little change in design, it can be used in a variety of places and is equally satisfactory in all of them. This point is well brought out in the following description of the ways in which Messrs. Mather & Platt's pumping sets have been employed.

Fig. 1.—Main Pumping House at Burslem Corporation Sewage Works.

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The first example is that of the low-lift turbine pumping plant supplying circulating water to the cooling towers at Salford Electricity Works. This cooling plant requires 750,000 gallons of water to be circulated per hour at full load, and this quantity is dealt with by the four Mather & Platt patent turbine pumps shown in Fig. 2. Each of these pumps is direct coupled to and mounted upon the same base as a direct-current steel-clad semi-enclosed motor made by the same firm, the couplings being of their special flexible type. The bodies of the pumps are of cast iron with specially arranged branches to suit the conditions of the piping. It will be noticed from the illustration that the suction branch divides into both sides of the pump allowing the water to enter on both sides of the impeller; thus the pump is in perfect balance. The water is discharged from the impeller into specially designed guides, allowing it to pass into the whirlpool chamber without shock. Each pump deals with 250,000 gallons per hour against a total head (including 10 ft. suction and

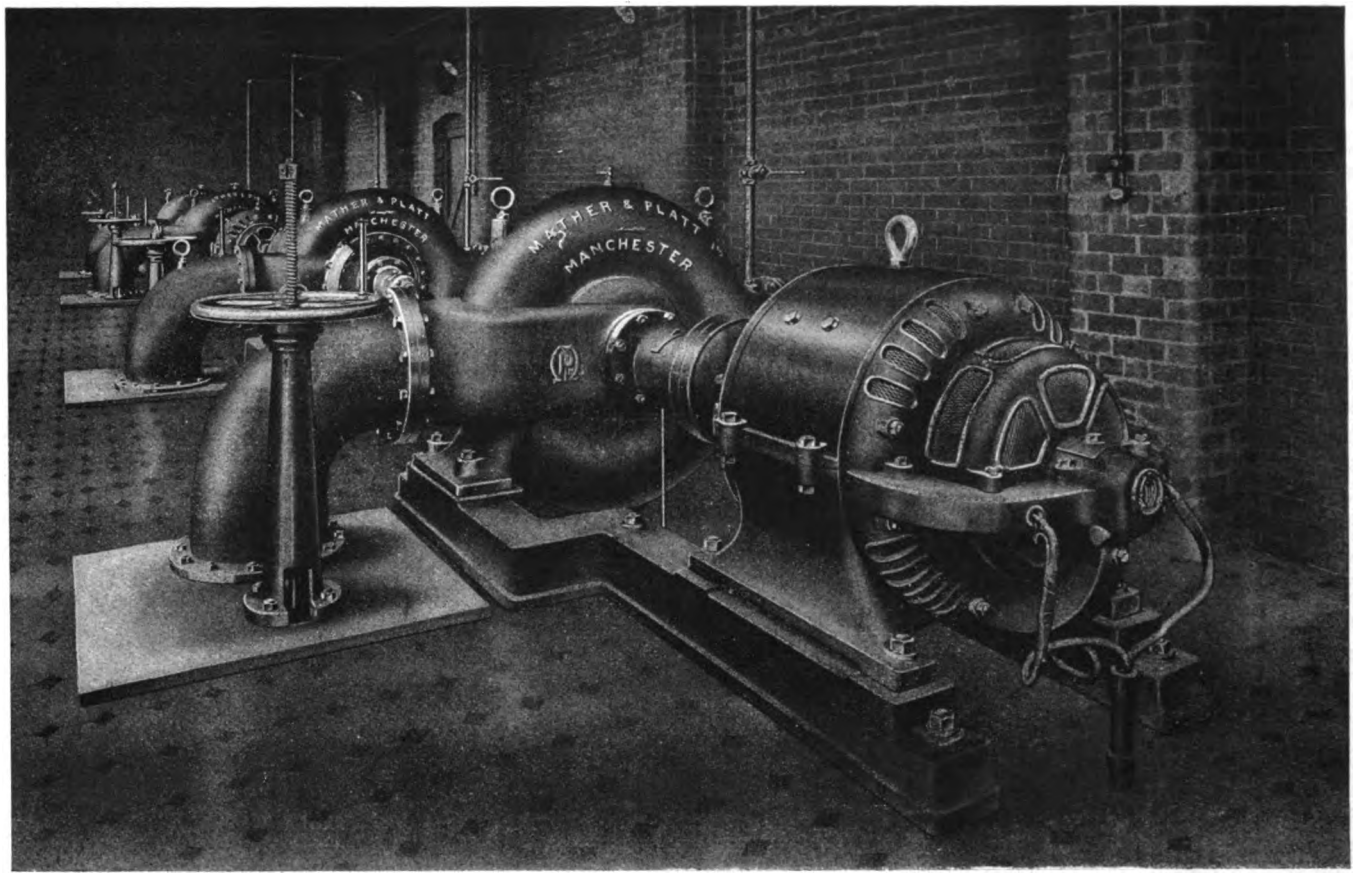

Fig. 2.—Mather & Platt Turbine Pumps at Salford Corporation Electricity Works.

calculated friction in piping) of 30 ft. when running at a speed of 450 to 500 revs. per min. Special bearings carried from the pump casing and quite independent, having no connection with the water, are provided. On both sides of the pump where the shaft passes through the casing water-sealed glands are provided to prevent air leakage.

The motors are each of 60 B.H.P. of the four-pole type compound-wound for 460 volts. Suitable starting pillars were supplied by the same firm, and the connecting cables from the starters to the motors are taken underground. A small low-lift pump of similar type, delivering about 33 gallons per minute against a head of 16 ft. running at a speed of 1,400 revs. per min., is provided for priming the main pumps.

Another example of this firm's work is the pumping plant at Falconbrooke Pumping Station, Battersea. This consists of three large Mather & Platt pumps each designed to deliver 13,333 gallons of storm water per minute to a height of 16 ft., the pumps being driven by large vertical gas engines to which they are direct coupled but mounted upon independent baseplates. The pumps are provided with brass air priming gear and hydraulically operated sluice valves. The suction handle to each pump is of the double type, entirely balancing the impeller and giving ample water-way. These pumps were manufactured to the usual strict requirements of the London County Council engineers.

The pumping plant at the Birchenwood Colliery forms a portion of a very large and complete electrical pumping plant carried out by Messrs. Mather & Platt. Steam is taken from existing Lancashire boilers to high-speed steam engines and Mather & Platt generators provide three-phase current at 2,600 volts at a frequency of 50 cycles.

The cable down the pits is of ample size. It is of the three-core type insulated with solid bitumen and double wire armoured. It is supported in the shaft by substantial cleats. In one shaft, known as the No. 18 pit, there is a pump of a capacity of 500 gallons per minute of the five chamber type which is driven by a squirrel cage motor of 130 B.H.P. capacity. This pump delivers against a total head from all causes of about 500 ft. Working in-bye is a small pump for dealing with water brought over from another pit and which has a capacity of 500 gallons per minute at a speed of 1450 revs. per min.; this is direct coupled to a three-phase motor of 27 B.H.P. In the shaft known as the No. 4 pit are three large pumps. The first of these deals with water brought over from another shaft and has a capacity of 400 gallons per minute and at a total head of 400 ft. 1450, revs. per min. The motor is interchangeable with the large motor already mentioned and is of 130 B.H.P. A special feature of this pump is that it is made entirely in a special quality of phosphor bronze to enable it to deal with the water which is exceedingly acid.

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The two further pumps in this pit are of a special type made by this firm for dealing with large heads. Each is of the six chamber type having a capacity of 800 gallons per minute against a total head of 900 ft. running at 1,475 revs. per min. The pumps are driven by motors of 375 B.H.P. with wound rotors. Suitable switchgear is provided for the whole of the above pumps. All this equipment was supplied and erected by Messrs. Mather & Platt. in accordance with the specification issued by the agent of the colliery.

The application of the electric motor to sewage pumping will be well illustrated by the equipment supplied by Messrs. Mather & Platt to the Burslem Corporation. This system includes, besides the usual tanks, distributing chambers, storm-water beds and filters, two interesting pumping plants situated respectively on the low and high levels. In the low-level pump house (Fig. 3) are six 3 in. diameter low-lift turbine pumps each direct coupled to a 1½ B.H.P. protected type shunt-wound steel-clad motor, wound for 440 volts and running at 1,290 revs. per min. with a 10 per cent. increase of speed. Complete starting and regulating switchgear is also provided. Each pump is capable of delivering 125 gallons per minute against a total head of 16 ft. including friction. The pumps are arranged in two groups of three pumps in each ; one group is used for lifting the low-level sewage from the low-level sump well, and discharges into the main high-level culvert prior to entering the screening and detritus tanks. Each pump has a 3 in. suction pipe fitted with gunmetal-faced sluice valve, and is coupled up direct to one common 6 in. suction pipe fitted with a screw-down foot valve. The delivery branches are coupled up to one common 6 in. delivery pipe. The second group is used for lifting the low-level storm water from the low-level sump well, and delivers into the main high-level feed carrier prior to its entering the storm beds. The piping is arranged in a similar manner to the low-level sets.

To each sump well is attached a special alarm and indicating apparatus, which operates with the flow, ringing a bell to call the attention of the man in charge, and at the same time indicating whether another pump is to be started up or one stopped. The priming of these pumps is affected by means of a feed pipe taken from the rising main of the main pumps.

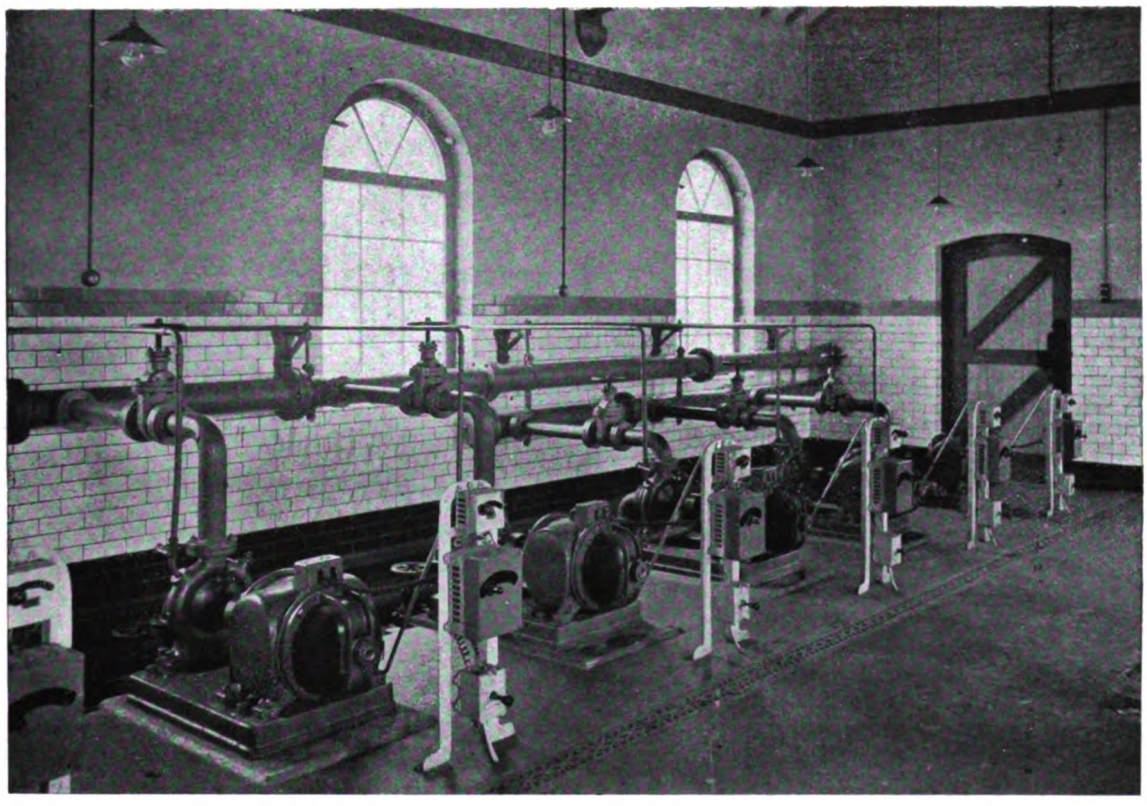

Fig. 3.—Electric Motors in Low-Level Pump House at Burslem Corporation Sewage Works.

The plant in the main pump house consists of: One 9 in. diameter patent turbine pump direct coupled to a 30 B.H.B. protected type shunt-wound steel-clad motor, wound for 440 volts and running at 775 revs. per min. with a 10 per cent. increase of speed, provided with complete starting and regulating switchgear. This pump delivers 1,390 gallons per minute against a total head of 35 ft. and has 9 in. diameter suction and delivery branches each fitted with a gunmetal-faced sluice valve. Two 6 in. diameter patent turbine pumps, each direct coupled to a 16½ B.H.P. protected type shunt-wound steel-clad motor with switchgear and wound for 440 volts, and running at 1,100 revs. and 10 per cent. increase of speed. Each pump delivers 695 gallons per minute against a total head of 35 ft. and

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has 6 in. diameter suction and delivery branches each with gunmetal-faced sluice valves. These three pumps are attached to the main suction pipe starting from 6 in. diameter and tapering to 15 in. diameter, where it then falls 12 ft. into the sump well and is here provided with a horizontal type foot valve. The delivery main also tapers from 6 in. diameter to 15 in. diameter, and then opens into a 21 in. diameter rising main. These pumps are primed from this rising main.

This pump house is also provided with special automatic alarm, indicating as previously described, and the plants run continuously throughout the 24 hours.

"Fielding" Oil Engines.

A POINT to which attention may be called in connection with a number of engines working on the Otto cycle is that they require no external heating once they are started, and therefore are raised to a level of those machines working on electrical ignition. In fact, their "self-containment" is even rather greater, for with electrical ignition accumulators may run down, while with a self-contained engine of the kind we are describing, as long as the engine is hot enough the charge will explode—the very fact of the explosion taking place causes the engine to remain hot enough.

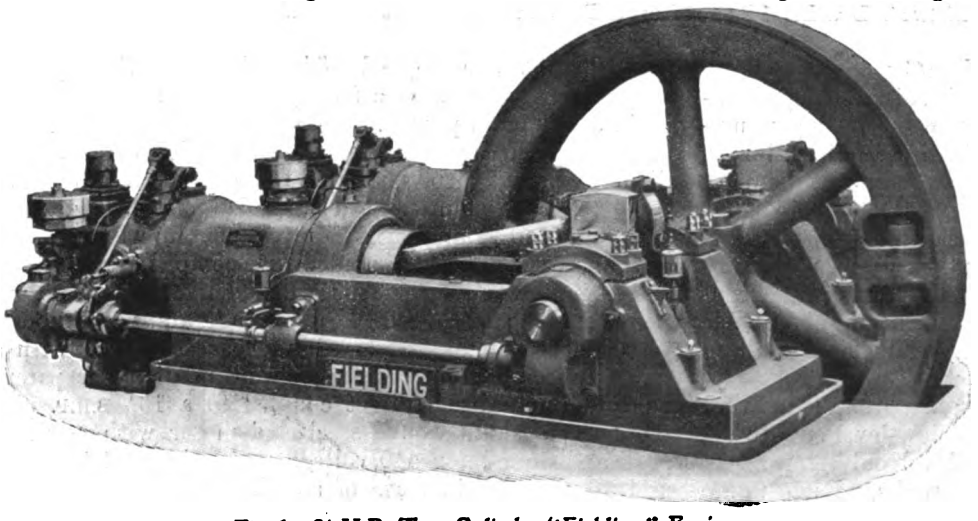

Fig. 1.—2½ H.P. Two-Cylinder "Fielding" Engine.

Messrs. Fielding & Platt, of Gloucester, have for some years been manufacturing the "Fielding" lampless oil engine, which works on the Otto principle. It is claimed for this engine that it fulfils all the requirements of a cheap, safe and handy motor, suitable for all purposes, and that in places where gas or steam cannot be conveniently used it will be found invaluable. It is economical in operation, the oil consumption being ⅛ pint per horse-power-hour, while, since it requires but little attention, the wages bill is reduced to a minimum.

Fig. 1 shows the standard 2½ H.P. "Fielding" engine, which finds a wide application in both country house and industrial work. Its capacity is sufficient to light a fair sized house, especially since the introduction of the metal filament lamp, while it can also be conveniently employed in driving, sawing, pulping or chaff-cutting machines. Similar standard engines having an output up to 60 H.P. are also made, while larger sizes can be obtained if desired.

It is claimed that 10 minutes' external heating is required to render the engine hot enough for starting and that the lamp can then be wholly removed. The speed is controlled on the "hit-and-miss" principle by means of a ball governor—a principle which is preferred by the makers to

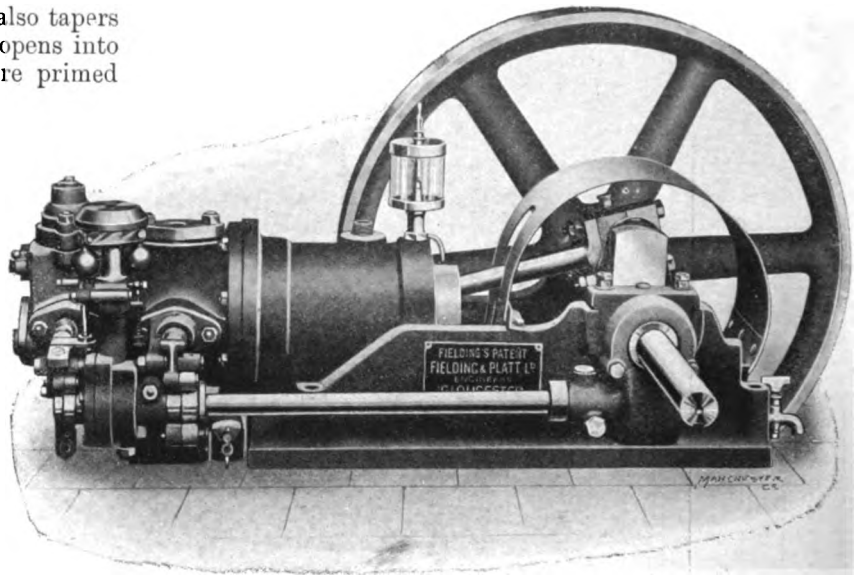

Fig. 2.—Portable Type "Fielding" Engine.

that of varying the force of the explosions, whilst it is found to be just as effective, the variation from no load to full load being only from 2 to 3 per cent. Once started, the engines are capable of being left all day long without attention.

"Fielding" engines of the one-cylinder type are made in 12 standard sizes, varying in output from 2½ H.P. to 60 H.P., while larger sizes up to 120 H.P. are fitted with two cylinders.

Turning to applications we illustrate in Fig. 2. a portable engine which, we understand, can easily be applied to the driving of farm machinery. This engine has a water-cooling tank. The illustration (Fig. 2) shows the latest type of portable oil engine, with water-cooling tank fixed underneath, which has sufficient capacity to run all day. The oil tank also contains sufficient for a day's run. The wheels are of

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specially large diameter, of wrought iron, made to "track," and very suitable for rough travelling. Driving pulleys can be fixed on either side of shaft to suit convenience of driving. It can be worked in all weathers, as after starting there is no lamp to blow out.

These engines are gradually replacing portable steam engines for agricultural and other work, the economy in fuel and attendance being very considerable. They are made in four sizes, of 7½, 9½, 11½ and 16 B.H.P. capacity. The "Fielding" engine is, it is claimed, an ideal motor for this class of work, being light, easy of transport, and self-contained, while it carries sufficient oil for a full day's run. The engine, when once started up in the morning, after being oiled round, does not require the attendance of a man, but can be left running, which means a considerable saving.

Control of Electrically-driven Pumps.

THE constantly increasing use of the electrically-driven pump has been, is, and will be undoubtedly assisted by the present excellence and reliability of automatic electric motor control apparatus. The "Igranic" automatic motor control apparatus manufactured by Adams' Mfg. Co. of Bedford, has solved many problems connected with the control of pumping machinery, which otherwise would have presented great difficulties, more especially where remote control of the motor was essential. This firm make automatic controllers for the smallest to the largest sized pumps, for direct or alternating current motors, for all voltages and all types of pump. The usual starting set for direct-current pumps driven by a motor whose horse-power does not exceed 20 is shown on Fig. 1. This consists of a solenoid operated starter, having mounted on the same slate base a magnetically operated main switch: a single-pole float switch operates this set to start and stop the motor. When the water falls to a predetermined level the float switch is thrown over and makes an electrical circuit. This in turn causes the magnetic main switch to close, and the starter correctly starts the motor driving the pump; when the water reaches the desired level the float switch "throws back" and causes the magnetic main switch to open and so stop the motor. All current making and breaking is thus taken by the main switch, which has a powerful blowout, and will rupture the fiercest arc.

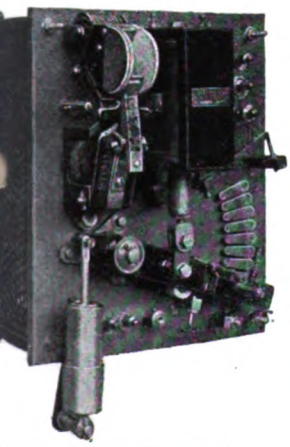

Fig. 1.—Adams Automatic Starter for Pumping Work.

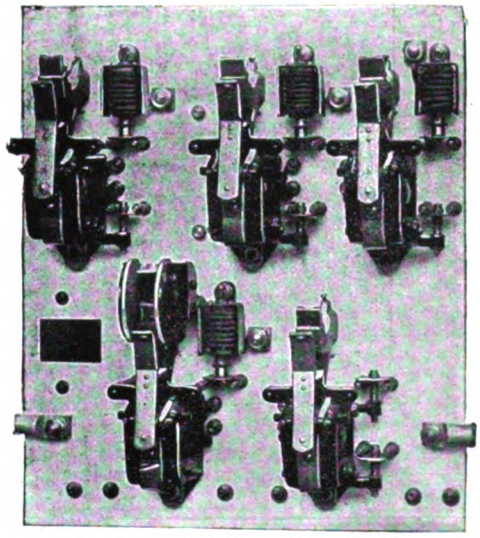

Fig. 2.—Adams Control Board for Motor Operation.

A form of starter for motors and pumps over 20 H.P. is shown on Fig. 2. This is a recent patented production of the firm, and it is likely to meet with very wide success, owing to the fact that the starting of the motor is accurately and automatically performed, irrespective of the load conditions. The float switch (or even a tumbler switch) causes the main switch to close, but the cutting out of resistance in series with the motor armature is accomplished by separate magnetically operated contactor switches, the rate of acceleration being automatically "steadied" by current relays in the armature circuit. These have the effect, it is claimed, of always giving a correct starting period, and never under any circumstances draw an excessive current from the line or cause violent acceleration of the pump. Indeed, they may almost be said to act intelligently, for they protect the pump as well as the motor, and anyone who knows what it means to get a long column of water into motion without producing any surging or other effects, will undoubtedly appreciate the advantages of this apparatus.

An important application of "Igranic" controllers is to the automatic operation of fire pumps from a distance. On the discovery of the fire it is only necessary to press one of the fire buttons scattered about, say, a country house, to start the motor-driven pump and get a plentiful supply of water at a good head. Many such installations are to be found all over England, and though subjected to frequent surprise tests, they are claimed never to fail. Other applications have been to sewage pumps, pumps for hydraulic machinery, and even to pumps for spirituous liquors. The construction of Adams "Igranic" control gear is robust and strong, and can be absolutely relied on to give constant and efficient service. This question of control is undoubtedly very important, and where electrically-driven equipment is employed on such work as fire pump supply it is essential that every care should be taken to ensure the reliability of the equipment. This seems to be done in the "Igranic" switchgear.

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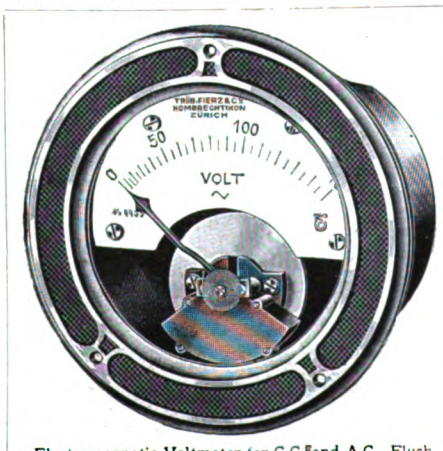

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Westinghouse Motors for Pumping Work.

AMONG the activities of the British Westinghouse Co. may justly be placed that of electrically-driven pumping plant. And it is not out of place that this should be so, for the driving of pumping plant is one of the most widespread uses of electric power in collieries and mines. The adaptability of the electric drive, and its immense advantages over any other form of power for this particular service, were generally acknowledged at a time when the manifold other uses of electric power in collieries were still under discussion. Whether the electric pumping sets are large or small, or whether they are far in-bye or at the shaft, they work with great efficiency and economy, and their general advantages are now well appreciated.

The pumping outfit shown in Fig. 1 has recently been installed underground at the Hebburn Colliery of the Wallsend & Hebburn Coal Co., near Newcastle. The motor, with its accompanying control gear, is of the British Westinghouse Co.'s standard design for this particular work; while the horizontal three-throw ram pump was built by Messrs. Frank Pearn & Co., of Manchester, and is capable of dealing with 600 gallons per minute at a head of 1,050 ft. The motor is of the three-phase induction type, with enclosed slip-ring. It is wound for 600 volts and develops 280 B.H.P. at 390 revs. per min. It is fitted with an extended shaft, rope pulley and out-board bearing. The motor needs practically no attention, and operates with high efficiency at all loads; the design being strong and substantial throughout. The control-box shown adjacent to the motor is provided with an oil-immersed combined main switch and circuit-breaker, to which the supply cables from the generating station are led, and an ammeter for showing the current passing; the conducting cables being taken into and out from the box through substantial insulating bushings let in the iron case. The controller, which may be seen at the extreme right of Fig. 1, is of the oil-immersed gas-tight drum type, and is fitted with special cable joint-boxes, which are bolted to lugs on the iron tank. It is connected between the control box and the motor, and consists principally of two intergeared drums, one of which controls the supply of current to the stator or stationery part of the motor, while the other varies the resistance in the rotor circuit, the number of steps being seven. The current-carrying parts are fitted with renewable arcing tips, which may be easily removed and replaced when necessary.

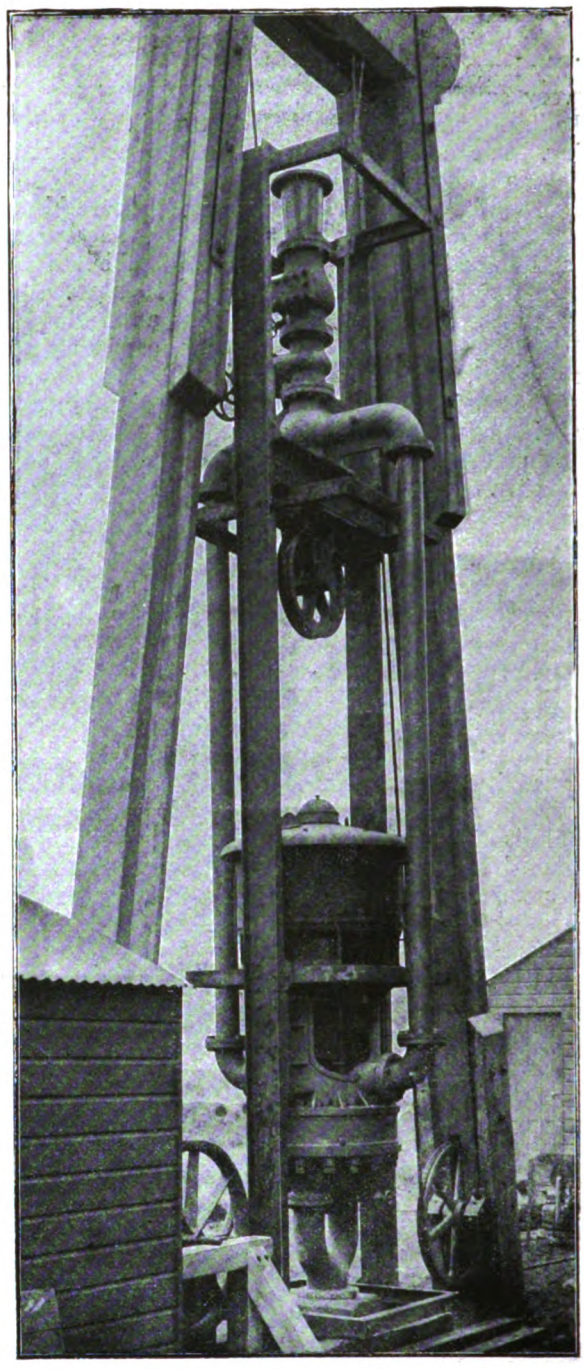

Fig. 2.—Westinghouse Pump at Tywarnhaile Mine.

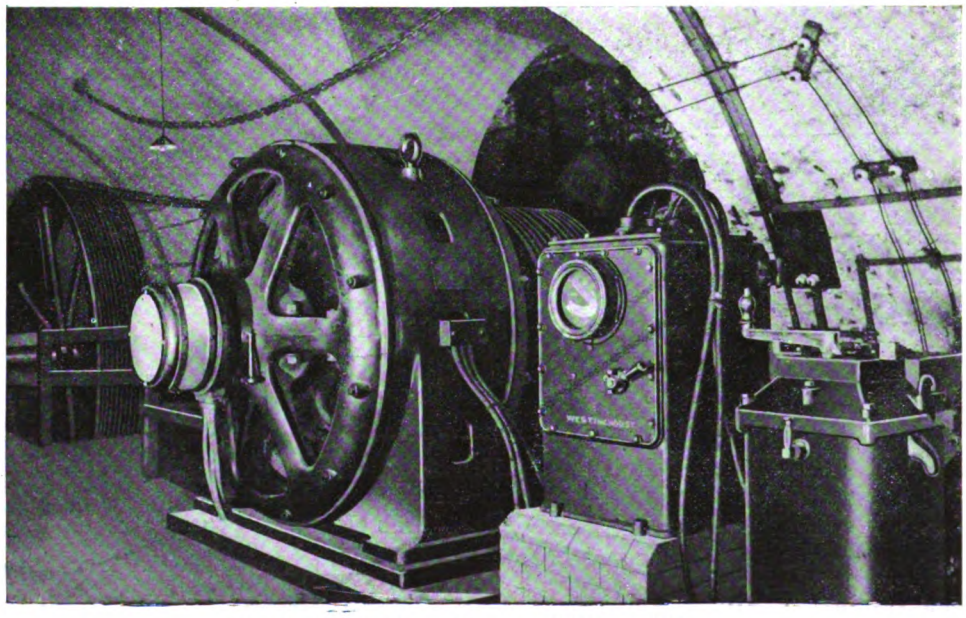

Fig 1.—Westinghouse Pump at Hebburn Colliery.

In connection with coaling work we may call attention to two Westinghouse three-phase squirrel-cage 3,000-volt motors, which are employed in operating centrifugal pumps for supplying water for coal washing. In this type of motor the rotor has no electrical connection with the outside circuit; and the connections to the fixed portion are made through a special water-tight connection box fixed on the side of the motor. The two control switch panels are placed near the set. The motors are of

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125 and 50 B.H.P. respectively, and are coupled direct to the pump spindles. They are supplied at 3,000 volts, 50 periods, and run at 600 revs. per min. The smaller pump works intermittently (without suction) against a head of about 35ft. The larger pump works under suction from depths varying from 15 ft. to 30 ft., and delivers its water in two stages. The first stage is approximately 41 ft. above the centre of the pump, and 75 per cent. of the water is taken off here; the second stage is 14 ft. higher, or 55 ft. from the centre of the pump. The total quantity of water pumped is about 3,500 to 4,000 gallons per minute.

Another interesting type of electrically-driven pump is that shown in Fig. 2. This illustration shows a 100 H.P. alternating-current sinking pump at Tywarnhaile mine in Cornwall. These vertical motors, besides being compactly built, are of a design embodying the first-class performance, simple construction and hardy characteristics of the ordinary Westinghouse horizontal motors.

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Problems of Electric Haulage.

THERE are certain industrial operations for which a motor seems eminently suited. To drive, say, a fan, requires that the driving agent should be capable of running for long periods under absolutely constant load, and such a condition is fulfilled, other things being the same, equally well by a steam engine as by a motor. But when we have to consider the question of driving plant whose operation gives a varying load, the problem is somewhat different. In the case of a hoist, for instance, the load rises almost momentarily from nothing to a maximum, and may drop again practically immediately to nothing, while these periods of activity are interspersed with intervals of doing nothing. The load which results is, therefore, by no means ideal, and what idealism there is is considerably reduced when steam driving is considered. There are always no-load losses, the acceleration is low and reversing difficult. As a set-off to this the motor is not expending energy when it is not actually working, it can be made to accelerate quickly and can be easily reversed.

It is, therefore, not surprising that electrically-worked hoists of large size are coming into extended use in shipyards, mines and factories generally. Unfortunately, in this country, progress has not been so great in this direction as abroad, though the favourable comments on the electric drive for this purpose in the report of the Royal Commission on Mines should not be without its effect on this state of things. On the Continent and in America more progress has been made, in the latter country especially in the shallow coal mine district.

The problems which have specially to be faced in dealing with such machines are mainly those pertaining to the great variability of the load and its effect on the motors themselves, and the operation of the line generally. Special precautions have to be taken to equalise the load as far as possible, to improve the load factor and to prevent dangerous surges on the line. The usual precautions attendant on the use of electricity in mines, such as fire-proofness and safety from shock, must, of course, also be taken.

The problem of equalising the load varies in complexity in haulages with the gradient up which the load is to be drawn. In a certain case in America, where the gradient varies between 5·0 and 8·5 per cent., a 500 H.P. compound motor is used controlled by semi-automatic magnetic gear. Line surging is practically eliminated by fixing a relay on the controller that prevents the starting switches from closing too rapidly. Another relay opens the circuit on overload, while, should the cars strike an obstruction, an arrangement is provided for bringing the motor automatically up to speed again. A very usual way of getting over the difficulty, especially in vertical, or nearly vertical, shafts, is to employ a balanced system in which the weight of the rising full cars is compensated, as far as possible, by the falling empty ones. There is, of course, besides all these ideas, the system of using a flywheel (a method which has been much before the public recently). This system has many advantages, almost its only disadvantage being the high first cost.

The more extended adoption of electrically-driven haulages in this country will follow as a necessary corollary of the general progress of the electric drive in mining work. It is a special subject, and must be specially considered, though there seems no good reason to believe that any problem of this type cannot be satisfactorily solved.

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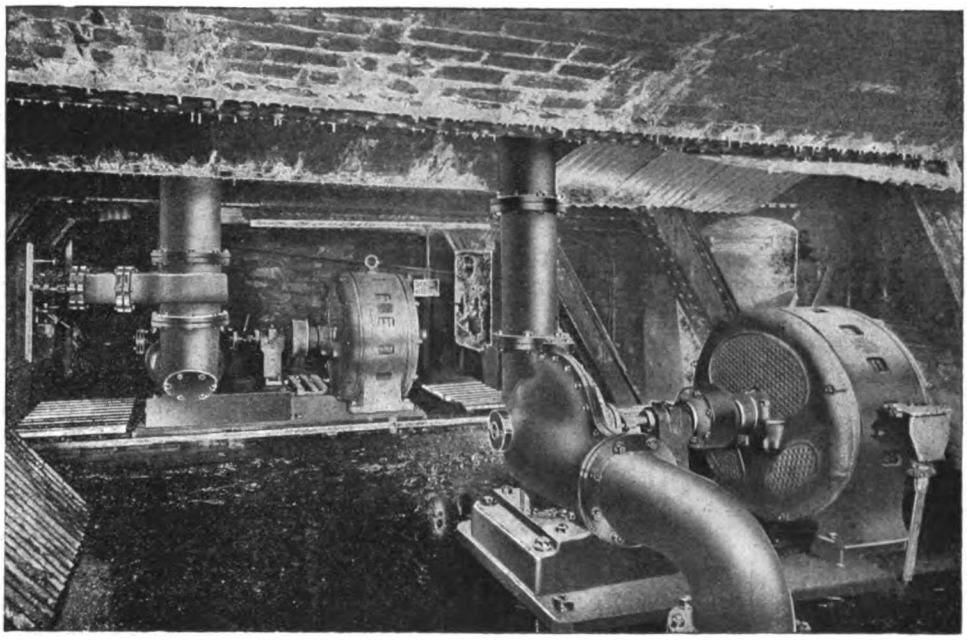

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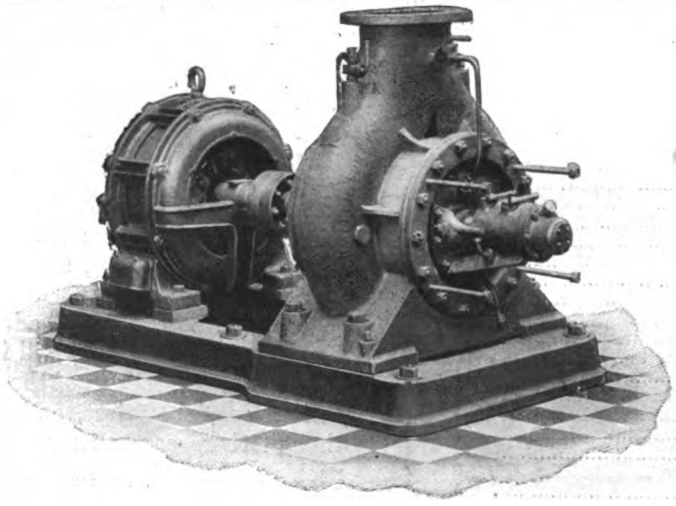

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Printed and Published by GEORGE TUCKER, at the Editorial, Printing and Publishing Offices, 1, 2 and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, APRIL 29, 1910

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,668. [No. 4. Vol. LXV.] FRIDAY, MAY 6, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Restricted Hour Supply.

THE annual report of Mr. P. J. PRINGLE, electrical engineer to the Burton-upon-Trent Corporation, shows an unusual state of affairs. Notwithstanding that the output of units by the electricity department is practically the same as a year ago, and that the number of higher priced units sold shows a considerable decrease, the surplus declared on the year's working is nearly double that of last year, and is the highest shown for many years. This happy result has been brought about by a reduction of no less than 27·6 per cent. in the cost of fuel, due to important economies introduced in the boiler house. With these we are not for the moment concerned. It is interesting, though, perhaps, disappointing, to notice that the revenue from private lighting is actually less than it was seven years ago, although the lamp connections have increased by 47 per cent. during that time. More satisfactory progress, however, is recorded as regards power supply. In this connection it will be remembered that the Burton undertaking is one of the few in this country which have made a feature of restricted hour supply. The success attending this system at Burton is well known, and recent experience merely adds to the favourable impression previously held. Mr. PRINGLE mentions that 80 per cent. of the total horse-power connected and 79 per cent. of the total number of units sold for power are used on the restricted hour principle. This seems to indicate that the consumption of energy per horse-power installed is not appreciably diminished when the restricted-hour system is adopted. As Mr. PRINGLE also mentions that the cost of generating the restricted hour units is only about 35 per cent. of the revenue obtained, it is evident these units must have had a very important effect on the financial success of the undertaking during the last year or two. As Burton power users are now obtaining energy on the restricted hour system at an average price of 0·855d. per unit, the advantages of the system are by no means confined to the supply undertaking.

Electricity in Coal Mines.

APART from the interest aroused by the likelihood of amended regulations for the use of electricity in mines as a result of the forthcoming report of the Departmental Committee appointed by the Home Secretary a few months ago to investigate this question, much attention has recently been paid to the apparatus used in collieries. Considerable discussion has also taken place in connection with the Paper read last year by Mr. ROBERT NELSON, H.M. Electrical Inspector of Mines, before the Institution of Mining Engineers, his unqualified decision in favour of the three-phase system, and also his advocacy of armoured cables, being criticised. A very interesting discussion took place last week on a Paper by Mr. W. W. WOOD, read before the Institution of Electrical Engineers. This Paper was mainly concerned with the question as to whether it is desirable to earth the neutral point of a three-phase colliery installation; but the question of armouring is also intimately connected with this problem.

A SLIGHT misunderstanding appeared to arise during the discussion, due to some speakers, who confined their attention to the underground installation, criticising those who dealt with the question of transmission lines, the former speakers overlooking, perhaps, the fact that the author introduced the question of transmission lines into his Paper. In this connection it may be pointed out that

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the question of an earthed neutral on a transmission line is different from that in the case of a mine.

At the present time efforts are concentrated on reducing any danger attending the use of electricity in collieries, and from that point of view the discussion has certainly proved valuable in bringing prominently forward the various features to be considered. It will be seen from our account of the discussion that opinion is by no means unanimously in favour of an earthed neutral or of armouring in all cases. Although, perhaps, an exception might be made in the case, mentioned by Mr. Wood, of a colliery where armouring is said to be destroyed in three weeks, due to the action of acids or salts, we think that a continuous earthed armouring is essential for cables used in mines. This system may possibly introduce a feeling of security not always justifiable, but with skilled attention—the necessity for which cannot be too strongly emphasised at the present moment—and the use of the protective apparatus now available, it should prove more satisfactory than running the risk of an arc or spark external to any cable, apart from the greater security against shock.

The Progress of Pure Science.

It is difficult for the engineer engaged in technical matters to follow at all adequately the continuous advance of pure science, and yet it is important that he should not lose sight of what is being done. Of course, he cannot well expect to keep in touch with the more abstruse branches, but an acquaintance with those subjects that may at any time become of practical importance is most desirable. It cannot be too fully borne in mind that advances in technical branches must largely be due to the utilisation, from time to time, of phenomena which have so far been regarded as of merely scientific interest. A case in point is the telephone relay of Mr. S. G. Brown, which is described in another column. The action of this instrument depends upon the electrical resistance of a minute spark-gap—a matter which has so far been passed over as of very little, if any, practical interest. Thus it behoves the engineer to keep his eyes open. It is with this object in view that we are starting in the present issue a series of articles by Mr. D. Owen on Recent Physical Research. Unfortunately, the pages of The Electrician are necessarily taken up too fully with technical matters for adequate attention to be paid to pure science. We hope, however, that these articles, which will appear at intervals, will to some extent serve to fill the gap and to keep our readers in touch with what is going on. The first article is on "Positive Electricity," and this will be followed by other contributions on subjects of rather greater practical importance than we can expect positive electricity to be for at least some time to come; though it must not be forgotten that the electron—so long associated with essentially pure science—is the starting point of Mr. Brown's relay, so that it behoves us to be guarded in our remarks.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Assab—Perim	July 8, 1909 ...	—
Balik Papan—Kwandang ...	Nov. 1, 1909 ...	—
Para—Maranham	Mar. 16, 1910 ...	April 23, 1910
Malta—Tripoli.....	Aprll 20, 1910 ...	—
Para—Pernambuco.....	April 25, 1910 ...	—
Mosambique—Majunga	May 3, 1910 ...	—
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"The Central."—The April number of this periodical contains articles ranging over engineering in general. They include "Main Drainage," by Mr. H. G. Lloyd; "American Hydro-Electric Development," by Dr. E. W. Marchant, and "Some Aspects of Chemical Engineering," by Mr. C. J. Guttmann. The issue is prefaced by a biographical notice and excellent photogravure of Mr. Wm. Duddell, F.R.S.

National Electrical Manufacturers' Association.—The Secretary (Mr. F. B. O. Hawes) informs us that he has received many communications with reference to the meeting which the Association is convening on 23rd inst. at Caxton Hall to consider the effect of Free Trade or Protection on the electrical industry, and we are asked to announce that admission will be by ticket, and that tickets will be sent by the Association to all its members, and to all the members, associate members and associates of the Institution of Electrical Engineers.

Electrical Mill Driving.—A new contract for electric power and lighting supply has this week been concluded between the Acme Mill Spinning Co., Pendlebury, and the Lancashire Electric Power Co. The contract came into operation on May 1st; it includes a portion of the Albion mill, which adjoins the Acme mill, and covers a long term of years. Considerable controversy has in past years been expended among electrical experts and mechanical engineering experts as to the entire suitability and economy of electric driving for large spinning concerns, and the settling of this contract may be regarded as an important declaration on the point. The Acme mills is one of the few large spinning mills in England without a chimney.

Personal.—The Salford Electricity Committee report that they have accepted, with very great regret, the resignation of Mr. V. A. H. M'Cowen of his position as electrical engineer to the Corporation. They have expressed their sympathy with him in the continued ill-health which has led to his resignation, and hope he may soon be restored to his usual health to enable him to continue a career which has been both honourable to himself and of benefit to the public. The Committee have further placed on record their high appreciation of the able and efficient manner in which Mr. M'Cowen has fulfilled his duties, and the sound advice he has always given the Committee, thereby rendering valuable service to the Corporation and the ratepayers generally.

Street Lighting in Paddington.—The employment of high candle-power metal filament lamps for street lighting is now receiving an interesting application in the Paddington district. The Metropolitan Electric Supply Co. have recently installed two 400 c.p. Osram lamps on an arc lamp standard in Westbourne-terrace, Paddington. The illumination is exceedingly good, and, in fact, seems greater than it really is, while the electric lamps are distinguishable both by their colour and greater brilliancy from quite a distance. The lamps themselves are mounted in fluted globes, and we understand that although these have been in use for a month it has not yet been necessary to clean them. Besides these lamps three gas pillars at the other end of the terrace, on the bridge crossing the Great Western Railway, have each been fitted with a 100 c.p. Osram lamp with similar satisfactory results.

A Thunderstorm Observatory.—It is announced that a thunderstorm observatory has been established in Spain by Señor G. J. de Guillen Garcia, in which atmospheric discharges, both local and distant, are detected graphically and acoustically. A wireless telegraph instrument is used for this purpose, because each lightning discharge is accompanied by electro magnetic waves similar to those used in wireless telegraphy. If there is a storm anywhere within a radius of 500 miles the observer is notified of the fact by the recording instrument. As all barometric depressions that pass over Western Europe come from the Atlantic Ocean, the new observatory gives meteorologists due warning of the approaching disturbance. By noting the intensity of the sounds produced in the receiver and observing whether they grow more distinct or less, it is possible to determine the approximate course of a storm.

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The Tramways and Light Railways Association.—The "Official Circular" of this Association for April contains corrections and additions to the list of members published in the March issue, full particulars in regard to the Association's Congress to be held in Dublin on May 12th and 13th next, correspondence with the Board of Trade in regard to third party accidents, copies of two recent judgments given in regard to rating of tramroads and to lease of tramways respectively, and other matters concerning the affairs of the Association.

London, Brighton & South Coast Railway.—With reference to the statements published concerning the further electrification of the L.B. & S.C. Co.'s suburban line to the Crystal Palace, we are in a position to state that whatever the directors have decided will not be publicly stated until the next meeting of the shareholders, when particulars will be furnished by the chairman and the decision of the directors will be made known. It is correct to state that the subject is under serious consideration, but this was clearly indicated in the chairman's remarks to the shareholders at the last meeting.

National Physical Laboratory.—Vol. VI. of "Collected Researches" has been issued by the National Physical Laboratory, and contains the following reprints:—

"Repeated Impact Testing Machine at the National Physical Laboratory," by T. E. Stanton, D.Sc.

"The Resistance of Materials to Impact," by T. E. Stanton, D.Sc., and L. Bairstow, A.R.C.Sc.

"Report of the Experimental Tank Committee (1908)." Part I., by the Committee: part II., with an Appendix, by R. T. Glazebrook, M.A., D.Sc., F.R.S.

"On the Resistance of Thin Plates and Models in a Current of Water," by T. E. Stanton, D.Sc.

"An Apparatus for Measurements of the Defining Power of Objectives," by J. de Graaff Hunter, M.A.

"On the Measurement of Wave-length for High-frequency Electrical Oscillations," by A. Campbell, B.A.

"On Magnetic Testing of Iron with Alternating Current," by A. Campbell, B.A.

"On a Method of Testing Photographic Shutters," by A. Campbell, B.A., and T. Smith, B.A.

"Non-inductive Water-cooled Standard Resistances for Precision Alternating-current Measurements," by C. C. Paterson and E. H. Rayner, M.A.

"The Proposed International Unit of Candle-power," by C. C. Paterson.

"On the Insulation of Inductive Coils," by A. Campbell, B.A., and T. L. Eckersley, B.Sc.

"On Cadmium Amalgams and the Weston Normal Cell," by F. E. Smith, A.R.C.Sc.

"The Elastic Limits of Iron and Steel under Cyclical Variations of Stress," by L. Bairstow, A.R.C.Sc.

"The Crystalline Structure of Iron at High Temperatures," by W. Rosenhain, B.A., D.Sc., and J. C. W. Humfrey, B.A., M.Sc.

Operation of an Edison Accumulator Car.—The "Electric Railway Journal" gives some figures regarding the operation of an Edison accumulator car which has been running regularly on the road since March 3rd. The car leaves the barn at 6 a.m., with the batteries fully charged. It travels over the line continuously until 8:30 p.m., during which time it handles the regular traffic of the line in 14 round trips, covering a distance of 66·78 miles. At 8:30 p.m. the car comes into the car house, is inspected and charged for five hours. The average expenditure of energy at the motors is 529 watt-hours per car-mile, and at the 'bus bars, 853 watt-hours per car-mile. On March 28th and March 29th a test was made to determine the mileage capacity of the car when carrying a normal passenger load. The car made 85 miles and then was found to be practically discharged. On the last trip in the 85th mile run the car took on 27 passengers at the Twenty-third-street ferry making a total of 31 persons with the motorman, conductor and two engineers. The track conditions are bad and there are 46 curves in each round trip. On the long run of 85 miles there were approximately 700 stops. The designers of this car had obtained by April 1st a record of performance of the Edison battery covering a period of 476 charges and discharges in commercial service. At the end of this number of complete charges and discharges, the battery was found to be 11 per cent. higher in capacity than when at first put into service. Translated into car-miles, taking 80 miles per charge (5 miles less than was secured in the test run), the car travelled 38,800 miles and the battery appreciated in capacity 11 per cent. over its original rating.

Schilowsky Monorail.—A demonstration was given at the Westminster Palace Hotel on Wednesday last of a monorail system, which is the invention of His Excellency M. P. Schilowsky. The model locomotive exhibited was equipped for steam operation, and was shown running over a short length of monorail track. Equilibrium of the locomotive and cars or trucks is obtained by means of what is known as a "gyro-car," this being (in the case of the model) a truck fitted with a steam-driven gyroscope, and a special device by means of which the stability of the system is maintained. The gyroscope is mounted on a vertical axis in a frame which is pivoted, at points below the centre line of the flywheel, to the truck itself. The gyro-frame is therefore free to oscillate in a longitudinal direction about the pivot points. Any movement tending to oscillate the flywheel frame applies a restoring couple to the gyroscope, and through it to the truck, maintaining the latter in a horizontal plane, irrespective of unequal loading or shocks. This restoring movement is applied to the gyro-frame through the medium of a pendulum, which is coupled by rope or chain to a swinging quadrant. A portion of this quadrant is fitted with a rack and when the pendulum swings over sufficiently this rack is brought into engagement with a constantly rotating pinion, driven in the model by a small steam engine. The quadrant is also coupled by a rod with the gyro-frame. When the pinion engages with the quadrant a smart shock or push is given to the gyro-frame, and the leaning tendency of the car which initially moved the pendulum is corrected. The model shown remained satisfactorily in balance, and demonstrated the feasibility of the system on the scale shown. It is claimed for the system that slow moving gyroscopes will be possible, and that only one flywheel is needed. Fuller details of the method are promised shortly.

Wireless Control of Airships.—An interesting model airship of the lighter-than-air dirigible type is at present being shown by Mr. Raymond Phillips at the London Hippodrome. The balloon, which is cigar shaped, is 20 ft. long by 5 ft. in diameter, and carries a wooden frame work suspended below it for supporting the equipment. This consists of four propellers, two of which have vertical axes and are worked in parallel to give upward or downward motion as required, and the other two are placed astern for propulsion. The latter are carried at the two ends of a horizontal beam, which is free to swivel round in a horizontal plane. If one propeller alone is rotating it takes up a position near the "keel," and thus throws the model round rapidly, but when both propellers are running the movement is straight forward. No rudder is provided. The propellers are run electrically by electric motors supplied with current from a 4-volt battery of accumulators. The wireless part of the equipment is simple. Electric waves are produced by a coil and small antenna in the usual way. The waves are received by a couple of transverse rods and a coherer, which, by means of a relay, permit an electromagnet to be energised and to pull over a lever. This lever in turn pulls round a drum provided with a number of contacts, and at the same time the coherer is decohered at the end of each stroke of the lever by a tapper worked by an electromagnet. At each impulse the drum is drawn round to a fresh position, and therefore to a fresh contact, by a ratchet action. In this way any desired contact can be obtained by maintaining the impulses for a sufficient time; that is, any of the motors can be worked, or any circuit closed for which contacts have been provided. The model is interesting and works well. As to the use of such wireless methods in war, the inventor does not hold any strong views. He states that he has a device in mind for preventing interference. In actual warfare, however, he does not anticipate wireless control of a ship's movements, but rather that a definite course would be set at the start, and that explosives would be dropped by wireless means at the desired moment.

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Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. B. S. Cohen contributes some notes on a recent article by Dr. A. Ebeling dealing with "Aerial Telephone Lines on the Pupin System."

Mr. D. Owen contributes an article on "Positive Electricity."

Before the Institution of Electrical Engineers yesterday evening Mr. S. G. Brown described a Telephone Relay which he has devised, and which depends for its action upon the electrical resistance of a very small spark-gap.

We give an account of the discussion which followed the reading of Mr. W. W. Wood's Paper before the Institution of Electrical Engineers on "Earthed versus Insulated Neutrals in Colliery Installations."

Legal.—Lord Dundas has delivered an interesting judgment in the appeal of Glasgow Corporation against the assessment of their municipal tramways by the Assessor of Railways and Canals.

The Official Referee (Mr. Pollock) has given judgment in the action brought by the Electrical Co. *v.* O. H. Thomas, Son & Co. for the recovery of money due for electric mining plant supplied by plaintiffs. The hearing of the case occupied about 40 days and judgment has now been given for plaintiffs on the claim and counter-claim, with costs.

Directors' Reports.—The report of the Great Northern Telegraph Co. for 1909 is interesting reading. The chairman (Commodore E. Suenson) in his remarks to the shareholders, touched upon several items of international importance.

The operations of the British Westinghouse Co. for 1909 resulted in a further small debit balance (£798), after considerable sums had been allotted to depreciation.

"Trade depression" has seriously affected the Welsbach Incandescent Lamp Co., whose directors were compelled to pass the dividend on the ordinary shares, and have expressed the view that there is no hope under existing conditions, of any dividend on this class of share. A writing-down of the capital by the sum of £843,000 is advised.

INSTITUTIONS AND SOCIETIES.

University of Cambridge.—It is proposed to appoint the Vice-Chancellor, the Master of St. John's, the President of Queen's, Prof. Hobson, Dr. Darwin, Mr. R. St. J. Parry (Trinity), Mr. J. B. Lock (Caius), Mr. W. L. Mollison (Clare), Mr. W. H. Macaulay (King's), and Mr. H. McL. Innes (Trinity) a syndicate to consider the financial administration of the various scientific departments of the University and the financial relations between these departments and the Museums and Lecture Rooms Syndicate. The syndicate are to confer with the Financial Board, the General Board of Studies, the Museums and Lecture Rooms Syndicate, the heads of the various scientific departments, and such other bodies or persons as they may think fit, and to report to the Senate before the end of Lent Term, 1911.

Among the recipients of honorary degrees to be conferred this term will be: Principal Sir Oliver Lodge, F.R.S., and Prof. W. H. Perkin, F.R.S.

Faraday Society.—This Society gave their first dinner on Wednesday, April 27th, at the Trocadero Restaurant, in honour of Prof. P. Walden, of Riga, and Prof. Ph. Guye, of Geneva, who came to London for the purpose of taking part in a discussion on "The Constitution of Water," which took place on the previous evening. The President, Mr. James Swinburne, F.R.S., was in the chair, and there was a very good attendance of members and their friends. Among the guests present were Sir Joseph Larmor, Prof. H. B. Dixon, and Dr. C. Chree. After the loyal toasts had been honoured, Mr. W. R. Bousfield proposed the health of the guests of the evening, Profs. Walden and Guye, dwelling particularly on the variety and importance of their contributions to physical chemistry, and emphasising the value of such visits as those of Profs. Walden and Guye to London in promoting a spirit of international friendship. Prof. Walden, who spoke first in English and subsequently in German, referred to the scientific relationship between Russia and Great Britain, remarking incidentally that the first Russian chemist was an Englishman, sent by Queen Elizabeth to Russia in the sixteenth century. Comparing the intercourse of men of science with physical reactions, with which his hearers would all be familiar, he remarked on the important part "association" and "dissociation" played in such intercourse and on the benefits to science resulting therefrom. Prof. Guye, who responded to the toast in French, dwelt on the debt which chemists all over the world owed to Faraday, and he gave an interesting account of Faraday's visit to Geneva when he accompanied Sir Humphrey Davy on his tour through Europe.

The health of the other guests was proposed by Mr. Bertram Blount, and Sir William Ramsay and Sir William Tilden responded. Dr. T. M. Lowry proposed the toast of "Kindred Societies," coupling with this the names of Sir Joseph Larmor, secretary of the Royal Society, Prof. H. B. Dixon, president of the Chemical Society, (which Dr. Lowry described as the "mother" of the Faraday Society), and Dr. Charles Chree, past-president of the Physical Society, (which he claimed might fairly be called the "father" of the Faraday Society), while the Institution of Electrical Engineers might be regarded as the "generous uncle," seeing that 48 out of the 50 meetings which had been held by the Society took place in the library of the Institution. To this toast Prof. H. B. Dixon responded.

In conclusion, Dr. C. Chree proposed the toast of the Faraday Society, coupled with the name of the president, Mr. James Swinburne, who, in his reply, dwelt on the work which the Society was doing in covering gaps in the borderlands of physics and chemistry, both on the theoretical and technical sides, which were not covered by existing societies.

Institution of Civil Engineers.—The council of this Institution have awarded a Telford premium to Messrs. J. Dalziel and J. Sayers for their Paper on "The Single-Phase Electrification of the Heysham, Morecambe and Lancaster Branch of the Midland Railway."

Birmingham Section of the Institution of Electrical Engineers.—The list of names which will be submitted at the Annual General Meeting on May 25, for election on the committee of this Section, is as follows: *Past Chairmen*, Messrs. R. A. Chattock, R. K. Morcom, and Prof. G. Kapp. *Chairman*, Mr. M. Railing. *Vice-Chairman*, Mr. A. M. Taylor. *Committee*, Messrs. J. H. Barker, W. C. Goodchild, J. P. Kemp, M. Kloss, W. J. Larke, F. M. Lea, J. F. Lister, F. J. Moffett, D. K. Morris, C. E. C. Shawfield, W. E. Sumpner and R. Threlfall. *Hon. Secretary*, Mr. H. B. Matthews.

Yorkshire Section of the Institution of Electrical Engineers.—At the Annual General Meeting of this Section the following were elected as officers for the Session, 1910-11:—*Chairman*, Mr. T. Harding Churton. *Vice-Chairman*, Mr. Wilson Hartnell. *Committee*, Messrs. J. D. Bailie, E. A. Barker, A. J. Cridge, W. Emmott, J. W. Hame, A. B. Mountain, S. D. Schofield, J. McFall Smyth, G. Wilkinson, W. B. Woodhouse, H. H. Wright and Dr. R. Pohl.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, May 7th.

Birmingham and District Electric Club.

7 p.m. Meeting at the Colonnade Hotel, New-street. Paper on "The South Staffordshire Mond Gas Distributing Plant," by Mr. Wm. Dudley.

WEDNESDAY, May 11th.

Junior Institution of Engineers.

7:30 p.m. Meeting at the Royal United Service Institution, Whitehall. Paper on "Notes on the Running of an Electricity Works," by Mr. L. H. Jockel.

THURSDAY, May 12th.

The Institution of Electrical Engineers.

8 p.m. Meeting at the Royal Society of Arts, John-street, Adelphi, W.C. Paper on "Street Lighting by Modern Electric Lamps," by Mr. H. T. Harrison.

FRIDAY, May 13th.

Royal Institution.

9 p.m. Meeting at Albemarle-street, Piccadilly, W. Discourse on "Radioactivity as a Kinetic Theory of a Fourth State of Matter," by Prof. W. H. Bragg, F.R.S.

Tramway and Light Railways Association.

THURSDAY and FRIDAY, May 12th and 13th.

Meeting at Dublin.

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, May 9th, "A" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 9:30 p.m.

Tuesday, May 10th, "B" Company.—Company Drill, 7 to 9:30 p.m.

Wednesday, May 11th.—Gymnasium, 6 to 9:30 p.m.

Thursday, May 12th, "C" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 8 p.m. Technical Drill, 8:45 to 9:45 p.m.

Friday, May 13th, "D" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 8:30 p.m. Technical Drill, 8:45 to 9:45 p.m.

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DEVELOPMENT IN THE PRODUCTION OF ELECTRIC POWER.*

ITS APPLICATION AND BEARING UPON THE IRON AND STEEL INDUSTRIES.

BY D. SELBY BIGGE.

Summary.—The author discusses recent developments in cheapening the cost of production of electric power, particularly in connection with the iron and steel industries. Exhaust and mixed-pressure turbines are referred to in this connection and the various types described, together with particulars of the saving to be expected. He next passes on to gas engines, and the use of blast furnace or coke-oven gas, and finally refers to electric rolling mills and electric furnaces. He points out that this country is suffering from lack of enterprise.

It has been the author's privilege to lay before the members of this Institute, from time to time, records of the various developments which have occurred in connection with electric power for industrial purposes. The progress made in this country during the past three years has been rather of the slow but sure order, and has not in any way been able to keep pace with the extraordinary enterprise and activity of the American and Continental manufacturers and engineers. It must be remembered that the author is confining himself, in remarks such as the above, to matters restricted to "electric power" and is not in any way referring to other industries. The acute depression of trade in this country during the past two years may have had a bearing upon the slow rate of progress made, but many opportunities have been lost during this slack period of bringing old works with obsolete methods up to date, and in making due preparations for working upon the bed-rock of economy when better times should set in. In this latter respect it must be realised that this country is to a large extent being outstripped by our American and continental competitors. Progress, therefore, and economy in productive methods are amongst the most important factors, if not the most important, in our being able to combat successfully the ever-growing competition with our home trade.

Coming now to the actual subject matter of this Paper, considerable progress has been made in the cost at which electricity can now be produced in iron and steel works having at their disposal waste gas, waste heat, and waste steam. One of the means by which this low cost of production has been attained has been brought about during the past three years by the advent of the mixed pressure turbine. As this is a subject to which the majority of iron and steel works, with their accessory sources of coal, coke, and iron-stone, are paying considerable attention at the present time, the author devotes some space to its consideration.

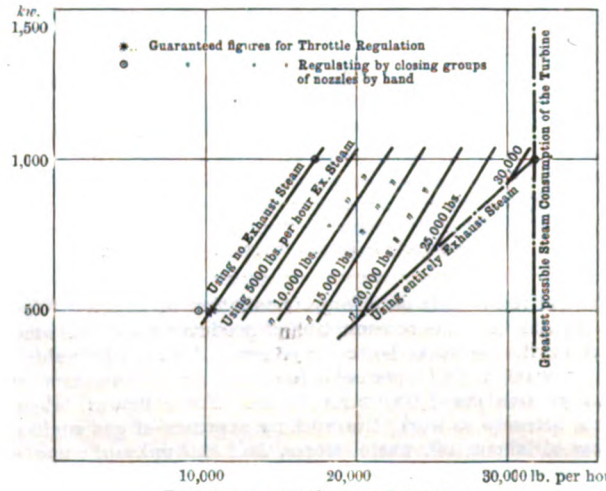
Mixed Pressure Turbines.—Whereas the purely exhaust type of steam turbine lends itself readily to those applications where a constant supply of exhaust steam is available, such as in the case of the exhaust from blast-furnace blowing engines, fans, pumping engines, &c., yet a want has been felt for a type of machine which could be relied upon to take full advantage of the steam available from engines working only intermittently. The latter condition is far more frequently met with in actual practice than the former, and the exhaust steam can now be fully utilised from intermittently working machines, such as winding engines, rolling mill engines, heavy punches and shears, compressors, steam hammers, and hoist engines. The exhaust steam recovered from such engines is conducted through pipes into a regenerative or heat accumulator, which in its turn feeds the turbine with steam at low pressure.

The action of a regenerative accumulator, taking water as the means of storing heat, is as follows:—The exhaust steam is taken from the engine, or engines, and mixed with the water until they become of the same temperature. Assume that a pressure of 1½ lb. to 2 lb. is allowed to take place in the accumulator. Directly the pressure drops, owing to the supply of exhaust steam being cut off, the water in the accumulator at once gives off vapour. If a vacuum is allowed to take place in the accumulator, further useful effect can be obtained. A valve should be fixed between the engines supplying exhaust steam and the accumulator, so that a vacuum cannot be carried further than the accumulator itself. The size and capacity of the apparatus is determined by the length of pauses which are required to be bridged.

The principles involved in the mixed pressure type of turbine are as follows:—The turbine is built in stages or impulse wheels, one set being designed and arranged for the working pressure of the existing boilers, and so constructed as to give off the full output of the turbine upon live steam when required, the other set being designed for the utilisation of exhaust or low-pressure steam received from the accumulator in the case of engines working intermittently, or direct from the exhaust of the engines running continuously. The low-pressure end of the turbine is also designed to give out the full rating or output upon low-pressure steam alone. The third condition is that in which, if the full supply of exhaust steam fails from any cause, live steam is automatically admitted to make up the temporary deficiency in the exhaust steam available. An important feature is that the high-pressure steam is admitted, when required, to the high-pressure stage without the intervention of a reducing valve, and thus the maximum efficiency is obtained from such high-pressure steam as may be used, to practically the same degree as in an ordinary high-pressure turbine. The governing and regulating arrangements by which this end is attained are absolutely automatic.

Not only can the mixed-pressure turbine be advantageously used in connection with rolling mill engines, winding engines, and other engines of the same category working intermittently, which do not possess, by the nature of the work they have to perform, the very high efficiency and steam consumption of cotton mill engines and triple expansion marine engines, but it has even been found possible to make use of exhaust turbines in connection with engines of the highest class alluded to above. It will be seen, therefore, that the field for the application of this system of power recovery is almost unlimited.

The author showed three diagrams illustrating the power recoverable in the shape of exhaust steam from three different types of engines. In the case of the simple engine it may be safely assumed, after making ample allowance for all losses, that in actual practice at least as much power can be obtained from the exhaust steam of such an engine as is obtained from the high-pressure steam in the cylinder. There are many engines in iron and steel works, and other kindred industries, to which this will apply. By converting such an engine into a condensing engine a comparatively small advantage will be gained, and so long as the engine is powerful enough for the work it has to perform it will undoubtedly pay to leave it as it is and utilise the exhaust steam in a low-pressure turbine combined with a condenser providing a high vacuum. The amount of power to be recovered in the case of a compound condensing engine amounts to 60 per cent. approximately. The third diagram showed that even in a triple-expansion high-pressure engine a considerable amount of power still remains to be recovered, but it might be found in works practice that it was not commercially advisable to make any alteration. In marine practice, however, there are undoubtedly possibilities of utilising the power lost. In order to obtain a high vacuum, first cost and power required to work the condensing plant should be carefully considered to avoid unnecessary expenditure in proportion to the results obtained.



Boiler press. 163·5 lb. per sq. in. Superheat 117° F. Exhaust steam 15·7 lb. per sq. in. abs. Cooling water 59 F. Revs. per min. 3,000.

STEAM CONSUMPTIONS OF A 1,000KW. (50 ∼) MIXED PRESSURE TURBINE.

The diagram herewith is of special interest as showing the actual steam consumption of a mixed-pressure turbine developing full load when supplied either partially or wholly with exhaust steam. The steam consumption is also shown for the turbine when using high-pressure steam only.

Cooling Plant.—With either the purely high-pressure, mixed-pressure, or exhaust type of steam turbines, it is essential that condensing plant should be installed. The three forms of cooling plant most commonly met with are the natural draught cooling tower, the open type cooling tower, and spray nozzles distributed over a pond. In this country the circulating water can be reduced to 80°F. or 85°F., ordinarily with natural draught cooling tower, or to 75 deg. with open-type cooling tower, which, however, occupies more space. Where ground space is not of great importance.

* Abstract of a Paper read before the Iron and Steel Institute.

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and especially in open situations, spray nozzles are to be recommended as excellent results are obtained by their use, and if properly installed it is quite easy to maintain the temperature of the circulating water at the prevailing atmospheric temperature.

The following figures may be of interest :—If we take two mixed-pressure turbine units, each of 600 kw. capacity, working on exhaust steam only, and exhausting into condensers of the multi-jet ejector type, it would be found that about 220,000 gallons of water would be circulated per hour in order to maintain a vacuum of 27½ in. with barometer at 30 in. The area of pond required for the spray nozzle cooling plant for the above quantity of water would be approximately 7,800 sq. ft.,—*i.e.*, a pond 130 ft. long by 60 ft. wide. The two 600 kw. units referred to above, when working together on exhaust steam only, would require a total of approximately 48,000 lb. of steam per hour, and it would be found in practice that this steam being collected and used in the turbine, and circulated through the condenser to the cooling pond, would result in approximately 10 per cent. of the 48,000 lb. of water fed into the boilers being saved. Therefore a generating station with a plant of the type described is really in a better position from a boiler feed point of view than it was when its various reciprocating engines were exhausting to atmosphere.

Having reviewed the general principles involved in the use of mixed-pressure turbine plant, the author gives a brief description of the salient points of some of the distinctive types. The following turbines are described and illustrated in this connection : Parsons, Rateau, Curtis, Bergmann, de Laval, Zoelly and Westinghouse.

Gas Engines.—As showing the recent improvements in gas engines, the author describes the Mather & Platt, Nürnberg and Cockerill-Westgarth engines. It is mentioned that a furnace producing 250 tons of iron per day delivers enough gas to generate 10,000 B.H.P., of which 2,500 B.H.P. are required for the furnace equipment, leaving 7,500 B.H.P. for electric generating or other purposes. The following figures are given as running costs of Nürnberg gas engines :—

Four-cycle Tandem Double Acting.

1,200 kw.	0·0359d.	per kw.-hour.
900 kw.	0·0452d.	„ „
300 kw.	0·1164d.	„ „

Four-cycle Single-cylinder Single Acting.

300 kw.	0·165d.	„ „

Careful tests made on a large installation of Cockerill-Westgarth gas engines show the consumption of producer gas at full load to be 65 cubic ft. per brake-horse-power-hour, the calorific value of the gas being 146 B.Th.U. per cubic foot, and the oil consumption to be 0·275 gallons per 1,000 B.H.P.-hours. From figures taken from plants actually at work, the working expenses of gas engines, consisting of labour, oil, waste, stores, &c., and upkeep, come out at approximately 0·045d. per kilowatt-hour, this being for units of about 1,000 kw. size.

Cost of Production.—In the case of small and separate high-pressure installations, with reciprocating engines, obtaining their steam from coal-fired boilers, and of a capacity of, say, from 300 to 500 kw., a very usual figure of cost of production, with interest and depreciation included, is 0·6d. to 1d. per unit, the actual figure varying with the local conditions and the price of boiler coal. In many cases, especially those ranging between 100 kw. and 400 kw., it may be found desirable to purchase current from a public supply in preference to generating current oneself, if no waste assets are available. When, however, it becomes a question of providing current for the complete electrification of a large works, or for the driving of rolling mills and heavy machinery, the operating of electric furnaces and other applications demanding a large amount of current, then the question of cost of production at once becomes a vital matter, and the fullest advantage should be taken of any waste assets either in the form of waste heat, gas, or exhaust steam, which may be to hand. The power which may be required for schemes such as the above will be found to be anything between 1,000 kw. and 10,000 kw.

An interesting case of the application of mixed-pressure turbines for the economical production of power is the electrification scheme recently carried out by the Fife Coal Co. in connection with their collieries in Scotland. The principle adopted has been to lay down mixed-pressure turbines at those collieries where the greatest amount of exhaust steam might be available, and feed the power thus generated into a common network of mains, from which power could be drawn off to supply the requirements of their other collieries in the district. The Fife Coal Co. possess five mixed-pressure turbines, each of 1,000 B.H.P., and one of 800 B.H.P. Current is generated at 3,000 volts, 50 cycles. It is yet too early to gauge the total savings resulting from this comprehensive electrification scheme, but at one of the collieries, where a 750 kw. plant has been in operation for a year, the cost of production, after allowing 12 per cent. interest and depreciation upon the capital outlay, including a complete standby unit, and including wages, oil, stores, waste, &c., and an allowance for live steam, amounts to 0·2109d. per unit, made up as follows :—

Interest and depreciation (12 per cent.) upon £9,400.....	£1,128
Station attendants	160
Stores, oil, &c.	45
Coal for live steam and firemen's wages	684
	£2,017

The output is 2,295,000 units, so that the cost of production works out as 0·2109d. per unit. At this particular colliery the net saving which has been actually effected already exceeds £3,000 per annum, but as the plant is not yet fully loaded up and more motors have to be added, the ultimate saving will be considerably increased.

Electric Rolling Mills.—It is now three years since the author read a Paper before this Institute on this subject. With the exception of a certain number of continuous rotation mills, very slow progress has been made in this country in the development of reversing mills of high power. Amongst the pioneers in this direction have been Messrs. Dorman, Long & Co., of Middlesbrough, who were, with Messrs. Bell Bros., amongst the first in this country to adopt electric driving in their works. Messrs. Alfred Hickman, of Bilston, have also been amongst the first, and latterly the Skinningrove Iron Co. have adopted the electric reversing mill. Owing to the cheapening of the cost of production of electric current, many iron and steel works are now seriously considering the possibility of electric mills.

To give some idea of the comparative progress made on the Continent and in this country during the past three years, the author has been informed that one firm of electrical manufacturers alone has laid down 300,000 B.H.P. of electrically-driven mills on the Continent, and 20,000 B.H.P. in Great Britain. This applies to both reversing and continuous running mills. Another large firm have laid down on the Continent 234 mills with a total output of 305,000 B.H.P., so that it will be seen that two firms alone have laid down during the past three or four years on the Continent 605,000 B.H.P. in this direction.

Electrical Furnaces.—Reference is made by the author to the Héroult furnace and to electric induction furnaces. In a 5-ton furnace of the former type, using cold scrap, 700 kw.-hours are necessary to produce 1 ton of finished steel ; this is reduced to 140 or 160 kw.-hours when the metal is charged in a molten state. Electric induction furnaces are divided into two distinct types, the "simple induction" furnace, and the "combination" furnace. The "combination" furnace has the advantage over the "simple induction" type, that it is an efficient refining furnace. The power consumed varies in direct proportion to the degree of refining considered desirable.

General Applications.—In addition to driving by motors practically the whole of the auxiliary plant appertaining to an iron and steel works, there are many subsidiary purposes to which electricity can now be applied, such as shunting and works locomotives, transporters, charging machines, lifting magnets, &c. Improvements have been effected by the introduction of slow-speed motors, eliminating gearing. Three-phase motors have been brought into general use for cranes, live rolls, and other work where formerly continuous-current machines only were available. Variable speed motors have been built for work requiring a wide range of speed which was previously obtained by change gears or other mechanical devices. It would, in fact, be hard to mention any item of machinery and plant in an iron or steel works which cannot now be advantageously driven electrically.

After referring to the use of transmission lines and the higher voltages now employed with safety, the author sums up as follows :—

After frequent visits abroad, and by means of keeping constantly in touch with the improvements and developments taking place in other countries, the author is forced to the conclusion that what we are primarily suffering from in this country is apathy, and frequently lack of enterprise. The economic conditions in some of our older works are deplorable, and are not to be encountered in the countries of our ever-increasing competitors. If we are to continue to hold our own as a great productive nation, greater enterprise will have to be exhibited, and closer attention paid to the rapid improvements which are being so constantly effected by our competitors in their productive methods. When the absolute necessity for keeping abreast of the times is fully realised, there is no country in the world better able to meet successfully the growing competition than our own. There is now every indication that in the iron and steel industries at any rate, far greater attention is being given to schemes whereby economies in cost of production can be effected, and this is a welcome sign.

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NEW METHODS OF TRANSMISSION EMPLOYED IN WIRELESS TELEGRAPHY.*

BY G. FERRIÉ.

Summary.—A brief review is given of the various methods that have been tried to obtain security in wireless telegraphy. A simple wave meter due to the author is described, and the calculation of damping is considered.

Among the numerous defects which were debited against wireless telegraphy on its first appearance the chief was that little security was offered as regards the messages entrusted to it; the reception of radio-telegrams could be spoilt, not only by the signals simultaneously sent from other stations, but also by the electric phenomena of the atmosphere. Although the numerous investigations which have been made with a view to remedying this state of affairs do not yet permit of absolute security for Hertzian messages, important improvements have been realised, and the situation is distinctly ameliorated. It is proposed to review briefly the various methods which have been tried, especial attention being given to those which have given the best results as regards the transmission.

The maximum of security would be obtained were it possible to realise, on the one hand, an emission of very regular unifrequent waves, having as small damping as possible, and, on the other hand, receiving and detector circuits of small damping, and which could only be set into vibration under the influence of an oscillatory movement of single, well-determined frequency. At the sender the desired result will be realisable when it becomes possible to generate sustained oscillations of sufficient power.

Since 1903, following Poulsen, numerous attempts have been made to utilise the singing arc supplied at low tension, with a view to producing such waves, but the results are not good enough for modern practice. The production of very high-frequency alternators for use in supplying the antenna directly without the intermediary of arc or spark is occupying attention in France at the present time, and the results obtained in this direction will shortly be published.

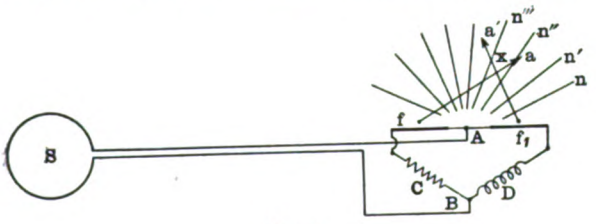

FIG. 1.

In the methods in actual use which employ the discharge of a condenser for generating the Hertz waves, either inductive or direct excitation is used. Wien has shown that the disposable energy is split up between the two vibratory motions whose wave-lengths differ the more the closer the coupling employed. It is, therefore, important to try to reduce the difference—that is, the coupling—at the same time keeping the value of the latter sufficiently high for the energy transference from the one circuit to the other to take place. It has been found that for values of the coefficient of coupling lying between 0·06 and 0·12 the energy is practically confined to a single one of those two oscillations, the slower or the faster, according to the relative values of the elements of the circuits. For the measurement of the coupling and the damping recourse is usually had to wave-meters and to the equations of Bjerknes.

Although there are many kinds of wave-meter, a new type has recently been devised by the author, which enables measurements to be made without any adjustments from a simple reading. The principle is as follows: Between two points, A and B (see Fig. 1), a certain effective E.M.F. (V) is maintained by means of a single loop, S, which encloses a part of the flux to be measured. Between A and B two circuits, *f*C and *f*D, are connected, each containing one wire (*f* and f_1) of a hot-wire ammeter and an impedance (C and D). Each of the wires *f*, f_1 controls a pointer (*a* and *a'*); these pointers are both capable of movement across the same scale. The currents which flow through each of the wires are given with sufficient approximation, for the case of damped waves, by the formula

$$I = V/(R^2+\omega^2L^2)^{\frac{1}{2}}; \quad I_1 = V/(R_1^2+\omega^2L_1^2)^{\frac{1}{2}},$$

whence $I/I_1 = f(\omega)$. For each value of ω the pointers cross at some point on a curve which can be empirically marked on the scale. The apparatus having been previously graduated, the measurement of the wave-length or frequency of an oscillating circuit is made by simply taking a reading of the point of intersection while the loop S is held near to the circuit.

For measuring damping the author has tried to apply the Bjerknes method directly, without plotting the curves, starting simply from the equation

$$Y\alpha_1\alpha_2(\alpha_1+\alpha_2) = E^2/16L^2 \quad . \quad . \quad . \quad (1); \quad \alpha_2 = R/2L,$$

whence $Y\alpha_1 R(2\alpha_1 L+R) = E^2/4$. Y is the maximum ordinate. A first measurement, giving R a certain value, allows of the determination of $Y(I^2)$ corresponding to resonance. Giving R, then, another value, Y′ is measured

$$Y'\alpha_1 R'(2\alpha_1 L+R') = E^2/4.$$

E being constant, the position of the circuits unaltered, and all the other elements known, it is possible to calculate $\alpha_1 L$ by means of these two equations. In using this method, in spite of every precaution, taking into account the skin effect and eliminating as far as possible all disturbing causes, it frequently happens that the values found are inacceptable, the calculated values being in some cases even negative. There are thus certain cases where is it incorrect to apply Bjerknes' equation in this manner.

The same anomalies are noticeable if the calculation is made by means of the maximum and a near point on the resonance curve, and also by the method indicated by Bethenod ("Lumiere Electrique," Vol. VIII., p. 301, 1909). These results may possibly be explained by the fact that the Bjerknes equations were established on the supposition that the discharge of the condenser in the circuit was complete, which is not always, if ever, the case.

The calculation of the damping of antennæ is not such a simple matter, owing to the apparent resistance due to radiation (radiation damping) and to the difficulty of measuring the low resistances of earth connections. It is, further, important in practice to keep down the ohmic resistance of the circuits. In the installations erected by the military telegraphs, and which are used chiefly by the War and Navy Departments, direct excitation is employed, and the resistance of the connections from the exciting circuit is reduced as much as possible, these being made of wide strips of thin sheet copper. Bethenod's formula for the high-frequency resistance of conductors shows particularly that it is important to diminish $2h$, the thickness of the sheet. Finally, the mass of the sparking electrodes has been made considerable, with a view to avoiding overheating during prolonged working.

This construction of the circuits has rendered it possible to make the capacity greater, other things being equal, and, as a result, increased the power brought into play, with loose coupling and reduced damping. Poincaré has shown that the radiation decrement of an antenna composed of several wires increases with the number of wires and with decrease of the mutual induction between the wires, hence with increase of the distance apart of the wires; but since the volume which can be given up to an aerial in space is limited in practice, it is advisable to employ a sufficiently large number of wires, within limits.

The method of charging up the condensers is also of importance, not merely as regards the quality of the spark, but also as regards ease of reception of the transmitted signals. Telephonic reception having been almost exclusively employed of late years, the number of sparks and the kind of sound they produce are both of some importance. The majority of installations at present employ low-frequency alternating current which is stepped up for charging the condensers by means of resonance transformers. With such transformers liberally designed, both as regards the iron and the copper circuits, it is easy to obtain pressure rises of 6 and even of 10. The number of sparks is not equal to the number of alternations, and it is possible, by suitable means, to vary the number of sparks between 10 and 20 on alternating current of 40 or 50 cycles per second. The sparks being so few in number, each represents a considerable power. Arcing is, however, not so persistent, since the sparks are due to pressure rises; but still, in order to avoid formation of an arc, the electrodes of the spark-gap have been made in the form of large parallel cylinders; for very large powers these cylinders should be kept rotating. A more musical note is obtained by using a metal wheel provided with teeth and rotating between the electrodes of the spark-gap. This suffices for 1 kw. to 2 kw., but if a larger amount of power is employed the heating is too great and arrangements must be made to ensure that the spark always jumps from the moving tooth to a new spot on the fixed electrode. For powers of 6 kw. to 10 kw. the author, with Fracque and Brenot, has obtained good results using a discharger arranged in the following manner: On a circular copper cylinder 25 cm. in length copper rods are fixed radially, each passing perpendicularly through the axis of the cylinder (*see* Fig. 2), and being equally spaced angularly; 15 or 20 such rods are used. The cylinder is driven by an electric motor, the minimum tangential velocity of the ends of the rods being 50 metres per second. The sparks occur along the length of the fixed elec-

* Translated and abbreviated from the Bulletin de la Société Internationale des Electriciens.

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trodes *ee* as each rod on the cylinder arrives in turn at the position where the air-gap is smallest.

A well-sustained musical note is obtained with this device, although some irregularity is caused by the blank spaces which occur in the series of sparks, and which are unavoidable when low-frequency alternating current of 42 or 50 cycles is used. A somewhat similar discharger has been installed at the Sainte Marie wireless telegraph station by Petit, the engineer of the telegraphs department. The use of such dischargers is, however, not limited to the case of alternating currents, for Marconi has for several years past been using a rotating disc discharger with direct current at 10,000 volts.

Instead of employing low-frequency alternating currents, it is advantageous to use alternating current of higher frequency—300 to 1,000 cycles per second—so as to be able directly to obtain sparks of the required frequency for a musical note. Such arrangements have, in fact, been employed by von Lepel and by the Telefunken Co. Investigations along this line have also been made by the author with Fracque and Brenot. These have shown that it is impossible to obtain a musical note with the ordinary discharger, since the blank spaces occur just as with low-frequency alternating current. If, however, the discharger is made in the form of a point opposed to a disc, a good musical note is obtainable; the better the longer the spark, which has been used up to 15 mm. These experiments were made using special alternators furnishing current of 1,000 and of 400 cycles per second. With the latter the note *g'* (about 400 vibrations) can be obtained, and by diminishing the excitation *c'*, and even *g*. These experiments have as yet, however, only been made with reduced power.

As regards the reception, the use of slightly damped waves has rendered it necessary to find new detectors. These are now available in the shape of detectors operating in virtue of their unilateral properties or as solid electrolytic cells.

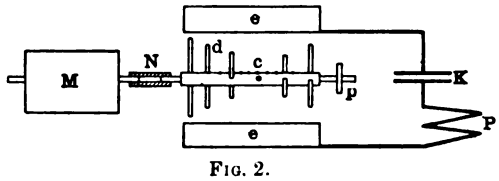

FIG. 2.

For still further safeguarding the receiver against disturbances caused by signals which are not intended for it, directive antennæ have been tried, with which a maximum intensity is obtained in a definite direction. One ingenious solution of this problem is that due to Bellini and Tosi, and this is being put into practical operation at Boulogne.

In conclusion, in spite of the inconveniences which radio-telegraphy still suffers from, but which may be expected shortly to be eliminated, the method finds every day new applications to the requirements of navigation, in the colonies and for home defence.

As an example, during the campaign in Morocco (January-September, 1908) all the official despatches of the expedition were transmitted from Morocco to Paris, or vice versa, by wireless telegraphy; from the interior to Casablanca by the field stations in communication with the "Kleber," and from Casablanca to Paris and inversely by the "Kleber" and the Eiffel Tower, the traffic reaching 3,000 words per day for the telegrams of the Ministry of War alone.

ELECTRICALLY DRIVEN REVERSING ROLLING MILLS.

At a meeting of the Institution of Engineers and Shipbuilders in Scotland some time ago, in connection with a Paper on this subject by Mr. C. A. Ablett, an important contribution to the discussion was made by Mr. T. B. Mackenzie. In view of the interest taken in this question at the present time we are pleased to be able to give the following account of Mr. Mackenzie's remarks:—

Since the first electrically driven reversing rolling mill was laid down at the Hildegardehütte Works, in Austrian Silesia, the matter has been very much in the minds of steel makers and their engineers, and has been the subject of several Papers, two at least of which have been by Mr. Ablett himself, and of a third he was the joint author. As I was one of a party of engineers and steelwork managers who visited the Hildegardehütte Works and saw the mill at work, it may be of interest if I put on record the leading particulars of the drive which was applied to a bar mill having four stand of housings, the rolls being 29½ in. diameter. The mill was originally driven by a twin reversing engine of the usual type, having steam cylinders 47¼ in. diameter, with a piston stroke of 49¼ in., the steam pressure being 90 lb. per square inch. On a vacant piece of ground beyond the engine was erected the electrical equipment, which consisted of three direct-current motors in series mounted on a shaft which was connected by an intermediate length with the mill. These motors had a normal capacity of 3,600 H.P., and a maximum of 10,350 H.P., and were capable of running up to a speed of 120 revs. per min. in either direction. The flywheel converter set consisted of a three-phase motor in the centre, of 1,500 kw. normal rating and 4,300 kw. maximum, operating on a 3,000-volt circuit with a frequency of 50 cycles. On each side of this motor was placed a flywheel 13 ft. in diameter, weighing 26 tons, and beyond this again the two variable voltage generators in series, each of 1,500 kw. normal and 4,300 kw. maximum rating, the E.M.F. of each varying from zero to 500 volts. The speed of the converter set was 300 to 375 revs. per min., a variation of 11 per cent. above or below the mean speed. There was also the usual exciter set, speed-regulating device, controller on driver's platform, switchboard, measuring instruments, &c., of a similar type to those described by Mr. Ablett. The whole equipment was able to take momentary overloads of 200 per cent. to run for half an hour with 75 per cent. and for two hours with 40 per cent. overload, and its cost was said to have been between £20,000 and £22,000.

At the time of our visit flat bottom rails weighing 90 lb. per yard were being rolled from 2-ton ingots, measuring about 17 in. square. Three stand of housings were being used, and 23 passes were given from the ingot to the finished rail, the total elongation being 27 to 30 fold. Of these passes, 14 were given in the cogging, 4 in the roughing and 5 in the finishing rolls. They were working at the rate of 20 tons per hour, but being short of orders the mill was only operated on the day shift.

To ascertain what power was being taken to roll the rails, and also to see what was being reflected back to the power station, we took 109 readings from the wattmeter at intervals of about 3½ seconds during the rolling of one ingot, and we found that the maximum input to the motor driving the flywheel converter set was 1,400 kw., the minimum 400, and the mean 1,050, being a fluctuation of 33 per cent. over and 62 per cent. under the mean. This is, of course, a comparatively small variation. Simultaneous readings were also taken of the amperes and volts of the variable voltage generators, showing that the maximum power taken by the mill was 4,800 H.P., the speed of the mill being 110 revs. per min. As the maximum power reflected back to the station was 1,875 H.P., the flywheels were absorbing peaks amounting to no less than 2,925 H.P.

As the mean power reflected back to the power station was 1,050 kw. and the output 20 tons per hour, energy was being absorbed at the rate of 52·5 kw.-hours per ton rolled. From published figures relating to this installation the energy taken from the power station is about 20 kw.-hours per ton when cogging and 25 to 60 when rolling bars, girders, rails, &c.

Electric energy to supply the whole works was generated in a power house situated near their blast furnace plant by three turbo-alternators, one being of a modified Parsons type and the other two of the Curtis type. The boilers were fired by waste gas from the blast furnaces. We were informed that, allowing for interest on capital expenditure, but charging nothing for the waste gas from furnaces, energy was being generated for 0·11d. per unit. The cost of electric energy to roll the above rails was, therefore, 5·8d. per ton. Taking £21,000 as the cost of the complete installation, and allowing 10 per cent. for interest and depreciation—and my experience enables me to say that with properly designed electrical plant of suitable size for the work no more is needed—we have £2,100 as the annual capital charge. This is equivalent to 4·6d. per ton, and added to the energy charge of 5·8d., gives 10·4d. per ton as the charge for power, but excluding wages of drivers and other attendants.

The operation of the plant was all that could be desired. The drivers of the old steam engine operated it from the start without the slightest hitch. The advantages of the drive from the purely engineering point of view are obvious: The torque is steady, thus reducing risk of breakdown; it is possible to tell how much power is being taken in each pass, thus enabling the roll designers to obtain the results required with the minimum expenditure of power; the consumption of oil is very much less than in a steam plant (indeed, I recently saw an electrically driven mill at work which has been running now for about 2½ years, and the managing director informed me that the original oil was still in the oil wells, it having only been necessary to take it out once and strain it); the whole control is performed with a single lever; the reversal is prompt; and there is no steam, oil, water and noise to cause annoyance.

From what I saw at Hildegardehütte and from all that I have been able to learn since, I am convinced that the electric driving of reversing mills has come to stay. It is, however, to mills of large output that it is most desirable to apply it, as with mills of smaller output the capital charges due to the comparatively high first cost of the plant are apt to be prohibitive.

I recently had occasion to compare the cost of driving a section mill, requiring, taking one section with another, about 20 B.H.P.-

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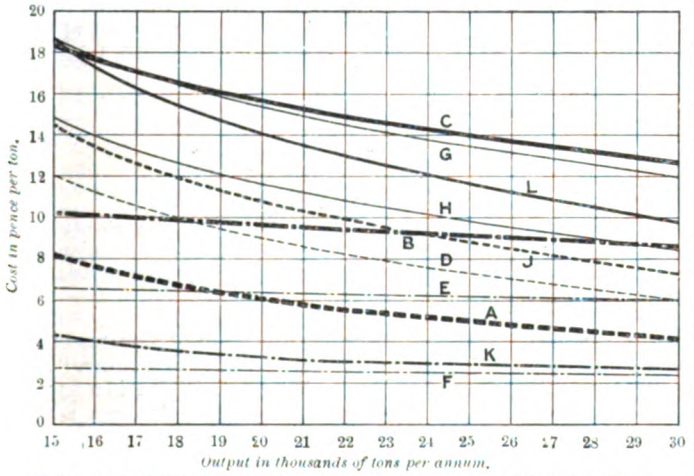
hours per ton of steel rolled, (1) with a compound condensing reversing engine, (2) with an all-electric reversing drive, and (3) with an electric reversing drive but with the motor of the flywheel converter set replaced by a mixed pressure turbine. As I am not at liberty to give exact figures, I will give others of about the same order of magnitude and preserving the relation of the amounts to each other. To enable the conclusions to be followed I will refer to Figs. 1 and 2, on which the steam drive is indicated by very thick lines, all-electric drive by thin lines and the turbo-electric drive by lines of medium thickness.

Compound Steam Drive.—A twin compound condensing reversing engine suitable for this mill with a barometric jet condenser, electrically-driven hot and cold water and dry-air pumps and cooling tower would cost about £5,000. Taking interest and depreciation at 10 per cent. gives £500 per annum as the capital charge. This is



Capital charge curves in dotted lines. Energy charge curves in chain dotted lines. Sum of above curves in full lines.

FIG. 1.

shown in curve A (Fig. 1) as a rate per ton between limits of output of 30,000 and 15,000 tons per annum, from which it will be seen that at 30,000 tons the rate is 4d. per ton, increasing to 8d. at 15,000 tons, the curve being a hyperbola.

The steam consumption of a compound reversing engine working under rolling mill conditions may be taken at 35 lb per brake-horse-power hour. With boiler plants such as are usually found in steel works and fuel at 6s. per ton, 100 lb. weight of steam can be generated for ¼d., including all boiler plant charges, interest, depreciation, upkeep, wages, fuel, water and the handling of the fuel and ashes. The cost of steam for the main engine is therefore 7d. per ton rolled. To this must be added the cost of current used to drive condenser pumps, say, 1·6d. per ton, bringing the energy charges to 8·6d. per ton. This may be taken as the cost at the maximum output of the mill, but will increase, as the output is reduced, since the rolls will be kept turning round waiting on billets, the condenser pumps will be

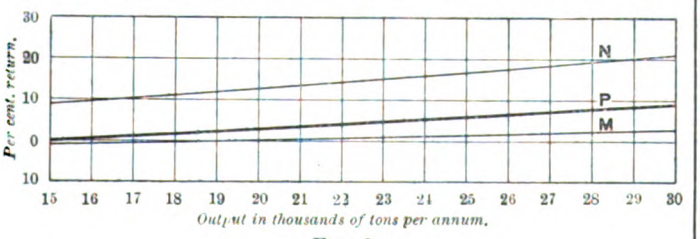


FIG. 2.

kept running full speed to maintain the vacuum, and as the condensation losses in the steam pipes depend mainly on the length and exposed area of the pipes these will also rise somewhat rapidly. We shall be about right if we assume the rate to rise to 10·2d. per ton at 15,000 tons output. This is shown by curve B (Fig. 1).

The sum of the capital and energy charges is shown on curve C (Fig. 1), and will be seen to be 12·6d. per ton at 30,000 tons, increasing to 18·2d. per ton at 15,000 tons output per annum.

All-Electric Drive.—The cost of a flywheel converter set with motor, flywheel, variable voltage generator, mill motor, exciter, speed regulator, controller, switchboard, measuring instruments, &c., will be, say, £7,500—that is, 1·5 times the cost of a compound steam plant. Taking interest and depreciation at 10 per cent. we get £750 as the annual capital charge. This, plotted as a rate per ton, gives curve D (Fig. 1), from which it will be seen that it amounts to 6d. per ton at 30,000 tons, increasing to 12d. at 15,000 tons output.

Taking the overall efficiency of the drive at 62 per cent., we get as input to the motor driving the flywheel converter set 24 kw.-hours per ton. This multiplied by the rate per unit will give the energy charges. I have plotted two curves, E and F, in Fig. 1, the former with current supplied at ¼d., the latter at $\frac{1}{10}$d. per unit. With current at ¼d. per unit, at which rate it can be produced in a fairly large power station using exhaust steam turbines working with the load factor customary in steelworks, the energy charges work out at 6d. per ton. This will increase, as the output diminishes, to 6·6d. per ton at an output of 15,000 tons. This is plotted in curve E. The sum of this and the capital charges is shown on curve G, from which it will be seen that the rate amounts to 12d. per ton at 30,000 tons, increasing to 15·6d. per ton at 15,000 tons output.

It will thus be seen that, with the maximum output assumed, the electric drive is 0·6d. per ton cheaper than steam, with an output of 20,000 tons they are equal, and at the minimum output assumed the electric drive is dearer than steam by 0·4d. per ton.

Suppose, however, that electric energy could be got for $\frac{1}{10}$d. per unit (which should be possible where gas engines using cheap power gas are employed); the energy charges will be as shown on curve F. The sum of curves D and F gives curve H, from which it will be seen that the rate per ton is 8·4d., increasing to 14·7d. at the minimum output. In this case the electric drive is cheaper than steam throughout the whole range.

Turbo-Electric Drive.—This plant has the highest first cost of all, as it only differs from the last in having a mixed pressure turbine substituted for the motor to drive the flywheel converter set, and in addition we require a heat accumulator, also a condenser with its pumps and cooling tower. The cost would probably not be less than £9,000—that is, 1·8 times the cost of the compound steam drive. The capital charges, plotted as before, give curve J (Fig. 1), from which it will be seen that they range between 7·2d. and 14·4d. per ton.

If enough exhaust steam could at all times be provided, no charge need be made for the energy to drive the turbine, as it would be covered by the capital charges on the plant. There would, however, be the current required for the condenser pumps. Under the conditions in which mills work, however, it is impossible to assume that exhaust steam alone would be sufficient to operate the plant, and some charge must be made for live steam. We shall probably be about right if we take rates of 2·6d., increasing to 4·2d., per ton as the cost of live steam for turbine and current for condenser pumps. This is plotted in curve K (Fig. 1). The sum of this and curve J gives curve L, from which it will be seen that the cost per ton is 9·8d. and 18·6d. per ton at the maximum and minimum outputs respectively. Compared with the steam drive there is a saving of 2·8d. per ton, decreasing to zero and becoming more costly by 0·4d. per ton at an output of 15,000 tons.

In Fig. 2 I have plotted the above savings in the rate per ton as a percentage return on the additional capital cost of the electric over the steam plant. With all-electric drive and energy at ¼d. per unit the return on the additional capital outlay of £2,500 is 3 per cent. at 30,000 tons, falling to zero at 20,000, and becoming 1 per cent. at 15,000 tons output, as shown in curve M. With energy at $\frac{1}{10}$d. per unit, the return is 21 per cent. at 30,000 tons, diminishing to 8·7 per cent. at 15,000 tons output per annum, as shown in curve N.

In the case of the turbo-electric drive, we have to earn interest on an additional capital expenditure of £4,000, and the return, as will be seen from curve P, is 8·8 per cent. at 30,000 tons, falling to zero at about 16,000 tons and becoming 0·6 per cent. at an output of 15,000 tons per annum.

The conclusion, therefore, which may fairly be drawn from the foregoing considerations is that for this particular mill, working under the conditions assumed, electric driving would only be commercially practicable with an all-electric drive, and then only if electric energy could be had for something under ½d. per unit. It must be clearly understood, however, that the diagrams I have plotted apply only to this mill, and cannot be taken as generally applicable. Each mill must, of course, be considered on its merits.

There is another conclusion which an examination of the curves leads to—viz., that the larger the output the better the case will be for electricity. Had it been possible under the conditions in which such mills work to increase the output considerably over the maximum I have assumed the turbo-electric drive would become a good commercial proposition, and even an all-electric drive with energy at ¼d. per unit might have been practicable. Indeed, I think it not improbable that we have been dealing in this case with the bottom limit of output at which it just begins to be commercially feasible to adopt an electric drive for a reversing mill.

It is difficult to estimate what must have been the cost per ton of rolling with the original steam engine which drove the mill at Hildegardehütte, already referred to. The first cost of the steam plant, including engine, foundation, pipe connections, &c., could not have

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been less than £6,000 erected complete, the annual capital charges on which are £600. With an output of 200 tons per shift, 11 shifts per week, and 50 working weeks per annum, the capital charges become 1·3d. per ton. If we assume the overall efficiency of this, the first reversing electrical equipment, to have been 5 per cent., the net power to drive the mill is 40 B.H.P.-hours per ton. A non-condensing reversing engine working under rolling mill conditions will not use less than 60 lb. of steam per brake horse-power-hour. The lowest rate which I have seen given as the cost of steam in Germany was 2 marks per metric ton, equivalent to 0·011d. per pound. The cost of steam is, therefore, 26·4d. per ton, which, added to the capital charges, gives 27·7d. as the cost of rolling with steam. We have already seen that the cost with electricity was 10·4d. per ton, a saving of 17·3d. per ton. With the output named this is equal to, say, £7,800 per annum, a return on the additional capital cost of the electric installation (amounting to no less than £15,000) of 52 per cent. The plant would, therefore, pay for itself in two years. This shows what can be done with a large mill and cheap electric energy, and it is only fair to add that if it had to be laid down to-day, with the experience which has since been gained, the first cost could be materially reduced.

The great advantage of electric driving being that it is easy to ascertain exactly what power is required for each section rolled, to ascertain, therefore, the cost of rolling any section a good way would be to have two diagrams plotted, one to show the capital charges (abscissæ being, say, tons per shift and ordinates rates per ton). A hyperbolic curve giving the capital charges for the whole mill equipment drawn across the diagram would enable the capital charges to be ascertained for the particular output wanted. The other diagram would have abscissæ and ordinates as before, but in this case there would be drawn across the diagram a series of curves giving the product of kilowatt-hours per ton into rate per unit for current. Then running up from the output to the appropriate energy curve the rate per ton would be read on the vertical scale. The sum of these and the wages charges per ton would then give the cost of rolling that particular section.

It is worthy of remark that in Germany, where the flywheel converter drive has been most extensively used, it is to mills of large output that it is applied, such as cogging, billet, rail and girder mills. In one case I saw outputs given of 60 to 70 tons per hour, which, as the curves on the diagrams prove, would be eminently suitable for the purpose, and very substantial savings might be expected. German steel works are (in the case of the larger ones at any rate) mostly equipped with blast furnaces, and as Germany may almost be said to be the home of the large gas engine, there can be no doubt that they are in an exceptionally good position to obtain cheap power. I fear, therefore, that we must admit that our German competitors in the world's markets are in many cases able by their more skilful utilisation of waste energy to roll their steel at lower rates for power than usually obtain in this country. This we cannot allow to continue. A beginning has certainly been made in Britain with the electrification even of reversing mills. At the works of Sir Alfred Hickman a 30 in. cogging and a 24 in. bar mill are so driven, and at the works of the Skinningrove Iron Co. there is a 36 in. cogging mill. The energy for these is generated, I believe, by gas engines using blast furnace gas. Messrs. Dorman, Long & Co. have a 28 in. cogging mill and a 16 in. bar mill, the energy for which is taken from the mains of the local power company. As experience is gained others are certain to follow.

The method of driving rolling mills described by Mr. Ablett in his Paper is not yet very old, and I venture to hope that considerable improvement will be effected, not only to reduce the cost but to increase the efficiency. An over-all efficiency of 62 per cent. surely admits of this. One method of reducing the cost is referred to by Mr. Ablett, where one converter set is used to drive the motors of two mills. We in the steelworks will at the same time have to try and reduce the cost of electric energy. One mode of doing this will be to utilise the heat in the large volume of gases that go up the chimneys of the open hearth furnaces. Some attempts were made in the past by interposing boilers between the furnace valves and the chimneys, but they were abandoned because the draught of the furnaces was interfered with. This difficulty could, I believe, have been easily got over by the adoption of some form of induced draught to draw the hot gases amongst the water tubes of the boilers. It would possibly also be better to generate the steam at low pressure so as to have a better heat gradient between the temperature of the waste gases and the water in the boilers. The steam from these boilers would then be used for turbo-generators.

In my opinion, however, it is to the gas engine that we must look for the real solution of the cheap power problem, and as patents expire and more engineers take up its manufacture we may expect considerable improvements not only from the thermo-dynamic standpoint, but also from that of first cost and freedom from breakdowns. I believe that in the steelworks of the future there will be no reciprocating steam engines at all. The whole of the fuel will be converted into gas, partly, no doubt, in blast furnaces, but also in gas producers, the ammonia will be extracted and the purified and washed gas used both for heating and for power; the steam necessary to saturate the air-blast and fix the nitrogen being generated partly, as I have suggested, by the waste heat from the open hearth furnaces, and partly by the heat in the exhaust gases from the engines themselves. The whole of the power for the works will be generated in a central station and distributed electrically to the various mills and auxiliary machinery about the works. The large reversing mills will be driven either in the manner dealt with by Mr. Ablett in his Paper, by some improved type of flywheel converter, or by the method proposed about a year ago by Messrs. Brown, Boveri & Co. But the medium and smaller mills will, I think, be three-high driven by continuous running motors, as the first cost of any system of driving them electrically as reversing mills will, I fear, at all times be prohibitive.

TESTS ON MICA TUBES.*

BY DR. K. FISCHER.

Summary.—Comparative tests are given showing the superiority of a new type of mica tube containing no paper and practically no binding material. Such tubes, being of mica alone, give very high electric disruptive results.

It is a known fact that the resistance of insulating materials depends partly on their purity and partly on the temperature. The breakdown voltage usually falls considerably with an increase of temperature, and mica is the only material which does not act in this way. It is not easy to work it up into tubes on account of its brittleness, and large pieces cannot be used owing to its high price. Consequently, in making micanite tubes, a good deal of paper is incorporated along with suitable binding material, and this makes it possible to turn out tubes of even thickness and smooth surface having, of course, a much lower breakdown voltage than if they were made of mica alone.

The firm of Meirowsky & Co. has made successful attempts to do away with the use of paper and binding material, and the following is a description of their methods and results. Thin plates are built up out of mica leaves by the addition of some binding material, the thickness of the plates being as uniform as possible. The plates are wound on one another under pressure until a tube of the desired thickness is obtained. The combination of a high pressure with a high temperature tends to drive out the small quantity of binding material, and the whole is compacted into a mass resembling a layer of solid mica. The tubes are then heated for several hours, until the last traces of the foreign substances are removed.

A number of these tubes have been tested in the firm's laboratory at Ehrenfeld according to the usual methods. The inside of the tubes is filled with iron rods, projecting from both ends, and the outside is covered with tinfoil, which, however, is kept at a sufficient distance from the ends. The temperature on the outer surface of the tube is taken by a thermometer, the bulb of which is wrapped in a piece of tinfoil and covered on the outside with a strip of felt. The maximum temperature is not reached till after one or two hours in some cases. The results of the tests are given in the following table, which shows the thickness of the tubes, together with the applied pressure and other particulars. Out of the 108 tubes which were tested, 13 broke down within the hour at temperatures very similar to those given in column 4; the remainder survived till the end of the test, which was limited to one hour. The temperatures were in many cases very high, and from these figures it seems possible to apply pressures in the neighbourhood of 15,000 or 18,000 volts per millimetre to the tubes, when they are at a temperature between 150°C. and 200°C. Such high temperatures are impossible in practice for various reasons; still, it is interesting to note that the figures show the likelihood of a possible improvement in high-pressure machines and apparatus. In so far as the tubes themselves are concerned, it is evidently possible to leave considerations of temperature out of account. It might perhaps be possible with enamelled wire to use smaller sizes in the construction of machines, and to obtain the same efficiency, and the designer may well find something alluring in the fact that these tubes can be used to withstand working pressures up to 7,500 volts per millimetre.

In order to compare the improvement which these tubes show when compared with similar products the curves herewith are given. Curves 3 and 4 are for tubes known under the name of "Pertinax,"

* Abstract of an article in the "Elektrotechnische Zeitschrift."

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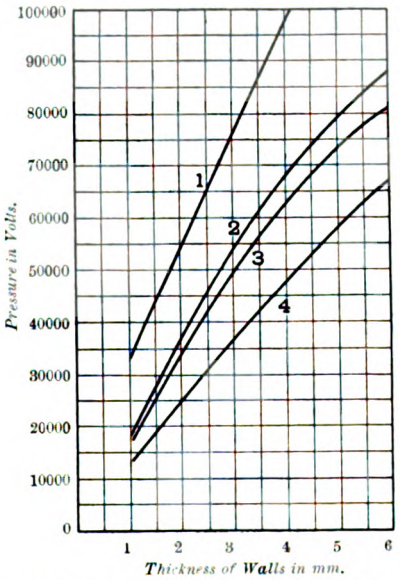
Tests on Improved Form of Mica Tubes.

Thickness of the walls in mm.	Applied voltage.	Temperature at beginning in degrees C.	Temperature at end in degrees C.	No. of tubes tested.	Duration of test in minutes.
1·0	15,000	18	90 of 95	4	60
1·0	18,000	18	110 ,, 115	4	60
1·5	18,000	18	95 ,, 110	4	60
1·5	21,000	18	108 ,, 132	4	60
1·5	25,000	18	128 ,, 136	4	60
1·5	28,000	19	155 ,, 170	4	60
1·5	30,000	19	162 ,, 178	4	60
1·5	33,000	20	170 ,, 225	4	60
2·0	33,000	20	185 ,, 205	4	60
2·0	35,000	20	198 ,, 218	4	60
2·0	38,000	20	235 ,, 290	4	60
2·5	35,000	20	125 ,, 145	4	60
2·5	38,000	20	146 ,, 152	4	60
2·5	40,000	20	159 ,, 168	4	60
2·5	43,000	20	170 ,, 182	4	60
2·5	45,000	20	198 ,, 205	4	60
2·5	48,000	18	190 ,, 225	4	60
3·0	50,000	20	158 ,, 164	4	60
3·0	53,000	20	167 ,, 171	4	60
3·0	55,000	22	178 ,, 205	4	60
3·0	58,000	22	195 ,, 225	4	60
4·0	58,000	22	156 ,, 167	4	60
4·0	60,000	22	180 ,, 185	4	60
4·0	63,000	22	210 ,, 230	4	60
5·0	65,000	22	150 ,, 165	4	60
5·0	68,000	...	185 ,, 194	4	60
5·0	70,000	22	210 ,, 280	4	60

constructed of paper impregnated with resin. Curve 3 is for the tube at ordinary temperatures, and Curve 4 for 80°C., the difference between the two being about 20 or 30 per cent. That for micanite is shown in Curve 2, and there is no sensible difference up to 80°C., the same being true for the pure mica tubes, which are the subject of this article and are shown in Curve 1. The surface of these mica tubes is very smooth and even, much more so than in micanite



BREAKDOWN VOLTAGES FOR TUBES OF VARYING THICKNESSES AND MATERIALS.

Curve 1.: Pure mica tubes at 80° C. Curve 2.: Micanite tubes 80° C.
Curve 3.: Pertinax tubes (cold). Curve 4.: Pertinax tubes at 80° C.

tubes of the usual construction; discharges due to unevenness of surface are, therefore, much more unlikely. When struck they emit a metallic sound, and are much stronger than other tubes. These qualities may be very useful in simplifying the construction and windings of high-tension alternators. It is becoming very usual to adopt the American plan of winding the coils in the tubes, and then mounting the complete thing in position on the machine, for which it is evidently necessary to use material capable of resisting a certain amount of rough handling. The mica tubes answer these purposes perfectly well. They can be made quite smooth and uniform with walls only 0·75 mm. thick, being composed in this case of convolutions consisting of very thin plates.

A TELEPHONE RELAY.*

BY S. G. BROWN.

Summary.—The author describes the present form of his telephone relay, which depends on the variation in resistance of a microscopic air-gap. This relay will magnify the very feeblest telephone currents about 20 times. He also describes an electric stethoscope which promises to lead to important developments in medical practice.

This relay is the outcome of six years' study, but has only been brought to its final form during the last eighteen months. Ever since the introduction of the telephone a real need was felt for a telephone relay when it was discovered that the distance over which telephones could be used was comparatively limited. Many inventors have worked on the problem, and it has been declared by eminent telephone engineers to be insoluble. Edison, soon after his invention of the carbon button transmitter, caused an electromagnet to act upon the iron diaphragm and thus turned it into a relay, but it was not a success. Hughes, in his Paper before the Royal Society in 1878, stated that a telephone receiver, if included in the microphone circuit and placed upon the resonant board, caused a continuous sound to be produced. Sir Oliver Lodge, in a Paper read in December, 1898, before this Institution, described a relay, consisting of three or four reeds or tuning forks, each carrying carbon contacts and working in series with one aonther. Each reed was arranged to resonate to one particular musical note, and when this note was passed through the string of relays, it was multiplied in power to a considerable extent. An instrument of this character, however, is not effective in intensifying speech. The invention of the powerful granular

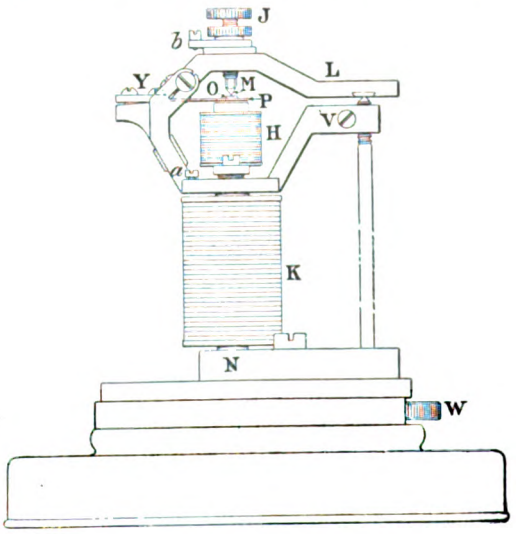


FIG. 1.—SIDE VIEW OF RELAY.

transmitters of the Hunning type stimulated further efforts to obtain the speaking relay, and some progress was made with this type of microphone, particularly in America. These relays, however, are only partially successful, and require relatively powerful currents to work them.

The author's telephone relay has had to be developed along quite new lines. It takes as its basis the researches of J. J. Thomson, Earhart, Kingsley, and others, with regard to the flow of electrons across a microscopic air-gap between two conducting surfaces at different potentials.† Earhart made a series of experiments on the difference of potential required to produce sparks whose length is comparable with the wave-length of sodium light, and he found that when the distance between the metal electrodes falls to less than about 3×10^{-4} cm. the spark potential falls off rapidly with the distance, and seems to become proportional to the distance—that is to say, when the electrodes are placed very close together, within a distance such that the average intensity of force F between the electrodes reaches a value of about a million volts per centimetre, the discharge or current passing is determined by the condition that F, which is V/d, reaches this value (where V is the P.D., and d the distance between the electrodes). If the metallic circuit of a dry cell be interrupted by a minute opening or space of the order of 5×10^{-7} cm., the metal at the point of interruption being platinum, the current will continue to flow round the circuit and across the opening, and any slight alteration in the length

* Abstract of a Paper read before the Institution of Electrical Engineers.
† *See* "Conduction of Electricity through Gases," J. J. Thomson, Chap. XV.

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of the space, which I shall call the conduction space, will vary its resistance and greatly affect the value of the current that flows round the circuit. This conduction space is therefore exactly what is wanted for the current-varying device of a telephone relay, where microscopic mechanical movements are to be transformed into large current changes. The dimensions of the conduction space are so small that it is difficult to ensure and maintain it by direct mechanical means. The current that flows across the space was therefore made to do its own adjustment, very much in the same way as the current that passes through the arc of an arc lamp is made to strike and maintain the length of the arc.

Fig. 1 is a side view of the instrument with the brass cover removed. N is a permanent magnet, continued by soft iron poles right up to but not touching the "invar" steel reed P. Round the soft iron pole extensions are wound the two sets of coil windings H and K. The telephone currents to be magnified circulate round the winding H and thus by varying the magnetism set the reed P in vibration. M O are the top and bottom metal contact-pieces, which are opened to an infinitesimal degree to form a microphone by the fine adjusting screw W and by the action of the local current passing through the contact and round the winding K. It is by the action of the local current

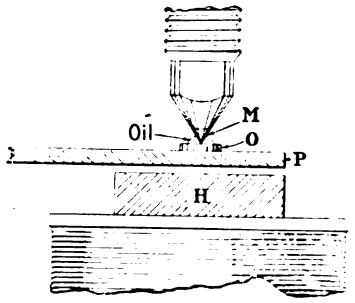

Fig. 2.—Enlarged View of Reed and Contact Pieces.

operating through this winding that the conduction space is formed and afterwards maintained. So good is the automatic adjustment that the instrument may be turned upside down, producing hardly any noticeable alteration in the value of the local current and without any effect on the working of the relay. The regulating winding K must not act when traversed by the rapidly varying telephonic currents—that is brought about by surrounding the iron under the coil by a closed circuited copper sheathing. Eddy currents set up in this sheathing by mutual induction destroy the self-induction of the coil.

Fig. 2 is an enlarged view of the reed P and the contact-pieces MO. In the present instrument the contact is made between metal pieces of hard osmium-iridium alloy. The top contact is pointed, the lower one is flat and is soldered to the reed, both are polished and work under a small drop of thin oil. In earlier instruments the lower contact O was carried by a thin iron disc, the relay was then very sus-

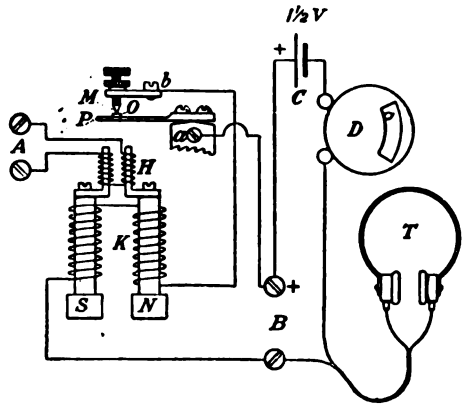

Fig. 3.—Diagram showing Connections of Relay.

ceptible to outside noises. For this reason a reed is now used, it exposes such a small surface to the air that it is practically unaffected by extraneous sound. Fig. 3 shows the connections of the relay. C is a dry cell (this is the normal voltage, which is as high as it is desirable to employ), K the low resistance regulating winding, T the receiving telephone or telephone head-piece of approximately 40 ohms resistance, D is an ammeter; when the microphone contact is opened so as to cut down the local current to half its maximum value the relay is usually at its best adjustment. The telephone currents to be magnified enter by the terminals marked A and circulate through the winding H.

The relay will magnify the very feeblest telephone currents. Speech or signals that are too faint to be heard in the ordinary Bell receiver may be heard clearly through the relay. This property of magnifying feeble telephone currents has made it particularly useful in wireless telegraphy. On replacing the telephone by the relay the increased sensitiveness thus obtained doubles the distance over which it is possible to receive signals. Its utility in this direction has been tested among others by the Admiralty and the Post Office. The relay is not easily affected by extraneous noises and vibration. It

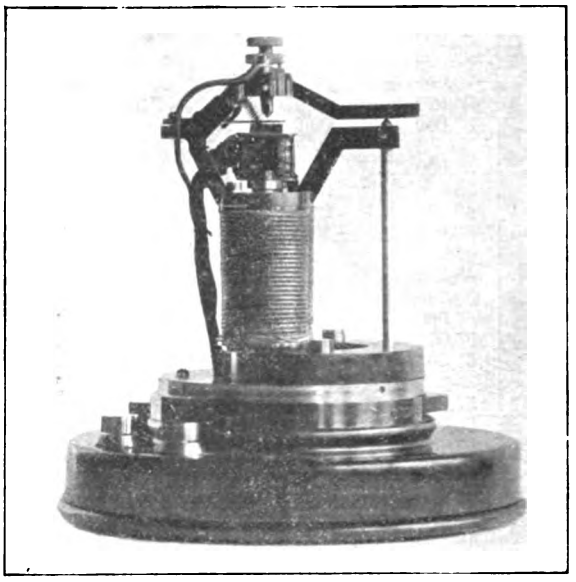

Fig. 4.—Telephone Relay.

can thus be carried on board ship and worked in all weathers. As regards its utility on ordinary telephone lines, speech may be magnified many times in loudness without perceptible loss in the articulation, and it will work with large currents to a point at which the Bell receiver in its local circuit is responding with uncomfortable loudness. Experiments prove that the telephone currents must be increased in strength to the extent of something like 20 times. If still greater magnifications are required, the simplest method would seem to be to employ two relays working in tandem. Their combined power would then be 400 times. In the majority of cases it is not necessary to add to the natural electrical damping of the reed, but if a piece of soft rubber be made to touch it, the voice can be transmitted with greater clearness even than if the conversation were taking place ordinarily in a room. This may be due to the complete absence of echoes. Fig. 4 gives a view of the relay.

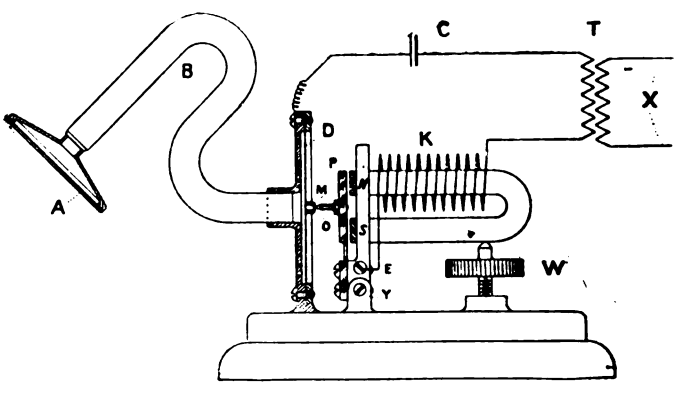

Fig. 5.—Diagram of Electric Stethoscope.

By means of the local regulating winding (Fig. 2) the metal contact MO is transformed into the most exquisitely delicate microphone, more sensitive, there is every reason to believe, than could be formed by light pressure between carbons. Such a microphone has rendered possible the construction of an electric stethoscope, an instrument by the use of which the sound of the heart or other internal organs may be greatly magnified. This, I have been informed, may render it possible to detect in the earlier stages, heart disease, aneurism and gall stones. Figs. 5 and 7 show the stethoscope. A (Fig. 5) is a shallow brass cell faced by a thin ebonite diaphragm, and is placed upon the part of the body to be examined, say the heart; the beating

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of the heart is communicated to the ebonite diaphragm, then to the air inside the tube B, and thus the metal diaphragm D is set in vibration. MO, as before, are the osmium iridium contact-pieces. M is mounted on the diaphragm, and O on the steel reed P. The magnet NS and the reed are carried by a brass frame E, which is pivoted or hinged at the lower support Y. The conduction space is formed between the contacts MO by turning the fine adjusting screw W, and by the automatic action of the local current from the cell C flowing through the winding K and round the magnet. T is a special telephone transformer of equal windings of, say, 20 ohms resistance in the primary and in the secondary. The electric stethoscope in its present form causes the sound of the heart to be three times as loud as in the ordinary stethoscope. This is scarcely sufficient for practical purposes. But if a telephone relay, such as I have described, be attached to the wires X of the transformer, the two instruments combined raise the intensity of the sound some 20 times and more, and this is ample for all ordinary purposes. At the invitation of two physicians I took the complete instrument to the London Hospital, where it was tested upon a number of diseased heart cases. The sound of the beats given out in the telephones was uncomfortably loud, and easily heard by the patient and all those that stood round, and this even if the telephones were in position on the head of the operator. The stethoscope as used increased the heartbeats to the almost complete exclusion of the shriller or breathing sounds. This has been brought about by mechanically tuning the disc D and the reed P of the telephone relay to the corresponding low note, and by a proper proportioning of the volume of air enclosed by the tube B.

I come now to a subject that it is interesting me greatly—it is still a matter of experiment—the production of a clear and loud-speaking transmitter. Such an instrument would give considerable comfort to the subscriber, and might save hundreds of thousands of pounds worth of copper for the companies. I am under the impression that the carbon transmitter has been developed to its full extent, ceaseless efforts having been directed to this end by the engineers of the large telephone companies. To make progress towards an ideal transmitter, carbon had, therefore, to be abandoned, not because of any serious defect in its microphonic qualities, which are good, but because of its bad conducting power. It would not transmit enough energy. One must pass much current in order to speak loudly, and a material was wanted that not only would conduct well, but would change its resistance to pressure more readily than carbon. I am pleased to say that I have discovered something that carries out my wishes well in both of these directions.

During some experiments with the telphone relay, attempts were made to dispense with the regulating winding and form the microphone by the mere pressure of the electrodes one against the other as with carbon. With gold, platinum, palladium, and rhodium, it was not possible to do so. On the contrary, a microphone could be formed by light pressure between the following: Iridium, ruthenium, osmium-and osmium-iridium alloy. They are arranged advancing in the order of their effectiveness, which is likewise the order of their hardness. With iridium the action was only just shown, while osmium-iridium alloy makes a microphone that can carry large currents, stand high temperatures, and is exceedingly sensitive to small changes of

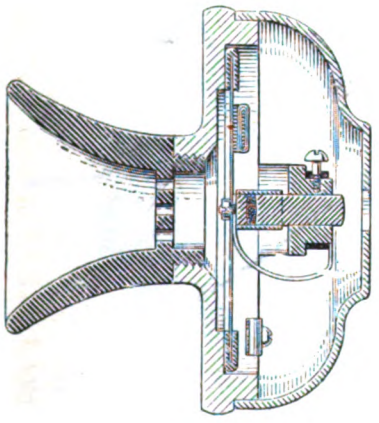

Fig. 6.—New Transmitter.

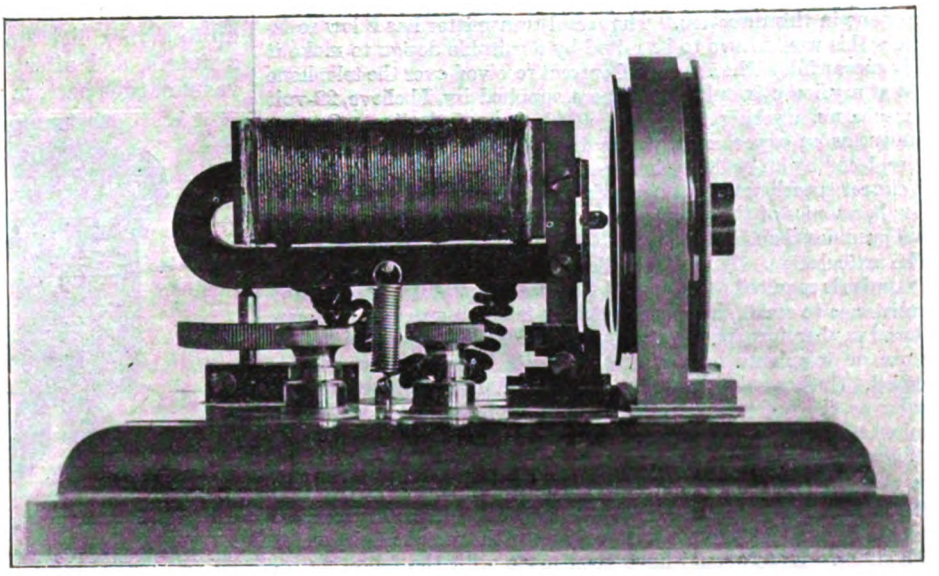

Fig. 7.—Electrical Stethoscope.

On other occasions, during private experiments, the instrument has been tuned so that nothing but the breathing sounds were audible. This power of discrimination should be of service in allowing the independent examination of various organs of the body. Replacing the telephone head-piece by a transformer, the stethoscope has been joined to the telephone service in my house, and for the sake of experiment, the sound of the heart has been transmitted over several miles of telephone line to doctors and friends in various parts of London. All reported that the sounds received in the telephone were as loud and clear as when heard locally. The line, therefore, does not appear to produce much loss or distortion. This trial proved that it is now possible for a specialist in London to examine a patient, say, in the country, stethoscopically, and to arrive at a correct diagnosis.

In consequence of its sensitiveness the apparatus is padded and guarded as far as possible from all outside disturbances, and the patient should be examined in a quiet room. If the instrument is provided with a small funnel in place of the tube B, it will pick up and magnify the slightest sound, and ordinary speaking may be increased to a deafening shout in the telephone. Such an instrument, when properly constructed for the purpose, may be of use to those who are afflicted with deafness. The relay has been used on the electrophone system, and by its aid, damping the reed with a piece of rubber, the speaking and music from the theatres are rendered with loudness and greater clearness than it is possible to have on the telephones supplied by the company, and by adding a loud speaker with trumpet the sounds can be heard in the room.

pressure. This alloy is by far the best of the whole series, as it is the hardest, and although expensive, can be readily purchased as natural grains or granules, sifted to any desired uniform size. As regards the effectiveness of carbon, I should be inclined to include it in the series between iridium and ruthenium. The chemical properties of carbon, ruthenium and osmium have likewise much in common, in that they resist the action of all acids, and are carried off as a gas by oxygen when strongly heated. Ruthenium and osmium are of little value for microphonic purposes if purchased in their commercial form as grains or powder. The grains must be first fused into a bead and then crushed into granules. This may account for the failure of previous experimenters who, in their endeavour to compete with carbon, tried nearly everything that could be mentioned, including ruthenium and osmium, but without success.

Several "solid back" transmitters have been taken and altered in various ways to make use of the new metal. In one case the ordinary carbon electrodes were entirely removed and replaced by sheet iridium-faced ones $\frac{3}{16}$in. in diameter; these electrodes were separated by a distance of $\frac{1}{20}$ in., and the space between was nearly filled by 3 grains weight of very fine granules of osmium-iridium kept in place by a rubber tube. This new transmitter would take permanently a current of $\frac{3}{4}$ ampere from a 2-volt accumulator. It was connected to the telephone service through a large transformer, which had a low-resistance primary of only $\frac{1}{10}$ ohm. The ordinary carbon transmitter, supplied in the usual way from the central battery, was kept in position in series for purpose of comparison. The results of several trials were as follows: Speaking on both occasions

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with equal force, first, directly into the mouthpiece of the carbon transmitter, secondly 12 in. away from the mouthpiece of the metal transmitter, the same volume was given in the receiving telephone. When the new transmitter was spoken into at a distance of 3 in. the sound was two or three times louder than is at present normal, and when spoken into directly, the sound at the far end was uncomfortably loud and the voice could be heard with ease 3 yds. away from the receiver. In all cases the articulation was clearer and crisper with the metal than with the carbon transmitter.

The first difficulty to contend with occurred after the instrument had been in use some months. This was a gradual weakening of the power of transmission, which was eventually found to be due to the iridium faces of the electrodes becoming superficially oxidised. To remedy this the iridium has been replaced by gold, which so far has proved satisfactory. Another improvement was to cone inwards the faces of the gold electrodes; this is to prevent the granules from unpacking, as they had previously a tendency to do when worked between plane faces.

An osmium-iridium granular transmitter has been constructed embodying all these later improvements (*see* Fig. 6); the electrodes have a diameter of $\frac{1}{4}$ in., and it will work permanently with 1 ampere at 2 volts. When joined to the telephone circuit and spoken directly into, the distant receiver will respond with overwhelming loudness. Such an instrument could be fitted in subscribers' premises where long-distance telephony was much in use, and distances could be spoken over, which at present offer considerable difficulties. As most of the transmitters in London are supplied with current from common or central batteries at the exchanges, it would be important to adapt the new instrument to this system, but up to the present nothing has been done in this direction. The metal transmitter has a low resistance; this would have to be raised by a suitable design to make it really successful. The amount of current received over the telephone wires at my house is only 0·06 ampere, supplied by, I believe, 22-volt accumulators, working through the 360 ohms of the line. On one occasion, as an experiment, the central battery carbon transmitter was replaced by an ordinary low-resistance metal one, and at the far end clearer speech was obtained, which was as loud as before. The upper harmonics of the voice are more faithfully transmitted by the metal granules than by the carbon—this accounts for the superiority in the articulation. A much smaller quantity of the metal powder or granules is required as compared with carbon, and its sensitiveness in resistance to small changes of pressure is much greater; the new material is, therefore, peculiarly adaptable for the purposes of a relay for use on telephone lines where moderate magnification only is required. Such a relay has been constructed using osmium-iridium powder as the resistance varying medium; it is simple in design, requires no adjustment, and so far gives a moderate magnification with good articulation.

APPENDIX.

Referring to the telephone relay, the efficiency of the microphone for speech transmission depends largely upon the metal employed for the contact. Experiments have been made with the following results: The metal must be unoxidisable. Thus materials like brass and aluminium are useless. If they partially oxidise like steel and silvers the magnifying power is small. With the following, good results were attained: Pt, Pd, Rh, Ir, Ru, Os, and osmium-iridium alloy. Carbon has been tried for one or for both of the contact-pieces; the magnifying power is then smaller than with the metals, and less current can be sent through, due to its greater specific resistance. Gold, due to its complete absence of surface oxidisation, makes an unstable contact, and the relay will buzz, very much after the fashion of an electric bell, under all ranges of adjustment. (Soft pure gold makes the best contact for an ordinary relay of any material that I am acquainted with.) Even with the metals of the platinum group the relay can be made to buzz by cleaning the contacts with a cloth, but stability of working can be again secured by oxidising the surface, by exposure to the air, or, what is much better, by applying thin oil to the surfaces of the contact. The nearer the relay is to this buzzing point the greater its sensitiveness; it is therefore advisable to clean the contact so as to obtain the buzzing action and to stop the action by the application of a small drop of thin oil. The harder the contact metal used the clearer the speech through the relay. With soft platinum the higher harmonics are more or less absent, but with osmium-iridium the articulation is quite clear and crisp.

Microphones are sometimes liable to produce faint bubbling and squeaking sounds; this is due, I think, principally, to want of hardness in the contact-pieces, especially if the upper bruises the lower piece. This sound can usually be stopped by shunting through a suitable resistance the winding of the telephone circuit. A microphone formed between two hard metals can touch only in one spot. As half the energy liberated from the local battery is normally dissipated at this point, the rise of temperature there may be very considerable. This heating puts a stop to any great handling of power by a single contact. For these reasons it is not advisable, with the normal voltage to pass more than, say, $\frac{1}{4}$ ampere; if the current is too great the sensitiveness will decrease with time; but if the current is kept small, say of the order of $\frac{1}{10}$ ampere, the delicacy may be perpetually maintained. It is fortunate that the harder varieties of the platinum group are the ones that are able to stand the higher temperatures.

Reference is finally made to some rough tests of a special form of the author's telephone relay and to the fact that there is still much to be done before the two-way repeater is practicable.

AERIAL TELEPHONE LINES ON THE PUPIN SYSTEM.*

NOTES ON A PAPER READ BY A. EBELING.

BY B. S. COHEN.

Summary.—Particulars are given of the loading adopted on various overhead telephone lines in Germany; and of the results obtained. Some particulars are also given of the cost of loaded lines and the financial results to be expected from such lines.

Dr. Ebeling describes the result of tests made by Messrs. Siemens & Halske assisted by the State Post Office. One of the earliest troubles experienced in the application of Pupin coils to aerial wires was the destructive effect of lightning. Owing to the necessity of maintaining the insulation of the line up to a very high standard, it was decided to employ earthed arresters, and after some experience bridged arresters of the vacuum tube pattern were adopted, and these were so arranged

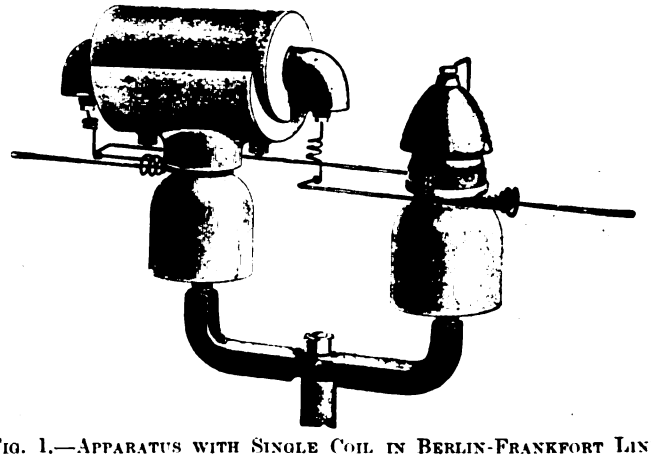

Fig. 1.—Apparatus with Single Coil in Berlin-Frankfort Line. (First nstallation.)

that if the glass tubes were shattered by the discharge the electrodes would come into contact, thus completely short-circuiting the loading coil.

These arresters have been found to protect the coils perfectly, even in cases where the lightning discharge has been strong enough to fuse the line wire. All the earlier equipments consisted of separate inductance coils in the A and B wires of the loop. The first line loaded was between Berlin and Frankfort-on-Main. This line was 580 km. long, and a 2·5 mm. bronze line was used with coils spaced at 5 km. The coils had an effective resistance of 8·7 ohms and an effective inductance of 0·11 henry. The average insulation of the loaded line was about 10 megohms, and consequently leakage played a negligible part in the attenuation.

The loaded line could be compared with a 4 mm. line 580 km. long run on the same poles and a 5 mm. line which took a slightly different route and was 540 km. long.

The relative transmission values of these lines observed by test confirmed the calculated values embodied in the following table.

It should be noted that the conductor termed bronze on the Continent nearly corresponds to the hard drawn copper used in this country. For example, the 2·5 mm. line has a resistance of 7·7 ohms per kilometre loop when unloaded and a

* Dr. Ebeling's Paper was read before the "Elektrotechnischer Verein" and was published in the "E.T.Z."

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Line.	Effect. res. in ohms per km.loop.,	Inductance in henrys per km. loop.	Mutual capacity, mfds. per km.	Attenuation constant, a.
5·0 mm. bronze	1·92	$1·86\times10^{-3}$	0·0063	0·00176
4·0 mm. ,, ...	3·00	$1·94\times10^{-3}$	0·0060	0·00262
2·5 mm. ,, without coils...	7·70	$2·14\times10^{-3}$	0·0055	0·00591
2·5 mm. ,, with coils	11·18	$46·10\times10^{-3}$	0·0055	0·00193

2·5 mm. English copper line has a resistance of 7·1 ohms per kilometre loop, or very little higher conductivity than the German bronze conductor. The loaded 2·5 mm. line corresponds to an unloaded 4·7 mm. line.

The following is a comparison of the attenuation lengths of the lines given in the previous table :—

Line.	Attenuation length, al.
5·0 mm.	0·95
4·0 mm.	1·52
2·5 mm. without coils	3·43
2·5 mm. with coils	1·12

Dr. Ebeling considers an aerial line to give good talk when $al=1·5$ and sufficiently practical talk if $al=2·5$. The limit of practical audibility is taken as being $al=3·5$ to 4·0.

It is interesting to note that when the terminal loops connected to the loaded line were so short that considerable reflection loss was experienced terminal transformers were inserted to diminish the reflection effect.

Measurements were carried out on the Berlin-Frankfort lines using a dynamometer. A constant sending current of 8·8 milliamperes at frequencies ranging from 600~ to 1,800~ was used.

Fig. 2.—Lightning Arrester without Heavy Current Protector.

Fig. 3.—Lightning Arrester with Heavy Current Protector.

The results, however, are stated to have been unsatisfactory, which was only to be expected, seeing that the sending current was excessive and the dynamometer was unsuitable, as it had an effective resistance of 400 ohms and an inductance of 0·4 henry.

A number of experiments were also carried out using a form of bolometer, but as the particular instrument used was considerably more insensitive than the dynamometer no improvement in the accuracy of the results was obtained.

Turning now to the mechanical details of the Berlin–Frankfort equipment, Fig. 1 illustrates the single coil mounted on a porcelain insulator, together with the vacuum tube protector.

Fig. 2 shows the vacuum tube protector without the outer case, which is itself shown in Fig. 3. This outer case is in halves, and has serrated edges, and in the event of the glass fracturing the halves are brought into contact, thus short-circuiting the loading coil. Fig. 4 shows apparatus mounted on pole.

Berlin–Stralsund Bimetallic Line.—After the Berlin–Frankfort line had been equipped and tested it was decided to equip a bimetallic line, *i.e.*, a copper-covered iron line, with Pupin coils, for further experiments, and the existing Berlin–Stralsund line, 240 km. long, of 4 mm. bimetallic wire, was chosen. The coils, at 4 km. intervals, were fitted in pot-shaped porcelain cases (Fig. 5), while the lightning protectors remained the same as before. This new form of coil pot was resorted to because the Berlin–Frankfort apparatus was not perfect from a mechanical point of view.

This line also showed a great improvement in speech after fitting with coils.

Hamburg–Konigsberg Bimetallic Line.—The 920 km. 5 mm. bimetallic line between Hamburg and Königsberg was then equipped with coils, using the same apparatus. The talk on

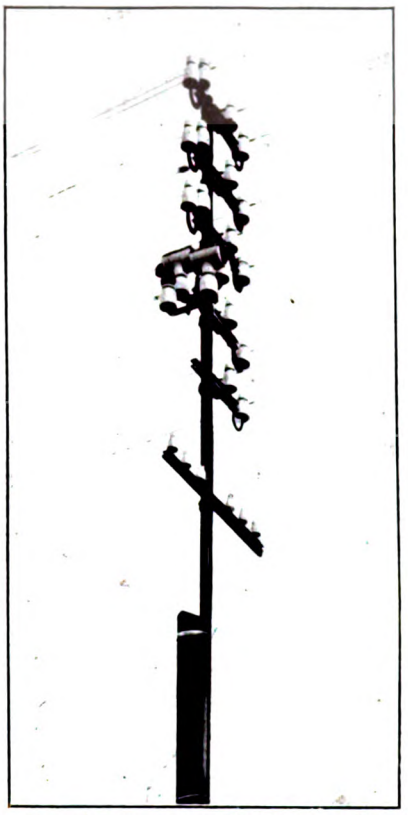

Fig. 4.—Single Coil Apparatus in Position on Berlin-Frankfort Line. (First installation.)

this line without coils may be considered equivalent to a 3 mm. bronze line. This line, however, was much affected by disturbances from high-speed telegraph circuits, which were run on the same poles. The loaded line was, therefore, first transposed at intervals of 500 metres, and this, whilst appreciably reducing the disturbances, did not remove them altogether. The principal source of the disturbance was then traced to a

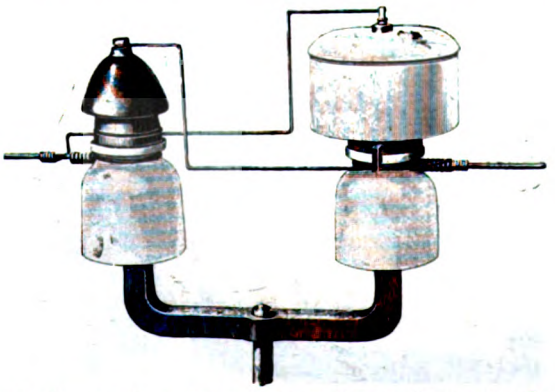

Fig. 5.—Single Coil Apparatus on Berlin-Stralsund Line.

Siemens rapid telegraph line, and considerable improvement was effected by inserting inductance into the line in order to reduce the peakiness of the telegraph waves. The loaded line was naturally more susceptible to disturbance than the unloaded line, owing to the greater transmission efficiency of the former.

A second equipment was now carried out on the Berlin–

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Frankfort line with coils mounted in a similar manner to those on the Berlin–Stralsund line. Although greater efficiency was reached than in the case of the earlier equipment, the mechanical details were still found to be imperfect. During the cold winters of 1906 and 1907 a considerable proportion of the porcelain caps were cracked, from which bad contacts and the introduction of moisture into the cases resulted.

A third equipment was therefore installed on the Berlin–Frankfort lines. In this equipment the weight of the apparatus was considerably reduced, and the coils were placed in metal cases which were completely soldered up. Separate coils were still used for the A and B lines. Fig. 6 shows the apparatus mounted on the pole, and Fig. 7 gives the details.

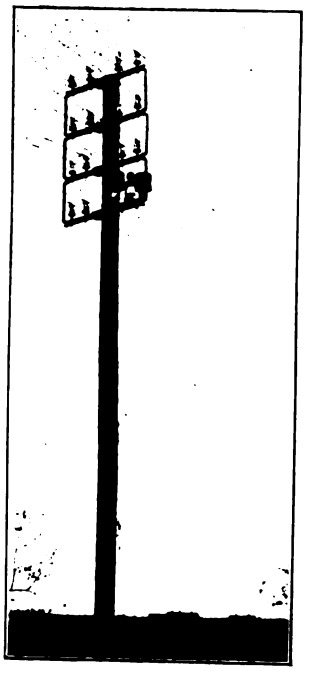

Fig. 6.—Single Coil Apparatus with Lightning Protector on Separate Insulator in Position.

The coils had a mean inductance of 0·105 henry and a mean effective resistance of 5 ohms. The calculated attenuation constant was 0·00176, which implied that the 2·5 mm. loaded line would be equal to a 5 mm. unloaded line, and this was found to be borne out by practical test. A further series of tests was carried out by a special speech method devised by Prof. Breisig, the details of which are not given. Comparisons were made of the loaded line against 5 mm. and 4 mm. unloaded lines, and 200 km. of 2 mm. line was connected to the end of the line under test, so that when the loaded line was tested the reflection losses would be reduced to a minimum. The attenuation length *al* of the 200 km. of 2 mm. line was 1·8. The following table gives the results of this test :—

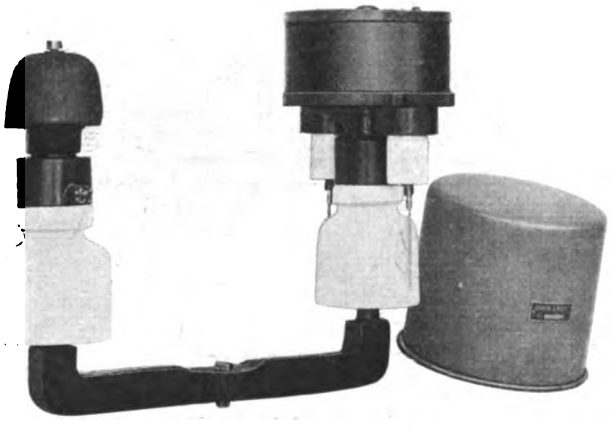

Fig. 7.—Single Coil Apparatus with Metal Cover Removed.

Lines.	*al* observed.	*al* calculated.
5 mm. + 200 km. 2 mm.	2·9	2·8
4 mm. + 200 km. 2 mm.	3·3	3·3
2·5 mm. with coils + 200 km. 2 mm. ...	3·4	2·8

It will be noticed that the observed value of the loaded line is equivalent to the observed value of the 4 mm. unloaded line. Tests were also made on the loaded line with and without the unloaded terminal line, but these appear to be contradictory, as the observed result should have been better when the loaded line is terminated by the unloaded line, and the reverse of this appears to have actually been the case. Without further details, one is inclined to attribute the error to the method of making the test.

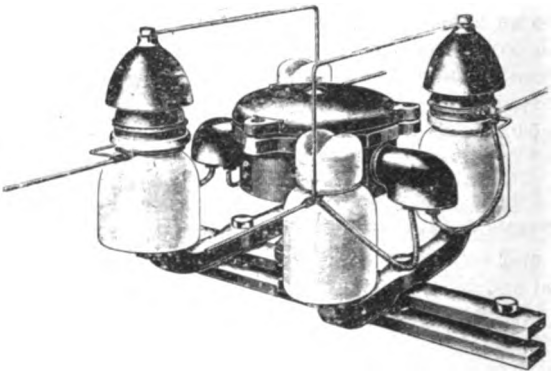

Fig. 8.—Experimental Double Coil Apparatus with Separate Lightning Protectors on Berlin-Magdeburg Line.

The Berlin–Frankfort line has now been working with the new apparatus for about a year without the least mishap, although the line has gone through the thunderstorm period of last summer and the cold period of last winter.

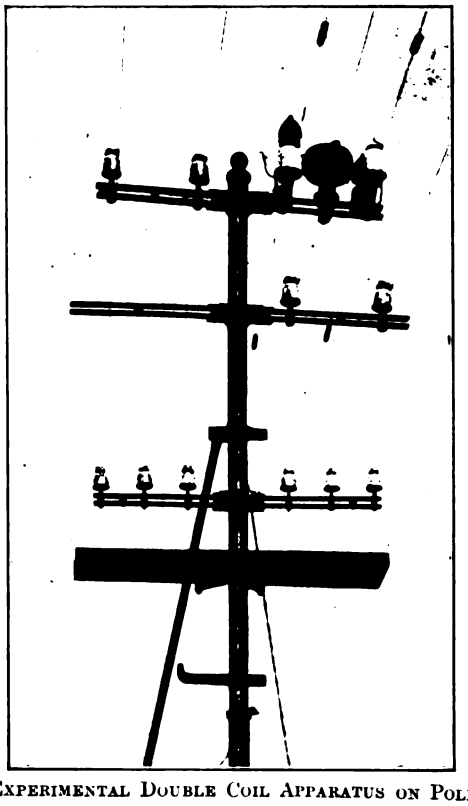

Fig. 9.—Experimental Double Coil Apparatus on Poles, Berlin-Magdeburg Line.

Dr. Ebeling refers to a series of tests made by means of an oscillograph, which appeared to confirm the improvements obtained in practice. He gives no further particulars, however but states that further tests are required. It was now decided to equip some lines with double coils—*i.e.*, coils having the two windings for the A and B lines wound on one core.

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After the Berlin Magdeburg line previously referred to had been reinstalled for some considerable time with double-wound coils, which gave satisfactory results, the use of double coils was generally adopted. Fig. 8 shows the complete apparatus as now used, with the coils enclosed in metal case, and Fig. 9 the same apparatus mounted on the pole.

A considerable number of these coils have been employed by the Austrian Government and also by the Royal Prussian Railway.

In one district, where in the summer of 1908 very violent storms occurred, not a single coil was damaged by lightning. The Paper concludes with a consideration of the economic value of loading aerial lines.

Dr. Ebeling first points out that a 3 mm. bronze line loaded is at the least equal to a 4·5 mm. unloaded line, allowing for reflection losses. Then, as 1 kg. of bronze costs 1·70 marks,

1 km. double line of 3 mm. bronze costs	220 marks.
1 km. „ „ 4·5 mm. „ „	500 „
Saving by using 3 mm. bronze	280 „

The price of coils when spaced 8 km. apart is about 50 marks per kilometre, so that 1 km. of 3 mm. loaded line costs 270 marks. Approximately, therefore, the loaded line costs half that of an equivalent unloaded line.

With a 600 km. loaded line of 3 mm. bronze, therefore, the saving would be about 138,000 marks (£6,900).

The Paper was followed by a discussion, which was not published at the time these notes were made.

This Paper is of considerable interest, as it gives a very good idea of the progress made in Germany in the loading of overhead telephone lines. The experiences of others in the loading of overhead conductors has led to the general conclusion that the insulation of the lines must be maintained at a decidedly high figure and doubt has even been expressed in some quarters as to the possibility of maintaining lines at a sufficiently high insulation in a damp climate to enable the advantages of loading to be realized. It is permissible, however, to infer from Dr. Ebeling's Paper that no special difficulty from low insulation has been met with in Germany.

THE APPLICATIONS OF ELECTRICITY TO FIELD ENGINEERING.*

BY COL. R. E. B. CROMPTON, C.B.

The applications of electricity to field engineering may be divided into three heads: first, for army signalling, which, when electricity is used, has advanced through the various forms of the telegraph, field telephone and, last, but most important, that of wireless telegraphy. The second is its application as a ready and convenient means of producing light, either in large units for searchlights or projectors, or in smaller units for carrying on operations by night, or for lighting field hospitals. The third is that by which the electric transmission of power can be made available for providing power plant at points where such is needed in field operations. Among these may be mentioned pumping plant for field water supply, power for driving machine tools in field workshops; and it is probable that at no distant date electro-chemical developments might be made available for the purification or sterilisation of water supply, and for other sanitary or hygienic purposes.

On the question of the field telephone some personal experience in the South African War may be useful to record. When studying the equipment for the working of the field searchlights it was decided to take out a certain number of bicycles, on which could be mounted reels carrying wire which, it was hoped, it would be possible to lay on the veldt as a convenient means of communication between the generating plant and projectors. It was found, however, that such a short length of insulated wire could be carried that a few miles of very fine uninsulated No. 22 gauge copper wire was taken out on reels, and this was found to be unexpectedly useful, for the surface of the veldt was rarely insufficiently dry to insulate this wire, so that it was possible to obtain audible speech through the Swedish cavalry pattern field telephone equipment up to distances of several miles, and what was still more unexpected, although these circuits were frequently interrupted by stray cattle, or by vehicles cutting the wires and dragging the several ends some distance apart, it was found that it was still possible to get audible speech through the very considerable gap at these points of fracture, and that the speech was very good when the two ends, although separated, had been dragged for some little distance, as was usually the case, so that the few yards of wire close to the fractured ends were practically parallel to one another. This fact is mentioned, for it shows how easy it was to provide a very simple means of telephone communication by carrying on ordinary bicycles reels of wire weighing only 20 lb. or 30 lb. The radius of action of this equipment would, of course, be greatly increased if the modern motor bicycle were used. Under such conditions great lengths of this same wire could be carried, and there is no doubt that improvements can be made in the condenser portion of the transmitting and receiving apparatus, which no doubt was the cause of our being able to obtain audible signalling through such considerable air gaps.

As regards wireless telegraphy, during the manœuvres which have taken place during the last two or three years, the author has paid close attention to the working of the Muirhead equipment, which is the one that has, up to the present, been used both by the Royal Engineers and by the Wireless companies in London, under Colonel Bain, and has formed an opinion that this wireless equipment is capable of very great further development in the direction of making the transmitting and receiving stations entirely self-contained and self-propelled, in other words that each station should consist of one or possibly two motor cars, carrying the generating and transmitting machinery, and also supporting the poles or antennæ or other means of keeping stretched the transmitting and receiving wire.

After referring to the early history of electric lighting, and to the difficulties attendant on the use of glass mirrors owing to gun fire—a difficulty which was overcome by mounting on springs the Mangin mirror—the lecturer said that the use of projectors was rapidly extending for naval purposes, and also at defended ports where large searchlights were fixed in emplacements so as to enable the approach of the enemy to be observed during the darkest nights whether as a fleet, squadron, single vessel or even torpedo boat.

At the time of the South African War, however, the problem had to be faced not only of making the searchlights or any other artificial lights we might wish to use conveniently portable, but also to devise the simplest method of generating the current required. Eventually it was decided to employ small traction engines; these drove dynamos by belts, the dynamos being mounted on brackets fixed in front of the smoke box. This arrangement was used in connection with the projectors which, towards the latter end of the war, were mounted in fixed positions at various points in the Transvaal and the Orange Free State, and did good service in sweeping the veldt with a strong beam. They were also very effective in assisting to protect some of the collieries on which the supply of coal for Army purposes depended, and no doubt the employment of the searchlights on the headworks of these collieries enabled the defending force to be greatly reduced. Probably the main reason why the projectors themselves were so seldom at first employed in field work, was that the engines and dynamos were found so useful for supplying electrical energy for lighting purposes for the reinstatement of bridges, for certain deviation work on the railway reconstruction, and, most important of all, at points where stores required to be transhipped by night from the railway to the A.S.C. waggons, that the three sets of engines and dynamos were always at work and could not be spared for work admittedly experimental in connection with projectors.

The proper position of a searchlight emplacement in respect to the guns the firing of which it is intended to aid, is a problem which has been much discussed, and on which very varying opinions still obtain. Personally the author is against fixed lights. He believes that artillery fire at night can be rendered most effective by the searchlights being movable, along a certain track in a covered way parallel to the front to be defended, the position on this track being communicated by signal from the officer directing the artillery fire, who again is informed by the gun layers which positions give them the best sight of the fairway and of the enemy's approach. At any rate, he believes that as far as we know the best practice for placing searchlights in defended positions is not in fixed emplacements, but that covered ways should be provided along which several of the searchlights can be easily moved and directed, in the manner above described.

In the early days searchlights, both on land and sea, were provided with inclined lamps; at sea these at first were nearly always hand worked, but on land, in a few cases, they were provided with automatic means of maintaining the length of the arc, but the lamps taken out to the Cape were automatic and provided with horizontal carbons, and this arrangement has since been practically universally adopted. The lamp now used by the Admiralty, and designed at Chelmsford, is the same pattern as the lamps designed

* Abstract of a lecture delivered at the Royal Engineers' Institute, Chatham.

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and used in South Africa. Much improvement has been made in the mirrors. The Mangin mirrors were very effective, but very heavy. Their weight threw the whole projector out of balance, and Parsons, Chance and others in this country produced glass mirrors of much less weight and quite as effective. Just about the time of the war Cowper-Coles invented the palladium-faced metallic mirror, and some of these mirrors were taken to the Cape in addition to those of the usual glass pattern. Mr. Parsons also distinguished himself by improvements in methods of grinding parabolic mirrors, and succeeded in getting short focus mirrors to work, which

FIG. 1.—36 IN. MILITARY PROJECTOR.

were far more effective than the long focus spherical mirrors which had been hitherto used, and further than this he devised methods by which a beam could be projected through a narrow vertical slit, such as a porthole, the searchlight itself and the men working it being thus protected from the enemy's fire.

The latest thing now under discussion are the gold-faced mirrors, which have been introduced here and abroad, and which, although they are slightly, that is to say about 5 per cent., inferior to silver-

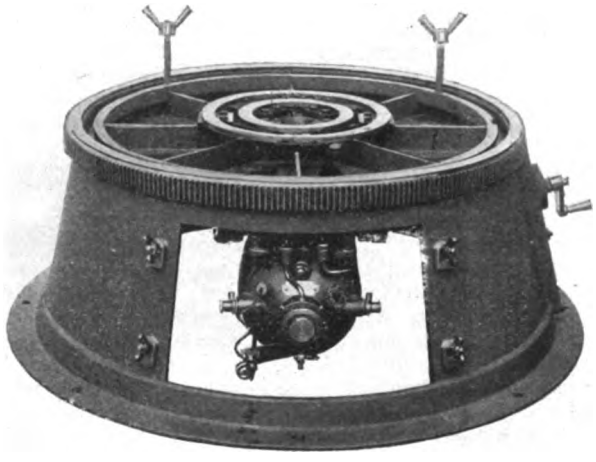

FIG. 2.—BASE OF 36 IN. ELECTRICALLY CONTROLLED PROJECTOR, SHOWING TRAVERSING MOTOR.

plated mirrors when both are equally well polished, yet the gold preserves its surface, and hence its reflecting power. so much better than silver, that after a few hours' exposure the gold-plated mirror has the advantage.

Recently a good deal has been done in the perfecting of searchlights for naval purposes. They have been made automatic, all movements worked electrically and controlled from the bridge, and a great deal has been done to render them easily dismounted, and taken below during daylight hours.

As has been already pointed out, after all the means of rapidly and economically producing artificial light for night operations at railhead or other railway reconstruction works, reconstruction of bridges or of deviations is probably the most important use for electricity in field service. The equipment at the Cape was of the crudest description, and while valuable experience was gained with it, as far as the author is aware no attempt has been made to standardise or to reproduce in a more permanent form the very crude systems of derricks, poles, cable reels and other appliances which are necessary for these methods of lighting.

One of the difficulties met with in working field searchlights, as well as in working the detached installations, was the great weight of the cables that have to be handled. This was because low-pressure current was used. All the searchlights were arranged in parallel, consequently the currents dealt with were large. It is evident that for the future it would be far better to standardise all the cables so as to be of the right section to carry about 10 amperes, and to generate at about 1,000 volts. To arrange small arc lights for depot lighting purposes in series circuits, and for searchlight or for lighting by means of incandescent lamps to use motor transformerr to bring down the 1,000-volt to a working pressure of 80 voltss which is a convenient one to use at the terminals of the lamps of the searchlight. Although this arrangement was fully worked out and laid before Army Headquarters at the time, as far as the author is aware it has not been acted on. Even at that time there would have been no difficulty in placing the motor transformer, that was

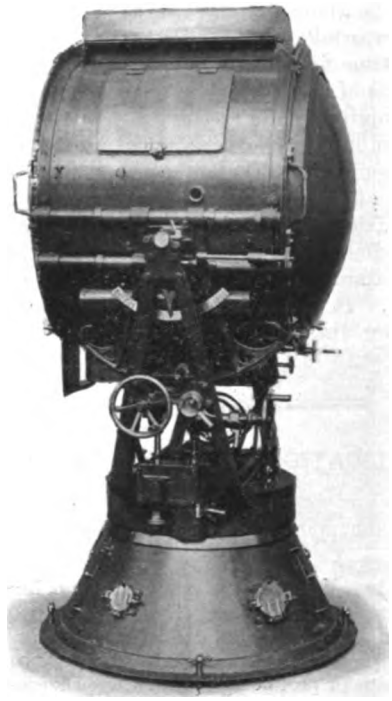

FIG. 3.—36 IN. ELECTRICALLY CONTROLLED PROJECTOR.

then necessary, on the limber of the searchlight. In these days of auto-transformers the matter can be very much simplified. Not only is the transformation effected with one revolving armature, but the ratio of pressure transformation can be varied through very wide limits. The author is therefore justified in thinking that the current for the field searchlight equipment should always be generated in such a manner that the cables need only be of a size to carry 10 amperes, and that the transformation be effected at or near the point of employment.

It is obvious that the two great commercial developments of arc lighting which have taken place during the last few years, namely, that of enclosed arc lamps with the reduction in the size of the unit, and the great reduction in the labour of re-carboning, and again for larger units the use of flame arcs, will both of them be advantageous for the lighting of such night operations as were found necessary in South Africa. But for other uses, such as those that are about to be described, the metallic filament lamps which are now being so rapidly introduced will also take their part. Artificial lighting by means of incandescent lamps was found of great use in the field hospitals. Many difficult and dangerous surgical operations were able to be carried on during the night, and life was thereby saved, and everywhere it was generally admitted that the work of our great field hospitals was greatly helped by our being able to fit them with electric light throughout.

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Towards the latter period of the war two or three systems of defence lighting using incandescent lamps were used. It was found that it was possible to fit up wire entanglements and other spots, at which it was desirable to have early notice of the approach of the enemy, with incandescent lamps which were so screened and directed and controlled that the sentry on hearing any noise could switch on a particular circuit of lights at some distance from himself which thus enabled him to locate a scout or spy endeavouring to obtain access to the defended position. This use of artificial lighting for the defence of fixed posts deserves further working out.

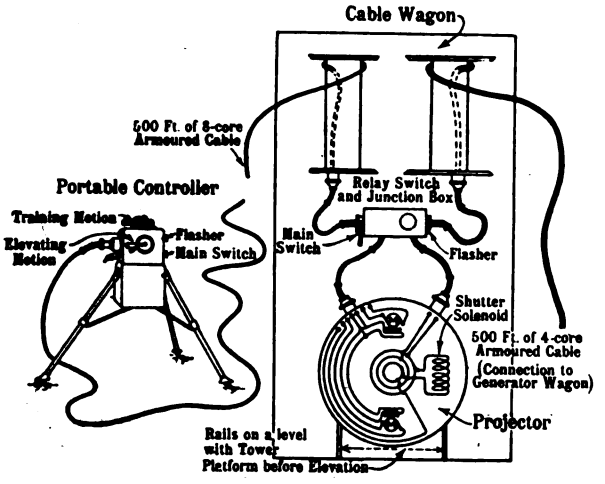

FIG. 4.—DIAGRAMMATIC ARRANGEMENT OF CABLE WAGON AND CONTROLLER FOR MILITARY PROJECTOR.

The third group, namely, the use of electric transmission of power, has not as yet been taken at its full worth. The fact that power can be supplied by overhead or buried cable to considerable distances from the generating source will no doubt enable many operations demanding the use of power to be carried on in isolated redoubts or other defended posts. It is hardly necessary to enumerate the number of such applications. Many defended posts are placed on high ground where the water supply is very difficult to obtain, and where hitherto it has been found necessary to send horse-hauled water tanks under escort, either daily or at frequent intervals of time. In such cases pumping plant could be installed

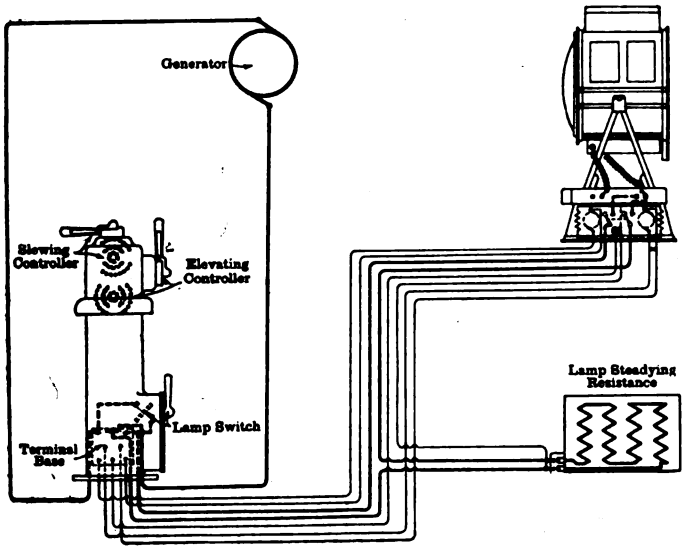

FIG. 5.—DIAGRAM OF EXTERNAL CONNECTIONS FOR ELECTRICALLY CONTROLLED PROJECTOR.

on the low ground, water supplied under pressure through small pipes, and the power transmitted by wire from a generating source. The same power, of course, would be very useful for driving the well-boring machinery which has now become a regular part of the field equipment of a modern army. It is evident, also, that the enormous increase of mechanical appliances that must be carried by the modern army demands that the means of repairing or replacing damaged parts by spare parts should be carried on at a point as near to the front as possible—in other words, that the floating workshops that now accompany our fleets at sea must be imitated on land by portable workshops forming part of the engineer's park; but the ready way in which electrical power can now be applied will enable the engineer's park to contain machine tools and thus enable repairs and renewals to be carried out in a way that was quite impossible when hand power only was available.

Although it is practically certain that great developments will take place in the direction of electric transmission of power to aid the field engineer, up to the present little has been done, mainly for the reason I have shown, that it is only since the Russo-Japanese War following on our own South African War that we have realised the very large part that electric lighting must take in field operations. As I have shown, the equipment for lighting has been very insufficiently considered, but as soon as it is considered and provided, the power and other uses which I refer to in my opening remarks are sure to receive further development.

Probably the best means of instantaneously generating the electrical energy required for field operations, whether for searchlights, incandescent lighting or transmission of power, would be by using tractors or motor waggons fitted with electrical transmission apparatus. There are several forms in use, the Thomas system being one which appears particularly suited for the purpose. The power unit, in this case an internal combustion engine, drives a generator directly coupled to its crankshaft, and the torque required to propel the machine is communicated through a motor and the Thomas system of gearing. The system is one which lends itself to ready disconnection of the generator and motor as transmission apparatus to work as one unit for generating energy for external use either for lighting purposes or for transmission of power.

In the course of the lecture a number of interesting photographs were thrown on the screen, showing the development of the searchlight from the earliest days, and especially the types used by the men of the Electrical Engineers (London Division) during the South African War. Just recently portable searchlight sets have been designed and made by Messrs. Crompton & Co. for a foreign government which embody the ideas enunciated in the above Paper. The accompanying illustrations show one or two types of modern searchlight and the way in which they can be controlled from central points.

AUTOMATIC PROTECTIVE SWITCHGEAR FOR COLLIERY SERVICE.*

BY E. B. WEDMORE.

Summary.—The author discusses the arrangement of trip coils and the discriminating action of automatic leakage devices in mines. He also refers to armouring and the earthing of the neutral point of three-phase generating plant.

In making any comparison between alternating and direct-current systems, there is an inherent difference which materially affects leakage problems. Should one pole become earthed on a direct-current system, the generating plant serves to maintain a constant, positive or negative charge on the other pole, the charge on the whole system remaining stationary. On an alternating-current system, however, owing to the repeated alternation of polarity, if one pole were to become earthed at any point, the generating plant would alternately charge and discharge the whole system through that point. This charging current serves to screen any change in the insulation resistance of the system, and on high-tension systems of any magnitude increases the risks arising from leakage. The recommendations embodied in this Paper apply principally to alternating-current systems, and the discriminating devices in particular are suitable only for alternating-current service.

On a completely insulated three-phase system, complete protection can be obtained by the use of automatic switches having tripping devices connected in two only of the three conductors. Where the mid-point of the system is earthed, a fourth conductor, namely, the earth, comes into use, and serves as a return conductor in case the insulation between one conductor and earth breaks down; therefore, in this case a tripping device is inserted in each phase, so as to obtain complete protection. This arrangement gives equal protection against overloads, faults between phases and faults to earth.

On high-tension circuits it is customary to employ current transformers to excite the trip coils; and where this is done it is possible, by a simple artifice introduced by the writer, to obtain independent control of the adjustments for operation on overloads and on leaks to earth. This consists (*see* Fig. 1) in the transfer of one trip coil

* Abstract from the "Transactions" of the Institution of Mining Engineers, by permission of the Council, of a Paper read at a meeting of the Midland Institute of Mining, Civil, and Mechanical Engineers, on December 5th last.

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from the usual position into a return circuit common to the three current transformers. This coil will then be operative only on faults to earth, and the other two will take care of all overloads or faults between phases. By the use of this device independent control is obtained of the adjustments for operation on faults to earth and on overloads. For example, the overload coils at 1 and 2 may be controlled by a delaying device adjusted to operate on a sustained overload, but to prevent the switch from operating on a momentary overload. At the same time, the third trip coil may be adjusted to operate instantaneously on a leakage current of less than normal load.

Mr. Robert Nelson's suggestion * consisted substantially in the provision of devices capable of automatically disconnecting feeders in case of a small leak. By the use of a sensitive relay at point 3, the protection required is obtained without the use of the special transformer, carrying all three conductors, previously suggested for this service. Where a sensitive relay is employed, it is necessary to

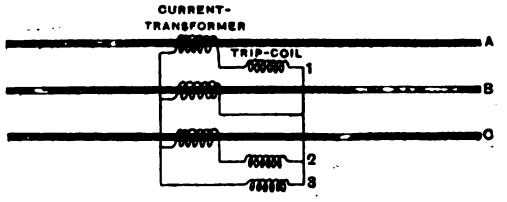

FIG. 1.

ensure similarity of the three current transformers, as otherwise, say, on a momentary overload, a current would flow in the relay, representing a spurious leak. This current, due to internal differences, is kept within limits by using a form of overload device which normally makes no demand on the current transformer. This takes the form of a trip-coil shunted by a low resistance fuse (Fig. 2). Where relays are employed, the oil switches are operated by trip coils excited off any convenient source of supply, preferably independent of the alternating-current supply, such, for instance, as the exciter circuits or a small battery. Where individual motor or other circuits are furnished with a low-voltage release, this may be utilised for the purpose, the relay short-circuiting the winding; and a current limiting resistance is used in series, as shown in Fig. 3. When installed in this way, the use of leakage devices involves a minimum of addition to the usual equipment. The current transformers provided for the usual instrument equipment serve also for the automatics, and the relays—only one of which is required on each three-phase main—are the principal addition.

Should such a device be installed on any feeder, any leak to earth, not only in that feeder, but in any distributing circuit fed by that feeder, will be effective in cutting off the supply. It may be argued that, in the case of a bad "fall" the immediate disconnection of electric supply from that part of the mine is justified; but such a course cannot be contemplated in case of a leak developing, say, on the terminal board of a small motor. The writer proposes to overcome this difficulty by the use of leakage devices in series. To render this arrangement effective, some discriminating arrangement is necessary, as a leak on any one motor will affect all the devices in series, right back to the generating plant. This may be obtained

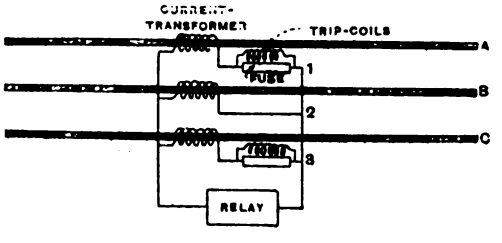

FIG. 2.

by grading the settings of the leakage devices, using a fine setting for individual motors, a heavier setting for branch circuits, and a still heavier setting for the main feeder. In the rare event of a heavy fall or other accident causing sudden and extensive damage to a cable or other device, one cannot guarantee discriminating action. Tests have shown, however, that discriminating action can be obtained in some measure in the majority of instances of severe damage, even on high-tension systems; whilst on systems of medium voltage the shut-down is confined to the damaged circuit in nearly every instance.

The author next gives particulars of various tests carried out on some cables supplied by Messrs. Callender's Cable & Construction Co., Mr. R. Nelson (H.M. Electrical Inspector of Mines) being present at some of the tests. The cables were laid on a hard foundation of iron blocks, and in some instances were deliberately placed across the sharp corners of the blocks. Damage was caused in three ways:—(*a*) By dropping on to the cable, from a height, a 15 cwt. pug intended for breaking up heavy castings; (*b*) by repeated blows with a heavy hammer; (*c*) by the use of a blunt cutting tool, driven home with a heavy hammer. These tests show the rapidity with which the relays operate and their ability to discriminate with only a small difference in the settings.

Next, as to the important question of reduction of risks from explosion and fire, a number of comparative tests have been made, firstly with leakage relays in use, and, secondly, without such relays. In order that fire and smoke might issue, it was found necessary to

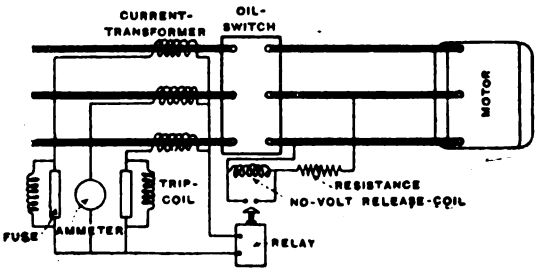

FIG. 3.

damage the cable very severely, and the most effective means proved to be successive blows of a heavy hammer. When the relays were not in use, smoke and flame issued in several instances; but in no case was it possible to produce any sign of flame, or even of smoke, when the relays were in service. The arcing would have been more marked, especially in the case of the 500 volt cable, if the branch circuit had been protected by common series fuses having a time-limit three or four times as great on a given overload as those employed in shunt to the trip coils. By a converse argument it

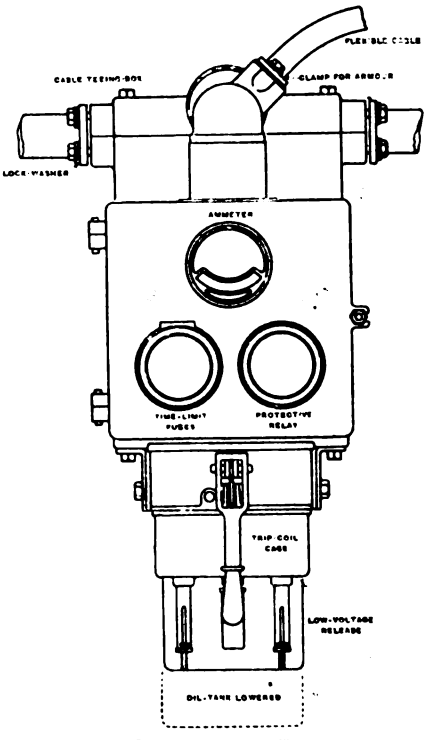

FIG. 4.—FRONT ELEVATION OF GATE-END SWITCH.

might be thought that if over-load devices giving a much shorter time limit had been employed, the same immunity from fire would have been obtained as was obtained with the relays. There is ground for this conclusion only in the case of very severe damage causing a rapid rise of current; but by the use of such devices all faults would have to develop into heavy faults before they could be dealt with, and would lead to failure of supply on momentary heavy overloads. The dangers attending the use of electricity in mines are threefold, viz., (1) danger from shock, (2) danger from fire, and (3) danger from explosion. Leakage is in all these the principal contributory cause. Danger may be reduced to a minimum if armoured cables be employed, whereby all live parts are enclosed throughout, from the main switchboard to the individual motors, by a continuous metallic covering well earthed. Every switch,

* Paper on "Electricity in Coal Mines," *Trans.* Inst.M.E., 1909. Vol. XXXVII., p. 459.

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motor, or other device, should be ironclad and provided with substantial fittings for making mechanically and electrically sound connections between the metallic cases and the metallic armouring on the cables. Fig. 4, for example, shows a typical joint between the cable armouring and a metallic case in which the armouring is firmly held under a solid metal clamping plate. This joint, if made with lock washers under the nuts, will never come loose. Several types of flexible cables suitable for this system are obtainable with metallic armouring. If this system be employed and efficiently carried out with apparatus and material designed for the purpose, all leakage currents will be confined to the metallic covering, thus removing all risks except those arising from actual rupture of, or severe arcing in, the cable. If automatic leakage devices be employed, the danger arising from these risks also is reduced to a minimum.

It is true that where the earthed neutral system is employed the majority of defects will result in leaks which will cause the automatics to operate before the fault can be discovered by other means and the faulty portion isolated. Where, however, discriminating devices are employed, and especially devices such as the leakage devices advocated by the writer, the electric supply should not be disturbed except at and beyond the point where the defect exists.

In the past where the neutral has been earthed, it has been necessary to employ a connection capable of passing sufficient current to operate the overload device with the heaviest setting on the largest feeder. Where there are but few main feeders this involves every fault developing into a heavy load on the system before the automatics operate; and should only a portion of the generating plant be running, a fault in a main feeder amounts to a short-circuit on the system. Where leakage relays are employed, however, it is possible to employ a resistance in the earth connection, which limits the leakage current under the severest conditions to a fraction of normal load. Such a connection will not prevent the operation of the leakage devices with certainty, and will serve under normal conditions to hold the mid-point of the system at earth potential; neither will it interfere with the function of the earth connection in preventing the development of small static disturbances.

The use of the armoured system with the neutral earthed ensures every defect receiving prompt attention, as every defective portion is promptly isolated and put out of service; and this tends to ensure efficient supervision, inspection, and maintenance.

Another objection urged has been that there is greater risk of shock from touching live metal where the mid-point is earthed, the idea being that the potential at the point touched is reduced to earth potential through the operator's body if the whole system is insulated. Where continuous metallic protection is provided, there is little opportunity of coming into contact with live metal. In any case, the added safety resulting from not earthing the mid-point is negligible except on the smallest systems, as the charging current of the whole system has to pass through the body of the operator before the potential is reduced.

The consideration of automatic devices necessarily involves the discussion in detail of all kinds of trouble and sources of weakness. This tends to produce a false impression of insecurity, unless the arguments are carefully followed and due weight given to the comparative infrequency of occurrence of many of the abnormal conditions dealt with. The purchase of good material and appliances is undoubtedly the surest way of automatically reducing danger and controlling continuity of supply, and amongst the latter may well be included appliances designed to meet the risks peculiar to the mining industry.

ELECTRIC BRAKING ON THE GLASGOW CORPORATION TRAMWAYS.

The following is an abstract of the discussion which took place at a meeting of the Glasgow local section of the Institution of Electrical Engineers when Mr. A. Gerrard read his Paper on this subject. An abstract of this Paper appeared in our issue of April 8th, and of the discussion when this Paper was read in London in our issue of April 15th.

Mr. J. Ferguson (chief engineer, Glasgow Corpn. tramways) said he knew that the experiments were carried over a lengthy period in all conditions of weather and track, and the results obtained were valuable. He thought the following were some reasons for not adopting electric brakes:—(1) Rapid application caused skidding; (2) frequent use at all speeds sent up maintenance charges; (3) their safety depended upon the controller contacts, which were liable to get out of order; and (4) electric brakes could only be usefully applied on a running car—*i.e.*, they could only be tested under running conditions. With regard to the solenoid control advocated, he thought the first two objections were removed, and he anticipated the maintenance cost would also be reduced. The low voltages and current with solenoid control would also be beneficial to the equipment. The absence of skidding was highly appreciated by the motormen. The Paper did not claim to remove objections (3) and (4). Regarding the disadvantage due to contacts likely to get out of order with dust or dirt, &c., he mentioned that his department now regarded this fault as a minor one, for the following reasons:—During a day's run of 120 miles they had ascertained that there was almost one application of the brake per mile per car. There were 600 cars on an average running per day. That meant there would be about 18,000,000 applications of the electric brake per annum. For the year 1909, in the "defect" reports received, only 17 were for defective electric brakes, a truly satisfactory result.

Mr. W. McWhirter thought that thanks were also due to the Glasgow Tramways Committee, as it was most unusual to find a Corporation (except on the Continent) making public any experiment like this. He asked Mr. Gerrard for the cross-section of the magnets. No doubt the length of core caused the weak pull. According to the curve shown, the magnet appeared saturated. The magnet had far too little iron in it, as with 5 amperes there was 50 per cent. more pull than at 40 amperes in the older make. In type 26C the pull was doubled. In type 25B he thought the magnets too powerful. They were very unstable on the straight part of the curve, and he was sure this would be very marked. Referring to the enormous rise in voltage, he thought the design of the traction motors contained too much iron. Experiments showed the magnetisation of these to be low down on the curve. No doubt, of course, the motors were designed for traction purposes only, and not for braking effects. The application of the solenoid control would shunt the field magnetisation and thus reduce the tendency for the voltage to rise. This was quite a good arrangement, and he thought it had come to stay. Regarding the pull, he mentioned that from experiments he had found it possible to get 160 lb. per square inch tractive effort.

Mr. Maxwell (Electric Control, Ltd.) thought the most important point was not touched on, namely, the usefulness at low speeds. The combination resorted to in Glasgow of both hand and electric brakes was, he thought, not good practice. He thought the car should have a lower schedule speed. In speaking with Mr. Dalrymple recently on brakes, the latter said air brakes required more room than it was possible to give on the single truck cars at present in use, while double trucks or double bogies were too long and not suitable for turning the corners. The schedule speed was, he believed, 6 miles per hour on the average. He instanced that American practice was to have four 30 B.H.P. motors per car and air braking.

Prof. Bailey (Edinburgh) confined his remarks more to the surging effect referred to. He imagined some was due to the electromagnets being sluggish. If an air-gap were introduced in the track magnetic circuit it would, he anticipated, accelerate the magnets coming off and reduce the surging. He agreed with Mr. McWhirter that there was too much iron in the motors. At 4 miles per hour he presumed there would only be 2 or 3 amperes for solenoids, but he did not think that was a point against it.

Mr. Sam. Mavor asked for the contact sectional area of the magnet.

Councillor Hoey (member of the Glasgow Tramways Committee) thought the Paper was an excellent and huge advertisement for the Westinghouse Co. He advised the officials to devote more time to finding out what could be done, not on what was being done.

Mr. Robertson, who was interested in railway brakes, asked Mr. Gerrard if he did not find that the 25B type solenoid would lift the car off the tracks and cause the surging referred to, and also if the 1908 type was still in use.

Mr. Geo. Stevenson asked for particulars of the cost and life of the brake shoes. Also, as the approximate miles per hour was given to three decimals, what sort of stop watch was used?

Mr. Gerrard, in reply, said the area of core in the old type of brake was 3 in. diameter, and in the new 26C 5 to 6 sq in. The shoe area in the old type was 23 sq. in., in the new small type 23 sq. in., and in the new large type 26 sq.in. He found the small new type was the best for coasting. He agreed with Prof. Bailey's remarks that the large magnet was sluggish. There was an excess of iron in the traction motors, but they were not designed as everyone knew for electric braking purposes, as this system of braking was unheard of 15 years ago. He had been requested to curtail the length of the Paper; however, he could assure them that solenoid braking was as good at 2 miles as at 18 miles per hour. The hand brake was seldom used, as it was found that the electric brake was quite good and efficient, and experiments proved that the latter was better at 3 miles per hour than the hand brake. It was found that the freedom from accidents with electric brakes was such that they were not warranted in equipping the cars with air brakes; a step which would only increase the weight of the cars without giving additional security, as accidents were not unknown with air brakes. The surging referred to was principally due to badly trimmed brake shoes. Solenoid shoes, of course, would reduce this. There was no air-gap in the magnet circuit. The large magnet was sluggish, but the practice was to put in even three magnets. Regarding Councillor Hoey's remarks, he could assure him they had come to the last word in electric braking, but with regard to advertisement he might say that both the Glasgow Tramways Department and the British Westinghouse Co. had spent money in making the experiments, and any advertisement therefrom could hardly be eliminated. The 1908 design was not now used. He could not say anything as to costs, except that it was anticipated that the running and maintenance costs would be very much reduced, the armatures not being subject to such severe service.

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Published every Friday, Price Sixpence; Post Free, Sixpence-Halfpenny.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON
(ONLY ADDRESS.)
Tel.: Holborn 6363 (Two Lines). *Tels.*: ELECTRICIAN NEWSPAPER LONDON.

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PHOTOMETRIC UNITS.

When asked what sort of person an archdeacon was, DISRAELI said that he was a man who performed archdiaconal functions. In the same way, he would probably have said that a candle-power was the power of a candle, and a horse-power the power of a horse. He may very possibly have been right about the ecclesiastic; but the candle-power and horse-power are not to be disposed of in the same easy manner. The candle and the horse were probably the best things of their kind in the worlds of lighting and traction a hundred years ago; but now they seem rather out of date, and are not to be taken very seriously as scientific units.

Confining our attention to the candle, the English unit is a sperm candle, six of which weigh a pound, and which burns 120 grains of wax in an hour. Other countries have different standards, and the usual practice everywhere is to refer to some sort of primary flame standard, such as the Pentane, Carcel, or Hefner lamp. About a year ago a serious effort was made to free the matter from the bewildering confusion into which it had sunk, and to agree on an international unit for the expression of candle-power. The authorities in Great Britain, France and the United States agreed to adopt the same arbitrary unit, and this was certainly a great step forward. It involved practically no

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alteration of the standard adopted in England and France, seeing that the English candle was almost exactly the same as the "bougie décimale" in France. But the American standard (which had not been so completely defined as that in other countries) had to be lowered by 1·6 per cent., and this was done on the understanding that the three countries would unite in keeping the unit constant, and would call it the International candle. As a matter of fact, it is evident there has never been any great difference between the three standards adopted by these countries, and it merely needed, as one would have thought, half an hour's talk to settle the matter. But the immense inertia that had to be overcome is probably only understood by those who have had to do with International Commissions, and, even now, Germany remains outside the scope of any real agreement.

It must be admitted to have been extremely unsatisfactory that no common standard could have been found that was agreeable to all parties. The most that could be done was to agree that 1 Hefner candle-power is equal to 0·9 English candle-power; or in other words, Germany and England interpret the words "candle-power" in two different senses. From the scientific point of view, this difference is a matter of little importance, and it is easy to correct and allow for it. And, after all, it is absurd to suppose that photometry will ever be one of the exact sciences, except to the very few. This may sound heretical, but it is none the less true. Every observer has his own peculiarities; the only thing that can be said with certainty is that the personal equation tends to disappear if the number of observers is very great. The colour of the light is also a disturbing factor, the colour of the primary standards being mostly reddish, whereas that of other sources of light may have a tendency in some other direction, which can only be neutralised by artifice. Experience in the observer is only a form of artifice, by means of which the brain adjusts itself through certain trickery to compare things that are intrinsically different. Moreover, the primary standards are themselves liable to vary with the amount of atmospheric moisture, or pressure, or with the quantity of carbonic acid present in the air. With all these independent variables, exact results cannot, as a rule, be expected. Yet International Commissions have almost always confined themselves to the scientific aspect of the matter, and, seeing that no standard lamp has been found to be perfect, the expression "candle-power," which is the only thing that interests the commercial world, has been left to shift for itself.

Wherefore, seeing that at best only an approximation is to be attained, it seems impossible to suppose that a truly international agreement, on a commercial basis, as to the meaning of "candle-power" is out of the question. Might not the Institution of Electrical Engineers make friendly overtures to the Elektrotechnische Verein, with a view to the suggestion that in future German lamps should be rated according to their International candle-power, on the assumption that 1·11 Hefner candle-power is equal to 1 International candle-power? This proposal would not interfere in any way with the use of the Hefner lamp as a standard, which is an excellent one of its kind, though it would certainly be preferable to adjust it to an international value. We do not know what objections the world of commerce in Germany, as distinct from the world of science, would be likely to raise. Possibly the position is hedged in with legal considerations. But it is expressly proposed to call the new unit the International candle-power, and therefore it is evidently different from the Hefner candle-power, or from any other candle-power to which the jurists might conceivably pin their faith.

The cynic might reply to all this that the uncertainty prevailing is such that it cannot be removed by any such step as this. The rating of an incandescent lamp at 16 c.p. is notoriously only the roughest approximation; and it is not so many years ago that arc lamps fell nominally under two headings—viz., those that gave 2,000 c.p., and those that only gave 1,000 c.p., the actual candle-power being neither of these values. An incandescent lamp is usually rated according to its horizontal candle-power in some direction, or according to its mean horizontal candle-power. In an arc lamp, the mean hemispherical candle-power is taken, while its light is never steady for a second at a time, and it is only possible to make an approximation by some rule-of-thumb method. Still, these are minor imperfections in our system, which cannot immediately be smoothed out of the way by a stroke of the pen. It is the difference of 10 per cent. between the German ratings and those of other countries, which introduces a wholly unnecessary element of uncertainty. Would it not, we ask, be within the province of the Institution of Electrical Engineers to approach the Elektrotechnische Verein in a business-like spirit in the matter? During Dr. KAPP's year of office a specially favourable opportunity seems to present itself, as he has been at different times in intimate contact with both bodies. We think it is needless to say that the successful accomplishment of this task would be very thankfully received on all sides.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Auto-Transformer Design. By ALFD. H. AVERY. (London: E. & F. N. Spon.) Pp. 60. 3s. 6d. net.

The cost of electrical apparatus of almost every kind depends in a very great measure upon the magnetic qualities of the best iron, and the conductivity of the best copper. The slightest reduction in the iron losses or increase in the copper conductivity means in many cases a relatively great saving in material. Thus when some years since, the so-called alloyed iron was introduced with not much over half the hysteresis loss and negligible eddy current loss, it became possible to work at greatly increased flux density with the same core loss. But in small transformers, the design of which was controlled by the no-load loss and not by heating, the increased output due to working at higher flux-values meant higher permissible losses; so that, instead of working at, say, 30 per cent. higher flux density to get the old loss, one could work at 50 per cent. or 60 per cent. higher flux density, and 20 to 50 per cent. higher current density, and still get the same percentage no-load loss and full load efficiency. The output for a given size of small transformer could thus be nearly twice as much as before for the same efficiency, or, say, 50 per cent. above the old output with an increased efficiency. Then when the metal filament

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lamp came, and with it the demand for small house transformers, it was not only possible to provide these transformers at a smaller cost, but with less no-load loss and a higher efficiency than was formerly possible.

In the book before us, Mr. Avery deals first of all with the very great saving in material arising from the use of auto-transformer connections as compared with those of two-winding transformers, and with the advantages of balancer transformers when they can be employed. After discussing the economy of metal filament lamps he proceeds to the elementary principles underlying transformer design.

It would be easy to criticise the book in many particulars. The author, while not directly advising it, talks of cutting out the pieces of iron, which form the core, by hand, and truing them with a file (p. 44). He talks of the energy taken from the mains by a true wattless current, although he explains that such current is useless for practical purpose (p. 40). Among other things he repeats the common statement that it is necessary to insulate the corner bolts of cores to avoid eddy current loss. Is insulation really needed? So long as such bolts are symmetrically placed with regard to the flux there ought to be no appreciable eddy current loss in the bolts.

The author gives a complete account of the building of core, coils and case of one type of transformer.

Possibly the book may be a little disappointing to the actual transformer designer, but it is intended also for the user and the contractor, to whom it should prove very useful with its excellent photographs and good tables. D. K. M.

Uber Elektronen. By Dr. W. Wien. 2nd edition. (Leipzig: B. G. Teubner.) Pp. 39. M.1·40.

The progress accomplished since 1905 has not led to any revolution in the original conception of the electron theory, and the distinguished Würzburg physicist has been able to bring his original lecture up-to-date by adding a number of valuable notes. The most important recent development is the exact formulation of the principle of relativity, chiefly by Einstein and Minkowski. This principle, which renounces all possibility of discovering absolute motion, introduces some very novel conceptions of mass, space, time and force. But it has the advantage of throwing a bridge between ordinary and electromagnetic mechanics, and it is, moreover, strongly supported by the recent experiments of Bucherer and Hupak. The little work before us, though not by any means exhaustive, even as regards the enumeration of the departments of physics to which the electron theory has been usefully applied, is a lucid and more or less popular survey of many of its more important results. E. E. F.

Examination Questions in Electrical Engineering set by the City and Guilds Institute, 1900—1908. (London: S. Rentell & Co.) Pp. 95. 1s. net.

In this little book are given questions set in the three grades of the City and Guilds examinations in electrical engineering. To many of these questions, involving numerical solutions, the answers are given, and in the case of the papers set in 1908 all the questions are very completely worked out. We do not profess to have read all the answers, but those at which we have glanced appear to be to the point, the only exception being one in which the loss in a transmission line 2 miles in length is given as 97·67442 H.P.—surely an undesirable degree of accuracy. We do not doubt that the book will prove useful to teachers, not merely from the cramming point of view, but also in helping them to select suitable problems with a minimum of trouble.

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RECENT PHYSICAL RESEARCH.

POSITIVE ELECTRICITY

BY D. OWEN.

As Helmholtz and Maxwell independently remarked, Faraday's Laws of Electrolysis point to the conclusion that atoms of electricity exist just as surely as do atoms of matter. In liquids the ratio e/m of charge to mass is known to vary with the chemical nature of the ion, being least (nearly 10^4 E.M. units of electricity per gramme) in the case of hydrogen. The carriers of negative electricity in liquids are never less than atomic in size. In gases, on the other hand, during the passage of a current, we now know that there are present negatively charged particles of mass far smaller, namely, $\frac{1}{1700}$ part of the mass of the H atom. Moreover, these particles are the same no matter what the gaseous molecule from which they are extracted. Furthermore, the mass of these negative particles appears to be purely electrical in origin; for it is found by experiment to increase with the speed in a way that had already been predicted in the case of motion of a purely electric charge. Again, the effect of a magnetic field on the light emitted by a gas (the Zeeman effect) is evidence of the presence of negatively charged particles associated with the light-giving molecules; and exact measurements establish very conclusively the identity of these particles with those found in the electric discharge in gases at low pressures. The phenomena of the conduction of electricity and of heat in metals have been correlated on the assumption of the presence of these free electrons or corpuscles within the inter-molecular spaces of the metal.

The existence of the negative electron, or corpuscle, may now be regarded as firmly established. One or more corpuscles may be abstracted from a molecule. The molecule is then said to be positively charged. What is this positively-charged residue? Is the negative the only kind of *electricity*, the rest of the molecule being *matter*? Or is there a *positive electricity*, distinct from the *matter* of the molecule? Or is the residue left on separation of the corpuscle *positive electricity*, possessing, like the negative, inertia—in fact, all the inertia—of the particle? The first and third questions are clearly one and the same. An affirmative answer would mean that the molecule was composed simply of negative and positive electricity, all the properties of the molecule, including its mass, being explicable in terms of electricity.

Accepting, then, the existence of the negative electron as proved, an important question arises as to what fraction of the mass of the molecule is due to the electrons present. Granted a sufficient number, the whole of the molecular mass might be accounted for as the electric inertia of the electrons. The number of electrons in a hydrogen atom would have to be some 1700, in a mercury atom 200 times as many, and so on. On this point an important Paper by Sir J. J. Thomson appeared in June, 1906, laying down three lines of argument, based on experimental data, all leading to the conclusion that the number of electrons in the atom is of the order of its atomic weight (H = 1). The number in a hydrogen atom would be 1, or at all events not a large multiple of 1; in the mercury atom 200, and so on. This, if granted, leads to the result that by far the greater part of the mass resides in the positively-charged residue of the atom. What, then, is the constitution of this residue? Is it composed of small units, which, like the electron, are the same for all substances? If so, what is the charge of each and its associated mass? Attempts towards the elucidation of these questions have been made mainly by examination of the mechanism of the passage of electricity through gases. These investigations show that in a vacuum tube there are rapidly moving streams of positively electrified particles, corresponding to the now well understood streams of electrons or cathode rays. These positive streams were first observed by Goldstein in 1886, being called Canal rays. They are seen streaming through a hole in the cathode in a discharge tube, their direction being perpendicular to the front surface of the cathode and away from the anode. Similar rays are

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seen streaming from the cathode in the opposite direction, from cathode towards anode; these are Goldstein's K_1-rays, also since denoted by the term "retrograde rays." In all, Goldstein specifies five types of positively-charged ray in the vacuum tube. In hydrogen gas the canal and the retrograde rays—to specify the chief types—are rosy red in colour; in air they are blue. They cause metallic salts, on which they impinge, to emit the characteristic light of the metal—*e.g.*, sodium salts glow with an intense yellow light, salts of lithium with a red light, &c. When they fall on thin metallic films the film is disintegrated. Later on, in 1906, REICHENHEIM discovered the Anode rays, consisting of rapidly-moving positively-charged particles starting from the anode, one stream moving forward towards the cathode, a second stream in the opposite direction. These various streams of positively-charged particles may conveniently be grouped together under the title of POSITIVE RAYS, as suggested by Sir J. J. Thomson.

Whilst Goldstein traced the direction and apparent seat of origin of positive rays, WIEN made measurements of the ratio of charge to mass and of their velocity. The measurements disclosed the fact that the positively-charged particles concerned differ essentially from the negative electrons in having large masses of the order of the mass of the atom. In 1907 Sir J. J. THOMSON began a series of important contributions to our knowledge of these rays. Of these we will now give a brief account. The canal rays are found to possess speeds of the high value 2×10^8 cms. per sec.—that is, nearly one-hundredth the speed of light, a speed which, though enormous, is yet inferior to the speeds attainable in the cathode rays (6×10^9 cms. per sec.). The values of the e/m ratio and of the velocity are obtained from the deflections produced by the combined application of known magnetic and electric fields, the rays being received on a Willemite phosphorescent screen. The first series of experiments ("Phil. Mag.," May, 1907, and September, 1907) showed that the particles in the canal rays were of two kinds, the value of e/m for one set being 10^4, for the other $10^4/2$. The remarkable result was found that these values are the same no matter what the gas in the tube may be, whether hydrogen or oxygen, or heavy vapours like CCl_4 or $UrCl_4$. They are seen to be the same as for the atom and the molecule, respectively, of hydrogen, if we suppose that the charge carried is the same in each case as that carried by the H atom in the electrolysis of liquids. Careful and prolonged experiments confirm the fact that these values are found when special means are taken to exclude hydrogen from the tube. Or, to reverse the procedure, starting with a gas entirely free from hydrogen, it appears that the gradual introduction of hydrogen does not affect the character of the phosphorescence produced by the deflected beam. If, for example, oxygen be used, there are no particles present whose e/m ratio equals $10^4/16$ or $10^4/32$—that is, involving an atom or molecule of oxygen. The retrograde rays by a similar examination appear to be of one kind only—namely, positively-charged particles having the same speed (2×10^8 cms. per sec.) as the canal ray particles, but with the larger value of e/m—that is, 10^4.

It should be remarked that there are positive rays of much slower speed which possess values of e/m which are characteristic of each gases, 10^4 for H, $10^4/16$ for O, &c., which, therefore, correspond to positively-charged molecules of those gases. It is only in the case of the high-speed particles that the high value of 10^4, independent of the nature of the gas in the tube, is found. It will be seen that the results for high-speed rays strikingly resemble those now familiar in the case of the cathode rays. Sir J. J. Thomson puts forward the view that we have here proof of the existence of a definite *unit of positive electricity*, which can, like the corpuscle, be detached from the molecule.

The more recent Papers of Sir J. J. Thomson are largely concerned with the manner of production of the positive unit from the molecule. One striking experimental result is that the kinetic energy of each particle in the rays is many times greater than the work that would be done upon it in virtue of its fall down the electric field in the tube. This velocity is practically independent of the fall of potential across the tube. A total fall of 3,000 volts produces the velocity 2×10^8 cms. per sec., which a simple calculation—equating Ve to $\frac{1}{2} mv^2$—shows to correspond to a potential drop of 20,000 volts. The view is therefore taken that a molecule of gas in the discharge tube receives energy from the collisions with it of the cathode ray particles. This energy the molecule accumulates until the point of explosion is reached, when a "neutral doublet," composed of one unit of positive electricity and a corpuscle, is shot out at high speed.

The canal and retrograde rays are on this view regarded as consisting, at their inception, of neutral doublets. Their high speed renders them comparable with the particles of a gas at very high temperature, say, some hundreds of thousands of degrees Centigrade. Dissociation may take place, resulting in the production of particles of free positive and negative electricity respectively. These in their turn may re-combine to a neutral doublet; or the neutral doublet may unite with a corpuscle to form a negatively-charged particle of mass practically unaltered, since the mass of the corpuscle is almost negligible. The canal and retrograde rays would thus be composed of charged particles, negative as well as positive, whose e/m ratio is 10^4, and of neutral doublets. The experimental observations are in agreement with these conclusions, which are further confirmed by later experiments of considerable interest, which may be briefly described. A beam of canal rays is subjected to two magnetic fields in succession, their directions being perpendicular to each other and to the direction of the rays. The first field may be placed near the cathode, the second further along the beam, which goes on and impinges upon the usual phosphorescent screen. The effects on the screen may be represented as in Figs (*a*), (*b*) and (*c*).

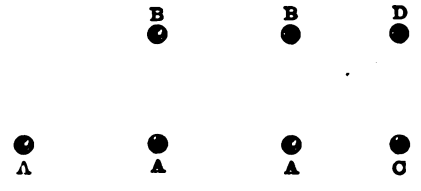

FIG. (*a*). FIG. (*b*). FIG. (*c*).

A of Fig. (*a*) represents the bright spot on the screen before either magnetic field is on. Fig. (*b*) represents the effect of switching on the first field. Two spots are now seen, one at A in the undisturbed position, the other at B, whose deflection corresponds to the ratio $\frac{e}{m} = 10^4$. Clearly the spot A is produced by rays unaffected by the field, therefore presumably uncharged while passing through it. Fig. (*c*) represents the effect when both fields are on. The undeflected spot A is still seen, corresponding to particles that have remained uncharged in their path through it. A new spot appears at C, showing deflection by the second field of particles which have acquired their charge since leaving the first field. A spot still persists at B, proving that particles which were charged in their passage through the first field have lost their charge in the space intervening between the two fields. The spot at D is due to particles which have kept their charge from the first field to the second. The equality of the deflections AC and BD proves the equality of speed and e/m ratio of the two sets of particles concerned. Here we have simple evidence of the dissociation and re-association of oppositely-charged particles, which, on the view here considered, are the units of positive electricity, and corpuscles, respectively. The "neutral doublet" has been invoked also in the explanation of the mechanism of ionisation in gases at higher pressures under the influence of X-rays, &c. The experiments of Wellisch (July, 1909) show that the velocity of positive ions in a mixture of a heavy gas, say CCl_4, with hydrogen, is practically the same as that of a charged hydrogen molecule, though the direct dissociating effect of the ionising agent is almost solely confined to the heavier molecules. It is considered impossible that the large molecule, minus a corpuscle, could transfer its positive charge to the smaller one, as an increase in potential energy would be

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involved. The results are in harmony with the view that the act of ionisation consists in the ejection from the molecule of a Thomson neutral doublet, which breaks up into the positive unit of electricity and a corpuscle, these then uniting with the molecules present in the gas to form the moving ions.

This account of the views held by Sir J. J. Thomson cannot be said to give a very clear perception of the nature of the positive unit. The high-speed positive particles in the vacuum tube are independent of the gas whence they are produced. The ratio of charge to mass is known, but not the absolute value of either. Whether the value of the charge of the positive unit is equal to that of the negative electron is not determined. The ratio e/m is the same as for a H atom in the electrolysis of acidulated water. Does this mean that a hydrogen molecule is composed of two units of positive electricity and two corpuscles? Again, if the preliminary to ionisation of the molecule is extrusion of a fundamental constituent of all molecules, namely, the neutral doublet, with subsequent decomposition of the latter, one would expect to find positive particles of $e/m = 10^4$ amongst the rays emitted by radio-active bodies. Prof. Rutherford's remarkable series of experiments on the α particle prove that this body is a positively charged atom of *helium*; thus we have a mass about four times as great as that of the hydrogen atom, although the velocity of the particle (10^9 cms. per sec.) is many times greater than that of the high-speed positive rays in the vacuum tube.

In conclusion, other lines of experimental research which have a bearing on the question of the existence of a free positive unit of electricity may be touched upon. It is well known that the Hall phenomenon varies in sign in different metals. The same remark appears to be true of the Zeeman effect. This effect of a magnetic field on the period of vibration in line spectra has been explained satisfactorily in terms of the electron, the e/m ratio deduced from the observed displacement of the lines working out to be equal to that obtained in experiments in the gas discharge tube and on the β-rays emitted by radio-active bodies. Jean Becquerel (1909) has shown that the Zeeman effect applies also in the case of the absorption bands of some crystalline bodies and their solutions. Furthermore, he records that he has observed a reversal of sign; that the sign of the accelerated circularly polarised component, as viewed *along* the direction of the magnetic field, is in some cases opposite to that hitherto observed. This result is confirmed by Dufour in the case of certain gaseous emission spectra. In the previous year Prof. R. W. Wood had discovered a *positive* rotation in the case of some of the absorption bands produced when plane-polarised light is passed through sodium vapour in a magnetic field. If the normal effects in the above-mentioned classes of phenomena are due, as has been supposed, to the presence of negative electrons, the question arises as to whether the reversed effects are to be taken as implying the presence of positive units or positive electrons.

Mention may be made, too, of the discovery, by Stark, of Göttingen, of the Doppler effect in the light emitted by the positive rays in a vacuum tube discharge. Measurements of this effect lead to the determination of the speed of the particles emitting the light, and seem likely to contribute to our knowledge of positive electricity.

Progress along these various lines of research will be eagerly awaited in the near future.

EARTHED *VERSUS* INSULATED NEUTRALS IN COLLIERY INSTALLATIONS.

We give below an account of the discussion which took place at a meeting of the Institution of Electrical Engineers last week, when Mr. W. W. Wood read a Paper on this subject. An abstract of this Paper was given in our last issue.

Mr. J. G. Wilson said the keynote of the Paper was that each case should be considered on its merits; but, nevertheless, there was a tendency on the part of the author to lean towards an insulated neutral, or, at any rate, to avoid a general practice of earthing the neutral. In fact, the author in his conclusions stated that "generally an insulated neutral was better where permanent plant was at work and the cables were not liable to mechanical damage." The speaker thought that these qualifications rather cut down the conclusion, because there were in most cases underground portable tools supplied with electricity, and cables underground were as much as any liable to mechanical damage. The speaker advocated earthing the neutral, and further than that, whether the supply to the pit was obtained from a supply company and transformed down or whether it was generated locally, all underground cables should be armoured and the armouring should form a continuous connection both to earth and to the neutral point of the system. He doubted very much the advantage claimed by the author that the danger of shock was reduced in the case of an insulated neutral, since with an extensive supply it was impossible in practice to avoid leakages to earth, and even were it possible to do so it would not be continuously possible. Moreover, Mr. M. B. Field had authoritatively pointed out in his communication in Vol. XLI. of the "Proceedings," that even apart from earths on the different phases the tendency of the capacity effect was to keep the neutral point of the system at or about earth potential, and that insulating it was no safeguard against shock. The speaker thought, however, that what was more important than shocks was the danger from explosion by ignition of gas or coal dust underground. Assuming that the installation was a good one and that the switchgear underground was of the modern enclosed type, there was yet the possibility, over which the engineer had least control, of the roof falling on to the cable. If the latter was thoroughly armoured it should stand a great deal, but if damage did occur to the insulation it was most important that the supply should immediately be cut off, and he thought that was the gist of the whole matter. If the neutral point of the system was unearthed the supply would not be cut off unless one phase was forced in contact with another, and even then the current had to rise to a value perhaps double that of the capacity of the motors served by the cable, and considerable heating and arcing inside the cable would occur, which might result in exposing an arc. If, on the other hand, the neutral point were earthed, the supply could be cut off instantaneously either by a balanced protective system or by having the cut-out furnished with a trip coil connected in series with the sheathing of the cable. The author had well pointed out the importance of reliability of supply, and under that heading had quite rightly suggested that anything like continual cutting off of the supply by those devices would be very harassing to colliery managers. The reliability of supply was really most important in the department of winding and fans, both of which were done at bank, and neither of which, if the supply was properly arranged, need be affected by the tripping of an automatic switch in circuit with the underground cables. The temporary cutting off of the supply underground from haulage, or even pumps, while exceedingly objectionable, should not be considered where it was a question of actual danger to the mine by explosion. He thought the subject of flashing to the casing of switchgear, &c., touched on in the Paper, was really a question of design, of which it was impossible to overrate the importance, but altogether distinct from the subject of the Paper. In conclusion, he strongly advocated the earthing of the neutral in all cases of a three-phase supply to collieries.

Mr. H. W. Clothier said the author claimed for an earthed neutral that it was possible to isolate a damaged circuit, whereas with the neutral insulated the claim was that the damaged circuit was not interrupted. He thought that any system which allowed a damaged circuit to remain in use was unsatisfactory. He advocated metallic armouring from the generator to the load, and said the advantage of having thorough metallic armouring on all cables was prominent when the risks of explosions was considered. It was important to avoid flashing external to the cable. He knew of cases of falls of roof on armoured cables where the damaged circuits had been isolated automatically, and the action had been so rapid that it had been impossible to detect the place where the "short" had occurred. He did not think one could have too many earth plates in a mine. The illustrations in the Paper should not be taken too seriously as arguments against earthing the neutral. The defects shown by them could also be made to apply to insulated neutrals. The author suggested that the size of the earth wire should be large enough to carry a current which would blow the fuses of the plant. This did not give an adequate idea of the necessary dimensions of an earth wire. The cost of the system of leakage protection (originated by Mr. Price), shown in Fig. 4 of the Paper, was very little more than the ordinary overload protection. The statement about the price of armoured cables also should be corrected, as the cost of armoured cable was not double that of unarmoured cable. For small cables the difference in cost might be 40 to 50 per cent., but in larger cables it was somewhere in the neighbourhood of 20 per cent. His, the speaker's, conclusions were that (1) sound, metallic, continuous armouring should be used throughout the system, (2) for safety this must be efficiently earthed, (3) the neutral point should also be earthed, if only for the fact that by so doing a better and safer system of automatic protection was obtained. His remarks mainly referred to low-tension systems in mines, as he understood the author's Paper left no doubt as to the advisability of earthing the neutral on the high-tension circuits of power supply undertakings.

Mr. W. H. Patchell thought that the earthing of metal casings was more important than the question of whether the neutral point should be earthed of not. In his opinion the conductor should be enclosed in a metallic casing and thoroughly well earthed. He thought also that if more money was put into the skilled attention that was given to the installations less trouble would result. A good deal had been heard of faults due to falls of roof, but it was very hard to run a case to ground where there had been a flash due to a fall in a mine. He did not say that such a thing could not happen, and he thought it was for them as electrical engineers to take proper precautions to prevent an explosion from

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such an occurrence when it did happen. He thought it would be a good thing if authors when quoting Papers gave the references. The remarks quoted with reference to the American Institute were not recent, and were not those of the President of the American High-Tension Committee, Mr. Mershon, but were President Scott's introductory remarks to a Paper by Mr. Blackwell some seven years ago. Whether the conditions had since changed depended rather on what earthing they were considering. The matter was again discussed by the American Institute of Electrical Engineers in 1907, when, as far as the discussion went, they practically paired for earthed and the unearthed arrangements. The bulk of the evidence was in favour of earthing the centre of a star-connected low-tension distributing system.

Mr. W. C. MOUNTAIN regarded Mr. Wood's Paper of considerable practical value, because whether the neutral should be earthed or unearthed in connection with colliery work was an entirely different problem from the high-tension schemes referred to in Mr. Patchell's remarks. In connection with colliery installations one had two main objects in view: (1) to ensure as far as possible that the lives of the men working underground should be protected by having the safest possible system; (2) that the machinery installed underground should also work with the least possible risk of breakdown. It must be remembered that in colliery installations, whilst there were isolated instances of motors being run at a voltage as high as 5,000, the ordinary voltages with which one dealt were either 650, which came within the limits of medium pressure, or 3,000, which was the maximum allowed under what was at present known as high pressure; and there was no doubt that the bulk of the work in collieries would be carried out at a pressure not exceeding 650 volts, except for larger motors in connection with heavy pumping and haulage schemes. As earthing the neutral merely limited the pressure which one would receive in getting a shock to 58 per cent. of the maximum voltage, it was quite clear that as regards safety to life nothing could be gained by earthing the neutral, even on a voltage of 650, because this would mean that any person touching a live wire when standing on the earth would still receive a shock due to a voltage of 375, which would be fatal in most cases. With the higher pressure—namely, 3,000 volts—of course the certainty of death would be greater still. Dealing with the question of mechanical breakdown he believed that certainly for all voltages up to the limit of medium pressure—*i.e.*, 650—and almost as certainly up to voltages of 3,000, there was a distinct advantage in keeping the neutral insulated, because with a proper system of earth detectors, which could be used with an insulated neutral, it was possible to detect immediately the existence of an earth and to remedy the defect as quickly as possible. He had found, after many years' experience both with continuous current and later with three-phase current, that in all collieries, due to the changes of temperature, accumulation of dirt on connections, and the fact that in some cases colliery motors did not receive the same attention as motors which could be more carefully examined in daylight, there was a great tendency (when they were subjected to a constant pressure between the frame of the machine and the conductors due to earthing the neutral) for creeping to take place which finally broke down the insulation; he, therefore believed that, except perhaps in installations where the voltage was very high and where there was a difficulty in getting the same comparative degree of insulation in the slots of the motors and on the windings as on medium pressure work, for practical reasons it was desirable not to earth the neutral. There seemed to be a great deal of confusion in the minds of men connected with the colliery trade as to what earthing really meant, and when one spoke of earthing the neutral they were liable to confuse it with earthing the machinery itself. He considered and strongly recommended that anything of a metallic nature which was liable to be touched by any of the attendants, and which contained electricity, such as the motor frame and switchgear frame, should be as permanently and absolutely earthed as possible, but in connection with earthing it required to be made clear as to how these permanent and satisfactory earths could be obtained. There was no doubt very great difficulty in many dry mines in obtaining an earth, and under such circumstances, unless one relied upon non-earthing of motor frames and the maintenance of a high perfection of insulation throughout, it became necessary to consider the armouring of cables and using the armouring as an earth return. It was also possible to lay in the ground disused haulage ropes which could be permanently earthed to the pump and connected to the frames of the motors and switchgear, and this would form a very efficient arrangement. Of course, a further alternative was to have, in the case of unarmoured cables, an earth shield on the cable itself. He knew that he was not voicing the opinion of some of the leading colliery men when he advocated this system of earthing frames in preference to the maintenance of a high degree of insulation, and he was informed quite recently that in a prominent colliery in the Midlands, where they had had 15 coal-cutters at work on a totally unarmoured system and the cutters had been running for 12 years, they had never had an accident of any kind. At one time they suffered from breakdowns of the motor coils and armatures, due to intermittent leakages, but now that they had taken precautions to ensure that any earth which might appear was immediately rectified, the coalcutters had run almost without breakdown, and they cut as much as 15,000 tons of coal with one machine without taking out the armature or making any repairs. Personally, he believed in the use of armoured cables for colliery work, at any rate where there was any liability of accident due to a fall of the roof, but there were undoubtedly many positions in a colliery, such as in travelling roads and in other places where the roof was well supported, where it was not necessary to use armouring for mechanical protection, and under such circumstances he thought it was rather hard to insist upon the use of armouring if it were merely for the purpose of being able to use a protective device, such as the Merz-Price. There was no doubt, however, that where there was any risk of the roof falling and the cables becoming damaged, armouring afforded a very great mechanical protection, and he considered that generally for colliery work armouring was to be recommended in all installations where the voltage exceeded 650. It was, however, only fair to state that in all his 22 years' experience he had never known of the severance of an armoured cable through a fall of roof, and the experiments which were conducted in connection with the previous inquiry into the use of electricity in mines showed how extremely difficult it was either seriously to damage or cut a heavily armoured cable. Assuming that armouring was adopted, it, of course, enabled a protective device to be used, and, whilst he did not wish for a single moment to depreciate the advantages of such devices when applied in suitable places, he did not think there were very many positions in a colliery—*i.e.*, an ordinary colliery installation—where such a device was required, nor would there be any advantage from its adoption. To his mind the use of apparatus of this kind, which was automatic in its action, would give an altogether false sense of security, and everyone knew if one had to depend upon automatic gear such gear had to be very constantly tested and tried to see that it was in working order; and very often when really required to work it was found to fail, therefore, he considered it was far better to rely upon thoroughly sound mechanical work, constant supervision and the use of proper earth detectors. To sum up the position finally, he thought that Mr. Wood's Paper had created a very useful discussion, and, whilst he generally agreed with the previous remarks as to the desirability of earthing the neutral in connection with high-tension central station schemes, he still felt that for colliery work, knowing all the difficulties which existed, a system with unearthed neutral carried out in a sound mechanical manner was to be preferred, and if colliery owners and those in charge of colliery installations would only insist upon their machinery and plant being properly looked after by competent men the fear of accident which existed at the present time in the minds of some people would then be entirely unwarranted.

Mr. J. F. C. SNELL said that Mr. Mountain had left him unconvinced on the question of the earthing of the neutral of three-phase systems, and other speakers had rather digressed in dealing with the question of earthing on transmission lines. They were dealing with the earthing of the neutrals in colliery installations, and he was bound to say that after the very careful investigation which Mr. Patchell, he (the speaker) and a few others had to make on behalf of the Institution in connection with the new Coal Mines Regulation Acts, he felt it was imperative that the neutral of a three-phase system should be earthed, nor did it interfere in any way with the simplicity of the system. In conjunction with a complete system of armouring it seemed to him that one then obtained a thoroughly good distribution system, and one which protected the employé from danger of shock, and, what was much more important, it minimised the risk of explosion, either of gas or of coal dust. The cables, however, must be completely armoured, and he suggested that all joints should be thoroughly bonded and the frames of all fixed machines should also be bonded to the armouring, so that throughout the whole of the distribution system a completely armoured and protective system was obtained. It was a safeguard in case of faults, it entirely eliminated earthing troubles and it was a complete protection against the many dangers which occasionally arose in certain mines. On looking up the "Journal" of the American Institute of Electrical Engineers he found that the armouring of cables was usually protected by jute; but one objection raised to this was "that the miners had a habit of removing the jute from the cables and using it for kindling fires." Incidentally, they also "used oil from the transformer cases in order to re-light their lamps"! The author stated in the Paper that in places where there was no danger of accidental contact, damage from falls of roof or sets off the line, or of explosion, "armouring was an unjustifiable expense." Mr. Snell thought that by eliminating those four things the author had eliminated all the dangers that arose, and as one or other of these dangers was practically always present in collieries it seemed that armouring was justifiable and absolutely necessary. It would be a great mistake if armouring throughout were not made compulsory in collieries, otherwise patchy systems would result, and he hoped that compulsory armouring would be included in the new Regulations. He agreed with the author that the cost of maintenance was of greater importance than first cost. This was a question in which the first cost was really immaterial.

Mr. E. B. WEDMORE said that he was in entire agreement with the remarks of the last speaker. He did not agree with the author's view in regard to the statistics. If all those fatalities which occurred where electricity was not in use were struck out, the percentage would stand at a higher figure. It was their duty to reduce that figure. A detailed examination of the statistics showed that in the majority of cases the danger might have been avoided by employing the system advocated by Mr. Snell, Mr. Wilson, Mr. Clothier and other speakers. He thought that the arguments put forward by the author against earthing the neutral point were, in many cases, faulty, in that he referred to defective systems that ought never to have been employed. The illustrations in the Paper all showed systems which should not have been employed. The author seemed to suggest that it was a proper course in collieries where the neutral point of the system was insulated to operate the plant with one pole gone to earth, but the speaker thought it would need a stronger argument than love of money to justify such a course in the large majority of collieries. When one pole had gone to earth, unusual stress was thrown on the other two poles, thus finding out the weak points on those two poles, and bringing about a short-circuit. It was stated that there was need for better insulation and greater creeping distances where the neutral point was earthed. He did not know on what grounds that claim was brought forward. Cable makers had advocated greater insulation where the neutral point was insulated. The argument in regard to the

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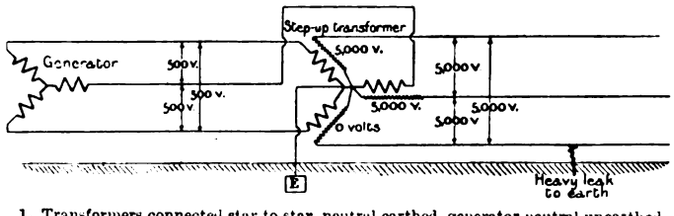
safety of operating with the neutral point earthed seemed to be largely based on the fact that if one kept the neutral point insulated one could allow the system to go to rack and ruin without any shut-down. He was certainly in favour of a continuous metallic covering, earthed at one or more points, and if that was granted then there were good arguments for the leakage devices which had been referred to as unnecessary complications. That idea had arisen from a misunderstanding as to the character of the devices advocated. In many cases discriminating action against leaks could be obtained by means he had suggested, with a corresponding simplification of the automatic devices.

Mr. H. M. Sayers was in favour of the earthed neutral. He pointed out that the earthed neutral on a three-phase system ensured a definite distribution of the potential, one advantage of which was that the designer of all the apparatus in use knew with what pressure he had to deal, and could distribute his insulation in the most economical and efficient way. Another advantage was that it provided a constant watch upon the insulation on every branch of the system, so preventing a high-resistance fault remaining undetected until an accident found it out. He thought the advantage claimed by the author that leakage to earth *probably* resulted in isolating the damaged circuit should be put more strongly. It was only a matter of proper devices to ensure that leakage was discriminated from overload current and positively ensured isolation of a damaged circuit. He challenged Mr. Wood's suggestion that under the conditions shown in Fig. 1 of the Paper (*see* diagram herewith) the mains might be subjected to the full pressure. The distribution of pressure shown on the high-tension side of the transformer was impossible. Further, under such circumstances, the pressure of the generator would undoubtedly fall considerably, and he could not understand, if there were any kind of leakage trip device on the circuit, under what conditions the first indication of anything wrong would be the arcing of a lightning arrester. He was glad to see that most of those who had taken part in the discussion were in favour of a completely armoured system and



1. Transformers connected star to star, neutral earthed, generator neutral unearthed.
2. Earth occurs on one phase and short-circuits it.
3. Voltage on short-circuited phase falls to zero, on other two rises to full-line volts, increasing stress on insulation of two phases in ratio of 58 to 100.

considered it the proper system for all fixed work. Mr Mountain had made an exception for portable apparatus. Special precautions might be taken in such cases, but there were such things as flexible armoured cables.

Mr. H. Brazil said that in regard to earthing, a point which had not been raised was whether to earth direct or through a resistance. He thought earthing through a resistance was desirable, and in the discussion on Mr. Rider's Paper had described an earthing resistance of the carbon powder type which was very suitable for that purpose. At the time referred to the resistance was more or less theoretical, but since then one had been made and was in use on a large 11,000-volt system in the north of England. This resistance allowed 200 amperes to pass to earth when a fault occurred, and if the pressure was kept on, this increased to 330 amperes in about one minute. By the use of this resistance, all the advantages of a direct earthed neutral—viz., the limiting of the rise of pressure due to surges or resonance—were obtained, without the disadvantage of an abnormally large current flowing to earth; further, the automatic cut-outs were only called upon to break the current for which they were set, instead of perhaps 10 times that amount, as might be the case with the neutral earthed direct.

Mr. C. H. Wordingham endorsed other speakers' remarks as to the safety of earthing. He thought it was rather weak-kneed in central station practice to run normally with the middle wire earthed, but to insert a resistance when a fault occurred. He, therefore, advocated direct earthing instead of through a resistance.

Mr. S. Z. de Ferranti simply wished to repeat what he had said before in regard to earthing under other circumstances—viz., he thought most emphatically that it was desirable thoroughly to earth the neutral point, and not only to earth the neutral point but also substantially to cover and enclose the whole of the parts carrying a potential high enough to do any damage.

The Chairman (Mr. S. Evershed) said he would like to add his word on the side of those who believed in earthing the neutral, and certainly on the side of those who endeavoured to enclose all parts in a metallic sheath.

Prof. D. Robertson (communicated) was of opinion that the neutral point should be earthed in every case. So far as shock was concerned an insulated system would probably be virtually earthed by the capacity of the system, seeing that the current required to produce a serious shock was so small, while any slight leak in one main would make the others more dangerous than they would be in a system with its neutral earthed. He failed to see how the author got the 16 per cent. advantage in favour of the insulated system in the matter of insulation strain. The stress between the mains was the same in both cases, and if the neutral point of the insulated system happened to be at earth potential the stresses between each and earth would also be identical in both. But if, as was more likely to be the case, one of the mains, or the apparatus connected to it, was more leaky than the others, the potential of those others would differ more from that of earth than in the earthed system, and the strain on the insulation would be greater, not less than with the latter. The best use was made of mains when they were all at equal potentials relatively to earth. The smaller liability to flash over to the metal casings with the insulated system, to which the author referred, was due to the fact that the system was very kind to its weakest part as regards insulation from earth, for it adjusted the potentials so as to throw the burden of the strain on the other mains, and no arc could be formed so long as the rest of the system was good. The fault did not cause any particular inconvenience or give any very obvious indication of its existence, and in very many cases it would be left undiscovered, or unremoved, until another developed elsewhere, when the results would be at least as bad as on the earthed system. Meanwhile the insulation had been strained by anything up to 73 per cent. above the normal. That was the great objection to unearthed systems. Mr. Wood's objection to the earthed system in Fig. 1 was not a valid one. No one who knew what he was about would allow three-phase transformers to be connected in the way shown in Fig. 1 of the Paper (*see* diagram herewith). Unless there was a fourth conductor in the primary system joining the neutral points of the generators and transformers, the primaries should always be mesh-connected, and certainly the double-star arrangement should never be used. To prevent triple frequency currents circulating between generators running in parallel with their neutrals connected could be entirely avoided by designing alternators so as to have no harmonics in their E.M.F. wave whose order was a multiple of three. It was only necessary to have six slots per pole and connect the windings so that any one and the *second* from it formed one phase, instead of connecting adjacent ones as was usual.

Mr. J. S. Peck (communicated) mentioned that the reference in the Paper to the instability of the neutral point with star to star connected transformers was correct where three separate transformers were used, or where the three-phase transformer was of the shell type or of the Berry type. Such transformers should never be connected star to star unless the neutral points of generator and transformers were earthed or were connected directly together. The delta to star connection was greatly to be preferred for transformers of the above types. With the core type three-phase transformer, the neutral might be considered stable even with the star to star connection, for a short-circuit across one phase would cause excessive currents to flow in the other phases, and so trip the breakers. With the neutral points of transformers and motor both earthed it was possible to transmit three-phase current in the event of one line conductor becoming open-circuited, while with unearthed neutrals or with the neutral at only one end of the circuit earthed, only single-phase current could be transmitted with one line conductor open-circuited. He disagreed with the author and saw no difference in the stress on the insulation whether the neutral point was earthed or not.

Mr. F. O. Hunt (communicated) said with reference to Fig. 4 of the Paper and in view of the fact that there appeared to be a tendency on the part of some engineers to regard leakage trip gear as a complete solution of the safety problem, it might be desirable to place on record some figures relating to the length of time which, by reason of the inertia of the switch parts, must elapse before the action of the trip gear could cause isolation of the faulty section. By means of an oscillograph record during a short circuit test of a turbo-alternator at a local colliery it was found that nearly three periods elapsed between "make" and "break." As the frequency was 40, that indicated a duration of about $\frac{1}{15}$ second, which would, undoubtedly, be long enough for the ignition of gas or coal-dust if they were present at the fault.

Mr. A. F. Stevenson (communicated) thought that actual contact with colliery work brought one into line with the author's summing up of the case—viz., that it was generally preferable to insulate the neutral. In the event of a motor or armoured cable failing on an earthed neutral system at a time when the plant had to be kept running and could be by removing the earth wire or bonding, the temptation was great to do so, with the result that the motor or the armouring was in a highly dangerous condition. On the introduction of leakage indicators, as ordered by the Home Office, it was found that shocks were much more severe. His experience with automatic devices was that they were only of use where the "good man" had charge of them, otherwise they would be wedged or tied up so as to stop their being a nuisance. It was in the pit where the staff was insufficient that simplicity was needed.

Mr. W. Bolton Shaw (communicated) thought the advantage lay with the earthed neutral, but it should be worked in conjunction with armoured cables and switch boxes, &c., having their casing solidly connected to the armouring, which should be earthed at the generator and so connected to the neutral. With that arrangement a leakage to earth almost always developed at once into a "short," and brought out the circuit-breaker, thus isolating and at the same time locating the faulty circuit. He considered that the risk of fire from a momentary short-circuit, especially when confined within an earthed envelope, was very much less than from a continued leakage. The opening of the circuit as the result of a leakage had three great practical advantages over a mere indication on a leakage indicator. It stopped the trouble at once, it showed on which circuit it was and it prevented the circuit from being worked with the fault still on. Regarding shock, he thought that the advantages claimed by the author for the insulated neutral seldom existed under ordinary working conditions on an installation of any considerable size. There was always a certain amount of leakage on the system from phase to phase via earth, and that was recognised by the present Home Office rules, which permitted a leakage current of $\frac{1}{1000}$ of the maximum supply current. The leakage indicator did not indicate the amount of that leakage, but only showed whether it was out of balance. If it was not much out of balance, the neutral point would be

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very little different from earth potential. A person coming in contact with any one-phase merely shunted a portion of the leakage on that phase, and unless the leakage was extremely small the effect on the P.D. between that phase and earth would be slight. The voltage of the shock he received would, therefore, be practically the same as in the case of a system with earthed neutral. The danger from the flash due to a "short" was minimised in the case of switches, &c., by the flame or gas-tight cases required by the electricity rules. He was strongly in favour of using paper lead-covered armoured cables wherever practicable. With that type of cable he had had very heavy "shorts" occur without showing any signs outside the lead covering. Armouring did, no doubt, add to the cost of cables, but it had the great advantage of providing a substantial and visible earthed conductor to which all frames and covering could be connected. It also added greatly to the durability and mechanical strength of the cable, and the latter could be moved from one road to another—as was often necessary—with much less risk of damage than unarmoured cable. The sine of earth wires, he thought, should also be determined with a view to plenty of mechanical strength, and it was also advisable to have them stranded. With transmission lines having an earthed neutral and carried on iron posts it might be advisable to connect all the posts together by an earth wire, which could be fixed above the line wires and so serve as a lightning guard. The reason he suggested that was because he had known a line wire break away from an insulator and fall on the cross arm, which was iron as well as the post. The post was set in the ground without concrete, but had attached to its lower end anchor or fin plates of considerable area giving a reasonably good earth contact. The voltage of the line was 3,300, but the resulting fault was not sufficient to trip the overload circuit-breaker which was set for about 80 amperes. He found on measuring the earth resistance between two adjacent posts which were 56 yds. apart that it amounted to about 40 ohms, and was practically the same between posts three spans apart, so that between the neutral earth and any post the resistance would be above 20 ohms. In addition to this the neutral was earthed through a 12 ohm grid resistance. He did not think a resistance in the earth connection to the neutral of a high-tension system served any useful purpose. The argument that it prevented an excessive current when a short to earth occurred seemed to him to be against rather than for it. In any case, a "short" between phases produced a much larger current, and there was no serious difficulty in coping with it. As to earthing the neutral with generators running in parallel, he had found the system of having the neutral of only one generator switched on to the earth bar at a time to work perfectly satisfactorily. There was a rather curious effect produced where generators were paralleled by a bank of lamps cross-connected direct on to the 'bus bars. If the incoming generator was run up with its neutral earthed as well as that of the running machine, the lamps showed an intermediate bright point first on one set and then on the other between the in and out of phase positions. That might be mistaken for the "in phase" position and lead to the machine being switched in at 120 deg. out of phase.

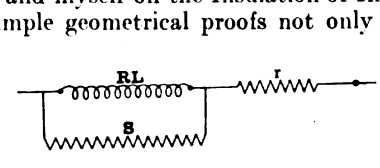
Mr. W. W. Wood, in reply, said he was glad to see that several of those more intimately connected with mining work agreed that it was desirable to lay down no hard-and-fast rule as to whether the neutral should be earthed or insulated. Among those who were in favour of earthing the neutral under any circumstances, there seemed to be rather a tendency to regard the question from the point of view of the high-tension central station of large size; but, of course, there was a good deal of difference between the conditions governing the running of such a station and many colliery plants. In the case of the latter, although it might be very inconvenient to stop during a shift, it was nearly always possible to arrange that any underground plant could be shut down at a few hours' notice (*i.e.*, at the end of the shift) without inconvenience, and it was often of considerable importance to keep the plant going for a few hours. With regard to one speaker's suggestion that as long as the winding and fans could be kept going it did not matter about stopping haulage or other plant, he appeared to have overlooked the fact that if the main haulage were stopped the only thing left to wind would be the men. The advocates of the earthed neutral had not put forward any very powerful arguments in its favour, but seemed to have devoted their attention to proving that it was just as likely that one would get a shock on an insulated system (1) on account of the natural tendency of the neutral position to be fixed, as shown by Mr. Highfield, and (2) on account of the fact that there must be some slight leakage on other parts of the system. This was, of course, regarding the matter from the point of shock alone, and disregarding the question of reliability of supply. Replying to these two points, however, (1) While a shock due to capacity effect could be received on an alternating-current system through making contact with one phase and earth alone, the current which could flow could not exceed the charging current, and was not likely to be as great as that. In a very large or high-tension system this charging current might be sufficient to produce fatal results, but on many 600-volt colliery installations at, say, 40 or 50 cycles, the charging current was quite small. (2) While on even a completely insulated system there must be leakage, on a 500-volt system of medium size this leakage (if the installation were kept in good order) was so small that while it would be quite sufficient to deter anyone in making a practice of treating live terminals with contempt, it would be very unlikely to produce fatal results. In any case it was obvious that there was more chance of surviving shock if it was received where the neutral was insulated. As the first object of either system was to secure the safety of those working underground, it would seem advisable to adopt that system which gave a greater degree of safety. When the neutral was earthed one relied on a single set of insulation, but where the neutral was insulated there were two such sets of insulation in series, both of which must fail before troublesome or dangerous conditions arose, and by means of the leakage indicator required by the Home Office Regulations it was possible to see that both these sets of insulation were being kept in good condition. Replying to Mr. Sayer's challenge to Fig. 1, by referring to the discussion on a Paper presented to the American Institute of Electrical Engineers by Mr. F. O. Blackwell, it would be seen that Mr. P. N. Nunn, engineer of the Telluride Power Co., stated that the conditions shown in this diagram not only could occur, but frequently had occurred on his system, which was connected as shown in the diagram. The reason the lightning arresters were the first signs of anything wrong was because these arresters were set for the normal working condition of a maximum voltage of 58 per cent. of the line volts between any point and earth, and owing to the abnormal conditions which had arisen there was, as a matter of fact, the full line volts between two phases and earth. As to the advantage of the earthed neutral enabling the designer to know the exact voltage with which he had to deal, this, of course, was so, but with the average colliery voltage, say, either 650 or 3,000, the difference to the designer was quite negligible. Mr. Patchell was correct in his remarks about President Scott, but judging from the Paper read by Mr. Marchant before this Institution a short time ago the conditions in America were still very much the same, and although it would appear that earthing the neutral on these extra high-tension lines would be the best thing to do, the majority of American plants worked very satisfactorily with a delta connection and insulated neutral. With regard to Mr. Wordingham's suggestion that there should be no half measures, and the neutral be earthed with as low a resistance as possible, such a practice seemed more suitable for a supply station than for the average colliery installation, where the object was to reduce any liability to flashing or arcing underground as much as possible. The author agreed that armouring of cables was very desirable, and on high tension possibly absolutely necessary, but the fact must not be overlooked that in many collieries there were salts or acids which attacked the armouring, and Mr. Knight, of Messrs. Callender's, in speaking recently at Barnsley at a meeting of the Institution of Mining Electrical Engineers, stated that he knew collieries in Yorkshire where the armouring would not last three weeks. Of course, no reliance could be placed on armouring under these conditions. As to Mr. Wedmore's remarks, the fact that there were only 1 per cent. of electrical deaths did not convey very much until one considered that during 1908 approximately 1,280 people were killed in mines and collieries from all causes, and about 14 from electrical causes, and of these 14 some were pure accidents and some wilful carelessness. The main points which the author had endeavoured to bring out in his Paper were: (1) As long as the earthing of motor cases and switch cases was effectively maintained there was no danger from shock, but as soon as this earthing was faulty dangerous conditions could arise, against which neither leakage trips nor other devices could protect. (2) That wherever there was an earthed neutral the danger of these conditions was increased. The author's description of the size of earth wire was criticised, but it appeared unnecessary to specify that the wire should also be mechanically strong, as this was so obvious. Finally, the author saw nothing in the arguments brought forward to cause him to change his opinion that while there were no doubt certain installations where it was better to earth the neutral, it would be unwise to do this without first taking into account the particular conditions of each installation.

CORRESPONDENCE.

ON THE EFFECT OF SHUNTING INDUCTIVE COILS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have to thank Mr. G. W. O. Howe for correcting (in your issue of April 22nd) the misinterpretation of the late Mr. H. E. Harrison's experiment which occurred in the Paper by Mr. Eckersley and myself on the Insulation of Inductive Coils. Mr. Howe's simple geometrical proofs not only elucidate the



problem, but give immediately two of the approximate formulas. Permit me now to state Mr. Harrison's interesting result, putting his geometry into algebraical form for greater definiteness.

If r be a non-inductive resistance in series with a choking coil (R, L), *in some cases* the total impedance is *increased* by shunting the choker by a resistance S. This may be proved as follows:—By the usual symbolic method it is easy to show that the total impedance (Z_1) is given by the equation

$$Z_1^2 = \frac{[r(R+S)+SR]^2+(S+R)^2L^2\omega^2}{(R+S)^2+L^2\omega^2}.$$

If the values of R, L, r and ω are suitably chosen, this expres-

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sion has a maximum for a value of S between ∞ and 0. For example, when R=1, r=20, and $L^2\omega^2$=10,

$$Z_1^2 = 451 + \frac{3388S - 561}{S^2 + 2S + 11}.$$

By differentiating and putting $\frac{d(Z_1^2)}{dS} = 0$ in the usual way we find that Z_1^2 has a maximum when S is about 6. Thus the total impedance without any shunt is $\sqrt{451}$; when a shunt of 6 ohms is applied, the impedance *rises* to about $\sqrt{476}$. It should be kept in mind, however, that in many cases no maximum occurs between S=0 and S=∞.—I am, &c.

Teddington, April 27. ALBERT CAMPBELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In connection with Mr. A. Still's letter in your last issue, it may be of interest to state the particular experiment to which both the late Mr. H. E. Harrison and Mr. A. Campbell were referring when discussing the peculiar effects produced by shunting inductive coils. Early in 1893 Mr. G. W. Partridge showed Mr. Harrison that shunting an inductive coil which is in series with a non-inductive resistance had sometimes the effect of increasing the impedance of the whole circuit. Mr. Campbell investigated this effect experimentally at Faraday House, and Mr. Harrison, in THE ELECTRICIAN for June 2nd, 1893, showed that the interesting and paradoxical results can be simply explained by elementary geometry.

The analytical proof is also simple. If the choking coil (0, L) be shunted by the resistance x and a resistance (r, 0) be in series with it, then if Z be the total impedance we have

$$Z^2 = \left\{\frac{x\omega^2L^2}{x^2+\omega^2L^2} + r\right\}^2 + \omega^2\left\{\frac{Lx^2}{x^2+\omega^2L^2}\right\}^2$$

and hence, by the differential calculus, Z is a maximum when

$$x = \frac{\omega^2L^2}{2r} + \frac{\omega L}{2r}(\omega^2L^2 + 4r^2)^{\frac{1}{2}}.$$

I am, &c.,

Faraday House, London, May 2. ALEXANDER RUSSELL.

THE METHOD OF DUALITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The problem discussed in the preceding letter gives an interesting example of the method of duality. By means of this method* every electrical theorem can be reciprocated into another theorem which is sometimes of greater practical importance than the first. In order to get the reciprocal theorem all we have to do is to write currents, choking coils, condensers, series, mesh, dynamo, &c., for the words voltages, condensers, choking coils, parallel, star, motor, &c., in the first theorem. Similarly to deduce the formulæ for the second theorem from the formula for the first we have merely to write C, E, 1/R, K, L, &c., for E, C, R, L, K, &c. For example, Partridge's theorem can be stated as follows:—

1. When a constant effective P.D. is applied at the terminals of the conducting path afforded by a non-inductive resistance R in series with a shunted choking coil, the effective current in the main is a minimum when

$$x = \frac{\omega^2L^2}{2R} + \frac{\omega L}{2R}(\omega^2L^2 + 4R^2)^{\frac{1}{2}},$$

where x is the non-inductive resistance shunting the choking coil L.

The reciprocal theorem is:—

2. When the effective value of the current in the main is kept constant and we have two branch circuits, one being a fixed resistance R, and the other a condenser K in series with a variable resistance x, then the effective P.D. between the terminals of the fixed resistance is a maximum, when

$$1/x = \frac{\omega^2K^2R}{2} + \frac{\omega KR}{2}\left(\omega^2K^2 + \frac{4}{R^2}\right)^{\frac{1}{2}}.$$

The formula in (2) is deduced from the formula in (1) by writing 1/x, 1/R and K for x, R and L respectively.

The chief value of the method, however, lies in its use for indicating more convenient methods of making measurements and for suggesting novel instruments and machines of value in electrotechnics.—I am, &c,

Faraday House, London, May 2. ALEXANDER RUSSELL.

* Russell, "Alternating Currents," Vol. I., Chapter XVII.

"ELECTRIC CABLES: THEIR CONSTRUCTION AND USE."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I make a protest against the tendency of unfair and often ignorant "reviews" of technical works which appear in your columns.

With a large number of your readers, I look to such reviews for guidance before purchasing any work on a technical subject in which I am interested.

On more than one occasion recently I have happened to read reviews on books in my possession, or at my disposal, and have found points criticised ignorantly, and I must say spitefully.

The latest instance occurred in your review of Coyle and Howe's "Electric Cables, their Construction and Cost."

The first paragraph makes a peculiar reference to the Engineering Standards Committee and its "experience." The coefficient for copper as adopted by the Committee is *known* to be wrong, and has been discarded by most up-to-date cable manufacturers, and the table as published by Coyle and Howe is now generally adopted.

I should be glad if your reviewer can point out a single case where specific gravity is used erroneously, and advise him to "read" the authors' remarks on the specific gravity of paper cables. I fail to find any confusion in the chapter on telephone cables, and on this subject your reviewer is evidently an "amateur."

By some people, like your reviewer, it appears that the book was *not* wanted, as it gives too much valuable information away, which hitherto has been kept under lock and key; but for a large number of engineers the book has filled a long felt want. Although catalogues of to-day are very profuse with information, one can hardly expect in this age of "associations," trusts, &c., cable manufacturers to show their customers that after allowing a fair margin of profit a cable should cost £200, and he finds he has to pay £400 for it as the book demonstrates, I cannot imagine any *business* engineer sitting down in "satisfactory contentment."

It is very obvious your reviewer is interested in "fancy" prices being paid and keeping the customer in ignorance.

The book in question was most favourably reviewed by your contemporaries the "Electrical Review," the "Electrical Engineer," "Gummi Markt," of Hamburg and "Le Caoutchouc et Gutta Percha," of Paris.

This or any book ever published is not perfect, and I feel sure no one would appreciate fair criticism more than an author, and the least a subscriber can reasonably expect is that reviews should be free from petty jealousy, "Association" influence and wilful misrepresentation.

Finally, it would perhaps surprise your reviewer if he could ascertain how many cable works in England and on the Continent have a "*number*" of these much despised "amateur" works in daily use.—I am, &c.,

April 26. A LOVER OF FAIR PLAY.

["A Lover of Fair Play" stigmatises our reviews as being often unfair, ignorant and spiteful. A mere assertion of this character is easily made, but goes for very little. If he is right, we must conclude that "A Lover of Fair Play" knows more about the subjects at issue than do the numerous well-qualified reviewers to whom these books are submitted. This, we suggest, is improbable. In fact, their names are a sufficient guarantee to the contrary. If the criterion of a good review is that it must be favourable, nothing is easier; but THE ELECTRICIAN readers have a right to expect something more than mere colourless statements of approval. With regard to the

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particular review of "Electric Cables: Their Construction and Use," we have communicated with the reviewer, who is an engineer perfectly well known in the cable industry. He sees no reason to modify his review, and he did not refer to the authors as "amateurs." "A Lover of Fair Play" would have been better entitled to notice if he had permitted us to publish either his name or his initials.—ED. *E.*]

PROF. FLEMING'S LECTURES IN TELEGRAPHY AND TELEPHONY.

At the conclusion of his recent Postgraduate Lectures given at University College, London, on the Propagation of Electric Currents in Telegraph and Telephone Cables, Prof. J. A. Fleming set an examination paper to be worked by the members of the class. As the lectures were attended by over 70 telegraph, cable and telephone engineers, and as Dr. Fleming's engagements did not permit of the individual examination of the papers, he has requested Mr. G. B. Dyke to work out the solutions, and these have now been placed in our hands. As the subject is of very general interest at the present time we reproduce the questions and answers below.

Question I.—Plot, as lines radiating from any origin, the vectors: $\cosh(0{\cdot}5+j0{\cdot}8)$, $\sinh(0{\cdot}5+j0{\cdot}8)$, $\sqrt{\coth}(0{\cdot}5+j0{\cdot}8)$.

Solution.—Writing out these functions as vectors, we have

$$\sinh(0{\cdot}5+j0{\cdot}8) = 0{\cdot}363+j0{\cdot}809 = 0{\cdot}887\angle 65°\,50'$$
$$\cosh(0{\cdot}5+j0{\cdot}8) = 0{\cdot}786+j0{\cdot}374 = 0{\cdot}870\angle 25°\,27'$$
$$\therefore \quad \coth(0{\cdot}5+j0{\cdot}8) = 0{\cdot}981\angle 40°\,23'$$
$$\therefore \quad \sqrt{\coth}(0{\cdot}5+j0{\cdot}8) = 0{\cdot}990\angle 20°\,11{\cdot}5' = 0{\cdot}929-j0{\cdot}342.$$

These vectors may be plotted as shown in Fig. 1.

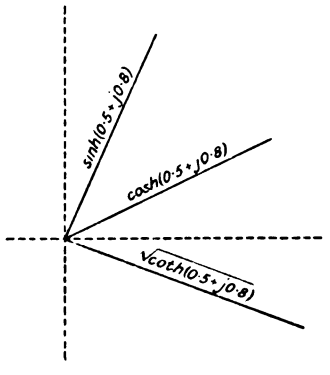

FIG. 1.

Question II.—If a length of 40 miles of standard cable (88 ohms, 0·001 henry and 0·054 mfd. per loop mile) has an alternating E.M.F. of 5 volts, and frequency $5{,}000/2\pi$ applied to one end; calculate the P.D. at the receiving end when this end is insulated, and the current if short-circuited.

Solution.—We have

$$\text{Initial sending end impedance } Z_0 = \frac{\sqrt{R+jpL}}{\sqrt{jpC}} = 573\angle 43°\,23' \text{ vector ohms.}$$

$$\text{Now, attenuation constant} = \alpha = \sqrt{\frac{Cp}{2}\left\{\sqrt{R^2+p^2L^2}-pL\right\}} = 0{\cdot}106.$$

$$\text{and wave-length constant} = \beta = \sqrt{\frac{Cp}{2}\left\{\sqrt{R^2+p^2L^2}+pL\right\}} = 0{\cdot}112.$$

$$\text{Hence attenuation length} = Pl = (\alpha+j\beta)\,l = (0{\cdot}106+j0{\cdot}112)\,40 = 4{\cdot}24+j4{\cdot}48.$$

For far end open,

$$\text{Receiving end P.D.} = V_2 = V_1 \operatorname{sech} Pl = \frac{5}{34{\cdot}70\angle 245°\,42'} = 0{\cdot}144\angle 114°\,18' \text{ vector volts.}$$

For far end short-circuited,

$$\text{Received current} = I_2 = \frac{V_1}{Z_0}\operatorname{cosech} Pl = \frac{0{\cdot}144\angle 114°\,18'}{573\angle 43°\,23'} = 0{\cdot}252\angle 157°\,41' \text{ vector milliamperes.}$$

Question III.—Taking the above cable, let a telephone receiver be placed at the receiving end, having an impedance of $1{,}275\angle 63°\,48'$ vector ohms. Calculate the current through the telephone for the same sending voltage and frequency as in Question II.

Solution.—For a line as long as 40 miles we may use the approximate formula

$$\text{Received current } I_2 = \frac{V_1 \operatorname{sech} Pl}{(Z_0+Z_r)}.$$

Now $Z_0 = 573\angle 43°\,23'$

and $Z_r = 1{,}275\angle 63°\,48'$

and $Z_0+Z_r = 1{,}233\angle 37°\,25'$

$$\therefore \quad I_2 = \frac{0{\cdot}144\angle 114°\,18'}{1{,}233\angle 37°\,25'} = 0{\cdot}117\angle 76°\,53' \text{ vector-milliamperes.}$$

Question IV.—Taking 40 miles of the above cable, let it be loaded at 2-mile intervals with Pupin coils each of effective resistance 10 ohms and inductance 0·2 henry. Calculate the attenuation constants for the unloaded and loaded 40-mile lengths.

Solution.—As the leakance is zero we have

$$\text{Attenuation constant} = \alpha = \sqrt{\frac{Cp}{2}\left\{\sqrt{R^2+p^2L^2}-pL\right\}},$$

and for the unloaded cable

$$R = 88 \text{ ohms}, \quad L = 0{\cdot}001 \text{ henry}.$$
$$C = \frac{0{\cdot}054}{10^6} \text{ farad per mile and } p = 5{,}000.$$

Hence $\alpha = 0{\cdot}106$.

For the loaded cable

$$R = 88+5 = 93 \text{ ohms}, \quad L = 0{\cdot}001+0{\cdot}1 = 0{\cdot}101 \text{ henry}.$$
$$C = \frac{0{\cdot}054}{10^6} \text{ farad per mile and } p = 5{,}000.$$

Hence the "smooth" attenuation constant $= \alpha' = 0{\cdot}032$.

$$\text{The wave length constant} = \beta' = \sqrt{\frac{Cp}{2}\left\{\sqrt{R^2+p^2L^2}+pL\right\}} = 0{\cdot}370.$$

$$\text{Hence the wave length} = \frac{2\pi}{\beta'} = 17 \text{ miles.}$$

We have therefore 8½ coils per wave, and hence the "smooth" attenuation constant 0·032 gives a very close approximation to the true value.

Question V.—Given a submarine cable 1,000 miles long, having resistance 3 ohms and capacity ¼ mfd. per nautical mile, worked without terminal condensers. Assume a letter S sent, uncurbed, with 20 volts

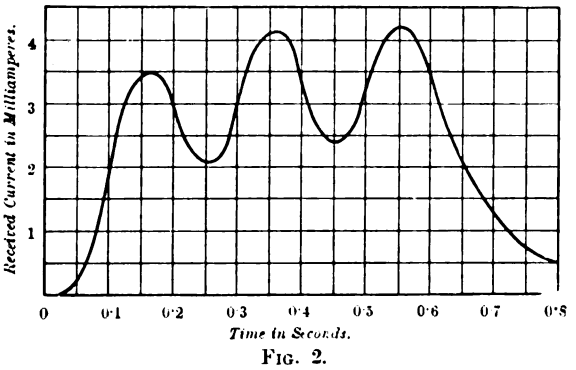

FIG. 2.

impressed E.M.F., each dot and each space being 0·1 second long. Predetermine the curve which would be drawn by the pen of the syphon recorder at the receiving end.

Solution.—

$$\text{Let } \mu = \frac{\pi^2}{CRl^2} = \frac{\pi^2}{\frac{1}{3\times 10^6}\times 3\times 10^6} = 9{\cdot}87$$

and let $e^{-\mu t} = \theta$

and $f(\mu t) = \frac{1}{2}-\theta+\theta^4-\theta^9+\theta^{16}-$, &c.

Then if the letter S is sent, the received current I_t after a time t is given by

$$I_t = \frac{2V}{Rl}F(\mu t) = \frac{1}{75}F(\mu t) \quad \text{in this case.}$$

$$\therefore \quad I_t = \frac{1}{75}\{f(\mu t)-f(\mu, t-0{\cdot}1)+f(\mu, t-0{\cdot}2)-f(\mu, t-0{\cdot}3)+f(\mu, t-0{\cdot}4)-f(\mu, t-0{\cdot}5)\}.$$

The received current can, therefore, be calculated for any assigned value of t. If this is done for several values, and the results plotted, the form of the received signal may be drawn as shown in Fig. 2.

Question VI.—If a power transmission line 50 miles long consists of a pair of No. 4 S.W.G. copper wires each 5·9 mm. diameter placed 1 metre apart, and if these lines are carried on poles 40 ft. above the ground,

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calculate the capacity, inductance and impedance of this line for currents of a frequency of 25 ∞, assuming the copper resistance to be 2 ohms per loop mile.

Solution.—Capacity per mile in microfarads.

$$= \frac{0{\cdot}0194}{\log_{10}\frac{2D}{d}},$$

where D=distance apart in centimetres. d=diameter of wire in centimetres.

$$= 0{\cdot}00766 \text{ mfd.}$$

$\therefore$ Total capacity = 0·383 mfd.

Inductance per mile in microhenrys

$$= 1{,}483 \log_{10}\frac{2D}{d},$$

$$= 3{,}752 \text{ microhenrys}$$

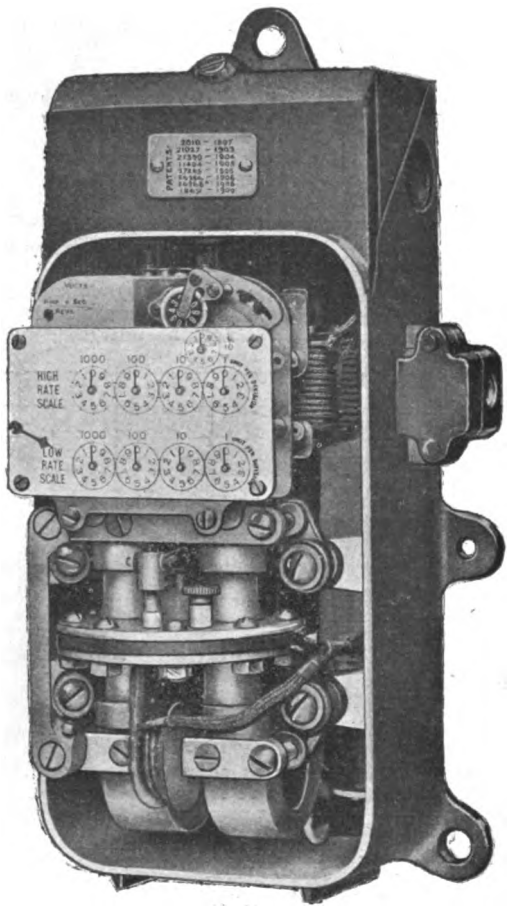
$\therefore$ Total inductance = 0·1876 henry.

Initial sending end impedance $= Z_0 = \frac{\sqrt{R+jpL}}{\sqrt{jpC}}$

$$= 1{,}318 \angle 36°43' \text{ vector ohms.}$$

FERRANTI TWO-RATE CONTINUOUS CURRENT METERS.

Messrs. Ferranti have added to their activities in the meter world by the production of a two-rate continuous-current meter, an inside view of which is shown in the accompanying illustration. This



Inside View of Ferranti Two rate Meter.

type of meter is provided with two sets of dials, each of which indicates the energy consumption in Board of Trade units. The lower dial indicates the consumption during one portion of the day and is generally arranged to indicate that portion of the energy consumed at the cheaper rate. The higher dial indicates the consumption of that portion of the energy charged at the higher rate. In general arrangements the meter is of the Ferranti-Hamilton standard continuous-current type, while the two-rate train consists of two sets of recording dials of the ordinary kind and an intermediate change-over gear of novel construction. The meter spindle drives the $\frac{1}{100}$ and $\frac{1}{10}$ unit spindles in the usual manner. This arrangement is an advantage which is not usually possessed by two-rate meters, as it allows testing to be effected much more easily. The $\frac{1}{10}$ unit spindle drives the first wheel of the intermediate change-over gear wheels, and this in its turn drives two others of a wheel train, the latter of which may gear either with the wheel on the unit spindle of the lower recording dials or with the wheel on the unit spindle on the higher recording dials, according as the change-over lever is in the low or high-rate position. The construction of this gearing is epicyclic in character so that by the rotation of the lever about the centre of the first wheel no rotation of the second wheel occurs when these two wheels are of the same diameter. In the act of changing from registering on one dial to registering on the other dial no rotary motion is given to the dials. A shunt circuit, consisting of an electromagnet, resistance and automatic time switch all in series and taking about $\frac{1}{60}$ of an ampere, provides the energy to operate the change over from low rate to high rate. The automatic time switch "makes" the shunt circuit at the beginning of the high-rate period. This energises the electromagnet which attracts the armature and operates the change-over of the gears. The shunt circuit is "made" during the whole of the high-rate period and the meter registration is on the higher dials for this period. At the end of the high-rate period the automatic time switch "breaks" the shunt circuit and allows the armature to fall away and bring the dial wheel out of gear with the high-rate wheel and into gear with the low-rate wheel. The shunt circuit is "broken" during the whole of the low-rate period and the meter registration is on the lower dials for this period.

LEGAL INTELLIGENCE.

The Electrical Co. v. Thomas, Son & Co.

The hearing of this case, which has lasted 40 days and has established a record as a reference before the Official Referee, was concluded last week, when Mr. Pollock heard further evidence by plaintiffs in connection with the defendants' counterclaim.

Mr. Chas. P. Sparkes, said he had visited the Lynvi Colliery in 1908 at plaintiffs' request and examined the plant there. This plant was suitable for the work, but he advised plaintiff company that there were not sufficient reserves. There was no spare generator and the pumps were not arranged to the best advantage. The sump was very much smaller than usual, and the danger was of loosing the machinery by being drowned out. In his opinion the failure of the machine to excite was probably due to the brushes being allowed to get loose or the motor to get dirty. He did not know of any other reason. It was very necessary to have a skilled man to work the plant. In the early days, when it was very difficult to get a skilled man, trouble with the commutator was far more important than it was at present. He knew the plant which plaintiffs had supplied, and having regard to the enormous risks they ran witness reported to them that to run a single generator for over 2,000 hours involved great risk to the contractors, greater than any ordinary contractor would take. He advised plaintiffs to come to a settlement with defendants. In his opinion it was not business for the plaintiffs to go on running so great a risk as keeping the "slant" unwatered with such a plant. There was undoubtedly some mistake in connecting the exciter that might cause some of the trouble complained of in regard to the machine. If either of the current "paths" were broken—that was to say, if the generator "path" was broken through a "fault," the machine could not produce any current On the other hand, if the field were improperly connected the machine would be unable to build up sufficient field to give any current. Anyone, however, putting the machine to work originally would detect this very easily. If anything went wrong with an exciter the usual method of endeavouring to ascertain the trouble was first of all to increase the speed of the machine. It was quite possible that a machine, owing to shock in transit, or being knocked about in some way, might entirely lose its residual magnetism, and then when it was put up in the first instance it would be necessary to use a small battery to excite it. Once, however, it had become magnetised, unless the machine stood for a very long period, was subjected to vibration, or was knocked about, it was not very likely that it would lose its magnetism. It was quite possible for a machine to lose its residual magnetism if taken to pieces. After such an operation the residual magnetism of a machine certainly got weaker, and he thought that in this instance the question of speed of the engine had been overlooked in the endeavour to get the exciter to work after it had been cleaned.

This concluded plaintiffs' evidence on the counterclaim.

Counsel having addressed him, the Official Referee delivered judgment on Saturday. He reviewed the evidence, &c., at considerable length. Considering, he said, how Mr. Thomas had always urged upon the Electrical Co. the necessity of proceeding with their work without delay, it was a matter of surprise that he took a month to conclude the contract. It was also curious that Dec. 23 was put forward as the date the plant should be erected. On Dec. 21, however, defendants wrote to plaintiffs to say that the buildings at the mine were not ready to receive the plant, and that Mr. Thomas would write to the plaintiffs when they were ready to receive it. Therefore, the delay up to that time was obviously due to defendants and not to plaintiffs. There were entries in the daily reports of defendants showing that considerably

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later than that the building was not in a finished state. As regarded the difficulty of the belt, and the point which was raised that it was not included in the contract, he was of opinion that, even assuming the belt was shown on the drawings, that would not help Mr. Thomas's case. This also gave rise to more delay, for which plaintiffs were not responsible. As was usual during this time, defendants were complaining of delay, and plaintiff company were writing making excuses, because they did not want to offend defendants, but it seemed to him that plaintiffs had good ground for saying that the delay was not theirs. He found that the contract of 1905 was completed somewhere about the middle of February, 1907, and it was clear upon the evidence that between August, 1906, and June, 1907, some 1,594 tons of coal were got out of the mine. There was no doubt that difficulties occurred during that time. There were difficulties with the exciter, which failed from time to time, but that failure did not interfere with keeping the water out of the mine or with working the coal. In his view, the chief difficulty, if not the whole difficulty, in regard to the exciter was due to the improper attention bestowed upon the machine by those in the employ of defendants. There was obviously no one there who knew anything at all about the electrical plant. There was no expert of any kind there on defendants' behalf, and when an expert went down on plaintiffs' behalf the machine was put in order and worked very well. There was a suggestion that the trouble with the exciter was due to some fault for which plaintiff company were responsible, but witnesses called for plaintiffs showed that the machine ran perfectly well for a certain length of time and the difficulty could not be due to any inherent defect in the exciter; but, on the other hand, was due to improper attention. He therefore came to the conclusion that there was no material defect in the machine. It was pretty obvious that the steam pipes were responsible for some of the mischief which arose. Mr. H. W. Thomas went so far as to say that he cleaned the exciter 12 times in one day, but he (Mr. Pollock) did not for a moment believe that. As to the flooding of the mine he did not believe that the accident arose from anything for which plaintiff company were responsible, and there was no proper evidence upon which he could base such a finding. The new agreement after the flooding out of the mine was entered into, and defendants' contention was that this new agreement was a continuation of the agreement made in 1905, and upon this point of view Mr. Thomas had based the counterclaim. He (Mr. Pollock) did not agree with that contention, and, in his opinion, the agreement of June, 1907, was an entirely fresh one. At that time, plaintiffs had completed their contract, but the mine was flooded, and it was necessary to take some steps to unwater it. They came to the very simple conclusion that they must start afresh to deal with this uncontemplated state of things, and they showed that they intended to hang up the proceedings and leave the dispates which had arisen over the 1905 contract to be settled afterwards. The new agreement was consequently entered into, and at this time plaintiff company were undoubtedly desirous to show that the plant was effective for unwatering the mine, because they did not wish it to be said by anyone that their plant could not do the work. This new contract for unwatering the mine, however, had nothing whatever to do with the original contract under which they had only got to supply pumps that would be capable of dealing with the work. The new contract was to get rid of the water in the mine whatever the amount of it was. In entering into this contract plaintiffs were going to great expense and were doing so for the benefit of defendants. They declared that they would get rid of the water and they ultimately did so, but they did not say they would do so within any specified time. As soon as they started to deal with the matter Messrs. Thomas began to complain, but Mr. Thomas was in the habit of complaining, and that could not be avoided. The Official Referee quoted freely from the correspondence between the parties, but he came to the conclusion that the damages defendants claimed were too remote, and he did not agree that defendants had suffered the enormous amount of damage they claimed nor could such damages be recovered. The strike was the actual cause of the mine being flooded and not any failure on the part of plaintiffs. In fact, he thought plaintiffs had acted very reasonably throughout. The evidence given on behalf of defendants was unreliable. The time the case had occupied (40 days) was wholly unjustifiable, and had arisen in a great measure from the way in which defendants had brought it forward. They had put forward a counterclaim for £31,000. Most of the time had been occupied in dealing with the counterclaim, and many of the items in that claim had been grossly exaggerated. Documents to which plaintiffs ought to have had access were not produced until the inquiry had been in progress some time; no survey books were produced, and there was the greatest difficulty in getting hold of the plans. He had taken a general view of the material facts of the case, and upon those material facts he had come to the conclusion that plaintiffs' view was right and that the plaintiffs had, subject to a small matter which he would deal with, completed their contract in February, 1907, sufficient to entitle them to recover those items which he should mention; and that with regard to that part of the case—that was the only part of the case with regard to which Mr. Oliver Thomas could recover any damage at all—all the subsequent operations in the mine were conducted under the agreements of June 20, 1907, and Nov. 15, 1907—and that no damages were recoverable (they were not claimed indeed) on behalf of Mr. Oliver Thomas in respect of those two matters. He had not been put in a position on behalf of defendant to enable him to say what damage he was entitled to in respect of that portion of the period during which it was admitted there was a breach by plaintiffs of their contract. There was not a fraction of evidence on behalf of defendants to which he could appeal to enable him to deal with it. It was quite clear to his mind, having regard to the fact that the mine was kept unwatered from Aug. 11, 1906, that the damage must be very small. He thought it could be only in respect of any extra coal used, any possible extra labour (he did not know whether there was any caused) and any extra wear and tear of the steam pumps employed while plaintiffs failed to complete their contract. For plaintiffs it was admitted it might amount possibly to £50. He accepted that admission, and he found £50 for that. Upon that basis he found in favour of plaintiffs on the claim. The items were £1,150, £51. 1s. 4d., £87. 18s. 4d., £4. 17s., £10. 4s. 7d., £2. 4s. 6d., making a total of £1,306. 5s. 9d. There was the set-off of £151. 4s. 10d., and also the £50 damages. Deducting those items from the £1,306. 5s. 9d. made the amount £1,105, for which there would be judgment, with costs of claim and counterclaim.

Reid Newfoundland Co. v. Anglo-American Telegraph Co.

On Thursday last week the Judicial Committee of the Privy Council (Lords Macnaghten, Collins and Shaw of Dunfermline, and Sir Arthur Wilson) heard legal arguments in an appeal from a judgment of the Supreme Court of Newfoundland.

Mr. Danckwerts, K.C., and Mr. R. E. Moore were counsel for appellants; Sir Robert Finlay, K.C., and Mr. Rowlatt for respondents. Respondents are successors of the New York, Newfoundland & London Telegraph Co., incorporated under an act of the Newfoundland Legislature in 1854. By sec. 14 of that statute the use of any part of the territory of Newfoundland by any other persons than the company for telegraphic communication was prohibited for 50 years, subject to a right of pre-emption by the Government of the colony. Appellants were lessees of the Newfoundland railway system. In 1907 they erected along a section of their railway a line of telegraph, which it was proposed to use for working their system, and it was in respect of this intention that the present action was brought by respondents, on the ground that such action was an infringement of an agreement made in 1888 between them and the Newfoundland Railway Co. The question in dispute was whether under that agreement respondents had the right to prevent appellants from erecting and using such a line of telegraphs. The Supreme Court decided in favour of respondents, and ordered appellants to remove the telegraph line in question.

Their lordships reserved judgment.

Valuation of Tramways.

In the Bill Chamber of the Court of Session (Edinburgh) on Thursday last week Lord Dundas delivered his considered judgment in the appeal by Glasgow Corporation against the valuation of the municipal tramways made by the Assessor of Railways and Canals. The yearly rent or value of the undertaking had been fixed by the assessor at £278,070, but for the Corporation it was urged that the figure should be £230,573. Lord Dundas has found the value of appellants' undertaking to be £258,838, and to that extent he allowed the appeal. In delivering judgment, Lord Dundas said that the principal, if not the only, question involved was whether or not the word "railway" as it occurred in sec. 3 of the Valuation of Lands (Scotland) Amendment Act, 1867, was sufficiently wide to include "tramway," so as to make appellants' undertaking a subject of compulsory assessment by the Assessor of Railways and Canals. The argument for appellants was forcible, but he allowed the argument of assessor's counsel to proceed, because (1) the point seemed to be fairly raised by the alternative (in one view the primary) contention of appellants, and (2) his lordship desired to have the assistance of counsel upon a point which, as his lordship thought, it was pars judicis to determine apart from the attitude assumed by counsel upon either side. Leaving authority out of account, he would come without much doubt or difficulty to an affirmative conclusion upon the question he had indicated. There could be no doubt that a tramway was a kind of railway. Each ran upon rails with flanged wheels. He had not, he confessed, been able to see any force in the suggested differences between a railway proper and a tramway. Their structural character was substantially the same. The definitions of "tramway" in dictionaries and in the common use of language brought it within the idea and meaning of a railway. He therefore held, in the absence of authority, that the language of sec. 3 of the Act of 1867 was sufficiently wide to include, for the purpose in question, appellants' undertaking, and he thought that sec. 7 of the Valuation of Lands (Scotland) Acts Amendment Act, 1894, pointed in that direction. The collocation of the words there used seemed to him important and significant. The section spoke of "railways, tramways, canals," &c., and the word "tramways" appeared to be used as exegetical of railways, and was placed between them and the other compulsory subject of valuation by the assessor, namely, "canals." It looked as if the draughtsman in 1894 assumed that tramways were, in the eye of the law, a form of railway, and as such within the compulsory purview of the Assessor of Railways and Canals. But when he turned to authority he found a direct and satisfactory confirmation of his own a priori opinion. In 1873 Lord Shand, sitting as Lord Ordinary on the bills, decided a case on appeal by Glasgow Tramway & Omnibus Co. against the valuation of their undertaking by the Assessor of Railways and Canals. That decision proceeded upon the preliminary point with which he (Lord Dundas) was not concerned. But Lord Shand said:—"A tramway is a species of railway, and railway and tramway undertakings respectively take their names as such from the fact that they possess and use for purposes of conveyance rails fixed in the ground, but differing somewhat in form of construction. In the sense of the Valuation Acts the Lord Ordinary is of opinion that a tramway company is included under the term railway company, which term is not limited to such railway companies as use locomotive power." His lordship could not doubt that in

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expressing that opinion Lord Shand had before him the language of sec. 3 of the Act of 1867, and it appeared that his lordship's opinion had been adopted and followed in practice ever since. In these circumstances the Lord Ordinary was prepared to decide that appellants' undertaking fell properly within the jurisdiction of the Assessor of Railways and Canals. Certain English cases referred to by counsel did not appear to have any direct bearing upon the question at issue, involving as it did the construction of a particular section in an Act of Parliament applicable to Scotland. That point being determined, there was little or nothing more that required to be decided. Counsel agreed that if he should come to the conclusion he had reached the valuation should stand for this year at £258,838, and he would find and declare accordingly. He might observe, however, that while the mode in which the assessor had been in use to ascertain the amount of the deduction authorised by the statute seemed quite a reasonable one, it was not in strict conformity with that prescribed by sec. 3 of the Act of 1867.

Wright v. Peters.

Last week Mr. Justice Jelf and a common jury heard this action in which plaintiff (an electrical engineer) sought to recover from defendant, a solicitor, the balance of £97 for work done at his house.

Mr. DRURY, for plaintiff, said that in April last plaintiff got into communication with Addinell & Co. (Ltd.), electrical engineers, of Snow-hill, London, E.C., and he was asked by them to give an estimate for work to be done at defendant's house and for a time he thought he was dealing with the company. He agreed to do the work for £97. The time came when he wanted to be paid some money on account, and on April 22 he got a letter signed S. G. Addinell, one of the directors, enclosing a cheque for £25 and stating that as they could not get the signatures of the other directors they sent their solicitor's cheque. That cheque was signed "McIntire and J. Capel Peters." Defendant thought that extraordinary but continued to do the work. However, he could get no more money, and subsequently discovered that on May 18 a receiver had been appointed on behalf of the debenture holders of the company, which seemed to have come to grief. Plaintiff went to Somerset House where he found that the company had a nominal capital of £1,500 in £1 shares and that 1,000 of them had gone to the promoter. The solicitors to the company were stated to be Messrs. McIntire & Peters, and the latter appeared to be a director and secretary as well. The only other directors were Messrs. Addinell and McIntire. Messrs. Peters and McIntire seemed to have taken charges upon the whole of the company's property and when the receiver went in there was only 9d. in cash belonging to the company.

His LORDSHIP said that plaintiff clearly had no ground of action against defendant, as the transaction had been with the limited company. It was not a case for the jury, and judgment must be for the defendant, with costs. An application for stay of execution was refused.

British Aluminium Co. (Ltd.)—On Tuesday Mr. Justice Swinfen-Eady dismissed, by consent, two petitions for the winding up of this company.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the position of borough electrical engineer at Keighley. Candidates must be thoroughly trained engineers, with a knowledge of both h.t., three-phase alternating and d.c. supply. Applications to the town clerk, Mr. Wm. Bagshaw, Town Hall, Keighley, by May 18. See also an advertisement.

An engineer is required at a private house, to drive suction gas plant for electric lighting, and have care of accumulators, telephones, &c. Applications to Secretary, Avenue House, Church End, Finchley, N. See advertisement.

A draughtsman is wanted with first-class experience in d.-c. motor design. See an advertisement.

There is a vacancy for a premium pupil at Watford electricity works. Applications to the Chief Engineer. See an advertisement.

The Electricity committee of Salford Corporation invite applications from thoroughly experienced men, with first-class technical training, for the position of superintendent of the hired meter and testing department. Commencing salary £120, rising to £180. Particulars from the borough electrical engineer, Mr. Victor A. H. McCowen, Electricity Works, Frederick-road, Pendleton, Salford. Applications to the town clerk, Mr. L. C. Evans, by mid-day Monday, May 9.

The Belfast Commissioners under the Irish Universities Act, 1908, will proceed at an early date to the appointment of a professor of engineering. Particulars from the Secretary, Mr. Arthur Jaffe, Queen's University, Belfast.

A junior lecturer and demonstrator in physics is required at the University of Sheffield. Salary £150 per annum. Applications to the Registrar by June 1.

Bridlington Council have appointed Mr. Geo. Robinson electrician at the Prince's Parade.

Abertillery Council have appointed Mr. Dan Lloyd manager of their electricity works, and Mr. E. O. Rake electrician.

Mr. C. W. Salt, chief assistant electrical engineer at Bradford, has been appointed borough electrical engineer at Torquay, out of about 150 applicants. Mr. Salt has been five years at Bradford, prior to which time he was second assistant electrical engineer at Croydon.

The following were selected to appear before the Electric Light committee:—Messrs. A. W. Clegg (Accrington), J. M. Keenan (Torquay), J. W. Turner (Huddersfield), B. S. Hornby (Bolton), C. N. Hefford (Leeds), and C. W. Salt (Bradford). The committee recommended Mr. Salt by seven votes to three for Mr. Keenan. It was proposed, as an amendment to the approval of the recommendation, that Mr. Keenan be elected. On a vote Mr. Salt received 18 votes to Mr. Keenan's 12, three members not voting. Mr. Salt was accordingly declared elected.

St. Pancras (London) Electricity commitee has promoted Mr. G. T. Rawson, second clerk, to the position of first clerk at a salary of £150, increasing annually by £10 to £200.

Mr. C. E. Smith, chief engineer of the Rosario Electric Co., has been appointed chief engineer of the Compañia de Electricidad de la Provincia de Buenos Aires.

Mr. W. B. Adams has been appointed engineer-in-charge of the generating station of the Rio Tinto Copper Co., Spain.

EDUCATIONAL NOTICES.

Technological Scholarships.—The West Riding (of Yorkshire) County Council offer minor technological scholarships (value up to £50 each per annum) tenable by persons who have had practical experience at a trade for at least one year and have concurrently attended day or evening classes, or are pupils about to leave secondary schools. Full particulars from the Education Department (Technical Branch), County Hall, Wakefield.

Faraday House.—Major O'Meara, late R.E., C.M.G., will deliver a special lecture to the Third Year Students on May 20, commencing at 10 a.m. The subject of the lecture will be "Depreciation."

Belfast Municipal Technical Institute.—The new extension of the buildings of this institute, rendered necessary by the demand for increased accommodation, was formally opened by the Lord Mayor (Coun. R. J. M'Mordie) on Tuesday.

Accrington.—The Council offer to supply electricity in bulk, on certain terms, to Haslingden, for seven years.

Acton.—Mains are to be laid at a cost of £150 to supply current to 14 new houses.

At the last meeting of the Electricity committee the question of reducing the expenditure of the electricity department was considered.

Coun. YOUNG asked the chairman questions as to the duties of the electrical engineer (Mr. J. M. Blair) and his assistant, and later sprang a motion that the services of Mr. Blair should be dispensed with.

Coun. WITHERS thought if it was the intention of the committee to pass such a motion it should not go forward on the same minutes as the vote of censure.

Coun. CRANE said he could not vote for such a serious motion as discharging one of the chief officials without further considering the matter. When he came to the meeting he had no idea that such a motion was to be proposed, and he should not like to feel that they were doing anything that would damage the prospects of one of the officials by passing a surprise motion.

Coun. YOUNG said he had no wish to do harm to Mr. Blair, but acted on the ground of economy, as they could not afford to keep him.

Mr. BLAIR pointed out to the committee that the working of the undertaking had been a very up-hill one from the start, and now that they were turning the tide and beginning to show a profit he scarcely thought it fair to him to dispense with his services.

After further discussion, the resolution of Coun. Young was altered as follows:—"That the electrical engineer be requested to send in his resignation, to terminate in three months' time." The motion was carried by 5 votes to 2.

The report has, however, been referred back.

Belfast.—The plebiscite on the proposal of the Corporation to purchase the Cavehill and Whitewell tramways has resulted as follows: For the purchase, 26,485 votes; against, 7,925; majority for purchase, 18,560.

Blackpool.—The borough electrical engineer and tramways manager (Mr. C. Furness) reports that during the year ended March 31 the total units generated were 3,884,151, a net increase of 68,759. 8,692 tons of coal (8,316 last year) were used, costing £4,450 (£4,660).

There was an increase of 128 in the number of consumers, compared with 91 increase in 1908-9, and it is anticipated that when the official figures are obtainable the result of the past year's working will show a surplus of approximately £6,500 after meeting all expenses and providing for interest and sinking fund charges. The estimated surplus was £6,000. In 1907 the surplus was £8,229; in 1908 £8,456; and in 1909 £7,255.

Bournemouth.—On Tuesday the Corporation received a report from the tramways manager (Mr. C. W. Hill) recommending that

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the conduit system through the centre of the borough should be abandoned, and overhead construction substituted. Mr. Hill estimates that a saving of £3,000 per annum would thereby be effected. The report states that the conduit causes more disorganisation of the system than anything else, and the loss of revenue is considerable, apart from the great dissatisfaction to the travelling public. The report has been referred to the Tramways committee.

Brazil.—The Ministry of Communications and Public Works is to expend £52,000 on the construction of a telegraph line between the States of Matto Grosso and Amazonas.

Brighton.—The wiring at the Pavilion is to be overhauled at a cost of £500.

Burton-upon-Trent.—The past year's working of the electricity department shows a surplus of £1,473, compared with £881 in 1908-9.

£1,346 is being transferred to renewals fund. Sales of current for lighting decreased by £206, owing to extended use of metal filament lamps and to bad trade, but supplies for power and heating have increased by £25 and for tramways £38. Fuel cost has decreased by £641 (0·284d. per unit compared with 0·386d.), and the engineer (Mr. P. J. Pringle) calls attention to the fact that the fuel now used is little more than smudge. Gross profit is £6,621 (against £5,866). Lamp connections have increased 47 per cent., due to reductions in price, the use of metal filament lamps and economy exercised by consumers. Power units produced £2,163, the average price being 0·953d. per unit. Connections for power and heating are equal to 977 H.P. Works costs were 0·712d. (against 0·810d.), total costs 0·918d. (1·033d.), and capital charges 0·808d. (0·79d.). 80 per cent. of the total horse-power for power is supplied on the restricted hour principle, and the mean price paid by these consumers is 0·855d. per unit. It is calculated that the generation of current for this class is only about 35 per cent. of the revenue. Total revenue was £12,474 (against £12,444); units sold 1,529,600 (against 1,527,841), number of (equivalent) 8 c.p. lamps connected 34,829 (33,615); and maximum load for lighting and power 500 kw. (504 kw.) and for traction 375 kw. (as in previous year).

Cheltenham.—An inquiry was held last week into the Council's application for sanction to borrow £4,000 for the electricity undertaking.

The TOWN CLERK stated that the total amount of the loans already sanctioned was £180,760, and the total amount expended on the undertaking £162,632, leaving an unexpended balance of £18,078.

The Inspector (Mr. H. Ross HOOPER) asked how the balance was arrived at, but neither the town clerk (Mr. Seacome) nor the electrical engineer (Mr. Bache) was prepared to furnish the details. Mr. Bache explained that since his appointment (five years ago) he had allocated the capital expenditure strictly to the purposes for which the loans were obtained; but in the earlier days of the undertaking that practice had not been followed, and it was impossible to say exactly how much of certain loans remained unexpended, though he could give approximate figures.

The INSPECTOR expressed himself dissatisfied with that method of keeping the accounts. The loans raised ought to be ascertainable within even a few pence, else how were they to know how the concern stood at any time? He did not know how they could proceed with the present application if they could not tell him how the unexpended balance was made up. Where was the necessity for borrowing another £4,000 if they had an unexpended balance of £18,078 in hand?

The TOWN CLERK replied that the money was not in hand. What he meant by "unexpended balance" was the aggregate amount of money they had taken power to raise under different loans, but had not raised.

The INSPECTOR: Then these balances should have been cancelled.

The TOWN CLERK stated that he was taking steps to get that done.

The INSPECTOR asked to be furnished with a full statement of the capital expenditure up to March 31, 1910, with the position of each separate loan. When that was ascertained he strongly advised the Corporation to cancel the unexpended parts of the loans and to start with a clean sheet as from April 1, 1910. £1,000 of the present loan was for meters, and he reduced that to £500. £1,000 was for services, and £2,000 for mains, and the Inspector expressed himself favourable to the loans for those purposes, adding £500.

Coding Telegrams.—Some discussion has arisen round a statement made by Mr. George G. Ward, manager and vice-president of the Commercial Cable Co., as to the extent to which telegraphic messages are coded for sending over the submarine telegraph cables of the world with an almost irreducible minimum of error or necessity for repetition.

Mr. Ward, in a letter to the Speaker of the Canadian Senate on the subject of the bill for controlling cable rates which has recently passed the Canadian House of Commons, stated, as an example of the experience of the cable companies, that 147 coded words were used to represent 2,940 words of plain text.

As a reply to Mr. Ward one writer (in the "Financial News") asserts boldly that Mr. Ward exaggerated the number of plain words which such coded messages can contain, and in proof of these statements takes the A.B.C. Code, and finds that only 476 words are represented in 147 coded words. We would point out that in a discussion of this kind it is useless to adopt the public codes as representing the last word in coding skill. Codes like the A.B.C. are intended for the use of the general public chiefly, and bear no relation in the matter of condensation and completeness to the hundreds, nay thousands, of private codes in use in which the reduction in the number of code words necessary to convey lengthy messages has been reduced to a fine art. It may be taken for granted that Mr. George Ward's figure is that of actual experience. We have before us at the time of writing a private code which approximates very closely to Mr. Ward's estimate, and which, moreover, can be used in a manner to considerably increase the number of words given by Mr. Ward.

It is interesting to note that, if 147 words (representing 2,940 plain language words) can be sent over the Atlantic cables for £7. 7s. sterling, this sum represents actually $\frac{3}{5}$d. per word, and that, assuming the code words to represent only half the number of plain words given by Mr. Ward, such coded telegrams amplified into plain language words would cost only 1¼d. per word over the Atlantic cables.

Derby.—Sanction to a loan of £9,850 for additional plant, mains, services and motors has been applied for. Mains extensions at a cost of £940 have been sanctioned.

Dock Lighting.—Belfast Harbour Commissioners decided on Tuesday to purchase a 65 H.P. Allen steam dynamo, 15 arc lamps, switchboard, &c., at £1,947, for lighting the new graving dock.

Doncaster.—The tramway extension to Marshgate was opened for traffic on Wednesday.

Dundee.—On Saturday the inauguration took place of the system of electric lighting extending the whole length of the High-street and Bank-street, Lochee, the lamps numbering 16 of the duplex Excello type. Lochee is a busy town about 2½ miles from Dundee and linked up with a service of cars.

Exhibitions.—The Imperial Russian Technical Society is organising an international exhibition of electric railway plant and apparatus.

The exhibition will be held from Aug. 15 (28 old style) to Nov. 15 (28) this year, and will be divided into three sections: (1) Applications of electricity to steam railways; (2) electric traction on main lines, light railways and tramways; and (3) utilisation of waterfalls in the generation of electrical energy for power. The committee of organisation will lay a special track on the standard gauge of a total length of 2 miles.

We have received circular No. 19 relating to the international exhibition of railways and land transport (May to November, 1910) to be held at Buenos Aires in connection with the Centenary celebrations of the Argentine Republic. The circular states that works in connection with the railways and land transport exhibition will be terminated at the date fixed for its inauguration in May, and exhibitors are requested to inform the managing committee of the exhibition in due time of the arrival in Buenos Aires of the goods they are sending, giving marks, numbers and quantities, and to pay the dues for hire of ground, &c., before remitting the goods. A model of the label to be attached to exhibits sent accompanies the circular. Senhor Ignacio Orzali is acting secretary to the organising committee.

The second Municipal and Health Exhibition, which is being held at the Royal Agricultural Hall (London, N.), will be opened to-morrow, Saturday. It will contain several features of interest to municipal engineers, borough surveyors, &c.

Edinburgh.—On Tuesday the Council approved the minutes of the Lighting committee recommending the erection of cooling towers at the Corporation Electricity works.

German East Africa.—It is reported from Frankfort-on-Main that the Governor of German East Africa has granted a concession to Herr Cieseniss, of Frankfort, for the erection of electric power works at the Pangani Falls. A syndicate is being formed with a capital of 6,000,000 marks (£300,000), and at the outset the generating plant will have a capacity of 30,000 H.P., to be afterwrads enlarged to 80,000 H.P. It is proposed to use the power for the manufacture of artificial nitrates from the atmosphere.

Glasgow.—The chief engineer of the electricity department, Mr. W. W. Lackie, has issued a pamphlet setting out the terms and conditions of supply and the general rules for the prevention of fire and other risks to be observed in wiring for the supply of electrical energy.

Grangemouth.—The Council's consulting engineers, Messrs. MacIndoe & Donald, recently reported on public electric lighting, and the Council have now adopted a recommendation of the electric Lighting committee to light several streets by metallic filament lamps

Holland.—J. H. Müller, of the Hague, has obtained a concession from the Communal Authorities of Gouda for the construction and working of electric tramways between Gouda, Haastrecht, Oudewater, Montfoort and Utrecht, and between Gouda and Rotterdam.

Hospital Lighting.—At the recent meeting of the Governors of the Meath Hospital and County of Dublin Infirmary it was decided to make a public appeal for the cost of lighting the hospital by electricity.

Hungary.—Mátyásföld Landlord Association have decided to establish electricity and water works, at an estimated cost of 281,000 kronen (£11,700), which will be advanced by the president of the Association (Mr. Josef Paulheim).

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Institute of Chemistry.—The following pass list of the examinations in April has been issued:

In the intermediate examination, of 11 candidates 8 passed, viz., A. Cunningham, A. A. Eldridge, J. W. Flint, B.A., A. Gemmell, B.Sc., H. Lowe, B.Sc., J. Porter, H. Shankster, T. A. Smith. Two candidates passed the final examination in mineral chemistry (J. Shelton, J. Weintroube, B.Sc.) and one in physical chemistry (F. G. Martin). Of two candidates who presented themselves in organic chemistry, one passed (W. T. Munro); and of 12 examined in the chemistry of food and drugs, eight passed: B. M. Brown, B.Sc., C. L. L. Claremont, B.Sc., R. L. Collett, B.A., S. Elliott, L. Goodban, T. S. Haines, G. F. Morrell and S. Smith.

Italy.—An electric tramway is to be constructed shortly between Spezia and Cadimare.

Keighley.—The borough electrical engineer (Mr. J. M. Smyth) has been compelled to tender his resignation on account of ill-health.

At the meeting of the Council on Tuesday the chairman of the Electricity committee (Mr. Whitehead) said that Mr. SMyth's resignation was due to medical advice.

Mr. B. S. Brigg said he wished to associate himself with the expressions of regret at the threatened breakdown of Mr. Smyth's health and his resignation. Mr. Smyth's work in the capacity of borough electrical engineer had been very arduous, as he had had practically to plan and build up the electricity department, and he had carried it out most satisfactorily.

The report of the electrical department showed that 1,071,457 units of electricity had been sold during the 12 months ended March 31, an increase of 192,700 units over the previous year.

The tramway receipts for the year ended March 31 amounted to £8,771. 19s. 9½d., an increase of £626. 16s. 1d.

Kingston-on-Thames.—The Council have informed Maldens and Coombe Council that they are prepared, subject to the approval of the Board of Trade, to enter into arrangements for supply of electricity in Coombe on conditions to be arranged.

Leeds.—The general manager of the tramways (Mr. J. B. Hamilton), has been instructed to prepare an estimate of the cost of extending the tramways to Shadwell.

Leyton.—The surveyor has been instructed to prepare estimates for lighting the remainder of Lea Bridge-road by arc lamps, and (alternatively) by clusters of electric incandescent lamps.

Light Railway.—Bacup Corporation Light Railway Order has been submitted to the Board of Trade for confirmation. Objections by May 21.

London County Council.—On Tuesday it was agreed to lend £6,880 to Fulham for electric lighting.

Electric Cars.—An adjourned recommendation to invite tenders for 250 electric cars of the bogie truck, double-deck type, was agreed to.

St. James & Pall Mall Electric Light Co.—The adjourned recommendation of the Highways committee was submitted to the effect that no objection be offered to the proposals of the St. James & Pall Mall Electric Light Co. to vary its standard pressure, and was adopted.

Reconstruction of Tramways.—The Highways committee's proposal to expend £5,500 for the reconstruction of the existing horse tramways from Tooley-street to Deptford and the construction of authorised tramways from Evelyn-street to Nelson-street, Greenwich, was adjourned.

Cars for Hilly Routes.—In connection with the decision of the Council in June last to authorise the construction of a specimen car for hilly routes, the Highways committee reported that a car had been completed and had worked satisfactorily. The truck and magnetic brake were, however, arranged to accommodate two sets of special slot brake mechanism. As the Board of Trade were satisfied with one set of this mechanism on each car will be sufficient it is proposed that the 39 cars shall only be fitted with one set. The committee recommended that tenders from selected firms be obtained for the supply of the 39 car bodies and that the British Westinghouse Co. be asked to submit an offer for the magnetic brakes required.—*Carried.*

Marylebone (London).—The Baths committee have requested their chairman to give notice of motion to rescind the resolution adopted by the Council in February last for overhauling, re-wiring and putting into proper condition the electrical installation at the baths, and the Electric Supply committee are to be permitted to carry out the work at prime cost, plus a small percentage for supervision.

The Electricity committee have authorised the general manager to let all consumers have arc lamps at a price which allows for current at £8 per kilowatt and 1d. per unit.

Middlesbrough.—The annual report of the borough electrical engineer, Mr. H. M. Taylor, submitted to the Electric Lighting committee on Wednesday, stated that there was a net profit of £1,301 on the past year's working, against £1,277 in the previous year.

National Electrical Manufacturers' Association.—The next committee meeting will be held at Balfour House, Finsbury Pavement, E.C., on the 10th May, at 2:30 p.m.

St. Helens.—The 60 c.p. lamps in the main streets are to be replaced by 100 c.p. metal filament lamps, and 45 additional posts, with two lamps attached, are to be erected where required.

On Wednesday the Council increased the salary of the borough electrical engineer (Mr. E. M. Hollingsworth) from £400 to £450 per annum, with two subsequent increments of £25 to £500.

Salford.—The Electricity committee has decided to advertise for a successor to Mr. Victor A. H. M'Cowen, borough electrical engineer, at a commencing salary of £500, rising by biennial increments of £50 to £700 per annum.

Southampton.—An inquiry was held here last week into the application of the Council for sanction to borrow £13,000 for additional generating plant and £3,000 for mains, services and meters.

The Town Clerk gave the usual statistics and said the total amount sanctioned to March 31 last was £212,619, and the total sum expended £209,414.

The borough electrical engineer (Mr. H. F. Street) gave particulars of the growth of the electricity undertaking, and of the additional generating plant which would be necessary to cope with the increased requirements of the town.

The inspector (Mr. H. Ross Hooper) said the custom of the Board of Trade now was only to sanction loans for new plant, &c., on provisionally accepted tenders, when the bodies applying had decided exactly what work should be done and what it would cost. He suggested that the Corporation should buy meters out of revenue, for it was clear that the present system was not to the benefit of the ratepayers or the undertaking. Southampton Corporation was one of the few local bodies who were now borrowing for meters.

The inquiry was adjourned for the provision of certain statistics.

Southwark (London).—Acting on the advice of the borough electrical engineer (Mr. D. M. Kinghorn) the Electric Light committee recommend that extensions of the electricity works be carried out at an estimated cost of £6,909, including a 600 kw. turbo generator (£3,300), foundations, &c. (£180), switchgear (£300), condensing plant (£1,800), cooling tower (£1,000), and £329 for contingencies.

Stepney (London).—The Electricity committee report having been approached by large firms who require a supply of electricity for lighting and power (one is at present generating its own supply) and who desire to have a combined rate for lighting and power. Such a rate is not at present in force, but, acting on the report of the borough electrical engineer and manager (Mr. W. C. P. Tapper), the committee have decided (subject to the usual sanction) to meet the request, and recommend that to power users who are willing to guarantee a minimum half-yearly bill of £200 the rate shall be £3 per annum per E.H.P. demanded, divided into 12 monthly payments (based upon the monthly demand) and ½d. per unit for electricity consumed whether for lighting or power, provided the total lighting demand in E.H.P. does not exceed 25 per cent.; also that the committee be empowered to charge fixed rates calculated on the above scale when the load factor is guaranteed.

Sweden.—The Swedish Budget for 1911 provides for additional expenditure on railway and canal works, and £80,000 for electricity works at Trollhättan.

Underground Telegraph Cables.—At Wednesday's meeting of Newcastle-on-Tyne Chamber of Commerce it was stated that the Postmaster-General had intimated that provision would be made in this year's estimates for the completion of the underground lines between Leeds and Stockton. This would complete the underground connection between Newcastle and London.

Walthamstow.—The electricity undertaking is to pay £300 per annum and the tramway undertaking £100 per annum towards the establishment expenses of the Council.

Warrington.—At the meeting of the Corporation on Tuesday Ald. Smethurst announced that the net profits on the electricity undertaking for the past year had been £1,691, against £943 for 1908-9, and on the tramways undertaking £2,750, against £2,307.

The salaries of several officials were increased, including that of Mr. F. V. L. Matthias, chief electrical engineer, from £350 to £400.

Wigan.—The L.G. Board have informed the Council that, in regard to their recent application for sanction to borrow £36,000 for the electricity undertaking, the Board will raise no objection to the Council commencing the works at once.

Wireless Telegraph Notes.—The German Government has established wireless telegraphic communication between Palm Island and Yap Island, one of the Carolines, situate 70 miles north of New Guinea.

The Hawaiian Islands have now been completely linked up with wireless telegraphy, the system employed being described as a composite one, chiefly of the "Massie" type. The day range of the principal station at Kahuku is 400 miles, and the night range is said to be 1,250 miles. The station is reported by the operating company (the Mutual Telephone Co.) to be in frequent communication at night with Sitka (Alaska), a distance of over 2,000 miles.

The Allan liner "Carthaginian" reached the Clyde on Saturday last in tow of the "Hesperian." The "Carthaginian" had broken

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down 235 miles west of Malin Head. She was fitted with wireless, and her message for assistance was picked up by her companion liner, the "Hesperian." The former vessel had 800 emigrants on board. Mr. E. Dexter was the Marconi operator on the "Carthaginian," and reported that in boisterous weather there was a mishap to the machinery which left the vessel helpless. The "Hesperian" picked up her message five hours after the mishap. Mr. Sutherland is the operator on the "Hesperian."

According to the Paris "Matin" it is intended to instal wireless telegraphy at several important port stations in French West Africa with the view of connecting up the interior of the country. At Timbuctoo (according to the same authority) a station is to be erected to enable communication with Oran and Bizerta, and to form a base for radio-telegraphic communication across the Sahara.

Another report states that a wireless station has been established at Port Etienne and Dakar, and that communication has already been opened with Oran and Bizerta, the work having been largely due to Commandant Ferrie, Director of Military Telegraphs at the Eiffel Tower, Paris.

Workhouse Lighting.—The L.G. Board have authorised Belfast Guardians to borrow £6,000 for electric lighting plant.

York.—The City electrical engineer (Mr. J. W. Hame) has also been appointed tramways manager at an additional salary of £100 a year.

Electrical Engineers (London Division) Annual Sports.—The Corps of the Electrical Engineers, London Division (T) will decide their Corps trials and Championships at the London County Athletic Grounds, Herne Hill, on Wednesday, May 25, commencing at 6:30 p.m. The following are the events:—100 yds., 440 yds., 880 yds., and 1 mile running; ¼ mile, 1 mile and 5 mile cycling; 120 yds. hurdles; long jump; high jump, and inter company tug-o'-war. Quartermaster-Sergt. G. A. Applebee is the secretary of the committee in charge of the arrangements.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

The Corporation of the City of LONDONDERRY invite tenders for supply, delivery and erection of a 400 kw. mixed-pressure d.-c. turbo-generator, condenser, pipe work, floor plates, &c., switchboard panels, instruments and connections, economiser, dampers, pipes, valves, &c., and feeder cable, connections, &c. Specifications, &c., from the city electrical engineer, Mr. R. V. Macrory. Tenders to be addressed to the Town Clerk, Municipal Offices, Londonderry, by May 21. See also an advertisement.

The Tramways and Electricity committee of BELFAST Corporation invite tenders for motor boosters and switchgear and extension of lighting switchboard. Specifications, &c., from the city electrical engineeri Mr. Thos. W. Bloxam, M.I.E.E. Tenders to the Town Clerk, City Hall, Belfast, by 10 a.m. May 23. See also an advertisement.

St. Pancras (London) Borough Council invite tenders for supplying 21 flame arc lamps with 20 suitable iron cradles. Copies of specification, conditions of contract and form of tender from the electricity department offices, 57, Pratt-street, Camden Town, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett) Town Hall, Pancras-road, London, N.W., by noon Monday, May 23. See also an advertisement.

SOUTHAMPTON Corporation invite tenders for supply of a 1,000 kw. steam generator, boiler, alternator and motor alternator. Particulars, specifications and forms of tender from the borough electrical engineer, Mr. H. F. Street, electricity works, Western Shore, Southampton. Tenders to the town clerk, Mr. R. R. Linthorne, Municipal Offices, Southampton, by May 24. See also an advertisement.

The Lighting committee of DUBLIN Corporation invite tenders for supply and erection of flame arc lamps and arc lamp pillars. Specifications, &c., from the city electrical engineer, Mr. Mark Ruddle, Fleet-street, Dublin. Tenders, addressed to the Chairman of the Lighting committee, 3, Cork-hill, Dublin, not later than May 20. See also an advertisement.

Tenders are invited up to June 14 for supply of 100 party line common battery telephone wall sets, 10 party line common battery table sets, 100 switches, common battery, single extension and intercommunication, and 3,000 telephone protectors to the Postmaster-General's department in VICTORIA. Tender forms and specification at the Commonwealth office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to June 7 for supply of one frame, main distributing, to the Postmaster-General's department in WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W. See also an advertisement.

LEICESTER Tramways committee want tenders for supply of mixed pressure steam turbine direct-coupled to 750 kw. d.c. generator, with condensing plant, switchboard, &c., and two Lancashire boilers, with fuel economiser, piping, &c. Forms of tender from the Tramway Engineer, Belgrave-road, Leicester.

BRAY (co. Wicklow) Council want tenders by May 9 for supply of 330 yds. $\frac{7}{16}$ concentric paper-insulated lead-covered steel-armoured cable and 65 a.c. single-phase electricity meters. Specifications, &c., from the Electrical Engineer.

The Commissioners of H.M. Works and Public Buildings require tenders by May 19 for the erection of a telephone exchange at Cubie-street, GLASGOW. Forms of tender, &c., from the Clerk of Works, Head Post Office, Glasgow.

BECKENHAM Council require tenders by 4 p.m. May 23 for wiring work, including canvassing, and (alternatively) for wiring only. Specifications, &c., from the Resident Engineer, Electricity Works, Beckenham.

WALLASEY Council want tenders by May 30 for two years' supply of a.c. transformers. Specifications from the Electrical Engineer, Seaview-road, Liscard.

METROPOLITAN ASYLUMS BOARD want tenders by 10 a.m. May 11 for supply of electrical accessories, ironmongery, &c. Forms of tender from the Board's Offices.

MANCHESTER Tramways committee want tenders by 10 a.m. May 10 for supply of steel tie-bars for tramrails. Specifications from the tramways manager.

ECCLES Electricity committee invite tenders by 10 a.m. May 12 for supply of 2,000 yds. h.t. concentric paper-insulated cable. Particulars from the Borough Electrical Engineer.

RADCLIFFE Council want tenders by May 14 for supply and erection of a 300 kw. c.c. dynamo. Specification, &c., from the engineer.

Tenders are invited (up to May 17) for supply to the Postmaster-General's Department, VICTORIA, of 50 coin attachments. Tender forms and specifications from the High Commissioner's Office, 72, Victoria-street, London, S.W.

The Postmaster-General of the Commonwealth of AUSTRALIA requires tenders up to May 17 for supply of 2 tons of wire, twisted pair, outside distributing, No. 16 Legal S.W. gauge. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W.

Tenders are invited up to June 8 for the supply of protectors, switchboards (small) and common battery telephones to the Postmaster-General's Department, QUEENSLAND. Tender forms, specifications and general conditions may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W.

Tenders are required by June 8, 1910, for the supply of six sections of common battery switchboard and equipment, jumper wire and cable to the Postmaster-General's department in QUEENSLAND. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W.

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Tenders are invited, up to May 18, for the supply of paper insulated lead-covered and brass ribbon taped cable to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to June 1, for the supply of eight sections of common battery switchboard to the Postmaster-General's Department, NEW SOUTH WALES. Tender forms, specifications, and general conditions may be obtained at the Commonwealth offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, MELBOURNE (Victoria) wants tenders by May 24 for supply of six miles of lead-covered paper-insulated screened 50-conductor telegraph cable, and by June 14 (fresh tenders) for subscribers' equipment for Hawthorn Telephone Exchange.

Australasia.—A Wellington (N.Z.) firm desire to obtain quotations, from British manufacturers, for solid drawn steel conduit and fittings, screwed with standard gas thread, and for insulated cable, made by a firm belonging to the Cable Makers' Association, or equal thereto, and another Wellington firm wish to hear from makers of all kinds of electric cable. Catalogues, with information as to discounts, &c. (quoting preferable c.i.f. and e.), to H.M. Trade Commissioner, 9, Grey-street, Wellington.

TENDERS RECEIVED AND ACCEPTED.

At the meeting of Manchester Corporation on Wednesday, the chairman of the Electricity committee (Mr. Howarth) stated that the committee had accepted a tender from a Milan firm (through the General Electric Co.) for the supply of l.t. house service cable.

He said that the English prices asked were from 3s. 1¼d. to 3s. 6d., against 2s. 3¾d. by the Milan people. He suggested that there was a combination among British manufacturers which had the effect of raising and maintaining prices, and by letting that contract the committee saved £158.

Objection was taken to the acceptance of the contract as contrary to the standing orders, seeing that the Council had no knowledge of the hours of work, rate of wages and conditions of labour in Milan. It was proposed to refer the matter back to the committee, but this was rejected by 40 votes to 29.

St Pancras (London) Council have received the following tenders for the supply of open-type arc lamp carbons:—

Sloan Electrical Co. ..	£687	15	0	Siemens Bros. Dynamo Works	1,279	8	11
W. Giepel & Co.	744	2	6	Sirius-Werke A.-G....	1,386	0	0
H. G. Mayer & Co. ...	756	0	0	Johnson & Phillips (samples not submitted)	777	0	0
Crompton & Co.	763	14	9				
Ship Carbons (Ltd.)).	774	10	3				
G. Braulik	813	15	0				
General Electric Co. ..	922	18	0				

Nuneaton Corporation have received the following tenders for a water-tube boiler and a feed pump:—

Boiler.

Edwin Danks & Co. (*accptd.*)..	**£710**	Brightside Foundry & Eng.Co..	£925
Babcock & Wilcox.....	715	Clarke, Chapman & Co.	997
Hawksley, Wild & Co.	795		

Feed Pump.

F. Friedenthal (*accptd.*)	**£90 & 109**	J. P. Hall & Sons.....	£141 & 163
Edwin Danks & Co.	£106 & 132	Lee, Howl & Co.	143
John Spencer (Ltd.).....	108	Brightside Foundry & Eng. Co.	144
J. Reynolds & Co.....£108 & 126		Hawksley, Wild & Co.	160
Hayward, Tyler & Co....£110 & 120		Clarke, Chapman & Co.	213
Babcock & Wilcox	135		

Salford Council have accepted the following tenders for annual stores for the electricity department:—

W. Turner (Ardwick) Ltd., asphalte bridges; Cowans (Ltd.), circuit-breakers; Electrical Co., switches and cut-outs; W. T. Glover & Co., bitumen cables and bare copper stranded wire; H. R. Mansfield, stoneware conduits; Albion Clay Co., stoneware conduits and stoneware pipes; John Bassett, tinned copper strip; Johnson & Phillips, copper fuse wire and white tape; L. Andrew & Co., mica sheets, rubber gloves, rubber overshoes and rubber caps for cables; Veritys (Ltd.) and General Electric Co., high and low-speed motors (½ to 7½ H.P.); Electric Construction Co., high and low-speed motors (10 to 15 H.P.); Lancashire Dynamo & Motor Co., high and low-speed motors (20 to 50 H.P.); Hanchett, Barratt & Co., 12 single-phase house transformers, £5. 10s. each.

Dublin Lighting committee recommend the acceptance of the tender of the British Insulated & Helsby Cables at £17,532 for the supply of extra high-pressure and low-pressure cables for a period of two years.

Warrington Council have accepted the tender of J. Howden & Co. for a 1,000 kw. turbo-alternator at £4,255; that of the British Westinghouse Co. for a 750 kw. rotary converter at £1,850; and that of Cowans (Ltd.) for switchgear at £506. 5s.

Southampton Council have renewed the annual contracts with W. T. Glover & Co. and the Craigpark Electric Cable Co. for supply of cable.

Edinburgh Electric Lighting committee recommend acceptance of the tender of the Lahmeyer Electrical Co. for 12 months' supply M.S. metal filament lamps.

London County Council have accepted the tender of Bruce, Peebles & Co. for three-phase motors for the second section of the central car repair depot at £575.

Poplar (London) Council have accepted the tender of the Worthington Pump Co. for motor-driven feed pump at £218. 10s.

Bolton Electricity committee have accepted the tender of Ed. Beanis & Co. for mechanical stokers.

Gloucester Corporation have accepted the tender of W. Geipel & Co. for arc lamp carbons at £111. 16s. 7d.

Salford Corporation have accepted the tender of the Northern Electrical Co. for wiring the Wellington-street school at £133. 13s.

BUSINESS NOTICES.

The D.P. Battery Co. have appointed as their representatives in Argentina (Messrs. Milne, Makein y Cia., Suipacha 88, Buenos Aires), and in Turkey, Messrs. Wm. Sprowson & Son, Constantinople. The agency of the latter firm is for Turkey, Greece and the Balkans.

Mr. Chas. E. Gunner, who has been so long identified with conduit practice both with the G.E.C. and latterly with Simplex Conduit (Ltd.), has severed his connection with the latter firm, and is now engaged in perfecting a number of improvements relating to conduit and installation practice generally, of which we hope to give particulars in an early issue.

Messrs. Davies & Ransome, Caxton House, Westminster, have been appointed sale agents in London and the South of England for the Buffoline Noiseless Gear Co.

Mr. Thomas W. How, managing director of the Empire Roller Bearings Co., has been appointed managing and consulting director of the Horsfall Destructor Co., Pershore, in succession to the late Mr. Arthur Greenwood. The business of both companies will be directed from the London address, 15, Victoria-street.

Messrs. D. H. Bonnella & Son have taken over the agency for M. S. metal filament lamps.

Sale by Auction.—Messrs. Horne & Co., 35, Old Queen-street, Westminster, S.W., will sell by public auction at the Royal Arsenal, Woolwich, on May 19 (by order of the Secretary for War) some unserviceable and obsolete stores, including quantities of iron, steel, copper, gunmetal, lead, bronze, &c., also lathes, machine tools, electric cable, telegraph instruments, electric lamps, &c. May be viewed on Tuesday and Wednesday previous to and on morning of sale. Catalogues from the War Office, Whitehall, the Ordnance Office, Tower, and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Plant for Sale.—Eastbourne Corporation advertise for sale a 50 kw. steam alternator. Particulars from the borough electrcial engineer, Mr. J. K. Brydges.

Electric Supply Publicity.—In our issue of Feb. 25 we described a poster which was being issued by the electric light companies in London with a view to inducing the public at large to more fully appreciate the value of electricity for domestic purposes. This showed the portion of London visible from the neighbourhood of the Houses of Parliament illuminated by a gigantic glow lamp. We have now received from the committee which is dealing with this publicity work a reproduction of this illumination in card form, suitable for hanging in a show-room or shop window. As before, space is left for the insertion of the name of a supply authority.

Whitsuntide Holidays.—The countryside is looking its best, and the facilities offered by the railway companies for visiting the charming rural spots which abound on most routes out of London and the other cities and towns of England have been greatly extended this year, and comfortable and expeditious travel has been well provided for. We have seen several of the printed booklets containing the arrangements for the holidays, and amongst these is the "A.B.C. Programmes" issued by the Great Central Railway Co. There are over 300 seaside and inland health resorts in the Midlands and the North which can be reached in quick time at very low fares, and the choice of destination stretches away up to the far north of Scotland. Nearer London the Vale of Aylesbury, the Chiltern Hills and Stratford-on-Avon should particularly appeal to rest and holiday seekers. Express corridor trains with buffet car accommodation leave Marylebone at suitable times on Friday, Saturday, Sunday and Monday, May 13, 14, 15 and 16, and full particulars of times of departure, fares and other information are contained in the programme under notice, which may be obtained free at Marylebone Station, from any of the Company's town offices and agencies, or by post from the Publicity department, 216, Marylebone-road, N.W.

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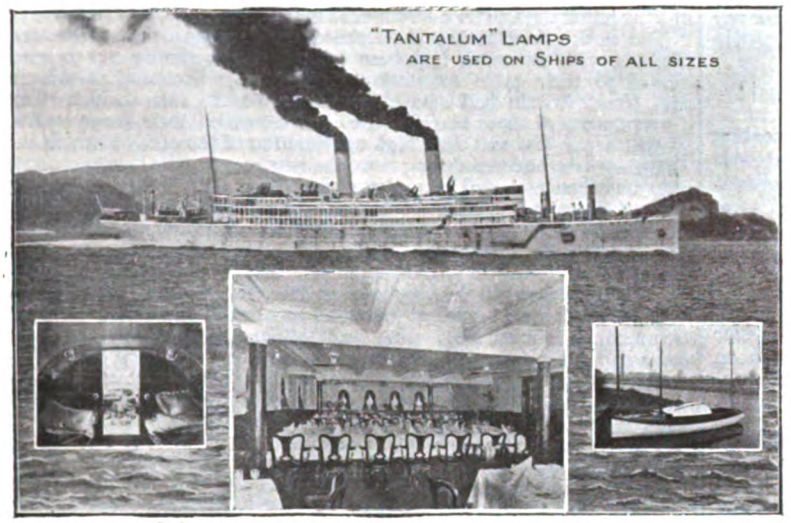
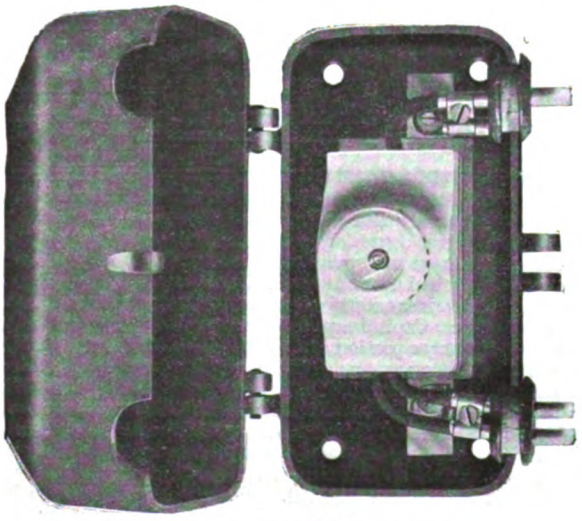
Tantalum Lamps for Ship Lighting.—Tantalum lamps are used for all classes of ship lighting, from a man-of-war to a ferry-boat. The illustration herewith shows an Atlantic liner, on which more than 1,000 Tantalums are installed, in comparison with a pleasure motor yacht. The strength of the lamp enables it to withstand the severe vibration experienced on board ship. The centre inset shows one



SHIP-LIGHTING "TANTALUMS."

of the handsome interiors to be found on the larger types of vessel. Messrs. Siemens Bros., the manufacturers of the Tantalum lamp, make a speciality of electric light fittings for ship and yacht lighting, and all interested in that class of work should obtain particulars and prices when considering new installations.

Concentric Wiring on the O.S. System.—Messrs. Siemens Brothers & Co., Caxton House, Westminster, S.W., have sent us a copy of their new catalogue A 517 (supplementary to No. 517), in which the advantages of the O.S. Wiring System for concentric purposes are described. Messrs. Siemens Brothers claim that the O.S. system, when employed for concentric wiring in any combination of its two component parts, effects a saving in the cost of materials and labour, which may reach as high as 40 per cent. Besides the general features of the system, the advantages of low voltage are explained in the catalogue. It is shown how the consumer can save in current and outlay on lamps by using low voltage Tantalum lamps, and, in connection with alternating current supplies, by installing a double-wound transformer. The latter apparatus are listed in convenient



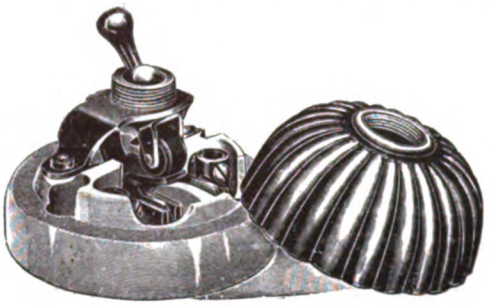
"STANNOS" HOUSE FUSE BOX.

form and sizes, from 250/5,000 watts, and for secondary pressures from 20/230 volts; the approximate number of Tantalum lamps of various candle-powers being shown, which can be connected to various listed pressures.

A novelty is the "Stannos" House Fuse Box, illustrated herewith, which is employed where "Stannos" wires, run on the concentric system, are used for the purpose of supplying separate houses, outbuildings, &c. (as in the case of the Fixed Price Light Co.'s system). The box consists of a small cast-iron case with hinged lid, containing a Siemens "Zed" cartridge fuse with non-interchangeable cartridge, and the sheathings of the "Stannos" wires are clamped at each entry to the iron case, the two clamps being bonded together. A small window is provided in the lid of the box to enable the fuse to be inspected without unsealing the case.

In addition the catalogue contains prices and particulars of "Stannos" wires for concentric purposes, Tantalum lamps, and general instructions for concentric wiring on the O.S. System. It is of interest to point out that "Stannos" wires are now being made in the following sizes: 1/18, 1/16, 3/20, 7/20, 7/18 and 7/16.

Tumbler Switches.—The accompanying illustration shows a new tumbler switch put on the market by Messrs. Marsh, Son & Co. It has been designed with a



[NEW FORM OF TUMBLER SWITCH.

very large break and all the metal parts are quite heavy enough to carry considerably more current than the 10 amperes for which it is designed. The make-and-break are very quick and the live parts are well protected. Arrangements have been provided to allow the switch to be used on looping-in systems.

CATALOGUES, &c.

AMPERE CELL.—Messrs. D. H. Bonnella & Son have issued a pamphlet dealing with the "Ampere" cell, whose large output of 5 amperes admirably adapts it for use in telephone, experimental and medical work. The cell is composed of a specially prepared compressed carbon block, carefully wrapped in cloth, a cylindrical zinc with lead connector and a circular glass jar of special design with a papier-maché cover.

ST. HELENS CABLE.—The St. Helens Cable & Rubber Co. have ready a small catalogue in which are arranged card illustrations and details of various equipment supplied by the company. These include cables and wires of all kinds and rubber goods generally.

SUNDRY INDIARUBBER GOODS.—We have received from the India Rubber, Gutta Percha & Telegraph Works Co. a copy of their latest list dealing with mechanical and sundry indiarubber goods. These include such articles as indiarubber sheets, hose of all kinds, gloves, corks, door-stops and many other useful articles and apparatus.

EDISWAN FITTINGS.—The Edison & Swan Co.'s latest catalogue deals with shop, factory, colliery, street and traction fittings. A glance through this catalogue shows a wide field of goods which this company are able to turn out, covering a good range of "everybody's requirements."

A.E.G. APPARATUS.—From the Allgemeine Elektricitäts-Gesellschaft come three pamphlets dealing respectively with the generating stations at Besswitz, an automatic electrically-worked pump for house supply work, and a new controller. The station described in the first pamphlet is intended for the supply of energy to farmers and other agricultural workers.

CROMPTON INSTRUMENTS.—Messrs. Crompton & Co. have completed a catalogue which deals with electrical instruments of the moving coil type for continuous-current work. In this are illustrated and described the many patterns of this taype made by the firm. The list should be in the hands of all electrical engineers and contractors.

FERRANTI TWO-RATE METER.—Messrs. Ferranti Limited have issued a pamphlet dealing with a new two-rate meter recently designed by them. This instrument is described at some length on another page of our current issue.

HENLEY'S FLEXIBLE CABLES.—We have received from Messrs. W. T. Henley's Telegraph Works Co. a list describing their twin flexible cables, which are provided with an earthing core in compliance with Home Office Regulations. They are made in two types, C.M.A. flexible and standard flexible, the former being composed of high conductivity 36 S.W.G. wires insulated with pure vulcanised

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indiarubber and taped. The earthing conductor is composed of copper wire of the same size braided with cotton and compounded. The three cores are made up together circular with jute wormings strongly braided and served over all with preservative compound. The insulation resistance of such a flexible is 600 megohms per mile at 60 deg. after 24 hours' immersion in water.

JAHNS GOVERNOR.—Messrs. Jens Orten-Böving & Co. are issuing a catalogue on this subject which describes a governor suitable for use in governing turbines and engines very closely, in accordance with the present requirements.

BANKRUPTCIES, LIQUIDATIONS, &c.

At the London Bankruptcy Court on Wednesday the first meeting of creditors took place of Samuel Walter Hart, inventor and patentee of the Hart accumulator. Debtor attributed his failure to depreciation in value of his shares and other property. Liabilities were £3,000, but he claimed that the assets should exceed these when realised. In the absence of an offer, the Official Receiver was left in charge of the estate under an administration in bankruptcy.

The first meeting of creditors of Robt. E. Joy (trading as the Bristol Electrical Co.), 143, Cheltenham-road, Bristol, will take place on May 11, at 26, Baldwin-street, and the public examination on May 13 at the Guildhall, Bristol.

A receiving order has been made against John Filmer Davie, electrician, late of 10, Gt. Castle-street, London, W. First meeting of creditors May 10 at Bankruptcy-buildings, London, W.C., public examination at same place on June 8.

The Electric Conversion Synd. (Ltd.) is being wound up voluntarily. Mr. F. S. Salaman, 1, Oxford-court, Cannon-street, London, E.C. is liquidator. Meeting of creditors at same address on May 9.

The Davey Electric Co. (Ltd.) is being wound up voluntarily. Claims to Mr. J. Andrews, 20, North John-street, Liverpool, by June 9. A meeting of creditors will be held at 112, Whitechapel, Liverpool, on May 17.

COMPANIES' MEETINGS AND REPORTS.

Great Northern Telegraph Co. (Ltd.)

At the meeting held on April 30 at Copenhagen the chairman (Commodore E. Suenson, D.R.N.), in rendering an account of the working of the company during 1909, said the company's cables again suffered rather severely from interruptions. In Europe there had been 23 on seven cables and in the Far East 21 on five cables, without reckoning those on the cables in the Yangtze river and its tributary, the Whangpoo, where the regulation of the navigable channel near the Woosung bar had caused numerous interruptions and difficulties. The cable repairs and renewals had kept their cable steamers occupied: the "H. C. Orsted" in Europe for 142 days and the "Store Nordiske" and the "Pacific" in the Far East for 260 days, of which 15 in Europe and 78 in the Far East were for other administrations. The landlines via Kiachta and via Wladiwostock across Russia and Siberia connecting their two submarine systems, the one in Europe and the other in the Far East, had more and more won favour with the telegraphing public. Notwithstanding the appreciable decrease in traffic between Europe and the Far East, the amount of traffic passing over the company's routes had decidedly increased. On Oct. 1 last the same reduced rate as that via India was introduced by both routes via Russia for press telegrams between Europe and the Far East. The reductions in the European rates (adopted by the International Telegraph Conference at Lisbon in 1908) had been in force since July 1 last. These reductions, in conjunction with those of the local rates in the Far East (mentioned last year) and the general depression in commerce and shipping in 1909 had seriously affected their traffic receipts. The decrease had, however, been counterbalanced by increased receipts from the company's participation in other telegraphic undertakings and particularly by a profit on exchange of £4,700 in 1909, compared with a loss on exchange of about £15,300 in the previous year. Their receipts from "sundries" had also been higher, and it was due to those fortunate circumstances that the board felt justified in proposing the same total dividend as for 1908, viz., 18 per cent.

In spite of the continued progress of wireless telegraphy in the field naturally belonging to it (communication from ship to ship, between ship and shore or shore and small islands, and for strategical purposes) the year had not, as far as they knew, witnessed the establishment of any new wireless connection of importance competing with the telegraph by wire, although several such connections had been projected. The company had, nevertheless, acquired the exclusive right of using between several countries certain patents for wireless telegraphy, for which they had been in negotiation for some years past. In taking that precaution the board had, however, been prompted mainly by its desire to meet the repeated wishes of many shareholders. It was evident that in a field where the practical application of a discovery, although showing remarkable progress, was still as much in its infancy as that of wireless telegraphy, inventions of one day were liable to be out-distanced on the next day, that the possession of a patent of an invention did not confer the right to use it in the absence of concessions to that effect from the interested governments, and, finally, that the exploitation of wireless telegraphy had hitherto not proved remunerative except, as they sincerely hoped, to the inventors, who had certainly deserved a substantial reward for their marvellous inventions and their arduous labours. If they had acceded to the wishes of some shareholders it was due to a desire to reassure them and to provide as far as possible against all contingencies rather than to their being actually convinced of the utility of the invention outside its own particular field.

The notice terminating their concession for the cable connecting Norway with Denmark had been followed by a similar notice with regard to their cable connecting Norway with Scotland. Denmark and Great Britain had also given notice for the same cables. The Governments of these two countries had expressed their sincere regret at that separation and their high appreciation of the services which the company had rendered during more than 40 years. The fact that those two Governments, and also those of Sweden and Russia, had been pleased to extend all their other concessions in those countries, was the best proof of the sincerity of those assurances. The Norwegian Government, acting in accord with the other interested Governments, had expressed its desire to purchase the two cables in question, the cable landed at Arendal in Norway and at Hirtshals in Denmark, 69 n.m. long, and the cable landed at Egersund in Norway and at Peterhead in Scotland, 272 n.m. long. The negotiations regarding the purchase price had not yet terminated, but the price would be based exclusively on the actual technical value of the cables, without any addition for goodwill. The loss did not affect their general system; their universal system, extending from the West of Europe to the East of Asia, would remain intact. The company's negotiations with Japan regarding their future relations with that Empire after the expiration of their exclusive privileges at the end of 1912 had not been resumed during the past year because the Imperial Government had not expressed any desire to that effect. It might be mentioned that the company enjoy in Japan the same right as they possess in several other countries connected by their cables to continue working in connection with the Government lines after the expiration of their exclusive privileges. Japan did not, therefore, run any risk of becoming suddenly deprived of the use of the Great Northern cables. The fact of these cables being private and neutral property had been of great value to Japan, and it was partly due thereto that during the last wars of that Empire they remained unmolested and that Japan was able to maintain telegraphic communication with the whole world. If they had been Government-owned cables belonging to one of the belligerent powers they would have been legitimate booty for the other, even if it had not had command of the sea. Any hostile power, strong or weak, will easily find means of cutting or destroying a submarine cable, if such an act be considered legitimate, but will hesitate if by doing so it lays itself open to just reproaches for destroying private and neutral property and to claims for compensation. This consideration had probably, amongst others, induced the great maritime powers as Great Britain, Germany, France and the United States, to adopt the principle of leaving their international submarine connections to private enterprise and exploitation, particularly where they form part of a universal system such as the Great Northern.

Their traffic receipts, &c., had increased by about £9,600, owing to the circumstances previously mentioned, and sundries by about £2,760. Salaries and wages had decreased by £5,380, expenses of stations, offices and agencies had increased by £430; ordinary supervision, &c., of lines and repairing steamers by about £2,640; instruments and cells by £480; maintenance of buildings by £1,600, on account of the installation of new offices in London; sundries by about £1,100. Rates and taxes were less by £720; travelling expenses by £190, and bank commisison, &c., by £100, thus making the total decrease of expenses about £170.

AUCKLAND ELECTRIC TRAMWAYS CO. (LTD.)—The chairman (Mr. C. G. Tegetmeier) stated at the meeting on Monday that the results of the past year showed steady and progressive business.. Out of the profits they had set aside for depreciation £15,000, compared with £12,500 in 1908. Expenditure on renewals and reconstructions would vary from year to year. They had over 22 route miles of track, and they had to look forward to the time when extensive reconstructions of the permanent way would be necessary. Capital expenditure showed an increase for the year of £56,601. The larger portion of that was for additions to their power station and distributing system. The new 600 kw. set that had been installed during the year brought the capacity of their plant to 2,725 kw. The expenditure also included the enlargement of the power sheds and repair shops and the cost of five new cars. Eight more cars are in course of construction, bringing the total stock of cars to 100. They carried 28,736,000 passengers, an increase of 2,592,000, and the passenger receipts show an increase of £16,538. Working expenses were heavier owing to increased car-mileage and to higher scale of wages paid to the employés. Repairs and maintenance cost £30,153, an increase of £4,073. A dividend of 6 per cent. per annum was paid on the ordinary shares.

BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. (LTD.)—The directors, in their report for 1909, state that, notwithstanding serious trade depression, accompanied by unusually severe competition, they can report an improvement in results of the year's trading. Trading profits were £84,156, from which have to be deducted depreciation on machinery, plant, &c., £6,480 (in addition to £10,262 reserved for general depreciation), expenses on surplus land and buildings (£5,673), interest on 6 per cent. prior lien debenture (£14,700), interest on 4 per cent. mortgage debenture stock (£49,654), leaving £7,647. This balance has been ab-

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sorbed by the appropriation of £5,300 required for the prior lien redemption fund, expenditure on contracts of previous years (£2,485), and by writing off £660 from expenses of prior lien debentures issue, leaving a debit balance of £798. This, with the debit balance of £6,521 brought forward, makes £7,319, and is now carried forward. In addition to a substantial sum appropriated out of revenue during the year for maintenance of buildings, machinery and plant, a further £16,742 has been applied to depreciation of these items. While there has been a smaller output for the home market the export business shows an appreciable improvement. Mr. P. A. Lange, general manager of the works, has been elected to a seat on the board.

BROMLEY (KENT) ELECTRIC LIGHT & POWER CO. (LTD.)—At the recent meeting Mr. F. E. Gripper said that the company had had a very satisfactory year. The lamp connections had increased substantially, and, notwithstanding the introduction of the metal filament lamp, their receipts from sale of current had not fallen off. The rateable value of the undertaking under the new assessment had been very nearly doubled, but they had appealed and got it very largely reduced. The directors proposed to pay 7 per cent. for the second half of the year (making 5½ per cent. for the year), the same as in 1908.

CITY OF SANTOS IMPROVEMENTS CO. (LTD.)—Mr. D. M. Fox announced at the meeting last week that, including the San Vincente line, about 15 miles of railway and tramway had been electrified, and there remained about 15 miles to be converted. In spite of the wish of the inhabitants of Santos and San Vincente to have the remainder of the system electrified, and notwithstanding the efforts of the directors to induce the Camara to come to terms, no definite contract had yer been entered into.

DEUTSCH SÜDAMERIKANISCHE TELEGRAPHENGESELLSCHAFT, A.G.—From Aug. 26 to Dec. 31, 1909, this company made a net profit of M.187,623 (£9,481) and a dividend of 6 per cent. is to be paid. The cable of the company has been working only between Borkum and Teneriffe until the second portion—Teneriffe to Monrovia—was opened a few weeks ago. The final portion—Monrovia to Pernambuco—is expected to be finished by March next. The cost of construction has been covered by the issue of M.6,000,000 of new shares and M.9,850,000 of 4½ per cent. debentures.

EASTERN TELEGRAPH CO. (LTD.)—The directors' report for the six months ended December 31, 1909, states that the revenue amounted to £620,942. 4s. 1d., from which are deducted £204,871. 2s. 10d. ordinary expenses and £45,667. 12s. 6d. expenditure relating to maintenance of cables, sundry differences in exchange and income tax payable abroad, leaving £370,403. 8s. 9d., to which is added £55,068. 15s. 11d. brought forward, making a total available balance of £425,472. 4s. 8d. After providing for income tax payable in England, interest on mortgage debenture stock and dividends on preference stock, which together absorb £81,019. 7s. 6d., there remains a balance of £344,452. 17s. 2d., out of which the directors have placed £130,000 to general reserve and have paid an interim dividend of 1¼ per cent. on the ordinary stock, amounting to £50,000. The directors now recommend the declaration of a final dividend on the ordinary stock of 1¼ per cent. and a bonus of 2 per cent., amounting together to £130,000, both payable on May 11, tax free, and making, with the three previous payments on account, a total distribution of 7 per cent. for the year 1909. It is proposed to carry forward the balance of £34,452. 17s. 2d. The company, in combination with the Associated Companies, has made arrangements for the transmission of a special service of British Imperial news, available for distribution throughout the British possessions served by the Associated Companies, whereby a considerable addition to the volume of Imperial news is being provided without any increase of cost to the public.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) The report of the directors for the half-year ended Dec. 31 states that the gross receipts amounted to £315,034. 18s. 7d., against £306,889. 10s. 7d. for the corresponding half-year of 1908. Working expenses, including £17,997. 0s. 10d. for maintenance of cables, absorb £143,674. 0s. 4d. against £151,507, leaving £171,360. 18s. 3d. From this is deducted £3,841. 9s. 3d. for income-tax payable in England and £15,048 for interest on debenture stock, leaving as the net profit for the half-year £152,471. 9s. Adding £58,844. 3s. 1d. brought forward there is an available balance of £211,315. 12s. 1d. One quarterly interim dividend of 1¼ per cent. has been paid for the half-year, and it is now proposed to distribute another of like amount, making, with the interim dividends paid for the first half-year a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share (or 2 per cent.), making a total distribution of 7 per cent. for the year 1909. £50,000 has been transferred to general reserve, and the balance of £26,315. 12s. 1d. is carried forward.

ELECTRIC SUPPLY CORPORATION (LTD.)—For the year ended Dec. 31, 1909, the gross earnings were £23,801, an increase of £2,561 on 1908. The sum taken into net revenue account was £9,300, compared with £6,566. After paying interest there remains £3,780, against £2,397. The equivalent of 113,699 8 c.p. lamps is connected, against 97,778 8 c.p. in 1908; and 2,492,416 units were sold, against 2,034,087. The directors report continued and excellent progress by the Dumbarton Tramways Co. and the Hendon Electric Supply Co., the total number of lamps taking supply from the latter at Dec. 31 last being over 23,000 8 c.p., compared with 12,600 in 1908.

JOHNSON & PHILLIPS (LTD.)—For the year ended Dec. 31, 1909, the profit on trading accounts, &c., after making provision for bad and doubtful debts, and after charging to revenue upwards of £3,691 for maintenance of buildings, plant, &c., amounts to £15,359. 7s. 6d., making, with £681. 2s. brought forward, £16,040. 9s. 6d. Deducting directors', auditors' and trustees' fees (£1,503. 15s. 8d.), interest on debenture stock (£7,850. 13s.), reserve re debenture sinking fund (£5,059. 11s. 6d.), and interest on second debentures (£684. 1s. 2d.) the sum of £942. 8s. 2d. has been carried forward. The directors report that the business of the company during the year under review was adversely influenced by depression in trade throughout the country. The disinclination generally shown to place large orders, and consequent active competition, kept prices low, while the cost of raw materials ruled high. In October, the compounding shop was destroyed by fire. While the company incurred no direct loss, considerable difficulty was occasioned to the cable department, and it was necessary to equip temporary premises to avoid delay in the execution of contracts. The profit for the year shows an increase of £5,322 over the preceding year. Should the electrical trade improve, of which there seems to be some indication, the directors believe that the company is in a position to secure its full share of any business increase. The directors have appointed Mr. Walter Claude Johnson and Mr. Thomas Dence additional members of the board, and Mr. F. S. Paterson has retired.

LEWES & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—For the year 1909 the revenue amounted to £2,402. 3s. 5d., an increase of £107. 8s. 7d. The expenses, including £448. 16s. for interest on temporary loans and a provision of £55 for battery renewals, amounted to £1,970. 15s. 9d., leaving a profit of £431. 7s. 8d., which, added to £33. 13s. 1d. brought forward, makes £465. 0s. 9d. The directors recommend that £450 be placed to depreciation and renewals account, and £15. 0s. 9d. carried forward. The demand for electrical energy for lighting and power continues to increase steadily, and at the end of the year the equivalent of 14,116 8 c.p. lamps (11,915 for lighting and 2,201 for power) were connected to the mains, against 12,357 8 c.p. in 1908. The 120 kw. Diesel oil generating set installed in October, 1908, has generated nearly all the units required during the year at considerably reduced cost per unit.

MUSSELBURGH & DISTRICT ELECTRIC LIGHT & TRACTION CO. (LTD.)—The balance at credit of net revenue account for the year ended Dec. 31 was £6,180. 13s. 7d., making with £131. 13s. 9d. brought forward £6,312. 7s. 4d. After deducting interest on debentures for the year (£2,501. 9s. 7d.) the balance was £3,810. 17s. 9d., of which £2,000 was placed to reserve and renewals fund, and after writing off certain items £1,255. 16s. 9d. was carried forward. Within the last two years extensions of the lighting mains to Inveresk and Levenhall have been carried out, the capital expenditure incurred having been met out of the cash resources of the company, and, as the directors do not wish to further deplete the working capital, they have decided to postpone the declaration of a dividend until the cash at their disposal warrants it. The balance of £1,255. 16s. 9d. carried forward will permit of a dividend of 2½ per cent. being paid on the preferred shares, and this they expect will be done towards the end of July. As compared with 1908, the profits (exclusive of interest, &c.) show an increase of £2,247. 12s. 1d., out of which the tramway undertaking takes credit for £1,892. 7s. 11d., and the lighting undertaking £355. 4s. 2d. The traffic revenue for the year amounted to £12,450. 8s. 9d., against £9,711. 10s. 1d., the receipts per car mile being 9·27d., compared with 8·72d., and the number of passengers carried was 2,224,024. The increased receipts are being maintained.

NEWCASTLE, EMLYN & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—At the recent meeting the chairman (Dr. Powell) said that the company commenced supply in September last, and, with an increasing number of customers, it might safely be assumed that the company would soon have a balance in hand and be in a position to declare a dividend. The future prosperity of the company was assured.

PARA ELECTRIC RAILWAYS & LIGHTING CO. (LTD.)—The receipts for 1909 were £225,916, an increase of £20,605. The expenditure in Para was £120,309, against £152,637 in 1907-8, the net earnings (subject to London expenses) being £105,606, against £52,674. After providing for London expenses, debenture interest and sinking fund, the balance is £60,589, to which has to be added £9,863 brought forward, making £70,453. The dividend on the preference shares has been paid (£17,498) and the directors have added £15,000 to reserve for depreciation and renewals and £10,000 for contingencies, leaving £27,954. Out of this amount it is proposed to pay the arrears of cumulative dividends on the preference shares for 1906 and 1907, which amount to £27,000, leaving to be carried forward £954. Since Dec. 1, 1909, the receipts show an increase of £13,842, compared with the corresponding period last year.

RANGOON ELECTRIC TRAMWAY & SUPPLY CO. (LTD.)—The directors' report for the year 1909 states that owing to the increasing demand for energy it has been decided to extend the power station and to instal an additional 2,500 kw. turbine, thereby increasing the capacity of the station to 5,000 kw. In comparison with 1908, the traffic receipts for 1909 increased by over 15 per cent., and the traffics so far received for the current year show further steady growth. The receipts from the private lighting and power department have doubled those of 1908, and a further substantial increase is looked for during the present year. The gross profits for the year amounted to £42,170. 8s. 5d., and with interest, &c., £42,225. 1s. Deducting Liverpool office expenses (£2,388. 13s. 5d.), interest on debenture stock (£7,341. 13s. 1d.), provision for redemption of debenture stock (£3,872), depreciation (£774. 17s. 4d.), and transferring to reserve £5,000, the balance was £22,847. 17s. 2d., and, with £383. 2s. 5d. forward, £23,230. 19s. 7d. The preference dividend required £15,000, and formation expenses were £2,300, leaving available £5,930. 19s. 7d., out of which the directors recommend an ordinary dividend of 3 per cent.

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(tax free), requiring £5,310. 0s. 7d., leaving £620. 19s. to be carried forward.

RIVER PLATE ELECTRICITY CO. (LTD.)—After providing for administration expenses and depreciation on fixed plant, the revenue account for 1909 amounted to £37,342. 3s. 4d., debenture interest £10,000, leaving £27,342. 3s. 4d., which, with £5,623. 10s. 9d. brought forward, makes £32,965. 14s. 1d. The directors propose paying the balance preference dividend (£6,000), a dividend of 9 per cent. for the year on the ordinary shares (£10,800), placing £10,000 to general reserve and this, with other outpayments, leaves £5,140. 11s. 1d. to be carried forward. A contract has been made with La Plata Electric Tramways Co. for supply of all power required on that company's tramway system. The first section of the tramways was opened in January last, and it is expected that the remaining sections will be in service in the course of the year. The board report a steady and continuous growth of business both at La Plata and Tucuman. The futher business offering and the necessity of maintaining the existing services at a high state of efficiency have required the immediate provision of a large extension of the generating plant and installations in La Plata city and Ensenada port, and with this view a suitable riverside site has been acquired. This station will be equipped with two 1,500 kw. steam turbo-alternators, to be in service in time for the lighting season of 1911. The progress at Tucuman has also necessitated the provision of additional plant and mains.

SINGAPORE ELECTRIC TRAMWAYS (LTD.)—The report for 1909 states that the excess of revenue over expenditure was £28,511, against which has been charged interest, depreciation and royalty (£28,376), leaving a profit of £134. As compared with 1908 the revenue showed an increase of $17,194, the passengers carried an increase of 13,806, and the car-miles run an increase of 193,354. Notwithstanding increased car-mileage the working expenses showed a decrease of $5,258. Trade in Singapore was improving, and it was anticipated that increased traffic receipts would result. The revenue from lighting and power supplies continued to increase satisfactorily, being 62 per cent. higher than in 1908 and 216 per cent. higher than in 1907.

SOUTH METROPOLITAN ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.) At the meeting last week Mr. C. G. Tegetmeier said their tramway receipts had been adversely affected by the weather. The electric lighting department had shown satisfactory increase. With the increasing use of metal filament lamps the directors had increased, as from October last, the price of current for lighting by ½d. per unit.

SUBMARINE CABLES TRUST.—For the year ended April 15 the revenue amounted to £25,259. 18s. 1d. and the expenses to £1,160. 0s. 6d., leaving £24,099. 17s. 7d., to which is added £228. 8s. 4d. brought forward, making an available balance of £24,328. 5s. 11d. After providing £17,952 to meet payment of coupons, £6,201. 1s. has been transferred to redemption fund, leaving £175. 4s. 11d. to be carried forward. During the year 52 certificates have been redeemed by purchase in the open market with the surplus funds of the trust, costing £6,201. 1s.

URBAN ELECTRIC SUPPLY CO. (LTD.)—At the meeting on Wednesday the chairman, Mr. P. D. Tuckett, said that this was the last year of the guarantee, and for a time the ordinary shareholders might have to forego their dividend. Probably a new arrangement would be made with Edmundson's Electricity Corpn., and probably a scheme would be brought forward for writing down the capital.

WELSBACH INCANDESCENT GAS LIGHT CO. (LTD.)—The directors' report states that the continued trade depression has prejudicially affected the company's sales, and that the net profit for the year shows a decrease, and the board regret that the result of the past year's trading does not allow of any further distribution to the shareholders. As regards the ordinary shares, it is impossible, in view of existing conditions, to hold out any hope of dividends.

WEST AFRICAN TELEGRAPH CO. (LTD.)—Revenue for the year ended Dec. 31, 1909, amounted to £59,099. 8s. 10d., from which is deducted £15,737. 3s. 2d. ordinary expenses and £6,520. 16s. 3d. for expenditure relating to the maintenance of cables and income tax abroad, leaving £36,841. 9s. 5d., added £1,731. 3s. 9d. brought forward, making an available balance of £38,572. 13s. 2d. £1,406. 13s. 6d. has been provided for income tax, £27,000 has been transferred to general reserve and an interim dividend of 2 per cent. (tax free), absorbing £4,621. 16s., has been paid. The directors recommend payment of a final dividend of 2 per cent. (tax free) (making 4 per cent. for the year), £922. 7s. 8d. being carried forward.

WEST COAST OF AMERICA TELEGRAPH CO. (LTD.)—The directors' report for the year ended Dec. 31, 1909, states that the gross receipts were £50,416. 6s. 11d., against £52,612. 13s. 2d. in 1908. Working expenses were £39,204. 13s. 7d., compared with £33,193. 7s. 10d. After providing £6,000 for interest on the 4 per cent. debentures, £800 for interest on the 4 per cent. income bonds and £614. 4s. 2d. for income tax, there remains £3,797. 9s. 2d., which, added to £629. 5s. 3d. brought forward, made £4,426. 14s. 5d. £1,000 has been placed to general reserve, and the directors recommend payment of a dividend of 2½ per cent., tax free, amounting to £2,813, leaving £613. 14s. 5d. to be carried forward. The company's old cable repairing steamer "Retriever" has been sold, and replaced by a new vessel bearing the same name.

WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)—The directors' report for the half-year ended Dec. 31 states that the amount to credit of revenue is £34,678. 12s. 1d., against £34,871. 14s. 5d. for the corresponding half-year of 1908, and the expenses have been £23,557. 18s. 6d., against £22,160. 3s. 3d. The balance is £11,120. 13s. 7d., to which is added £1,529. 12s. 8d. interest on investments, and £659. 15s. 2d. brought forward, making an available total of £13,310. 1s. 5d. The directors propose that this amount be dealt with by paying a dividend of 6s. per share on the first preference shares for the six months to Dec. 31 (£10,368. 18s.), and paying 9s. per share on account of dividends accrued to Dec. 31, 1909, on the second preference shares (£2,101. 1s.), leaving £840. 2s. 5d. to be carried forward. The expenses of repairing cables, charged to revenue, amount to £7,980. 14s. 7d., compared with £6,658. 12s. 1d. This is exclusive of an expenditure of £2,414. 8s. 11d., which has been charged to reserve, in respect of 33 knots of new cable used in the repair and partial renewal of the St. Kitts–Antigua, and of the Jamaica San Juan sections.

WESTERN TELEGRAPH CO. (LTD.)—The directors' report for the half-year ended Dec. 31 states that the revenue amounted to £391,504. 9s. 9d. and working expenses to £141,022. 6s. 9d. After providing £16,000 for debenture stock interest and £7,558. 4s. 7d. for income tax, there remains £226,923. 18s. 5d., or, after adding £6,463. 14s. 10d. brought forward, £233,387. 13s. 3d. First and second interim dividends, amounting to £62,379, have been paid, and after transferring £155,000 to general reserve and £10,000 to land and buildings depreciation fund, there remains £6,008. 13s. 3d., which is carried forward. The company's cable between Ascension and Buenos Aires has been successfully completed and will be opened for traffic this month.

NEW COMPANIES.

ALLEN WEST & CO. (LTD.) (108,870)—Reg. April 15, capital £20,000 in £1 shares, to carry on the business of electrical and mechanical engineers, &c. Private company. A. West is one of the first directors. Reg. office, 47, Victoria street, Westminster, S.W.

CHARLES A. DAY & CO. (LTD.) (109,249.) Reg. April 27, capital £2,000 in £1 shares, to take over the business of ironmongers and electricians carried on at Macclesfield as Charles A. Day & Co. Private company. First directors, C. A. Day and Mrs. S. Day.

DIAPANAD (LTD.) (109,209.)—Reg. April 26, capital £2,000, to carry on the business of electrical and illuminating engineers, and to acquire and turn to account a certain invention for improvements relating to illuminated signs and indicators. Private company. Reg. office, 40, High Holborn, London, W.C.

CRAMPTON & CO. (LTD.) (109,320.)—Reg. April 29, capital £2,500 in £1 shares, to carry on the business of electricians, contractors, engineers, manufacturers of and dealers in electrical apparatus, &c. Private company. First directors, W. J. Crampton, S. Crampton and E. B. Crampton.

EXPRESS CABLE INVENTIONS (LTD.) (109,071)—Reg. April 21, capital £50,000 in £1 shares, to acquire from H. Knudsen his patents and other rights in certain inventions for transmitting and receiving, photographs and printed and typewritten messages by wireless telegraphy and over cables and land lines, &c. First directors, Col. H. S. Fitzgerald, B.C., A. C. Hall and T. E. L. Oakley (all permt.). Reg. Office, 29A, Charing Cross road, London, W.C.

GRINDELL MATTHEWS WIRELESS TELEPHONE SYND. (LTD.) (109,260.) Reg. April 27, capital £20,000 in £1 shares, to carry on the business of electricians, electrical and general engineers, manufacturers of apparatus and appliances for telephonic or telegraphic systems, and to adopt an agreement with F. Rouse Pool & Co. First directors, Sir J. Clifton Robinson, Sir William Bull, M.P., Sir Frederick Frankland, Bart., F. Rouse Pool and J. Cameron.

CITY NOTES.

MEMORANDA (May 5).—**Bank rate 4 per cent. (since March 17, 1910). Price of silver,** 24⅛d. per oz. Consols 81⅛—81⅜ for money; 81⅛-81⅜ for account. Consols Pay Day, June 1; Stock and Shares Continuation Days, May 10 and 29; Ticket Days, May 11 and 26; Pay Days, May 12 and 27; Mining Shares Carry Over Day, May 9.

PRICES OF METALS (London).—*Copper*, cash, 55⅞; three months, 56⅜. *Lead*, English, 12⅜—12⅝; foreign, cash, 12¼—12⅜; three months, 12½. *Spelter*, 21¾—22¼. *Tin*, English, 147¼—149¼; foreign cash, 148¾; three months, 150. *Iron*, Cleveland, cash, 49/6½, and three months, 50/5½.

DUDLEY, STOURBRIDGE & DISTRICT ELECTRIC TRACTION CO. (LTD.)—After placing £2,000 to renewals and £998 to depreciation a dividend of 2 per cent. (2s. per share) has been declared on the ordinary shares for the year to Dec. 31.

RIO DE JANEIRO TRAMWAY, LIGHT & POWER CO. (LTD.)—It is announced that the Brazilian High Court of Justice has issued an injunction against the Cia Brazileira de Energia Electrica, restraining them from exercising a concession to use the streets of the city for supplying electric light and power for 90 years, in competition with the Rio de Janeiro Tramway Light & Power Co.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed May 26 a special settling day in $500,000 additional capital stock of the *Shawinigan Water & Power Co.* The Committee have been asked to appoint a special settling day in and grant a quotation to 99,400 £1 fully paid shares of the *Llandudno & Colwyn Bay Electric Railway (Ltd.)* (special application); and to allow a further issue of £23,500 5 per cent. mortgages (redeemable) of the *North Metropolitan Electric Power Supply Co. (Ltd.)* to be quoted.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdire	April 22	213	— 11	16	3,457	+ 89
Anglo-Argentine	„ 29	45,190	+ 3,900	17	741,279	+ 62,751
Ayr Corporation	„ 30	234	— 10	50	13,847	— 114
Baker St. & Waterloo Ry.	„ 30	3,490	+ 85	17	58,370	+ 925
Barnsley	„ 22	179	+ 25	16	2,730	+ 116
Barrow	„ 22	226	— 7	16	3,618	+ 343
Bath Electric Trams, Ltd.	„ 27	725	+ 13	17	11,956	+ 1,197
Birmingham Corporation	„ 30	6,622	+ 132	4	28,388	— 1,365
Birmingham & Midland	„ 15	800	— 254	15	12,123	+ 215
Blackburn Corporation	..	..	..	..	..	..
Blackpool and Fleetwood	„ 30	307	— 72	..	..	..
Bolton Corporation	May 1	2,251	— 86	5	9,900	— 1,544
Bombay	April 1	2,623	+ 18	13	35,255	+ 2,279
Bournemouth Corporation	„ 27	1,640	+ 32	4	6,067	— 1,228
Bradford Corporation	..	..	..	..	..	..
Brighton Corporation	May 1	835	— 9	§4	3,607	— 694
Bristol Trams & Carriage	April 29	5,429	+ 270	50	286,235	+ 22,346
Burnley Corporation	„ 30	1,183	— 42	17	21,455	+ 554
Burton Corporation	May 1	258	+ 5	§4	1,110	— 70
Bury Corporation	„ 1	1,123	+ 23	§4	4,912	— 754
Calcutta Tramways Co.	April 30	₹50,224	+ ₹4,028	17	₹888,900	+ ₹30,954
Camborne-Redruth	„ 30	114	— 3	17	1,993	— 58
Cardiff Corporation	„ 30	2,070	+ 6	5	8,917	— 824
Cavehill	„ 22	70	— 7	16	1,168	+ 140
Central London Railway	„ 30	5,647	+ 72	17	93,706	+ 372
Charing C., Euston & H'stead	„ 30	3,825	— 185	17	65,050	— 350
Chatham & Dist. Lt. Rys.	„ 28	730	— 74	17	12,904	+ 541
City & South London Rly.	May 1	3,226	+ 63	17	56,003	— 392
City of Birmingham	April 22	2 774	+ 118	16	44,932	+ 2,588
Colchester Corporation	„ 27	162	— 2	17	2,729	+ 417
Cork Electric Trams Co.	„ 28	452	+ 55	17	7,430	+ 302
Croydon Corporation	„ 22	1,575	+ 130	16	4,869	— 307
Devonport & Dist. Trams	„ 22	397	+ 32	16	6,463	+ 650
Dover Corporation	„ 30	180	+ 4	4	790	— 94
Dublin & Lucan Railway	„ 29	125	— 3	17	1,962	+ 24
Dublin United	„ 29	5,062	— 195	17	86,287	+ 2,951
Dudley-Stourbridge	„ 22	696	— 34	16	11,232	— 355
Dundee Corporation	„ 27	1,120	— 28	†50	58,200	— 634
East Ham Council	„ 30	976	— 25	¶4	4,193	— 154
Exeter Corporation	„ 30	289	..	4	1,210	— 195
Gateshead & Dist. Trams	„ 22	920	— 30	16	15,194	— 260
Glasgow Corporation	„ 30	17,882	+ 469	‡48	812,293	+ 3,105
Glossop Trams	..	..	..	..	..	..
Gloucester Corpn.	„ 27	249	— 7	4	1,012	— 26
Gravesend-Northfleet	„ 22	186	— 8	16	3,013	+ 126
Great Northern & City Rly.	„ 30	1,490	+ 53	17	25,717	— 469
Gt. Northern, Piccadilly, &c.	„ 30	6,105	+ 160	17	103,105	+ 4,340
Greenock & Port Glasgow	„ 22	590	+ 26	16	8,507	+ 1,170
Hartlepool Tramways	„ 22	216	+ 12	16	3,302	+ 118
Hastings Elec. Trams Co.	„ 28	858	— 93	17	13,741	+ 383
Hong Kong	„ 30	$9,068	+ $885	17	$144,885	+ $13,785
Huddersfield Corpn.	..	..	..	..	..	..
Hull Corporation	„ 30	2,585	+ 122	4	11,221	— 179
Ilford District Council	„ 30	486	+ 26	4	2,073	— 138
Ilkeston District Council	„ 27	112	— 10	4	448	— 93
Ipswich Corporation	„ 30	346	— 1	4	1,503	— 142
Isle of Thanet Co.	„ 30	359	— 39	¶30	9,200	+ 250
Jarrow	„ 22	112	+ 1	16	1,773	+ 96
Keighley Corporation	..	..	..	..	..	..
Kidderminster & District	„ 22	89	— 5	16	1,386	+ 43
Kilmarnock Corporation	„ 30	138	— 8	50	7,221	— 205
Lanarkshire Trams Co.	„ 28	1,303	+ 101	17	22 544	+ 2,268
Lancashire United	„ 27	1,176	— 29	17	20.704	— 82
*Leamington	„ 22	146	— 9	16	2.319	— 12
Leeds Corporation	„ 30	6,645	+ 265	4	28.666	+ 40
Leicester Corporation	„ 30	2,199	+ 43	16	36,820	+ 2,554
Leith Corporation	„ 30	559	+ 51	50	29,406	+ 3,491
Lincoln Corporation	„ 30	169	+ 60	5	642	..
Liverpool Corporation	„ 23	10,653	— 16	16	171,338	+ 3,958
Liverpool Overhead Rly.	May 1	1,427	+ 135	18	23,461	+ 160
Llandudno&ColwynBayRy.	April 29	164	— 7	§21	3,036	+ 149
*London County Council	„ 16	39,765	+ 2,899	¶2	91.219	+ 8 041
London United	„ 30	5,817	— 66	17	96,399	+ 7,002
Lowestoft	„ 30	133	+ 6	31	4,576	+ 308
Maidstone Corporation	„ 30	150	— 21	4	660	— 144
Manchester Corporation	„ 30	14,619	— 127	4	62,836	— 2,059
Mersey Railway	„ 30	2,151	+ 92	17	34.106	+ 700
Merthyr	„ 22	183	— 21	16	3,048	— 197
Metropolitan Dist. Railway	„ 30	10 782	+ 638	17	184.130	+ 18,316
Metropolitan Elec. Trams	„ 22	6,995	+ 815	16	108,436	+ 20,894
Middleton	„ 22	277	— 30	16	4,446	— 403
Nelson Corporation	„ 30	131	+ 3	§4	582	— 73
Newcastle-on-Tyne Corp.	„ 30	3,841	..	¶4	16,051	— 1,762
Newport (Mon.)	„ 30	621	+ 9	5	3,250	— 29
Northampton Corporation	„ 29	438	— 24	4	1,807	— 241
Oldham, Ashton & Hyde	„ 22	511	— 15	16	8,436	— 120
Oldham Corporation	May 1	1,856	— 1	5	9,958	— 951
Perth (N.B.) Corporation	April 27	139	— 9	§49	7.672	+ 66
Perth (W.A.) Elec. Trams	„ 29	1,472	+ 134	17	26.958	+ 1,951
Peterborough	„ 22	104	— 2	16	1,588	— 22
Portsmouth Corporation	„ 30	1 783	+ 14	4	7.719	— 1,269
Potteries	„ 22	1,850	+ 143	16	27,319	— 310
Preston Corporation	..	..	..	..	..	..
Rotherham Corporation	„ 28	609	+ 12	4	2.364	— 141
Rothesay	„ 22	103	— 69	16	1.159	+ 25
Salford Corporation	May 2	4,468	+ 61	†5	20.081	— 1,033
Sheerness	April 22	46	— 1	16	679	— 7
Sheffield Corporation	May 1	5,911	+ 295	¶5	31,383	+ 955
Singapore Trams	April 30	$9,676	+ $731	17	$170,691	+ $4,741
South Metropolitan	„ 22	762	— 47	16	11,710	+ 728
South Staffs	„ 22	797	..	16	12,773	— 167
Southend Corporation	„ 27	436	+ 30	4	1,664	— 178
Southport Tramways	„ 22	248	— 17	16	3,868	+ 135
Stalyb'dge,Hyde,&c.,Jt.Bd.	..	..	..	..	..	..
Sunderland Corporation	May 1	1,075	— 9	5	4,577	— 567
Sunderland District	April 27	472	— 17	26	10.600	— 930
Swansea Trams	„ 22	989	+ 22	16	15,559	+ 1,604
Swindon Corporation	„ 27	129	+ 8	..	..	..
Taunton	„ 22	39	— 1	16	635	+ 86
Tynemouth and District	„ 22	158	— 12	16	2,479	+ 246
Tyneside Trams Co.	„ 27	369	— 22	17	6,459	— 320
Wallasey District Council	„ 30	840	— 15	§3	3,603	— 568
Walsall Corporation	„ 30	504	+ 3	17	8,949	+ 435
Warrington Corporation	„ 25	372	+ 9	4	1,483	— 34
West Ham Corporation	„ 21	2,300	+ 77	3	6,839	— 547
Weston-super-Mare	„ 22	60	— 33	16	665	+ 2
Wolverhampton Co.	„ 22	389	+ 7	16	6,408	+ 140
Wolverhampton Corpn.	„ 27	838	+ 79	4	3,359	+ 71
*Worcester	„ 22	253	— 9	16	3,874	+ 81
Wrexham	„ 22	98	— 4	16	1,488	+ 15
Yorkshire W.R. Trams	May 1	1,150	+ 60	18	21,562	..
Yorkshire Woollen District.	April 22	966	+ 82	16	14,949	+ 1,500

* (a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days, ‡ Minus 2 days, § Plus 3 days, ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	NAME.	Price Wed. May 4	Rate per cent. Yielded.	Dividend Due.	Business Week to May 4. High est.	Business Week to May 4. Low est.
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9½	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	9¾—10¼	5 17 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅜—7½	6 7 0	March	7¼	..
5	3/6	Do. 7 per Cent. Pref.	7—7¼	4 13 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 9	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4 —4¼	5 11 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4⅝	4 17 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —100	4 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	..	..	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¼—4⅜	5 3 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3¼—4¼	5 9 6	March	4⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11½—12	5 16 6	Feb, Aug	12⅛	11⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	12⅛	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 —103	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¼—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7½—8	6 0 0	Feb, Aug	7⅛	7⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	10¼—11¼	5 6 6	Mar, Sept	10⅛	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103—106	4 5 0	Jan, July	..	..
St.	4½%	†Do. Second Deb. Stock	97 —100	4 10 0	May, Nov	102	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4½	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅝—5¼	4 15 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7⅛	5 6 8	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅛—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94⅛—96⅛	4 3 6	..	..	..
St.	4%	Kensington & Kngthg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —99	4 1 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1½—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4½—5½	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	92 —94	4 4 0	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	4 —4⅛	5 0 0	April, Oct	4	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¼—4⅝	4 12 6	Jan, July	4⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	96½—98½	4 11 6	June, Dec	..	..
5	4/0	Newcastle Elec. Supply Ord.	4¼—4½	4 5 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾—4⅞	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	..	..
10	9/0	North Metro. Elec. Power Sup. 5 Morts.	99 —101	4 19 0	..	..	..
5	4/6	Notting Hill Electric Ord.	11⅞—12¼	5 17 6	March	..	..
5	5/0	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
5	3/6	St. James' & Pall Mall Elec. Ord.	8½—9	5 11 0	Feb, Aug	8⅛	..
St.	3½%	Do. 7 per Cent. Pref.	6¼—7¼	4 16 9	Feb, Aug	7⅛	..
5	..	Do. 3½ per Cent. Deb. Stock (red.)	84—88	3 19 6	Jan, July	87	..
5	4/0	Smithfield Markets Electric Sup. Ord.	1⅝—2⅛	..	Feb.	..	..
St.	5%	South London Electric Supply Ord.	2¼—3⅛	6 11 0	April	101⅛	..
1	..	Do. 5 % 1st Mort. Deb. (red.)	100 —103	4 17 6	..	..	..
1	0/8½	South Metrop'n Elec. Lt. & Power Ord.	⅛—¼	..	..	..	..
St.	4½%	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	..	..
5	2/6	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	½—1	..	April, Oct	..	..
St.	4½%	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
5	5/0	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	2/3	Westminster Elec. Sup. Ord.	8¼—9	5 10 0	Mar, Sept	8⅞	8½
		Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	5⅛	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97½	96½
1	..	Bath Elec. Trams Pref. Ord.	⅛—¼	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—¼	6 13 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	83 —86	5 5 6	Jan, July	83½	..
10	6%	Bristol Tramways & Carriage Ord.	6⅜—7⅛	8 5 6	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7¼—7⅝	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	1 —1⅛	..	June, Dec	..	..
10	3%	Do. 6 per Cent. Cum. Pref.	3¾—4⅛	7 5 6	Feb, Aug	3⅞	3⅞
St.	5%	Do. 5 Cent. Perpetual Debs.	90 —93	5 7 6	April, Oct	92½	..
St.	4½%	†Do. 4½ per Cent. 2nd Deb. Stock	66 —71	6 7 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	70 —72	5 4 6	Feb, Aug	70½	70½
St.	4%	Do. 4 per Cent. Pref. Stock	66 —68	4 11 0	Feb, Aug	67½	..
St.	2%	Do. Deferred Stock	53 —55	3 12 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	96 —99	4 2 0	Jan, July	97	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	34½—35¼	3 9 6	Feb, Aug	35	..
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	106 —108	4 12 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —105	4 15 0	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	102½	..
St.	4%	†Do. 4 per Cent. Perpetual Debs.	98 —100	4 0 0	May, Nov	99½	98⅛
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	⅛—¼	..	Feb, Aug	⅛	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 —98	4 2 0	Jan, July	99¼	96⅛
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3¼—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	70 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅛—1⅛	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan, July	..	..
10	..	London United Trams, 5% Cum. Pref.	2¼—3	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	69 —72	5 11 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅜—⅝	..	..	⅝	..
1	..	Do. Deferred	⅛—¼	..	April	⅛	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅜	5 12 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 —100	5 0 0	Jan, July	98⅛	97½
St.	1%	Metropolitan Railway Consolidated	43¼—44	2 5 6	Feb, Aug	43⅛	42½
St.	2½%	Do. Surplus Lands Stocks	67 —69	3 19 6	Feb, Aug	67	..
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	89½	89½
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	86½	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87½	87
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	92½	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Wed., May 4	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to May 4. Highest.	Business Week to May 4. Lowest.
		Electric Railways and Tramways—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	91 —93	3 15 0	Jan, July	91½	..
St.	..	Metropolitan District Railway Ord.....	23 —23½	..	Feb, Aug	23½	22½
St.	..	Do. Extension Pref. (5 per Cent.).....	69 —71	..	Feb, Aug	..	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	..	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	75½	72
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	103	..
St.	4%	Do. Guar. Stock 4 per Cent.....	102 —104	3 17 0	Mar, Sept	103	102½
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	143 —145	4 2 9	Jan, July	144½	143½
St.	4%	Do. 4 per Cent. Ditto.....	96 —98	4 1 0	Jan, July	97½	96½
1	..	Potteries Electric Traction Ord.	½—¾	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	½—¾	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock.....	84 —87	5 2 6	May, Nov	85	84½
1	..	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	½—¾	..	..	..	..
St.	4%	Do 4 per Cent. Deb. Stock.....	67 —71	5 12 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	60 —65	7 9 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoups	38 —40	..	June, Dec	39½	39½
..	5%	†Do. 5% Prior Lien Bonds.....	100 —101	4 19 0	..	100½	100½
..	4½%	Do. 4½% Bonds with coup. 5	88 —90	4 18 0	..	89½	86½
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	97 —99	4 1 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	¾—¾	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1¼—2¼	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	78 —81	5 11 0	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101 —103	4 7 0	..	..	..
1	..	Aron Electricity Meter Ord.....	⅛—⅜	..	..	..	..
1	7½d.	Do. 6% Cum. Pf.	⅝—¾	6 8 0	April, Oct	..	..
1	3/2½	†Babcock & Wilcox Ord..... xd and bon us	4¼—5½	3 18 3	April, Oct	5⅛	5⅛
1	0/7½	†Do Pref.....	1⅞—1⅞	3 16 3	..	1⅞	..
5	6/0	British Insulated & Helsby Cables Ord..	6½—7½	6 18 0	July, Feb	6½	..
5	3/0	Do. 6 per Cent. Pref.....	6 —6½	4 10 9	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	98 —101	4 9 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.....	⅜—⅝	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	97 —99	6 1 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	48 —52	7 14 0	Jan, July	49½	48½
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	25 —29	15 10 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.....	10 —10½	6 3 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	5¼—5½	4 11 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	102½—104½	4 6 0	Nov, May	..	..
1	1/9	Castner-Kellner Alkali Co.....	2¼—2½	5 3 9	May, Nov	2⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	104 —107	4 4 0	Feb, Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—⅜	6 11 9	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	¼—½	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	¼—½	7 0 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	¼—½	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	½—¾	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	½—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	¾—1	6 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	1⅛—1⅛	5 5 3	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅞—⅞	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1¼	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅞—1	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1½	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	73 —76	5 18 0	Jan, July	..	..
2	..	Electric Construction Co.....	½—¾	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1⅛—1⅛	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs ..	61 —66	6 1 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7¼—8½	5 1 6	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	12½—12⅝	8 2 6	Feb, Aug	12½	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 3 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 3 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Works....	15 —15½	6 7 6	Feb, Aug	16½	15
10	5/0	Do. 5 per Cent. Cum. Pref.	10½—10⅝	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97½—99½	4 0 6	April, Oct	..	..
1	..	National Elec. Construction Co.	⅛—¼	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅞—1	..	No.	..	..
1	..	Do. 6 per Cent. Cum. Pref.	¾—1	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	30/0	Telegraph Construction & Maintenance..	33 —35	5 17 0	Mar, July	33½	33
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 11 0	..	2⅜	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1⅜	4 4 3	..	1⅜	1⅛
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	109 —112	4 11 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 16 0	June, Dec	102½	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —106	4 5 0	June, Dec	105	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	100 —103	4 12 6	..	106	..
10	8%	J. G. White & Co. 6% Cum. Pref	9½—10½	7 12 0	..	..	..
1	..	Willans & Robinson Ord.....	¾—1	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1½—2½	9 0 0	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	65 —75	5 6 8	May, Nov	65	..
		Telegraphs.					
10	..	Amazon Telegraph	3½—3¾	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100 —102	4 18 0	June, Dec	..	..
St.	15/0	Anglo-American	59 —61	5 19 0	F.My.Ag.N	..	..
St.	30/0	Do. Preferred	101 —102	5 18 0	F.My.Ag.N	101½	101
St.	25/0	Do. Deferred	17½—18½	6 16 3	F.My.Ag.N	18	17½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	86 —88	4 11 0	Jn.Ap.Jy.O	86	..
10	6/0	†Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	†Do. Preference 10 per Cent.	16½—17½	5 12 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3½—3¾	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable.....	13½—13¾	6 3 6	Ja.Ap.Jy.O	14	..
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.).	100 —102	4 18 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	136 —139	5 1 0	Ja.My.Jy.O	138	135½
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	86 —89	3 19 6	Ja.My.Jy.O	..	..
St.	4%	†Do. 4 per Cent. Mort. Deb. Stk. (red.)..	101 —103	3 17 6	May, Nov	101	..
St.	2/6	Eastern Extension	13 —13½	5 2 0	Ja. Ap. Jy.C	13½	13
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	†Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101½	3 18 6	May, Nov	..	..
10	26/0	†G.N (of Copenhagen), Ex Coupon 78	30¾—31½	5 19 6	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt.Db.(red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European ..... ex all	51½—53½	6 1 6	May, Nov	..	..
100	$1½	Mackay Companies Common	88 —93	4 16 6	Ja.Ap.Jy.O	..	..
100	$1	Do. Preference	77 —80	5 0 0	Ja.Ap.Jy.O	..	..
1	..	Marconi's Wireless Teleg. Co.	½—¾	..	April	..	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	98 —100	4 0 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 14 0	May	..	..
100	4%	Do. 4 per Cent. Debs.....	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	½—¾	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9½	6 10 0	May, Nov	9½	8½
0	20/0	Do. 6% 2nd Pref.	8½—9½	6 10 0	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.....	100½—102½	4 17 6	Jan, July	..	..
1	3/0	Western Telegraph.....	13½—14½	4 17 6	Mr, Jn, O, D	13½	13⅝
	4%	Do. 4 per Cent. Deb. Stock (red.).....	101 —103	3 17 6	June, Dec	..	..
	4%	Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	—	..	..
		Telephones.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	138 —141	5 13 6	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	103 —105	3 15 6	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99½—101½	4 18 6	Mar, Sept	..	..
5	3/0	Chili Telephone	8⅛—8⅜	4 15 3	August ..	..	..
1	0/7½	†Monte Video Telephone Ord.....	¾—1	7 0 0	Nov	..	..
1	0/6	†Do. 5 per Cent. Pref.	¾—⅞	5 14 6	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	104 —105½	5 15 6	Feb, Aug	104½	104
St.	6%	Do. Def. Stock	124 —126	4 16 6	Feb, Aug	125½	124½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 10 6	Feb, Aug	10½	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 10 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.....	5⅛—5⅜	4 12 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.).....	97 —99	3 11 0	June, Dec	97½	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	98 —100	4 0 0	Jan, July	98	..
..	4½%	†New York Telephone Co. 30 yr. Bnds.....	98 —99	4 11 0	..	..	98½
1	0/7½	Oriental	1⅛—1⅜	4 15 0	April, Oct	1⅛	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock.....	86 —88	4 11 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100 —102	4 8 0	Jan, July	1..	..
5	3/0	United River Plate.....	7¼—7½	5 9 0	July	7⅛	7⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅜	4 9 0	June, Dec	5⅜	..
St.	4½%	Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan, July	..	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2¾—3¾	8 18 0	Jan, July	..	..
5	2/0	Globe Telegraph & Trust	10¼—11	5 9 0	Sp,DcMrJu	10½	10½
10	3/0	Do. 6 per Cent. Pref.	13¼—13½	4 8 0	Sp,DcMrJu	13½	..
10	6%	†Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	128	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4¼—4½	5 2 6	April, Oct	4½	4⅜
5	2/6	Do. 5% Cum. 2nd Pref.....	4⅜—4½	5 5 6	Jan, July	4½	..
5	2/6	Do. 4% Deb. Stock	92½—92	4 7 0	June, Dec	91½	90½
St.	4½%	Do. 4½% Deb. Stock	96 —98	4 12 0	..	97	96½
5	2/6	Auckland Elec. Trams. 5% Deb. (red.).....	10 —107	4 13 6	Jan, July	106	..
5	4/6	†Brisbane Electric Trams. Invest. Ord	6½—7½	4 5 0	May	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.....	101 —101	4 6 6	Jan, July	103½	..
St.	4½%	British Columbia El.. Rly. Df. Ord.	143 —143	5 8 0	Mar, Sept	143	142½
St.	8%	Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	124½	124½
St.	6%	Do. 5% Cum. Perp. Pref. Stock.....	108 —110	4 11 0	Jan, July	109	107½
St.	5%	Do. 4½ per Cent. 1st Mort. Debs.....	101 —103	4 7 6	April, Oct	..	..
40	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	101½—103½	4 1 6	..	103	101½
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	..	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	96	95
5	2/6	†Calcutta Tramways (1 to 137,610).....	4¼—4½	4 2 6	Mar, Sept	4½	4¼
100	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5	5 0 0	Jan, July	4½	..
1	4½%	Do. 4½% 1st Deb. Stock (red).....	99 —102	4 8 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	¼—½	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5½—5¾	4 8 3	F.My,A.N	..	..
100	5%	Do. 4 per Cent. Deb. Stock.....	97 —100	4 0 0	June, Dec	..	..
100	5%	†Colombo Tr. & Ltg. 5% 1st Mt. Db.....	94 —97	5 2 6	May, Nov	..	..
5	2/6	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	81	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94½—97½	5 2 6	Feb, Aug	..	..
..	..	Kalgoorlie Elec. Trams Sh.	⅞—⅞	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock.....	95 —98	5 2 0	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	76½	..
5	0/7½	†Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
100	5%	Do. 5 per Cent. Reg. Mort. Debs.....	100 —104	4 16 0	Jan, July	..	..
100	5%	Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
5	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	95 —97	5 2 6	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	129 —131	4 15 0	..	..	..
5	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	95 —96	5 4 0	..	95½	95
5	5%	Do. 6% 50 yr. Mort. Bds.....	98½—99½	6 0 3	..	99½	99
St.	6%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	102	..
100	5%	†Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	..	..
1	0/6	Perth Elec. Trams Ord.	⅜—½	5 14 0	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5½—5¾	5 2 6	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	..	..
100	$1	Ric Janeiro Tram, Lt. & P. Co.....	95 —97	4 2 6	..	95½	95½
100	$1	Do. 30 yr. Gold Bnds.	97½—98½	5 1 0	..	98½	97½
100	$2½	Do. 50 yr. Mt. Bnds	86 —87	5 15 0	..	86½	86½
5	5%	Sao Paulo Tramway, Light & Power Co. $100 Stock	147 —149	5 8 6	..	..	..
100	5%	Do. 5 per Cent. 1st Mt. $500 Db.	102½—104½	4 15 6	June, Dec	103½	..
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5¼—5½	5 2 0	Mar, Sept	..	..
5	6/0	Bombay E.S. & T. 6% Cm. Pf.....	10½—11	5 9 0	..	..	..
St.	4½%	Do 4½ per Cent. Deb. Stk. (red).....	95 —97	4 12 6	Jan, July	96½	95½
St.	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock..	96 —98	4 18 0	..	..	..
St.	4%	Calcutta Elec. Supply Ord.	6¼—6½	5 18 9	April, Oct	6⅜	6⅛
St.	4%	Canadian Gen. Elec. Co. Com. St.....	114 —117	6 2 6	..	116	114½
St.	4%	Do. 7% Cm. Pf. Stock	117 —120	5 16 6	..	120	119½
100	$3½	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
5	5%	Elect. Development Co. of Ontario.....	82 —85	5 16 0	..	82½	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
500	5%	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
..	..	Kalgoorlie Elec. Power & Ltg. Ord.	¾—⅞	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	¾—⅞	8 0 0	April, Oct	..	..
100	$1	Madras E. S. Corp. Ord.	2¼—2½	..	..	..	..
500	5%	Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
100	$1½	Do. 5% 1st Mortg. Deb. Stock.....	92 —94	5 6 9	..	..	..
1	1/2½	†Montreal Lt. Ht. & Power Co. Cap. St.	136 —140	4 15 6	F,My,A,N	141½	141
1	1/3	†River Plate Electricity Co. Ord.	1½—2	4 0 0	April	2	1⅝
1	1/2½	†Do. 6 per Cent. non-Cum. Pref.	1½—1⅝	5 4 0	May	1⅝	1⅜
100	4%	Do. 5 per Cent. Deb. Stock	103 —105	4 15 6	Jan, July	..	..
1	1/3	Rosario Ele . Co. Ord.	8½—9	..	..	..	..
100	4%	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
10	..	Do 2nd Pref.	8½—8¾	6 14 6	..	..	..
10	6/0	Shawinigan Water& Power Co.Ca.	101½—103½	4 7 0	..	102	..
0	20/0	Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	..	..
100	5%	Do. 4½ Per Con. Mt. Db. St.	101½—103½	4 7 0	..	102½	..
1	3/0	Toronto Power Co. 4½% Db. St.	101 —103	4 7 6	..	..	..
	4%	Victoria Falls Power Co. Pref.(1 to 808,000)	¾—⅞	5 14 0	Jan, July	..	..
	4%	Do. (808,081 to 1,700,000)	¾—⅞	..	..	..	..

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,669. [No. 5. Vol. LXV.] FRIDAY, MAY 13, 1910. PRICE SIXPENCE (by post, 6d.). Abroad 9d., or 12 cents, or 90c., or 8½p.

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NOTES.

Le Roi est Mort, Vive le Roi!

IT is with profound regret that we have to record the death of H.M. KING EDWARD VII. In so doing it may be remarked that we speak rather as loyal and loving subjects than as electrical engineers, for although the benefits conferred by his Majesty's actions upon the country as a whole were shared equally by engineers as by other inhabitants, his duties were too multifarious for him to pay any special attention to scientific work, or to study those engineering details which figure so largely in our daily life. The loss, both to our country and to the dominions beyond the seas, is none the less great; how great, it is too soon to tell with any certainty, nor can we tell in what abundance the seed sown by him for our good during the past few years will bear fruit.

IT would not be fitting, even in these few lines, to write of the late King without some mention of his efforts to secure permanent peace between the nations of the world. Without wishing to view this lofty ideal merely through the narrow aperture of the engineering world, it may be said that, in so doing, the King was aiding in an exceedingly direct manner the universal progress of engineering. When two nations are barbarously attacking one another with the weapons of war, neither time, money nor energy can be employed in the development of civil engineering in the true sense of the word. Forth Bridges cannot be erected, irrigation schemes cannot be perfected, scientific intercommunication must suffer, while all that is noblest in engineering is toppling to the ground through decay and the destructive efforts of the opposing forces. The longer the world remains at peace, the longer time has the engineer to perfect his theories and to develop them in practice. Engineering is really a constructive science, while war is a destructive science in every way, so that, in using his influence in favour of the former, KING EDWARD not only conferred benefits on engineering which should not lightly be forgotten, but advanced us appreciably towards that ideal when warlike weapons will be no more. During the course of his life KING EDWARD was brought into direct contact with engineering at the opening of the railway bridge across the St. Lawrence at Montreal, and at the opening of the Forth and Tower Bridges in this country. He passed through a university course in science under PLAYFAIR, and his recognition of the importance of scientific education was well indicated by his speech after laying the first stone of the new building of the Imperial College of Science and Technology at South Kensington. Finally, in founding the Order of Merit he conferred a unique honour on scientific work.

ON the purely human side of the question we may note with unqualified satisfaction that his

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dealings with other nations brought him the well-merited name of "KING EDWARD, the Peacemaker," a name in which we, as a nation, should be proud to participate. Those actions by which he earned this high-sounding title have caused his loss to be felt universally, as the remarkable outbursts of sympathy with this country, which have been lately reflected in the newspapers of the world, have clearly shown during the past week. In these days of national ambitions and jealousies, when misunderstandings are liable to arise on the slightest pretext, the value of tact and diplomacy, in the best sense of the word, being concentrated in the highest personage of this kingdom is truly an attribute to be prized, and is one which we can ill afford to lose. Engineers will miss KING EDWARD'S appreciation of anything new or likely to contribute towards the welfare of his Empire. Within the last few weeks of his life he was taking a keen interest in the progress of aerial navigation, and he was among the first to appreciate the possibilities of the automobile, while it was always his practice to invite inventors to explain their apparatus to him. He thus encouraged the ingenuity of his subjects in a way which cannot be overrated.

IN offering our condolence and congratulations to his present Majesty, KING GEORGE V., we cannot but dwell upon his exceedingly difficult task in following in the steps of his father. The wide outlook that he must necessarily have obtained during his extensive travels cannot, however, but help him in this respect, and we have no doubt that his best endeavours will be to maintain the welfare of his people at the present high standard. KING GEORGE, we are proud to record, has from time to time been brought into close contact with engineering work. His naval experiences must have convinced him of the possibilities of both steam and electrical engineering, while his keen practical interest in such lowly operations as stoking cannot fail to remind us that in him we shall always have a sympathiser whose interest in our doings will not be merely theoretical. Our shortcomings also are not unknown to him, as witness his famous dictum, "Wake up, England!" on his return to this country a short time ago. His speech on that occasion might with advantage be read and re-read by those concerned with our industrial progress.

IN our late King we possessed a truly precious asset, and though, in accordance with divine dictates and human frailty, he has passed away, his place is directly taken by a worthy successor, whose loyalty to his subjects and devotion to his kingly duty cannot but accentuate our heartfelt cry: "Long live the King!"

The New London-Paris Telephone Cable.

IT may be well to state that most of the reports in the daily Press as to the results to be obtained with the new telephone cable laid across the Channel last week are very misleading. This cable has not been put down with the object of improving telephonic communication between London and Paris, but as an experiment to test the capabilities of Pupin coils under practical conditions. It is true that the normal increase in the number of telephone messages between the two countries would necessitate, sooner or later, an increase in the number of cables across the Channel, but the main object of the Post Office was to put a "loaded" cable to a practical test. The question of reducing attenuation in submarine cables is of particular importance to the Post Office at the present time, since it is wished, if possible, to obtain direct telephonic communication between London and Germany without the cables touching French or other territory. The success of the present experimental cable would, therefore, undoubtedly lead to important developments, and it may be mentioned that the French Administration intend to lay down a similar cable at an early date.

CONSIDERABLE misunderstanding also appears to exist as regards the results to be obtained with the "loaded" cable, it being stated that communication will, in future, be possible even between the Midlands and Paris. As a matter of fact, however, at the present time one can speak from Liverpool, Manchester, Leeds or Hull to Paris, and from the Midlands through to Lyons, and under favourable conditions, even from Leeds to Lyons. When the new cable is in operation the total distance over which speech will be possible will be increased by about 100 miles. In this connection it may be mentioned that by the addition of the Pupin coils the equivalent length of the new cable between Dover and Cape Grisnez has been reduced from 10·5 miles to 3·4 miles of standard cable. This is a saving of 7·1 miles of standard cable, which saving represents about 140 miles of heavy aerial telephone line, or 70 miles of ordinary telephone line, these representing, therefore, the additional distances over which telephonic communication will be possible. It must not be forgotten that the "threefold" improvement due to "loading" affects only the submarine section of the line, although some of the accounts in the daily Press would imply that the limiting distance of telephonic speech will be increased in this ratio.

Advances in Telephony.

FOR some years past it would appear that telephonic investigators have for the most part given up the attempt to obtain a substitute for carbon in the transmitter, and it has been left to Mr. S. G. BROWN to break away from the trammels of carbon and make metallic transmitters of both single and multiple contact pattern which are capable of competing with the present patterns of carbon instruments. Mr. BROWN'S most successful results have been obtained with the extremely hard alloy of osmium and iridium, and a full description of his application of hard metals to the construction of telephonic speech relays, repeaters, electrical stethoscopes and granular transmitters will be found in his I.E.E. Paper published in abstract in last week's issue

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We publish this week the discussion on his Paper, from which it will be gathered that the possibilities of Mr. BROWN's new apparatus are considerable. The discussion also brought to light the fact that a great deal of work would be required before the apparatus could be considered to have entered the field of practical telephony, however immediately applicable the apparatus would be to wireless telegraphy and for medical purposes.

THAT the carbon transmitter has not by any means reached finality is well shown by the striking tests published in these columns (Nov. 19, 1909, p. 229) on the Egnér-Holmström transmitter, which demonstrate that decided improvements can be effected by suitably designing a carbon transmitter to carry a considerable current. The Shreeve repeater, which is in practical use in the United States and is the invention of an Englishman formerly with the Silvertown Company, was referred to by Messrs. KINGSBURY and COHEN, and it will be interesting to see how Mr. BROWN's repeater, when he has evolved it for both-way working, will compare with the Shreeve from the practical standpoint. The application of the repeater with metallic transmitter to the stethoscope appears to have produced a strikingly sensitive instrument which according to Dr. VOYSEY may render possible the diagnosis of certain diseases in the earlier stages. At present, however, it is a little difficult to speak with certainty as to the future of Mr. BROWN's interesting and ingenious instruments.

The Telephone as an Aid to School Management.—According to the "Electrical Review and Western Electrician" the use of the telephone in schools is becoming more and more extended. The telephone has, for instance, been found a great help to the organisation of the Williamson Free School of Mechanical Trades, where it is used for the work usually carried out by bells, speaking tubes or messengers. The Williamson school consists of thirty buildings extending over 230 acres. The telephones used are of the automatic intercommunicating type. They have become very popular, and were installed by four of the students under the direction of the Western Electric Co.

Electric Traction on the Long Island Railway.—According to the "Electric Railway Journal" the Long Island Railway has been extending its electric zone and making many expensive improvements. With the opening of the tunnels it will have for its passenger service two tunnels from Seventh-avenue and Thirty-second-street to the Sunnyside yard in Long Island City; a six-track line from Sunnyside yard to Woodside, eight tracks from Woodside to Winfield; six tracks from Winfield to Glendale Junction and Jamaica. It is estimated that there will be a saving of from 20 to 25 minutes in each direction to people living in towns on the concerned lines, over the time at present required to cross the ferry and take the tram.

Oil Consumption at the Berlin Power Station.—According to the "Electrical Review and Western Electrician," the Berlin electricity works have recently published some figures showing the saving in the cost of oil due to the displacement of reciprocating engines by steam turbines. In the fiscal year 1905-1906, when the first turbines were installed, there were required 554,514 lb. of cylinder oil and 206,373 lb. of engine oil. The output of the station for the year in question was 166,865,122 kw.-hours. In the fiscal year, 1909-1910, the output of the station was about 210,000,000 kw.-hours, but owing to the fact that the station is now operated entirely by steam turbines the consumption of cylinder oil was only 103,400 lb. and of engine oil also 103,400 lb.

Single-Phase Traction in Prussia.—According to the "Electric Railway Journal" the Prussian State Railways are preparing to equip for single-phase operation a section of steam railroad track, 18·6 miles in length, comprising the main line division between Bitterfeld and Dessau. The general design of the overhead construction and car equipment is to follow that of the Hamburg Altona line with the significant difference that the motors will be built for 15 cycles instead of 25 cycles. The power house, which will be located at Bitterfeld, is to have a two-pole 3,000 kw. turbo-alternator running at 900 revs. per min. The present electrification will cost about £96,000, and if successful will be followed by the electrification of the lines between Leipzig, Magdeburg and Halle at an additional cost of £1,300,000.

Ionisation produced by Cathode Rays ejected by X-Rays. A Paper on this subject was recently read before the Royal Society by Mr. R. D. Kleeman. The results of the author's experiments are given in the annexed table, in which are also placed the total ionisations obtained by Prof. Bragg with the α-particle. It will be seen that the two sets of values relative to air are very nearly the same. The energy spent in making an ion thus seems not to depend in any marked degree on the nature of the ionising agent.

	Cathode rays.	α particle.
Air	1·00	1·00
Carbon dioxide (CO_2)	1·08	1·08
Ethyl oxide ($C_4H_{10}O$)	1·23	1·32
Pentane (C_5H_{12})	1·31	1·35
Benzene (C_6H_6)	1·20	1·29
Ethyl chloride (C_2H_5Cl)	1·33	1·32
Chloroform ($CHCl_3$)	1·34	1·29

High-Tension Transmission Insulation.— The "Electrical World" gives an account of a suspension type of insulator for use with very high tensions. Each insulator is in two parts. The upper part is of the so-called thimble type and the lower is of the rod type, the whole forming a chain which can be extended indefinitely. The thimble shape of the insulators protects thoroughly from the weather the upper parts of the rod insulators by which spring suspension is provided. This construction gives a resiliency so that the chain of insulators is relieved in all its parts, as well as in its entirety, from the results of sudden or abrupt strains usually so destructive to mechanism of this kind. The various parts of the insulators may be detached and replaced by other parts and the total number of parts may be increased or diminished, at will, after the original structure is built. This feature is specially important in instances where after the installation of a conductor the voltage is increased.

Electric Traction on Mont Blanc.—According to "The Times Engineering Supplement," the funicular railway from Le Fayet to the summit of Mont Blanc, the first section of which was completed last July to the Col de Voza, 5,495 ft., is to be continued, and contracts have just been given out for building the second section, 7 miles in length, up to the Aiguille du Gouter, at a height of 12,000 ft. Up to a height of a little over 8,000 ft. the railway will be in the open, but from this altitude up to 12,000 ft. it will pass through tunnels. From 12,000 ft. to the summit of Mont Blanc, 15,782 ft., a tunnel will have to be driven under the glaciers in order to protect the line against avalanches; but this last portion of the line will not be constructed until the other sections are realising dividends. The cost of the line, as far as the Aiguille du Gouter, is roughly estimated at £5,000,000, and for the third short section £2,000,000. The Strub cog-wheel system is employed, and the motive power is electricity. The steepest grade will not exceed one in five, and the minimum speed will be four miles an hour. Twelve trains a day will be run to the Aiguille du Gouter, and every station will be fitted with air-tight rooms containing oxygen for travellers who may be attacked by mountain sickness.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Assab—Perim	July 8, 1909	—
Balik Papan—Kwandang	Nov. 1, 1909	—
Malta—Tripoli	April 20, 1910	—
Para—Pernambuco	April 25, 1910	—
Mambique—Majunga	May 3, 1910	—
Madagascar—Reunion	May 3, 1910	May 10, 1910
Suakim—Jedda	May 6, 1910	—
Benny—Duala	May 6, 1910	—

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Low Cost of Electric Pumping.—According to the "Electrical Review and Western Electrician" the change-over at Wahpeton from steam to electrical operation of the city pumps has been accompanied by a great reduction in cost. Heretofore the coal alone cost £3. 12s. a day, while the electric power for running the pumps costs only £1. 5s. a day. The power is obtained from a hydroelectric plant near Fergus Falls.

Wireless in Railway Working.—The "Railway and Engineering Review" states that the Pennsylvania Railway officials are still making experiments with wireless telegraphy with a view to ascertaining its efficacy for railroad work. The mast in use for the tests is erected near Altoona, on the mountain, at a point 1,655 ft. above sea level, the receiving apparatus itself being 1,735 ft. above the level of the ocean. Communication already has been established with various wireless stations along the Atlantic coast, as well as with various vessels at sea.

Central Station Training.—It may be remembered that some years ago the Newcastle-upon-Tyne Electric Supply Co. inaugurated an "improver" system under which men who had just finished their apprenticeship were able, as Junior Assistants, to gain experience of large power supply work in the generating stations, substations and the extensive transmission and distribution systems throughout the area of this Company, and the other power companies with which they are associated. The Newcastle Company has been the nursery for central stations in all parts of the world, many of its employees having from time to time found good billets elsewhere. It is gratifying to note that the value of the experience gained in this Company's service is so fully appreciated. Only this week, by arrangement with the Newcastle Company, a considerable number of assistant engineers have sailed for South Africa to take up important positions on the staff of the Victoria Falls & Transvaal Power Co., whose chief engineer, Mr. Bernard Price, also came from the North of England. He was in fact for several years closely connected with the extension of the Newcastle Company's system.

High-Voltage Strains in Dielectrics.—At a special meeting of the Boston Section of the American Institute of Electrical Engineers held at the Massachusetts Institute of Technology, Prof. D. C. Jackson presiding, an illustrated lecture on "High-Voltage Strains in Dielectrics" was given by Mr. H. S. Osborn. The speaker emphasised the mathematical simplicity attending analyses of insulation strains in single-conductor cables, compared with the difficulties bearing upon the study of multi-conductor outfits, and showed diagrams of potential gradients and gave formulæ for intensities and stresses The relations between diametrical ratios and dielectric constants and the effects of leakage conductance on charging current were considered. The insulation resistance of cable paper was given as about 10,000,000 megohms per cubic centimetre, and of rubber as 800,000,000 megohms per cubic centimetre. Grading of insulation was valuable in small wires and also in large conductors for high voltage service. The volume of insulation required for a given service was much less with graded cables, frequently from 25 to 35 per cent. of the quantity needed in ungraded cables. An approximate solution of potential distribution was possible for three-conductor cables, but this appeared to be out of the question in generator and transformer coils. The work of Dr. Russell and Mr. Watson in cable insulation testing, as discussed in the *Proceedings* of the Institution of Electrical Engineers, was reviewed, and graphic studies of charging currents and other phenomena were presented.

Economies of an Electric Signalling System.—Mr. F. P. Patenall, of the Baltimore Railway, in a recent report speaks in the highest terms of the efficiency and economy of the electric signal system compared with oil burning signals. On the Washington branch, between Baltimore and Washington, 69 electric lamps were lighted and extinguished 1,259,250 times, while on the Metropolitan branch, between Washington and Germantown, 38 electric lamps were lighted and extinguished 208,050 times. During this period there were but nine failures, four being caused by lightning and five by filaments burning out. When burning, the lamps consumed approximately half an ampere, and on the Washington branch, where 50 trains are running in each direction daily, each lamp burns 1 hour and 40 minutes each 24 hours, the lamps lighting upon the approach of trains both by day and night. The entire expense of maintaining the 107 signals during the year, including labour, was £2,157. It is interesting to note that 32·4 lb. of blue vitriol were used per signal per month. The current for lighting the lamps was obtained from the same source as that for operating the signalling motor—namely, six cells of a storage battery charged by 18 gravity cells for each pair of signals. At interlocking points, where frequently four signals are operated from the battery, seven storage cells are used, charged by 21 gravity cells. In conclusion, it is reported that the system not only operated more satisfactorily than the oil system, but with higher economy, the wages of five lamp men, equivalent to £45 a month, having been saved since the system was put in operation.

Street Lighting in the City of Westminster.—In connection with the street lighting contracts in Westminster we have received from the Westminster Electric Supply Corporation a copy of a proposal made by them in conjunction with their tender. It will be remembered that this Company already light the St. George's, Hanover-square, district by 962 open type arc lamps. This contract remains in operation until 1931. They offered, if they were given the street lighting in the rest of the district supplied by them, to change these lamps, free of charge, to flame lamps, thus increasing the total candle-power from 500,000 to 1,800,000 c.p. Metal filament lamps would also have been substituted where carbon lamps are now used. The electric supply company pointed out that the district is now lighted by 1,074 gas lamps giving approximately 90,000 c.p., while under the new specification the alternatives suggested would give 216,000, 264,000 and 682,200 c.p., or something intermediate between these values. In the first case the capital expenditure would be £3,600, and the maintenance £7,800 per annum; in the second and third the capital expenditure would be £4,000 and £13,220, and the maintenance £8,800 and £7,185 respectively. In the alternative proposal the capital expenditure would be nothing, and the maintenance £7,921 per annum. This alternative proposition would cost £75 per annum more than the price tendered, but by its acceptance it was pointed out the Council would obtain the same high standard lighting as laid down for the specified district in the adjoining area which is more than twice its size.

Terrestrial Magnetic Disturbances at Greenwich.—At a meeting of the Royal Society on April 28th, a Paper on "The Rotatory Character of some Terrestrial Magnetic Disturbances at Greenwich and on their Diurnal Distribution" was read by Mr. R. B. Sangster. The Paper commenced with an investigation of the changes in direction of the line of total magnetic force at Greenwich on October, 1903, $12^{d}\cdot 18^{h}\cdot$ to $23^{h}\cdot$ when a considerable magnetic disturbance was in evidence. Measurements of the published registers of all three force components were made at equivalent time intervals of about 5 minutes, whence was obtained a diagram showing the variation of the force component perpendicular to the line of total force. The diagram showed there was an almost wholly rotatory motion of the transverse disturbance vector, the trace consisting of six distinct convolutions varying greatly in size but consistent in anticlockwise progression. Several other disturbances during epoch 1900-07 were examined in detail, and it was shown that a right- or left-handed rotatory character in the motion of the disturbance vector was of fairly frequent occurrence, while change from left to right not uncommonly occurred about midnight. It was also found that the same direction of rotation often persisted for several hours, and tables of the diurnal distribution of right- and left-hand rotatory disturbance were furnished to show that those of right-hand character were entirely absent during the hours 4 p.m. to 9 p.m., while, meantime, the left-handed rotations were very prevalent and reached a notable maximum at 8 p.m. Other points in the diurnal distribution were noted, including the more decided effect resulting from a seasonal grouping of the seventy disturbed days dealt with.

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Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. F. Fernie contributes an article on the subject of Electrolysis by Stray Currents and Its Effect upon Underground Cables.

We give an account of the discussion which followed the reading of Mr. S. G. Brown's Paper on "A New Telephone Relay" before the Institution of Electrical Engineers.

Dr. A. Ebeling recently read a Paper before the Electrotechnischer Verein, on the subject of "Long Interurban Telephone Lines on Pupin's System." We give a translation of this and a short account of the discussion which followed the reading of the Paper.

We give an account of the uses to which electricity is being applied on the Panama Canal.

Sir George S. Gibb is retiring from his close association with the management of the Underground Electric Railways of London in order to take up the position of chairman of the newly-appointed Road Board.

Heckmondwike Council have applied for sanction to a loan of £24,159 for their electricity department.

By the narrow vote of 18 to 17, Hampstead Council have referred back a proposal to substitute electricity for gas lighting throughout the borough, in order to afford the Gas Light & Coke Company an opportunity of fitting up a trial installation of about 20 inverted gas burners "for observation."

At the meeting of the Iron and Steel Institute last week, Mr. W. Borchers read a Paper on the Girod Furnace. We give an abstract of the Paper and the remarks of those speakers who took part in the discussion.

We also give an account of the discussion in connection with the Paper on "Electric Power in the Iron & Steel Industries," read by Mr. Selby Bigge at the same meeting.

An inquiry was held at Colchester last week into the application of the Council for permission to borrow £8,000 for extensions of the electricity undertaking.

Harrogate Council have decided to convert 500 lamps from gas to electricity.

Yarmouth Council are converting 192 gas lamps for electric lighting, and it is estimated that the annual saving will be £76. 6s. 8d. An inquiry was held on Tuesday into the application.

Grimsby Corporation have applied for permission to borrow £2,000 for street lighting.

Companies' Meetings, &c.—The report of the directors of the Calcutta Electric Supply Corpn. states that additional generating plant has been put down at the Ultadangha station of the Company and that negotiations are proceeding for the purchase of a site for a new high-tension generating station.

The directors' report of Callender's Cable & Construction Co. states that the value of the business done during 1909 showed a considerable reduction, compared with all recent years. Arrangements have been made for increasing the Company's business in foreign countries, and the engineering department at the Erith works has been extended.

INSTITUTIONS AND SOCIETIES.

Institution of Electrical Engineers.—On account of the death of His Majesty King Edward, the ordinary general meeting of this Institution, which was to have been held yesterday evening, did not take place.

The Royal Society.—In consequence of the death of His Majesty King Edward, Patron of the Society, no meeting of the Royal Society will be held until further notice.

Royal Institution.—In consequence of the lamented death of His Majesty King Edward (the Patron of the Royal Institution), and out of respect to his memory, the president has decided that the lectures and evening meetings will be discontinued until further notice.

Tramways and Light Railways Association.—Owing to the death of His Majesty King Edward, the Congress of this Association, which was to have been held at Dublin yesterday and to-day, has been postponed.

National Electrical Manufacturers' Association.—We are informed by the Secretary (Mr. F. B. O. Hawes) that some of the tickets for the meeting on Free Trade *versus* Protection, posted to members of the Institution of Electrical Engineers, appear to have gone astray. If any members desire to attend and find they have not received tickets, they are requested to communicate with Mr. Hawes.

Royal Meteorological Society.—In consequence of the death of His Majesty King Edward, the meeting of the Society which had been fixed for Wednesday, May 18th, has been postponed to Wednesday, May 25th.

Incorporated Municipal Electrical Association.—To meet the convenience of those who wish to travel to the meeting of this Association at Glasgow, arrangements have been made by our contemporary, "Electrical Industries," for special saloon carriages to be attached to the 2 p.m. train from Euston to Glasgow on June 13th. This train, which arrives at Glasgow (Central) at 10:20 p.m. will be found most convenient by visitors. It stops at Willesden, Rugby, Crewe, Preston and Carlisle—at all of which stations holders of the special tickets may join the saloon carriages. It is proposed to arrange a programme of entertainments in the train on the journey to Glasgow, and also, if possible, on the return journey on Friday, June 17th. Further, visitors may book hotel accommodation through our contemporary at the Grand Hotel, where a suite of rooms has been reserved. The special inclusive charge for guests so booked will be 5s. for room and breakfast. Applications for railway tickets and hotel accommodation should be sent at once to "Electrical Industries" (Special Train Department), 37-38, Strand, London, W.C.

Electrical Association of Victoria.—The annual meeting of this Association took place on March 17th. Mr. H. R. Harper, the retiring president, said there had been a large increase of members. A motion by Mr. W. J. Mountain that certificates should be issued to members of three or more years' standing was passed. A resolution was carried referring to the council the question of altering the name of the Association. Mr. A. Henrick Jackson, who was elected president, said they all looked forward to the amalgamation of the various electrical associations into one Australian Institute of Electrical Engineers. Mr. Percy Rosling and Mr. J. D. Gillan were elected vice-presidents. Mr. Rosling is also hon. treasurer, and Mr. E. H. W. Westwood is hon. secretary.

Mr. Jackson, in the course of his presidential address, said that in the early days, electrical men were more closely connected with mechanical engineering; now, with the perfection of electrical plant, the application of electrolytic methods to chemical processes, and the speculative researches as to the nature of the atom, the pendulum had swung into the domain of chemistry. He suggested as a subject calling for further attention, the question of the influence of minute quantities of foreign bodies on the capacity and life of secondary cells. Perhaps some of the University Research Fellowships might be dedicated to this end.

Arc Works Engineering Society.—The annual general meeting and conversazione of this Society was held in the Arc Works Club House, Writtle-road, on Friday, April 29th. The report of the committee for the past session showed that the Society was in a thoroughly satisfactory condition. Eighteen meetings have been held during the session at which Papers covering a wide range of subjects have been given by members and friends of the Society. The Society offers premiums for Papers read at its meetings by pupils and apprentices at the Works. The annual general meeting was followed immediately by a conversazione, which was presided over by Col. Crompton, and at which Lord Rayleigh was present. After a short musical programme a Paper on "Aeroplanes" was read by Mr. C. Crompton.

Glasgow Section of the Institution of Electrical Engineers.—At the meeting of this Section held on Tuesday last the following were selected as office bearers for the session 1910-11. *Past Chairmen*, Messrs. F. G. Bailey, W. W. Lackie, E. G. Tidd; *Chairman*, Mr. Sam Mavor; *Vice-Chairman*, Mr. J. A. Robertson; *Chairman of Students' Section*, Mr. H. A. Mavor; *Hon. Secretary and Treasurer*, Mr. J. E. Sayers; *Members of Committee*, Messrs. J. T. Bottomley, J. Ferguson, Magnus Maclean, J. C. Macmillan, Wm. M'Whirter, W. C. Martin, T. B. Murray, T. C. Parsons and Robert Robertson.

ARRANGEMENTS FOR THE WEEK.

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Tuesday, May 17th, "B" Company.—Company Drill, 7 to 9:30 p.m.

Wednesday, May 18th.—Gymnasium, 6 to 9:30 p.m.

Thursday, May 19th, "C" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 8 p.m. Technical Drill, 8:45 to 9:45 p.m.

Friday, May 20th, "D" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7:15 to 8:30 p.m. Technical Drill, 8:45 to 9:45 p.m.

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LONG INTERURBAN TELEPHONE LINES ON PUPIN'S SYSTEM.*

BY DR. A. EBELING.

Summary.—On the grounds of greater efficiency, of absolute reliability and of ultimate economy, long overhead trunk lines for telephone circuits should be replaced by underground cables. Leakance is a factor which cannot always be considered negligible in the calculation of the attenuation coefficient, and it is shown how the actual influence of any given leakance depends on the conductance. An accurate method, available for quite short lengths of core, of measuring the leakance at telephonic frequencies is described, and the figures for definite cores are given. Cable with "loadance" can be manufactured in which leakance is negligible.

The great havoc wrought by the snowstorms of November last in Germany, especially in the environs of Berlin, on the overhead telegraph and telephone wires, gave rise to numerous articles in the daily press in which the question was discussed as to whether it were not possible to obviate by the use of underground cables the disturbance to traffic caused thereby; but the conclusion generally reached was that though long telegraph circuits could be, and for some years past in Germany had been, placed underground, it was not possible to do the like for telephone circuits for efficient commercial traffic. The positive proof is here given that not only is it possible to lay long telephone lines underground which would be more efficient than overhead wires, but even ultimately more economical. This result has been arrived at by the Siemens & Halske A.G. as the result of actual experiments on the loading of cables with inductance on the Pupin system, which has been effected with the most striking results, and the benefits of which have caused its rapid introduction in most countries, especially for the industrial districts of the Lower Rhine and Westphalia, and for cable lines of several hundred kilometre lengths in North America. The special series of experiments here detailed were undertaken in order to clear up apparent differences between the actual observed values of the attenuation coefficient and those given by calculation from the electrical data of the circuit.

The attenuation coefficient determines the efficiency of any telephone circuit, and thus of a "pupinised" circuit, so termed because it differs from an ordinary circuit by the introduction of inductance coils at definite points according to the formulæ of Prof. Pupin. The general formula for the attenuation coefficient per kilometre is given by the expression

$$\beta = \sqrt{\tfrac{1}{2}[\sqrt{(S^2+p^2C^2)(R^2+p^2L^2)}+SR-p^2CL]} \quad . \quad (i.)$$

where $p=2\pi n$, n being the number of periods per second, R and L the effective resistance and inductance of the loop, and S and C the leakance and capacity taken wire to wire per kilometre. In circuits with high inductance, *e.g.*, pupinised conductors, this expression can be simplified and reduced to the form given by Prof. Breisig ("E.T.Z.," 1908, p. 588)

$$\beta = \frac{R}{2}\sqrt{\frac{C}{L}}+\frac{S}{2}\sqrt{\frac{L}{C}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (ii.)$$

L here includes the value per kilometre of the inductance added by the coils. The leakance S is the reciprocal of the apparent insulation resistance and has been generally assumed as negligible seeing that the insulation with direct current, especially in the case of paper cables, is of the order of thousands of megohms; hence if S=0, the two expressions above become respectively

$$\sqrt{\tfrac{1}{2}pC(\sqrt{R^2+p^2L^2}-pL)} \quad . \quad . \quad . \quad . \quad (iii.)$$

and

$$\tfrac{1}{2}R\sqrt{\frac{C}{L}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (iv.)$$

Béla Gáti was the first to announce the fact that ("Measurement of Electrical Resistance," by Barretter, "E.L. and M.B.," 1908, sec. 13) in ordinary paper-insulated telephone cables a very much lower value of insulation obtained for alternating currents at frequencies comprised within the limits of human speech, and in the cables he tested he found that at 2,000 ~ the insulation was about 0·1 megohm or only about one ten-thousandth of the value given by the usual method of direct-current measurement. These measurements were obtained by the alteration in the resistance of a very thin wire, heated by the alternating currents at the frequency in question, observed first on a short piece of the cable, and then on a condenser of the same electrostatic capacity, with a resistance in parallel, adjusted until the current was the same in the two cases. Prof. Breisig has also (*loc. cit.*) directed attention to the effect of this leakance value on the attenuation coefficient in pupinised cables.

While Béla Gáti found a leakance, as above stated, of about 10 micromhos for paper cables, Prof. Breisig by calculation from tests made on a submarine cable, found a leakance of 2·3 to 3·8 micromhos per kilometre. The construction of this cable differed, however, from the normal, in that the copper stranded conductors were close wound with layers of fine iron wire. Attention may be at once drawn to the fact that in the comparatively short pupinised cables laid by the Telegraph Administration, conductors of light section have been employed, and the attenuation coefficient is fairly high, and that in such cases leakance plays but a very small part; but as soon as the problem is entertained of laying long cable lines, heavier conductors will have to be adopted, so as to reduce the attenuation coefficient and that then leakance may play a prominent part.

The following Table I. has been calculated on certain assumed data to exhibit this influence; the values per kilometre being L=0·1 henry, C=0·04 mfd., while the leakance has been taken at 10 and 3 micromhos, as above found in definite instances and also at 1 and 0·5. The resistance of the conductor, including that of the loading coils, is taken at 70 and 10 ohms for the two sets corresponding to conductors of 0·8 and 2 mm. diameter respectively.

Table I.

R, ohms.	L, henry	C, mfd.	S, micromhos.	βR.	βS.	β.	Δ%
70	0·1	0·04	10·0	0·0221	0·0079	0·0300	36
70	0·1	0·04	3·0	0·0221	0·0024	0·0245	11
70	0·1	0·04	1·0	0·0221	0·0008	0·0229	4
70	0·1	0·04	0·5	0·0221	0·0004	0·0225	2
10	0·1	0·04	10·0	0·0032	0·0079	0·0111	247
10	0·1	0·04	3·0	..	0·0024	0·0056	75
10	0·1	0·04	1·0	..	0·0008	0·0040	25
10	0·1	0·04	0·5	..	0·0004	0·0036	12

The column headed βR gives the value calculated from the first member of formula (ii.) when leakance would be neglected, βS that calculated from the second member of that formula, the next column contains the sum of these two, and therefore the true value, while the last gives the percentage difference due to βS. With the resistance of 70 ohms it is only the 10 micromhos leakance that introduces any considerable alteration, while on the other hand, with the resistance of 10 ohms, it is only the leakance of 0·5 that is of negligible import. The values here assumed were chosen intentionally, so as to exhibit the subject in a convincing manner, but with the lower resistance the influence of leakance would be lessened by reducing the inductance, as shown by Lüschen ("On the Effective Leakance of Telephone Cables, and the Effective Time Constant of Pupin Coils," "E.T.Z.," 1908, p. 1105), in special cases. By the choice of suitable coils some decrease in the βS term can be secured without great increase in βR. Prof. Breisig's figure of about 3 micromhos agreed satisfactorily with the values deduced by other measurements from the attenuation coefficient on some lengths of cable, but this was an exceptionally high figure, and we believe that for paper cables in general their leakance may be taken as very small, even if not completely neglected. There remains the further hypothesis that even if the leakance be negligible, and differences between the calculated and observed values of the attenuation still exist, such may be ascribed to some unknown losses in the coils themselves; so that investigation of their leakance was also necessary. It was clearly obligatory to find some reliable method of directly measuring the leakance itself, even when its amount was very small.

*A Paper read before the Electrotechnisches Verein. Translation communicated by the author. "E.T.Z.," 1910, p. 420.

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The solution of this problem was found by Dr. Adolph Franke and is based on the method and form of apparatus described in detail by him in his thesis for the Doctor's degree, published in 1891. (A. Franke, "The Propagation of Electricity in Telephone Conductors and Apparatus," "E.T.Z.," 1891, p. 447.) This Paper contains a full description of a special form of high-frequency alternate-current machine, which he, being at that time in the service of the Government Telegraphs, had had constructed at their instance and with which he conducted a full series of measurements on the electrical constants of telephone lines and apparatus. The same machine and methods have also been employed by Dr. Breisig in his valuable researches.

In the course of his general treatment of the subject, Dr. Franke states the following simple equation as applicable to circuits if of no great length,

$$I/V = Sx + i2\pi nCx. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (v.)$$

where I and V are the current and voltage at the beginning of a line insulated at the far end, S the leakance, C the capacity (both per unit length), n the frequency and x the length of the circuit.

Introduce into the circuit of the alternating current in series with C_2 the short length of twin insulated conductor with the other ends free, an adjustable condenser C_1, which has no measurable leakance, and adjust the capacity until the voltage across its terminals is the same as across the cable. Then at the terminals of the condenser

$$I/V_1 = i2\pi nC_1. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (vi.)$$

and of the cable

$$I/V_2 = S + i2\pi nC_2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (vii.)$$

where S and C_2 are the values for the length under test, the current I being the same in both.

Hence $$\frac{V_1}{V_2} = \frac{S + i2\pi nC_2}{i2\pi nC_1} = \frac{S}{i2\pi nC_1} + \frac{C_2}{C_1};$$

but with voltage of true sine curves,

$$V_1 = Ke^{i2\pi nt},$$

and $$V_2 = Ke^{(i2\pi nt + \alpha)};$$

Hence $$\frac{V_1}{V_2} = e^{-\alpha} = \cos\alpha - i\sin\alpha = \frac{C_2}{C_1} + \frac{S}{i2\pi nC_1},$$

and therefore $\cos\alpha = 1 = \frac{C_2}{C_1}$ and $\sin\alpha = \alpha = \frac{S}{2\pi nC_1}$,

where α, the phase difference between the voltages at the condenser and cable terminals, is a very small angle, and therefore

$$S = \alpha 2\pi nC_1. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (viii.)$$

The angle α is usually of the order of a few minutes of arc, and as the original machine did not allow of measuring such a small angle within the requisite limits of accuracy, a special one was constructed with the necessary modifications so as to allow of a finer reading being taken, the details being worked out under the assiduous attention of Mr. A. Becker. The figure for the leakance on long lines deduced by the indirect method of measurements conducted by the Testing Department of the Telegraph Administration were not rendered any more accurate by the use of this modified machine.

From the value of S for the length of cable tested, the value per kilometre is given by simple proportion, and the angle α is a constant for any short length of the same type of cable. Thus, with one type of cable the angle α was measured at 12′ to 13′ when the length of cable was increased from 75 to 150 metres, and in all our measurements these are approximately the limits of the lengths that were tested.

As the angle α was also found to be constant for different frequencies, the actual value depending on the nature of the core tested, it appears that the leakance is directly proportional to the frequency. The accuracy of this method was fully confirmed by testing a condenser in parallel with a known constant resistance, as S and C being both constant quantities, α would vary inversely as the frequency. Table II. gives the results of the measured and calculated values for a condenser

Table II.

n.	α	
	Measured.	Calculated.
512	25′	26·8
640	20′	21·8
896	13′	15·3
1,100	12′	12·5

of 0·00605 mfd. in parallel with an alcohol resistance of 6·6 megohms.

The agreement between these figures is satisfactory as the limit of error in the measurement of the angle was about 2′.

In the case of the cable which was used for the most important experiments, and which was specially adapted for the Pupin system of loading, the leakance per kilometre at 900 ∿ was 0·45 micromho, the variation in separate conductors being less than 4 per cent. In two gutta-percha-insulated cores which happened to be available, but not of usual submarine cable dimensions, immersed in salt water, the leakance per kilometre at 900 ∿ was 9·3 and 10·6 micromhos respectively, which agrees with the value found by Prof. Breisig on a gutta-percha cable having cores with continuous inductance, where the increase of leakance with periodicity is noticeable, but in whose figures for paper cable no such alteration appears.

Our tests, however, of paper cores with conductors of 1·5 mm. diameter show a maximum leakance per kilometre of 0·74 micromho at 900 ∿. Numerous tests were made on various types of cables and conductors, which give promise of great interest as to the nature of leakance, but the account of these must be reserved for a future occasion. This same method can also be applied to the testing of the inductance coils themselves, as they may be treated as conductors with evenly distributed capacity. One type of coil, inductance 0·2 henry, gave a leakance of between 0·036 and 0·04 micromho while in another type of the same inductance 0·21 to 0·28 micromho was found; both of which types have been used in the loading of cables recently laid, and may be taken as of normal manufacture, so that a very small leakance is evidently obtainable in such coils. Being now in possession of all the necessary data for the leakance of cable and coils, it was possible to check the agreement between theory and practice for Pupin's formula by actual measurement, introducing the correction, of course, of his sine rule which gives the relation between the values obtained on circuits containing continuous and spaced inductance. For this purpose it was necessary that the measurements of the attenuation coefficient should be accurately effected, and though the method used by the Experiment Department of the German Telegraphs was available, and which we need not now describe, it labours under the disadvantage of requiring long and tedious calculations from the figures given by the readings, and for our ends a method, if equally reliable, was desirable, which would allow a speedy calculation, because, as may be imagined, a very long series of tests had to be made, before reaching the simple results ultimately attained.

Had it not been possible to measure the leakance itself directly, then any difference between calculation and observation could be ascribed to some variation in such leakance, and in spite of many special experiments, the conclusion had been arrived at, that an accurate value of the leakance was not obtainable by the indirect method previously stated, as so many different factors entered simultaneously into the question, now cleared up by the independent measurement of the leakance. A simple method of determining the attenuation coefficient is afforded by the measurement of the current at the near and far ends of a circuit, provided it be of sufficient length. Most of the readings were taken by oscillographs which recorded simultaneously the curves of the two currents, from the amplitude of which the intensities could be determined. By the equation $I/I_b = 2e^{-\beta l}$, where these are the currents at the beginning and end of the line of length l, the value of β is readily calculated. The length of line was usually about 100 km., and the results given by this method and that of the Government Department were in thorough

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concordance, if the line was of the sufficient length as above stated. Tests were also made with the Franke instrument, by measuring the voltage at the terminals of inductionless resistances interposed at the two ends of the line and thereby determining the two currents; this method had the disadvantage of introducing high resistances into the circuit as compared with the extremely small resistance of the oscillograph; but both methods gave equally concordant and sufficiently reliable results. The main series of tests were made on a 10-pair paper-insulated cable with 0·8 mm. conductors, which was available in separate equal lengths of 1,300 metres, so that an even distribution of the inductance coils, *i.e.*, at 1,300 metres apart, was obtained, and the frequency generally was 900, which may be taken as representing the mean tone of the human voice, but measurements were made at other periodicities also, and in Table III., are contained the values obtained at 500, 900 and 1,200 ∿, at which observations could be made with the greatest accuracy, and which cover all practical requirements. This table gives the frequency and the mean values of the effective resistance, inductance, capacity, and leakance all measured for a length of 1 km. of the twin core, taking into account the separate values for cable and coils; the attenuation coefficient βR, if only the first member of formula (ii.) is used, and which may be considered the ideal value of β; then βP, which includes the increase due to Pupin's sine rule, and then βQ, taking into account all the factors, including leakance, and which is the correct value given by calculation; the last column βM gives the values found by actual measurement. The agreement between these last two columns is extremely close.

Table III.

n.	R, ohms.	L, henry.	C, mfd.	S, micro-mho.	βR.	βP.	βQ.	βM.	
								A.	B.
500	71·4	0·154	0·0308	0·27	0·0160	0·0160	0·0163	0·0162	0·0162
900	74·0	..	..	0·48	0·0166	0·0167	0·0173	0·0177	0·0173
1,200	76·7	..	..	0·64	0·0172	0·0175	0·0182	0·0187	0·0184

Table IV.

n.	β			Micromhos.			
	2	3	4	5	6	7	8
500	0·0168	0·0169	0·0172	0·35	0·33	0·07	0·28
900	0·0172	0·0175	0·0180	0·59	0·59	0·13	0·46
1,200	0·0179	0·0186	0·0194	0·94	0·84	0·24	0·70

The figures under A and B are for cables equipped with coils of similar form but of slightly different construction, the leakance of which was very small and, in fact, equal to that of the first type of coil previously mentioned, *i.e.*, about 0·04 micromho. Under B are given the mean values of observations made on several days both by oscillograph and Franke's machine, and under A the results of one set of observations alone, and in this case also the difference between calculation and measurement is extremely slight. The difference between βQ and βP reveals the effect of leakance and varies for the periodicities given between 2 per cent. and 4 per cent.; but, as already stated, leakance would play a much more conspicuous part in a cable with heavier conductors. On referring back to Table I., it is seen that the leakance here measured corresponds to about the value of 0·5 micromho, and is thus of little moment; and even with the leakance of 1 micromho, the increase in attenuation could, as already mentioned, be counteracted to some extent by a reduction of the inductance. This treatment of the question, where high leakance obtains, has been considered by Lüschen (*loc. cit.*) and by Devaux-Charbonnel ("Etudes sur les Lignes Télégraphiques," "La Lumiére Electrique," 1909, 327), but with paper cables this difficulty does not enter, as it is possible in their case to secure very small leakance. Other measurements were made on a cable actually in work, with conductors of 0·9 mm., the leakance of which had not been measured before the cable was laid, and Table IV., column 2, contains the values of β, given by calculation from the electrical data, omitting both Pupin's sine rule correction and the leakance; column 3 gives the figures corrected for the former omission, and column 4 the actual measured value, and, by application of formula (ii.), it is easy to determine the leakance, which is, of course, the sum of that of cable and coils, and these are set out in the other columns, 4 giving the value thus calculated, 5 the same under the assumption that the leakance is proportional to the periodicity, and taking 0·59 at 900 ∿ as the basis. The coils were of similar construction to type 2, above mentioned, with a leakance of 0·25 micromho at 900 ∿, and the value per kilometre is given in column 7, while the difference, column 8, gives the leakance of the cable alone, which is shown to be very small and at the same time to be in concord with the actual values, obtained on the experimental cable, given in Table III.; but this is not remarkable, as these cables were of the same special construction, though these extremely close values are no doubt partly fortuitous. The results of our experimental research may therefore be stated shortly as follows:—

1. Cable loaded on Pupin's system gives results absolutely in accordance with theory.

2. Cables manufactured by the Siemens & Halske, A.G. specially for the application of this system, have such low values of leakance that its influence on the attenuation coefficient is negligible.

3. A short length of cable is sufficient for the accurate measurement of the actual leakance.

4. A negligible leakance in the inductance coils can also be secured.

We are, therefore, in possession of data, the gaining of which, however, was no mean labour, which furnish us with the means of giving a definite decision as to the length of cable which it is possible at the present time to work loaded on the Pupin system.

Adopting the electrical values which we have now at hand for calculating the attenuation coefficient, we are in a position to state that with coils of the best form, and cable properly constructed, efficient working can be secured on trunk lines of 1,000 km. in length without a greater diameter of the conductors than 3 mm. All important trunk lines in Germany would be shorter than this.

It must be remembered that this conclusion is due to the fact that circuits composed of cable alone can be worked with a less volume of sound than overhead circuits, because the latter, liable as they are to great changes in insulation, never afford the efficiency theoretically allowed, and are also much more subject to external disturbances, so that heavier conductors must be employed than would be otherwise necessary; while in a cable this extra reserve of power is not required, because the efficiency once established is always the same. Special experiments conducted by the Siemens & Halske A.G. have shown that for long telephone lines a value of βl between 3·5 and 4 is not too great. This product of attenuation coefficient and length, first introduced by Prof. Breisig as the efficiency factor, and termed by him the "attenuation exponent," gives a clear picture of the value of any circuit in a simple form. An increase in the size of conductor will in general secure with an increase of the length the same value of βl. It was a simple matter, therefore, to arrange different values of βl in the testing room where 300 km. of 0·8 conductor cable was available; on which, loaded with inductance coils, a value of βl up to about 6·5 was attained, at which figure the volume of sound was extremely low but the articulation still clear.

Experiments were also instituted, with the co-operation of the telegraph authorities, on lines under actual traffic conditions, which showed that the attenuation was but slightly affected by the interconnections at the different exchanges.

Though we have shown that, on technical grounds, no difficulty can be urged against the laying of long telephone cables, the question has still to be considered in its economic aspect, and a complete answer can be furnished only by the Telegraph Administration who have ready at their disposal all the requisite data. We can, however, arrive at some

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approximate idea, at any rate applying to long trunk cables where the number of circuits to be provided is not too restricted, *i.e.*, for interconnection of important towns between which considerable business is carried on. As such towns will, however, be served by a certain number of overhead lines already in existence, it will not be possible to replace them by cables with an actual saving of expense, so that we can limit the question merely to the case either of the number of circuits being so great that difficulty is experienced in adding any more, or to that of the advantages accruing from the use of underground cables as being of sufficient weight to warrant this extra first cost, and of this extra cost being recouped in future years.

The advantages afforded by the cable circuits may be stated as follows :—

1. The efficiency of communication once secured is always the same, barring actual faults, which, of course, occur very seldom.
2. Cross talk is effectively eliminated.
3. No interruption is occasioned due to disturbance from external causes.
4. No anxiety is felt as to the cost of repairs due to snow-storms, &c., nor as to interruption of traffic caused thereby.
5. The maintenance of the cables is a much smaller item than that of overhead lines.
6. On laying the cables, a certain number of spare wires can easily be provided, which will allow for the easy development of the trunk communications.
7. The reliability and rapidity of communication gains the confidence of the public, and the use of the telephone thereby extended warrants the introduction of such reserve circuits.
8. By the sale of the bronze overhead wires, which at the present time command a high price, the expense can be considerably reduced.

Even putting on one side the reliability and excellence of communication, which take first rank in the appreciation of the public, and also the introduction of spare wires, which would entail some little extra expense, we still have the actual items of reduced maintenance which in the course of the life of the cable would be considerable. A definite figure on this point is available from the Paper communicated by Major O'Meara, engineer-in-chief of the British Postal Telegraphs, to the Congress at Budapest (K. Strecker, International Congress of Telegraph Engineers at Budapest, 1908, "E.T.Z.," 1909, p. 127), according to which the maintenance of an overhead wire amounts to 2·9 marks or, say, 3 marks per annum per kilometre more than for a wire in an underground cable; while as regards reserve wires we should be able, by adopting, as has been the practice for some time in England, the Dieselhorst-Martin type of cable, to limit considerably the actual number of reserve wires, since independently in addition to the single pairs, 50 per cent. of reserve is provided owing to its special construction, as in this type the well-known combination of two metallic circuits to form a third metallic circuit is available, the possibility of which in overhead circuits is negatived by the variable and low state of their insulation, while in ordinary underground cables this combination is, owing to cross talk, rendered impossible.

The special pupinisation of these extra circuits can also be effected only as they come into use, *i.e.*, as the circuits become fully occupied.

That the cost of the telephone cables will not be inordinately high the following instance will show. Assume a line 500 km. long (about the mean length of important trunks in Germany), and that the route is already supplied by 14 circuits of 4 mm. overhead bronze wires, a cable of 28 pairs will be adopted, as it is a certainty that the number of circuits would soon have to be increased. The cost of such a cable, including the laying and equipping with Pupin coils, will be about 10,000 marks per kilometre, or, say, a total of 5 million marks. By the sale of the bronze wires about 2 million marks could be recouped, less the cost of removal, which shows the comparatively high value of the break up cost of this wire; and thus a total first cost of about 3 million marks would be entailed. The annual saving of cost in the maintenance of this cable would, according to the figure given above, amount to 84,000 marks, as compared with an equal number of overhead circuits, which represents a considerable interest on the capital; but if the gain in increase of receipts due to the reliability, security and rapid development of traffic be taken into account, and it be remembered that cables as now constructed are very long lived, and the sinking fund for their renewal correspondingly low, the conclusion may safely be drawn that the laying of important telephone cables is to be advocated on economical grounds.

The length of important trunks in Germany would reach a total of about 4,000 km., which, for 28 pair cable, would represent a total outlay of 50 million marks, reducible to 30 million marks by the sale of the existing bronze wires. But if the decision be taken to place all the important conductors underground, the telegraph lines would also come into this category, and with this in view, there would be no hesitation at the present day in inserting them into the same cables with the telephone wires, without any fear of inter-disturbance; this is proved by the long lengths of such combination cables now laid in England; though naturally, if the number of conductors of each class is sufficient, separate cables could be laid.

The question has been confined solely to cables loaded on the Pupin system, *i.e.*, with inductance added at distributed points, as cables with continuous self-induction are practically ruled out, owing to the lengths required, as well as on economical grounds.

As to the efficiency of such cables, a clearer view is also now presentable as a consequence of the results above given for their leakance; we hope to return to this subject in the future.

At any rate, we think we have proved that no hindrance now exists to the placing in cables of all important trunk telephone lines in Germany, and thus freeing our telephonic communications from all uncertainty and disturbance, which in the towns themselves has been already secured by the networks of underground cables which are everywhere replacing the overhead wires.

DISCUSSION.

Prof. BREISIG was the only one who made any remarks at the reading of the above Paper, and these may be summarised as follows :—

The author states that for the 1,000 km. lines he adopts an attenuation length of 3·5 to 4. Our trunk lines in Germany have only 1·5 to 3. With the former figure communication is carried on as if, so to say, the subscribers were in adjoining rooms, and is afforded by such lines as Berlin–Cologne or Berlin–Hamburg, and the latter obtains for longer lines, such as to Copenhagen, in which the volume of sound is very different from that of the former, and careful attention is required. The experiments made at "Wernerwerk" certainly gave good communication with $\beta l = 3{\cdot}5$, and even fair with $\beta l = 4$, but this was between skilled employés, and would not be sufficient for the general public, and if attenuation lengths of 3·5 to 4 were adopted instead of the present values of 2 to 3 as the limit, protest on protest would be received from the telephone subscribers. The mode of representing the attenuation coefficient given by Campbell in his Paper on "Loaded Telephone Circuits," communicated to the "Phil. Mag." in 1903, a Paper which, by the way, deserves to be more widely known than it appears to be, gives the clearest view as to the effect of leakance, and is $\beta = \frac{R}{2}\sqrt{\frac{K}{L}}\left(1 + \frac{S}{K}\cdot\frac{L}{R}\right)$ (misprinted in the "E.T.Z."). The proper division of cost between that of coils and core separately, in order to procure a cable of given attenuation length at the lowest cost, is a question still remaining for consideration. In the test with the oscillograph, the reflected current wave, which, in the simple formula used for determining βl by the ratio of the sent and received currents, is neglected, was still about 2 per cent. of the direct wave, and therefore of the same order of magnitude as the differences due to leakance shown in Table III., so that it is hardly conceivable that the results of observation can be taken as confirming calculation, especially as the received current also was only a small percentage of that sent. On the question of the inferiority of overhead lines, special experiments have been made by comparing long trunk lines with standard artificial cable, and the results showed that an addition of 0·5 to the attenuation length was sufficient to allow for the disturbance arising from external causes. For the line Berlin–Paris, 1,100 km. in length, the attenuation length is 2·2, which contains ample allowance for leakance over the calculated value. No doubt, however, can now exist as to the benefits to be derived from the pupinisation of U.G. cables.

Dr. EBELING, in reply, agreed that the oscillograph tests showed merely that no discrepancy could now be detected between observed and calculated results, and stated that further experiments would be put in hand with cables containing heavier conductors, for which the more accurate methods of testing, as used by the telegraph department, would be employed.

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COMMUTATION PHENOMENA AND MAGNETIC OSCILLATIONS OCCURRING IN DIRECT-CURRENT MACHINES.*

BY G. W. WORRALL, M.SC.

Summary.—In the first part of this Paper the author, after discussing the theory of commutation, describes a research on the influence of contact resistance, speed, commutating E.M.F. and width of commutating pole on commutation, the phenomena being studied by means of the magnetic oscillations recorded by search coils on the pole shoes. The cause of the difference in behaviour of the positive and negative brushes is also investigated. The latter portion of the Paper is devoted to an examination of the magnetic oscillations occurring in various parts of the machine.

The experiments described in this Paper were undertaken as an extension to direct-current machinery of the investigations upon alternators which the author had previously been engaged upon.†

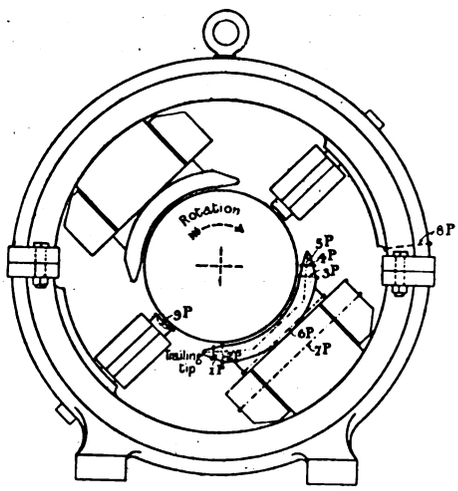

FIG. 1.—DIAGRAM OF MACHINE AND POSITION OF COILS ON POLES.

The magnetic oscillations were observed by means of E.M.F.s induced in search coils placed on the machine parts in such positions as to link the oscillating flux. The E.M.F. waves were photographically recorded by means of a Duddell high-frequency oscillograph and revolving drum camera. The machine employed in the investigation was a two-pole generator with adjustable commutating poles; the brushes were of carbon and of a width equal to one commutator segment plus insulation.

The principal details and conditions of running of the machine, of which a diagram is shown in Fig. 1, are given in the Paper. Search coils were placed on the pole system and armature as shown in Figs. 1 and 2. The analysis of the oscillations recorded was only

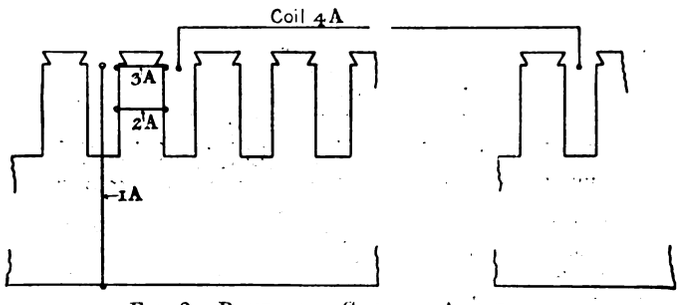

FIG. 2.—POSITION OF COILS ON ARMATURE.

possible by the accurate knowledge of the position of the armature corresponding to a point on the oscillograph record. This was obtained by means of a contact maker placed on the shaft of the machine and connected up to the oscillograph in the way devised by the author for the previous researches. During the instant of contact the oscillograph was shunted by a small accumulator, thereby producing a momentary current and hence an isolated peak in the record which was being taken. This peak corresponded to a predetermined position of the armature.

The contact maker employed was described by Arnold in "Die Gleichstrommaschine," Vol. I., and as no description appears to have been published in England a translation is, with the kind permission of Prof. Arnold, given below: "The construction of the contact maker is shown in Fig. 3. The contact is not of the rubbing type but of the pressure type, and the duration of contact is so short that the apparatus works well even with alternating current of high frequency. The apparatus consists of a contact disc, S, rigidly coupled to the machine shaft, a graduated disc, T, and a movable ebonite piece, G. On G are mounted, insulated from each other, the two contact springs f_1 and f_3 and the opposing springs f_2 and f_4. On S is mounted a raised steel piece n_1. G is rotated to any desired position relative to n_1 and clamped by the screw s. The finger z serves to read the position of G. The current circuit through the conductors a and b is closed once in each revolution when n_1 comes under f_1; f_1 is thereby raised until it comes into contact with the contact surface k_1 of the spring f_3. But the contact continues only for an instant, for in the next instant the springs f_1 and f_3 are together raised and break the contact at K_2 on which f_3 rests. In order that contact shall not be made again after n_1 has passed, there is a second piece, n_2, displaced axially and radially to n_1 which raises f_1 and holds it up until f_1 returns to its original position. The contact maker was devised by G. Schade, mechanic of the Electrotechnical Institute at Karlsruhe. The Physical-mechanical Institute of Dr. Th. Edelmann, at Munich, has undertaken its manufacture." The contact maker was found to be absolutely certain and accurate; the duration of contact was, at the normal speed of the machine, considerably less than $\frac{1}{10000}$ second.

The magnetic oscillations occurring are due to two main causes: (1) Movement of the armature teeth in the magnetic field; (2) commutation of the armature current in the short-circuited coil. The first class of oscillation was fully dealt with in the previous Papers on alternators, and the results then obtained apply equally to direct-current machines. The oscillations of the second class were found to be far more important, and in most parts of the machine greater

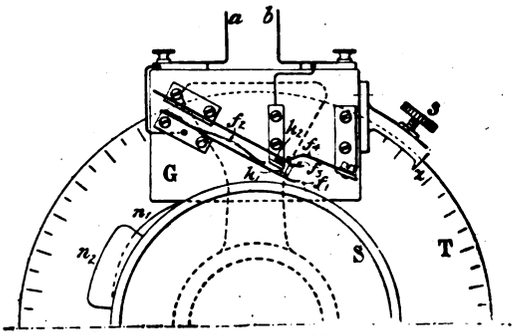

FIG. 3.—CONTACT MAKER.

in magnitude than those of the first class. These oscillations were due to the change of current in the short-circuited coils, and since there were two such coils there were two sets of oscillations, which were displaced relatively to each other 180 deg. owing to the number of commutator segments being odd (45). Although the currents in the two coils changed in relatively opposite directions, the position of one coil was the reverse of that of the other and hence the magnetic oscillations produced were in the same direction. Thus the number of oscillations occurring in a revolution of the machine was twice that of the commutator segments. The coil at the instant of short-circuit was opposite to a pole-piece and linked the main flux, hence the magnetic oscillation caused a pulsation in the main magnetid circuit which could be readily observed by means of the search coil 5 P wrapped round the pole-shoe. Since the flux at each instant is proportional to the current in the short-circuited coil, the E.M.F. induced in a search coil linking the flux forms a picture of the commutation taking place.

The usual method of commutation research is to measure the short-circuit current directly by means of a resistance inserted in an armature coil, but this method only gives results for two adjacent segments and the coil between them, and gives no indication of the nature of the commutation taking place at other points of the commutator. Such results are liable to be very misleading, due to the brush not making uniform contact. The method here adopted is free from all such objections, and by its means many interesting and important phenomena have been brought to light.

COMMUTATION PHENOMENA.

Theory of Commutation.—The theory of commutation has been the subject of very considerable discussion in recent years. On the one side it is stated that commutation should take place in a neutral field, while on the other it is stated that commutation should take

* Abstract of a Paper read before the Birmingham local section of the Institution of Electrical Engineers.

†*Journal*, I.E.E., Vols. XXXVII., XXXIX., XL.

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place in a commutating field. The author shows that both lines of reasoning lead to the same result (that the direction of the resultant perpendicular velocity of the coil side coincides with the direction of action of the resultant field), and the apparent diversity of opinion is merely due to different methods of expression. These conditions for good commutation cannot hold in practice during the whole of the commutation period, but only during the final instant. It is, however, generally possible to obtain satisfactory commutation without compensating or rendering non-existent the self-induction E.M.F. of the coil. This may be effected by a proper choice and disposition of the contact resistance of the brush.

The author obtains an equation for the necessary variation of the contact surface over the rear segment, and Fig. 4 shows the shape of the brush surface to comply with the equation. The shape of brush obtained in this way, although not in itself practicable, points the way to the proper disposition of the resistance over the contact surface to obtain approximately straight-line commutation. The resistance of the contact surface over the rear segment must be very low compared with that over the forward segment, and this relation must hold not merely at the end of the period but quite early in the period. This disposition of the resistance may be approximated to by cutting away a portion of the surface of an ordinary brush as shown in Fig. 5. In this way the resistance to the forward segment is made high before, say, one-half of the short-circuit period has expired. The direct effect of such a disposition of the contact resistance is that the P.D. forcing the current to change is made high during the early portion of the short-circuit period, and hence the commutation is accelerated at the beginning instead of at the end of the period. This prevents a rush of current at the final instant, and renders the current change much smoother. The magnitude and disposition of the contact resistance and the self-induction of the coil determine what may be called the natural period of commutation, while the mechanical design and speed of the machine determine the available period.

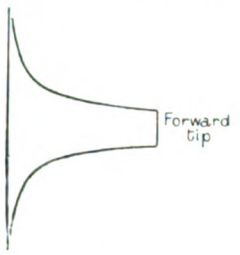

Fig. 4.

The natural period may be defined as the time required for the current to commutate under the conditions existing in the circuit of the coil, while the available period is the duration of the short-circuit.

Although theoretically the current would always occupy the whole of

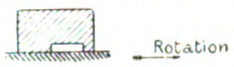

Fig. 5.

the available period in commutating, practically the current would reach a value closely approximating to its final value in a certain definite time which may be less than the available period. The available period in a given machine is proportional to the speed, but the natural period was found to be but slightly influenced thereby. The relation which the one period bears to the other, and the actual magnitude of the natural period, determine the efficiency of commutation. By efficiency is meant not merely whether the commutation is sparkless or not, but whether the commutation takes place with the maximum rate of change of current at its lowest possible value. The simplest way of varying this relationship is by varying the speed of the machine. Hence there is a certain critical speed below which the machine is sparkless and above which sparking takes place. When the conditions are such that the natural period cannot be adjusted sufficiently to obtain efficient commutation, an external or commutating E.M.F. must be introduced into the circuit. If the commutating E.M.F. be provided by means of commutating poles, the presence of the latter considerably increases the self-induction of the coil and the flux due to armature reaction in the commutating zone. The latter must be opposed by an equal flux from the commutating poles before any commutating E.M.F. is generated in the short-circuited coils.

So far nothing has been said with regard to the polarity of the brush, and indeed it is usual not only in theory but in actual experimental work to pay no regard to this point. But it is well known that the contact resistance of the positive brush is different from that of the negative brush. In fact, it is quite possible, as indeed was found in this research, for an alteration of the conditions which improves the commutation under the negative brush seriously to deteriorate the commutation under the positive brush. Thus, for example, the slit cut in the brush, as in Fig. 5, may improve the commutation under the negative brush, but may render the commutation under the positive brush much worse.

The above theoretical considerations may be summarised as follows: (1) In order to neutralise or render non-existent the self-induction E.M.F. of a coil at any instant the relative movement of the field and coil side must take place along the line of action of the resultant field at that instant. (2) Efficient commutation may be effected by a suitable adjustment of the natural period of the coil, and this may be done by properly disposing the contact resistance over the brush surface. (3) When the contact resistance is properly disposed the resistance to the forward segment is relatively high at an early stage of the commutation period. (4) Sparking at the forward tip of the brush is due to the available period being shorter than the natural period. (5) For every machine there is a critical speed at which the available and natural periods are just equal to each other, and below which the machine runs sparklessly. (6) A reduction of the natural period accelerates commutation during the early part of the short-circuit period, and increases the efficiency of commutation by lowering the maximum rate of change of the current, thereby causing a better distribution of current over the contact surface accompanied by a reduction of temperature. (7) The acceleration may be effected by a commutating E.M.F. If the natural period exceed the available period and the commutating E.M.F. be too small, sparking takes place at the forward tip of the brush, and if the commutating E.M.F. be gradually increased the commutation is shifted backwards until sparking takes place at the rear tip of the brush. (8) The natural period of the coil when short-circuited by the positive brush is not necessarily the same as when short-circuited by the negative brush.

Brush-holder.—In the early stages of the research it was found that the commutation was exceedingly irregular. It was thought that these irregularities were mainly due to mechanical defects of the brush-holder, and as the work proceeded this view was fully confirmed. Several types of brush-holder were tried, including the finger and reaction types, but with all these the contact surface was by no means constant. This was found to be due to a variable coefficient

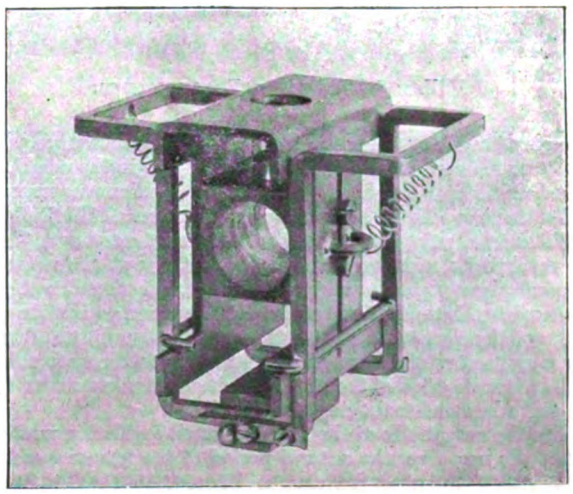

Fig. 6.—New Type of Brush-holder.

of friction between the carbon and the commutator surface, and to slight differences in the commutator surface. The incapability of the brush to adjust itself automatically to such varying conditions caused the commutation to be very uncertain in its nature. The author had the opportunity of examining some of the most modern brush-holders in actual use, and found that in all these the same difficulties existed, that the contact surface was not certain, and that the contact pressure was not uniformly distributed. A very common evidence of this is that the surface, when newly rubbed up with emery paper and allowed to polish by running the machine, polishes up first at the rear tip owing to the tipping effect of the friction.

A new brush-holder (*see* Figs. 6 and 7) was designed and constructed entirely free from these objections, and was used in all the experiments described in this Paper. The holder consists of a carrier, A, mounted on the brush bar, and clamped thereon by the screw B. A double plate, C, is mounted and capable of sliding on the carrier A, and is guided in its motion by a stud working in the slot D, and can be clamped in any position by the screw E. Two metal frames, F_1 and F_2, are held against this plate by the springs G_1 and G_2, respectively, in the positions shown. Their lower ends are formed into half-bearings, which press on to the axis H, upon which the carbon is mounted. The carbon is free to rotate upon the axis H, and is prevented from moving with the commutator by the tangential force exerted by one of the frames, F; one frame corresponds to each direction of rotation, and is inoperative in this respect when the rotation is reversed. Either end of the brush axis is free to lift independently of the other end. Hence the brush is free to adjust its position to any change in the commutator surface radially, circumferentially,

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and laterally. When this brush-holder was in use the surface of the carbon was always uniform, and the commutation remained always the same, even if the brush were removed and then replaced.

Experimental Results.—The commutation phenomena already theroretically considered were experimentally studied by means of the magnetic oscillations recorded in coil 5 P on the pole shoe. The oscillations recorded were due both to the movement of the teeth in the main magnetic field and to the commutation of the armature current; but, as will be seen from Fig. 8, the two kinds of oscillations were easily distinguished from each other. Thus A shows the tooth oscillations alone as recorded on open circuit, and B the oscillations recorded on full load. C and D are records obtained by running the machine as a generator with full-load resistance in circuit, but with only one commutator brush down, the circuit being completed through a slip-ring connected to a point in the armature. In these two latter records, when the tapping point was in the neighbourhood of the commutator brush, only the tooth oscillation was recorded, and as the tapping-point rotated the commutation oscillation appeared until when the point was opposite the commutator brush the oscillation reached its maximum value. Thus C shows the magnitude of the oscillation due to the negative brush, and D that due to the positive brush. The magnitude of the positive brush oscillation was very much smaller than that due to the negative brush, not due to any lack of symmetry of the magnetic system, but entirely to a difference in the natural period of the short-circuited coil when under the positive and when under the negative brush.

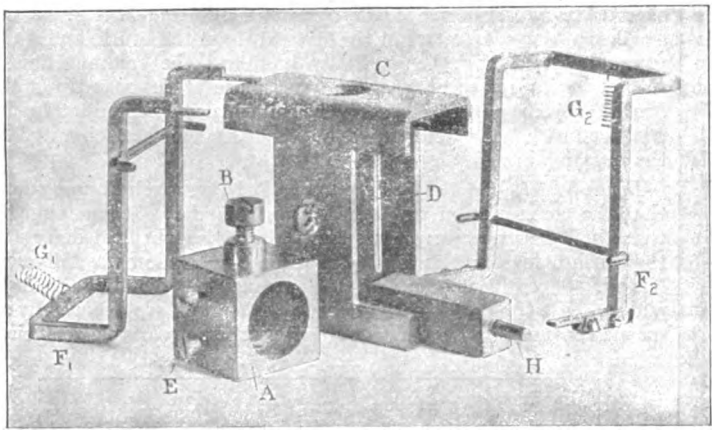

Fig. 7.—Parts of Brush-Holder.

Since the magnitude of the positive brush oscillation was less than that of the negative, the natural period of the former was less than

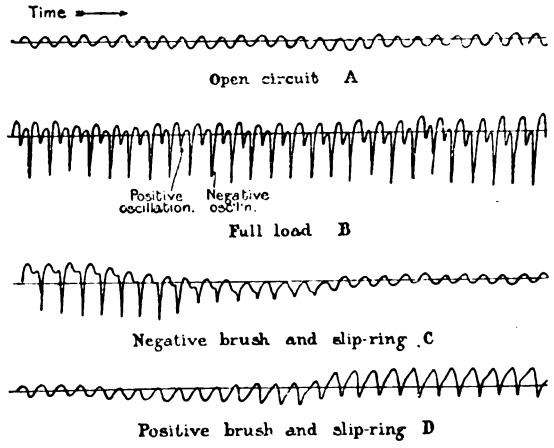

Fig. 8.

that of the latter, and since it may be assumed that the self-induction in the two cases is the same, it follows that the contact resistance of the brush when positive was higher than when negative. This result agrees with those obtained by Arnold and others.

The commutation oscillation consists of a single peak; the magnitude of the peak is proportional to the maximum rate of change of the current in the short-circuited coil and its magnitude and position in relation to the contact maker indicates the nature of commutation taking place. When the peak is small and occurs early, the commutation is efficient; but when the peak is large and occurs late in the period, the commutation is completed by a rush of current and sparking is liable to take place.

The resultant oscillation in a given machine may have eight different shapes. The shape is determined by three factors—*i.e.*, direction of rotation, direction of current and direction of field. Fig. 9 shows the various shapes of oscillations obtained, and the circles to the right of the figure show the relations of the three factors referred to. The curved arrow indicates the direction of rotation, the horizontal arrow that of the current and the vertical arrow that of the field. If the commutation oscillation peak occurred exactly at the middle of the period, record G would approximately correspond to A, record H to B, record E to C, and record F to D, and there would only be four varieties of resultant oscillation. The movement of the peaks to the left can be very clearly seen by comparing the records as above.

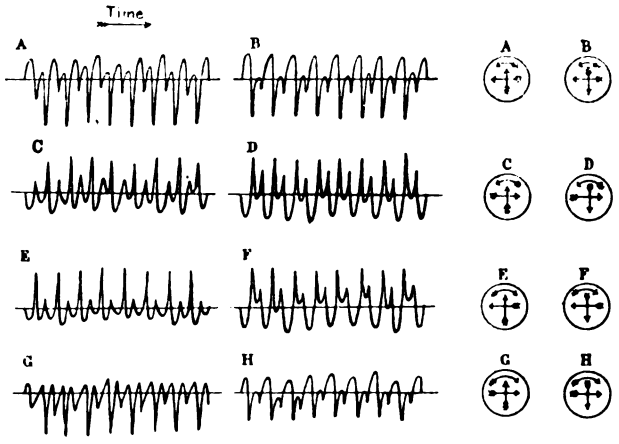

Fig. 9.

Still another variation can be given to the shape of the resultant oscillation by shifting the brushes through a fraction of a period, and thus displacing the phase of the commutation oscillation in relation to the tooth oscillation. The actual magnitude of the negative peaks when produced by the normally positive brush is not exactly the same as when produced by the normally negative brush, and vice versa. This is partly on account of their differing relation to the tooth oscillation, and partly on account of the fact that a brush normally positive required to run a very long time (usually several days continuous running) before it became a normal negative one.

Influence of Contact Resistance on Commutation.—A very marked influence on the commutation taking place was also noted when the commutator was respectively cold and hot. Fig. 10 shows the records obtained. A was recorded when the commutator was cold after standing over the week-end; temperature of room 15°C. B was recorded after the machine had been running several hours and the commutator had attained the temperature of 29°C. The negative oscillation increased considerably with rise of temperature, while the positive oscillation diminished slightly. This was caused by a decrease in the contact resistance of the negative brush, while that of the positive brush varied but little.

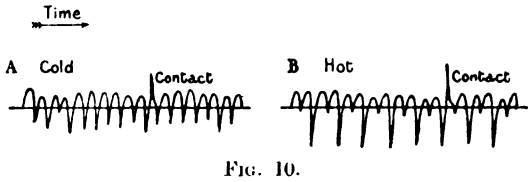

Fig. 10.

The author also illustrates the influence of contact resistance on commutation by records obtained under the same conditions, but when a little petroleum had been rubbed on the commutator. The petroleum increased the contact resistance and thereby reduced the natural period of the short-circuited coil with the resulting diminution of the oscillation and the maximum rate of change of the current. The least trace of petroleum is sufficient to influence commutation.

Disposition of the Contact Resistance.—It was pointed out in the theoretical discussion that commutation could sometimes be improved by a proper disposition of the contact resistance over the brush surface. This was effected by means of the brush shown in Fig. 5. Only the negative brush was varied, as the commutation under the positive brush was already very satisfactory. The negative oscillation was gradually reduced in magnitude as the width of the forward portion of the brush surface was reduced, until the width of the latter was a minimum consistent with mechanical strength.

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In this shape of brush the contact surface of the brush is equally divided between the two segments when about one-quarter of the short-circuit period has expired, and just before one-half the period the contact resistance over the forward segment is confined to the narrow strip at the forward tip of the brush. The reduction of magnitude of the oscillation is, as pointed out in the theory, due to earlier commutation. With a full surface the negative brush had a tendency to spark on full load, but when the forward surface was reduced to 2½ mm. all sparking disappeared, and with a 2 mm. surface the machine could be run on a 75 per cent. overload without any trace of sparking. Thus the overload capacity of a machine may be greatly increased by a suitable disposition of the contact surface.

The same experiment was tried with the positive brush, but with very different results. The positive oscillation was very small even with the full surface, and hence any alteration in the brush surface could hardly improve matters. When the brush was cut away the oscillations immediately increased to about the same magnitude as those due to the negative with the full surface brush.

(To be concluded.)

EDISON STORAGE BATTERY.*

ITS PRE-EMINENT FITNESS FOR VEHICLE SERVICE.

BY W. E. HOLLAND.

Summary.—A detailed description is here given of the Edison cell and of the experiments which led up to its present form. In conclusion, the features of the cell are discussed.

The "A" type Edison cell is the outcome of nine years of costly experimentation and persistent toil on the part of its inventor and his associates. The principle on which the action of this new battery is based is the oxidation and reduction of metals in an electrolyte which does not combine with, and will not dissolve, either the metals or their oxide; and an electrolyte, furthermore, which, although decomposed by the action of the battery, is immediately re-formed in equal quantity, and, therefore, in effect is a constant element, not changing in density nor in conductivity. A battery embodying this basic principle will have features of great value where lightness and durability are desired. For instance, the electrolyte being a constant factor, as explained, is not required in any fixed and large amount, as is the case with sulphuric acid in the lead battery. Thus, the cell may be designed with minimum spacing of plates and with the greatest economy of space that is consistent with safe insulation and good mechanical design. Again, the active materials of the electrodes being insoluble in, and absolutely unaffected by, the electrolyte, are not liable to any sort of chemical deterioration by action of the electrolyte, no matter how long continued.

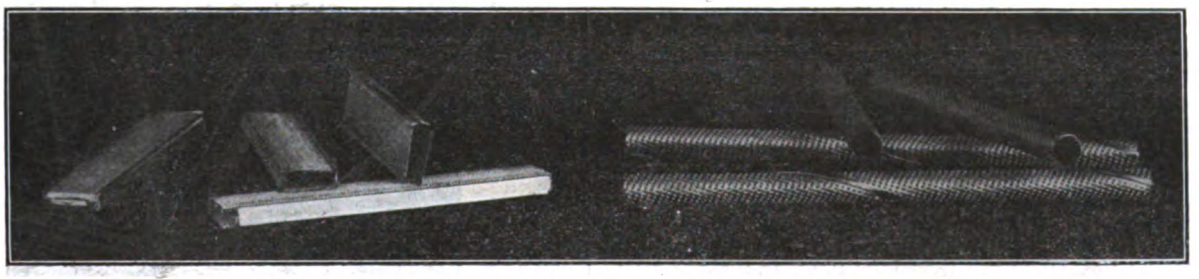
Those who have had experience with lead batteries know what attentive care is required to prevent "sulphation," which is caused by chemical action of the electrolyte on the active materials. They will also appreciate that such a disease-free battery as this is the augury of a beneficient revolution in electric vehicle practice.

The electrolyte of the Edison battery is a 24 per cent. solution of potassium hydrate, having in addition a small amount of lithium hydrate. The active metals of the electrodes—which will oxidise and reduce in this electrolyte without dissolution or chemical deterioration—are nickel and iron. These native elements are not put in the plates as metals, but one (nickel) in the form of a hydrate, and the other (iron) as an oxide. The containing cases of both kinds of active material (Fig. 1) and their supporting grids (Fig. 2), as well as the cell poles with connection parts (Fig. 3), and even the retaining can and its cover (Fig. 4), are all made of nickel-plated steel, a material in which lightness, durability and mechanical strength are most happily combined, and a material beyond suspicion as to corrosion in an alkaline electrolyte.

An essential part of Edison's discovery of active materials for an alkaline storage battery was the preparation of these materials. Metallic powder of iron and nickel, or even oxides of these metals, prepared in the ordinary way are not chemically active in a sufficient degree to work in a battery. It is only when specially prepared iron oxide of exceeding fineness and nickel hydrate conforming to certain physical as well as chemical standards can be made that the alkaline battery is practicable.

Having discovered the basic elements of the alkaline storage battery, the inventor set about to find the best means of supporting and making electrical connection with the active materials and to perfect the mechanical design. It was found, as expected, that the active materials were not of themselves sufficiently conductive to work efficiently except in exceedingly thin layers. Some conducting substance which would not be changed by chemical action must, therefore, be mixed with the active materials to bring every particle into good electrical contact with the conducting support. Graphite was first thought of and was tried, both with the iron and with the nickel material. At first it gave only fair results, but after a particular quality in the form of thin scales had been developed the results were good. It was soon superseded in the iron electrode, however, by mercury, which was found to hold the iron particles in much better contact and give better voltage to the cell at high discharge rates.

In the nickel electrode graphite was used until the recent advent of the "A" type cell. The results as to capacity were good when cells were new, showing that graphite performed well the function of bringing every particle of the active nickel into good electrical contact with the conducting support. But, unfortunately, in time it became apparent that this most durable form of conducting carbon was unable to withstand the disintegrating action of the strong oxidisers formed at the nickel electrode during charge. The result was that cells of this type, in service, would gradually lose capacity from deterioration of internal contacts in the nickel plates.



Fe. Ni.

FIG. 1.—THE TWO KINDS OF PERFORATED CONTAINERS INTO WHICH THE IRON AND NICKEL ACTIVE MATERIALS ARE LOADED.

One other feature of the former types of this cell remains to be commented on as a point contributory to their deterioration. It is a bothersome characteristic of all storage batteries that the active materials expand and contract during charge and discharge of the cell. This point was not properly taken care of in the first types produced, although much attention had been given to it. In the "E" type, the immediate predecessor of the "A" type, rectangular containers (like those used in the iron plate to-day) were used for supporting both kinds of active material. These containers, after loading and mounting in a support grid, were subjected to heavy pressure in a die designed to concave and corrugate each loaded container, or pocket, the idea being to make an elastic construction which would maintain a constant spring pressure on the active materials. In the iron plate this construction proved perfectly satisfactory, and, as mentioned, is still used.

The nickel material proved more troublesome, however. It would expand when charged, and would not contract again; and its expansion was found to be cumulative, increasing gradually in extent, until in time the elastic limit of the perforated steel was exceeded, and the internal contacts became disarranged. Notwithstanding these facts, the "E" type Edison cell, with nickel plates of flat-pocket construction and containing graphite, was used in commercial service with excellent results, having a useful life of from three to five years, and showing itself to be more economical than the lead battery and much more dependable.

In the "A" type cell the construction of the two kinds of plate is radically different. The negative, or iron plate (Fig. 5), has the familiar flat-pocket construction. Each negative contains 24 pockets, a pocket being ½ in. wide by 3 in. long, and having a maximum thick-

* Abstract of an article in the "Electrical World,"

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ness of a little more than $\frac{1}{8}$ in. The positive or nickel plate (Fig. 6) is seen to consist of two rows of round dots or pencils, 30 in number, held in a vertical position by a steel support frame. The pencils have flat flanges at the ends (formed by closing in the metal case), by which they are supported, and electrical connection is made. The frame is slit at the inner horizontal edges, and then folded in such a way as to make individual clamping jaws for each end flange. The clamping is done at great pressure, and the resultant plate has great rigidity and strength. The perforated tubes into which the nickel active material is loaded are made of nickel-plated steel of high quality. They are put together with a double-lapped spiral seam, to give expansion resisting qualities, and, as an additional precaution,

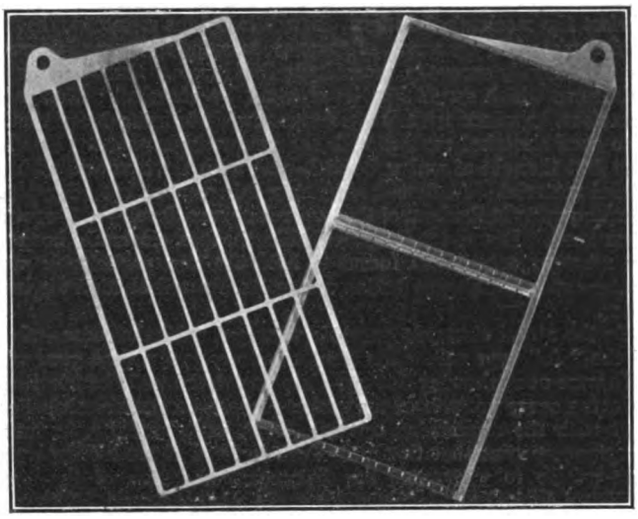

FIG. 2.—THE TWO TYPES OF SUPPORTING GRIDS.

small metal rings are slipped on the outside. Each tube is $\frac{3}{4}$ in. diameter by $4\frac{1}{8}$ in. long, and has eight reinforcing rings.

It will be seen that the "A" positive plate has been given the theoretically best design, to prevent expansion and overcome trouble from that cause. Actual tests, long continued under very severe conditions, have shown that the construction is right and fulfils the most sanguine expectations.

The use of graphite was not so easy to eliminate. The inventor realised that a metal insoluble in the electrolyte and able to withstand electrolytic oxidation was the logical thing, and, naturally, he thought of nickel at once; so nickel and other metals were tried in various forms and under different conditions of mixture with the nickel hydrate. The results at first obtained might have been considered good had the inventor not previously developed the efficiency

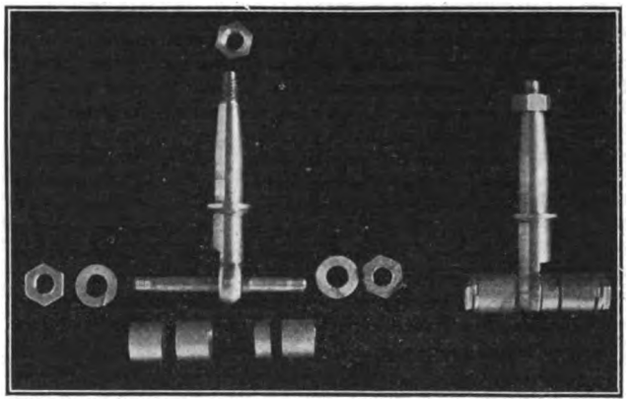

FIG. 3.—CELL POLES AND THEIR CONNECTIONS.

of graphite so far, and known what high specific capacity could be realised in nickel hydrate. As it was, the results were considered unsuccessful. Eventually nickel was found to give highly satisfactory results if made into thin flakes of a certain quality and loaded into the tubes in layers interspersing with layers of nickel hydrate.

An idea of the conditions inside a loaded tube can best be had by microscopic examination. Fig. 7 shows a magnified section of a regularly loaded tube which has been sawn lengthwise. The vertical bounding walls are edges of the perforated metal containing tube; the dark horizontal lines are layers of nickel flake, while the light-coloured thicker layers represent the nickel hydrate flake. It should be noted that the layers of flake nickel extend, practically unbroken, across the tube, and make contact with the metal wall on both sides. These metal layers conduct current to or from the active nickel hydrate in all parts of the tube very efficiently. There are about 350 layers of each kind of material in a $4\frac{1}{8}$ in. tube, each layer of nickel hydrate being about 0·01 in. thick; so it will be seen that the current does not have to penetrate very far into the nickel hydrate, one-half a layer's thickness being the maximum distance. The perforations of the containing tube, through which the electrolyte reaches the active material, are also shown in Fig. 7.

From the foregoing it will be understood that the troublesome member of the Edison battery has always been of nickel. The iron active material and the design of the iron electrode were developed to a high degree of perfection some years ago, and have since remained unchanged, except that improvements have been made in the manufacturing processes.

The characteristics of the Edison battery, which fit it so pre-eminently for transportation service, may be summarised as follows: (1) The perforated container construction prevents loss of material by disintegration, doing away with sediment short-circuits and the necessity of cell washing. (2) A steel containing can has very obvious mechanical advantages over a hard rubber jar, and the expensive delays and trouble caused by jar breakage in lead batteries

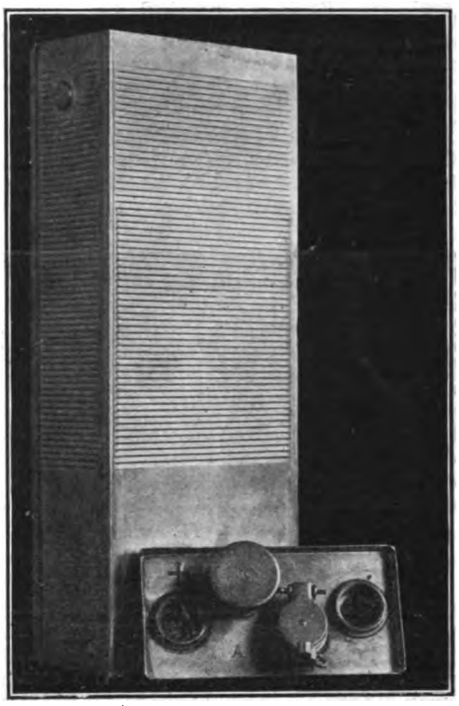

FIG. 4.—THE RETAINING CAN AND ITS COVER.

is thus eliminated. (3) The steel and copper connectors used in connecting cell posts are easily removable, and make it possible to disconnect or replace any cell of a battery in a very short time without the employment of skilled labour, such as a "lead burner." (4) The steel and nickel construction of the plates makes "buckling" impossible; even a dead short-circuit of the poles will not affect the condition of the plates in the slightest. (5) The simplicity of the care required enables one garage man to look after a large number of batteries, or makes it possible in private service for anyone to care for and operate his own pleasure vehicle with little trouble and most satisfactory results. (6) The materials used in the cell being exceedingly durable by nature, and the construction being very rugged, a cell will stand an almost unlimited amount of vibration and shock without injury. (7) Freedom from "sulphation" or any kind of chemical corrosion eliminates a very insidious source of trouble and depreciation. (8) Lack of corrosive fumes prevents destruction of the metal work of vehicles and of the garage equipment. (9) The light weight of the battery in comparison with lead batteries gives it many evident advantages. The wear on tyres is reduced; the vehicle can be built lighter; the cost of battery and of charging current required for moving unprofitable load—*i.e.*, the weight of battery and vehicle—is much reduced, or, in other words, a much larger percentage of the total weight transported will be paying load. This characteristic of lightness also makes possible the building of

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machines of exceedingly high mileage capacity. (10) The crowning feature of the Edison battery, however, is its great durability. It is safe to say that this feature alone would have insured the battery's success without the many attendant advantages which it possesses. (11) The so-called efficiency of the Edison battery is low, being normally about 60 per cent., where a lead battery, if new and in good condition, would give 75 to 80 per cent. If charging current were the principal item of expense in vehicle operation this fact might be serious, but it is universally recognised that cost of charging current is an insignificant item, and of no practical account in comparison

FIG. 5.—THE NEGATIVE OR IRON PLATE.

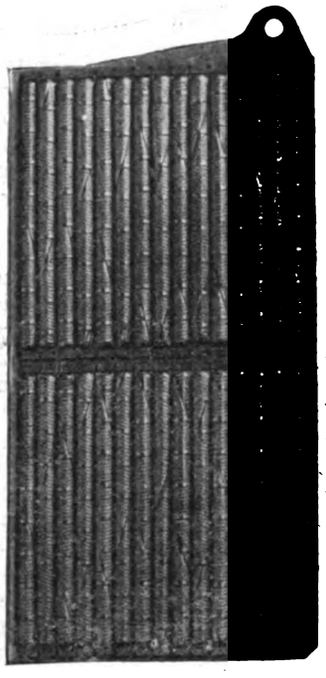

FIG. 6.—THE POSITIVE OR NICKEL PLATE.

with the other factors of care and maintenance. Moreover, as is well known, a lead battery does not long remain "new and in good condition," and its high first efficiency accordingly is not maintained. The true measure of a battery's efficiency is the ratio of the total cost of operation over a long period of time to the load carried and the distance travelled, due allowance being made for reliability. Expressed in a formula

$$\text{Practical efficiency} = \frac{\text{Total cost of maintenance and operation}}{\text{Paying load} \times \text{miles carried} \times \text{reliability factor}}$$

the "reliability factor" being percentage of working time that the

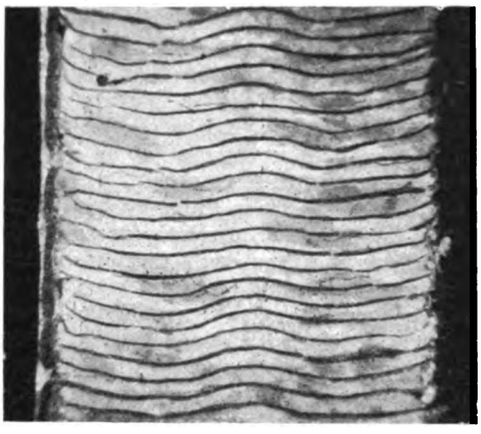

FIG. 7.—SECTIONAL VIEW OF A LOADED TUBE, MAGNIFIED ABOUT 8 DIAMETERS.

machine is in commission. In the light of this practical formula it can truly be said that the efficiency of the Edison battery is high—much higher than that of any other.

In conclusion the writer says that the points here presented are not speculations or mere assertions, but are proven facts, the results of innumerable laboratory and road tests which have come under his direction or observation.

THE APPLICATIONS OF ELECTRICITY AT THE PANAMA CANAL.

The Panama Canal is very much in the public eye at the present time, chiefly, it must be admitted, owing to the extra enormous expense which it is now anticipated will have to be met before this work is completed. It is impossible to estimate the cost of so stupendous an undertaking with any degree of accuracy until the construction is fairly well advanced, and rarely has this fact been so well instanced as in this case, where the ultimate outlay necessitated will be about three times that which was originally expected. It is natural, therefore, that every economy which it is possible to effect is now being brought forward, and hence the adoption of electricity, with its efficiency in operation, has been on a larger scale than is usual with this class of work.

The arrangement of the Canal in outline is, first, to remain at sea level from the Atlantic Ocean entrance to the Gatun Locks, which are in three flights, the distance being about 5 miles. Here the water level will be raised 85 ft., and continue thus till the Pedro Miguel Lock, which will be at the entrance to the Miraflores Lake, some 5 miles from the Pacific coast. At this point the level will drop to 50 ft. above sea level, sea level being reached through the Miraflores Locks (a flight of two), which will be situated at the other end of the Miraflores Lake.

While the general work of excavation will be on a huge scale throughout the whole length of the Canal, it is easy to see that the most important portion of it is concentrated at the three sets of locks, and it is not surprising, therefore, to learn that the electric generating stations are situated in the vicinity of the locks. At Gatun, where the largest and most difficult work has to be accomplished, owing to the provision of three flights of locks, a large power house is already in operation, and while it has been erected entirely for the constructional needs of the Canal, it will serve permanently for the production of power required for various purposes when the Canal is in operation. The installation consists of three 1,500 kw. steam turbo-alternators, alternating current being used almost exclusively for all purposes. The alternators are three phase, and generate current at 2,200 volts, with a frequency of 25 cycles per second. There are three rotary converters in the power house, one of 300 kw. and two of 500 kw. each, for supplying direct current, which is employed for certain special purposes. The design of the power house is in accordance with modern practice, and separate pairs of boilers are installed for each turbine set. From the Gatun generating station power is taken to various parts of the Canal in the vicinity, cables being, in the main, carried on poles. A second power station at Miraflores is now nearly completed, and will be exactly similar to the existing one, and contain an equal amount of plant, and supply power for all the work at Miraflores and Don Miguel Locks. The two stations will work in parallel after the Canal is completed, or may be arranged to supply separate portions of the Canal and be independent. An interesting feature of the new power house lies in the fact that it is built in reinforced concrete.

Apart from these two main power stations, there are three smaller and older ones, which are now worked by the Canal authorities, though previously under the control of the Panama Railroad Co., and they are chiefly for the purpose of supplying current for lighting and various power purposes in the towns where they are situated. They are all on the Pacific side of the Canal, one being at Balboa, on the coast, one at Empire and one at Gorgona, which is practically midway between the Atlantic and the Pacific. At these places there are large labour encampments, and the demand for lighting is continually increasing, some 20,000 lamps being installed in various districts during last year. In spite of the stations being small and not modern, and the load chiefly a lighting one, the total cost of production is only about 1½d. per unit, with a total output for the three stations of about 4,000,000 units annually.

Returning to the large power station at Gatun, the chief demand for power is in the handling plant, which has been installed for the construction of the locks and dams. Sand and cement are brought up to a barge dock through a channel from the French Canal, and are there unloaded, the cement being transferred direct to the cement shed alongside by means of 10 electric cranes, while the sand and stone are conveyed to a large heap some 500 ft. nearer the lock by means of one single and one duplex Lidgerwood cableway, the towers for which are some 800 ft. apart, and run on rails, so as to be moved to any position as required. There is an automatic electric railway, which conveys cement, sand and stone to the electrically operated mixers, which are situated close to the middle of the centre of the three locks, and the mixed concrete is loaded on another automatic electric railway running parallel to the three locks for their whole length. From this railroad the concrete is transported as required

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to build up the locks by means of four duplex Lidgerwood cableways, which span the locks and have towers some 75 ft. high and about 800 ft. apart. These run on tracks parallel to the axes of the locks, and can readily be travelled to suit the work.

All these Lidgerwood cableways are electrically operated, and are quite self-contained, and the adoption of electricity is somewhat of a novelty, since it is not often that, in works of this nature, electric power is available. One motor is sufficient for all the movements, and by means of friction drums the bucket can be hoisted, run out, tipped and returned; but it has been found that the employment of two motors with a series-parallel control, as with a tramway system, is much more economical and convenient. In raising the bucket the motors are put in series at first, and the hoist is accomplished at a moderate speed; but in traversing the buckets the motors are in parallel, and a very much more rapid motion of the bucket is obtained than would be the case if the speed were limited to that allowable in lifting the load. It is evident that, for this purpose, electricity has a great advantage over steam for operating cableways, and it has been found that the economy in the working of this plant has been very marked.

There is a large amount of pumping machinery electrically driven at various parts of the Canal, and at the Gatun Waterworks a turbine pump capable of dealing with 70,000 gallons of water per hour has recently been installed, indicating how rapidly the demand for water is increasing. In view of this, it has been decided to construct an entirely new pumping station, together with a reservoir of a capacity of 600 million gallons of water. All the pumping plant will be electrically driven, the type employed being the efficient and comparatively cheap high-pressure turbine pumps, which are now so effectively ousting the duplex and triplex machines.

Electricity is always an important factor in the difficult and dangerous operation of rock blasting, and the common method employed is to fire the fuses in series by means of magneto ignition. At Panama this led to many accidents, and did not work at all satisfactorily, the fuses frequently failing to fire, and being a considerable source of danger to steam shovels if left. The means now adopted is to have wires running the greater length of the Canal, current being supplied from one of the lighting stations at 2,300 volts. From these cables wires are taken to small 5 kw. transformers, with a ratio of 20, and from the secondary current is taken (at about 110 volts) to a number of fuses, usually about 100 at a time, connected in parallel. It has been found that misfires are practically unknown, and there is the further advantage that, as so large a number of fuses are exploded at once, a relatively greater amount of rock is dislodged than by the previous arrangement. The holes are drilled some 5 ft. or 6 ft. into the ground and are 3 in. or 4 in. in diameter.

When the Canal is completed there will be a large demand for power from various users, and this demand will rapidly load up the plant rendered available for other purposes by the completion of the constructional work. It is probable that various works will be opened up, besides which there will undoubtedly be electrically-operated light railways and tramways, and one of the most interesting applications of electric power will be its employment for towing vessels, since these will not be permitted to enter the locks under their own steam. The probable method adopted will be to have powerful electric locomotives running along the sides of the locks, while electric capstans will, of course, be employed. There will be numerous electric cranes, and it is proposed to work the many gates and valves by electricity, and the 9,000 kw. provided at the two large power stations mentioned above will be none too much for the entire electrical equipment of the Canal when it is in full swing.

ELECTRIC CABLES.*

ELECTROLYSIS.

BY F. FERNIE.

Summary.—The author first considers the general phenomena of electrolysis as observed in the neighbourhood of electrical networks. He then discusses in more detail the corrosion of lead-covered cables and armoured cables, and the effectiveness of earthing.

Probably no general rule can be laid down for the protection of underground cables and pipes from electrolysis. The conditions on every system vary, and each case has to be considered separately. The conduction of soil is probably entirely electrolytic; hence the nature of the soil—the kind of salts which it contains—largely influence the amount of electrolysis. Corrosion chiefly occurs on those cable sheaths or pipes which are at a higher potential than the surrounding soil, and become the anode of the electrolytic cell thus formed. The corrosion of a metal anode is caused by the combination of the metal with a variety of anions, which may be oxygen, OH, NO_3, SO_4, CL, and other acid radicles. Corrosion of lead generally results in the formation of various oxides, which, being insoluble, will be found at the point of corrosion. Nitrates and nitrites cause a large electrolytic corrosion of lead, but lead nitrate is readily soluble in water, and may, to a large extent, disappear. Lead oxides formed will slowly turn to carbonates by absorption of Co_2. Chalk and other carbonates tend to decrease the corrosion of lead. The corrosion of iron also produces the formation of iron oxides. Chlorides tend to increase the action and nitrates to diminish it.

The corrosion of iron depends on whether the surface is active or passive. Iron in the passive state is assumed to be covered with a thin film of oxide ($Fe_3 O_4$) or oxygen, which acts as a kind of varnish and protects it from further corrosion. Iron can be made passive by treatment with nitric acid, so that on re-immersion in the acid it is not attacked, if the surface be not rubbed. Iron is also rendered passive by immersion in molten caustic potash or soda (free from water), and to some extent by alkaline solutions. The presence of carbon dioxide, however, may cause passive iron to corrode. Carbon dioxide is supposed to play an essential part in the ordinary rusting of iron. In Edison's iron-nickel accumulator, the iron is prepared in a special way in order to make it active. Iron can be changed from the active to the passive state by a high current density. Possibly the mechanism of the passive condition of iron may be similar to the "valve action" of aluminium and other metals with alternating currents. Galvanised-iron pipes afford an instance of kathodic (secondary) corrosion. Electrolysis of the soil causes an alkaline liquid to collect at the cathode, resulting in the removal of all the zinc and followed by very rapid "chemical" corrosion of the iron.

Intermittent currents may also corrode an iron cathode, by causing alternate oxidation and reduction. (By "intermittent" currents are meant continuous currents, with occasional stoppages of perhaps some hours.) Alternating currents may cause serious corrosion under certain conditions, more particularly of lead. The amount of corrosion depends on a large number of conditions, amongst which are frequency of the current, the nature of the electrolyte, and current density. It would seem that when any irreversible chemical change takes place at an electrode, alternating currents must cause corrosion. For instance, if, when a metal electrode is anode, it forms metal cations; these may combine with some of the anions to form an insoluble salt, so that the metal ions cannot be re-deposited at the succeeding half waves; or a soluble salt may be formed in the first instance, which a secondary action may convert into an insoluble salt. For instance, lead plates in a solution of sodium nitrate and sodium carbonate might be converted into lead carbonate by an alternating current, the soluble lead nitrate first formed being converted by a secondary action into the insoluble lead carbonate. It is obvious that the frequency of the current must considerably affect such actions. The rate of diffusion of ions in the electrolyte must also have some influence on the rate of corrosion, for a certain proportion of ions formed may diffuse away from the electrode, thus escaping re-deposition, and causing slow corrosion. The lower the frequency the more this would tend to occur. Also other ions in the solution may be more readily discharged than the metal ions formed from the electrode, thus allowing a number of the metal ions to diffuse away. The corrosion caused by alternating currents is generally less than 1 per cent. of that due to an equivalent continuous current, but under suitable conditions, the corrosion (of lead in particular) may be much greater than this. In general, increasing frequency decreases the corrosion. Iron, however, in some solutions is said to corrode more rapidly as the frequency is increased, probably up to some limiting value.

It is a difficult matter to differentiate electrolytic and chemical corrosion. Electrolytic corrosion generally causes rough irregular patches on the surface of the lead, whilst

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regular cone shaped holes are sometimes eaten into the lead by chemical corrosion. Similar shaped holes are occasionally caused by electrolysis, where the lead is only touching the electrolyte at points, the holes being filled with oxides of lead. Even where comparatively large patches of lead are affected by chemical corrosion, the outline of the patch and the depth are generally regular. Holes are sometimes burnt in lead by arcs, and the holes resemble the cone-shaped holes mentioned above. Electrolytic and chemical corrosion being probably one and the same thing ultimately, the mere appearance of the pitting is not sufficient to distinguish them.

Small pipes are subject to more rapid action than larger pipes, for with any given current strength the current density must be greater on their surfaces. Also with any given potential difference the apparent surface resistance of any given area of a small pipe is less than that of a corresponding area on a larger pipe, and hence the current density must be greater in the case of the smaller pipe. Cast iron is less readily corroded than wrought iron. A coating of rust on a pipe may help to protect it, but on the other hand, might increase the corrosion by exposing a larger area of metal, owing to the roughening of the surface beneath the oxide, and might also decrease the contact resistance by encouraging a more intimate contact of moisture with the metal.

Current leaves a pipe surface chiefly on the side nearest to the rails or other cathode, and the amount of current leaving the opposite side of the pipe, and "bending round," appears to be inappreciable, judging by the localisation of the corrosion.

A buried cast-iron pipe that has been subject to electrolysis—one that has formed an anode—is easily recognised. Its external appearance is not much altered, but if the electrolysis has been of long duration, the whole of the pipe will be found to have lost its crystalline structure and all metallic lustre. It will have somewhat of the appearance of a soft shale, and layers can be readily prised off with a knife. In bad cases, a penknife blade can easily be driven through the pipe. Pipes that have not been electrolysed very long have only the outer skin affected, and when this is flaked off, the metal underneath is found hard and normal. To give an instance, a central supply station (three-wire continuous current) had a more or less permanent leak on the negative main, and for two or three years the leakage current seldom shewed a less value than 10 amperes. Consequent upon this, a number of cast-iron water pipes close to the station were found when dug up to be in the condition described above, so much so that it was impossible to take some lengths out, without breaking them. A cast-iron pipe laid in a sandy soil, and containing a third wire cable, the insulation on which had broken down, was found to be in a very similar condition. This pipe probably acted as an anode whenever there was a leak on the negative side of the system. Owing to the insulating, quickly drying nature of the soil, the current density must have been very small. A third case may be mentioned of a cast-iron pipe laid parallel to a solid laid distributor. This cable was positive, and developed a fault which continued for some months, the total leakage current at any time being certainly less than one ampere. The pipe for some feet on either side of the fault was partly converted to this characteristic shaly state. The current appeared to have got on to the pipe immediately opposite the fault, and to have left it chiefly on the side opposite to that on which the cable lay.

On the other hand a chemically corroded iron pipe, such as one that has been laid in ashes, is entirely different in appearance. It is roughened and pitted, possibly with holes eaten in it in places, and often shows a variety of colours. Very old gas service pipes often have this appearance. Electrolytic corrosion also sometimes takes the form of pitting; the appearance of the corroded iron probably depends on the nature of the soil, and to some extent on the kind of iron.

The surface resistance between pipe and earth has been found to equal about 0·2 ohm per square metre, and the resistance of a metre cube of earth to be about 125 ohms.*

If the soil is very dry and of poor conductivity, then very little current will be shunted out of the rail, unless special facilities occur for it. For instance a water pipe laid parallel to the rails might be generally buried in a dry soil, but which contained here and there conducting patches of wet soil. Such patches might be caused by leaky joints in the pipe; in such a case most of the shunted current would flow in the pipe itself and corrode it where it left the pipe. Probably pipes which form a "short cut" for the return current are those most likely to carry large currents.

The potential difference measured between rails and pipes, &c., will in general be a resultant E.M.F., as there are, in addition to the E.M.F. caused by the current, back E.M.F.s caused by polarisation at the surfaces of pipes. Messrs. Cunliffe (*v.s.*) regard pipes laid at a greater distance than 3 ft. from the rails as out of danger, because nearly the whole fall of potential due to a current flowing in soil is within 3 ft. of the electrodes. If a pipe near the rails differs from the rails by a potential v, then all other pipes further from the rails than this pipe will, if there is no current flowing in them, be also at a potential v with regard to the rails. Similarly if the earth is regarded as a conductor, then if all the fall of potential occurs within 3 ft. of the rails, all earth beyond 3 ft. will be at the same potential, and thus any pipe buried 3 ft. from the rails will be at the same potential as the earth surrounding it, so that no current will enter or leave it from the earth. Yet the pressure between the pipe and rails might be considerable. One case of tramway current corrosion we have seen was on a water valve, about 4 ft. from the rails; the soil was generally sandy, but there was a small leakage of water from the valve. A maximum difference of potential of 3·2 volts was observed between the valve and the rails, but in general it was about 2 volts, the valve being positive. The maximum potential difference between pipes and rails observed at Strasburg was 2·8 volts, and the mean 2·2 volts, with the pipes + , the maximum pressure with the pipes negative was 11·5 volts and the mean 4·0 volts, and there was "marked corrosion on gas and water pipes made of iron in the danger area, and in unfavourable soil." *

The lead sheaths of tramway feeder cables are obviously liable to electrolytic action and even fusion. American practice is to insulate the lead as much as possible and divide it into sections, while leadless cables are largely used in England. An attempt to earth and bond the lead of positive feeders is not to be commended, as it encourages heavy rushes of current along the lead whenever there is a momentary short-circuit on the system. Instances have occurred of several feet of lead being burned off such feeders by a short-circuit. No electrolytic trouble appears to have been recorded with single-phase traction lines, although the fall in potential along steel rails must be much greater with alternating currents—certainly twice as great for moderate frequencies.

Electrolysis on three-wire lighting and power systems is of a rather different order from that occurring on traction systems. The most serious form of damage, which is often called electrolysis, but which is not, is the burning and fusion of lead sheathings and pipes.

On a well-laid and well-maintained system of mains, earth currents of any magnitude do not normally occur. But on any fair-sized network there must always be small leakage currents, chiefly from consumers' premises and over "ends." Any damage caused by these small currents may be made inappreciable by bonding and earthing the lead sheathing of the wires. Bonding ensures a much larger surface by which the current may enter or leave the lead, and thus greatly reduces the current-density.

Efficient earthing prevents current leaving the surface of the lead at all. These small leakages are nearly always from the negative side of the system, and hence all the anodic corrosion must take place on neighbouring and better earthed sheathings or pipes. But the lead of a negative leaky cable is itself frequently corroded; for instance, where passing through cement or plaster, and the corrosion must be cathodic in these cases. It is probably a combination of chemical and electrolytic cor-

* Haber and Goldschmidt, THE ELECTRICIAN, Sept. 23, 1906.

* THE ELECTRICIAN, July 20, 1906. Report of Commission of the German Gas and Water Companies on Earth Current.

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rosion, the latter acting as a reducing agent. Lead that forms the cathode of an earth circuit generally has a distinctive blue appearance, which is probably due to the removal of the film of oxide which exposed lead surfaces acquire. Lead covered wiring of buildings should undoubtedly be all bonded and earthed, since the whole installation is protected by fuses. The case is rather different, however, for street mains, where the danger is not so much electrolytic corrosion as fusing and burning. The method on which the mains are laid decides the course to be adopted. The initial difficulty is *efficient* earthing. The contact resistance of any earth plate which is carrying a current, and is an anode, rapidly rises, because it drives moisture away from it.

Whilst earth plates may lessen corrosion caused by minute currents, they cannot deal effectively with large currents. This is exemplified in the case of a fault occurring on a cable drawn into a galvanised iron pipe 50 ft. long and 2 in. external diameter, which caused the copper of the cable to be welded hard on to the pipe. About 18 in. away and running parallel was a lead water pipe. The P.D. between this and the galvanised-iron pipe was measured, and was 218 volts, yet the current passing was only 3 amperes! The soil was ordinary red garden loam. Permission may sometimes be obtained to bond the lead sheathings on to water pipes; this, of course, makes a capital earth, yet its expediency may be doubted. For suppose a network of lead-covered cables laid "solid," the lead being bonded together wherever possible and earthed at some point or points, the third wire being earthed at the station to a water pipe. On a fault occurring, the lead being in direct contact with the copper a very large current will flow, which is likely to burn off bonds here and there, but presuming everything holds up, it may shut down the station, or at any rate one section of the network, and reliability of supply becomes of greater importance every year.

A very good earth also defeats its object in another way, by forcing such a heavy current to flow along the lead sheath, between the fault and the earthing point, as to cause a considerable fall of potential along the lead. This tends to make the current arc to earth at intermediate points. This large current may be prevented by disconnecting the third wire earth connection, or by inserting resistance in it. If this be done the immediate effect is to raise or lower the third wire earth potential above or below earth some 200 volts or so. The result of doing this will be to start a number of third wire earths on any old network, chiefly on consumers' premises, and also nearly to double the potential between the opposite pole and earth. This will tend to cause additional faults, is contrary to the B.O.T. regulations, and may be dangerous to life. If a "solid" system is *perfect—i.e.*, with the lead everywhere insulated, there is obviously no object in earthing or bonding, for, supposing a fault to occur, there is no path for the current, and no current can flow. But there are, with most methods of laying, weak places, generally at saddles and where the cables enter manholes, where the current will get to earth and burn holes in the lead if there is no metallic path provided. Bitumen also breaks down and allows current to flow, if the lead be "alive" for any length of time.

These weak places may be far distant from the actual fault, and this is the danger of continuous lead without earth connections. Sometimes every saddle provides a path for the current, and corrosion then takes place at every such point. If now the lead be broken at short intervals, say at every joint, the corrosion or burning is limited to the particular length of cable in which the fault occurs.

This incidentally illustrates one of the advantages of a draw-in system, as with it the faulty length of cable is readily pulled out, examined and renewed if necessary. Further, long lengths of lead cables, all with the lead electrically continuous and earthed, actually invite tramway currents to travel along them. If the lead is insulated and broken into sections, there is no temptation to such currents to use it. On the whole, then, in laying down a system of mains, with the view of preventing electrolysis and burning, the surest method would appear to be to break the lead into sections, and thoroughly to insulate it. An attempt to do this is made on some British systems, but the more popular course is to bond and earth the lead; the earthing is done at definite places, an attempt being made to insulate the lead by laying the cable "solid" everywhere except at these points. The system devised by the Howard Asphalt Troughing Co., of insulating the lead and earthing sections through a light fuse, seems quite sound. The fuse acts as an indicator of the state of the section. It will, however, be often impossible to insulate the lead of service cables right up to the cut outs; but the service lead may be insulated from the main lead. A partial course is the worst, such as some cables bonded and some not, and partial or bad earths, such as earth plates generally provide.

The lead of lead-covered cables laid in metal pipes should be made as continuous as possible, and should be well earthed. An analogous case is that of two or more lead-covered cables in one duct, a fault occurring on one is sure to burn holes in the others if the lead of each cable is not thoroughly bonded to the rest. If it were possible to make a line of iron pipes electrically continuous by bonding at the joints or otherwise, they would thoroughly protect lead-covered cables drawn into them from electrolysis by tramway return currents.

(To be continued.)

THE GIROD FURNACE.*

BY W. BORCHERS.

Summary.—The author first describes the Girod furnace and gives details of its working and cost. He then refers to the works of the Société Anonyme Electrométallurgique Procédés Paul Girod at Ugine, giving particulars of the installation.

About six years ago,† the author, reviewing the progress of electrode furnaces up to that date, stated that a furnace simpler than that of Héroult could not be found. He had now to correct that judgment, for, in his opinion, the Girod furnace was now the simplest and safest, as far as construction and running of electric electrode furnaces were concerned. In the author's laboratory a Girod furnace of 30 kw. to 36 kw. capacity is being used, while elsewhere, for steel smelting, it is being used in sizes of 300 kw. to 1,200 kw. It is a combination of a resistance and an arc-heating furnace. The metal to be smelted serves as one of the electrodes; it is covered by the refining slag as an electrolytic conductor, while a carbon block (or several carbon blocks), introduced from above through the cover of the furnace, forms the opposite electrode above the centre of the bath. The arcs play between the carbon blocks and the slag, and no doubt here the largest amount of heat is produced. A second heat-producing zone is the layer of slag through which the current passes to and from the metal. Last, but not least, the metal itself becomes an important source of heat on account of the effective manner in which the electric current is made to pass through the molten metallic body, and this is the most important feature of the Girod process. The contact pieces are of such cross section and length that every one of them will take up only a certain part of the whole current without being overheated, and therefore without excessively increasing its resistance. An additional regulation of the temperature and resistance of each contact piece is effected by cooling the ends of these bodies, which contain small chambers, by means of circulating water. These bodies, which are made of pure iron to avoid any deterioration of the furnace charge, are therefore not only the conductors between the furnace charge and the current generators, but serve also to ensure regular and uniform distribution of the current traversing the centrally hanging carbon rod or rods radially to and from the periphery of the bath. This is important not only for uniformly heating the bath, but also for keeping every part of the liquid metal in constant motion. In running a furnace with as high a current density as is found necessary to smelt iron and steel, it can easily be observed that the passage and the transformation of the electric current into heat is accompanied by violent mechanical motion of all particles of the liquid. This movement, however, accelerates the contact between the impurities of the iron and the refining slag floating on top of the bath. The Girod system of arranging the electrodes and contacts is a safeguard against any stagnation of parts of the liquid furnace charge, and for this reason the advan-

* Abstract of a Paper read before the Iron and Steel Institute.

† Borchers, "Elektro-Metallurgie," 3rd edition, 1903, p. 536.

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tages of the induction or transformer furnaces and of electrode furnaces are combined in the Girod furnace, while the imperfections of both forms have been overcome.

The peculiar arrangement of electrodes and contacts gives the Girod furnace a special advantage over other electrode furnaces when cold scrap is to be smelted. As soon as possible after charging the hearth of the furnace the upper electrode is lowered until it rests upon the heap of scrap, and the current is compelled to pass by means of numerous small arcs through the whole mass of scrap to the periphery of the heap on the hearth bottom. The heap breaks down simultaneously in all parts in a very short time, and there is no sticking of cold pieces to the bottom of the furnace, and no necessity for stirring up and loosening such lumps from the hearth and endangering the latter. The author illustrates a 2½ ton and a 12 ton furnace, giving details of the size of the various parts.

It will easily be understood, that if, during a smelting operation, pieces of the ends of the contact bodies melt and dissolve in the steel, no harm will be done to the latter, as the contacts consist of pure iron, and the quantity of iron, which in such a case combines with the liquid charge of the furnace, is proportionally so small that the qualities of the charge will not be influenced thereby to any perceptible degree.

The applicability of the Girod furnace is in no way restricted by the nature of the raw materials. It may be fed with cold scrap or with molten metal. When feeding cold scrap the whole charge is not put in at one time. After the larger part of the charge has been shovelled or otherwise thrown upon the hearth, the current is sent through the heap in the manner already described. The rest of the charge is put into the furnace, together with the first batch of the refining ingredients. Taking a 2 ton furnace as an example, the charge consists of 2,000 kg. to 2,500 kg. of iron scrap, and the first batch of flux usually consists of about 80 kg. of lime and 220 kg. to 250 kg. of iron oxide in the form of ore, which, with the iron oxide that covers the scrap, serves as an oxidising agent. The smelting of the iron charge and of the first batch of refining flux requires four and a half to five hours. On the slag becoming exhausted of iron oxide, and, therefore, of its oxidising power, samples of the bath are taken and tested to ascertain the degree of refining of the molten metal. According to the degree of purification, the furnace now receives (of course, after the first slag has been skimmed off) a second, and if necessary a third batch of lime-iron oxide. After the removal of the last slag the surface of the metal bath is thoroughly cleansed by throwing in about 30 kg. to 40 kg. of lime and skimming this off after a while. The further treatment of the iron bath depends upon the presence or absence of impurities which could not be removed by the lime-iron oxide refining and upon the quality of steel to be produced. According to these circumstances, deoxidising or otherwise refining agents are employed, such as ferro-manganо-silicon, ferro-aluminium-silicon, ferro-manganо-aluminium-silicon, and other alloys. For producing carbon steels, an addition of Swedish charcoal iron or of a kind of iron very rich in carbon, made in a separate electric furnace of the steelworks, can be made. The final step in the production of special steels is the addition, after these refining operations, of iron alloys with metals like nickel, tungsten, and chromium.

The author, in the present Paper, confines himself to describing the practical working of the furnace. The total duration of one smelting operation from the starting of the current to the casting of the finished product into ingots or moulds covers about eight hours, assuming that the raw material is not pure. Pure raw material, of course, will require less time and less power.

The smaller of the two types of furnaces used in steel works are run with alternating currents of about 300 kw. at about 60 to 65 volts. The larger furnaces require 1,000 kw. to 1,200 kw. at 70 to 75 volts. Taking into account a loss of 10 to 11 per cent. of the charge by oxidation and evaporation, the power required to make 1 ton of steel in a small furnace is 900 to 1,000 kw.-hours, and, in a large furnace, 800 to 900 kw.-hours. The consumption of carbon electrodes amounts to 12 kg. or 15 kg. per ton of steel, including the short pieces, which remain in the holders, when the latter have reached the lowest point at which they can withstand the radiating heat of the bath.

The lining of the furnaces, mostly consisting of calcined dolomite, will withstand at least 80 charges. Thereafter the side walls, into which cavities have been eaten by the slag around the level of the molten bath, will require repairing, and these repairs will subsequently need to be effected at shorter intervals. The bottom of the furnace will, however, stand 120 to 160 charges without repair. The thickness of the bottom will have by then been reduced by about 100 mm. Furnace linings will stand a considerably longer time if liquid charges are used. One furnace working in this manner was run for 200 charges without any repairs. The linings of the furnace covers require more frequent renewal. In the small furnaces they need repairs after 25 to 30 charges, and in the larger furnaces after 20 to 25 charges. The other parts of the furnace are not worn out as fast as the linings and electrodes. The furnaces which have so far been put into operation still possess their original outfit.

At the works at Ugine only scrap iron is used as raw material for steel making as well as for the manufacture of iron alloys. The larger part of the scrap is soft iron and steel, the smaller part pig and cast iron. The average percentage of impurities in the raw material used over a long period of operations was:—Carbon 0·4-0·5 per cent., silicon 0·15-0·25 per cent., manganese 0·5 -0·7 per cent., sulphur 0·06-0·09 per cent., phosphorus 0·08-0·1 per cent. The degree of refining that can be reached in the Girod furnace can be seen from a table in the Paper, giving analyses of the various brands of steel produced.

The cost of the different types of Girod furnaces and of complete plants are as follows:—A small 2½ ton furnace, including regulators for the electrodes, measuring instruments, tilting device mechanism, and the conductors from the furnace to a dynamo or transformer near the furnace room, costs about £600. A large 12½ ton furnace with a similar outfit will cost about £1,200. The manufacturing costs of the electrodes amount to three or four francs per ton of carbon body. A complete plant with one 2½ ton furnace for regular running and one furnace for reserve, and with all appliances and melting house, but without dynamo or transformer, will cost approximately £8,000 to £12,000; and a plant working with a large 12½ ton furnace, £12,000 to £16,000.

To carry out the Girod processes for the purpose of making alloys and steel, a company, under the name of Société Anonyme Electro-métallurgique Procédés Paul Girod, Ugine, Savoy, in France, was formed several years ago. This Company is owner of the Girod Alloy Works, in which also the first experimental 2 ton steel furnace was tried. The fact that at the present day 19 furnaces with 400 to 600 E.H.P. are kept running, and that 12 new furnaces, each of 1,200 E.H.P., are being put up, shows to what extent this manufacture has been developed. In the future the older works will only make alloys, and the old steel furnace will be transferred to the new steelworks.

The Company also owns an electrode factory with the most perfect and modern installation, capable of turning out daily 10 to 12 tons of electrode carbons in diameters up to 350 mm. and in lengths up to 1,600 mm. of round or square cross sections. At present only 7 tons are made daily, for which only one furnace is required; a second furnace will be built as soon as the demand increases. The raw materials for the electrodes are retort graphite, petroleum coke, anthracite coal, and anhydrous tar. The solid materials are ground in ball mills, kneaded with tar in double screw mixers and in Chilian mills. The mixture is then stamped to big blocks which are finally pressed into blocks of the dimensions given above. The burning of these blocks is effected in gas-fired ring furnaces, the blocks being placed in large fireclay tubes and covered with coal dust.

The Company owns several water powers. The power house which was built for the old works is situated about 3 km. above Ugine, on the Arly river. Here a strong dam with gates diverts the water into a tunnel, which leads it to a pipe line directly above the power house at Ugine. Ten Pelton wheel turbines drive as many direct-coupled dynamos furnishing 8,000 to 9,000 E.H.P. The second power station, furnishing a further 12,000 E.H.P., is situated above Le Fayet. The tunnel and the pipe lines are large enough for carrying the water for 20,000 H.P., but the turbine house is only fitted with turbines and dynamos for the lower power. It will soon be enlarged. Three-phase current is transmitted at a pressure of 45,000 volts to Ugine, where it is transformed down to 2,500 volts for the large machines, and to 60 to 75 volts for the furnaces. A further reduction of pressure to 500 volts and to 110 volts is made, the last mentioned pressure being employed for lighting and for small motors, and 500 volt direct current for locomotives, cranes, &c.

Besides this power the works of Ugine are obtaining on lease 6,000 E.H.P. from a power station at Bionnay, upon the Bonnant river near St. Gervais, and during the winter months they also obtain 8,000 to 10,000 E.H.P. from the Société d'Electro-métallurgie Sud-Est at Veuthon, near Albertville. From both stations the current is furnished at a pressure of 45,000 volts.

The plant which has been installed for the new steelworks, most of which is now in running order, is as follows:—Three electric furnaces, each of 2 tons capacity. One of these only makes small steel castings. Two large electric furnaces, each of 10 to 12 tons capacity. The steel produced in all these furnaces, except the one mentioned, is cast into large ladles worked by electric cranes, and

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run into ingots, which are sent to the rolling mills. Working with several furnaces steel castings (dynamo frames) up to 20 tons have been made. For the mechanical and thermal treatment of the steel ingots the most effective modern machinery and other installations have been erected.

The rolling mill has two three-high stands of rolls, one of which is able to take ingots up to 525 mm. diameter and 400 kg. weight, and rolls them down to rounds of 125 mm. diameter, while the other stand will roll ingots of 325 mm. diameter to smaller rounds, squares, and sections. The other outfit of this mill consists of two furnaces for heating the ingots before they go to the rollers, and of the necessary cutting and sawing machinery for the rolled blocks.

There is a large forge containing nine hammers operated by compressed air. The heaviest of these hammers weighs 5 tons; the weights of the other eight hammers range from 1 ton to 2 cwt. Here specially tough forgings are made for automobile machinery, shaftings, gears, tool-steel rods, and projectiles. Besides several annealing furnaces already in operation, a large shop is being built for tempering, annealing, and hardening large forged or cast-steel pieces. A second forge is being erected, which is to be fitted up with a 1 ton forging press, one forging hammer of 10 tons weight, and three stampers with falling hammers of 3 tons, 2 tons, and 1 ton respectively.

The steel foundry contains a carpenter's shop for making the patterns, a sand separating plant, a number of moulding machines, the necessary moulding frames, drying and heating furnaces, and a sand blast plant for cleaning the finished castings. The foundry with its present installation will be able to turn out about 10 tons of steel castings daily, but as mentioned above pieces up to 20 tons in weight can be cast.

The following firms have ordered Girod furnaces, and in some cases have been operating them for some time past:—Oehler & Co. (Switzerland); Société John Cockerill (Seraing, Belgium); Stotz & Co. (Stuttgart, Germany); Stahlwerk Becker (Krefeld, Germany); Gutehoffnungshütte (Oberhausen, Germany); Ternitzer Stahlwerk, Schoeller (Ternitz, Austria); Danner & Co. (Judenburg, Austria); Ungarisches Staats-Stahlwerk (Diosgyor, Hungary).

DISCUSSION.

Mr. J. H. Heap said that the present Paper might very well have been considered with Mr. Selby Bigge's Paper, because, taken together, they showed clearly two aspects of an important question—viz., the best means of harnessing waste gas and the best end to which the power when harnessed might be applied. He thought that it was a reproach to them that so little had been done in this country with the electric furnace. They had left the whole of the experimental work to Frenchmen chiefly, secondly to Italians and thirdly to Germans. The condition of affairs in this country, especially in the Middlesbrough district, afforded a splendid opportunity for steel manufacturers to conduct experiments with the electric furnace for manufacturing steel. Taking some of the hydro-electric schemes abroad, the cost per unit was as high, or higher, in most cases than the cost per unit would be by harnessing up the waste gas in the most economical way. He was sorry that a metallurgist of the author's standing had not preferred to give a general summary of the electric furnaces of the present day, in order that manufacturers could have seen what a competent and independent authority had to say on the merits of the various furnaces. He also could not understand the author's logic in approving of the Girod furnace. Taking his conclusions, what one came to was that it was better to take the simplest type of furnace without going into any of the particular improvements of other furnaces. The only point, so far as he could see, in which there was a special feature in the Girod furnace was in the contact pieces, and he was doubtful whether they would last long, even in spite of the arrangement for cooling. He asked the author why it was, if there was the advantage he claimed in having the simplest type of furnace, inventors had spent so much time in devising means for getting over the difficulties of the first designs. The author seemed to take it for granted that there would be a circulation of the contents of the bath. That was not so, however, without some special arrangement. He thought it was strange that it should have been left to Sheffield to be the first to take up the electric furnace. The best place in his opinion was Middlesbrough. His reason for saying that was that, to get the ideal conditions for the electric furnace, one must in the first place have cheap power, and secondly cheap material. The most obvious means of utilising the electric furnace was to take a low-grade steel and refine it, so as to make a high-grade steel. Where could that be done better than in the Middlesbrough district? The ideal electric furnace was that which could use the commonest material and bring it up to the highest grade, employing the cheapest power for the purpose, and he did not know of any district to compare with Middlesbrough for that purpose.

Mr. E. H. Saniter thought that what Mr. Heap said with reference to the very incomplete comparison which was made between the Héroult and Girod furnaces should be remedied. The president had referred on the previous day to incomplete comparisons; this was a glaring instance of an incomplete comparison. What he should like to ask Dr. Borchers was: Did the Girod furnace consume one kilowatt less current to make a ton of steel than the Héroult furnace? That would be very interesting information from such an authority. There was also another point between the furnaces. As far as he could see in the Paper, the Girod furnace, according to Dr. Borchers, was the better type of the two furnaces, because there was only one hole through the roof and one electrode. He did not see any other reason given in the Paper for that, except that the author said something about the resistance of the bath increasing the heat. It was well known that the resistance of the molten metal in the bath played a very small part in the heat generated. The other point was that, comparing the two furnaces, in the Héroult the reaction area was three times as big. He would like the author to say if it was an advantage to have the larger reaction area in the Héroult furnace.

Prof. J. O Arnold said in connection with Sheffield and electric melting furnaces, so far as he, in conjunction with the university authorities had been responsible for this development, the only question they had to consider was the relative melting capabilities of the crucible and the electric furnaces. They did not want a refining machine, but a melting machine, and for that reason they selected the Kjellin furnace. The quality of the material used would remain unchanged, namely, the finest Swedish iron, which produced the finest steel in the world, as handled in Sheffield. The problem they wished to solve at the university was: Is electrically melted steel equal in quality to that melted by the 150-year old crucible process?

Mr. F. W. Harbord said that he had had the opportunity of seeing all the electric furnaces at work with the exception of the Kjellin, and he was surprised that the author should state that the Girod was the simplest. As a matter of fact, a statement like that was rather dangerous. It depended entirely on the particular purpose for which the furnace was required. As compared with the Héroult furnace, the Girod furnace had the advantage with the small sizes, it was true, having only one hole through the roof instead of two; but that did not apply to the larger sizes, where the Girod furnace had to have two electrodes through the roof taking up furnace space, as in the Héroult. The question of electrodes and the circulation of the bath was very small. Nearly all the furnaces claimed special advantages from circulation, and in these days, when one had 200 ton furnaces, one found that one could get quite sufficient circulation without any electrical current, and he did not think in a small furnace of the size which was generally used that circulation was of any importance. It appeared, also, that all the furnaces had practically the same consumption of energy. The amount of refining done in a given time was entirely independent of the electrical part. It was simply a question of having the silicon in the right position to do the work, and both the Girod and Héroult were equally good at refining. Therefore, as the consumption of energy was the same, as also was the product, the question could only be settled by each person taking into consideration his own particular conditions and carefully investigating them. He thought there would be considerable trouble from the bottom electrodes, as when tilting the furnace some of the lime or slag was almost certain to get round the electrodes. He would recommend them, before adopting any kind of electric furnace, to spend two or three weeks at the works, so that they could see in operation for a long period the different types and learn the advantages and disadvantages of each.

Mr. D. F. Campbell made a few remarks about the large electric furnaces in operation in America and compared them with large furnaces of the Girod type. It seemed to him that the statement of simplicity was very true, but he did not think the figures in the Paper in any way justified the opinion that the Girod furnace was the simplest. In the first place, if one compared a 12½-ton furnace with a 15-ton furnace in operation in South Chicago, one found that the 12½-ton furnace of the Girod type had four holes in the roof and 16 electrodes in the bottom. To his mind the holes in the bottom were much more likely to be a source of trouble than the holes in the roof. In electric furnace work it seemed to him to be advisable to stick as far as possible to the open hearth practice and not introduce any novelties. Another point was that the holes in the bottom were liable to become centres from which the dolomite lining would rise, and the steel was liable to get under the layers of dolomite and the bottom would break up. In the furnace in South Chicago the bottom usually lasted about 4,000 to 5,000 heats, with, of course, ordinary settling after each heating. The roof, which was made of silicon brick, usually lasted about 100 to 150 heats. The cost of the roof for a 15-ton furnace was about £12, which worked out at about 2d. per ton for the roof. The point which was particularly brought out in the Paper was the arrangement of the electrodes in the bottom. In practice it was a custom to put a large quantity of lime on to the bottom when smelting, and put the scrap on to that, thus protecting the bottom from the large pieces of scrap. As regards power consumption, at South Chicago, or Worcester, where the 15-ton furnace was in operation, the consumption varied according to the amount of refining necessary. He thought the old idea that electric furnace work depended on cheap water power was a great mistake.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Proceedings of the Royal Society." Vol. LXXXIII. No. A. 565. Series A—"Mathematical and Physical Sciences." (London: Harrison & Sons.) 2s. 6d.

"Optical Instruments Simply Explained." By H. T. Davidge. (London: Percival Marshall & Co.) 6d. net.

"Soldering, Brazing and the Joining of Metals." By Thomas Bolas. 4th edition. (London: Dawbarn & Ward.) 6d. net.

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ELECTRIC POWER IN THE IRON AND STEEL INDUSTRIES.

We give below an account of the discussion that took place at the meeting of the Iron and Steel Institute last week, when Mr. Selby Bigge read his Paper on this subject. An abstract of this Paper was given in our last issue:—

Mr. T. Westgarth said that the Paper was really a consideration of what had been done and what could be done in the utilisation of waste heat. In regard to what had been done to utilise waste heat in England, the speaker cited a case at Barrow where a number of gas engines had been installed for providing the blast for the furnaces and to provide electricity for the works. That also furnished a large quantity of surplus gas, which was taken to boilers providing steam for the steel works engines, and immediately resulted in a saving of 1,500 tons of coal per week, equivalent to about £50,000 a year. In another case they had collected waste steam, admitted it to accumulators, and from these had driven low-pressure turbines to generate the electricity for the works, but they had not thought it wise to go so far as to drive their mills and heavier machinery electrically from that source. He supposed the determining factor was that of capital outlay. It was a serious matter in existing works containing good boilers and steam engines to scrap the plant, and it seemed to be a convenient way of effecting economy to use the exhaust steam in that way. In the case of Messrs. Hickman, they had gone a step further and generated sufficient electricity for their requirements, and were driving a very efficient mill by electricity from the same source. In the case of Messrs. Samuelson, where they had no particular use for surplus energy, they sold their exhaust steam to a power company who distributed the energy generated by low-pressure turbines in the supply mains. The speaker thought that was a very economical way of utilising waste heat. There were many ways of using waste heat, and it was to his mind impossible to lay down any general rule. In view of the diagram shown by the author, however, there seemed to be a very strong argument why one should, if possible, use gas engines.

Mr. C. H. Merz thought that in a good many cases the use of exhaust steam turbines or mixed pressure turbines was advocated where the conditions were not properly looked into. Why was there such a passion for mixed pressure turbines? He thought it was because the installation of an exhaust turbine was a happy medium between scrapping old plant and putting in new. With regard to the vacuum mentioned by the author, there were very few cases in this country where such a vacuum was obtained. The expensive part with exhaust and mixed pressure turbines was the condenser, which, however, the manufacturer was not interested in, and therefore he cut it as fine as possible. Regarding the figures for capital cost given by the author, he thought that they were too low for the average conditions, and did not represent the true state of affairs. For example, two 600 kw. turbines could not be completely installed for £9,000. If they were, then they had been installed in existing buildings, or else the condenser equipment had been cut fine. Mr. Bigge put his interest and depreciation as 12 per cent. per annum. The speaker thought it was absurd to talk about writing off plant of that kind in 20 years. The author gave cost of production as 0·2109d. per unit, but considering the latest type of engines and taking repairs into account, the cost of production was nearer 0·5d. per unit, and then there was no allowance for exhaust steam. There were, of course, conditions where the use of exhaust and mixed pressure turbines was justified, viz., such as in the case of Messrs. Samuelson, where they had no use for the whole of their power, and where the very heavy capital expenditure could be made up by using the plant at absolutely constant and continuous load throughout the year. Those were the conditions under which exhaust turbines would prove satisfactory. He wished most emphatically to say, therefore, that managers of iron and steel works should not jump at the conclusion that the exhaust or mixed pressure turbine was the best, because in a good many cases that was not so. He entirely agreed with the author as to the question of high pressure.

Mr. W. C. Mountain said that the whole thing resolved itself into the question as to what the adoption of exhaust steam would cost and what saving would be effected by its adoption. He thought the author was fairly correct in the figure he gave for the cost per unit. The question of rolling mills was one very prominently before them at the present time. He read a Paper some years ago on electric winding, and the conclusion he came to was that it was doubtful whether electric winding would be commercially successful. That remark applied very well to the question of exhaust steam at the present time.

Mr. H. Crowe asked the author whether the 15 per cent. for auxiliary machinery shown in the diagram included blowing engines, or whether they were not considered as auxiliaries, and had been left out of the diagram altogether. The author did not say whether the blowing was done by gas or steam.

Mr. W. J. Larke said, as to the desirability or possibility of using waste gas in blast furnaces, he knew that when considered from the point of view of thermal efficiency it was not an efficient method of using the available gas, but most of the speakers seemed to agree that the one determining factor in the question was not the thermal efficiency, but efficiency measured in £ s. d.—*i.e.*, commercial efficiency. It was quite impossible to make any statement which would be generally applicable, and he agreed with Mr. Merz that every case should be considered on its merits.

Mr. W. Williams said that the way in which he utilised waste gas was by taking gas from certain blast furnaces and using it for raising steam which was sent down to the steel works. A portion of the exhaust steam was then collected and was used for generating the whole of the electric power and driving the blast to work the furnaces. At the present time they were connecting up further plants, and were very satisfied with the results obtained. He thought the keynote was struck when one said that each case should be considered on its merits. Mr. Merz rather doubted the 28½ in. vacuum, but he, the speaker, had found no difficulty in obtaining it.

Mr. J. Mulholland was in a favourable position for collecting data, and thought it would interest them to know that the high power gas engine had now reached a stage at which the following claims could be made: The first cost of a gas engine driven by waste gas was, if not lower, at least as low as that for first-class steam engines using waste gas in boilers. The cost of repair and maintenance for the gas engine was probably lower than for steam plant, with its boiler, condensing plant, feed-water pumps and economiser; and the supervision of a gas engine using blast furnace or coke oven gas was certainly much less and simpler than the steam plant. The superiority of the gas engine as regards heat economy was, he felt justified in saying, an acknowledged fact among engineers.

Mr. Selby Bigge, in reply, said the gas engine had of recent years been enormously improved and simplified. He thought Mr. Merz's remarks about engineers' love of old plant, and their use of the turbine because it was an easy thing to apply, was a reflection on works engineers. Mr. Merz had said that a vacuum of 28½ in. was not often obtained, but Mr. Williams said he had found no difficulty in maintaining such a vacuum, which was a very ordinary one. He had obtained up to 29 in., but 28 in. was the most usual vacuum to work with. He quite agreed with Mr. Merz that the condenser plant must be big enough. Schemes were often spoilt by putting in condensing plant which was too small. With regard to writing off the cost in 20 years, he would be sorry to advocate a scheme with mixed pressure turbines which could not show a return of the capital in three or four years. He thought that his allowance of 12 per cent. for interest and depreciation was a fair figure. He had found the actual cost of production to be invariably below 0·25d. per unit, otherwise it was not worth applying the exhaust turbine. He had obtained the opinions of those who had had actual experience with mixed pressure turbines. Everyone confirmed the figure which he had put forward, by stating that they were producing their electricity at ¼d., or even lower, per unit. Mr. Merz had said that the figure for capital outlay was too low. They were exact figures, however, taken from an actual case. In reply to Mr. Crowe's question as to whether the blowing engine was included in the figure of 13 per cent. for auxiliaries, the engine was included if it were a gas blowing engine, but not otherwise.

Electricity Supply in Vienna.—A recent issue of the "Neue Freie Presse" contains a review of the large electrical enterprises carried out by this municipality during the administration of the late mayor, Dr. Lueger. The original municipal electric power plant was completed by the Austrian Schuckert Works in 1901, at a cost of £1,326,800, but with the additions since made, the total investment has reached £2,520,400. After a bitter struggle, the municipality managed to secure possession on May 1, 1908, of the International Electric Co. for £764,400, and of the Vienna Electric Co. for £212,000. The municipality endeavoured to buy up the private companies as early as 1901, and while it connected its system to dwellings, Dr. Lueger forbade the private company to do the same thing. The city endeavoured to get the police to carry out this prohibition, but this aid being refused, the Mayor made use of the fire department in destroying connections installed by the private companies. In consequence of this arbitrary action and the evident determination of the municipality to control the electricity situation at any cost, the private companies sold their properties. Up to the present time, the city has succeeded in paying all fixed charges on its electrical investment and during the last year had even a surplus of £210,000. This profit, however, has only been obtained by reason of the very high price charged for energy taken by the municipal street railway system, so that it is a case of robbing Peter to pay Paul. Moreover, the original estimates for the cost of the completed system were exceeded by £900,000, and the consumers have had no benefit from municipal ownership through any reduction in the price of electrical energy. The ambition of the municipality to have a complete monopoly of electricity supply has not yet been achieved, as there is still a private company known as the Austrian General Electric Co. which carries on a large business.

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SPECIAL NOTICE.

In consequence of Friday, May 20th, having been appointed a day of National Mourning in connection with the obsequies of His late revered Majesty King Edward VII., THE ELECTRICIAN will be published on Thursday morning, May 19th, instead of Friday morning, May 20th.

Contributions, Correspondence, Advertisements and other matters intended for next week's issue should therefore reach us not later than first post Wednesday morning, May 18th.

ECONOMY IN THE BOILER HOUSE.

In the earlier days of electric power stations every attention was given to the electrical side in regard to efficiency, but comparatively little consideration was bestowed upon the operation of the steam-raising portion of the plant. Perhaps this was a little natural, for the average electrical engineer had been reared with electrical ideas as his main principles in life. It was comparatively easy to know how one stood in regard to electrical losses and losses in generation, and they were more easily fixed once for all than in the remainder of the plant, so that the boiler house received the smaller share of attention. This attitude towards steam generation has been somewhat general, as is rendered evident by a consideration of water softening. At one time it was quite a common practice to use boiler fluid and thus to use the boiler as a kind of water softener, generally with very undesirable results; or, not unfrequently, no attempt at softening of any kind was made. Fortunately, it has been realised of recent years that water softening should take place not in the boiler but outside it,

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and that any outlay on a water softener is very soon repaid by the very much smaller consumption of coal and the better condition of the boilers. In that respect present practice is more enlightened than it used to be.

It is, however, also necessary to remember that the heating side of the tubes or boiler surface is in many respects as important as the water side. Those engineers who have worked on refuse destructors in conjunction with steam-raising plant know very well the marked effect produced by dust in diminishing the steam-raising power of a boiler. Dust is difficult to deal with, because it lies somewhat thickly and very soon collects, thus preventing the transmission of heat from the flue gases. What is true of dust is also true, though to a less extent, of soot, for this is by no means a good conductor of heat; and although the soot and pitchy matter take a longer time to collect than dust, their effect is certain to be shown in a reduced evaporative capacity of the boiler. So far this effect has not attracted very much attention on the part of engineers, but we are glad to see that Mr. P. J. PRINGLE, electrical engineer to the Burton-upon-Trent Corporation, has now taken the matter up with very considerable success.

Mr. PRINGLE'S attention was first directed to the subject by tests on the flue gases and by attempts to get a larger percentage of CO_2. In overhauling boilers it is usual to brush down the outer surfaces with a hard brush. This frees the surface from any serious collection of soot or soft deposit, but it does not go far enough. This point has, no doubt, been appreciated by the makers of economisers, in which scrapers are continually in motion. A somewhat similar method of cleaning the soot from the boiler and tubes has now been adopted by Mr. PRINGLE, who periodically scrapes them down with hard steel scrapers so as to get as near the metal surface as possible. The deposit was found to be of a hard, ashy nature, varying in thickness from $\frac{1}{32}$ in. to $\frac{1}{8}$ in., but becoming more tough and pitchy towards the cooler parts of the flue. If the usual sooty deposit is added to this there is a total thickness of as much as $\frac{3}{8}$ in. in some parts.

The scraping is carried out at periods of two months, or after about six or seven weeks' service, and at a cost of about 15s. per boiler. The result of this treatment has been a very marked increase in the efficiency of the boilers. Perhaps this result is shown most simply by remarking that during the past year there has been a saving of 14·8 per cent. in the total amount of fuel used, compared with that in the previous year, notwithstanding that the output has been slightly greater during the 12 months ended March 31st last. The saving, however, is considerably larger than is indicated by this figure, since greater use is being made of poorer grades of fuel. In fact, the saving is more clearly indicated by stating that the coal bill for the period in question actually showed a reduction of 27·6 per cent. It is interesting to notice that out of about 280 undertakings for which statistics are available there are only 30 having a lower fuel cost per unit than that obtained at Burton-upon-Trent. Considering that the undertaking is not large, and that the yearly load factor is only about 20 per cent., this performance must be considered as extremely satisfactory, and we hope that other engineers will take the matter up and pursue the subject so ably tackled by Mr. PRINGLE.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Leçons d'Electrotechnique Générale. By P. JANET. 3rd edition. Vol. II. (Paris: Gauthier-Villars.) Pp. iv. + 325. Fr. 11.

The second volume of the third edition of this work has followed quickly upon the first, which was reviewed in these columns during the early part of the year. The book before us is in every way a companion volume to the first, which dealt with general principles and continuous currents. The treatment of the subjects is thus not at all of a descriptive nature, but is rather a mathematical study of the properties of alternating currents and alternating current apparatus. This volume then will again appeal to the advanced rather than to the elementary student.

The book consists of eight chapters, the first of which is devoted to a general study of harmonic functions, vector diagrams being carefully treated. The second chapter deals very fully with sinusoidal alternating currents, and the third with non-sinusoidal. Fourier's series and its applications are gone into at considerable length, and a useful table is given for the analysis of wave forms containing odd harmonics up to the seventeenth order. The fourth chapter, on alternators, is chiefly devoted to the theory of windings, and to the wave shape. The effect of the distribution of the armature conductors, and the influence of the armature teeth upon the resulting wave shape are both discussed at some length. The various devices adopted to eliminate harmonics are briefly mentioned. A short chapter follows on choking coils, and then a fairly long chapter on the theory of transformers. The theory of the transformer is attacked from both the mathematical and graphical points of view, the circle diagram being very fully treated. The final chapters are devoted to the characteristics of alternators with constant reactance, and the armature reaction of alternators with variable reactance. Blondel's and Potier's methods are both given at considerable length.

The treatment of the subject matter is very uniform and very thorough, and so far as we can see the author has omitted no point likely to be of theoretical interest. Extensive bibliographies follow the chapters on transformers and alternators, and these should be very valuable to the student who has the standard French technical papers at his service.

The parallel running of alternators, the compounding of alternators, converters, alternating-current motors and transmission of power are dealt with in the third volume, which has not yet been published in its third edition. When the series of these three books is completed it will form a very useful text book for the advanced student who has a liking for mathematics. The intending purchaser should remember that the books are supplied in thin paper covers, so that he will find it necessary to have them re-bound. A. E. CLAYTON.

Die Vektoranalysis und ihre Anwendung in der Theoretischen Physik. By Dr. W. v. IGNATOWSKY. Vol. VI. of "Mathematisch-Physikalische Schriften für Ingenieure und Studierende." Edited by E. Johnke. (Leipzig: B. G. Teubner.) Pp. vi. + 102. M 3.

The extensive use of vector analysis in all branches of mathematical physics, and more particularly in electromagnetism, has created a demand for a good introductory treatise on the subject. Such a treatise can only be written by a thoroughly competent mathematician, as it is essential that the reasoning should be rigorous, and that the limitations of the theorems should be accurately stated. Judging by the first volume of this book we think that it meets the demand.

The author not only gives a thorough discussion of the differential and integral operators used in vector analysis, but he also gives geometrical illustrations of their meaning. We were surprised that no reference is made to Heaviside's excellent work on this subject. Many physicists in this country believe that the word "curl," which mathematicians use for the process by which current is derived from magnetic force, is

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due to Heaviside. As a matter of fact he popularised it, but Maxwell was the first to propose it.

In a footnote the author tells us that "curl" is an English word, but he leaves the reader to decide whether it is derived from a "lock of hair" or a "cork-screw."

This volume is exclusively mathematical, and the rigorous reasoning of the mathematician is apparent on every page. Although the subject is a difficult one, the absence of superfluous physical illustrations which cumber many other books on this subject makes progress rapid. We can cordially recommend this book to all physicists and engineers whose knowledge of mathematics is sound and extensive. A. R.

Funktionentafeln mit Formeln und Kurven. By Dr. Eugen Jahnke and Fritz Emde. Vol. V. of "Mathematische-Physikalische Schriften fur Ingenieure und Studierende." Edited by E. Jahnke. (Leipzig: B. G. Teubner.) Pp. xii + 174. M.6.

To physicists and engineers having a slight knowledge of Bessel's, elliptic, and hyperbolic functions we can heartily recommend this book. Many exact solutions of important practical problems have been obtained in terms of these functions, and this book enables the mathematical engineer to utilise such solutions.

The practical man frequently rails at the mathematician for using a notation with which he is unfamiliar. He may be familiar, for instance, with Legendre's notation for elliptic integrals and would welcome a formula containing these functions. The mathematician, however, generally prefers to give his results in Gudermann's, Jacobi's or Thomæ's notation. We have even come across a formula for the mutual inductance between two coils in which the functions were given in Weierstrass's notation. We have known students who have attempted to wade through mathematical treatises which were hopelessly beyond their depth in order to find out how such functions are computed. If lucky, they may come across some weird series which will enable them to compute the function, possibly after great labour. To men of this type this volume will be invaluable, for not only are tables of the numerical values of the functions given, but also the various definitions, notations and formulæ for the functions.

From personal experience the reviewer can say that the possession of this book ten years ago would have saved him weeks of hard arithmetical labour. He is looking forward to using it frequently in the future. The only errors he has noticed are those in the tables for the ber and bei functions. The corrections for these tables will be found in Papers by Dr. A. Russell and Mr. H. Savidge read recently before the Physical Society of London. A. R.

PLATINUM RESISTANCE THERMOMETRY AT HIGH TEMPERATURES.

In a recent issue of the "Bulletin of the Bureau of Standards" particulars are given of an investigation carried out by C. W. Waidner and G. K. Burgess to determine the advantages and limitations of platinum resistance thermometers at high temperatures, especially with reference to reproducibility of scale, method of calibration, formulæ best expressing the relation between resistance and temperature, effect of impurities in the platinum wire, changes due to high temperatures, and the most satisfactory method of construction and use. The reproducibility of high temperatures by the melting or freezing points of metals obtained from different sources and furnished as chemically pure was also studied.

Eleven resistance thermometers were used, made of wire of varying degrees of purity and of various sizes from 0·1 mm. to 0·6 mm. diameter, and with resistances, R_0, ranging from 0·11 ohm to 21·5 ohms. Two of these thermometers were made of pure palladium wire 0·3 mm. diameter, while the other nine were of platinum. Three types of thermometer were used, which may be briefly designated as compensated lead type, potential terminal type, combined compensated lead and potential terminal type. In the compensated lead type, due to Callendar, two fairly large platinum leads (preferably over 0·6 mm. diameter), as nearly identical as possible with the leads to the coil, run down the stem of the thermometer, and are connected at their lower ends. When these leads are put into the arm of the Wheatstone bridge adjacent to the arm in which the thermometer coil is inserted the thermometer is compensated for variations in temperature of the leads to the coil, due to variable depth of immersion. To compensate for the effects of heat conduction from the coil along the heavier platinum leads, the ends of the compensating leads are joined by a short length of fine platinum wire of the same size as the wire of which the coil is made. In thermometers of the potential terminal type two leads are fused to each end of the coil. In this type of thermometer both the current and potential leads may obviously be made of much smaller wire than for the compensating lead type. The method of using this thermometer consists in comparing the P.D. at the terminals of the coil with the P.D. at the terminals of a known resistance carrying the same current. In thermometers of the combined compensated lead and potential terminal type the current leads should be made of fairly large wire to secure better compensation.

The investigations are described in detail by the authors, and the following general conclusions are reached.

Temperature Scales.—Temperatures defined by the resistance thermometer of pure platinum calibrated by Callendar's formulæ at 0 deg., 100 deg. and 444·70 deg. (the boiling point of sulphur), agree with temperatures on the generally accepted gas scale in the range 0° C. to 1,100° C., to within the degree of reproducibility of the latter. Thermometers made of impure platinum, and calibrated in the same way, do not define the same temperature scale as that of pure platinum, the divergence increasing with the impurity of the metal. If thermometers of impure platinum are calibrated at a fourth temperature, such as the silver freezing point, and the difference coefficient of the Callendar formula is written $\delta = a + bt$, then the scale so defined by these thermometers is brought into very close agreement with that of the thermometer of pure platinum.

The Dickson formula $(R + a)^2 = p(t + b)$ is not applicable to either platinum or palladium thermometers at high temperatures. The palladium thermometer, calibrated by the Callendar method, gives temperatures agreeing to 1 deg. with the scale of the platinum thermometer up to 600 deg. It requires a fourth degree equation to express its resistance temperature relation from 0 deg. to 1,100 deg.

The table below of freezing points represents the scale of the resistance thermometer of pure platinum as determined from this investigation, using only the purest metals.

Thermocouples of *Pt*, 90 *Pt*–10 *Rh* and *Pt*, 90 *Pt*–10*Ir*, calibrated at three temperatures in terms of the formula $E = a + bt + ct^2$, define a temperature scale in the interval 200 deg. to 1,100 deg., which is in agreement with the platinum resistance scale at intermediate temperatures to within 0°·3.

Behaviour of Platinum Thermometers.—When used at high temperatures the constants of platinum thermometers undergo gradual changes, which necessitate frequent recalibration in work of high precision. The use of thermocouples for work above the freezing point of silver is therefore much less laborious. These changes in thermometric constants are greatly reduced, but not completely eliminated, by annealing the thermometers for at least several hours at a temperature higher than that at which they are subsequently to be used. For thermometers of pure platinum, the changes in their constants after the thermometers have been annealed, are very much less than for those of impure platinum; thus, R_0 changes only by a few tenths of a degree for pure platinum, but by several degrees for impure. These changes are least for pure platinum wires of large diameter and suspended free from strains. For such thermometers, made of wire 0·6 mm. in diameter, R_0 changed by only a few tenths of a degree after repeated and continued heatings at 1,200 deg. to 1,300 deg.

For impure platinum wire the effect of high temperatures is to decrease R_0 and to increase the fundamental coefficient, ϵ, that is,

Metal.....	Sn.	Cd.	Pb.	Zn.	Sb.	Al.	Ag_2Cu_2	Ag.	Cu.	Cu_2O
Freezing point	231°·92	321°·01	327°·43	419°·37	630°·71	658°·0	779°·20	960°·9	1083°·0	1063°·2
Average deviation for purest metal	0·02	0·02	0·10	0·02	0·30	0·5	0·25	0·20	0·5	0·3
Reproducibility factor	0·06	0·26	0·10	0·06	2·3	1·2	..	..	1·0	..

The average deviation of a single observation is a measure of the precision attained when two or more thermometers were used in a single metal sample. The reproducibility factor is the average deviation of the metals, designated as C.P. or better, from their mean freezing point.

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the effect is as if the wire became purer, possibly because of the evaporation of impurities, for example, iridium. If the platinum is pure, the slight changes indicate a contamination of the wire and the effect of strains, as is evidenced by decrease in c and the increase in R_0. The total change observed is a resultant of the effects of strains, of annealing, and of contamination and purification. In the use to which these thermometers were subjected in this investigation, the changes in the value of δ were almost within the limits of experimental error. For impure platinum there is evidence of a slight decrease in this constant.

Calibration Temperatures.—The freezing points of the pure metals are the most satisfactory calibration temperatures, being superior to boiling points in constancy, ease of manipulation, and reproducibility. Unless a very slow rate of heating is used, melting points are less satisfactorily fixed and apparently slightly higher than freezing points.

The temperature of the separation of the silver-copper eutectic is an entirely satisfactory fixed point at 779°·2, when the alloy is of the eutectic composition, or about 72Ag–28Cu. The eutectic point of copper-cuprous oxide is also a satisfactory calibration temperature at 1063°·2, when proper experimental precautions are taken to maintain the eutectic composition.

Boiling Point of Sulphur.—The temperature defined by the vapour of sulphur boiling at known pressure and under carefully specified conditions is a most satisfactory fixed point, reproducible to a few hundredths of a degree. These conditions are briefly: (*a*) Sulphur to be boiled in a glass tube 4 cm. to 5 cm. diameter and of sufficient length to insure ample depth of immersion in the vapour (tube about 40 cm. satisfactory). (*b*) Sufficient depth of liquid sulphur to avoid superheating, a criterion for the above conditions is absence of change in the observed resistance when the thermometer with its attached radiation shield is moved some centimetres up and down the tube). (*c*) Surrounding the coil of the thermometer with a suitable radiation shield to avoid the cooling effects of the condensed sulphur running down the stem of the thermometer and of radiation to the cooler parts of the apparatus.

Both gas and electrically heated sulphur boiling point tubes were used; the former gave a temperature 0°·03 or 0°·04 higher than the latter.

The determinations of the sulphur boiling point by different observers is discussed at length. The determinations of these observers are in satisfactory agreement, the values found ranging, with one exception, from 444°·5 to 444°·7. The bearing of some recent work with the gas thermometer on the value of the sulphur boiling point is considered, which shows that the above value may be too high. The evidence, however, is not sufficient as yet to warrant any change in the generally accepted and widely used value of the sulphur boiling point.

S. G. BROWN'S TELEPHONE RELAY.

The Paper read by Mr. S. G. Brown last week at the meet- of the Institution of Electrical Engineers, and of which we gave an abstract in our last issue, aroused great interest. We give below an account of the remarks of those speakers who contributed to the discussion;—

Mr. J. E. Taylor said that on the first occasion when he saw Mr. Brown's relay he was not quite so much impressed with the instrument as he had expected. It certainly did magnify sounds very considerably, but it appeared to be a little unstable in its action. However, at a later date his views were considerably modified. He found that, provided one could get suitable points and a good instrument to start with, it would maintain its adjustment and keep its magnifying properties without a great deal of variation, and he could testify to the fact that it was capable of picking up wireless telegraph signals which were entirely inaudible on the ordinary telephone receiver. Signals which were just audible were very considerably magnified, probably something like 20 times, as the author had stated. He believed that the reason why the instrument did not behave so well on the first occasion as on the second was that the upper contact point had got slightly flattened. He asked the author whether it was necessary that extreme care should be paid to keeping the point of the upper contact as perfect as possible in order that the magnifying power of the instrument should be properly maintained, and its reliability and constancy assured. Regarding the author's new form of microphone, he was much struck with the volume of sound which it was possible to obtain at the end of an artificial line representing 60 miles of standard cable. When it was considered that 43 to 45 miles of standard cable was the utmost length of that type of cable which could be reliably spoken through using ordinary telephone apparatus, and that through the 60 miles of cable which Mr. Brown employed he had heard the speech quite plainly, one would appreciate that the instrument was capable of giving considerably better results than any carbon microphone, at any rate under laboratory conditions. It was a little early to predict what utility there might be for the new appliances, but he thought the instruments were extremely interesting and suggestive of future progress.

Mr. B. Davies referred to the work carried out by Sir Oliver Lodge on this subject some 10 or 11 years ago. Sir Oliver worked with carbon, which at that time was about the only material one could think of that would act successfully, and carbon, as a matter of fact, was in its microphonic qualities excellent. If one traced the characteristic curve of carbon—*i.e.*, the curve representing the relation between the current and the pressure exerted on the carbon points—it would be found to be excellent in itself, but, curiously enough, it was difficult to obtain. An experiment was performed some 10 years ago by Sir Oliver to show that, if a carbon point were fixed to an arm of a balance like that of the Kelvin balance—and underneath another carbon fixed to the supports, whilst at the other end one had two coils, one fixed to the arm and the other to the supports, it was possible in that way to vary the pressure, however light, exerted between the carbon points without disturbing the system and one could draw the curve very nicely. If, however, the pressure were suddenly released, the chances were that the original curve could not be regained. He asked whether the author had obtained such a curve for his relay. Sir Oliver's primary object was to produce a monotone instrument. In this he was signally successful, the instrument giving remarkable results. The difficulty with the carbon when used for the voice was that although the speech was moderately good for one instrument, there was a loss in articulation on working in tandem which was rather serious. With regard to two relays in series, he asked the author what results he had obtained in that way. Ten years ago it was thought that a great deal of the loss was due to the carbon itself. The power was frittered away, due to the want of elasticity. The hardness of materials was certainly a most important point in the author's relay. He asked the author if he had tried the relay on a really long line. There was no getting over the loss in the line itself—the loss of articulation due to distortion. As they knew that the author's instrument would really magnify well, and, he supposed, articulate well also, it might be possible to work on distortionless lines—*i.e.*, lines supplied with proper leakances in order to get the maximum articulation. They were far from that at the present time. He then showed one of Sir Oliver Lodge's instruments. The whole instrument was suspended by means of springs in order to suppress the effects of extraneous noises and mechanical tremors.

Prof. J. Perry asked Mr. Davies whether the instrument was for the transmission of one musical note.

Mr. Davies: Yes. Sir Oliver's experiments on speech were made with instruments that were aperiodic, but owing to the loss in articulation they were not so successful as the monotone experiments.

Dr. Voysey, although he could not pretend to understand the technical details of the relay, appreciated its application to the purpose of an electrical stethoscope. He had tested such a stethoscope in the out-patients' department of a hospital and over the telephone and had been much impressed by it. What might be the ultimate practical value of the instrument it was yet difficult to predict. It might enable us to demonstrate that what were now regarded as simple sounds were in reality compound, and it might be the means of splitting them up into their constituents. It might enable us to determine the exact relationship in time between the occurrence of the heart contraction and the heart sounds. Clinically, it might render it possible to detect sounds in the body which at present we might suspect to exist, but had been unable to hear owing to the fact that our capacity had been limited to the sensitiveness of the ear itself. For instance, we might hear a sound caused by the friction of gall stones in the gall bladder, of calculi in the kidney, or of the passage stream along an aorta roughened disease. It would be very difficult to damp down or exclude extraneous sounds or to tune the instrument at will to different sound wave-lengths, but Mr. Brown had already solved so many difficult problems it would be a bold man who would deny him this success.

Mr. J. F. Kingsbury said he would like to fill in part of the gap from the author's opening statement to where he reached his own relay. He did not think the author did complete justice to the workers in the intervening period. In 1905 there was a patent No. 11,605 standing in his (Mr. Kingsbury's) name as representative of the owners, which represented a repeater known as the Shreeve repeater. This was unquestionably a practical telephone relay. He spoke through it some five years ago himself, and it had been continued in every day commercial use. He thought, therefore, the credit should be given to Mr. Shreeve for having solved the practical difficulty of the telephonic relay. There had been a demand for a telephone relay for a long time. The first patent for a repeater was taken out by Gilliland in 1881. He said that there should be a demand for a repeater for telephones as there had been a demand for repeaters in telegraphs. That was so, but it was true that the demand had not been filled in such a way that it could be regarded as a satisfactory method for general adoption. The repeater which had been employed had not been used largely. It was subject to drawbacks in the shape of adjustments, which experience only would overcome. He expressed his appreciation of Mr. Brown's relay, but said it must be realised that there were still difficulties to be overcome. A relay that talked only one way was not a practical system. As to the construction, Mr. Brown had, undoubtedly, gone on new lines, but he (Mr. Kingsbury) sometimes wondered in looking over Mr. Brown's description whether the two metallic contacts were not somewhat akin to the Berliner microphone. Of course, the automatic adjustment arrangement was entirely different from anything that Berliner ever thought about. The transmitter also was very satisfactory, but he wondered whether the author had not been somewhat misled by the statements which he quoted from authorities in

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regard to carbon. Carbon had been, whether the subject of a patent or not, invariably used for telephonic purposes. That it was the best that had come before the experimenters he took for granted from its continual use.

Mr. B. S. COHEN emphasised the point mentioned by Mr. Kingsbury as to the action of the transmitter in the relay. Some tests had been carried out in the National Telephone Co.'s laboratory on both the telephone relay and the metallic granule transmitter. The results obtained with the relay were not quite so good as those obtained by the author, but that was probably due to want of experience in adjusting the apparatus, although considerable time was spent in preliminary adjustment. With one relay placed at the centre of a line, the improvement due to the relay was equivalent to 19 miles of standard line, judging purely by volume. Articulation tests were then carried out on 44 miles of standard cable with a relay in circuit and on 25 miles without the relay. It was found that the number of words missed was 55 per cent. more with the relay than without, so that the articulation with equal volume was about 55 per cent. worse with the relay. The lengths of cable were then readjusted to give equal audibility, which, of course, included both volume and articulation. The result was that the relay gave a net improvement of 8 miles of standard line. Of course, that appeared to be very little, but it had to be borne in mind that 8 miles of standard line would represent about 250 miles of trunk line. It had also to be remembered that the improvement would be considerably reduced when double repeaters working both ways were used. The Shreeve repeater referred to by Mr. Kingsbury was in use on several long lines in the United States by the American Telegraph & Telephone Co. It was generally used in series at the middle of the line whose total length was not less than about the equivalent of 12 miles of standard line. With shorter lengths some trouble was experienced. To get the best results the repeater had to be at the exact centre of the line, so that the line on each side of it balanced. More than one repeater could be inserted in a line; for example, on one of the long lines running from Boston, 1,500 miles long, three repeaters were worked in series, and the net improvement was 18 miles of standard line. The results obtained with the author's metallic transmitter were decidedly encouraging. Under favourable conditions the transmitter gave an improvement for the commercial common battery transmitter of about 10 standard miles and the articulation was good. It would be realised from that figure that the transmitter was quite promising provided that the commercial product could be turned out in bulk with the same efficiency. It was unfortunate that the author had been unable to design an instrument of that type capable of working on the standard common battery circuit. That limited its usefulness. It was to be hoped that the author would be able to overcome that difficulty. Undoubtedly, a considerable amount of work was still necessary to make both the relay and the transmitter of value for practical telephonic purposes.

Mr. A. C. BOOTH had experimented with Mr. Brown's relay during the last three months. It was first tried for intensifying the received signals at radio-telegraph stations, and gave very promising results, magnifying the received signals from 4 to 12 times. It had also been tried for working as a repeater for telephone purposes—*i.e.*, it was placed in the middle of an artificial telephone line of 68 miles of standard cable—with the result that the speech at the end of this line was very little inferior to that over 34 miles of standard cable without the relay. When the line was put direct through 68 miles speech was practically nil. As a further test the relay was placed half way along 108 miles of standard cable, and although conversation was out of the question, one could clearly distinguish that speech was being transmitted, whereas without the instrument the 108 miles of cable were absolutely silent. As regards actual trunk line working, they had not yet more than commenced that stage of the experiments. Having dealt with the practical advantages of the instrument, he next referred to its weaknesses. In the first place, although the adjustment was simple, it had been his experience that the instrument took time to settle down to its work; sometimes more than an hour had been spent continually regulating before good results could be obtained (that, of course, might be due to insufficient experience). Secondly, in regard to radio-telegraphy, the detectors were as a rule absolutely silent except when signals were being received, whereas the relay gave a very slight, but appreciable, noise, due to its microphonic qualities. This noise was not the whistling or humming that arose with a too sensitive adjustment, and although so small it seemed to have a disturbing effect on the operators, who, it must be remembered, had to wear headgear telephones for several consecutive hours daily. As regard trunk telephone circuits, it was obvious that such a very sensitive instrument would magnify any defects or disturbances that might exist upon a line, and as a rule the longer the line the greater the number of minor defects, and it was on the long lines that such an instrument would be used. Then as regards the to and fro conversation, the switching necessary for this was certainly a disadvantage, and if the public were paying 10s. for three minutes he was afraid the switching operations would appear to occupy more time than the conversation. The instrument had not been in use sufficiently long to give any idea as to its stability under continuous working conditions, and he fancied that some slight re-regulation would occasionally be necessary. This, of course, was another weakness, as the telephone public expected perfect speech with no lost time, quite irrespective of the length of line employed. In conclusion, he considered that Mr. Brown's invention marked a very long stride in the direction of that most desirable object, a perfect telephone repeater.

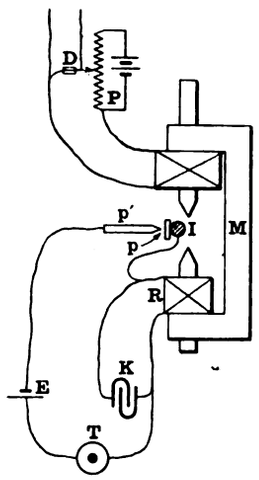
Dr. W. H. ECCLES confined his remarks to the application of the telephone relay to wireless telegraphy. A disadvantage about relays was that they would magnify atmospheric and other disturbances as well as the sounds received from the station. Last year he had been working on one which tended to be acoustically selective; in fact, if one took Mr. Brown's relay and put instead of a reed an iron wire and stretched the wire so that its natural frequency was equal to that of the singing notes used in modern wireless telegraphy, regulating the gap in the same way as the author did, one then had the relay which he, Dr. Eccles, had brought with him to that meeting. This relay (*see* diagram herewith) was based on almost the same principle as that of Mr. Brown, except that it was selective, having a free wire instead of a damped reed. One difficulty he found with this selective form was that it did not select perfectly. The fact was that when one put a singing wire very near to a point in oil one got such considerable damping that the possibility of getting perfect selectiveness was much reduced. He thought this was one of the chief objections against good selectivity. He usually worked on the Clifden signals as heard in London up till last December. They were very faint, and although he could get them magnified two or three times, he found that one of the vices of the instrument was that it quickly started singing on its own account and would go on for five or ten minutes. p' and I (*see* diagram) were on one support, M on another. The contact pp' was made very lightly at a distance from the poles of M, and then the two supports were moved towards one another till the contact pp' opened very slightly. If x was the thickness of the air film or oil film at the contact, $x\rho$ its electrical resistance, R the resistance of the regulating coil, a the film thickness in the undisturbed position of the wire, the restoring force on the wire was given by

$$F \propto x - a - \left(\frac{b}{R + x\rho + c}\right)^2,$$

where b and c were constants governed by the E.M.F.s at E and P. Thus

$$\frac{dF}{dx} \propto 1 + 2b\rho \frac{\sqrt{x-a}}{(R+x\rho)^2}$$

in the equilibrium position—which was thus seen to be remarkably stable. At the beginning of the Paper the author referred to the theory of gases and the passage of ions across a very narrow air-gap, and then proceeded later in the Paper to put oil in the gap to get rid of the air. He (Dr. Eccles) agreed with Mr. Cohen's supposition that a main point in the explanation of the relay was that the resistance of the thin film of oil at the contact (nothing was a perfect insulator) altered with variations of the thickness. Taking that, one could get a good idea of the size of the gap that was maintained by the automatic regulation devised by Mr. Brown. Some years ago Dr. P. E. Shaw measured by the method of electrical touch that the minimum audible sound involved a diaphragm movement of 0·7 milli-micron, or 0·028 of a millionth of 1 in. Further, by the same method Dr. Shaw measured displacements as small as 0·016 millionth. This measurement proved, by the way, the possibility of electrically relaying inaudible motions. Taking this change of thickness as causing about one-half of 1 per cent. variation of the film resistance, it was found that the conduction space in Mr. Brown's instrument must be not greater than, say, about 4-millionth inch, a distance including about 100 molecules. Now, the half wave-length of blue light (the limit of microscopic vision) was about 6-millionth inch. From these figures one could appreciate the beauty of the automatic adjustment developed to perfection by Mr. Brown. He, the speaker, as also another experimenter with the same crude instrument here shown, had not achieved success, and, therefore, the more warmly congratulated Mr. Brown on his wonderful instrument.



D. Detector connected in a receiving circuit. P. Potential divider. M. Soft iron magnet energised by steady current through detector. I. Cross section of iron wire stretched to acoustic resonance with signals. p, p'. Platinum contacts. K. Condenser. T. Telephone. E. Voltaic cell. R. Regulating Coil.

Mr. E. H. RAYNER asked whether it was necessary to have the point of negative polarity, or could it be positive?

Mr. BROWN said it was advisable to have it negative, as it worked better. The reason was the same as that for which the small carbon in an arc lamp was made negative. The ions flowed better to a small point.

Mr. RAYNER, continuing, said that the author mentioned the use of invar for the reed only. Was that for magnetic or mechanical purposes? Would it be an improvement to use invar more extensively to keep the dimensions constant and to avoid temperature changes?

Mr. BROWN said that invar was used for the purpose of keeping the temperature constant and to keep the reed from warping, as it was likely to buckle under the effect of temperature. Of course, it would be better if the whole of the instrument was made of invar, but they had not got as far as that yet.

Mr. D. H. KENNEDY said that with Mr. Booth he compared the effect of having the telephone relay in the middle of 68 miles of cable as against speaking over a cable 34 miles long without the relay. The former gave louder results, but the second case gave better articulation. There was a little difference in the quality, but it was not great; in fact, not more than one was accustomed to find in changing from one transmitter to another. Subsequently, he listened to the same voice speaking through 108 miles with the relay at the centre, and he was able to follow what was being said. When the relay was cut out the cable was quite dead. On the question of adjustment, when making the above trials he put the

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instrument slightly out of adjustment, but he found no difficulty in getting it back into adjustment. He was struck with the wonderful way in which the milliampere-meter needle followed the movement of his hand on the adjusting screw. He had also heard at London the effect of speaking from Glasgow with the relay in circuit; there was greater audibility, but, unfortunately, there was also a great increase in the extraneous noises. That, of course, was one of the lines for further investigation by Mr. Brown, also the question of reversibility. He did not know whether the author had considered the possibility of using the instrument in the same way as the telegraph local sounder relay was employed—that is, to have a relay at each of two stations with a switch in the receiver case to alter the connections so as to cut in the relay when listening, and the transmitter when speaking. He also asked had any oscillograph records been taken. On the question of carbon, he thought it had been definitely shown that carbon did not change its resistance under pressure and that the microphone phenomenon was one which depended upon greater or less intimacy of contact between the particles. Finally, he thought that the instrument would really increase the distance over which telephone speech would be possible and it was, therefore, a very definite and noteworthy achievement.

Mr. W. M. MORDEY read a passage from the discussion on a Paper on "A New Telephone Transmitter," by John Munro, in March, 1883. Prof. Hughes, the inventor of the microphone, in speaking on the question of carbons, said "The point brought out by Mr. Munro is one which I tried to point out in my first Paper, viz., that by means of metallic contacts we could transmit speech just as well as with carbon by employing a number of contacts." Again, Mr. Munro, in the Paper, stated: "For the carbon microphone is now shown to be only *one* illustration of Prof. Hughes' wide discovery that a delicate contact between any two *conductors* has the property of transmitting sounds. The Reis original transmitter, with a delicate platinum joint, is seen to have been another illustration of the same phenomenon. Prof. Silvanus Thompson has recently presented proof that Reis did send articulate words by his transmitter; and I believe there is no doubt he did. I have myself heard by telephone, and understood, single words spoken direct to the platinum contact of a Reis transmitter. Reis, then, employed a platinum microphone, without knowing it, as early as 1861; and Edison used a carbon microphone, without knowing it, in 1877. The discovery by Prof. Hughes in 1878 threw a flood of light on both inventions." He (Mr. Mordey) did not bring those two statements up in order to lessen the credit due to the author, but merely to remove any impression that there was anything new about using metal itself for telephonic purposes.

Prof. J. PERRY said that the theory of the instrument was exceedingly simple, and that he would communicate it for publication in the "Journal."

The CHAIRMAN (Mr. S. Evershed) drew attention to the fact that the author's instrument was not, strictly speaking, a relay. No complete telephone relay had ever been invented, nor had any approach to one been made. In the case of telegraphy we used an instrument which enabled the feeble currents which arrived at the far end of the line to be restarted, or rather new currents were started, precisely the same in value, number, frequency and duration as those transmitted from the original station. Such an instrument might, he thought, legitimately be called a relay; but when one came to telephony the problem was totally different. In telephonic speech currents, in the first place one had a large number of waves of different frequencies and amplitudes. They all started out in the right phase relation, amplitude and frequency for articulate speech, but they arrived at the far end of the line with their amplitudes all out of proportion and their phase relations all wrong. A true telephonic relay must therefore not only restore the original amplitudes but also restore the waves to their original shape and phase relation. He was not at all sure that it was not an impossible problem to solve. In conclusion, the speaker was very much struck with the possibilities of Mr. Brown's repeater for wireless telegraphy.

Mr. S. G. BROWN reserved his reply to the discussion for the "Journal."

CORRESPONDENCE.

EFFICIENCY OF SHORT SPARK METHODS OF GENERATING ELECTRICAL OSCILLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having just read with unpraiseworthy delay the controversy contained in recent numbers of THE ELECTRICIAN regarding the efficiency of wireless telegraph plants, I think it may be useful to point out how a simple test can be effected.

On switching the aerial off and on, different R.M.S. currents i_1 and i_2 are to be read in the primary oscillatory circuit. In most wireless telegraph plants the power supplied to the primary oscillatory circuit remains invariable with or without the aerial; the power in any manner wasted through action of the primary oscillations can be expressed by Ki^2, where K is a constant of the particular plant under test. It follows that the efficiency of transference of energy from the primary circuit to the aerial is

$$\frac{i_1^2 - i_2^2}{i_1^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

When there is a doubt as to the exactitude of premises stated one may determine with a calorimeter the powers h_1 and h_2 wasted by heat, without and with the aerial, in the primary discharge gap whose resistance may in some cases change; and we may measure the powers P_1 and P_2 supplied to the primary circuit without and with aerial, which is always easy. Then expressing the power wasted by the primary oscillations by the formula $Ki^2 + h$, K can be determined from $Ki_1^2 + h_1 = P_1$, and the efficiency is

$$\frac{P_2 - Ki_2^2 - h_2}{P_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

I am aware that K varies slightly if the oscillatory period of the primary circuit is affected by the pressure of the aerial, but the small errors that may be due to this cause will not lead to any such misconception of the matter as appears to be common.

It will be obvious to anyone wishing to carry out an absolute test of scientific accuracy that he can avoid the error which has been mentioned.

Regarding the principal point under debate, viz., the efficiency that can be obtained by application of Prof. Wien's impact method, I find in my notes referring to experiments made with direct current high tension (30,000 volts) that the variation of primary oscillation current when switching the aerial on and off was usually 1 to 2, showing efficiency of transference of energy from primary to aerial equal to

$$\frac{2^2 - 1}{2^2} = 75 \text{ per cent.}$$

Lyons, France, May 3. R. C. GALLETTI.

"ELECTRIC CABLES: THEIR CONSTRUCTION AND COST."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Under the heading "Electric Cables: their Construction and *Use*" in your current issue, you print a letter from "A Lover of Fair Play" on the subject of the attack on our book "Electric Cables: their Construction and *Cost*." As our book has nothing in it about the *use* of electric cables and, moreover, its chief aim is to determine the cost, I must ask you to kindly correct this in your next issue.

Your remarks at the foot of "Fair Play's" letter also refer to the above erroneous title, and at the same time infer that your reviewer had the courage to put his *name* to the review, whereas it is signed "F. J.," which may mean anything.—I am, &c.,

Old Charlton, May 6. F. O. HOWE.

[We regret the error mentioned. The inference, however, is without foundation.—ED. E.]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You were good enough to publish my protest against unfair reviews appearing in your columns and also to add a reply.

The charge of merely making assertions is funny, seeing that I gave concrete examples which you carefully avoid; for instance, on the question of copper coefficient. Your reviewer stated that the coefficient as given by Messrs. Coyle and Howe was wrong. I, with practically the whole electrical industry of this and other countries, say it is *right*, and any fairly well educated youngster of 14 can settle it by experiment and *prove* it is right. I consider that as your reviewer is wrong on such a simple matter it is more than probable he is wrong on such subjects as specific gravity, "quad cores," &c.

In my protest I did not ask for a "favourable" review, I asked for a "fair" review. Give both good and bad points as your contemporaries did when reviewing this particular work.

I made no statement that your reviewer accused the authors of being amateur. Your reviewer (innocently perhaps) suggested the work was written *for* amateurs; but I say your reviewer would be surprised if he knew how the professional cable manufacturers use the book daily.

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Your last paragraph falls a bit flat, as your reviewer did not give his name but only initials, which can mean anything. It is difficult to realise that the engineer, "F. J.," is "well known in the cable industry" for his "good" works, when he is so lax with such an important item, as the copper coefficient is, to a cable manufacturer.

I regret I am compelled for business reasons to write under the *nom de plume* of

May 9. A Lover of Fair Play.

["A Lover of Fair Play" in our last issue made some general assertions apart from the review in question, and it was to these that our remark, as to the small value of assertions, applied. This was obvious. As to the temperature coefficient of copper we would remind our correspondent that the members of the Sub-committee on Cables were as follows:—*Chairman*, Robert Kaye Gray; *Representing the Admiralty*, C. H. Wordingham, L. J. Steele; *Representing the War Office*, Capt. A. H. Dumaresq, R.E.; *Representing the Crown Agents for the Colonies*, Llewellyn Preece; *Representing the General Post Office*, Martin F. Roberts; *Nominated by the Cable Makers' Association*, T. O. Callender, W. E. Gray, A. H. Howard; *Nominated by the Eastern Telegraph Co.*, H. A. C. Saunders; *Other Members of Committee*, Alexander Siemens, H. A. Taylor, A. P. Trotter.

With all due respect to a "Lover of Fair Play" we think that such a committee should know what is satisfactory; we suggest at least that between them they know more than the proverbial school boy. Nevertheless, we do not doubt that a letter of complaint written to the Secretary of the Engineering Standards Committee would receive every attention.—Ed. E.]

FARADAY SOCIETY.

At the meeting held on April 26th, at the Institution of Electrical Engineers, a general discussion took place on

"The Constitution of Water."

Prof. J. Walker, F.R.S., occupied the chair, and in opening the proceedings remarked on the extreme complexity of the problem of ascertaining the real nature of water, and on the great progress that had been made in recent years in the accumulation of quantitative data bearing on its solution.

Prof. P. Walden, of Riga, made the first contribution to the discussion in the form of a Paper entitled

"Is Water an Electrolyte?"

The Paper included a number of observations that had been made in order to determine whether water, when dissolved in a medium possessing powerful ionising properties, might not itself become an electrolyte. To secure an adequate answer to this question it was considered necessary to make use of media of which the specific inductive capacity was greater than that of water. The liquids selected were hydrogen cyanide (HCN), formamide ($H{\cdot}CO{\cdot}NH_2$), nitrosodimethylamine ($(CH_3)_2N{\cdot}NO$), formic acid ($H{\cdot}CO{\cdot}OH$) and sulphuric acid, the first two solvents being characterised by a specific inductive capacity greater than 84, the value of water. In passing, it may be noted that Prof. Walden's discovery of the use of formamide as a solvent represents a "find" of extraordinary importance, which even if it stood alone would form an adequate recompense for the labour involved in his masterly survey of the wide field of organic liquids. This solvent appears to reproduce nearly all the valuable qualities of water, including its convenient freezing point and boiling point and its powerful ionising properties, but will mix freely with important groups of compounds which do not dissolve to any marked extent in water.

Hydrogen cyanide, which with its high specific inductive capacity and great fluidity provides ideal conditions for electrolysis, was found when used as a solvent for water to give molecular conductivities of the order of 0·009, as contrasted with 300 for a salt such as potassium iodide; the low molecular conductivity of the water dissolved in hydrogen cyanide finds a parallel, however, in the low conductivity of hydrogen cyanide dissolved in water. Formamide, with a similar specific inductive capacity, but much smaller fluidity, gave for the molecular conductivity of water values (about 0·016) only slightly higher than in the case of hydrogen cyanide. In the case of formic and sulphuric acids the specific inductive capacity is lower than that of water, sulphuric acid being further handicapped by its extraordinary viscosity, but both solvents gave increased values for the molecular conductivity of water—namely, about 0·17 in formic acid, but rising in the case of sulphuric acid as high as 74. From these observations it is clear that the conductivity attributed to the water does not depend on the physical qualities of the solvent, but on some chemical relationship between solvent and solute. It was suggested by the author that water, acting as an amphoteric electrolyte, could form a salt when mixed either with a strong acid or with a strong base, and that the high conductivity of mixtures of sulphuric acid and water, and the slight conductivity of mixtures of formic acid and water, were due neither to free acid nor to free water, but to the presence of an oxonium sulphate or formate in the liquid. The absence of conducting power in mixtures of water with hydrogen cyanide or formamide was attributed to the weakness of their acidic and basic qualities and the impossibility of combining them with water to form a salt-like electrolyte.

Prof. Ph. A. Guye, having given a résumé of the results of diverse researches concerning the phenomena of molecular association, conducted both in his laboratory at Geneva and in that of Prof. P. Dutoit at Lausanne, showed how the conception according to which association was a simple phenomenon of chemical polymerisation permitted of our predicting various properties of associated liquids. He then indicated that it was even possible to calculate the order of magnitude of the association factor in the liquid phase if the degree of association or of dissociation were known in the vapour phase.

Mr. W. R. Bousfield, K.C., and Dr. T. M. Lowry read a Paper on

"Liquid Water a Ternary Mixture: Solution-Volumes in Aqueous Solutions."

The Paper described an extension to other solutes of some curious observations made five years previously in the case of aqueous solutions of caustic soda. The solution-volumes of the soda were found to vary largely with the concentration and with the temperature, the most remarkable feature of the variations being the occurrence of a maximum of solution-volume at about 60° C. in liquids of all concentrations. The gradual conversion of the ordinary slightly concave expansion curve into a strongly convex curve had now been traced through a series of solutes—chloral hydrate, sugar, acetic acid, silver nitrate, potassium, sodium, calcium and lithium chlorides. The authors conclude that the presence of three constituents in the liquid (ice, water and steam, or trihydrol, dihydrol and monohydrol) is absolutely necessary in order to account for the complex changes of volume that have been observed in water and in the solutions prepared from it.

Mr. W. Sutherland sent a written communication to the discussion in which he brought forward the view that water of crystallisation is solid hydrol in a special state. According to the writer's theory, water vapour, when nearly a perfect gas, is hydrol, H_2O. Ice is trihydrol $(H_2O)_3$. Water is a mixture of trihydrol and dihydrol $(H_2O)_2$, in varying proportions, at ordinary temperatures containing about one part of the former to two of the latter. The formula $(H_2O)_3$ for ice explains its crystalline form, the hexagonal prism. This the author pictures, assuming the electron theory of valency, according to which tetravalent O is an atom associated with three negative and one positive electrons, the electron pair being available for the purpose of joining the three oxygen atoms together, while the two negative electrons attach it to two H atoms through their positive electrons.

The author applies the hydrol theory to the consideration of solutions. He regards the ionisation of all electrolytic solutions as complete at all strengths. The so-called degree of ionisation is really the relative mobility of the ions; the original ionic theory ignored the electric forces acting between the ions and the ionising forces keeping the ions apart. When the ions are moved past one another in solution by means of an E.M.F., two viscosities of electric origin are encountered, one due to the electric forces between the ions and the water molecules, and the other due to neighbouring ions. Thus the mobility of an ion is proportional to the cube root of the concentration; the hypothesis of chemical union between ion and solvent is as unnecessary as the theory of partial ionisation. Nevertheless, a term is required for the mutual energy of ion and solvent. This theory of electrolytic solutions explains Walden's law on the dependence of ionic mobility on dielectric capacity and also Ostwald's valency rule. The effect of the solute on the solvent is also discussed.

Mr. H. Brereton Baker gave a striking experimental demonstration of the influence of purification in retarding the action of water on sodium amalgam. The conductivity of the water was a little lower than two reciprocal megohms. It is probable that non-conducting water, if it could be obtained, would be perfectly inactive chemically.

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DEPOSITION OF ALUMINIUM FROM AQUEOUS SOLUTIONS, USING ROTATING CATHODES.*

BY S. A. TUCKER AND E. G. THOMSSEN.

From experiments carried on with copper and other metals deposited on a rotating cathode, it is known that the current density can be raised very greatly and the nature of the deposit be generally improved. It seemed possible that if the speed of rotation could be sufficiently increased, that the current density might be raised to such a high value that metals could be deposited from aqueous solution which under ordinary circumstances would not deposit at all. It was determined to try the effect of a rapidly revolving cathode in the case of aluminium, as it is well known to be impossible to deposit this metal from an aqueous solution upon a stationary electrode. High speeds of rotation are difficult to obtain, and the difficulties increase with the speed of rotation. The first experiments were therefore carried on with an electrically-driven cathode revolving at 3,200 revs. per min. The electrolyte was an aqueous solution of aluminium chloride or sulphate with an anode of sheet aluminium. The cathode consisted of a brass or copper rod of 5 mm. diameter. No sure indication of metallic deposit was obtained, but several times a black substance was found on the cathode on quickly removing it from the bath. Various changes were made in the conditions, such as variation in the current density and increase of rotation up to 3,500 revs. per min., which gave a rather more pronounced result, but nothing that could be called a coherent metallic deposit was obtained.

By using a very concentrated or pasty solution and rotating the cathode as fast as possible with the apparatus at hand, better results were obtained—the blackening was much more marked and was found to be invariably on the side of the cathode having the greatest peripheral speed due to the slightly eccentric motion of the revolving rod. This gave the clue to the requirements for depositing the metal, as it indicated the necessity of higher speeds of rotation and the use of pasty solutions. With the construction of a better bearing running at about 5,000 revs. per min., the deposits obtained were still black, but on closer inspection a trace of metal substance resembling aluminium was obtained. It was found that on quickly withdrawing the bath from the cathode, which was still revolving, that the deposit had a metallic lustre for a moment. However, it turned black almost instantly on exposure to the air. In order to raise the speed of rotation a small air turbine was constructed which enabled a speed of about 10,000 revs. per min. to be reached. With this apparatus much better results were obtained; the deposits on being first withdrawn from the electrolyte were metallic aluminium, but after a time tended to blacken on exposure to the air. This is probably due to the fine state of division in which it is formed at the cathode. In order to prove that the deposits obtained were really aluminium, they were carefully washed to free them from any adhering electrolyte and then dissolved in potassium hydroxide. As the deposits were very thin, a great many were dissolved in the solution in order to procure enough of the metal to subject to test. These tests left no doubt as to the certainty of the deposit obtained being aluminium.

One very noticeable fact in connection with the deposit is that the aluminium obtained at the highest speed retained its metallic lustre longer than when obtained at the lower speed. The blackening was hastened whenever the deposit was exposed to the air and whenever there was much water present in the electrolyte at the time of deposition. Several of the deposits were quickly placed in melted paraffin to protect them from the air and remained bright for weeks. After standing for a few days in the paraffin there was usually no tendency to blacken on again exposing to the air. The deposits were always extremely thin and, as before noted, invariably on the side of the cathode having the greatest peripheral speed. In the cases where the cathode ran perfectly true the deposit completely surrounded the rod.

The temperature of the bath must also be considered in such experiments. If the temperature exceeded certain limits no satisfactory deposit could be obtained. From a series of runs with various temperatures it was found that from 30° to 40°C. gave the best results. The time during which the electrolysis was conducted was for a few minutes only, since running for longer periods did not give as good results. Bad tendencies seem to increase with time. There was considerable variation in voltage and current due to change in resistance of the bath, probably due to several causes, such as formation of film, change of concentration, or vortex effect of the rapidly revolving cathode which tended to expose more or less of the cathode surface to the electrolyte.

It was thought advisable to obtain an air turbine of better construction than the one previously used, as any increase in speed would tend to give better results. The apparatus was used with compressed air at 30 lb. pressure and ran with very little vibration, giving a high speed of rotation. The revolving parts cause a hum which at high speeds is a piercing high note which is far from pleasant to work with, otherwise the apparatus is entirely satisfactory. The actual speed of rotation was estimated by comparison with a recording siren to be from 15,000 to 20,000 revs. per min.

On repeating the experiments with this apparatus the results obtained were somewhat better than before. It was found possible to burnish some of the deposits which were slightly black on a buffing lathe with rouge, the deposit then having the same appearance as polished aluminium.

The conditions under which these later experiments were conducted were as follows: Cathode: brass, 5 mm. diameter. Anode: sheet aluminium, 35 sq. cm. Electrolyte: pasty solution of aluminium chloride. Temperature: 30° to 40°C. Duration of electrolysis: 5 to 6 minutes. Revolutions of cathode per minute, 15,000. Current in amperes: two to four. Average voltage, 15. Current density at anode: 0·085 amperes per square centimetre. The deposit was only obtained on eccentric portion of the cathode, which portion had an area of 200 sq. mm., giving a current density at the actual cathode of 2 amperes per square centimetre.

The practical value of such a method for depositing aluminium is indeed small, as the quantity of metal obtained is but a small part of that theoretically obtainable for current used. The voltage necessary to conduct the experiments is also very high, and the practical difficulty of obtaining such speed of rotation is very great. The experiments are interesting, however, as showing that under certain conditions it is possible to obtain aluminium by electrolysis of its aqueous solutions.

* Abstract of a Paper read before the American Electrochemical Society.

MEXICO LIGHT & POWER CO.*

BY H. E. WEST.

Until a few years ago Necaxa, about 75 km. north-east of Mexico City, was noted as the site of one of Mexico's greatest waterfalls. Within the last seven or eight years it has carried especial interest as the location of one of the largest, if not the largest, electric power stations in Mexico. The Mexico Light & Power Co. has installed a plant, that, starting with modest proportions, has now assumed a stupendous scale. It is a Canadian enterprise, under the leadership of Dr. Pearson, closely allied to the interests which have recently concluded the San Paolo tramway and light plant in Brazil.

Power has been furnished for the last four years to Mexico City, operating there the tramways, mills and street and house lighting. From 10,000 H.P. to 12,000 H.P. has been utilised at El Oro, 175 miles distant, for operating mining machinery, mills and for lighting. To large consumers the charge is £10 per horse-power-year. The mines of Pachuca will soon be able to utilise this cheap and constant source of energy.

At the present time there are six 5,000 kw. hydro-electric generators installed, whilst two of 10,000 kw. are being added. This will normally increase the output to 50,000 kw. Each 5,000 kw. generator, however, can be run at 8,000 kw. Within two years, on the completion of the present installation, an out-put of 200,000 kw. is anticipated. The generators are of Siemens-Schuckert manufacture. A steam plant of 13,000 H.P. also exists in Mexico City, to render assistance at any time should occasion arise. To deliver 1 kw.-hour at Mexico City 'bus bars requires 1¼ cubic metres of water at Necaxa.

When the reservoirs at present completed and under construction are filled with the surplus waters of the wet season, the storage will be about 155,000,000 cubic metres, sufficient, with the present consumption, to last 300 days. In addition to this is the constant flow, which it is proposed to increase from the tapping of the watershed to the south.

The daily load varies from 20,000 kw. to 32,000 kw., probably averaging 24,000 kw. over the 24 hours. Each generator is fixed to a vertical shaft, at the lower end of which is the impact wheel, 9 ft. in diameter. The weight is 36 tons. At present the water efficiency is 73 per cent. By amended buckets and larger nozzles, the efficiency is expected to reach 86 per cent. Although at work over three years, no perceptible wear is noticeable on the steel buckets, notwithstanding that considerable sand is carried in the water.

* Abstract of an article in the "Mining World."

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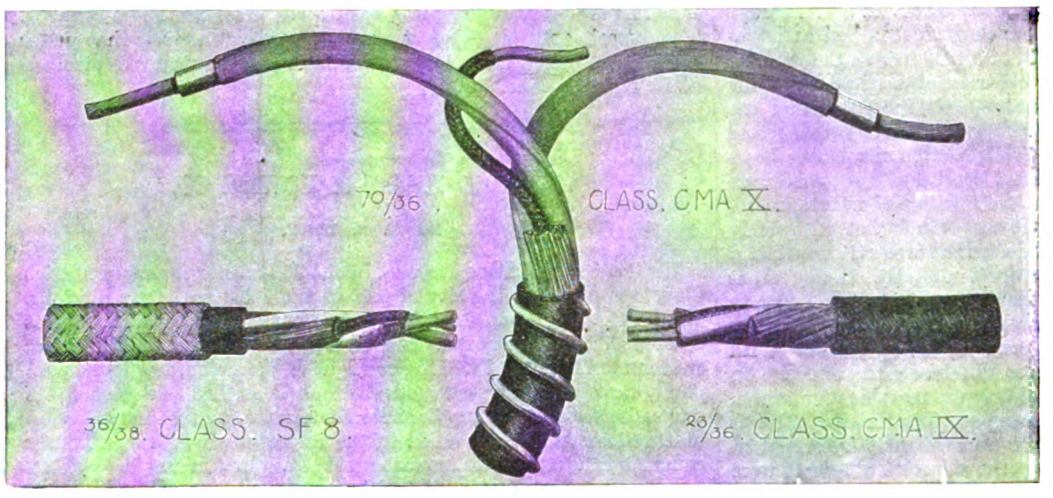
The generators run at 500 revs. per min. and generate at normal load 850 amperes at 4,000 volts. The pressure is transformed to 60,000 volts and the energy carried by a three-phase line, of No. 000 copper, on steel towers to Mexico City. There are four transmission lines carried on two sets of towers. From the city two transmission lines convey the current 125 miles to El Oro, where approximately 12,000 H.P. is constantly utilised. New windings are now being installed at the power house, so as to transform the energy to 80,000 volts.

The Necaxa power plant scheme started on a comparatively small scale, mainly the Necaxa reservoir and tributary waters. Then a larger scheme utilising both pressure and volume from the Laguna dam was proposed, and afterwards discarded. The waters from the Tenango and Catapuxtla rivers and various creeks will enable the capacity to be raised to 200,000 kw. Finally, the waters from the Coacoyuanca reservoir were secured, and from this latter scheme 300,000 kw. are anticipated. The capital of this enormous enterprise already amounts to £8,000,000, and there are employed 7,000 operatives, including 100 foreigners. The basis of the present and proposed operations covers 1,500 sq. km.

HENLEY'S TWIN FLEXIBLES.

Last week we mentioned that Messrs. W. T. Henley's Telegraph Works Co. had recently placed on the market a line of twin flexible cable bound up with an earthing core, in accordance with the Home Office regulations. We are now enabled to give in the accompanying illustration a general view of these cables, which are made in two distinct classes, the C.M.A. and the S.F.



EXAMPLES OF HENLEY'S NEW TWIN FLEXIBLE CABLES.

In the C.M.A. class the conductors are composed of high conductivity tinned copper wires 0·0076 in. in diameter (No. 36 S.W.G.), which are insulated with one coat of pure indiarubber and two coats of vulcanising indiarubber, taped with proofed tape. The earthing conductor is composed of high conductivity plain copper wires, 0·0076 in. in diameter (No. 36 S.W.G.), braided with cotton and compounded. The three cores (two insulated and one earthing core) are laid up to circular form with jute wormings, and are strongly braided and served over all with preservative compound. The insulation resistance of the finished cable is 600 megohms per mile at 60° F. after 24 hours' immersion in water and one minute's electrification. Two modifications of this cable are also made, one being fitted with an armouring of No. 18 galvanised-iron wire, and the other with an armouring of No. 30 galvanised-iron wire braid.

The S.W.F. conductors are composed of high conductivity copper wires 0·006 in. in diameter (No. 38 S.W.G.), lapped with cotton and insulated with two layers of vulcanising indiarubber. The earthing conductor is composed of high conductivity plain copper wires, 0·006 in. in diameter (No. 38 S.W.G.), braided with cotton and compounded. The three cores (two insulated and one earthing core) are laid up circular with jute wormings. They are then strongly braided and served over all with preservative compound. The insulation resistance is 300 megohms per mile after one minute's electrification. Two similar modifications, armoured respectively with iron wire and tape, are also made in this class.

LEGAL INTELLIGENCE.

Postmaster-General v. Tottenham Council.

On Tuesday the Railway and Canal Commission (Mr. Justice A. T. Lawrence, the Hon. A. E. Gathorne Hardy, and Sir James Woodhouse), heard an application on behalf of the Postmaster-General (who proposed to erect overhead telephone and telegraph lines in St. Anne's-street, Tottenham) against Tottenham Council. The P.M.G. applied under the Telegraph Acts 1863-1909 for the consent of the local authority to carry out the work but he was met with a refusal, and then the matter was referred to the county court judge of the district (Judge Wheeler) for arbitration. Having heard the parties, Judge Wheeler gave his award in favour of the Council, and the Postmaster-General now appealed.

Sir ROBERT HUNTER (for the P.M.G.) urged that the award of the County Court Judge was unreasonable; and for the local authority it was contended that the decision was reasonable, as the Council had themselves converted overhead lines into an underground system at a cost of £3,500, and had laid down since 1899 new underground lines at a cost of £2,500; and, further, the Postmaster-General himself had since 1899 applied to them for permission to lay down in the same thoroughfare underground lines for telegraphic communication and these lines had been laid down.

Sir ROBERT said the real point was the principle involved, as the P.M.G. was bound to consider economy and cost of outlay in these matters, because that cost was thrown upon the taxpayers. With regard to the danger and inconvenience which was expected to result in the erection of posts for carrying overhead lines, the danger was really negligible. With regard to the objection of future traffic it was very difficult to deal with speculative objections of that nature. As to tram lines running along the road, the P.M.G. was always willing to place his wires on the trolley poles; in fact, it was a common practice in new tramway Bills to insert a clause giving the P.M.G. that power.

Major W. A. J. O'MEARA, C.M.G., engineer-in-chief to the P.O., gave evidence, and said in some parts of London it cost as much as £800 a mile to lay pipes to take underground wires. The public were clamouring for a cheap telephone system, but he did not see how they were to secure it upon such lines as were now in dispute. In regard to the underground system there were difficulties which arose in cases of long distance telephhny. The electrostatic capacity of the cables was not so great when underground, and their efficiency for long-distance talking was consequently limited. With the overhead system that difficulty would not arise. In America so well was that recognised that long detours were made round the cities in order to avoid laying the wires underground.

Mr. Justice LAWRENCE pointed out that Tottenham Council had gone to considerable expense in preserving the underground system which they desired in their district, and he suggested the possibility of the Council making some offer to the P.M.G. in the way of a contribution towards the difference in the cost which would enable the parties to come to terms.

Mr. FREEMAN, K.C., said the Council were afraid the P.M.G. would establish a precedent in that matter, and pointed out that he was attacking many districts in connection with the telegraph and telephone systems.

Sir R. HUNTER said that many local authorities had already agreed to share the expense of an underground system by paying for the trenches, &c.

Mr. FREEMAN said his clients were willing to meet the P.M.G. inasmuch as they would do the whole of the work for £50 which the P.M.G. said would cost £84.

Sir ROBERT HUNTER said he could not accept this offer, and the hearing proceeded.

Mr. Freeman called evidence for the Council.

Mr. Freeman and Sir Robert Hunter having addressed the Commissioners,

Mr. Justice LAWRENCE, in giving judgment, said that they found that it was impossible to lay down a principle in these cases, and all they could do was to consider the whole of the circumstances and then give the best opinion on them they could. They felt most strongly the consideration urged by Sir Robert Hunter, namely that the Postmaster-General must consider economy in these matters in order that telephonic facilities might be extended as widely as possible and for his part in considering this particular case he could not find that the special character of the road would justify him in requiring the Postmaster-General to take a

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course he was disinclined to take if that stood alone. He did not see that there was any such danger in an overhead line as would induce him to say that an overhead line could not be put up with safety nor did he think that the continuity of the road would be destroyed by such a line, but in that case it was a small matter, and the community had a strong feeling on the matter. Under the circumstances it seemed to him that it was a case in which one ought not to press the desire for economy against the views of the community and, therefore, they thought that if the authority undertook to do the work of laying the pipes, trenching, &c., for £50 they ought to say that the system adopted should be the underground system.

The other Commissioners gave judgment to the same effect.

The Law of Distress for Rent.

A Divisional Court (Mr. Justice Darling and Mr. Justice Bucknill) recently heard an appeal from a decision of the Lambeth County Court judge in an action, Shenstone *v.* Freeman, which raised the question of the exemption from distress for rent of goods let on hire. It appeared that plaintiffs (a firm of pianoforte dealers) sued defendant (a bailiff) for damages for the alleged illegal seizure of a piano belonging to plaintiffs in default of certain rent due in respect of the premises from which it was taken. The wife of the tenant of the premises obtained the piano from plaintiffs under a hire-purchase agreement, by the terms of which plaintiffs remained the owners of the piano until all the instalments under the agreement had been paid. Only one instalment had been paid when the piano was seized for rent due. Plaintiffs, following the procedure prescribed by sec. 2 of the Law of Distress Amendment Act, 1908, served a declaration upon the landlord of the premises, in which they stated that the piano was their property, and that the tenant had no right or beneficial interest in it, and subsequently instituted proceedings. Sec. 4 of the Law of Distress Amendment Act, 1908, provides that the provisions of the act exempting from seizure the goods of an under-tenant, lodger or other person not being a tenant of the premises, or having any beneficial interest in the premises, which may be upon the premises when a seizure is made, shall not apply " (1) to goods belonging to the husband or wife of the tenant whose rent is in arrear, nor to goods comprised in any bill of sale, hire-purchase agreement, or settlement made by such tenant, nor to goods in the possession, order or disposition of such tenant by the consent and permission of the true owner under such circumstances that such tenant is the reputed owner thereof. . . ." The County Court judge held that the seizure was justified on the ground that the piano was in the possession, order or disposition of the tenant by the consent and permission of the true owner, under such circumstances that he was the reputed owner of it. And he gave judgment for defendant. Plaintiffs appealed.

Mr. SIMON, K.C., submitted that the piano was not in the possession, order or disposition of the tenant, but of his wife, and, further, that even if that were not so, upon the facts before the County Court judge there was no evidence of any consent by plaintiffs that the husband should have possession of the piano or that he was the reputed owner of it. The piano, although it was the subject of a hire-purchase agreement, was not an agreement made " by such tenant," but by his wife. He submitted that the words " made by such tenant " must be construed to govern not merely the word " settlement " which immediately preceded it, but also the words " hire-purchase agreement " and " bill of sale."

Mr. ATKIN, K.C., for defendant, contended that evidence had been presented upon which the County Court judge was entitled to come to the conclusion of fact at which he arrived, and consequently no appeal lay.

Mr. Justice DARLING, in giving judgment, said in his opinion the piano, which had been let on a hire-purchase agreement to the wife, was (in the words of sec. 4 of the Law of Distress Amendment Act) " goods belonging to " plaintiffs. He thought the piano was not comprised in any hire-purchase agreement made by the tenant, because the wife (a Mrs. Wyard), who made the agreement for hiring the piano, was not the tenant. It was argued that the piano was in the possession of the tenant, but he did not think it was, although he was not prepared to say that there was absolutely no evidence that it was so. Granting, for the sake of argument, that the piano was in the tenant's possession, he thought that there was no evidence that it was in his possession by the consent and permission of the true owners. The words of the statute were " Goods in the possession, order or disposition of such tenant by the consent and permission of the true owner under such circumstances that such tenant is the reputed owner thereof." Even if it was in such possession, he did not think there was any evidence that it was in his possession in such circumstances that the tenant was to be taken as the true owner. He was not going to deal with the question whether the words " hire-purchase agreement made by the tenant " used in the act meant a hire-purchase agreement made by the tenant by which he granted the goods or whether they meant an agreement by which he hired them. He came to the conclusion that the words " shall not apply to any hire-purchase agreement " really meant a hire-purchase agreement to which the tenant was a party in some way. Take the case of a person who had given a bill of sale over some of his furniture, or the more simple case of a person who has got a motor on a hire-purchase agreement, and went to stay with a friend who owed his landlord rent. Suppose the landlord put in a distress for rent whilst the owner of the motor was stopping there. If the contention of defendant was right, that motor could be seized for the rent of the friend with whom the owner of the motor was staying. Did the Legislature really mean that ? He did not think so. It was perfectly true that the words might mean it, but there was authority for saying that all things are not exactly what they seem, and that was a statement particularly true of Acts of Parliament. He thought the words could be read in the way contended for by plaintiffs, and that such a reading was more consonant with what he thought they ought to mean than the construction put upon them by defendant. That being so, the appeal must be allowed.

Mr. Justice Bucknill concurred, and the appeal was allowed, with costs. Notice of appeal has been given.

Coslett Anti-Rust Synd. (Ltd.) v. Lennox.

On Friday, before Mr. Justice Joyce, plaintiffs moved for an injunction to restrain an alleged infringement of a patented process for coating metals to prevent rust.

Mr. HUGHES, K.C., for plaintiffs, said no question of the validity of the patent could arise, as defendant was one of the assignors to plaintiffs. Defendant said that the patent was invalid (but plaintiffs said he was estopped from asserting this), and that he had not infringed the patent. But he submitted on the evidence, including that of defendant himself, that he was infringing.

Mr. WALTER, K.C., for defendant, said infringement was denied, and offered the usual undertaking to keep an account.

Mr. HUGHES said on April 10, 1906, the patent was granted to one Coslett, whose name had been given to the process. In June, 1907, he assigned a quarter share to defendant and one-tenth to a Mr. Moore. On Dec. 20, 1907, a company was formed to take over the whole of the patent, and Coslett, Moore and Lennox joined in assigning the patent to the company. Lennox became a director. Lennox had ceased to be a director, and was carrying on business as the Coventry Anti-Rust Synd., which, it was alleged, involved the use of the precise process of plaintiffs or something very similar to it.

Mr. WALTER offered an undertaking not to use that process. He would undertake not to use any process in which electricity did not play a part. The defendant was using a process in which the essential part was the use of electric current. Plaintiffs' process was not an electrical process. He refused to give any undertaking with regard to that electrical process.

Mr. HUGHES : You are using our process plus the electric current.

His LORDSHIP : That may be an improvement.

Mr. HUGHES : If so we are entitled to it. We say defendant's process is a colourable imitation of ours.

Mr. WALTER contended that there was no warrant by an assignor that a patent was valid, and nothing to prevent him subsequently challenging its validity. What defendant was doing was not an infringement of the patent.

His LORDSHIP said that as there was a serious question of infringement, and also a bona fide issue as to the validity of the patent, it would be contrary to practice to grant an interlocutory injunction. Defendant must keep an account. There would be no order on the motion, except that costs should be costs in the action.

Luscombe v. Fryer.

On Wednesday, before Mr. Justice Parker, a motion was made on behalf of plaintiff to reverse the decision of the Official Referee (Mr. Muir Mackenzie) dismissing the action of plaintiff for damages for wrongful dismissal. The facts were reported in our issue of March 18. After hearing legal arguments, his Lordship dismissed the motion, with costs.

PARLIAMENTARY INTELLIGENCE.

SCOTTISH PROVISIONAL ORDERS.

At Edinburgh last week the Commissioners under the Private Legislation Procedure (Scotland) Act, 1899, held an inquiry into the draft provisional orders set down for consideration. The Earl of Kintore presided, and the other Commissioners were the Earl of Mansfield, Mr. J. S. Ainsworth, M.P., and Mr. Harry Hope, M.P.

DUNFERMLINE ORDER.

The order promoted by the Dunfermline & District Tramway Co. sought power to extend the undertaking, and to raise £90,000 additional share capital and to borrow £40,000, &c.

Mr. WILSON, K.C., for the promoters, said that when the order was originally presented 10 different extensions were contemplated, but the Wemyss Tramway Co. were also applying for power to extend their system to the north-east. Subject to the approval of the Commissioners the Dufnermline Co. decided to limit their claim for extensions to the north to the tramway from Lochgelly to Lochore. That company were seeking power to carry the tramway to Cardenden, but there was an understanding that that portion would be really for the benefit of the Wemyss Co. Both in the north and in the south the extensions were called for to serve large and increasing populations. It was now quite certain that there was to be a completed naval base at Rosyth, and the men employed in connection with the work would find it a great convenience if the tramway were formed. The company contemplated that the tramway should come down to the dock gates at Rosyth.

Evidence was given for the promoters, and an arrangement come to whereby the promoters undertook to widen markedly narrow parts of the road on condition that the County Council provided the ground for widening.

The preamble was passed subject to adjustment of clauses.

WEMYSS TRAMWAYS.

The consideration of the order asked by the Wemyss Tramways Co., which sought power to make extensions of their system was next pro-

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ceeded with. The proposed tramway was unanimously supported by the surrounding villages.

The Commissioners desired that the promoters should not be given power to alter the position of the line as shown on the deposited plans to any greater extent than was commonly allowed. As to widening, the Commissioners were of opinion that where the tramway line was single, and occupied the centre of the roadway at any of the points on which they had heard evidence, the width of the roadway should be increased to 27 ft., and where the line was on the side of the road to 24 ft., the road authority to supply any extra land required free of expense to the promoters. Where 24 ft. could not be got the line must be doubled. As regarded the bridges, a provision should be inserted similar to that adjusted in the Dunfermline Order for the Cardenden Bridge (27 ft.).

KIRKCALDY ORDER.

The order promoted by Kirkcaldy Corporation asked for an extension of the burgh boundaries, authority to construct and work additional tramways, to extend the area of electricity supply, &c. The Corporation asked power to borrow for tramways £9,000.

After taking evidence and hearing counsel, Lord Kintore said the Commissioners were equally divided, and under these circumstances the clauses with regard to the extension of boundaries were refused. The adjusted clauses were considered on Friday.

JOINT ELECTRICITY SUPPLY PUBLICITY SCHEME.

The Electric Supply Publicity Scheme is now well under way. The Joint Committee's aim is to issue publications which will finally cover the whole area of supply possibilities.

USE THE ELECTRIC SUPPLY
ALREADY INSTALLED IN YOUR HOUSE
FOR IRONING.

A HOT IRON ALWAYS READY
BY MERELY TURNING A SWITCH.

The first step was taken by issuing a poster and showcard dealing with the use of the supply for general lighting, together with a typical circular with the same bearing, the whole of which was given gratifying and widespread support by various undertakings, both London and provincial (municipal and company owned). This has now been followed by the present issue of a poster and showcard, which deal with electric ironing, forming the first of a series dealing with the uses of the supply for domestic purposes. The poster (40 in. by 25 in.), lithographed in five colours, is of a design to make an effective display on the hoardings. The showcard is smaller (15 in. by 20 in.), but of identical design and colouring, and of a most tasteful character, and thus eminently suitable for display in showrooms, offices, shop windows, &c. (A reduced illustration accompanies this notice.) Further, as an extension of the foregoing, a handy-sized and illustrated four-page folder has been got out, which, while compact enough to be slipped into the ordinary envelope enclosing accounts or correspondence, is yet comprehensive enough to touch on all the domestic uses for lighting, heating and cooking, &c.

With the same end in view a mail card has been designed dealing also with electric ironing. This is in a size for enclosing with correspondence and bears an apposite illustration reproduced in colours. The present issue should be of the greatest service to supply undertakings, since it provides material for useful advertising without incurring expense in distribution. It thus marks a distinct step in advance.

COMMITTEE FOR PROTECTION OF ELECTRICAL INTERESTS.

It has been decided to abandon the formation of the Electrical Industrial Association of Great Britain, and a Committee has instead been created with the above title. We are informed by circular that, at a meeting on Friday last (the Hon. Arthur Stanley, M.P., presiding), the following rules were adopted:—

1. The primary object of the Committee is to endeavour to secure united action with a view to the protection and advancement of the commercial and legislative interests of the British electrical industries, and for that purpose to take such steps as may from time to time appear advisable, and to co-operate, as far as possible, with all institutions, societies and associations having similar or kindred objects.

2. The name of the Committee shall be the "Committee for the Protection of Electrical Interests," and may be shortly referred to as the "Electrical Committee."

3. The number of the Committee shall be limited to 80 members (besides the president, hon. treasurer and hon. secretary). Any casual vacancy may be filled by the Committee at an ordinary meeting.

4. Any gentleman connected with the electrical industry and receiving the support of not less than five members shall be eligible for election by the Committee. Election shall be by ballot; two black balls shall exclude, there being not less than six members present.

5. Every member of the Committee shall pay an annual subscription of one guinea, to provide for the expenses of the Committee; and any member whose subscription remains unpaid more than three months after it becomes due shall be liable to have his name removed by the Committee from the list of members.

The Committee (it is announced), in its collective capacity, starts with neutrality on all contentious matters. Proposals for the election of a president, hon. treasurer and hon. secretary will be submitted at a meeting of the Committee to be held at an early date.

Following is the first list of members of the Committee:—

G. L. ADDENBROOKE	E. H. FREEMAN	A. RASHLEIGH PHIPPS
J. F. ALBRIGHT	E. GARCKE	ARTHUR H. PREECE
A. BRUCE ANDERSON	WM. GEIPEL	W. LLEWELLYN PREECE
L. B. ATKINSON	J. BARBER GLENN	W. R. RAWLINGS
A. K. BAYLOR [DOES.	F. E. GRIPPER	J. S. RAWORTH
LT.-COL. H. R. BED-	ROBERT HAMMOND	H. B. RENWICK
H. R. BEETON	H. W. HANDCOCK	THEODORE RICH
E. BERGTHEIL	W. C. C. HAWTAYNE	J. R. SALTER
T. BROWETT	J. S. HIGHFIELD	A. H. SEABROOK
J. CECIL BULL	HUGO HIRST	STEPHEN SELLON
E. CHARRINGTON	F. HOPE-JONES	A. M. SILLAR
GEO. CONATY	E. M. LACEY	J. F. C. SNELL
A. N. CONNETT	J. G. LOBRAIN	C. P. SPARKS [M.P
W. B. COWNIE	J. A. LYCETT, J.P.	HON. ARTHUR STANLEY,
A. DICKINSON	W. L. MADGEN	J. GRICE STATTER
SYDNEY DOBSON	R. K. MORCOM, M.A.	A. A. CAMPBELL SWINTON
BERNARD DRAKE	SYDNEY MORSE	W. A. VIGNOLES
A. H. DYKES	W. C. MOUNTAIN	F. J. WALKER
H. JUSTUS ECK	W. M. MURPHY, J.P.	H. LAWS WEBB
G. K. B. ELPHINSTONE	LEE MURRAY	JOSEPH WETZLER
R. S. ERSKINE	F.H. NALDER [C.B.	W. B. WOODHOUSE
W. B. ESSON	HON. C. A. PARSONS,	A. P. WOOD
S. Z. DE FERRANTI	W. H. PATCHELL	

H. FOULDS ..... Electrical Standardising, Testing & Training Institution.
ALBERT GAY ..... Associated Municipal Electrical Engineers of Greater London.
T. B. GOODYER..... Metropolitan Association of Electric Tramway Managers.
L. G. TATE ..... Electrical Contractors' Association (Incorporated).
A. DE TURCKHEIM ... Incorporated Association of Electric Power Companies, Tramways & Light Railways Association
J. GLYNN WILLIAMS... Institution of Mining Electrical Engineers.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A first-class man, with previous experience in small armature winding, is required. See an advertisement.

Applications are invited for the position of borough electrical engineer at Keighley. Candidates must be thoroughly trained engineers, with a knowledge of both h.t., three-phase alternating and d.c. supply. Applications to the town clerk, Mr. Wm. Bagshaw, Town Hall, Keighley, by May 18.

A lecturer in engineering subjects is required at Durban Technical School, Natal. Salary £250, rising by annual increments of £25 to £350 a year. Applications to Mr. W. A. Narbeth, Eltham, Kent, by May 23.

The professorship of physics at University College, Reading, will shortly become vacant. Particulars from the Registrar.

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A lecturer in mathematics (to specialise in practical mathematics) is required at the Municipal Technical Institute, Belfast. Commencing salary £140, increasing to £180 per annum.

A junior lecturer and demonstrator in physics is required at the University of Sheffield. Salary £150 per annum. Applications to the Registrar by June 1.

Mr. Chas. W. Rycroft, of Battersea, has been appointed assistant electrical and mechanical engineer at Swindon.

Mr. C. Holman, assistant engineer at Surbiton, has been appointed engineer and manager of the Lymington Electric Light & Power Co., in succession to Mr. G. Salter, who has obtained an appointment at Hamilton.

Acton.—In reference to the note in our last issue (p. 162) to the effect that the Electricity committee had resolved to ask the electrical engineer (Mr. Blair) to send in his resignation, we are pleased to note that the Council referred the matter back, and that the vote of censure on a hard-working official has been rescinded.

Argentina.—The "Review of the River Plate" states that the Hippodromo and Centenario depots of the Anglo-Argentine Tramways Co., at Buenos Aires, are approaching completion, and that the latter will accommodate 200 cars. The rolling stock already comprised 1,300 motor tramcars and 400 trailers, to which are to be added 50 recently received from England and Belgium, 80 which will arrive shortly, and 50 which are being constructed in Buenos Aires.

Official approval has been given to the proposal of the Central Argentine Railway Co. to substitute electric for gas lighting on passenger trains.

The first section of the electric tramways in the town of Mendoza is to be ready for opening by the end of this year.

At a meeting of residents of General Belgrano (Buenos Aires Province) a proposal by Messrs. Matta & Fuente to form an electricity supply company was approved.

Aston.—At the Council meeting last week the Electricity committee's report stated that there was a profit of £4,694 on the past year, against £2,941 in the previous year. It was decided to place £2,000 to reserve and to apply £2,600 in aid of the district rate.

Asylum Lighting.—Metropolitan Asylums Board have entered into a fresh agreement with the County of London Electric Supply Co. for supply of electricity for lighting and power at Tooting Bec Asylum.

Australasia.—The "Australian Mining Standard" says Zeehan (Tasmania) Council have agreed to supply electric power to the Oonah Mines Co. at 2½d. per unit for a minimum of 3,600 units per week.

Statistics prepared by the Commonwealth statistician (Mr. G. H. Knibbs) show that at June, 1909, there were 389¾ miles of tramway in the Commonwealth States, of which 251¼ miles were worked electrically, 36 miles by horses, 56¾ miles by steam and 45¾ by cable. 179⅜ miles were owned by the Government and the same length by companies, the remainder (31 miles) being municipal. The gross revenue of the whole of the lines was £1,439,209 during the year, and the working expenses (of all except the Queensland lines—which could not be obtained) were £945,046. Queensland tramways produced £192,271 of the receipts. The total number of passengers was 226,775,000.

The revenue of the Commonwealth Postmaster-General's department for the year ended June, 1908, included £651,124 from telegraphs and £411,164 from telephones. Expenditure on cable subsidies, telegraph and telephone works, &c., during the same period was £392,036. At December, 1908, there were 3,411 telegraph stations and the length of telegraph lines was 44,554 miles. The total number of "one-state" telegrams increased from 7,162,927 messages in 1905 to 8,735,719 in 1908, and inter-State messages increased from 1,975,546 to 2,543,963. Cablegrams despatched and received in 1908 were 453,190, against 225,125 in 1901. The total amount spent on telephone construction to December, 1908, was £2,264,986, there were 285 telephone exchanges and 70,564 instruments in use. Rentals received during the year were £382,803 and cost of construction was £300,254. Telephone wires in use were 145,572 miles, compared with 47,276 at December, 1901.

Mortlake (Victoria) Shire Council have not adopted their committee's recommendation to borrow £2,500 for the erection and equipment of electricity works, and it is stated that the work will be carried out by a company.

Hobart (Tasmania) Council have decided to accept the offer of the Complex Ores Co. to supply electricity for lighting the city three years hence and a contract is to be prepared.

Electricity works at Korumburra (Victoria) will shortly be opened. Nearly all the business houses and many private residents have sent in demands for current.

The Melbourne Tramways & Omnibus Co.'s lease will expire in about six years, and there is an agitation on foot for the acquisition of their undertaking by the Melbourne Tramways Trust, which is composed of seven members representing Melbourne City Council and 10 representing the 10 suburbs served by the lines. The company's system comprises 43½ miles of cable tramway and 3¾ of horse line. The lines were constructed by the Trust and leased to the company for 32 years. The Minister for Railways (Mr. A. A. Billson) proposes that the Government should take over the tramways and work them by electricity in connection with the railways.

Recently Malvern (Victoria) Council were informed that the Tramway Trust had agreed to a modification of the plans, which had resulted in the line being laid close to the kerbstone in some places, but it was explained that an amended order in Council would be sought limiting the speed to 4 miles an hour at a corner where the line was near the kerb, and that "the conductor would precede the car on foot." The line will be opened about the end of May.

Hawthorn (Victoria) Traders' Association recently urged the Council to adopt electric lighting, and pointed out that every other suburb of Melbourne had electric light. In the draft agreement with the Melbourne Electric Supply Co. the right to supply power to any tramway that might be constructed would be conceded to the company, but the Council are opposed to this clause.

In reference to the recent discussion regarding the acceptance of the tender of the Fitzroy Dock authorities for the steam and electrical plant for the Lithgow (N.S.W.) Small Arms Factory, it is definitely stated that the tender of the Fitzroy Dock was £6,946, and that none of the tenders received in London were lower. Alternative full tenders by Messrs. Haes & Eggers (for the Lancashire Dynamo Co.) were £8,457 and £7,338, while their tenders for electrical apparatus only were £2,672 and £2,592.

The Defence Department has applied to the Governor-in-Council of Victoria for an order authorising the construction of an electric tramway to connect the Marebyrnong cordite works with the Essendon electric tramway at Newmarket.

Complex Ores (Ltd.) propose to generate electrical energy by means of water power from the Great Lake, and have offered to supply electric power up to 500 H.P. to Launceston Council at the same prices as those recently quoted by the company for a supply to Hobart Council—viz., 1¾d. per unit with a load factor of not less than 33 per cent., increasing to 3d. per unit if the load factor drops to 16 per cent.

Woollahra Council are considering the question of lighting the district (a suburb of Sydney) by electricity.

On March 9 the extension of Adelaide (N.S.W.) electric tramways to the western suburbs was formally opened. The chairman of the Tramway Trust said the inner circle, equal to 55 miles of single track, was now completed, and arrangements were in hand for 25 miles of construction in the outer circle.

Dunedin (N.Z.) electric tramways are reported to have earned a gross profit of nearly £30,000 during the year ended March 2.

Tolwong Mineral Co. (N.S.W.) have decided to instal electric power plant for working their new aerial tramways.

It is stated that Mr. M. W. Fink has withdrawn his offer to supply electricity in Brighton (Victoria), and the Melbourne Electric Supply Co., the only other tenderer, has already given the required guarantee of its ability to carry out the work.

Austria Hungary.—The Aussig local authorities have decided to construct an electric tramway 3½ miles in length, from Pokau to Tellnitz, at a cost of 270,000 kronen (£11,250).

Bangor.—The total income of the electricity department for the year ended March 31 was £30,540, against £30,497 last year.

After paying expenses the gross profit was £1,631. Interest was £875 and sinking fund £1,224. The year's deficit was £468, against £490 last year.

Barnsley.—The chairman of the Electricity committee (Ald. Brady) reported to the Council on Tuesday that though the introduction of metal filament lamps had reduced the consumption of electricity in the majority of cases by 30 per cent., the past year's working of the electricity department had been most successful. They had been enabled to strengthen the reserve, and the undertaking had never been in such a successful condition.

Birmingham.—The accounts for the year ended March 31 were presented to the Tramways committee on Tuesday.

The net profit was £56,442, and the committee decided to place £23,528 to reserve, the balance (£32,915) going to relief of rates. The last sum is £3,500 more than the amount given to relief of rates in 1909, and is regarded as satisfactory, as, owing to the decrease in the hours worked by the staff, the yearly wages bill has been increased by about £8,000. The increased profit is due to a general improvement of traffic.

On Wednesday the Electric Lighting committee decided to set aside £10,000 to relief of rates out of the past year's profits of the electricity department.

Bournemouth.—For the year ended March 31 the traffic receipts of the tramways were, with sundry receipts £85,540.

Expenses were £55,677. 4s. 4d., leaving gross profit £29,862. 11s. 8d., an increase of £3,325. 13s. 6d. over the previous year. The deficit is about £2,140.

Bridlington.—An unopposed inquiry was held on Wednesday into the application of the Council for permission to borrow £3,000 for extensions of the electricity works.

Canada.—The Public Utilities committee of Brandon recommend erection of electric power works and construction of electric tramways. It is proposed to put down four 187 kw. steam driven generators.

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Medicine Hat Municipal authorities propose to establish an electric power plant, to be driven by natural gas, at an estimated cost of £10,250.

It is reported that application has been made to the Regina City Council by a new company, whose representative is Mr. Lawford Grant, general manager of the Canadian British Insulated Co. (Montreal), for a concession to construct an electric railway of about 8 miles in length.

The town of Bracebridge, Ontario, is erecting municipal electricity works.

Canadian Telegraphs.—The Canadian Pacific Railway and the Great North-Western Telegraph Companies recently put into effect the night lettergram service between all points in Canada and the United States. By this service lettergrams of 50 words or less can be transmitted for the same rate as a 10-word message, day rate, and one-fifth of this rate is charged for each additional 10 words or less. The letters must be written in plain English.

Chertsey.—The Rural Council have acceded to the application of the Woking Electric Supply Co. to be allowed to supply electricity to 29 houses in the parish of Chobham.

China.—Mr. Hewlett (acting British Consul) states that a Chinese electric lighting company was established at Changsha during 1909. The contract for the plant was awarded to a German firm.

Mr. Consul H. H. Fox, writing on the trade of Wuhu for 1909, says that the Wuhu Electric Light Co. (a Chinese company under Chinese management) commenced operations in May, 1909, and supplies current regularly to about 4,000 lamps in the native city. It is proposed to use electric power for the rice cleaning machinery in a local mill.

Colchester.—An inquiry was held last week into the Council's application for sanction to borrow £8,000 for the electricity undertaking.

The Town Clerk stated that the proposed loan was required for excess expenditure on previous loans sanctioned (about £934) and for new works, including £2,700 for five miles of mains. The mains were for districts where a supply of current would in the immediate future required For house services £1,125 was included. They had two generating sets, which had become too small for requirements, and the Electric Light committee desired to substitute for these one generating set, for which £1,300 was required. The Hythe and Lexden sub-stations, for which £960. 6s. 4d. was wanted, had already been put down, and were working satisfactorily.

On the advice of the inspector (Mr. H. Ross Hooper) the question of the generating set was left in abeyance, and other items were altered, the amount of the loan being reduced to £7,453.

Crewe.—It was reported to the Council last week that the net profit on the past year's working of the electricity undertaking was £1,219. £500 had been voted to relief of rates.

Darlington.—Application has been made for sanction to a loan of £1,500 for condensing plant.

Darwen.—There was a profit of £573 on the past year's working of the electricity undertaking.

Denmark.—Consul Liddell says the Copenhagen communal loan of 1910 (which amounts to about £2,000,000) will probably be devoted to the erection of power stations, amongst other works, during the next few years.

Dundee.—The Ward-road Brass Works have adopted electric lighting, and Messrs. Walker & Thomson, oil refiners are adopting the electric drive.

Eccles.—The Council offer to supply current to the Crown Theatre at 2½d. per unit subject to an undertaking being entered into that the supply shall not exceed at any time 25 kw., and that there be a guaranteed minimum yearly consumption of 25,000 units.

Electric Power on Tramways and Light Railways.—The Board of Trade have issued a revised edition of the regulations as to the use of electric power on tramways and light railways, which contain some slight amendments of the regulations issued in May, 1908.

Erdington.—It was reported to the Council last week that for the year ended March 31, the number of passengers carried on the tramways was 2,988,276, compared with 2,762,520 in 1908-9. Receipts were £13,953 (against £12,895). Receipts per car-mile were 11·06d. (10·49d.)

Fatalities.—In the Hamilton Sheriff Court on Thursday last an inquest was held on Alex. Hinshelwood, an electrician employed at the Glasgow Iron & Steel Works, Wishaw.

The foreman electrician, John Hill, stated that on April 2 he and deceased were executing repairs to an overhead electric charger. To make some tests he (Hill) went to the top of the charger and instructed deceased when he got the necessary signal to pull out the switch and replace the fuse. This was done twice, but on the third occasion, for some reason or other, Hinshelwood failed to pull out the switch, and he received a shock which proved fatal. The voltage of the current was 320. Deceased was a careful electrician, and had been four years at the works.

Other evidence was given, and the jury returned a verdict of death from electric shock.

An inquest was held on Monday on Geo. James Porter, superintendent at the Brush Electrical Engineering Co.'s Works, Loughborough.

It was stated in evidence that Mr. Porter was directing a test of a machine in which a fault had been found. He ran forward as the electric current was switched off and placed both hands on the machine to show another official the situation of the fault. The strength of the current was something like 2,000 volts, and he was killed almost instantly.

A verdict of accidental death was returned.

Gillingham.—The Council will supply electricity to the Naval Hospital at 1½d. per unit for power and at 2½d. for lighting.

Glasgow.—The Council have acquired 53,481 sq. yds. of land on the West side of Dalmarnock-road, at 8s. per sq. yd., for the erection of a new electricity generating station, &c.

Grimsby.—An unopposed inquiry was held on Tuesday into the Council's application for sanction to borrow £2,000 for superseding gas by electricity for street lighting.

The Inspector (Mr. H. Ross Hooper) pointed out that it was necessary to prove that the scheme was not going to be more costly than the present system, or that they were going to get something better at equal cost.

The borough electrical engineer (Mr. W. A. Vignoles) said that experiments had been made with metal filament lamps with highly satisfactory results. Not only did they get a much superior light, but they could do it at less cost than was paid to a private company for gas, and that, while the Corporation would lose a great consumer in the Great Central Railway Co., who, after November, would generate their own electricity, the saving in street lighting would go far to provide a profit as a set-off against the loss of £4,000 a year from the company.

Hackney (London).—The Electricity committee have had under consideration the question of developing the commercial side of the electricity undertaking and a deputation has visited the showrooms and offices of Marylebone and St. Pancras Councils, the Corporation of West Ham and also the Brompton & Kensington Electricity Supply Co.

In Hackney, since May, 1908, a sales department has been carried on in connection with the electricity undertaking, but it has suffered from the fact that there has been no show room and only one permanent officer, assisted by a temporarily employed clerk and assistant engineer. The committee are of opinion that the time has arrived when suitable premises should be taken in the vicinity of the town hall for the establishment of a showroom, and accommodation for those officers whose duty it is to deal more especially with the requirements of consumers as distinct from the generation of electricity. They have, therefore, made provisional arrangements to take premises in Mare-street.

Hampstead (London).—At the Council meeting last week the Lighting committee reported on the question of converting the whole of the street lamps from gas to electricity.

Previous to Dec. 20 last the inclusive charge per lamp-post per annum for a single upright incandescent burner was £3. 4s. 9d., but the Gas Light & Coke Co. offered to equip the posts with inverted burners and fully maintain them at an annual charge of £2. 19s. 10d. for the first five years, and afterwards at £2. 15s. 8d. per post per annum. On Feb. 24 the Lighting committee offered to take over the lighting of the whole of the posts, convert them to electricity, and maintain them at a cost of £2. 19s. 6d. per post for the first eight years, and afterwards at £2. 0s. 2d. per post per annum. This offer was conditional on all the lighting being handed over to them, and there were already some 340 lamps lighted by electricity, while Council had sanctioned the conversion of over 700 more, the materials for which were already largely in hand, and the work was being carried out. The Gas Company now offered to substitute an improved inverted burner, which they guaranteed would give an average of at least 60 c.p., at an inclusive cost of £2. 5s. for the first four years, and thereafter £1. 19s. 6d. for each post. This offer had been referred to the committee, and they had now prepared a proposal as follows, subject to the whole of the lighting of the borough being converted from gas to electricity :—

For posts fitted with two 35-watt lamps, £2. 5s. for first eight years and £1. 13s. 6d. subsequently; for posts fitted with four 35-watt lamps (or their equivalent), £3. 5s. and £2. 13s. 6d. (and 10s. per annum for every additional 35 watts). The following annual total cost of lighting the borough is based on there being 2,237 posts, fitted with one incandescent gas burner, or two 35-watt metal filament lamps. Present system, £7,242; inverted gas burners, £6,692 until 1915, and thereafter £6,226 (offer of Gas Company, Dec. 20, 1909). Electric incandescent, £6,655 until 1918, and thereafter £4,493 (scheme adopted by the Council Feb. 24 last); inverted gas burners, £5,033 until 1914, and afterwards £4,418 (offer of Gas Company March 16 last). Electric incandescent, £5,033 until 1918, and afterwards £3,747 (present proposal).

The committee recommended that the whole of the gas lamps in the borough should be converted to electricity under the scheme formulated.

Councillor Simmons moved that the report be referred back in order that the Council might avail themselves of the Gas Company's offer to fit up a trial installation of about 20 inverted gas burners for observation, and this was carried by 18 votes to 17.

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Handsworth (Staffs.)—The Board of Trade have sanctioned the borrowing of £19,150 in connection with the purchase of the cable tramways. The period of the loan is 40 years.

The board have appointed Mr. Alfred Lyttelton, K.C., M.P., as arbitrator to settle the terms of the lease of the cable tramways to be granted by the Council to the City of Birmingham Tramways Co.

Harrogate.—The Council have unanimously passed the scheme of the borough electrical engineer (Mr. Geo. Wilkinson) for an additional 500 lamps to be converted from gas to electricity. Competitive schemes have been submitted by both the gas and electricity undertakings, and the saving by substituting electricity was found to be a substantial one. The cost per post to be charged to the Lighting committee for a 50 c.p. lamp (including renewals and all accessories) is 17s. per annum, the lamp being extinguished at midnight.

Hebden Bridge.—To encourage the demand for electricity the Council have resolved to grant to consumers a sliding scale of discounts.

Heckmondwike.—The Council have applied for sanction to a loan of £24,159, of which £19,959 is for excess expenditure on the electricity works, £3,000 for condensing plant, £1,000 for cables, and £2,000 for house services.

Holland.—Consul W. A. Churchill says, in his report on the Amsterdam district for 1909, that there is a vogue in the Netherlands at present for electric tramways and electric light and power, and it is anticipated there will be an active demand for electric plant during the next two years. The same may be said with regard to the Dutch East Indies, where 20 important concessions were granted last year, besides which it is rumoured that the Java State Railways will be electrified.

A steam tramway (60 miles in length) is to be constructed shortly to connect various villages in the Haarlemmermeer district, at an estimated cost of £600,000. The name of this company, Hollandsche Electrische Spoorweg Maatschappy, indicates that electricity may be used later.

The Noord-Zuid-Hollandsche Tramweg Maatschappy increased their capital last year by £270,000, in order to improve and electrify their lines between Haarlem and Leiden. The estimated cost of electrification is estimated by the company at £1,075 per mile.

The light railway system in the province of Groningen is to be considerably extended, and part, if not the whole, is to be electric. Arnhem municipality are considering projects for electrification and extension of the horse tramways.

The Holland Electric Tramway Co.'s concession for an electric tramway between Amsterdam and Wyk-aan-Zee has been withdrawn.

Three Westinghouse benzine-electric motor carriages have been ordered for the Ooster Stoomtrom tramways between Zeist and Arnhem.

The cost of engineering works in the Netherlands and the Dutch East Indian colonies during the next few years is approximately as follows:—

Netherlands: Electrification of light railways and extension of steam tramways, £2,000,000; erection of about 10 electric power stations, £500,000; gas and water works, £1,250,000.

Colonies: Electric light and power in 12 towns in Java, electric water power stations in four towns in Java, electric high-tension transmission in three provinces in Java and two electric motor 'bus services in Soerabaia and Samarang (Java), £5,000,000; Electrification of the Java State Railways, £13,000,000; railways and harbour works in Sumatra, £15,000,000; total, Netherlands and colonies, £40,000,000.

The number of electric motors in use in Amsterdam during 1908 was 7,015. The municipal supply was d.c. at 220 and the Electra Co.'s a.c. at 72 volts and 50 cycles.

Plans have been drawn up for the construction and working of electricity works for the towns of Deventer and Zwolle (Overijssel province).

Huddersfield.—It was reported at the Council meeting recently that the tramways account showed a surplus of £6,807, compared with £2,061 last year, and an amount equal to $3\frac{9}{16}$d. in the pound has been devoted to relief of rates after setting aside £12,250 for depreciation and meeting interest and charges for redemption of debt.

Ilkeston.—The capital expenditure on the Corporation's tramway undertaking at March 31 was £47,630, compared with £47,578 in 1909.

Last year's traffic receipts were £6,887 (against £7,116), total receipts £7,061 (£7,379), or 7·06d. (7·3d.) per car-mile; working expenses were £6,025 (£5,856), including £1,495 (£1,543) for power. 359,284 (368,195) units were used, 1·48 (1·58) per car-mile. Gross profit was £1,036, and net deficit, after meeting interest, &c., and providing for sinking fund contribution, £2,086 (against £1,636). The increase in operating expenses is stated to be entirely due to special expenditure on track and overhead equipment and increase in wages of staff. The engineer and manager (Mr. H. P. Stokes) states that the average expenses at Ilkeston are in excess of those of only 22 out of 76 municipal tramway undertakings of which he has prepared statistics, and the average for the 76 towns is 6·3d. per car-mile, against 6·02d. at Ilkeston. Mr. Stokes has not been successful in getting permission from the Board of Trade to fit roof covers on cars, but proposes to carry the matter further.

The revenue of the electricity department was £3,180, working expenses £1,981 or £1,788 (against £1,979), exclusive of special work in consumers' premises. Gross profit was £1,200 (against £780), and the deficit £86 (against £432). Units purchased were 314,476 (against 283,220). Current is taken in bulk for the electricity and tramway departments from the Notts & Derbyshire Electric Power Co. £350 is being placed to reserve on tramway account and £500 on electricity account.

India.—The "Indian and Eastern Engineer" states that the Railway Board has authorised the electrification of the Jhansi workshops of the Indian Midland section of the G.I.P. Railway.

The Central Jute Pressing Co. (Calcutta) are erecting a new jute press near Chitpore, which is to be driven electrically, the electrical plant being supplied by the Lahmeyer Electrical Co., and erected under the supervision of their chief engineer in India, Mr. H. R. Speyer. The Lahmeyer Co. are also supplying the electrical equipment for the new Ocean Jute Press of Seth Hursook Dass Dooly Chand at Chitpore.

Italy.—The electrification of the Savona San Guiseppe State Railway is to be continued to Ceva, making the electric line 28 miles in length.

Genoa Provincial Council have granted to a preliminary committee of capitalists a 30 years' concession for the construction and working of an electric tramway from Savona to Valdo. A company, with £32,000 capital, is to be formed to carry out the work, and it is anticipated that the line will be completed by the end of 1911.

Japan-British Exhibition.—This exhibition will be opened to-morrow (Saturday), but on account of the death of King Edward there will be no formal ceremony.

Llanelly.—The Llanelly & District Electric Light & Traction Co. have commenced the work of erecting a generating station. Current will be available about August.

London and Suburban Tramways.—Through tramway services from Aldgate to Leytonstone and Ilford were opened on Wednesday. The fare for the whole journey on either route is 3d.

London County Council.—On Tuesday it was agreed to allow Poplar Council to repay by quarterly instalments all loans for electricity purposes which are at present repayable on the annuity method. £13,450 for electricity supply was loaned to Woolwich.

Tramway Construction Works.—The adjourned recommendation of the Highways committee for the reconstruction of the horse tramways from Tooley-street to Deptford and the construction of authorised tramways from Evelyn-street to Nelson-street, Greenwich, was agreed to.

Draught Screens.—It was agreed to expend £1,064 in providing draught screens to the remaining 133 cars which were constructed without them.

Monaghan (Ireland).—The Council have decided to proceed with an electricity scheme prepared by Messrs. Curran Bros. at an estimated cost of £2,000.

Municipal and Health Exhibition.—This exhibition was opened at the Agricultural Hall, London, N., on Saturday last, and will remain open until to-morrow. There is little of an electrical character to be seen, and we would ask, Why this lack of enterprise on the part of electrical engineers. Municipal work of all kinds is a field in which electrical engineers have already done much, but there is still a great deal to be accomplished, and advantage might have been taken of such an exhibition to show the many ways in which electric light and power may be employed in municipal enterprise. It may further be pointed out that several gas features are to be found at the exhibition, and that where our rivals are hard at work advertising themselves it surely behoves us to be also.

On Richard Hornsby & Son's stand will be found practically the only apparatus in the exhibition likely to be directly of interest to electrical engineers. This company are showing one of their patent suction gas plants and engines coupled to a dynamo for lighting country houses and other similar buildings. This set supplies a motor, the whole being controlled by Ferranti switchgear.

Messrs. Babcock & Wilcox have on show a model of their well-known water-tube boiler, while an example of their water softener is to be seen in full operation.

New Caledonia.—Acting Consul Maning states in his report for 1909 that three nickel reduction works are in course of erection, that one (an electrolytic process) was almost ready to commence operations, and another was expected to start smelting by November, 1910.

Penmaenmawr.—The Board of Trade have extended the period of the Council's provisional order by 12 months.

Reduction in Telegraph Rates.—It is announced that on and after June 1, there will be a reduction in the rate per word for telegrams from this country to Argentine, Chili, Peru, Uruguay, Paraguay and Bolivia to 3s. 7d. per word, and to wireless stations established in Peru (Masisea, Orellana, Requena and Iquitos) to 5s. 7d. per word.

Road Board.—Under the terms of sec. 7 (1) of the Development and Road Improvement Funds Act, 1909, the following have been appointed members of the Road Board: Sir George S. Gibb (chairman), Lord Pirrie, K.P., Lord Kingsburgh (Lord Justice Clerk of Scotland), Lord St. Davids and Sir Charles D. Rose, Bart.

In consequence of his acceptance of the chairmanship of the Road Board, Sir George Gibb will shortly retire from the board of the North Eastern Railway, from the position of managing director of the Underground Electric Railways Co. of London, &c.

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St. Pancras (London).—The borough treasurer, who has reported upon the report of the L.G. Board auditor on his audit of the Council's accounts for the year ended March 31, 1909, states that he has made arrangements with the Chief Electrical Engineer that for the future, as regards expenditure for mains, connections and meters, he will submit estimates of the cost for such purposes 12 months in advance.

South Africa.—The "British and South African Export Gazette" states that the Cinderella Consolidated Gold Mines are about to purchase a number of 5-ton skips and electric winders.

Johannesburg Corporation have recently purchased 8,000 tapered iron telegraph poles, 119 miles of covered wire and a quantity of tram rails, fish plates, bolts, &c.

Southwark (London).—The Electricity committee report that after considerable negotiation, the L.C.C. has agreed to the provision of recording instruments at the station, together with the necessary apparatus for taking records of pressure from pilot wires connected to the feeding points at the different places within the area of supply, in substitution for the four testing stations originally asked for. The cost of pilot wires and instruments is estimated at £370.

The Council will support Islington Borough Council in their attempt to get street boxes for electric lighting exempt from district surveyors' fees.

Spain.—The Spanish Minister of Public Works will (it is stated) shortly introduce a bill providing for an expenditure of £17,000,000 upon tramway and railway construction.

Stretford.—The Electricity committee has decided to put down an additional 500 kw. generating set, boiler and economiser, surface condenser and filtering plant, &c. Mr. T. L. Miller has been appointed to prepare specifications, to advise on the tenders, and to attend any loan inquiry at an inclusive fee of £140. The General Electric Co., British Westinghouse Co. and Lancashire Dynamo Co. have been asked to quote for the 500 kw. set, and Edward Heaton & Sons, Galloways (Ltd.) and Thomas Beeley & Son for the boiler, &c.

Telegraph Investments.—The stock and shareholders' meetings of a number of the leading telegraph companies are set out in the present issue of THE ELECTRICIAN, and are, in the main, interesting reading, as showing the settled value to investors of the stocks and shares of these companies. This satisfactory situation is emphasised in an article which appeared in the "Financier" (London) of May 10. In this article particular attention is drawn to the strong position held by these companies in respect to their very substantial reserves for all purposes.

Uruguay.—Concessions have been granted for the provision of telephone facilities in Maldonado by A. Zabala, in Carmelo, Colonia, and Colonia Arrue by Saturno Carbajel; and in an additional portion of Tacuarembo by Pedro Pomoli.

Venezuela.—A concession has been granted to the Provisional President of the State of Trujillo for the construction of a telephone line from Mendoza to Valera.

Walsall.—The L.G. Board has sanctioned loans for £8,345, including £1,000 for land, £1,250 for a sub-station, £1,404 for plant for sub-station, £3,691 for mains, and £1,000 for services.

Wednesbury.—The report of the electricity department for the year ended March 31 states that 433,267 units were sold, an increase of 209,559 units over 1909.

The receipts were £3,184. After paying expenses the gross profit was £1,485; interest and sinking fund charges came to £1,343, leaving a nett profit of £142. The ex-Mayor, in proposing the adoption of the report, said the report was very satisfactory. The scheme now in operation was economical, and the cost of supply compared favourably with that of larger undertakings. The charges were so moderate that many of the working classes were using electricity for lighting by means of slot meters. The total output had been nearly doubled during the year.

West Bromwich.—The Electricity committee reported to the Council on Wednesday that there was a decrease of £348 in the amount received from the sales of current during the past year, this being mainly brought about through a decrease in the amount received in respect of tramway traction.

West Hartlepool.—It was reported to the Council last week that the gross profit on the past year's working of the electricity undertaking was £6,888, an increase of £414 over 1909. Interest absorbed £2,475 and repayment of loans and sinking fund £3,296. The net profit is £1,128, against £584. The balance has been added to reserve. The net outstanding capital expenditure is £66,000.

Wireless Telegraphy.—We have already referred to tenders received by the Commonwealth P.M.-G. for the erection of wireless stations at Sydney and Fremantle. Further particulars are to hand from which it appears that five tenders were received, and that of the Australasian Wireless (Ltd.) has been accepted at £4,150 for each station. The next lowest was £7,000 each, but did not comply with the conditions, &c. Two other tenders were for £7,777 and £9,317. 10s. per station respectively, the highest being £19,020 per station! The successful tenderers are stated to have guaranteed a speed of 1,000 letters per minute, "whether by the oral method or by records." Australasian Wireless (Ltd.) is a new company, formed to acquire the rights for Australasia of the Telefunken system. The work is to be completed in 52 weeks from acceptance of tender under a £10 per week penalty. A further provision of the contract is the forfeit of £500 and the plant, so far as completed, to the Commonwealth in case of failure to carry out the contract. The station at Sydney is to be situated either at the North or South Head and the Fremantle station is to be either at Rottnest Island or on the hills behind the harbour.

Dinner.—Last week a dinner was given to celebrate the coming of age of the Bournemouth & Poole Electricity Supply Co. The whole of the dinner was cooked by electricity, and the oven and all other apparatus were installed in the dining room.

Amongst those present were: Mr. A. H. Sanderson, J.P. (chairman), Dr. J. Atkinson Hosker, J.P. (vice-chairman), Mr. H. P. Croft (M.P. for Christchurch), Mr. H. B. Renwick, Mr. W. D. Brightman, Mr. E. L. Ingram, and many others.

Mr. H. B. RENWICK, in proposing the toast of "The Chirman, Vice-Chairman and Directors of the Company," said he was one of the oldest members of the company, and it was now 21 years ago since the Bournemouth Electricity Co. commenced a public supply in Bournemouth in a modest way, from the overhead cable lighting system in the centre of the town. That modest undertaking was taken over by the Bournemouth & Poole Electricity Supply Co. 19 years ago, and had grown up to its present state of prosperity. A prospectus issued 19 years ago contained the statement that they had 60 consumers, 1,000 8 c.p. lamps connected and £3,000 revenue in excess of expenditure. He joined the staff as secretary some four years later, and they had then increased to 19,000 8 c.p. lamps connected, 250 consumers and a gross revenue of £7,350. Now they had 5,000 consumers, 200,000 8 c.p. lamps connected and the gross revenue was £57,000. The company had grown to one of the largest in the United Kingdom.

Mr. A. H. SANDERSON, in responding, said he felt it a great honour to be the chairman of the company. The management had been successful in steering the ship into calm waters, and they were now enjoying great prosperity.

Dr. J. A. HOSKER proposed the toast of "The Guests," and Mr. H. PAGE CROFT, M.P., replied.

The CHAIRMAN, who proposed the "Health of the Staff of the Bournemouth & Poole Electric Supply Co. (Ltd.)," complimented the company on the excellency and efficiency of their staff and employés.

Mr. E. L. INGRAM and Mr. W. D. BRIGHTMAN responded.

Yarmouth.—On the recommendation of the General Purposes committee it has been decided to convert 192 gas lamps to electric lamps during this and next year. It is estimated that a saving of £76. 6s. 8d. per annum will be effected.

In a report on the existing arc lights, which number 186, and cost £2,375. 12s. per annum, the surveyor suggests converting them to flame arcs, and 400 c.p. incandescent lamps, which will effect a saving of £200. 19s. 6d. This suggestion has also been adopted.

Electrical Football League.—The annual general meeting will be held on the 18th inst. at the offices of the St. James' & Pall Mall Electric Supply Co., 19, Carnaby-street, Golden-square, London, W. All football clubs attached to electrical firms within 15 miles radius of Charing Cross are invited to send two representatives, as the council are anxious to increase the number of clubs. Particulars can be had from the hon. secretary (Mr. H. W. Roberts), 71, Queen Victoria-street, London, E.C.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

NEWPORT (Mon.) Electricity committee invite tenders for supply and erection of two 400 kw. motor-generators, three-phase to d.c.; one 600 kw. motor-generator, three-phase to single-phase; and one 'bus-bar three-wire booster. Specifications, general conditions and form of tender from the borough electrical engineer and tramways manager, Mr. H. Collings Bishop, Town Hall, Newport, Mon. Tenders to the Town Clerk by first post May 31. See also an advertisement.

COVENTRY Electricity committee invite tenders for supply, delivery and erection of a 1,250 kw. turbo-alternator, complete with surface-condensing plant, &c., four water-tube boilers (straight tube type) and two fuel economisers. Specification, general conditions and forms of tender from the engineer and manager, Mr. Geo. Tough, and tenders to the Town Clerk, Hay-lane, Coventry, by first post May 30. See also an advertisement.

The Corporation of the City of LONDONDERRY invite tenders for supply, delivery and erection of a 400 kw. mixed-pressure d.-c.

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turbo-generator, condenser, pipe work, floor plates, &c., switchboard panels, instruments and connections, economiser, dampers, pipes, valves, &c., and feeder cable, connections, &c. Specifications, &c., from the city electrical engineer, Mr. R. V. Macrory. Tenders to be addressed to the Town Clerk, Municipal Offices, Londonderry, by May 21. See also an advertisement.

The Tramways and Electricity committee of BELFAST Corporation invite tenders for motor boosters and switchgear and extension of lighting switchboard. Specifications, &c., from the city electrical engineer, Mr. Thos. W. Bloxam, M.I.E.E. Tenders to the Town Clerk, City Hall, Belfast, by 10 a.m. May 23.

St. Pancras (London) Borough Council invite tenders for supplying 21 flame arc lamps with 20 suitable iron cradles. Copies of specification, conditions of contract and form of tender from the electricity department offices, 57, Pratt-street, Camden Town, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett) Town Hall, Pancras-road, London, N.W., by noon, May 23.

SOUTHAMPTON Corporation invite tenders for supply of a 1,000 kw. steam generator, boiler, alternator and motor alternator. Particulars, specifications and forms of tender from the borough electrical engineer, Mr. H. F. Street, electricity works, Western Shore, Southampton. Tenders to the town clerk, Mr. R. R. Linthorne, Municipal Offices, Southampton, by May 24.

The Lighting committee of DUBLIN Corporation invite tenders for supply and erection of flame arc lamps and arc lamp pillars. Specifications, &c., from the city electrical engineer, Mr. Mark Ruddle, Fleet-street, Dublin. Tenders, addressed to the Chairman of the Lighting committee, 3, Cork-hill, Dublin, by May 20.

Tenders are invited up to June 14 for supply of 100 party line common battery telephone wall sets, 10 party line common battery table sets, 100 switches, common battery, single extension and intercommunication, and 3,000 telephone protectors to the Postmaster-General's department in VICTORIA. Tender forms and specification at the Commonwealth office, 72, Victoria-street, London, S.W.

Tenders are invited up to June 7 for supply of one frame, main distributing, to the Postmaster-General's department in WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W.

LEICESTER Tramways committee want tenders for supply of mixed pressure steam turbine direct-coupled to 750 kw. d.c. generator, with condensing plant, switchboard, &c., and two Lancashire boilers, with fuel economiser, piping, &c. Forms of tender from the Tramway Engineer, Belgrave-road, Leicester.

CROYDON Corporation want tenders by 11 a.m. May 26 for lighting the two isolation pavilions and additions to the administrative block of the Borough Hospital, Waddon. Specification, &c., from the Borough Engineer.

The Commissioners of H.M. Works and Public Buildings want tenders by May 17 for steelwork of Glasgow labour and telephone exchange. Forms of tender, &c., from 3, Parliament-square, Edinburgh.

CLACTON Council invite tenders for annual supplies for the electricity department, including electrical service fittings, joint box compound, oils, cotton waste, bitumen, &c. Tenders to the Clerk by noon May 23.

DARLINGTON Electricity committee want tenders by May 25 for a cooling tower, electrically-driven centrifugal and air pumps and a boiler feed pump. Specifications, &c., from the Borough Electrical Engineer.

ST. PANCRAS (London) Council require tenders by noon May 23 for 12 months' supply of steam coal to their electricity stations. Specifications, &c., from the Electricity Department, 57, Pratt-street Camden Town, N.W.

ROCHDALE Electricity committee want tenders by noon May 25 for supply and erection of battery of accumulators, reversible booster and switchboard panels. Specification, &c., from the Borough Electrical Engineer.

RHYL Council want tenders by May 23 for 830 yds. of 0·125 and 370 yds. of 0·2 triple concentric cable. Specifications, &c., from Mr. E. H. Wright, electricity works, Rhyl.

BATLEY Corporation require tenders by noon June 1 for a lighting and traction switchboard for the electricity works. Specifications, &c., from the Borough Electrical Engineer.

MANCHESTER Tramways committee want tenders by 10 a.m. May 24 for supply of steel girder tram rails and granite setts. Specifications, &c., from the General Manager.

FINCHLEY Council want tenders by 11 a.m. May 28 for sinking a deep tube well at the electricity works. Specification, &c., from the Electrical Engineer, Squire's-lane, Finchley.

REIGATE Council want tenders by May 21 for fire-alarms, &c. Specification, &c., from the Town Clerk.

The Deputy Postmaster-General, BRISBANE (Queensland), will receive tenders until noon June 22 for supply of copper wire and accessories, covered wire, iron wire, insulators, ironwork and sal ammoniac and zincs for batteries. Local representation is necessary.

The acting Town Clerk, WELLINGTON (N.Z.), will receive tenders until 4 p.m. May 19 for supply of six pairs of electric tramcar trucks. Specifications from the Engineer and Manager, or can be seen at 73, Basinghall-street, London, E.C.

The Board of Control, WINNIPEG (Canada), will receive tenders until May 16 for supply of conduit, construction of conduit runs, and supply of sub-station transformers and switching apparatus. Specifications, &c., from the Power Engineer, Winnipeg.

The Deputy Postmaster-General, PERTH (W. Australia), will receive tenders until 3 p.m. May 24 for supply of four 40 ft. and 10 50 ft. steel towers. Local representation necessary.

TENDERS RECEIVED AND ACCEPTED.

London County Council have accepted the tenders of the following firms for tramway fittings and equipment :—

British Westinghouse Co., Dick, Kerr & Co., British Insulated & Helsby Cables, London Electric Wire Co. & Smith's, Liverpool Electric Cable Co., General Electric Co., Western Electric Co., Callender's Co., India Rubber, Gutta Percha & Telegraph Works Co., G. McLellan & Co., North British Rubber Co., J. G. Ingram & Son, Irwell & Eastern Rubber Co., F. Mountford, Brecknell, Munro & Rogers, Imeson, Finch & Co., T. Bolton & Sons, Dyer & Young, P. Hooker, A. Cort & Co., Micanite & Insulators, British Isola Co., Roburine Co., Ebonestos Mfg. Co., Wiggins & Sons, A. Round, Crystalate Mfg. Co., Bullers (Ltd.), Doulton & Co., F. W. Rowlands & Co., W. C. Wrigley & Co., J. Holroyd & Co., Hadley Bros., West Bromwich Spring Co., G. Salter & Co., J. Steel & Sons, Tempered Spring Co., Smith Bros. & Hill, Lion Spring Co., Dart Spring Co., Highton & Co., Player & Mitchell, G. D. Peters & Co., Hurst, Nelson & Co., Howarth & Hanson, E. Showell & Sons, Gabriel & Co., United Electric Car Co., Anti-Attrition Metal Co., Davis & Timmins, Deptford Engineering Co., F. W. Cotterill, Bayliss, Jones & Bayliss, E. H. Bentall & Co., Smethwick Stamping Co., Armstrong, Stevens & Son, Derited Stamping Co., J. B. Brooks & Co., Wilkes (Ltd.), C. Dunn (Ltd.), Woodall & Co., Central Marine Engine Works, Hunter & English, Blake Boiler Wagon & Engineering Co., Warren & Sons, East Ferry-road Engineering Co., Head, Wrightson & Co., C. Bunn (Ltd.), J. Williamson & Co., Northampton Direct Castings Co., T. Summerson & Sons, J. Crowley & Co., National Rail & Tramway Appliances Co., J. Martin & Son, Davis Gas Stove, Diamond Foundry, J. Wells (Ltd.), Brydon & Co., J. Crowley & Co., S. Osborn & Co., Cammell, Laird & Co., W. Shaw & Co., Hadfield's Steel Foundry Co., Edgar Allen & Co., T. Firth & Sons, T. Bolton & Sons, Isaac Storey & Sons, P. & W. McLellan, Frodingham Iron & Steel Co., Dermatine Co.

London County Council have also accepted the following tenders :

A. N. Coles (lowest tender) for roadwork and platelaying for reconstruction of tramways from Tooley-street to Deptford, £123,675. 19s. 10d. (Three tenders received; highest £133,920. Chief engineer's estimate £132,701. 0s. 2d. Mr. Coles is to be allowed to sublet the plough box covers and rain drain boxes to Hadfield's Steel Foundry Co., yokes and castings to the Anderston Foundry Co., tie rods, bolts and nuts to Bayliss, Jones & Bayliss, and jumper cables to Callender's Co., W. T. Henley's Co. and General Electric Co.)

David Bridge & Co. for shafting bearings, brackets, &c., for second section of central car repair depot, £456. 18s. (One other tender received, £553. 8s. Chief officer's estimate £510. Messrs. Bridge & Co. are to be allowed to sublet portions of the work to the Empire Roller Bearings Co.)

Alley & MacLellan (lowest tender) for air compressor and receiver for second portion of central car repair depot, £187. 10s. (Seven tenders received; highest £275. 10s. Chief officer's estimate £250. Messrs. Alley & MacLellan are to be allowed to sublet the air receiver to Muir & Findlay or T. Balmforth, and valves to Dewrance & Co.)

Patent Shaft & Axletree Co. for 4,800 steel driving wheel tyres for tramcars at 21s. 6d. each. (Sixteen tenders received; highest 50s. 9d., lowest 17s. 1d. Four were lower than the accepted tender, but the schedule as to wages was not filled in.)

John Batt & Co. for 1,600 steel tyres for driving wheels of tramcars at 15s. 9d. each. (Fifteen tenders received; highest 30s. Three were lower than the accepted tender, but the schedule as to wages was not filled in. Messrs. John Batt & Co. are to be allowed to sublet to Bochumer Verein Stahlwerke (Bochum, Germany) and the Vereinigte Stahlwerke van der Zypen und Wissener Eisenhütten A.G. (Cologne-Deutz, Germany, the manufacture of the pony-wheel tyres.)

Edinburgh Corporation have accepted the tender of the Lahmeyer Electrical Co. for supply of insulated cable for the year ending May 15, 1911, amounting to £5,202. 17s. 9d.

At the Council meeting questions were asked as to the tenders submitted, and in reply Mr. STEVENSON said any firm would accept the contract on the terms laid down by the Council with regard to standard wage, but the Council had no knowledge of whether the firm would pay the standard rate of wages. In their country the conditions of labour

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were entirely different. The point was that the Council was saving £660 on the contract. He moved approval, mentioning that the lowest British tender was £600 dearer.

Mr. RAWSON complained that the Council were penalising their own workmen and allowing foreigners practically to take the bread out of their mouths. He moved that the order be given to the British firm whose tender was next to the one mentioned.

This motion was carried by 23 votes to 9.

Hammersmith (London) Council received the following tenders for cables, the names in parentheses indicating where the cable was made: Western Electric Co. (*accepted*), **£660** (Woolwich); Standard Cable Co., £625 (Germany); Union Cable Co., £658. 4s. 9d. (Germany); Aubert, Grenier & Co., £672 (foreign); Callender's Cable & Construcion Co., £700 (Erith); Siemens Bros. & Co., £700 (Woolwich); Johnson & Phillips, £700 (Charlton); British Insulated & Helsby Cables, £705. 9s. 4d. (Prescot); W. T. Henley's Telegraph Works Co., £710 (London); W. T. Glover & Co., £715 (Salford); General Electric Co., £735. 8s. 9d.; Craigpark Electric Cable Co., £948. 16s. 6d. (Glasgow).

Wigan Corporation have accepted the following tenders for annual stores:—

General Electric Co., Dorman & Smith, Eckstein, Heap & Co., Metallic Seamless Tube Co., H. G. Mayer & Co., and Morgan Crucible Co., electrical accessories; Baxendale & Co. and General Electric Co., electric lamps; John Bolton, T. Tyldesley, G. Makinson and I. Sandback, engine room stores.

Dick, Kerr & Co., Hele-Shaw Clutch Co., Fleming, Birkby & Goodall, Brecknell, Munro & Rogers, Watlington & Co., Boydell & Co., L. Andrew & Co., British Westinghouse Co., S. Cook & Co., A. Clare & Co. and P. R. Jackson & Co., tramcar accessories; R. W. Blackwell & Co. and Imeson, Finch & Co., overhead material; R. Young & Co., engine room stores.

Bermondsey (London) Council have accepted the following tenders:—

Electricity meters, British Thomson-Houston Co. and Ferranti (Ltd.); time switches, Ferranti (Ltd.); demand indicators, Reason Mfg. Co.; cut-outs, General Electric Co.; ceiling troughs and terminals, General Electric Co.; standard fuses, General Electric Co.

Walsall Council has accepted the following tenders:—Rees Roturbo Mfg. Co., new transformer and switchgear, £715; Callender's Co., laying new trunk main, £1,286. 14s. 2d., and extending feeders and laying l.-t. cables £1,075. 13s. 7d.

Keighley Council have accepted the following tenders:—

E. Green & Son, economiser, £165; British Thomson-Houston Co., Tirrill regulator, £250; British Westinghouse Co., transformer and switchgear, £245. 18s.

Heckmondwike Council have accepted the tender of W. T. Henley's Telegraph Works Co. for cables for extensions to the premises of the Bradford Dyers' Association.

Walsall Council have accepted the tender of Callenders' Co. for cables at £2,361. 13s. 7d., and the Rees Roturbo Mfg. Co. for transformer and switchgear, £715.

Worksop Council have accepted the tender of the Mordey-Fricker Electricity Meter Co. for the supply of 50 prepayment meters at 43s. 9d. each.

Hammersmith (London) Council have accepted the tender of H. Mansfield for three-way ducts at £246. 13s. 4d., less 2½ per cent.

The Bastian Meter Co. have again secured the contract for 5 ampere meters at Edinburgh.

Southend Council have accepted the tender of Walter Scott (Ltd.) for 50 tons of 40 ft. tram rails at £7 per ton, plus 5s. for royalty.

Buxton Council have placed an order with Ferranti (Ltd.) for meters.

Huddersfield Council have accepted the tender of J. Marsden & Son for wiring the Birkby schools at £119.

Eccles Council has accepted the tender of Bertram Thomas for the extension of a traction switchboard for £48. 10s.

Lancaster Council have accepted the tender of E, Green & Sons for the renewal of economisers, at £120.

The tender of Messrs. Siemens Bros. Dynamo Works has been accepted by Walthamstow Council for supply of Tantalum lamps.

Dartford Council have accepted the tender of Johnson & Phillips for cables, and that of the Universal Electrical Mfg. Co. for a feeder pillar.

The contract for the electric lighting of St. Paul's Cathedral, Dundee, has been secured by Mr. T. C. Keay.

Johannesburg Corporation have placed orders with W. T. Henley's Telegraph Works Co. for 1,000 pairs of cut outs, and with Fraser & Chalmers for tram rails, fish plates, bolts, &c.

The Commonwealth Postmaster-General's Department, South Australia, has accepted the tenders of the British Insulated & Helsby Cables for jointing sleeves and switching cords; Western Electric Co. for condensers, switching and three-conductor cords; Gibbs, Bright & Co. for h.d. copper wire; W. Wallis for w.i. brackets for railway rails; Williams & Co. for iron spindles for insulators; H. Rowe & Co. for ammeters; and J. Bartram & Sons for condenser telephones.

BUSINESS NOTICES.

The partnership between Morgan Ivan Manderstjirna Williams and Harold W. Couzens (carrying on business as Morgan Williams & Couzens), consulting engineers, 39, Victoria-street, London, S.W., has been dissolved. Debts by Mr. Couzens, who continues the business under the old name, and at the same address.

Frank B. Hellon and Herbt. P. Tavernor (trading as F. B. Hellon & Co., electricians, 57, Moorfields, Liverpool) have dissolved partnership. Debts by Mr. F. B. Hellon, who continues at the same address.

Plant for Sale.—Eastbourne Corporation advertise for sale a 50 kw. steam alternator. Particulars from the borough electrical engineer, Mr. J. K. Brydges.

"Railway and Travel Monthly."—The first number of this magazine is just issued. Its articles range over railway matters in general, the most interesting being those descriptive of "Twentieth Century Railway Development," the new locomotive works of the London & South-Western Railway at Eastleigh, and "British Express Trains and Locomotives." We hope our contemporary will not fail to remember that there is an electricity section of railway working.

Kelly's Directory of the Building Trades.—We have received from Messrs. Kelly's Directories (Ltd.), 182-184, High Holborn, London, W.C., a copy of the 11th edition of this well-known directory, which contains 2,530 pages (exclusive of indexes) and about 300,000 classifications.

The directory is designed to give complete lists of all the various professions, trades and businesses connected with the constructive arts, and the publishers have spared no pains to make the new edition as complete and accurate as possible. No distinctions are made in the directory; a small town, if a builder carries on business in it, finds a place equally with the large provincial city or the metropolis itself. The work, which is as reliable as it is possible to make a book of so comprehensive a character, contains: (1) Lists of metropolitan, county and borough surveyors; (2) every ascertainable name in the towns and villages alphabetically arranged under each county; (3) the names under each particular trade (in London and its suburbs) alphabetically arranged; (4) the names for the rest of England, Scotland and Wales similarly arranged; (5) the names for Ireland arranged under towns and trades; and (6) the names for the Channel Islands and Isle of Man also arranged under towns. It is claimed that the whole of the names given in the directory have been personally checked by the publishers' canvassers and their returns afterwards arranged by a staff of clerks specially trained to the work. The directory is published at 30s.

"Export Merchant Shippers' Directory."—We have received from the Carter Publishing Co., 116, High Holborn, London, W.C., a copy of the 1910 (45th) edition of this directory, which appears to have been carefully revised. The work is divided into two volumes, Vol. I. being devoted to London and Vol. II. to the provinces. In addition to the list of exporters, places of shipment and classes of goods shipped, and the lengthy alphabetical index to the class of goods shipped, &c., much useful information of a commercial and business character is given. To increase the utility of the book generally, and particularly of Vol. I. (London section), memo pages have been interleaved in the itineraries of the City. The published price of the directory is 15s. 6d. nett.

"Lloyd's Lawyer."—From "Lloyd's Weekly News," 12, Salisbury-square, London, E.C., comes a copy of "Lloyd's Lawyer: Legal Advice for All," which contains much information on legal points likely to arise in connection with current business affairs. A feature of the publication is that it contains particulars of nearly all recent Acts relating to industrial matters, including the Trade Boards Act, the Children's Act, the Labour Exchanges Act, Workmen's Compensation, Small Holdings and Old Age Pensions. As might be anticipated in a first edition of a book of this character, many important subjects are omitted, but no doubt a revised edition will include some of those. The work, which contains a great deal of information of general use, is published at the popular price of 6d.

The Coming Holidays.—Modified as will probably be the holiday arrangements of many business men, owing to the course of public events, the busy man will still be interested in a publication which has been prepared for his special benefit to enable him to see at a glance the facilities which are offered on one of the best holiday routes in the kingdom—that of the London & South-Western Railway. The 12th annual official illustrated guide to the holiday and health resorts and show places on this extensive line has just been issued, and contains a large quantity of serviceable information and interesting illustrations of places in the United Kingdom, the Channel Islands,

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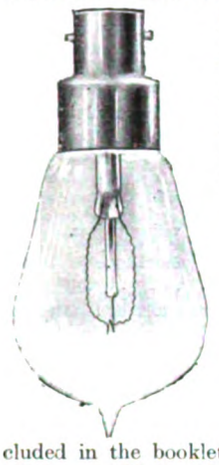
Normandy and Britanny which are reached with easy facility and comfort by this company's trains and steamers. These particulars include no less than 115 golf courses, in convenient proximity, many hundreds of hotels, furnished houses and apartments, and other information which will save time and temper in the solution of the difficult annual problem "Where to spend a holiday." 50,000 copies of this guide have been issued, and it can be obtained free at any station on the L. & S.W. system, or from any of the company's agents at home or abroad.

CATALOGUES, &c.

One-watt Battery Lamps.—Messrs. Siemens Bros. Dynamo Works have issued a price list of one-watt battery lamps suitable for use on pressures between 2 and 16 volts. These lamps have filaments of drawn wire and an efficiency of about 1 watt per candle-power. Users of this type of lamp should apply to Messrs. Siemens for this list, as it contains full details whereby great reductions are obtainable when large quantities of these lamps are purchased. The accompanying illustration gives a good idea of the general appearance of the lamps.



Two-pin Plug.—Messrs. Marsh, Son & Co. have placed on the market a new two-pin plug whose special feature is its flatness.

Wire Ropes and Fittings for Mining.—Messrs. W. N. Brunton & Son have ready a new catalogue dealing with this subject. Included in the booklet are particulars likely to be of use to mine managers. Those of our readers interested in this branch of work should obtain a copy of the catalogue.

Siemens' Woolwich and Dalston Works.—From Messrs. Siemens Bros. & Co. comes a pamphlet in which a full and interesting description of the company's works at Woolwich and Dalston. The details are likely to be of considerable interest to our readers, as in the latter works Tantalum lamps are manufactured, and we propose to recur to the subject again.

Alternating-current and Induction Motors.—Messrs. T. Harding Churton & Co. forward an interesting pamphlet on this subject. The question is dealt with not only from a commercial, but also from a technical point of view, and the information given should be of service to intending purchasers of motors.

Sterling Telephones.—The Sterling Telephone & Electric Co. send a publication dealing with their common battery automatic intercommunication telephones.

Gearing.—A pamphlet from the Buffoline Noiseless Gear Co. informs us that the company are bringing out a new catalogue dealing with gearing for all purposes and with Buffoline pinions made by a special process.

Motor-starters.—The Braulik Engineering Co. have ready a new list of motor-starters, controllers, &c., and a list dealing with motors and dynamos.

Passenger Cars for Lifts.—Messrs. A. & P. Steven have published a catalogue showing their designs of wrought-iron and wood lift cars. The catalogue is amply illustrated throughout, and indicates that the range covered by the firm in their manufactures is a large one.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during April, 1910, and (*b*) during the current year from Jan. 1 to April 30, with the increases or decreases compared with the corresponding periods of 1909:—

Electrical machinery (*a*) £44,170 (increase £9,579), (*b*) £181,589 (increase £27,661); telegraph and telephone cables (*a*) £15,743 (increase £8,190), (*b*) £52,921 (increase £20,563); telegraph and telephone apparatus (*a*) £16,895 (increase £690), (*b*) £58,796 (decrease £1,731); other electrical wires and cables, rubber insulated (*a*) £12,987 (increase £8,914), (*b*) £49,227 (increase £31,205); with other insulations (*a*) £2,825 (decrease £5,148), (*b*) £8,894 (decrease £28,967); carbons (*a*) £10,545 (increase £658), (*b*) £46,291 (increase £226); glow lamps (*a*) £32,987 (decrease £10,082), (*b*) £172,954 (increase £11,283); arc lamps and electric searchlights (*a*) £125 (decrease £143), (*b*) £1,401 (decrease £6,229); parts of arc lamps and searchlights (other than carbons) £6,825 (increase £3,066), (*b*) £24,199 (increase £8,077); primary and secondary batteries (*a*) £4,384 (increase £310), (*b*) £13,841 (decrease £4,440). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (*a*) £112,341 (increase £8,170), (*b*) £460,718 (increase £28,218).

Exports.—The exports of electrical machinery, material, &c., (*a*) during April, 1910, and (*b*) during the current year from Jan. 1 to April 30, and the increases and decreases compared with the corresponding periods of 1909, are as follows:—

Electrical machinery (*a*) £144,737 (increase £5,170), (*b*) £462,498 (decrease £11,667); telegraph and telephone cables (*a*) £60,896 (increase £13,406), (*b*) £804,136 (increase £658,402); telegraph and telepone apparatus (*a*) £17,126 (increase £1,451), (*b*) £52,480 (decrease £13,145); other electrical wires and cables, rubber insulated (*a*) £39,229 (increase £13,030), (*b*) £137,426 (increase £48,612); with other insulations (*a*) £32,443 (increase £12,426), (*b*) £79,131 (decrease £792); carbons (*a*) £1,612 (increase £1,204), (*b*) £6,190 (increase £3,719); glow lamps (*a*) £9,977 (increase £4,855), (*b*) £41,807 (increase £19,276); arc lamps and searchlights (*a*) £1,954 (increase £979) (*b*) £6,922 (decrease £142); parts of arc lamps and searchlights (other than carbons) (*a*) £1,162 (decrease £63), (*b*) £4,680 (decrease £1,614); primary and secondary batteries (*a*) £7,201 (decrease £767), (*b*) £33,570 (decrease £4,831). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £207,083 (increase £54,828), (*b*) £1,318,079 (increase £741,770).

BANKRUPTCIES, LIQUIDATIONS, &c.

The public examination took place last week of William Henry Palmer, electric light contractor, &c., formerly carrying on business in Great Castle-street, London, W.

In April, 1909, debtor sold his business to a company, which took over the assets, but not the liabilities, and he stated that he owed £1,070 to unsecured creditors and had no assets. Attributed his failure to trade losses and bad debts.

A first and final dividend of 3s. will be payable on May 23 (or subsequent Mondays and Wednesdays) at the offices of F. Nicholls White & Co., 14, Old Jewry-chambers, London, E.C., to creditors of C. H. W. Biggs (trading as Biggs & Sons), printer and publisher, 139 and 140, Salisbury-court, Fleet-street, E.C., and Glebe Lodge, The Glebe, Champion Hill, S.E., London.

A dividend is to be paid in respect of the separate estate of Joseph G. S. Cunnington, electrical engineer and contractor (lately trading with H. P. Allison, as Laing, Wharton & Cunnington, at 7, Great Newport-street, London, W.C.) Claims to Mr. A. Page, 28, King-street, Cheapside, London, E.C., by May 24.

A dividend is to be paid to creditors of Walter S. Jenkinson, electrical engineer, Rodborough, near Stroud. Claims to Mr. C. Scott, Station-road, Gloucester, by May 24.

A meeting to receive an account of the winding up of the Himalaya Electric Railway (Ltd.) will be held on June 10 at 28, Chapel-street, Liverpool.

The Failure of S. W. Hart.—*An Explanation.*—In reference to a paragraph appearing on p. 168 of our last issue we have received the following letter from the Hart Accumulator Co. (Ltd.):—

TO THE EDITOR OF THE ELECTRICIAN.

Sir: We wish to correct an erroneous impression that has arisen in some quarters in regard to the notice appearing in your issue of the 6th instant, relative to the meeting of creditors of Mr. S. W. Hart last Wednesday at the London Bankruptcy Court.

According to the report you publish it appears that Mr. Hart stated he was the inventor and patentee of the Hart Accumulator, and we wish to make it clear that there is no truth whatever in this statement of his, as the inventor and original owner of the "Hart" patents was our present engineer and managing director, Mr. E. J. Clark.

The matter is one which in no way concerns the position of our company, as although the name of Mr. Hart is associated with our own, this was only by reason of him being financially interested in one of our patents, and Mr. Hart has never taken any active part in the management, so that our business will not be affected in the slightest degree.

In regard to the debtor's statement that he attributed his failure to the depreciation in value of his shares, we fail to understand why this excuse should have been put forward, as our company has never been in a better position than it is to-day. From the date of formation of the company up to the present time our business has been steadily developing, and our works have been enlarged time after time to cope with the large demand that we have had to meet for our storage cells. We much regret that the name of our company has been brought by Mr. Hart into the matter of his bankruptcy, as there was not the slightest reason for him doing so, and as the report you publish only concerns the debtor's own private affairs we should be very glad if you will insert this explanation in your next issue to avoid any further misunderstanding.

The Hart Accumulator Co. (Ltd.),
Stratford, London, May 10. F. J. Holmes.

"The Inventions of Nikola Tesla."—"The Electrician" Co. have inquiries for copies of Mr. T. C. Martin's book, published about 1894, entitled "The Inventions of Nikola Tesla." Anyone desirous of disposing of copies of this book will please address the Publisher, 1, 2 and 3, Salisbury-court, Fleet-street London.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

*NOTE.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

February 14, 1910.

3,567 SNAGGE. Telephone receiver rest.
3,578 DUTTON & MCKENZIE & HOLLAND. Signalling and interlocking for railways and tramways. (Addition to No. 784 '09.)*
3,582 WALL. Call boxes for telephones and the like.
3,637 PATTERSON. Electric cab-controlling system for railways.*

February 15, 1910.

3,651 RUSHTON. Electric contacts for electric incandescent lamps and the like.
3,697 LUX. Electrically controlling valves. (Date applied for, 15/2/09.)*†
3,706 COMINGS. Packing incandescent electric lamps and similar frapile articles.
3,729 GUNNER. Shade carrier ring for electric lamp-holders and the like.
3,733 MARSEILLE & GOUIN. Manufacture of alkaline accumulator electrodes for preventing the dropping of active material therefrom. (Addition to No. 15,373/09. Date applied for, 8/3/09.)*†
3,756 CHISHOLM-ELLAMS. Facilitating the recording of telephone calls.

February 16, 1910.

3,802 CUNNINGHAM. Magneto-dynamo armatures.*
3,818 SIEMENS BROS. & CO. & DIESELHORST. Electric cables.*
3,833 B.T.-H. Co. (G.E. Co., U.S.) Material suitable for insulation and other purposes.*
3,847 HENKEL. Controlling devices for electrically-operated machines.*

February 17, 1910.

3,867 PEACE. Flame arc lamps
3,883 HOPE. Fusible cutouts for controlling electric circuits.
3,914 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke G.m.b.H., Germany.) Arrangements for regulating the position of the brushes on the commutator of a dynamo-electric machine.*
3,915 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke G.m.b.H., Germany.) Voltage regulation of dynamo-electric machines.*
3,926 & 3,927 A. P. LUNDBERG, G. C. LUNDBERG & P. A. LUNDBERG. Switches or other accessories used on electric lighting, heating or power circuits.*
3,954 RAMSBOTTOM. Electric safety switch.
3,977 DICKER. (Benjamin Electric Mfg. Co., U.S.) Portable holders for electric incandescent lamps.*
3,982 B.T.-H. Co. (G.E. Co., U.S.) Signal systems for railways and the like.

February 18, 1910.

4,066 ROGERS. Isolating and feeding electric cables and fittings for portable or fixed electric lamps.

February 19, 1910.

4,115 LUCAS, WALMSLEY & WALMSLEY. Apparatus for distributing electricity.
4,127 HUNT. Indicating and measuring leakage from electric circuits.
4,171 WESTINGHOUSE ELECTRIC CO. Electromagnetic brakes. (Date applied for, 3/3/09.)*†
4,182 GLOVER & GLOVER & CO. Electric resistance.
4,183 GLOVER & GLOVER & CO. Electrical contact.
4,184 GLOVER & GLOVER & CO. Ceiling rose for electric lights.
4,186 GLOVER & GLOVER & CO. Cord shortener for electric circuits.
4,190 GIBBS & SANDICROFT FOUNDRY CO. Electrical controllers.

February 21, 1910.

4,230 CUNLIFFE, CUNLIFFE & DEWHURST. Electric contacts for operating signal and other apparatus on electric tramways or railways.
4,251 HINDS & JAMES. Fixing telegraph, telephone and like wires to insulators.
4,257 WAINE. Re-setting devices for the trolleys of electric car systems or the like.
4,262 SIEMENS BROS. DYNAMO WORKS & PARKER. Dynamo-electric machines for voltage transformation.
4,263 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Regulation of electric frequency transformers.*
4,273 STROMBERG & WILLIS. Electric meters.*
4,299 CUNNINGTON. Twin electric incandescent lamp-holder.
4,309 DRYSDALE. Means for supplying power to electrically propelled vehicles.
4,318 THOMSON. Circuit-closers.*
4,320 HARDY & HUNGERBUHLER. Electrical accumulators.

February 22, 1910.

4,386 SMITH. Electric cutouts.
4,398 MARINO. Separators for electrical batteries and electrolytic apparatus.
4,446 GOTTSCHALK. Telephone transmitters.*

February 23, 1910.

4,463 TAYLOR. Charging or discharging accumulators or secondary batteries.
4,467 ELDRED. Electrical lamps and other goods having leading-in wires sealed through them.*
4,531 BROWN. Relay apparatus.
4,533 SIDAY. Combined fastenings and electric light controlling devices for doors.
4,567 PESCATORE & TUDOR ACCUMULATOR CO. Ventilation of electric accumulator cells.

February 24, 1910.

4,599 PAUL. Electrical terminals.
4,614 TAYLOR. Means for limiting short-circuits in alternating and direct-current circuits.
4,645 GORHAM. Resuscitating the negative plates of secondary batteries and assisting in their formation.
4,648 MILLARD & FOSTER. Trolley head for use on electric tramcars and the like.
4,669 DRYSDALE. Electrical transmission dynamometer.
4,678 ROCKSTROH. Controlling device.*
4,696 OLMSTED. Systems of and apparatus for the control of electric translating devices.*
4,697 WHITE & CARICHOFF. Control of electrically-operated switches. (Date applied for, 26/2/09.)*†

February 25, 1910.

4,713 BARNES & JENSEN. Electric lifts and other lifts and like apparatus.
4,722 SMITH. Electromotors.
4,724 TAYLOR. Commutator cleaning hand tool.
4,729 MCCLELLAND. Portable electric furnace or heater.
4,736 ELECTRIC CONSTRUCTION CO. & PENSABENE. Resistances used in connection with starting induction motors.
4,738 EGGINGTON. Device for checking telephone calls.
4,744 HOLMES. Starting switches for electric motors.*
4,758 COSTER. Magnet-dynamos for lighting and other purposes.*
4,783 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Devices for starting and controlling alternating-current motors.*
4,811 WHITE. Control of electrically-operated switches. (Date applied for, 27/2/09.)†
4,814 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Motor controllers.*

February 26, 1910.

4885 & 4886 JOHNSON & PHILLIPS & BROCKIE. Magazine arc lamps.
4,887 GRAFTON. Apparatus for obtaining constant potential in an electric circuit.
4,893 B.T.-H. Co. & DAWSON. Cooling of commutators of dynamo-electric machines.
4,906 BERNERS. Switches for electrical transformers.
4,907 FARNY. Dynamo-electric machines. (Date applied for, 1/3/09.)*†
4,910 MARCONI'S WIRELESS TELEGRAPH CO. & FRANKLIN. Wireless telegraph receiving stations.

February 28, 1910.

4,931 HIRST & BROOK. Starting apparatus for electric motors.
4,936 SWIFT & BAXTER. Electric clocks.
5,004 MILNE. Attachments for telephones.
5,034 FERRANTI. Regulation and control of electric currents.
5,036 WALL. Coin-freed apparatus for use with telephone call boxes and other purposes.
5,044 B.T.-H. Co. (G.E. Co., U.S.) Control of alternating-current electric motors. (Date applied for, 24/3/09. Comprised in No. 7,114, dated 24/3/09.)
5,048 HINSKY. Insulating conduits for electric wires or conductors.*

March 1, 1910.

5,054 DEAN. Protected or armoured electric switch fuses.
5,085 RAILING & GARRARD. Electric switches.
5,086 ROBERTS. Alternating current static transformers.
5,098 JACKSON & FOURNISS. Electric current collector gear.
5,117 & 5,118 SIEMENS BROS. DYNAMO WORKS, KIEFFER & SCHAFFER, KLOSS. Ventilation of dynamo-electric machines.
5,119 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke G.m.b.H., Germany.) Regulation of speed of polyphase electric motors.*
5,133 FESSENDEN. Electric signalling.*

March 2, 1910.

5,178 MACFARLANE. Electrically-driven centrifugal machines.
5,221 MORRIS & LISTER. Electrical switches and the like. (Addition to No. 21,938/07.)
5,246 GORHAM. Resuscitating the negative plates of secondary batteries and assisting in their formation.
5,261 & 5,270 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Multiple-switch devices for electric motors.*
5,266 BROUGHAM. (Poldihütte Tiegelgusszsthalfabrik, Austria.) Electrical induction furnaces.*
5,278 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*
5,282 RENDLE & CHURCHILL. Holding submarine cables.*
5,289 SCOULAR, SCOULAR & EVERETT. Incandescent electric lamps.

March 3, 1910.

5,299 COWCHER. Electric ignition apparatus for internal combustion engines.
5,313 HARVEY. Electrical indicators for use on trams, trains and the like.
5,360 CUEVAS, CORDO & DAVILA. Trolley wheels for collecting electricity.
5,374 CREED & COULSON. Telegraphic transmitters.
5,383 MURDOCH. (William MacIlwaine Robinson, South Africa.) Devices for connecting telegraph, telephone and other wires or conductors to their insulators or supports.
5,388 LEDERER & WESTINGHOUSE METAL FILAMENT LAMP CO. Manufacturing metal filaments for incandescent electric lamps. (Addition to No. 6,936/09.)

March 4, 1910

5,401 HOWARD & ALLEN. Switching apparatus.
5,416 RAILING & ANGOLD. Arc lamps.
5,452 SIEMENS-SCHUCKERTWERKE G.M.B.H. Arc lamps. (Date applied for, 9/3/09.)*†
5,479 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke G.m.b.H., Germany.) Current commutation of commutator frequency changes.*
5,486 SULMAN & PICARD. Separation and recovery of metals from their ores by means of electrostatic methods.

March 5, 1910.

5,553 BINGHAM. Wireless telegraphy and telephony.
5,554 BINGHAM. Duplex wireless telegraphy.
5,555 BINGHAM. Radio-telegraphy.
5,561 TITO LIVIO CARBONE. Arc lamps.*
5,571 MIDGLEY & VANDERVELL. Electric switches.*

March 7, 1910.

5,594 BARNHOLDT. Unidirectional current machines.
5,639 GROVES. Terminal piece for fixing to wires or cables.
5,652 HILL & TRIER & MARTIN. Constant-current dynamos.
5,654 WATKINS. Insulators for supporting the current rails or conductors. (Addition to No. 21,526/09.)
5,659 HARRISON. Electric lighting arrangements.
5,660 MALACHOWSKI. Arc lamps. (Date applied for, 30/7/09.)*†
5,691 LAKE. (Fabrik Elektrischer Zünder G.m.b.H., Germany.) Producing porous electro deposits.*

SPECIFICATIONS PUBLISHED.

1908 SPECIFICATIONS.

24,634 DICK, KERR & CO. (Thury.) Regulators for dynamo-electric machines.
24,643 TAYLOR. Charging and discharging electric accumulators. (Cognate applications, 1,959/09, 9,666/09, 10,913/09, 11,958/09, 13,250/09 and 13,701/09.)
25,844 CROUCH & ETCHELLS. Electric lighting or heating systems.
27,242 CROUCH & ETCHELLS. Electrical distribution systems.
27,862 DE BINGHAM. Teleegraphic recording apparatus. (Post-dated 22/7/09.)
27,960 SIEMENS BROS. DYNAMO WORKS, HIRD & GRIMSTON. Searchlights or projectors.

1909 SPECIFICATIONS.

534 VANDERVELL. Combined magneto and coil sparking mechanism for internal combustion engines. (Post-dated 9/8/09.)
843 BOWDEN, ANDERSON, ATCHLEY & BULL. Supports of overhead electric cables and the like.
1,582 THOMAS. Electrical power transmission. (Cognate application, 14,560/09.)
3,195 CROOKELL. Attachment device for the shades of electric lamps. (Post-dated 4/8/09.)
3,709 KOLBMINE. Electrical heating devices. (Date applied for, 19/3/08.)
3,717 ADAMS-RANDALL. Telephones.
3,851 CREESE. Electric clocks and like instruments.
3,854 REASON & REASON MFG. CO. Electric winding devices.
3,906 SIEMENS BROS. DYNAMO WORKS, BROADHEAD & HAWKINS. Systems of train lighting by electricity.
3,917 WITZENMANN. Armouring electric cables.
4,030 UNTERBERG & HELMLE. Contact-breaker for magneto-electric sparking apparatus for internal combustion engines. (Date applied for, 8/8/08.)
4,093 BROOK & HIRST. Multiple electric switches and automatic circuit-breakers. (Cognate application, 16,678/09.)
4,164 B.T.-H. Co. (G.E. Co., U.S.) Filaments or coherent conductors of refractory material.
4,181 STANSFIELD & HATT. Method of and apparatus for controlling the voltage of dynamo-electric machinery.
4,250 B.T.-H. Co. (G.E. Co., U.S.) Electric switches. (Request under sec. 19 not granted.)
4,374 BUCHANAN. Continuous-current dynamo-electric machines.
4,472 ALLGEMEINE ELEKTRICITATS GES. Controllers for dynamo-electric motors. (Date applied for, 24/2/08.)
4,480 NIKIFOROFF. Relay for telephone and weak alternating currents.
4,574 SOC. FRANCAISE ELECTROLYTIQUE. Extraction of copper from its ores and alicys. (Date applied for, 25/1/08.)
4,600 SCHOFIELD, EDWARDS & TICKELL. Signals for railways, tramways and the like. (Post-dated 13/8/09.)
4,672 BERRY. Electrical heating apparatus.
5,003 MOSER. Generating a synchronous alternating current of limited or defined strength.
5,081 MURPHY. Rectifying electric currents.
5,114 HEYWORTH. Secret telephone transmitters.
5,168 CROMPTON & CO., MACFARLANE & BURGE. Electrical regenerative control apparatus and system.
5,223 LACEY. Safety shut-off appliance for electrical controllers.
5,302 TATE. Electric terminals.
5,360 BURKS. Production of magnets from cast iron.

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COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Co. (Ltd.)

The seventy-sixth ordinary general meeting of this Company was held on Wednesday, under the presidency of Sir JOHN WOLFE BARRY, K.C.B.

The SECRETARY (Mr. A. R. Hardie) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, I feel sure that the stockholders at this meeting will like to take the opportunity, as a corporate body, of expressing to the Throne their sense of the great public disaster which has overtaken the nation in the death of our beloved Sovereign King Edward VII. It is a loss which is not only a public disaster, but which I think appeals to most of us—in fact, I may say to each and all of us—as a deep personal loss. The services of the late King were not confined to his own country and to the Empire over which he so well presided—they were really world wide, for the influence of his Majesty was felt in every part of the globe. I am, therefore, certain that the stockholders will feel with me that, as it happens we are assembled in general meeting just after the death of the King, a resolution should go from the meeting expressing not only their sense of the great public loss which has been sustained, but also of their profound sympathy with his Majesty, their Majesties the Queen and the Queen Mother, and with the other members of the Royal Family in their heavy bereavement. I, therefore, beg to propose the following resolution

"*That the stockholders of the Eastern Telegraph Co. in General Meeting assembled humbly beg leave to express to his Majesty the King their profound grief at the death of his illustrious and universally-beloved father King Edward VII., and to offer their respectful sympathy with his Majesty the King, their Majesties the Queen and Queen Mother, and with the other members of the Royal Family in their bereavement. The stockholders further ask to be allowed to express their profound and dutiful attachment to the Crown and their heartfelt sense of loyalty to his Majesty.*"

The MARQUESS OF TWEEDDALE seconded the motion, which was carried unanimously, all present upstanding.

The SECRETARY afterwards read the auditors' report.

The CHAIRMAN then said: Gentlemen, I am glad to say the directors are able to present a satisfactory report to the stockholders. The gross revenue for the half-year amounted, in round numbers, to £620,900, as against, for the corresponding half-year of 1908, £566,100, or an increase of £54,800. The income from messages and other receipts shows a satisfactory increase of £49,200, while interest on investments, &c., is £5,600 more than for the corresponding half-year. The improvement shown in our message receipts is spread over practically every branch of our traffic, and is largely attributable to business having reference to rubber and oil. It is, however, satisfactory to note that the receipts from traffic exchanged with South Africa show an increase of £10,000, while the receipts from traffic with India are £12,500 more than they were for the half-year to December, 1908. The South African traffic was not affected by the boom in rubber and oil, the improvement being due to commercial activity generally. On the expenditure side it will be seen that the expenses for the half-year amounted, in round numbers, to £250,500, as against, for the half-year ended December, 1908, £253,600, or a decrease of £3,100. The ordinary working expenses have increased by £2,500, while differences in exchange have adversely affected the comparison of the two half-years to the extent of £1,000. On the other hand, the item in the accounts under the heading of expenses attending maintenance of cables is £6,600 less than for the corresponding half-year, so that the nett result shows a decrease in the total expenses—as I have already stated—of £3,100. The actual expenses attending maintenance of cables show an increase of £4,300; but the amount received from foreign governments and other telegraph companies in respect of the charter of our cable ships is £10,900 more this half-year than in the half-year to December, 1908, the nett result being a reduction in the expenses of £6,600.

I referred at the last meeting to the operation that had been in progress for some time of gradually renewing the original Aden-Bombay cable. During the half-year a further 100 knots have been renewed, the cost of which, amounting to £10,676, has been charged as usual against the general reserve fund. There are about 220 knots of this No. 1 section still to be renewed. It has been decided to increase the reserve which has been made as a provision on account of the market fluctuations of our reserve fund investments, and a further £50,000 has accordingly been taken from the general reserve fund for this purpose, making a total provision on this account of £180,000. At the time this fund was originally created, the investments amounted to about £1,300,000, and a provision of about 10 per cent. on this amount was set aside. At the date of these accounts we have over £1,800,000 invested, and by increasing this provision to £180,000 the Board is continuing the principle adopted and generally approved in 1907. I think the nett result of the year's working may be considered satisfactory, as we have been able to carry £70,000 more to the general reserve fund than we did in 1908, while maintaining the payment of the usual dividend and bonus of 7 per cent.

Referring to the paragraph in the report on the subject of an extended news service, the Associated Companies have long been anxious to make some special arrangement whereby a considerable addition to the volume of British Imperial news might be distributed throughout the whole of the Empire, so that our colonies and dependencies might be more in touch with the facts and ideas of the mother country. You may remember that a substantial reduction in the rates of ordinary press messages exchanged with India, South Africa, Australia and many other places was brought into operation in August last year, and these rates remain in force, and are all in the above direction of greater inter-communication. But to attain more fully the special object which we had in view, it was necessary to make some arrangement by which the press conveying the news to the public through the medium of their publications should be allowed to send a greater number of words without addition to the contribution hitherto made by them.

It was not an easy matter to bring about a practical scheme acceptable to everyone, but I am glad to say that after much consideration and consultation with those interested in this important matter, we have been able to begin a service by arrangement with Reuter's Company. The arrangement enables that agency to have the distribution of 150,000 words per annum of Imperial news at Aden, which place is *en route* to all the Eastern colonies and dependencies of Great Britain. On the way to Aden the news is also made use of to supply Gibraltar, Malta, and Egypt. It is sent on to South Africa, and used *en route* for Zanzibar, Uganda, Seychelles and Mauritius. From Cape Town it is telegraphed to the British colonies on the West Coast of Africa. At the present time, part of the news is sent on for distribution from Aden to India, and is available for distribution amongst the Indian newspapers. We hope that in a very short time arrangements will be made with the Indian Government whereby the public in India may have the benefit of the whole of the increased service. Negotiations are still in progress, and we hope that before very long the British colonies of the Straits Settlements and Hong Kong will also receive the additional news, and similar negotiations are being carried on for the extension of the service to Australasia. I now move the adoption of the report and accounts, and the payment of the dividends and bonus set out therein.

The VICE-CHAIRMAN and MANAGING DIRECTOR (Sir John Denison-Pender, K.C.M.G.) seconded the resolution, which was carried unanimously.

A hearty vote of thanks to the Chairman, Directors and staff for their able administration of the Company's affairs was then carried unanimously, and the proceedings terminated.

Eastern Extension Australasia & China Telegraph Co. (Ltd.)

The seventy-third ordinary general meeting was held on Tuesday, under the presidency of Sir JOHN WOLFE BARRY, K.C.B.

The GENERAL MANAGER (Mr. F. E. Hesse) read the notice convening the meeting and the auditors' report.

The CHAIRMAN said: Ladies and gentlemen, we meet to-day under the shadow of a great national bereavement and disaster in the death of King Edward, who was a monarch revered and appreciated by the whole country, and, I may say, by every civilised nation—a monarch whose wise judgment and profound political wisdom, combined with a personal interest and sympathy with the highest and lowest of his subjects, were most remarkable. His high qualities were and are highly appreciated by one and all, so that each one of us feels his death to be not only a public disaster, but also a deep personal loss. I feel sure that the meeting will wish to record its sense of loss, its sympathy and condolence with the King and the Royal Family, and its attachment and loyalty to the Crown; and therefore I wish to move for the acceptance of this meeting—"That the shareholders of the Eastern Extension Australasia & China Telegraph Co., in general meeting assembled, humbly beg leave to express to his Majesty the King their profound grief at the death of his illustrious and universally beloved father King Edward VII., and to offer their respectful sympathy with his Majesty and the Royal Family in their bereavement. The shareholders further ask to be allowed to express their profound and dutiful attachment to the Crown and their heartfelt sense of loyalty to his Majesty." (Hear, hear.)

The MARQUESS OF TWEEDDALE, K.T., seconded the resolution, which was approved by all present upstanding.

The CHAIRMAN (continuing) said: Turning now to the accounts, when I last addressed you I mentioned that the commercial depression which had prevailed in the Far East for some considerable time, and had adversely affected our traffic receipts, appeared to be at last passing away. The improved report and accounts now before the meeting show that the views I then expressed were justified, and I am happy to say the present outlook appears to be still encouraging.

Dealing with the revenue, you will find that the figures for the past six months show that the gross receipts amounted in round numbers to £315,000, against £307,000 for the corresponding period of 1908, showing an increase of £8,000. The actual result, however, is better than these comparative figures indicate seeing that £15,000 of exceptional revenue in connection with the Tasmanian cables was included in the accounts for 1908 which does not appear in the present accounts; consequently, if this exceptional revenue were left out of the comparison, the receipts would show an increase for the half-year of roundly £23,000. The working and other expenses amounted in round numbers to £143,000, against £151,000 for the corresponding period of 1908, showing a decrease of £8,000, which is principally due to the expenses attending the maintenance of our cables having been considerably less during the past six months than in the same period of the previous year. Comparing the figures for the whole year, the results are as follows:—Gross receipts amounted to £606,000 for 1909, against £597,000 for 1908, or an increase of £9,000. The expenditure amounted to £337,000 for 1909, against £339,000 for 1908, showing a decrease of £2,000. Thus, in spite of the depression in the first half of 1909 the net result of the past year's working was £11,000 better than in 1908. The net profit for the half-year was roundly £152,000, and, after adding nearly £59,000 brought forward from the previous half-year, there remained an available balance of £211,000.

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The usual quarterly interim dividends of 2s. 6d. per share were paid during the past year, and it is now proposed to distribute a final dividend for the year of like amount, making a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution for the year 1909 of 7 per cent. on the share capital. The usual additions have been made during the past year to the maintenance ships', insurance, and depreciation funds, and, after applying £50,000 of the revenue balance to the general reserve fund, the sum of £26,000 is carried forward, or £8,000 more than in the corresponding period of 1908, when £18,000 was carried forward. I now move the adoption of the report and accounts, and the declaration of the dividend and bonus set out therein.

The MARQUESS OF TWEEDDALE seconded the resolution, which was carried unanimously.

Resolutions re-electing the retiring Directors (the Marquess of Tweeddale, K.T., and Sir John Wolfe Barry, K.C.B.) and the auditors were then carried, and a cordial vote of thanks to the Chairman, Directors and staff brought the proceedings to a close.

Western Telegraph Co. (Ltd.)

The seventy-third ordinary general meeting was held on Wednesday, under the presidency of Sir JOHN WOLFE BARRY, K.C.B.

The SECRETARY (Mr. E. Steer Hodson) read the notice calling the meeting and the auditors' report.

The CHAIRMAN then said: Gentlemen, before proceeding to the regular business of the general meeting, I feel quite certain that the stockholders of the Western Co. will like, as they are assembled at this sad time, when we are all mourning the death of our King, to approach the Throne with some resolution of sympathy, condolence and loyalty. The Eastern and the Eastern Extension Companies have both adopted a resolution and I shall ask you to make it your own, so that all the three companies —the Associated Companies—can send a resolution in the names of themselves individually and collectively. A resolution similar to that submitted to the meetings of the Eastern Extension and Eastern Telegraph Companies (set out on page 213) was then proposed by the chairman, seconded by the deputy-chairman, Sir John Denison-Pender, K.C.M.G., and approved on behalf of the shareholders by Mr. George Ennis, and carried unanimously.

The CHAIRMAN (continuing) said: We submit to-day a report and statement of accounts which we think you will consider satisfactory. The receipts from messages compared with the corresponding half-year show an increase of £43,408, and from other sources £4,428, together £47,836. All classes of telegraphic correspondence with South America and West and South Africa contributed to the improvement in our revenue, and I am pleased to say that the prospects for the current half-year are of a gratifying character. We are committed to a reduction in the tariff on June 1 next with South America, which will entail a considerable loss of revenue unless the traffic increases proportionately.

With regard to the general and other expenses, those incurred in London were more by £183; at the stations abroad they were increased by £5,683; the cost of maintaining the cables was more by £2,604; income tax shows an increase of £1,897, the four sums making a total of £10,367. Against this, however, there was a net reduction of the amount of other items due chiefly to expiration of royalties and reduced expenses in connection with improved apparatus for cable working at the stations. This decrease amounted to £1,121, making a net increase in expenditure of £9,246. An analysis of the accounts shows that the increase in salaries and wages and cost of training staff is due to annual promotions and to an increase in the number of the men employed required for our growing traffic. Travelling, house allowances and contributions to the pension fund were also consequently higher. We have also had to fit up new and larger offices at four stations and increase the staff quarters at another, causing an increase in the repairs and renewals of furniture account. Larger sums were spent on agencies, advertising, postage, office expenses and bankers' commission in connection with the increased revenue. Decreases are shown in the cost of the maintenance of our landlines, repairs to buildings, medical expenses, and one or two other items. First and second interim dividends, amounting to £62,379, have been paid, and after transferring £155,000 to the general reserve fund, and £10,000 to the land and buildings depreciation fund, there remains a balance of £6,008, which is carried forward to the next account.

The new cable referred to by me at the general meeting last November between the Island of Ascension and the River Plate has been successfully completed; the expenditure upon it has been met mainly out of our reserve fund and partly by the issue of debenture stock under the powers vested in the Board by the articles of association of the Company. In connection with the Argentine direct cable the Board are now considering the question of strengthening the means of communication in other parts of the Company's system. I now move the adoption of the report and accounts.

The DEPUTY-CHAIRMAN seconded the motion, which was carried unanimously.

Mr. J. BULL asked if the Chairman had any reason to alter the opinion which he had expressed at former meetings with regard to wireless telegraphy.

The CHAIRMAN replied that nothing had occurred up to the present to alter his general view, that for a service of telegraphy, except for ships, the cable had such advantages that it would always beat any system of wireless telegraphy. The great utility to his mind of wireless telegraphy was in the communication with ships, which could not, of course, be served by cable. He looked forward to still greater benefits and greater development in the communications between the land and ships and between ships and ships, but as far as anything they knew at present, for quickness, certainty and secrecy there was no comparison between the service given by a cable and that given by any system of wireless telegraphy.

A cordial vote of thanks was then passed to the Chairman, the Directors and the staff, and the proceedings terminated.

West African Telegraph Co. (Ltd.)

The twenty-fifth ordinary general meeting was held on Wednesday under the presidency of the MARQUIS OF TWEEDDALE, K.T.

The SECRETARY (Mr. John Cambrook) read the notice calling the meeting.

The CHAIRMAN referred feelingly to the sad circumstances under which they met, and a resolution of sympathy with the Royal Family was carried unanimously.

The CHAIRMAN then said: There is little in the accounts to which, I think, special attention need be drawn. Gross revenue for 1909 amounted to £59,000, against, for the year 1908, £56,300, or an increase of £2,700, due principally to our increased receipts from the South African joint purse. Interest and dividends on reserve fund investments are increased by £500. The working expenses for the year amounted to £22,200, against, for the year 1908, £24,800, or a decrease of £2,600. This is explained by the fact that the general expenses at stations show a reduction of about £800, while the expenses attending maintenance of cables are £1,600 less than they were for the previous year. Other items in the revenue account also show small decreases. The net result for the year is a profit of £36,800 (against £31,500 last year), which, with the balance brought forward from last year, enables us to make a substantial contribution to our reserve fund, and to pay the same dividend of 4 per cent., which has been declared for the last few years. The new staff quarters at Bolama, to which I referred at the last meeting, have been completed during the year, and the balance of the cost has been charged against the general reserve fund. I now move the adoption of the report and accounts.

The MANAGING DIRECTOR (Sir John Denison-Pender, K.C.M.G.) seconded the motion, which was carried unanimously.

The retiring director (Mr. Robert Kaye Gray) and the auditors were then re-elected, and a vote of thanks to the chairman, directors and staff brought the proceedings to a close.

West Coast of America Telegraph Co. (Ltd.)

The thirteenth ordinary general meeting was held on Tuesday, Sir JOHN DENISON-PENDER, K.C.M.G., presiding.

The SECRETARY (Mr. Fredk. L. Robinson) read the notice convening the meeting, and the auditors' report.

The CHAIRMAN, after feelingly referring to the illness and death of King Edward, said: I think the accounts and report leave very little for me to say, but there are one or two points on which, perhaps, you may like further information. As regards the traffics, they are £2,000 down. That is not a very serious matter, and really comes from a falling-off in the local traffic—the through traffic has been good—and from the cable being down in the year under review for 67 days against 57 in the preceding 12 months. That, of course, means that during the period of interruption there was a very considerable reduction of traffic, and the opposition got the business which would otherwise have gone over our line. But, unfortunately, when you look at the expenses you find that they are £6,000 up. In 1908 the expenses reached the sum of £33,200, whereas in 1909 they were £39,200. An increase of £6,000 looks a very considerable item on such a figure as £39,000, but I think that when I have explained the various items you will see that a great deal of it is entirely satisfactorily accounted for. First of all, you have the allowances on the coast which we have had to give, as living has become dearer. You have the increased value of the Chilian currency, which also makes a considerable difference to us. Then you have the usual things that we have at home—rent, rates, taxes and travelling expenses—and also, not a very considerable item, but still everything helps to mount up, we have had to open an agency at La Paz, in Bolivia. The increases in these items which I have mentioned come to £2,000 out of the £6,000. Cable work is not like manufacturing, where, when you have not the work to do, you can reduce your staff. In cable work you must keep your staff. A great many of the clerks are sent from England, and the local men have to be retained. Therefore, whether you have heavy traffics or not the staff charges remain pretty much the same. I have accounted for £2,000 out of the increase of £6,000. With regard to the remaining £4,000 it is really due to an increase in the cable repairs. The repairs have cost us considerably more because the ship spent 10 days longer at the work than in the previous year, and the amount of new cable put in has been considerably more. That is a charge which I have always said should not be, in my opinion, included in the general expenses, because we may assume that if we put in more cable one year we have taken out bad cable and have given that portion of the cable a new life. Therefore, we may hope that if we have an excessive charge for cable maintenance one year we shall get a relief in future years, so that if we could manage it—but I think it would be a very difficult thing—the cable repairs should be spread over a period of years. Then in 1908 you will remember we received £1,500 for the charter of our steamer. In the past year the steamer was not chartered. Consequently we are minus that sum, and that makes the comparison rather an unfair comparison with the preceding 12 months. The only new matter really that I can put before you this year is the new steamer which I referred to at the general meeting held last May. We had to replace the old steamer, which was 31 years old, and this new steamer delivered on your station has cost, roughly

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speaking, just under £20,000. We wrote down the old steamer in our books some years ago to £10,000. We received £3,000 for her when she was sold the other day, leaving a loss on that of £7,000. But I am glad to say that during the latter years we had raised a sum of £12,000 as "steamer depreciation fund," and therefore the cost of the new steamer will be, to a certain extent, reduced. At £20,000 she is not at all an expensive boat. She is doing her work well, she is a much steadier ship than the last one, and in every way I think she will prove to be a more satisfactory boat. I may also mention that when we send out cable to the coast we have to do so in tanks, and put it in a chartered steamer, or at any rate we had to get space in an ordinary commercial steamer, but the new steamer carried out that cable and so saved us in that way £2,100, which really goes in reduction of her cost. I do not think there is anything else to refer to, and I move the adoption of the report and accounts.

Sir ALBERT J. LEPPOC CAPPEL, K.C.I.E., seconded the motion, and it was agreed to unanimously without discussion, as was a resolution approving the dividend of 2½ per cent. (tax free).

The retiring director (Mr. Alexander Johnston) and the auditors were then re-elected, and a vote of thanks to the Chairman brought the proceedings to a close.

West India & Panama Telegraph Co. (Ltd.)

The sixty-sixth ordinary general meeting was held on Wednesday, Mr. WALTER BISHOP KINGSFORD presiding.

The MANAGER and SECRETARY (Mr. R. T. Brown) read the notice convening the meeting and the auditors' report.

The CHAIRMAN said: Gentlemen, our total receipts for the half-year amounted to £34,678. 12s. 1d., or only £193 short of those with which we are comparing. On the expenses side the total expenditure (£23,557. 18s. 6d.) is £1,398 more than that for the corresponding period. Of the increased expenditure of £1,398 no less than £1,300 is in connection with expenses attending repairs to cables. Nearly £800 of this is accounted for by our repairing steamer having been engaged for 97 days during the half-year, as compared with 63 days in the corresponding period, whilst the sale of old core, &c., realised about £500 less than it did in the corresponding half-year. The directors have charged revenue with £7,980. 14s. 7d. in respect of the normal expenses of repairing our cables, but the sum of £2,414. 8s. 11d., representing the cost of 33 knots of new cable laid in on special repairs to the Jamaica–San Juan and the St. Kitts–Antigua sections, has been charged to reserve account. At our last meeting I spoke of the exceptionally severe storms and floods which prevailed in November throughout the West Indies, and especially in Jamaica and Hayti. Two of our main cables landing in Jamaica were broken, thus cutting off communication for several days with all of our stations east of that island. Our cable between Jamaica and Colon was also interrupted during nine days from the same cause. Of course, these abnormal interruptions served to keep our repairing steamer very fully employed. Hence the increased expenditure. The storms and floods also badly damaged our land lines in Jamaica, and the repair of these cost us nearly the whole of the £268, the extra outlay shown under "Maintenance of land lines." As the result of the half-year's working, inclusive of interest and the amount brought forward from last half-year, there remains an available balance of £13,310 to be dealt with. I am very glad to tell you that the traffic receipts for the current half-year to the end of April show a satisfactory increase. I now move the adoption of the report and accounts and the payments therein set out.

Mr. HENRY HOLMES seconded that resolution, which was carried unanimously.

The retiring director (Mr. W. B. Kingsford) and the retiring auditors were then re-elected, and a very cordial vote of thanks to the chairman, directors and staff of the company brought the proceedings to a close.

Submarine Cables' Trust.

The thirty-ninth ordinary annual meeting was held on Tuesday, the MARQUESS OF TWEEDDALE, K.T., in the chair.

The SECRETARY (Mr. Sidney Collett) having read the notice calling the meeting,

The CHAIRMAN, after referring to the sad death of King Edward, said the revenue for the year to April 15 amounted to £25,259. Deducting working expenses and adding £228 brought forward, the available balance was £24,328, against £24,315 in the previous year. We have paid the usual half-yearly coupons at the rate of 6 per cent. net (absorbing £17,952), and with the surplus we have acquired 52 certificates, *ex* the coupon of reversion. This is the largest number of certificates we have ever acquired with the surplus funds of the Trust in any year, and absorbed £6,201, leaving £175 to be carried forward. We have now acquired and cancelled 1,260 out of the original 4,200 certificates. There have been some re-arrangements of our capital during the year, and our securities show an appreciation over original cost of £181,980. I now move the adoption of the report and accounts.

Sir JOHN DENISON-PENDER, K.C.M.G., seconded the resolution, which, after a brief discussion, was carried unanimously.

The re-election of Messrs. Deloitte, Plender, Griffiths & Co. and Messrs. Gane, Jackson, Jefferys, Wells & Co. as auditors was then approved, and a vote of thanks to the chairman and his co-trustees brought the proceedings to a close.

BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. (LTD.)—At the meeting on Monday the chairman (Mr. J. Annan Bryce, M.P.) said that though they were not able to show a profit on the past year's working, the figures showed a distinct improvement, compared with 1908. In regard to their holdings in other companies these represented holdings in the Clyde Valley Power Co.'s shares (about £200,000), Traction & Power Securities Co.'s shares (about £50,000) and Mersey Railway 4 per cent. debenture stock (about £30,000). The last security had considerably improved in value since the line was electrified, and it was now apparently earning its 4 per cent. interest on these debentures. The Clyde Valley Co. had turned the corner and was beginning to make profits, so that the directors had reason to hope that the value placed upon that security (its cost to the company) would eventually be realised. The Traction & Power Securities Co. shares had improved somewhat since last year, due to the improved position of the Mersey Railway and Clyde Valley Companies, in which they held large interests. He was glad to be able to say that, notwithstanding a most unpropitious year, the falling off in the amount of orders, compared with 1908, was only about 6½ per cent. It was particularly satisfactory to observe that the export business continued to expand, and all means were being adopted to develop that side of their operations, especially in the British possessions. They were continuing to cultivate friendly relations with the foreign Westinghouse companies, in conjunction with whom they were, and had been, doing a fair amount of business abroad. Competition had continued to be as severe as ever, and manifestly if there was only enough business to partially fill the works of manufacturing companies, there must inevitably result a cutting of prices; while they were specially handicapped by having works much too large for the amount of business offering. Paucity of orders led to demoralisation in prices under conditions of over-production, and they could only wait for revival in trade and the natural growth of the electrical business, meanwhile carefully fostering economy in all branches of the business. There were distinct signs of improvement in the volume of business.

CALCUTTA ELECTRIC SUPPLY CORP. (LTD.)—During 1909 7,856,383 units of electricity were sold, compared with 6,765,792 units in 1908. The number of houses connected was 5,078, against 4,396, and the equivalent connections in 8 c.p. lamps show an increase of 73,437 (from 378,835 to 452,272 8 c.p.). A considerable demand has arisen in the northern districts of Calcutta for electrical energy for power, and in order to meet this, and at the same time to economise the cost of production, it was proposed to erect a large h.t. generating station at Cossipore. Mr. Jenkin (of Sir Alex. Kennedy & Jenkin) has visited Calcutta to advise the board, and on his recommendation it has been decided to place at once some additional plant in the Ultadangha station of the company. Sir Alex. B. W. Kennedy has been appointed consulting engineer to the company. The net profit amounted to £67,023. 14s. 11d. (compared with £58,188. 0s. 4d.), and after adding balance forward (£3,303. 13s. 8d.) and deducting interim dividend at rate of 6½ per cent. on the ordinary shares, and the preference dividend, &c., the available surplus is £46,134. 5s. 11d., compared with £41,668. 13s. The directors recommend that £17,000 be placed to depreciation and renewals account, and a final dividend at the rate of 9½ per cent. on the ordinary shares (making 8 per cent. for the year), leaving £5,492. 1s. 3d. to be carried forward. There is no diminution in the applications for current, additional connections equivalent to 73,437 8 c.p. lamps having been made during last year, compared with 57,972 in the previous year.

CALLENDER'S CABLE & CONSTRUCTION CO. (LTD.)—The directors' report for 1909 states that the balance at credit of profit and loss account is £54,362. 5s. 9d., and, with £45,884. 10s. 7d. brought forward, the total is £100,246. 16s. 4d. Deducting debenture interest and preference dividend (£23,500) and appropriation for depreciation of buildings, plant and machinery (£8,294. 6s. 6d.), the available balance is £68,452. 9s. 10d. It is proposed to pay an ordinary dividend of 10 per cent., less tax (10s. per share whereof 5s., less tax, has been paid), absorbing £17,000, a bonus of 5s. per share (less tax) (£8,750), leaving £42,202. 9s. 10d. to be carried forward. The value of business done during 1909 showed a considerable reduction compared with recent years. The quantity of work available was even less than usual, and the struggle for orders was consequently severe, especially in the home trade. It is, therefore, with considerable satisfaction the directors notice the improvement in trade which has taken place since the beginning of the year, with the consequent increase in orders which have been placed with the company. The Anchor Cable Co. has again done well, and in spite of the extraordinary rise which has taken place in the price of rubber has been able to show even better results than in 1908.

COMPAGNIE BELGE DE TELEGRAPHIE SANS FIL (MARCONI SYSTEM). The "Financial News" states that at a meeting of this company on May 5 dividends of 50fr. on the ordinary shares and 24fr. on the founders shares were voted. The net profits for the past year were 47,229fr., against 26,706fr. in 1908. The increase in net profits is attributed to the daily paper the "Atlantic Daily News," which appears on all vessels of the principal French, German and Dutch steamship lines.

CRAIGPARK ELECTRIC CABLE CO. (LTD.)—At the meeting last week Mr. W. S. Brown, who presided, said that they were now in a very satisfactory position, having lost nothing in contracts through the rise in rubber. During the first few months of the year, owing to the appreciation in rubber, they barely made ends meet, but the latter part had witnessed a distinct improvement, and they were now in a sound position.

DELHI ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—At the meeting last week Col. Sir Buchanan Scott said the loss for the past year was £3,225, after charging debenture interest. The result was principally due to the low receipts from the tramway section during the winter months of 1908. The Diesel oil engine and other plant had arrived at Delhi, and its erection was nearly completed. The total cost of that extra plant was approximately £5,000. A satisfactory agreement had been made with Delhi Municipality for lighting Delhi for three years,

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and the directors were in negotiation with a department of the Government of India for a large amount of lighting.

DUDLEY, STOURBRIDGE & DISTRICT ELECTRIC TRACTION CO. (LTD.)—The directors reported at the meeting last week that the gross receipts for 1909 amounted to £44,357. 19s. 11d. Deducting expenses, including repairs and maintenance, placing £2,000 to renewals and increasing depreciation accounts by £997. 14s., there remains £6,875. 3s. 5d. Deducting preference dividend, and adding £136. 19s. 5d. brought forward, £2,012. 2s. 10d. remained available, and the directors recommended a dividend of 2 per cent. on the ordinary shares. Expenditure on capital account during the year amounted to £1,339. 17s. 4d. This account has been credited with £49,567. 14s. 3d., of which £49,505 represents the purchase price of the tramways and light railways in Dudley. The purchase of these lines by the Corporation has been completed and have been leased to the company for 30 years from Jan. 1, 1909. An arbitration is pending to determine the price to be paid by the company to the Corporation for electrical energy for the next five years. It is expected that the order authorising the transfer of the Smethwick Electric Lighting Order (1898) from the Birmingham & Midland Tramways to the Shropshire, Worcestershire & Staffordshire Electric Power Co. and the sale to the power company of the generating stations at Harts Hill, Amblecote and Lye will be obtained and the sale carried out in the course of the present year. The parcels and goods service has given satisfactory results.

ELMORE'S GERMAN & AUSTRO-HUNGARIAN METAL CO. (LTD.)—The directors' report for 1909 states that the position of the Metall Co. has improved. The weight of goods sold shows an increase of 243 tons. The large amount of freight which the company has now to handle has necessitated the installation of a railway siding, while the increased business required the erection of a large building for storage as well as bunkers for coals. A powerful hydraulic push bench has been erected, which has increased the speed in the production of the large sizes of copper tubes at a reduced cost. The home trade was not good during the year, and a large proportion of the sales was for export; the average selling price received was, therefore, less than in previous years, with the result that, notwithstanding increased sales, the net profit is very little larger. Owing to increased output the cost of production has been still further reduced. Although the dividend receivable from the Metall Co. is 10 per cent., against 9½ per cent. last year, the amount standing to credit of profit and loss is not sufficient to permit of a dividend being declared on the company's shares.

At the meeting on Wednesday the report and accounts were adopted on the motion by the Chairman, Mr. John MacFarlan.

GRAVESEND & NORTHFLEET ELECTRIC TRAMWAYS (LTD.)—The total revenue for 1909 was £11,280. 3s. 1d., compared with £11,207. 0s. 7d. for 1908. Profit was £1,113. 12s. 7d., compared with £788. 0s. 5d., and available balance is £1,173. 9s. 3d. In view of the exceptional expenditure incurred in litigation in regard to the metering of the current supplied by Gravesend Corporation, the directors recommend that this amount be carried to reserve. The directors have under consideration the question of appeal against the decision of the High Court in January last, or, in the alternative, of resorting to arbitration if they fail to obtain a fair allowance by friendly negotiation.

JOHNSON & PHILLIPS (LTD.)—Mr. R. W. Blackwell presided at the meeting on Wednesday and said that during the past year the company's business had improved to a certain extent. It had not, of course improved to the extent desired, but they had made a profit for the year over and above that of the preceding year of £5,322. It was the expectation and hope of the directors that the past year would turn out much better. It was, however, the case that for the last four to five months of the year practically all orders seemed to cease, and business was practically at a standstill. He thought that had been the case in almost every concern which had anything like a similar business to themselves. Of course, orders being slow, competition was much greater, and the business that was taken during the year was taken at prices which were distinctly low throughout, while both copper and rubber were ruling exceedingly high. During the five years of thee ompany's existence they had set aside for depreciation on machinery and plant £18,200, and they had redeemed debentures to the extent of £20,390. Under those circumstances it seemed that it was unnecessary that a special fund should be written off this year for depreciation. Things were looking fairly well for the present year. They were busier in the shops than they had been for a long time past, and they sincerely hoped that the profit for the present year would be greater than it was last year.

The report and accounts were adopted, and Messrs. W. Claude Johnson and Thos. Dence were elected directors.

RANGOON ELECTRIC TRAMWAY & SUPPLY CO. (LTD.)—At the meeting on Monday Mr. Frank Tobin said that the company had made very considerable progress. The ordinary shareholders would receive a small dividend (3 per cent.), and he hoped this was an earnest of better things to come. The most important and satisfactory branch was the tramway, which had vastly increased its takings. In regard to public lighting, there was little to be said; all had worked smoothly with the municipality. The demand for private lighting and power was beginning to grow rapidly. They had ordered a turbine larger than any they had hitherto used. They had made a contract for the supply of coal for the next two years at a figure which would show a very appreciable economy on that they had been used to up to the present.

WOLVERHAMPTON DISTRICT ELECTRIC TRAMWAYS (LTD.)—At the meeting last week the directors reported that the total revenue for the year 1909 amounted to £22,851. 3s. 1d. Deducting expenses (including debenture interest, repairs and maintenance) and providing £500 for renewals, left a profit of £64. 19s. 11d., making, with £197. 13s. 6d. brought forward, £262. 13s. 5d., which the directors recommend should be carried forward. The capital outlay amounted to £1,132. 19s. 8d. Capital account has been credited with the proceeds of the sale to Dudley Corporation of the lines and equipment in Dudley, and the cars allocated to those lines. The purchase by Dudley Corporation of the company's tramways in Dudley has been completed, and the purchase price received. The falling off in traffic receipts is attributed to the bad weather and to the severe depression in trade. The parcels and goods service has given satisfactory results.

NEW COMPANIES, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

BRITISH ELECTRIC AUTOMATIC MACHINES (LTD.) (109,404.)—Reg. May 3, capital £150,000 in £1 shares (25,000 preferred), to aquire, deal with and turn to account any invention relating to automatic postage, ticket vending and printing machines, automatic letter boxes, automatic stamp affixing and registering machines, and any invention relating to postal or railway appliances, &c. First directors, N. Von Nettelbladt, Capt. J. P. Wood and H. Limbeer. Reg. office, Caxton House, Westminster, S.W.

FRENKEL'S ILLUMINATED SIGNS (LTD.) (109,072)—Reg. April 21, capital £500 in 475 preference shares of £1 each and 500 ordinary shares of 1s. each, to acquire a licence granted to L. S. Levy by the Reflector Synd. and to carry on the business of manufacturers of and dealers in illuminated advertising signs, and to adopt an agreement with J. Frenkel & Co. Private company. Reg. Office, Basishaw House, Basinghall-street, London, E.C.

GARRETT, HUNT & CO. (LTD.) (109,995)—Reg. April 19, capital, £2,000 in £1 shares, to take over the business of electrical engineers and contractors carried on by C. W. Garrett and G. T. Hunt, as Garrett, Hunt & Co. Private company. First directors, C. W. Garrett, G. T. Hunt, and C. J. W. Daniels. Reg. Office, 181, High-street, Lewisham, S.W.

HILL & HARRINGTON (LTD.) (108,963)—Reg. April 18, capital £2,000 in £1 shares, to take over the business carried on as Hill & Harrington, and to carry on the business of electrical and mechanical engineers, contractors, &c. Private company. First directors, J. Harrington and G. R. Barham. Reg. office, 41, Berners-street, London, W.

W. F. PEARE (LTD.) (3,557.)—Reg. in Dublin April 21, capital £10,000 in £1 shares, to acquire business of an electrical engineer carried on by W. F. Peare at Waterford. Private company. First directors, Sir W. G. D. Goff and H. W. D. Goff. Reg. office, 3, Catherine-street, Waterford.

MORTGAGES AND CHARGES.

ACKROYD & BEST (LTD.)—Issue on April 14 of £1,450 debentures, part of a series of which particulars have already been filed.

BERRY CONSTRUCTION CO. (LTD.)—Particulars of £2,000 debentures, created April 11, has been filed, the whole amount being now issued. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

FERABIN LAMP & ELECTRICAL ACCESSORIES (LTD.)—Particulars of £2,500 debentures, created May 4, have been filed, the whole amount being now issued. Property charged, certain patent relating to galvanic dry cells and any other patents which the company may become entitled relating thereto under an agreement dated Jan. 28, 1910. No trustees.

RECEIVERSHIP.

MUNSTER ELECTRIC LIGHTING CO. (LTD.)—A notice of the appointment of R. H. Bindloss, 26, North John-street, Liverpool, as receiver, on May 2, 1910, under powers contained in debentures dated Oct. 1 and Dec. 27, 1909, has been filed.

CITY NOTES.

MEMORANDA (May 12).—Bank rate 4 per cent. (since March 17, 1910). Price of silver, 24⅛d. per oz. Consols 81⅝—81¾ for money; 81⅞-82 **for account. Consols Pay Day, June 1; Stock and Shares Continuation Days, May 25 and June 8; Ticket Days, May 25 and June 9; Pay Days, May 27 and June 10; Mining Shares Carry Over Day, May 24.**

PRICES OF METALS (London).—*Copper*, **cash,** 56¾; **three months,** 56⅝. *Lead*, English, 12¾—13¼; foreign, cash, 12⅝; three months, 12¾. *Spelter*, 21⅞—22⅛. *Tin*, English, 143—150; foreign cash, 150; **three months,** 152. *Iron*, Cleveland, cash, 50/-, and **three months,** 50/11.

CENTRAL ELECTRIC SUPPLY CO. (LTD.)—The 4 per cent. guaranteed debenture stock transfer books of this company will be closed from 18th to 31st inst. inclusive.

CHLORIDE ELECTRICAL STORAGE CO. (LTD.)—A dividend at the rate of 6 per cent. upon the preference shares has been declared. In future the company's financial year will end March 31 instead of June 30.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted a quotation to £300,000 5 per cent. first debentures of the *Manaos Tramways & Light Co. (Ltd.)*. The committee have been asked to allow a further issue of $1,500,000 7 per cent. cumulative preference stock (in shares of $100) of the *Mexican Light & Power Co. (Ltd.)* to be quoted.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdire	April 29	209	— 6	17	3,666	+ 83
Anglo-Argentine	May 6	44,568	+ 10,348	18	785,847	+ 73,099
Ayr Corporation	,, 7	218	— 13	51	14,066	— 128
Baker St. & Waterloo Ry.	,, 7	3,470	+ 315	18	61,840	+ 1,240
Barnsley	April 29	162	— 1	17	2,892	+ 116
Barrow	,, 29	236	+ 27	17	3,854	+ 370
Bath Electric Trams, Ltd.	May 4	746	+ 20	18	12,702	+ 1,216
Birmingham Corporation	,, 10	6,825	+ 431	5	35,213	— 934
Birmingham & Midland	April 22	805	+ 17	16	12,928	+ 232
Blackburn Corporation	May 4	1,009	— 87	‡6	6,045	— 770
Blackpool and Fleetwood	,, 7	418	+ 38	..	..	..
Bolton Corporation	,, 8	2,277	— 101	6	12,177	— 1,646
Bombay	April 7	2,831	+ 72	14	38,086	+ 2,366
Bournemouth Corporation	May 4	1,614	+ 92	5	7,681	— 1,136
Bradford Corporation	,, 7	4,937	+ 204	6	25,387	— 1,504
Brighton Corporation	,, 8	788	— 90	§5	4,395	— 785
Bristol Trams & Carriage	,, 6	5,686	+ 459	51	291,921	— 235
Burnley Corporation	,, 7	1,268	+ 6	18	22,723	+ 560
Burton Corporation	,, 8	252	— 4	§5	1,362	— 75
Bury Corporation	,, 8	1,103	— 106	§5	6,015	— 860
Calcutta Tramways Co.	,, 7	₹51,734	+ ₹1,446	18	₹940,634	+ ₹32,400
Camborne-Redruth	,, 7	115	— 6	6	2,108	— 64
Cardiff Corporation	,, 7	2,213	+ 115	6	11,130	— 709
Cavehill	April 29	59	— 7	17	1,227	+ 132
Central London Railway	May 7	5,720	+ 368	18	99,426	+ 740
Charing C., Euston & H'stead	,, 7	3,790	— 110	18	68,840	— 460
Chatham & Dist. Lt. Rys.	,, 5	771	— 18	18	13,676	+ 524
City & South London Rly.	,, 8	3,175	+ 218	18	59,178	— 174
City of Birmingham	April 29	2,766	— 12	17	47,698	+ 2,576
Colchester Corporation	May 4	171	+ 15	18	2,900	+ 432
Cork Electric Trams Co.	,, 5	494	+ 494	18	7,924	+ 795
Croydon Corporation	April 29	1,562	+ 138	17	6,431	— 169
Devonport & Dist. Trams	,, 29	388	+ 32	17	6,851	+ 682
Dover Corporation	May 7	178	— 2	5	968	— 96
Dublin & Lucan Railway	,, 6	147	+ 13	18	2,109	+ 37
Dublin United	,, 6	5,486	+ 237	18	91,773	+ 3,191
Dudley-Stourbridge	April 29	703	— 73	17	11,935	— 428
Dundee Corporation	May 4	1,195	+ 37	†51	59,396	— 594
East Ham Council	,, 7	996	— 16	¶5	5,189	— 170
Exeter Corporation	,, 6	304	+ 9	5	1,514	— 185
Gateshead & Dist. Trams	April 29	937	— 37	17	16,150	— 297
Glasgow Corporation	May 7	18,051	+ 72	‡49	830,344	+ 3,533
Glossop Trams	April 30	110	— 5	17	1,855	— 99
Gloucester Corpn.	May 4	266	+ 8	5	1,278	— 18
Gravesend-Northfleet	April 29	183	— 12	17	3,196	+ 114
Great Northern & City Rly.	May 7	1,449	+ 71	18	27,166	— 398
Gt. Northern, Piccadilly, &c.	,, 7	6,055	+ 345	17	109,160	+ 4,685
Greenock & Port Glasgow	April 29	609	+ 66	17	9,116	+ 1,236
Hartlepool Tramways	,, 29	231	+ 27	17	3,522	+ 145
Hastings Elec. Trams Co.	May 7	821	— 72	18	14,562	+ 311
Hong Kong	,, 7	$9,649	+ $1,035	18	$154,534	+ $14,850
Huddersfield Corpn.	,, 7	1,697	+ 61	5	8,994	+ 127
Hull Corporation	,, 7	2,659	+ 278	5	13,881	+ 98
Ilford District Council	,, 7	487	+ 3	5	2,561	— 135
Ilkeston District Council	,, 4	126	+ 8	5	575	— 85
Ipswich Corporation	,, 7	360	+ 24	5	1,864	— 112
Isle of Thanet Co.	,, 7	335	— 63	¶31	9,535	+ 187
Jarrow	April 29	110	+ 2	17	1,883	+ 98
Keighley Corporation	May 5	173	+ 10	5	804	— 36
Kidderminster & District	April 29	85	+ 3	17	1,471	+ 46
Kilmarnock Corporation	..	..	..	..	..	..
Lanarkshire Trams Co.	May 5	1,407	+ 196	18	23,951	+ 2,464
Lancashire United	,, 4	1,249	— 26	18	21,983	— 73
•Leamington	April 29	128	— 25	17	2,447	— 39
Leeds Corporation	May 7	7,001	+ 454	5	37,667	+ 605
Leicester Corporation	,, 7	2,336	+ 131	17	39,156	+ 2,685
Leith Corporation	..	..	..	..	..	..
Lincoln Corporation	,, 7	114	+ 2	6	755	+ 2
Liverpool Corporation	April 30	11,049	+ 508	17	182,388	+ 4,467
Liverpool Overhead Rly.	May 8	1,407	+ 63	19	24,868	+ 223
Llandudno&ColwynBayRy.	,, 8	182	— 23	§22	3,218	+ 126
•London County Council	April 23	40,938	+ 5,242	¶3	132,157	+ 13 283
London United	May 7	5,894	— 255	18	102,293	+ 6,747
Lowestoft	,, 7	137	+ 13	32	4,713	+ 321
Maidstone Corporation	,, 7	148	— 26	5	808	— 170
Manchester Corporation	,, 7	15,240	— 313	5	78,076	— 1,536
Mersey Railway	,, 7	2,057	+ 106	18	35,163	+ 806
Merthyr	April 20	177	— 11	17	3,225	— 208
Metropolitan Dist. Railway	May 7	10,911	+ 1,020	18	195,041	+ 19,336
Metropolitan Elec. Trams	April 29	6,966	+ 720	17	115,402	+ 21,614
Middleton	,, 29	263	— 39	17	4,713	— 442
Nelson Corporation	May 7	138	— 4	§5	720	— 77
Newcastle-on-Tyne Corp.	,, 7	3,789	+ 33	¶5	19,839	— 1,730
Newport (Mon.)	,, 7	636	+ 8	6	3,887	— 21
Northampton Corporation	,, 6	496	+ 2	5	2,303	— 239
Oldham, Ashton & Hyde	April 29	516	— 13	17	8,952	— 133
Oldham Corporation	May 8	1,694	— 221	6	11,652	— 1,172
Perth (N.B.) Corporation	,, 4	155	+ 16	§50	7,829	+ 83
Perth (W.A.) Elec. Trams	,, 6	1,523	+ 146	18	28,481	+ 2,085
Peterborough	April 29	97	— 13	17	1,686	— 35
Portsmouth Corporation	May 7	1,781	— 88	5	9,500	— 1,357
Potteries	April 26	1,784	+ 6	17	29,103	— 303
Preston Corporation	May 4	710	— 7	5	3,420	— 309
Rotherham Corporation	,, 5	603	+ 25	5	2,968	— 106
Rothesay	April 29	87	— 22	17	1,246	+ 3
Salford Corporation	May 9	4,470	— 72	†6	24,551	— 1,115
Sheerness	April 29	41	— 6	17	719	— 13
Sheffield Corporation	May 8	5,881	+ 261	¶6	37,267	+ 1,216
Singapore Trams	,, 7	$9,814	+ $27	18	$180,535	+ $4,768
South Metropolitan	April 29	754	— 22	17	12,465	+ 706
South Staffs	,, 29	787	— 3	17	13,560	— 170
Southend Corporation	May 4	441	+ 48	5	2,106	— 130
Southport Tramways	April 20	240	— 13	17	4,108	+ 123
Stalyb'dge,Hyde,&c.,Jt.Bd.	May 7	670	— 80	¶5	3,355	— 1,049
Sunderland Corporation	May 8	1,031	— 11	6	5,608	— 578
Sunderland District	,, 4	417	+ 8	27	11,018	— 921
Swansea Trams	April 29	1,064	+ 183	17	16,623	+ 1,787
Swindon Corporation	May 4	134	+ 23	..	..	..
Taunton	April 29	37	..	17	671	+ 83
Tynemouth and District	,, 29	149	— 9	17	2,628	+ 237
Tyneside Trams Co.	May 4	377	— 18	18	6,836	— 337
Wallasey District Council	,, 7	893	— 43	§5	4,486	— 612
Walsall Corporation	,, 7	523	+ 26	18	9,472	+ 461
Warrington Corporation	..	..	..	..	..	..
West Ham Corporation	April 23	2,322	+ 28	4	9,161	— 519
Weston-super-Mare	,, 29	64	— 13	17	729	— 14
Wolverhampton Co.	,, 29	387	— 10	17	6,795	+ 130
Wolverhampton Corpn.	May 4	875	+ 118	5	4,234	+ 189
•Worcester	April 29	247	— 15	17	4,122	+ 66
Wrexham	,, 29	91	— 8	17	1,579	+ 7
Yorkshire W.R. Trams	May 8	1,143	— 16	19	22,705	..
Yorkshire Woollen District	April 28	937	— 98	17	15,886	+ 1,599

(a) These comparisons are with the corresponding period last year. • Partly electrical. ‡ Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	NAME.	Price Wed. May 11	Rate per cent. Yielded.	Dividend Due.	Business Week to May 11. Highest.	Business Week to May 11. Lowest.
		Electricity Supply.		£ s. d.			
	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	10⅜	..
		Do. 4½ per Cent. Cum. Pref.	9¼—9½	4 12 0	Feb, Aug	..	..
10	4/6	Do. 6 per Cent. Cum. Second Pref.	9¾—10¼	5 17 0	Feb, Aug	..	..
10	6/0	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
St.	4½%	Brompton & Kensington Elec. Sup. Ord.	7⅛—7⅜	6 7 0	March	7⅛	7⅛
5	5/6	Do. 7 per Cent. Pref.	7 —7¼	4 13 0	Mar, Sept	..	..
5	3/6	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 9	June, Dec	..	..
St.	4%	Charing Cross (W. End & City) El. Sup. Co.	4 —4½	5 11 0	Feb, Aug	4½	..
	2/6	Charing Cross (W. End & City) El. Sup. Co.	4¼—4⅝	4 17 6	Feb., Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	97 —100	4 0 0	Jan, July	..	..
5	2/6	Do. 4 per Cent. Deb. Stock (red.)	101 —103	4 7 6	..	102⅛	..
	4%	Do. 4 per Cent. Deb. Stock (red.)	..	..	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	3⅞—4⅛	5 3 0	Jan, July	..	..
St.	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅜—4⅛	5 9 6	March	4⅛	3⅞
5	2/6	Chelsea Electric Supply Ord.	101½—103½	4 6 6	June, Dec	..	..
5	4½%	Do. 4½ per Cent. Deb. Stock (red.)	11⅛—12	5 16 6	Feb, Aug	11⅛	11⅛
St.	9/0	City of London Electric Lighting Ord.	12 —13	4 12 0	Jan, July	12½	12½
10	6/0	Do. 6 per Cent. Cum. Pref.	121 —125	4 0 0	June, Dec	..	..
10	5%	Do. 5 per Cent. Deb. Stock (red.)	100 —103	4 7 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	1⅛—2	..	April, Oct	..	..
		County of Durham Elec. P. D. Ord.	2⅛—3⅛	7 14 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	7⅛—8	6 0 0	Feb, Aug	7⅛	7⅛
5	6/0	County of London Elec. Supply Ord.	10¼—11¼	5 6 6	Mar, Sept	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	103 —106	4 5 0	Jan, July	10⅝	..
10	6/0	Do. 4½ per Cent. Deb Stock (red.)	98 —101	4 9 0	May, Nov	..	..
St.	4½%	†Do. Second Deb. Stock	4⅛—4⅜	5 15 0	April, Oct	4⅛	..
St.	4½%	Folkestone Electricity Supply Co. Ord.	4⅛—5⅛	4 15 0	Mar, Sept	..	..
5	3/6	Do. 5 per Cent. Cum. Pref.	101 —104	4 6 6	Feb, Aug	..	..
5	2/6	Do. 4½ 1st Deb. Stock (red)	7 —7⅛	5 9 0	April, Oct	..	..
St.	4½%	Hove Electric Lighting Ord.	7 —7⅛	5 6 8	Feb, Aug	..	..
5	4/6	Kensington & Knightsbridge Ord.	5⅞—6⅛	4 18 0	Jan, July	..	..
5	4/0	Do. 6 per Cent. 1st Pref	94⅛—96⅛	4 3 6	..	..	..
5	6%	Do. 4 per Cent. Deb. Stock (red.)	..	..	..	..	..
St.	4%	Kensington & Knigtbg. Co. & Notting Hill	96 —99	4 1 0	April, Oct	..	..
St.	4%	Co. (Joint Station) 4% Deb. Stock (red.)	83 —87	5 3 6	Jan, July	..	..
		Kent Elec. Power Co.	1⅛—2	4 10 0	Mar, Sept	..	..
St.	3½%	London Electric Supply Ord.	4⅛—5⅛	5 14 0	Mar, Sept	..	..
3	1/2½	Do. 6 per Cent. Pref.	92 —94	4 4 0	Jan, July	93	92
5	3/0	Do. 4 per Cent. 1st Mort. Deb	3⅞—4⅛	5 6 0	April, Oct	4⅛	3⅞
St.	4%	Metropolitan Electric Sup. Ord.	4⅛—4⅜	4 12 6	Jan, July	4⅜	..
5	2/6	Do. 4½ per Cent. Cum. Pref.	104 —107	4 4 0	June, Dec	..	..
5	2/3	Do. 4½ per Cent. Deb. Stock 1st Mort.	83 —86	4 1 6	Jan, July	..	..
St.	4½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	96⅛—98⅛	4 11 6	June, Dec	84⅛	..
St.	3½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	4⅛—4⅜	4 5 0	Feb, Aug	..	..
100	4½%	Newcastle Elec. Supply Ord.	4⅜—4⅝	5 2 6	Feb, Aug	..	..
5	4/0	Do. 5 per Cent. non Cum. Pref.	101 —103	4 7 6	Jan, July	..	..
5	5%	Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 19 0	..	..	..
100	4½%	North Metro. Elec. Power Sup. 5 Morts.	11⅜—12⅛	5 17 6	March	6⅞	..
100	5%	Notting Hill Electric Ord.	6⅛—7	5 0 0	March	6⅞	..
10	9/0	Oxford Electric Ord.	8⅛—9	5 11 0	Feb, Aug	8⅝	..
10	4/6	St. James' & Pall Mall Elec. Ord.	6⅛—7⅛	4 16 9	Feb, Aug	..	..
5	5/0	Do. 7 per Cent. Pref.	85 —88	3 19 6	Jan, July	..	..
5	3/6	Do. 3½ per Cent. Deb. Stock (red.)	1⅛—2⅛	..	..	..	..
St.	3½%	Smithfield Markets Electric Sup. Ord.	2⅛—3⅛	6 11 0	April	101⅛	..
5	4/0	South London Electric Supply Ord.	100 —103	4 17 6	..	..	..
5	5%	Do. 5 % 1st Mort. Stock (red.)	⅛—¼	..	..	..	..
		South Metrop'n Elec. Lt. & Power Ord.	1 —1⅛	6 4 6	Feb, Aug	1⅛	..
1	..	Do. 7 per Cent. Cum. Pref.	98 —101	4 9 0	April, Oct	..	..
1	0/8½	Do. 4½ 1st Deb. Stock (red.)	⅛—1	..	April, Oct	..	..
St.	4½%	Urban Electric Supply Ord.	2 —2⅛	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	79 —81	5 11 0	April, Oct	8⅛	8⅛
5	2/6	Do. 4½ per Cent. 1st Mort. Deb.	8⅛—8⅜	5 13 0	Mar, Sept	5⅜	..
St.	4½%	Westminster Elec. Sup. Ord.	5 —5⅛	4 2 0	Jan, July	..	..
5	5/0	Do. 4½ per Cent. Cum. Pref.	..	..	..	..	..
5	2/3		..	..	..	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97½	96⅛
1	..	Bath Elec. Trams Pref. Ord.	⅛—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅜	6 13 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	83 —86	5 5 6	Jan, July	85	..
10	6%	Bristol Tramways & Carriage Ord.	6⅜—7⅛	8 5 6	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7⅛—7⅜	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅞—1⅛	..	June, Dec	..	..
10	3%	Do. 6 per Cent. Cum. Pref.	3¼—4	7 10 0	Feb, Aug	3⅜	..
St.	5%	Do. 5 Cent. Perpetual Debs.	90 —93	5 7 6	April, Oct	92½	91
St.	4½%	†Do. 4½ per Cent. 2nd Deb. Stock	66 —71	6 7 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	70 —72	5 4 6	Feb, Aug	70½	69
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	87½	86½
St.	2%	Do. Deferred Stock	53 —55	3 12 0	Feb.	53½	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	96 —99	4 2 0	Jan, July	96½	95½
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4½—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Crd.	31 —35	3 10 0	Feb, Aug	34½	34½
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	106 —108	4 12 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —105	4 15 0	Feb, Aug	103	102½
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	100	..
St.	4%	†Do. 4 per Cent. Perpetual Debs.	98 —100	4 0 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb, Aug	97	95½
St.	4%	Do. 4 per Cent. Deb. Stock	96 —98	4 2 0	Jan, July	..	..
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3¼—4	7 10 0	Mar, Sept	..	..
10	4½%	Do. 4½ per Cent. Debs.	70 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅜—1⅝	6 4 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10⅛	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86⅛—88⅛	5 13 0	Jan, July	..	..
10	..	London United Trams, 5% Cum. Pref.	21—21⅛	..	Jan, July	2⅛	2⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	65 —70	5 14 0	Jan, July	69⅛	68
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅜—⅝	..	..	..	..
1	..	Do. Deferred	⅜—⅝	..	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—⅝	5 11 6	April	⅝	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 —100	5 0 0	Feb, Aug	..	..
St.	1%	Metropolitan Railway Consolidated	43⅛—44⅛	5 2 3	Jan, July	98⅛	97½
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	44	42½
St.	3½%	Do. 3½ per Cent Preference	89 —91	3 17 0	Feb, Aug	67	..
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	89⅛	89⅛
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87⅛	87⅛
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	92⅛	..

• In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shre	Last Dividend	NAME.	Price Wed., May 11	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to May 11. Highest.	Lowest.
		Electric Railways and Tramways—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	91 —93	3 15 0	Jan, July	92 ..	..
St.	..	Metropolitan District Railway Ord.....	23½—23⅝	..	Feb, Aug	23⅜	22½
St.	..	Do. Extension Pref. (5 per Cent.).....	68 —70	..	Feb, Aug	69½	68
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	..	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	102½	102
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	142 —144	4 3 3	Jan, July	143½	..
St.	4%	Do. 4 per Cent. Ditto.....	96 —98	4 1 0	Jan, July	97½	..
1	..	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	¼—½	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock.....	84 —87	5 2 6	May, Nov	..	84½
1	..	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—¼	..		..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	67 —71	5 12 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	58 —63	7 18 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoups	38 —40	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds.....	100½—101½	4 18 6		101½	100½
..	4½%	Do. 4½% Bonds with coup. 5	88 —90	4 18 0		..	90
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	97 —99	4 1 0		..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	¼—¾	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2½	..		..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	78 —81	5 11 0	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101 —103	4 7 0		..	..
1	..	Aron Electricity Meter Ord.....	⅜—⅝	..		..	..
1	7½d.	Do. 6% Cum. Pf.	⅜—⅝	6 8 0	April, Oct	..	..
1	3/2½	†Babcock & Wilcox Ord..... xd and bon us	5 —5½	3 15 6	April, Oct	5⅛	4⅞
1	0/7½	†Do Pref.....	1⅞—1⅝	3 16 3		..	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7	7 3 0	July, Feb	7⅛	6⅞
5	3/0	Do. 6 per Cent. Pref.....	5⅞—6½	4 16 0	Jan, July	5⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	103	102½
5	..	British Westinghouse 6 per Cent. Pref....	⅛—⅜	..	Feb, Aug	98⅛	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	98 —100	6 0 0		..	98½
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	52 —55	7 6 0	Jan, July	53½	51½
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	25 —29	15 10 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.....	9½—10½	6 3 0	Jan, July	10	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	5½—5¾	4 11 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	102½—104½	4 6 0	Nov, May	2[illegible]	2[illegible]
1	1/9	Castner-Kellner Alkali Co.....	2½—2⅝	5 3 9	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	104 —107	4 4 0	Feb. Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	¼—½	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	¼—1	7 0 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.....	¼—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	½—⅞	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¼—½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	¼—1	6 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	1⅛—1⅜	5 5 3	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅞—⅞	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	66	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅛—¼	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1¼—1½	..	May, Nov	1⅛	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)..	73 —76	5 18 0	Jan, July	..	..
2	..	Electric Construction Co.....	½—¾	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1⅞—1⅞	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs ..	61 —66	6 1 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7½—8½	6 1 6	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	12 —12½	6 5 0	Feb, Aug	12½	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 3 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 3 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Works....	14½—15½	6 9 0	Feb, Aug	14½	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10⅛—10⅝	4 12 0		..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97½—99½	4 0 6	April, Oct	..	..
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅞—1	..	No.	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅞—1⅛	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..		..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..		..	..
12	30/0	Telegraph Construction & Maintenance..	32½—33½	5 16 0	Mar, July	33½	32
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 11 0		2⅛	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1⅜	4 4 3		..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	107 —110	4 11 0		108	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 16 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —106	4 5 0	June, Dec	105	103
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	105 —108	4 12 6		107	106
10	8%	J. G. White & Co. 6% Cum. Pref	9½—10½	7 12 0		..	..
1	..	Willans & Robinson Ord.....	¼—½	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1½—2½	9 0 0	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	65 —75	5 6 8	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3½—3⅞	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100 —102	4 18 0	June, Dec	..	..
St.	15/0	Anglo-American	59½—61½	5 13 6	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	101½—102½	5 18 3	F,My,Ag,N	101½	100½
St.	25/0	Do. Deferred	18½—18¾	6 9 3	F,My,Ae,N	18¾	17½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	85¼—87¼	4 11 6	Jn,Ap,Jy,O	87	..
10	6/0	†Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	†Do. Preference 10 per Cent.	16½—17½	5 12 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3½—3⅝	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable	13½—13⅞	6 3 6	Ja,Ap,Jy,O	13½	..
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.).	100 —102	4 18 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	136½—136½	5 0 6	Ja,My,Jy,O	138½	136½
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	86 —88	3 19 0	Ja,My,Jy,O	87⅛	85⅝
St.	4%	†Do. 4 per Cent. Mort. Deb. Stk. (red.)..	101 —103	3 17 6	May, Nov	..	..
St.	2/6	Eastern Extension	13½—13⅝	5 2 0	Ja, Ap, Jy, O	13⅞	13⅝
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	102	..
25	4%	†Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101½	3 18 6	May, Nov	..	..
10	26/0	†G.N (of Copenhagen), Ex Coupon 78	30½—31½	6 0 0	Jan, July	31	..
100	4½%	Halifax & Bermuda 4½% 1st Mt.Db.(red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European ..... ex all	52 —54	6 0 0	May, Nov	53½	53½
100	$1½	Mackay Companies Common	86 —91	4 18 6	Ja,Ap,Jy,O	..	..
100	$1	Do. Preference	77 —80	5 3 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜—⅝		April	⅜	⅜
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	98 —100	4 0 0	June, Dec	..	..
2½	1/3	West Coast of America	1½—1¾	4 0 0	May	..	..
100	4%	Do. 4 per Cent. Debs.....	98 —10	4 0 0	Jan, July	..	..
10	..	West India & Panama	¾—⅞	..	May, Nov	¾	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9½	6 10 0	May, Nov	8½	..
0	20/0	Do. 6% 2nd Pref.	8½—9½	6 10 0	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.....	101 —103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph.....	13½—14½	4 18 0	Mr,Jn,O,D	14½	13½
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	101 —103	3 17 6	June, Dec	..	..
—	4%	Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	—	—	—
		Telephones.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	139 —141	5 13 6	..	..	..
St.	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	104 —105	3 14 6	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99½—101½	4 18 6	Mar, Sept	..	..
5	3/0	Chili Telephone	8½—8⅝	4 15 3	August ..	..	..
1	0/7½	†Monte Video Telephone Ord.....	¼—¼	7 0 0	Nov	..	..
1	0/6	†Do. 5 per Cent. Pref.	¼—½	5 14 6	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	104 —105½	5 15 6	Feb, Aug	105	104
St.	6%	Do. Def. Stock	123½—125½	4 15 6	Feb, Aug	124½	123½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 10 6	Feb, Aug	10½	10⅜
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 10 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref....	5⅛—5⅜	4 11 0	Feb, Aug	5⅛	5⅛
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.).....	97 —99	3 11 0	June, Dec	97	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	99 —100	4 0 0	Jan, July	99	..
..	4½%	†New York Telephone Co. 30 yr. Bnds.....	97½—98½	4 11 6	..	98⅛	97½
1	1/9	†Oriental	1⅛—1⅜	4 15 0	April, Oct	1⅛	..
1	0/7½	†Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock.....	88½—88¾	4 10 6	Jan, July	101⅛	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100 —102	4 8 0	Jan, July	..	..
5	3/0	United River Plate.....	7½—7¾	5 9 0	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 9 0	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan, July	..	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2½—3½	8 18 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10⅛—11	5 9 0	Sp,DcMr,Ju	10⅜	10⅛
10	3/0	Do. 6 per Cent. Pref.	13½—13⅝	4 8 0	Sp,DcMr,Ju	13⅝	..
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅜	5 1 3	April, Oct	4⅛	4⅛
		Do. 5% Cum. 2nd Pref.....	4⅞—4⅛	5 5 6	Jan, July	4⅞	4⅛
		Do. 4% Deb. Stock	90½—92	4 7 0	June, Dec	91½	90⅝
		Do. 4½% Deb. Stock	96 —98	4 12 0	..	97	..
		Auckland Elec. Trams. 5% Deb. (red.)....	105 —107	4 13 6	Jan, July	106½	..
		†Brisbane Electric Trams. Invest. Ord	6¼—7¼	4 5 0	May	..	..
		†Do. 5 per Cent. Cum. Pref.	5 —5½	4 13 0	May, Nov	5⅛	5⅛
		Do. 4½ per Cent. Db. Prov. Certs.....	101 —101½	4 6 6	Jan, July	..	..
		†British Columbia El., Rly. Df. Ord.	142 —147	5 9 0	Mar, Sept	145	142
		Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	124	122
		Do. 5% Cum. Perp. Pref. Stock.....	107½—109½	4 10 6	Jan, July	108½	107
		Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
		Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
		Do. 4½% Perp. Con. Deb. St.	102 —104	4 2 0	..	103½	103
		Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	98½	..
		Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	97	96½
		†Calcutta Tramways (1 to 137,610).....	4½—4⅝	4 2 6	Mar, Sept	4⅝	4⅝
		Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	..	..
		Do. 4½% 1st Deb. Stock (red).....	99 —102	4 8 0	Jan, July	..	..
		Cape Electric Tram Shares	⅛—¼	..	..	..	..
		City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 8 3	F,My,A,N	5⅜	5⅛
		Do. 4 per Cent. Deb. Stock.....	97 —100	4 0 0	June, Dec	..	..
		†Colombo Tr. & Ltg. 5% 1st Mt. Db.....	94 —97	5 2 6	May, Nov	95½	..
		Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	81	..
		Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	95 —98	5 2 0	Feb, Aug	..	..
		Kalgoorlie Elec. Trams Sh.	⅛—⅜	..	..	..	..
		Do. 5 per Cent. "A" Deb. Stock.....	96 —98	5 2 0	Jan, July	..	..
		Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	..	..
		†Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
		Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
		Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
		Manila Elec. Ry. $1,000 Gold Bonds.....	95 —97	5 2 6	Feb, Aug	..	..
		Manaos Trams and Lt. Co. 5% Debs.	88 —99½	..	..	..	88½
		Mexico Trams Co. Com. St.	130 —132	4 16 0	..	130½	..
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	95½—96½	5 4 3	..	96	94½
		Do. 6% 50 yr. Mort. Bds.....	98½—99½	6 0 6	..	99½	99
		Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	..
		†Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	..	..
		Perth Elec. Trams Ord.	⅛—¼	5 14 0	May	..	..
		Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
		Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 2 6	..	..	..
		Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	..	..
		Ric Janeiro Tram. Lt. & P. Co.....	95 —97	4 2 6	..	96½	95½
		Do. 30 yr. Gold Bnds.	97½—98½	5 1 6	..	98½	97½
		Do. 50 yr. Mt. Bnds	86 —87	5 15 0	..	86½	86½
		Sao Paulo Tramway, Light & Power Co. $100 Stock	147 —149	5 8 6	..	149	..
		Do. 5 per Cent. 1st Mt. $500 Db.	102 —104	4 16 6	June, Dec	103½	..
		Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
		Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5⅛—5⅜	5 2 0	Mar, Sept	..	..
		Bombay E.S. & T. 6% Cm. Pf.....	10½—11	5 9 0	..	..	..
		Do. 4½ per Cent. Deb. Stk. (red).....	95 —97	4 12 6	Jan, July	96½	..
		Do. 5 per Cent. 2nd Mort. Deb. Stock..	96 —98	4 18 0	..	97½	..
		Calcutta Elec. Supply Ord.	6⅛—6¾	5 16 6	April, Oct	6¾	..
		Canadian Gen. Elec. Co. Com. St.....	110 —114	6 3 0	..	116	111½
		Do. 7% Cm. Pf. Stock	117 —120	5 16 6	..	118½	..
		Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
		Elect. Development Co. of Ontario.....	82 —85	5 16 0	..	83½	..
		Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
		Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
		Do. 6 per Cent. Cum. Pref.	⅛—¼	8 0 0	April, Oct	⅛	..
		Kaministiquia Power Co.5% Gold Bnds..	102 —104	4 16 6	..	102½	..
		Madras E. S. Corp. Ord.....	2⅛—3⅛	..	..	3⅛	..
		Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
		Do. 5% 1st Mortg. Deb. Stock.	92 —94	5 6 9	..	..	..
		Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84½—85½%	5 17 6	..	84½	..
		Mexican Lt. & Power Co. Com. St.	79 —81	4 18 0	..	80⅛	80
		†Do. 7% Cum. Pref. St.	100 —102	6 17 6	..	101½	100
		Do. 5% 1st Mort. Gold Bnds.	89½—90½	5 11 6	..	90	89½
		†Montreal Lt. Ht. & Power Co. Cap. St.	135 —140	4 15 6	F,My,A,N	..	..
		†River Plate Electricity Co. Ord.	1⅛—2⅛	3 13 9	April	2⅛	1⅞
		†Do. 6 per Cent. non-Cum. Pref.	1⅛—1⅜	5 4 0	May	1⅜	..
		Do. 5 per Cent. Deb. Stock	103 —105	4 15 6	Jan, July	..	..
		Rosario Ele. Co. Ord.	8½—9	..	..	..	..
		Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
		Do 2nd Pref.	8½—8¾	6 14 6	..	6½	..
		Shawinigan Water& Power Co.Ca.	101 —103	4 7 6	..	103	102
		Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	108	..
		Do. 4½ Per Con. Mt. Db. St.	101½—103½	4 7 0	..	102½	101
		Toronto Power Co. 4½% Db. St.	101 —103	4 7 6	..	..	..
		Victoria Falls Power Co. Pref.(1 to 808,000)	⅜—½	5 14 0	Jan, July	..	..
		Do. (803,081 to 1,700,000)	⅜—½	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,670. [No. 6. Vol. LXV.] FRIDAY, MAY 20, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Diversity Factor.

APART from economies in running and in first cost due to the use of plant of large capacity, an electricity supply undertaking has the advantage, as against private installations, of a large diversity factor, due to the maximum demands of the various classes of load, and also of individual consumers, occurring at different periods throughout the day. The fixed charges on the necessarily large expenditure on mains may in many cases be sufficient entirely to counteract any economies in generation, but it is to the diversity factor that electricity supply undertakings must look to a large extent to obtain any economy over independent plants. In this connection we may mention some figures relating to the Commonwealth Edison Co., of Chicago, given in a recent issue of the "Electrical World." These seem to indicate that for private houses the diversity factor is 6·25, for commercial lighting 2·3, for a scattered motor load 2·5, and for large lighting or motor installations 1·4. In each case the ratio between the sum of the maximum demands of individual consumers and the actual maximum demand recorded at the generating station is given, and the figures will, doubtless, prove of interest to engineers in this country, as owing to the smaller use which is now being made of maximum demand indicators it is becoming more difficult to obtain particulars of this kind. The figure for residential consumers given above is very striking, a very much smaller figure being usually adopted. The difference is, perhaps, accounted for by the much greater use made of apparatus for electric heating and cooking in Chicago, this, of course, being likely to affect the result very considerably. In this connection, we may mention that some time ago in our correspondence columns Mr. R. S. HALE, of the Edison Electric Illuminating Co., Boston, gave an average figure of between 2½ and 5 for residential lighting for an infinite number of consumers; whilst Mr. F. FERNIE estimated for private house lighting in this country a value for the diversity factor of something over 1·5.

The Local Government Board and Street Lighting.

THE recent Local Government Board inquiry at Grimsby found Mr. H. R. HOOPER, the L.G.B. Inspector, in a critical frame of mind. The question at issue was whether a loan of £2,000 should be granted for the purpose of lighting the side streets by means of metal filament lamps. The Public Lighting Committee are of opinion that a better light can be obtained electrically than by the existing gas lamps. Mr. HOOPER, however, seemed to think that this was by no means evident, and he criticised some of the existing lighting, more particularly the arc lamps (which, by the way, are of an old type and are being replaced out of revenue), although this method of lighting was by no means connected with the question at issue. Mr. HOOPER concluded by stating that the Committee would have to show that the new light would be an improvement and that they could give electric light quite as cheaply. There is much to be said in favour of a due regard to such questions as cost and efficiency on the part of the Board, but we fail to see why Mr. HOOPER should proceed further and question the efficiency of the metal filament lamp for street lighting. Apparently, he is of opinion that the 63-watt lamp does not give anything like 50 c.p., and, that if it does, its life must be only 200 or 300 hours. Mr. W. A. VIGNOLES, Borough Electrical Engineer, stated that this was by no means the case, and that lamps in actual use at Grimsby had shown a life of 1,900 hours. Certainly this is borne out by the experience

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of other engineers, and we think that Mr. HOOPER might have made himself better acquainted with the position.

Rival Illuminants.

IN view of frequent statements that artificial illumination by gas is many times cheaper than where electricity is used, and of attempts to belittle the progress of electric lighting, it is interesting to notice that the gas industry does not view the present position with equanimity. Thus, at the meeting of the Welsbach Incandescent Gas Light Co. last week the Chairman referred to the "severity" of electric light competition, which had now made itself felt even in regard to the illumination of small houses. That the Company fully appreciate the future importance of electric lighting is shown by the Chairman's statement that the Board were convinced that they had adopted a right policy in entering the electrical business. Attention may also be called to the fact that whilst many electrical engineers are endeavouring to encourage the use of light units of greater candle-power, one of our contemporaries connected with the gas industry has been drawing attention to the frequent efforts now made to show gas consumers how they may effect considerable economies by the adoption of lower units of light where applicable. In this connection it is mentioned that burners may shortly be expected which will only consume between $\frac{1}{2}$ and $\frac{3}{4}$ cubic foot of gas per hour and give a light of about 17 candles. The advantages possessed by electric lighting in the way of easy control by switches has led to many attempts to introduce similar facilities with gas lighting. The apparent reluctance of the public to experiment with such contrivances, however, has doubtless led our contemporary to suggest that "a house after dusk always looks brighter, and gives the inmates a greater sense of comfort, by having a light in almost every room. With the small incandescent burner units this condition can be satisfied in an inexpensive way." We fail to see, however, how the inmates can see the house look brighter unless all the doors are thrown wide open, whilst the effect on the atmosphere of a gas jet in every room is not pleasant to contemplate. Moreover, most of us have an inherent desire to economise in these days of increasing financial burdens, and thus the switch is important, even with a more efficient light.

Power Plant on Piles.—According to the "Electrical Review and Western Electrician," the new station of the Atlantic City Electric Co., which is being built in a meadow near New York Avenue, offers considerable difficulty to the selection of a stable and permanent style of foundation. Owing to the extremely marshy character of the soil it was necessary to plan a piling system, and from the results of tests it is calculated that fifteen hundred and thirty piles will be necessary to support the station. The tops of these piles will be 6 in. below the level of low tide so that they will be constantly submerged. Upon them will be placed a solid mat or pad of concrete, upon which will rest the building and machinery foundations, some of which will be carried to 10 ft. above low tide.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Balik Papan—Kwandang	Nov. 1, 1909
Malta—Tripoli	Aprll 20, 1910
Para—Pernambuco	April 25, 1910
Mosambique—Majunga	May 3, 1910
Suakim—Jedda	May 6, 1910
Bonny—Dusla	May 6, 1910
Madagascar—Reunion	May 12, 1910

1,200-volt Continuous-current Traction.—According to "Engineering News," fourteen 1,200-volt direct-current systems for railways are at present in operation. Two of these are in Italy and 12 are scattered about the United States. It is stated that over 66,000 H.P. of 1,200-volt motors had been built or ordered up to December 31, 1909.

Electric Traction in Chicago.—A recent issue of the "Electric Railway Journal" mentions that the Chicago Elevated Railway Commission is considering five plans to solve the problem of "through routes" for elevated trains in that city. Thirty-eight plans were submitted to the Commission, and five of these were selected for more careful study. Mr. B. J. Arnold, who is chairman of the Commission, feels that progress has been made in narrowing down the work. It is pointed out that each of the four elevated railway companies is operating under a separate ordinance granted by the city, and that the interrelation of the elevated lines is caused by the joint use of the "down-town" Union loop. The companies are doubtful whether they can afford to haul passengers for a greater distance than about 6 miles for 2½d., but there is apparently a desire on the part of everybody concerned to reach a solution of the question if possible.

Curious Interruption to Service at the Gary Steel Works. Several interruptions to the electric service have lately occurred at these works without apparent reason. As will be remembered, the works are to a large extent operated by electricity generated on the premises by a large gas-engine plant, although connection can be made to an outside supply in cases of emergency. In seeking to determine the cause of the trouble, one man, said to be the night foreman of the power plant, was particularly zealous. One evening this man was found unconscious at the entrance to the concrete tunnel in the basement of the power house. When revived, he declared that he had solved the mystery, and that his injury had been caused by an intruder whom he had found meddling with the electric plant. Investigation is said to have proved, however, that the injured man himself was the meddler. The trouble was caused by short-circuiting the 'bus bars by a piece of iron pipe, and the mischief maker is believed to have struck an iron beam in hurriedly emerging from the tunnel, fracturing his skull. No serious damage was done to the plant, although the trouble caused the Steel Company some delay and annoyance. No motive is ascribed for the deed, and the sanity of the man who perpetrated it, and who is now in the hospital, is questioned.

Possibilities of Electric Traction in Japan.—According to the "Electrical World," in the opinion of an observant traveller who visited Japan recently there is a large future in that country for electric railways in addition to the Government steam railway system. This opinion is confirmed by interviews with a number of Japanese who are well informed on the situation. For a number of years, interrupted only by the exigencies of war, the Japanese Government has been taking over the steam railways belonging to private corporations and has been building connecting links to complete the system. The Imperial Government railways now consist of 5,248 miles of road and there are only 445 miles of road in the country under private ownership. These lines are widely scattered and have been built to serve private interests, such as mining works, rather than public needs. Ten years ago the Government owned but 979 miles of the 3,172 miles then in operation. One reason for believing that future railways will be largely electrically driven is that Japan has many water-powers which are going to waste, and these powers could be used to operate electric railways for feeding the steam lines in districts which are not reached by the latter. These lines should be cheaply constructed, for, apart from the rails, material is plentiful and labour is cheap. Japan, for instance, is sending sleepers to both the United States and China. The Government now operates about 25 miles of trolley lines round Yokohama Bay, and is extending these lines. The tramcars use the same stations as the steam railways in many places and connections are made between the two systems of transportation. Another reason why electric railways are well suited to supply the needs of

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Japan is that the chief function of the steam railways at the present time is the transportation of passengers. According to the last report of the Imperial Government railways, the receipts from passengers were £3,757,373 and from freight were £2,930,362. The passenger business more than doubled during the year. There is provision for three classes of passengers, and an analysis of the traffic shows that the third-class passengers were carried at the rate of a little more than 0·35d. per mile, and that the average fare paid by each passenger of this class was about 7½d.

London, Brighton & South Coast Railway Electrification. As we have already announced, nothing has been definitely decided concerning the further electrification of the suburban service of the Brighton Railway Co., but when the shareholders of the Company next meet it is probable that a definite scheme will be laid before them for the electrification of that section of the Company's suburban line which runs to the Crystal Palace. It is to be greatly regretted (on behalf of the Crystal Palace Co.) that this step could not have been taken by the Brighton Railway Co. at an earlier date. This, however, was not the fault of the railway company, as modern practice was not sufficiently advanced to admit of so important a step being taken earlier. We hope it will not now be too late to serve as an aid to the better financial position of the Crystal Palace.

Wireless Telegraphy on the Eiffel Tower.—At midnight of May 23rd a wireless message will be dispatched from the Observatory on the Eiffel Tower to vessels at sea. There is also a specially-designed clock on the Tower which, according to the "Matin," sends out at frequent intervals a different electric signal, and it is asserted by Capt. Guyon and M. Bouquet de la Grye that by this means the longitude of a distant locality can readily be calculated when local time is known. The object of the first-mentioned operation is that all chronometers at sea may be checked at noon, 8 p.m., and midnight. It will be remembered that the installation on the Eiffel Tower is already in regular communication with Dakar, Port Étienne and Rufsque on the Atlantic coast of N.W. Africa, as well as with the Canary Islands, and with Bizerta and Oran on the Mediterranean coast, and it is anticipated that the next group to come into the network will include Abecher and Loango and Brazzaville in the interior of Africa, and, later, that Port Étienne will be in direct touch with several South American countries.

Electric Locomotives on the Loetschberg Line.—According to "Le Genie Civil" the Bernese railway authorities have recently ordered some electric locomotives for operating this line. They will be of two different types of construction. The first type is carried on two bogies, the three axles of which are coupled together. Each of these bogies is operated by a 1,000 H.P. motor through cranks and gearing. Each motor is fed with current at a pressure of 420 volts, the line voltage being 15,000. The electrical equipment weighs 42 tons, and the locomotives complete weigh 86 tons, the axle pressure being 15 tons, except on the two end axles, where it is 13 tons. The tractive effort is 12·8 tons at a speed of 26 miles an hour. The second type of locomotive has a capacity of 1,600 H.P., and is made up of two identical units coupled together. Each of these units is fitted with motors which drive the axles through cranks, but without gearing. Each motor is fed from the secondary of a transformer, the output of each unit being 800 H.P. The electrical equipment weighs 50 tons and the locomotives complete weight 93 tons. These machines are designed for running at from 43 to 45 miles per hour.

Electrification of the Boston Railways.—According to the "Electrical World" public opinion in favour of electrification of the steam railways at Boston continues to exert pressure upon the legislature for early action requiring the adoption of electricity in the metropolitan district. A long statement was issued last week by Mr. W. C. Ewing, chairman of the Committee on transportation of the United Improvement Association, refuting some of the arguments of counsel at recent legislative hearings against electrification. It was pointed out that while the advantages of eliminating the smoke nuisance had been given considerable emphasis at hearings before the legislative committee on metropolitan affairs, the great transportation advantages of electrified service had repeatedly been emphasised before the legislature. Economy of operation derived from the running of short and frequent trains will benefit the public and the railroads. Short, frequent trains are exactly what the "suburbanite" needs. The flexibility of electrification will give more frequent service at reduced cost; the elimination of shunting will be most advantageous, and overcrowding will be diminished. With more frequent and cleanly service, population will be attracted to the suburban territory, as it is not under the present régime. The traffic of the railways will be greatly increased by the introduction of electric service. The Railroad Commission and the Joint Board of Metropolitan Improvements are strongly in favour of electrification, and it is contended that it is time for the legislature to take definite action requiring the railroads to make a positive move in the matter instead of postponing the introduction of a type of service desired by practically the entire population of eastern Massachusetts.

Static Strains in H.T. Circuits.—In a recent issue of the "Electric Journal" Mr. P. H. Thomas summarises the results of some experiments he has made on this subject. He states that when a "dead" transformer is connected to a live line a strain may be produced on the layers of the coil next to the terminal which may be as great as the line voltage. When a short line is charged suddenly from live 'bus bars there may be produced a momentary voltage which will be not more than double the normal. When a long line is charged, a strain similar to that in the short line is produced, doubling the potential first at the end of the line and afterwards along the whole length. This result assumes that the charging terminal of the line is abruptly raised to and maintained at full normal potential until the wave is fully formed, and also that the losses are zero. The fundamental principles governing the charging of a cable are the same as those of a transmission line. Opening an unloaded high-tension circuit may be nearly the equivalent of charging the circuit, since before the line is completely freed from the 'bus bars it is often momentarily recharged several times. When a branch of small electrostatic capacity is supplied with energy from a main line, the rise of potential at the farther end may be twice as great as at the end of the main line. In addition to switching, other causes of static strains are earthing, short-circuiting, lightning, &c., when these cause abrupt changes of potential. A rise of potential due to resonance is always possible, but genererally improbable. It requires that there be an oscillating circuit and an exciting cause which must be of very nearly the same frequency as the natural period of the oscillating circuit. When an alternating E.M.F. of high frequency is applied to a long line the danger that resonance will occur is usually greatest, as it may be produced by a large number of frequencies. High-voltage transformers should be so designed as to possess a good and constant factor of safety, both in the outlet terminals and between those turns of the winding which are next to these line terminals. This can usually be accomplished by providing extra insulation on the end portions of the windings, and by eliminating all voltage taps from these parts, confining them to the inner turns of the windings.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Dr. A. Fraenckel and Mr. B. J. M. Lane contribute an article on "Short-Circuit Losses in Alternating-Current Commutator Motors."

We give the first instalment of an article describing the new generating station of the Westminster Electric Supply Corpn.

We also give an account of the electrical equipment at Smith's Docks, Middlesbrough.

We conclude our abstract of the Paper on "Commutation Phenomena," read by Mr. G. W. Worrall before the Birmingham local section of the Institution of Electrical Engineers.

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Fulham (London) Council have adopted a scheme of free wiring of consumers' premises and also for letting metal filament lamps on hire for outside shop lighting.

An inquiry has been held into the application of Wimbledon Corporation for permission to borrow £5,800 for electricity supply extensions.

The report on the past year's working of Birmingham electricity supply undertaking has been issued, and shows that substantial progress has been made. Considerable extensions of the generating plant and mains are projected.

Companies' Meetings, &c.—The report of the Anglo-Argentine Tramways states that a concession has been obtained by the Company for the construction of subway electric tramways of an aggregate length of about 10 miles. The Company's concession has been fixed at 80 years, and it is proposed to create new capital to provide money for the new lines, extensions of the system, &c.

The report of the Allgemeine Elektricitäts Gesellschaft (Berlin) states that business is satisfactory, but prices have been affected by keen competition. Several of the departments show an increased output compared with the corresponding period last year.

INSTITUTIONS AND SOCIETIES.

Glasgow Section of the Institution of Electrical Engineers.—At a meeting of this Section on May 10th Mr. E. G. Tidd, the chairman, moved that a loyal address and vote of condolence be sent through the parent Institution to His Majesty King George V. The local committee as nominated were elected. It was intimated that it had been agreed that the local Section should unite with the Iron and Steel Institute for a joint excursion on the Clyde in the specially chartered steamer "Duchess of Hamilton" on June 9th.

Newcastle Section of the Institution of Electrical Engineers.—The following are the nominations proposed by the committee for the session 1910-11: *Chairman*, Mr. C. Faraday Proctor; *Vice-Chairman*, Mr. C. S. Vesey Brown; *Past Chairmen*, Messrs. J. Pigg, Mr. A. L. E. Drummond and Prof. H. Stroud; *Committee*, Messrs. J. A. Anderson, L. E. Buckell, E. Fawssett, H. F. Fisher, H. Henderson, J. H. Holmes, F. O. Hunt, W. D. Hunter, G. Ralph, H. L. Riseley, J. M. Robb, R. Rutherford, G. Stoney, C. Vernier, W. W. Wood and Prof. W. M. Thornton; *Hon. Secretary*, Mr. H. W. Clothier; *Hon. Treasurer*, Mr. W. A. Clatworthy.

Students' Section of the Institution of Electrical Engineers.—The annual report of this Section states that during the past session there have been 10 general meetings and the annual general meeting held in the Library of the Institution, in addition to those held by the local sections; the average attendance at these meetings was 25, the highest recorded being 35 on February 2nd. The opening address was delivered by Mr. J. H. Rider on November 17th and was entitled "The Importance of Attention to Details." Ten Papers, ranging over numerous subjects, were read and discussed. In pursuance of the idea adopted last session no visits have been arranged this year, but the committee would welcome any suggestions, especially to visit places which perhaps could not be seen except under the ægis of the Institution. The committee have adopted this course in view of the fact that the need for such visits is now amply supplied by the college engineering societies. Thirty-eight students took part in the summer tour to Germany, which, due to the efforts of Mr. E. W. Moss, was a pronounced success. The committee desires to place on record its appreciation of Mr. Moss's organisation of the tour. A tour has been arranged to take place from July 25 to July 30, 1910, to visit works in and around Birmingham. The sixth annual dinner took place at the Trocadero Restaurant on Wednesday, January 26, 1910. The dinner was very successful, but the number present was not so large as was hoped, and the Committee feel that this function does not receive the support it deserves from the Students' Section as a whole.

Institute of Metals.—As already announced, the annual May lecture of this Institute will this year be delivered by Prof. Gowland, F.R.S., who will take as his subject "The Art of Working Metals in Japan." The lecture will be given on Tuesday, May 24th, at 8:30 p.m., at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. Prof. Gowland's discourse will be illustrated by numerous diagrams and lantern slides. It will be of a topical character, in that it will deal with metallurgy in Japan, a country in which great interest is now being displayed as a result of the recently opened Japan-British Exhibition. In view of the special interest of the subject of the lecture, the Council of the Institute of Metals have decided not to confine admission entirely to members of the Institute. Tickets admitting visitors may therefore be had gratuitously on application to the secretary of the Institute, Mr. G. Shaw Scott, Caxton House, Westminster, S.W., to whom applications for tickets should be made not later than Saturday next.

International Congress of Radiology and Electricity.—We understand that a number of Papers have been promised for this congress, which, as we have already announced, will be held at Brussels on September 15th, 16th, and 17th. The range of subjects covered is very large. We are requested to state that communications relating to the physical sections should be addressed to Prof. Rutherford or Mr. W. Makower, at the Physical Laboratory, University of Manchester, and communications relating to the biological section to Dr. W. Deane Butcher, "Holyrood," Ealing, London, W. Intending members should, however, communicate directly with the general secretary, Dr. J. Daniel, 1, Rue de la Prévôté, Brussels.

Verband Deutscher Elektrotechniker.—The eighteenth annual meeting of this association will be held at Brunswick on May 25th, 26th, 27th and 28th. An extensive programme of lectures and Papers has been arranged, among them being the following: "On Art in Technology," by Prof. P. Behrens; "On the Latest Results obtained with Electric Cables on Extra-high Voltages," by Dr. L. Lichtenstein; "Indirect Lighting by High-Candle Power Tungsten Lamps," by Dr. B. Monasch; "The Compound Commutator Single-Phase Motor operating as Motor and Generator," by Mr. R. van Cauwenberghe; and "New Automatic Switchgear and Speed Indicators," by Dr. E. Wagmüller, as well as a discussion on the subject of "Electricity on the Land." Excursions and visits will be made to places of interest in the neighbourhood.

Society of Engineers.—We have been requested by the Secretary to remind our readers that the latest date on which essays in competition for the Status Prize can be received is Tuesday, May 31, 1910.

Railway Signal and Telegraph Engineering Institute.—A meeting of the members of the above Society was held at the St. Marylebone Church Institute on Wednesday, April 27th, at which Mr. E. Hollman, of the Metropolitan Railway, read a Paper on the "Spagnolletti System of Interlocking," as installed on a portion of that railway. The Paper was illustrated by a number of sketches, and an installation of the actual instruments as used, these being kindly lent by the engineer. After the reading of the Paper an interesting discussion took place, and a practical demonstration of the working as between two signal cabins was given, at which Mr. W. J. Buck assisted.

ARRANGEMENTS FOR THE WEEK.

MONDAY, May 23rd.

The National Electrical Manufacturers' Association.

8 p.m. Meeting at Caxton Hall, Westminster. Discussion on "The Effect of Free Trade or Protection upon the Electrical Industry," to be opened by Mr. Hugo Hirst (from the Protection point of view) and Mr. J. E. Kingsbury (from the Free Trade point of view).

THURSDAY, May 26th.

Royal Institution.

3 p.m. Meeting at Albemarle-street, Piccadilly. Lecture on "The Constitution and Internal Structure of Alloys," by Mr. W. Rosenhain (Lecture I.)

Institution of Electrical Engineers.

8 p.m. Annual General Meeting at the Royal Society of Arts, John-street, Adelphi.

FRIDAY, May 27th.

Physical Society of London.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: (1) "On an Oscillation Detector actuated solely by Temperature Variation of Resistance," by Dr. W. H. Eccles. (2) "Exhibition of a Resonance Transformer," by Mr. A. Eagle. (3) "The Limitations of the Weston Cell as a Standard of Electromotive Force," by Dr. S. W. J. Smith.

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, May 23rd.—"A" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 9:30 p.m.

Tuesday, May 24th, "B" Company.—Company Drill, 7 to 9:30 p.m.

Wednesday, May 25th.—Gymnasium, 6 to 9:30 p.m.

Thursday, May 26th, "C" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7 to 8:30 p.m. Technical Drill, 8:45 to 9:45 p.m.

Friday, May 27th, "D" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Company Drill, 7:15 to 8:30 p.m. Technical Drill, 8:45 to 9:45 p.m.

Saturday, May 28th.—Musketry at Runemede.

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NEW GENERATING STATION OF THE WESTMINSTER ELECTRIC SUPPLY CORPORATION.

Of the many metropolitan electricity supply companies, the Westminster Electric Supply Corporation, if not the oldest, must be numbered among those that started in the earliest days of electric lighting. The oldest is the London Electric Supply Corporation, which has completed 24 years of its career—many of them exceedingly eventful. The Kensington Company comes next, having supplied for 22 years, and two other companies have been in operation for 20 years, while over 19 years must go to the credit of the Westminster Corporation. It was so far back as 1889 that the Company obtained a provisional order, and in 1890 operations were commenced, a description of the original scheme appearing in THE ELECTRICIAN of October 31, 1890. Prof. (now Sir) Alex. B. W. Kennedy was appointed engineer of the undertaking in January of that year, and has since that date been continuously connected with the undertaking, the most recent generating station of the Company being designed by him. The reason for laying down this station and the arbitration in connection therewith are probably still fresh in the minds of our readers, but it may be as well here briefly to summarise the proceedings.

By the London County Council Act, 1900, the Council were empowered to obtain possession of the site of the Millbank-street station of the Westminster Electric Supply Corporation in connection with proposed improvements, including the construction of an embankment. Although the Council have not, up to the present, made much progress with this scheme, the supply company naturally felt the uncertainty of their tenure of the Millbank-street site, and were anxious to obtain the new station and site, which, by the terms of the Act, the London County Council had to provide. After lengthy negotiations, a site in Horseferry-road was offered to the Company. This site, although much larger than the Millbank-street site, had the disadvantages, compared with the latter, that it was no longer possible to obtain water-borne coal, or to dispose of ashes except by means of carting, whilst water for condensing purposes was not so easily obtainable as in the case of the Millbank-street station, which was close to the river.

These considerations were discussed in the arbitration which commenced in October, 1908, and which was reported in THE ELECTRICIAN of October 30, 1908, and subsequent issues. As the result of this arbitration the Council agreed to pay to the Westminster Electric Supply Corporation a sum representing the difference between the cost of coal delivered at Horseferry-road and of coal brought by barges to the Millbank-street site. This increase in cost was stated at the time of the arbitration to amount to no less than 2s. 6½d. per ton. It will be seen that as this agreement remains in force until 1931, when the electricity undertaking becomes purchasable by the Council, a very large sum is due to the Westminster Electric Supply Corporation on this account.

The Council also arranged to construct a subway and to lay four 20 in. pipes from the new generating station to the river, so that water for condensing purposes would be available from that source. The arrangements in connection with this supply of water are probably the most interesting feature of the new station.

An idea of the distance over which the condensing water has to be brought can be obtained from Fig. 1, which shows the general arrangement of the pipes. It may be mentioned that no grids are fixed at the intakes on the bed of the river, all strainers being situated in the power station. The four pipes are of slightly different lengths, so that the hot discharge from any pipe is not liable to enter other pipes through which cold water is flowing.

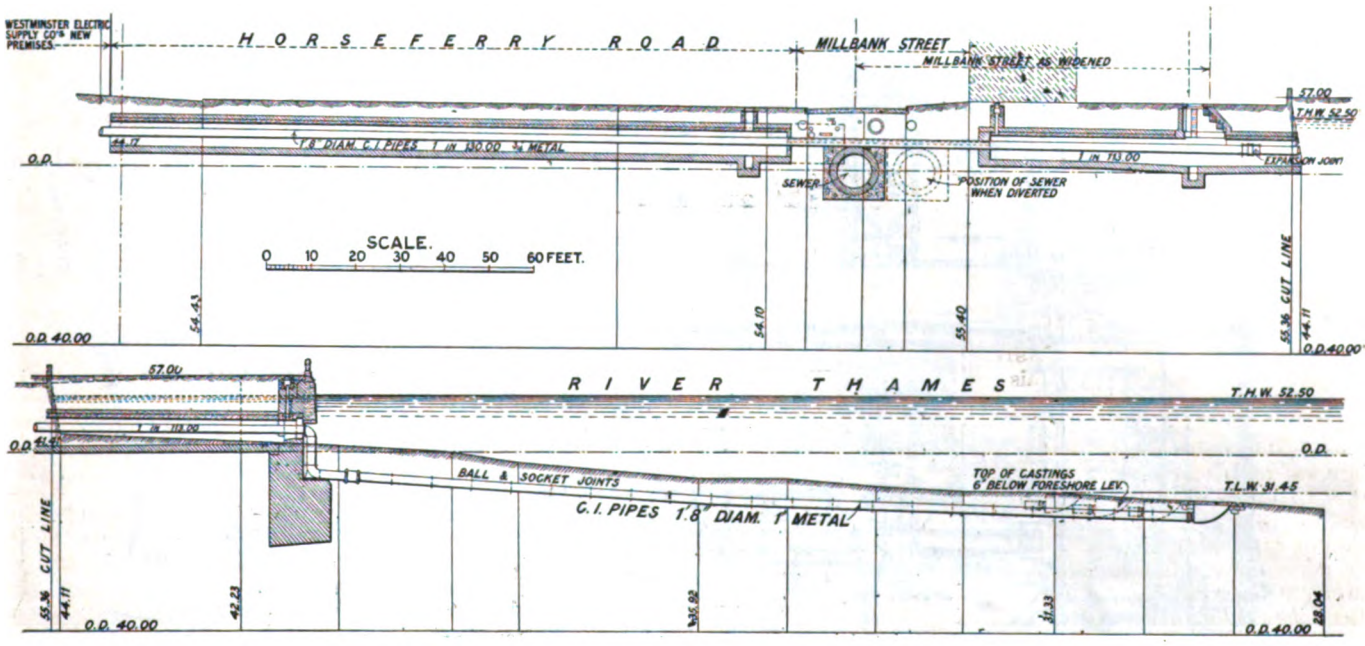

FIG. 1.—LONGITUDINAL SECTION OF SUBWAY AND WATERPIPES FROM HORSEFERRY-ROAD STATION TO THE RIVER.

Grids, comprising bars spaced about ⅞ in. apart, are fixed at the station on each of the four pipes and a very ingenious system has been adopted for minimising trouble due to choking of the grids and pipes. All the discharge from the condensers is passed through one pipe, whilst the other three pipes can, if necessary, be used for the intake. This results in the discharge pipe and grid being well scoured out, due to the high velocity of the water. When the pressure gauges show that any intake pipe is becoming choked, such pipe is used for the discharge from the condensers, and the pipe previously used for the discharge, and which has become cleared from deposit, is utilised for the intake. By changing over in this way it is possible to keep the pipes in a satisfactory condition, and to prevent a great deal of the trouble likely to arise where river water containing a lot of foreign matter is used for condensing purposes.

The water is drawn from the river by three electrically-driven Rees Roturbo pumps, and after passing through the above-mentioned grids and through these pumps, as can be seen from Fig. 4, the water flows through a Bailey and Jackson.

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rotary strainer, of which two are installed. The principle of this useful apparatus is now well known, owing to the attention which was called to it in connection with Mr. Rider's I.E.E. Paper on "The Electrical System of the London County Council Tramways." It will be remembered that these strainers, which are due to Messrs. Bailey and Jackson, of the City of London Electric Lighting Co., have proved very satisfactory at the Greenwich station of the Council. The unstrained river water passes through a slowly revolving grid on its way to the condensers, whilst the discharge flows through the grid in the opposite direction, thus washing away any deposit clinging to the strainer surface. The grid is rotated at a speed of about one revolution in two minutes. Each strainer is capable of dealing with 325,000 gallons of water per hour normally, and not less than about 500,000 gallons per hour in an emergency. It consists of a cast-iron casing in four parts, the casing being mounted upon a substantial cast-iron base, and provided with 18 in. inlets and outlets. Internally it is fitted with two rubbing strips, faced together back and front. An inspection cover is provided on the outside circumference of the top casing, while side inspection is provided for by four inspection blank covers. The cast-iron rotor, about 60 in. in diameter, is fitted with specially constructed brass grids, and is mounted upon a main shaft of 5 in. diameter, with gunmetal and leather packing rings, arranged to prevent the bye-passing of water as far as possible and also to allow of easy access for overhauling and repairs. A 1 in. water service for maintaining the water seal is provided, and the quantity of sealing water for each strainer amounts to about 400 gallons per hour.

Since at low tide the pumps are from 8 ft. to 10 ft. above the level of the river, it is evident that care must be taken to obviate trouble due to air accumulating at the highest points in the pipes so causing the pumps to lose their suction. As a precaution, therefore, a vacuum pump has been installed in the station and is connected to the higher points in the pipes; in this way air pockets are prevented.

Attention has already been called to the disadvantage of the new site in Horseferry-road as regards facilities for obtaining coal and the removal of ashes. Both these operations have to be carried out by means of carts. The general arrangement can be understood from Fig. 2, which shows diagrammatically the coal and ash-handling plant. Coal is tipped from carts at the roadway, indicated in Fig. 2, into a hopper on the basement floor. From this hopper a continuous conveyor, of the swinging bucket type, and supplied by Messrs. Spencer & Co., of Melksham, Wilts., raises the coal and conveys it into bunkers over the boiler house, measuring boxes and shoots being fixed as shown for each boiler. The conveyor is capable of dealing with about 25 tons of coal per hour, and is driven by a totally enclosed motor. All parts of the conveyor outside the building are covered in and protected by a framework of steel plates.

The ash transporter was specified to lift, at a rate of about 50 ft. per minute, a skip containing 40 cubic ft. of wet ashes from the basement outside the boiler house to the ash bunker overhead, from whence they are discharged through shoots to carts.

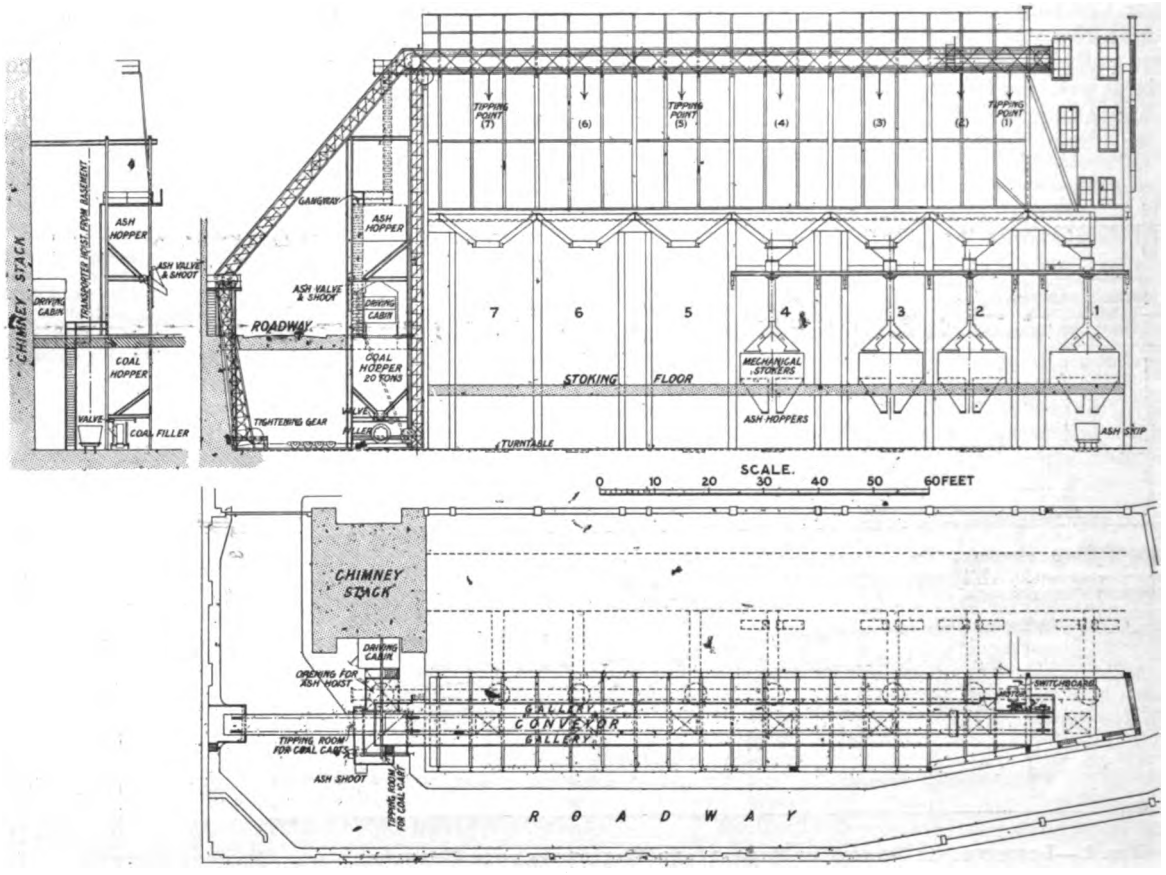

FIG. 2.—COAL AND ASH HANDLING PLANT.

The transporter is driven by a series-wound direct-current enclosed motor. Each ash skip stands on a trolley which runs on rails on the boiler house basement floor.

Before considering in detail the plant installed in the new station, it is interesting to note that by their Act the Council had to provide plant in the Horseferry-road station of equal capacity to that possessed by the supply company in their Millbank-street station. As a matter of fact, however, the new plant is of slightly greater capacity, the excess being paid for by the Company. The Millbank-street station has now been shut down, and was handed over to the Council on the first day of this month. The result is that the Westminster Electric Supply Corporation are now in possession of a station designed on modern lines, and considerable economies are expected to be shown in the costs of generation. The buildings have been constructed to meet all requirements until the undertaking becomes purchasable by the Council in 1931. As in the case of the Millbank-street station, a low-tension continuous-current supply only is given, but several motor-generators are installed,

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in which high-tension three-phase current supplied from the Grove-road station of the Central Electric Supply Co. is transformed to continuous current, these machines operating in parallel with the main generators.

Boilers.—Four Babcock & Wilcox boilers have been installed, each being fitted with superheater and operated in connection with an economiser. Each boiler, fitted as above, is capable of evaporating normally 20,000 lb. of water per hour, from a temperature of 75°F., into steam at a pressure of 200 lb. per square in. with 150°F. superheat; whilst when necessary each unit is capable of evaporating 25,000 lb. of water per hour.

The superheaters are of the usual Babcock type, consisting of solid drawn mild steel tubes 1½ in. external diameter, bent to shape and expanded at the ends, with wrought steel boxes.

The mechanical chain-grate stokers are of Messrs. Babcock & Wilcox latest pattern. In this, the movement of the grate is continuous, differing in this respect from earlier patterns, where a ratchet and pawl drive was adopted. The links are also closer together. This fact, together with their steady movement, allows a smaller class of coal to be burnt. The speed of the grate bars is variable to suit different classes of coal and conditions of firing, whilst the hopper is so arranged that the fuel is spread over the whole width of the grate, the thickness of the fire being regulated by a vertical movement of the fire door.

The shafting for driving the stokers extends for the whole length of the boiler house, and an electric motor is installed at each end, a clutch disconnecting either motor as required.

Each economiser consists of 160 solid drawn mild steel tubes, $3_{1}\frac{3}{8}$ in. outside diameter.

Water for the boilers is supplied by two Weir feed pumps and an electrically driven centrifugal pump by Messrs. W. H. Allen & Son, each being capable of delivering 60,000 lb. of water per hour against a boiler pressure of 210 lb. per square inch. The electrically driven pump is found to be more economical, but, on the other hand, the steam pumps will generally be employed, since the exhaust steam from these pumps is taken through a feed water heater, so that the feed water may be raised in temperature before it enters the economisers.

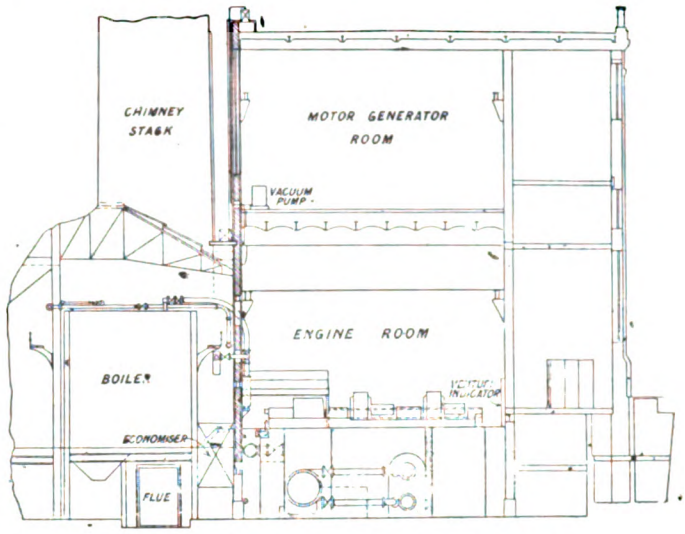

FIG. 3.—CROSS SECTION, SHOWING ARRANGEMENT OF PIPING, &c.

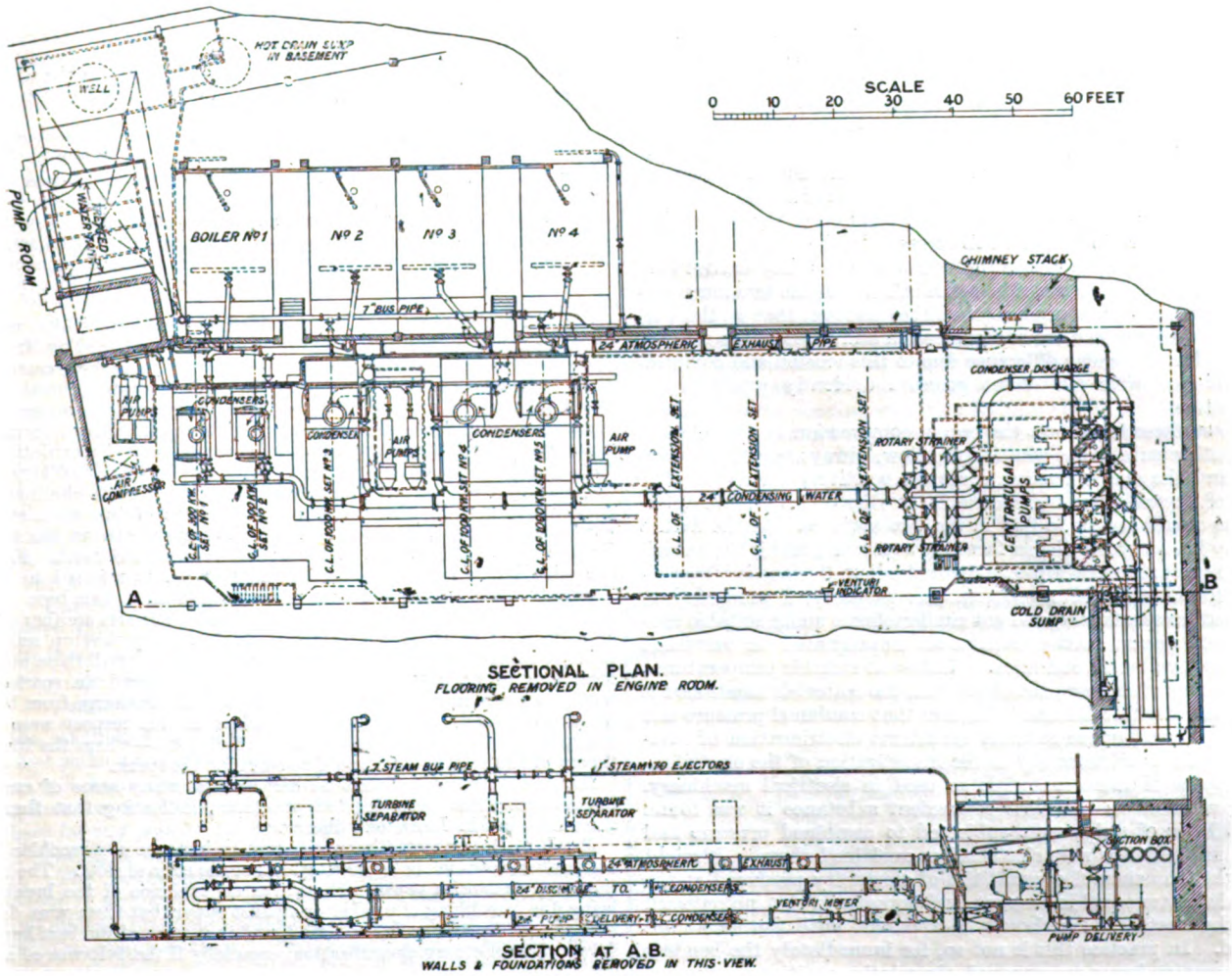

FIG. 4.—SECTIONAL PLAN AND ELEVATION OF GENERATING STATION, SHOWING GENERAL ARRANGEMENT OF PIPING, &c.

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A Lassen and Hjort water-treating and filtering plant has been installed for softening the make-up water for the boilers, and among other accessory plant may be mentioned two Lea water recorders, one measuring the hot well discharge and the other the make-up water, and a CO_2 recorder. The whole of the above plant, together with electrically driven centrifugal pumps for the hot well, &c., and all the pipe work has been carried out by Messrs. Babcock & Wilcox.

(To be continued.)

ELECTRIFICATION OF INSULATING MATERIALS.*

BY W. JAMIESON, B.SC.

The difficulty of carrying out experiments in electrostatics in this climate is well known, and as the author has had occasion for some years to show experiments of this kind to large classes of students, frequent failures led him to investigate the best kind of materials to use for producing electrification in a humid atmosphere. Of all the substances tried, by far the best was rolled celluloid sheet, particularly if the surface were well burnished. This, under the worst possible atmospheric conditions, electrifies with ease, and a gentle rub with the fingers suffices to raise the substance to a very high potential indeed. While this has to some extent been already known, though not made use of, in the manufacture of electrostatic apparatus, a further curious effect was discovered during the investigation; if two pieces of this celluloid sheet be drawn smartly between the finger and thumb, not only are the outsides electrified but the inside surfaces as well, one being positively the other negatively electrified. While seeking for an explanation of the phenomenon I found that on every occasion on which I tried the experiment the strip in contact with the thumb was +, but on asking others to try, no consistent results could be obtained; sometimes one strip was positively electrified, and on the next attempt negatively electrified.

Mr. M. MacCallum Fairgrieve, of Edinburgh Academy, having tried the experiment, found that the kind of electrification seemed to depend on whether the pieces were bent to one side or the other when drawn through the fingers, and this seems to be the true explanation. When the two strips are drawn through the fingers they are not only compressed but bent to one side or the other. Of the two inner surfaces in contact one is concave the other convex, that is, the particles of the one surface are in compression and those of the other in tension. The molecular difference due to this tension and compression combined with the direct pressure evidently produces the electrification.

Of the surfaces in contact the one in compression is, for celluloid and the other substances mentioned below, always negatively electrified, and the one in tension is always positively electrified. The amount of electrification is remarkable, in view of the minute differences one would expect to find in the two surfaces. In the dark a flash may be seen when the surfaces are separated, and if the experiment be repeated several times, a distinct odour of ozone is observed. Having found celluloid to possess this property, I proceeded to examine other substances, and got similar effects under suitable conditions with paper, shellac, substances impregnated or varnished with shellac, vulcanite and mica. Unless at suitable temperatures, and conditions of dryness, the effect with the materials mentioned is not so great as with celluloid. The fact that combined pressure and bending produced under suitable conditions electrification of insulating materials led naturally to the investigation of the electrification of layers of these materials as used in electrical machinery. Utilising celluloid as the most convenient substance it was found that if a layer of strips were subjected to combined pressure and bending, all the strips were electrified as explained above. It might be thought that since the quantities of electricity produced at the inner surfaces are equal in amount, and opposite in sign, no outward sign of the electrification should be apparent until the layers are separated. In practice this is not so, for immediately the bending and compressive forces are removed, the relative positions of the surfaces are altered; irregular leakage effects take place more at one place than another, and the result is that one electrification usually predominates, though the amount of this differential charge may be small.

In many electrical machines there are layers of insulating materials subjected to alternating stresses of pressure and bending combined; for example, in transformers due to the alternating field setting up vibrations, and in generators due to want of balance and change of flux. Is it possible that these layers could become statically charged in the way mentioned? To test this a layer of strips of celluloid was carefully discelectrified, and mounted, bent and compressed, on the base of a small motor running at 3,000 revs. per min. The spindle carried an eccentric load, thus vibrating the layers. After a time the layers showed electrification as a whole, while the separate strips were strongly electrified. At the same time a number of strips were fixed to the edge of a wooden disc (keyed on to the shaft of the motor) and loaded. This disc was eccentrically mounted. On rotating the motor at a rapid rate the layers became electrified as before. These experiments suggest the possibility of static charges being produced in electrical machines simply by vibration and rotation; it is possible, therefore, that cases of insulation breakdown may occur through these causes alone.

Besides the application to transformers and generators a further practical illustration of the phenomenon described is to be seen in printing machines. The author considers that much of the electrification of the paper produced in these machines is due to the combined bending and pressure exerted on the paper by rollers. It is probably for this reason that sometimes the sheets are + and sometimes — off the same roll. The author has constructed an electrical machine in which bands of celluloid running over pulleys produce + and — charges in this way. While the results given above are anything but complete and by no means conclusive, the author considers the subject worthy of further investigation. Though the differential charges mentioned are small they are cumulative and may become large in a long run. This would seem to indicate that more care should be taken to consolidate insulating material used in layers, and to prevent it coming adrift, and so setting up the kind of electrification mentioned.

DISCUSSION.

Mr. W. W. LACKIE (Glasgow), referring to the little sparks to be seen between the commutator bars, asked if such were due to the static charge referred to in the Paper.

Mr. CAMPBELL MCMILLAN thought that possibly the phenomena referred to in the note accounted for the static charges off belting. In the dryer atmosphere of New York he had seen a discharge across 14 in. to 18 in. Regarding the layers of insulation in the windings of machines, from a mechanical point of view any loose play was usually guarded against, more so at the end windings. In some large turbo sets which had broken down he found that there had been a material movement of the winding, due, no doubt, to the heavy torsional effects rubbing through the insulation.

Mr. W. MCWHIRTER had had much experience with faults, many of them inexplicable, but in view of the phenomena explained by Mr. Jamieson, there was no doubt that electrostatic action was the reason. Further, he found there was a greater tendency for this type of breakdown to develop on machinery with overhead lines, as the sudden release of the electrification in these lines during a thunderstorm, though there might not even be a lightning discharge, tended to puncture the insulation. As to the author's electrification of paper theory, he (Mr. McWhirter) over 25 years ago had been called in to try and get this trouble eliminated at a certain paper mill. His arrangement consisted of two rows of earth-connected discharging cones touching the paper both on the top and bottom sides, but he found that even that was not sufficient. Probably the scintillating sparking at the commutator bars referred to by Mr. Lackie was due to the fact that micanite, not mica, had been used as insulation between the bars. He thought there was also another cause—namely, the varnish in the insulation might have picked up small particles of carbon dust—a frequent source of trouble. Still there might be something in Mr. Jamieson's theory, as he only found the sparking referred to where micanite was used. As to static discharge from belting, he always found that the worst offenders in this respect were badly trimmed belts—*i.e.*, belts having a lot of slip, &c.—where the frictional theory of static electricity would account for the spark.

Mr. SUTCLIFFE stated that he had seen in many cases of armature breakdowns there were decided punctures, indicating that there was something in Mr. Jamieson's theory.

Mr. J. A. ROBERTSON (Greenock) gave an instance of a machine which had broken down in the equalising coils at the ends of slots. The insulation was presspahn paper. There was no evidence of the breakdown being due to rubbing of conductor against paper, but there were decided indications of puncture holes. He found that some of the best kept belt drives showed strong electrification, especially if the belt was of a laminated type.

Mr. JAMIESON, in reply, thought that the sparking between the bars would be due to the phenomena explained. In his experiments, he might say, he had made special precaution to prevent relative motion between the different layers of material. In regard to belts, from experiments he had made, he found that if two or more layers of celluloid or paper were made to pass over an even number of pulleys, say, 8 or 10, as shown in the diagram herewith, there was no sign of electrification, but if the laminated strip was made to pass over one or more (an odd number) of pulleys there was decided electrification.

* A Paper read before the Glasgow local section of the Institution of Electrical Engineers (slightly abbreviated).

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TELEPHONE CIRCUITS.*

BY PROF. J. PERRY, F.R.S.

Summary.—The author gives an easy method of calculation for the spacing of Pupin coils. This method gives a result practically correct, and can be used in the case of any network or other combination of resistances, inductances and capacities.

About a year ago Mr. Sidney Brown told me that he wished to place contrivances at equal distances in telegraphic or telephonic circuits and that it was necessary to make calculations, beforehand, because in a telephone line, say, of 300 miles or more with similar contrivances inserted every 1 or 2 miles, it was practically impossible to proceed by any kind of experimental adjustment. He spoke of various kinds of contrivance involving combinations of condensers and inductance coils and transformers and even rotary motors and generators; some in series with the line and others as shunts to earth. Exact investigation of what occurs in telephonic and telegraphic signalling in general is quite impossible. Transmitting and receiving instruments are various in their complexity: signals give rise to all sorts of functions of time and space; cables are not uniform in character, and when they are loaded with inductances, capacities, &c., the expressions employed in exact mathematical analysis are too complex for even the greatest mathematicians to deal with. Ordinary people like myself ought to keep on the lower levels and not talk about "waves" in such problems. The fundamental equation for v or c in an ordinary cable is exactly the same as that for the conduction of heat through a solid bounded by parallel plane faces; in the heat problem nobody dreams of talking about waves. It is easy to convert the differential equations into wave equations, and in the hands of exceptionally clever men the physical ideas involved become important. Even when Mr. Brown's problem is taken up in a mere mathematical way it is troublesome, and I can offer no exact solutions. I have, however, found a simple method of making the kind of calculation required, correct enough for all practical purposes and the method can be applied by non-mathematical persons. I mean that the necessary calculations may be made by any person who understands formulæ sufficiently well to be able to apply arithmetic to them. The idea came to me at St. Louis when I was listening to a Paper by Prof. Kennelly, but I then had no interest in pursuing the subject. Prof. Kennelly has published many illustrations of great value of the use of *cosh* and *sinh* functions; he gets no more credit now than Columbus did after he showed how to make the egg stand upright.

Let me say that much of the arithmetic consists in converting such an expression as $\alpha+\beta i$, where i means $\sqrt{-1}$, to the shape $r(\cos\theta+i\sin\theta)$, which is conveniently written $r(\theta)$. I need hardly say that if this is raised to the nth power the result is $r^n(n\theta)$ where n may be negative or fractional. Also when $r(\theta)$ operates upon such a function of the time as $a\sin qt$ it converts it into $ar\sin(qt+\theta)$. Cosh $r(\theta)$ and sinh $r(\theta)$ will be found tabulated (for $\theta=45^\circ$) by Prof. Kennelly. Unfortunately for our purposes we use only small values of r for which Prof. Kennelly's tables have only a few entries. But calculation is easy enough. Write $r(\theta)$ in the shape $\alpha+\beta i$. Then

$$\cosh r(\theta)=\cosh\alpha\,.\,\cos\beta+i\sinh\alpha\,.\,\sin\beta$$

and

$$\sinh r(\theta)=\sinh\alpha\,.\,\cos\beta+i\cosh\alpha\,.\,\sin\beta,$$

so that the calculation is easy for any values of α and β.

I will first make a few statements, the foundation of my reasoning.

1. It is well known that any looped line or cable containing a receiving instrument at the end of the loop has its equivalent in a cable whose far end goes to earth through the receiving instrument, the outer coating of the cable being everywhere to earth or of zero potential. The mathematical proof of this is very easy and I shall not give it, although I do not know that it has been published.

2. In all difficult problems cables are so long that for all practical purposes we may suppose them to be infinitely long. Thus it is well known to practical people that when lines of 30, 40, &c., miles of the same cable are experimented upon, the rate of diminution of current per mile is the same except for regions near the ends, and these end effects are much the same for all lengths of line except in short lines.

3. In any long, uniform cable at equidistant points, A, B, C, &c., when a simple periodic current is flowing, its value at these points being, C_A, C_B, C_C, &c., the ratio of C_A to C_B is the same as that of C_B to C_C, &c. This is true except near the ends.

4. In a long cable with perfectly similar contrivances, A_1A_2, B_1B_2, C_1C_2, &c., at equidistant places A, B, C, &c.; when a simple periodic current is flowing, its value at corresponding points being A_1, A_2; B_1, B_2; C_1, C_2, &c., the ratio of A_1 to B_1 is the same as that of B_1 to C_1, &c., and these are also the same as the ratio of A_2 to B_2, B_2 to C_2, &c. We may say the same about the voltages at corresponding points. It is seen that I assume an infinite line, but even in the case of an infinite line my assumption is that there is *some* diminution in the amplitude of the current from A_1 to B_1. If the circuit behaved like a mere ohmic resistance the current would be the same everywhere but the voltage would not.

5. Neither telephone nor telegraph signalling can be studied correctly through the behaviour of periodic currents, but it has been found in practice that in telephony, if we assume that all currents are periodic functions of the time, the frequencies being not much less than 600 nor much greater than 1,000 per second, the most important being 800, good transmission of such currents is found to mean good transmission of speech.

6. It is quite a usual thing to find that experimenters are using transmitting and receiving devices which are not the best for a particular cable. For a receiving instrument, for example, there is a best resistance and inductance (or combination of inductance, capacity, back E.M.F., &c.). In every case yet studied by me (but I can imagine others) the most suitable receiver causes the current and voltage near that end of the line to be different from what they would be if the line were infinitely long. Thus, for example, with simply periodic currents in the standard cable it will be found that at any place far from the ends, voltage divided by current is of the form $r(-45^\circ)$ or $\alpha-\alpha i$. If the telephone or other receiving instrument has a resistance R and an inductance L, each of which is proportional to the square of the number of turns of wire upon it, and if the effect on the instrument (such as the deflection of a coil, &c.) is proportional to the current turns received, this effect is a maximum if $R=\alpha$ and if $L=\alpha/q$, where q is 2π times the frequency. It is easy to show that if we wished the receiving instrument to produce the same effect as an infinite prolongation of the cable, it ought to have a resistance R and a negative inductance $L=-\alpha/q$, which is a capacity $1/\alpha q$. It is then not merely when unsuitable instruments are used, but also when the most suitable instruments are used that we have end effects.

7. A line with equidistant similar contrivances, when they are not too far apart, may be replaced (mathematically) by a line whose properties (as to resistance, inductance, capacity, leakance, &c.) are continuous, for many purposes of calculation.

The simplest case of uniform distribution of properties in an infinite line was studied in my Paper read before the Physical Society in 1893. Let v and c be the voltage and current at any place whose distance from the sending end is x; let $v_0\sin qt$ be the voltage when x is 0. If r, l, s and k are the resistance, inductance, leakance and capacity per unit length, we have

$$v=v_0e^{-hx}\sin(qt-gx), \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where

$$\sqrt{\frac{kqr}{2}}\sqrt{\sqrt{\left(1+\frac{q^2l^2}{r^2}\right)\left(1+\frac{s^2}{k^2q^2}\right)}\mp\left(\frac{ql}{r}-\frac{s}{qk}\right)} \quad (2)$$

is the value of h if the minus sign be taken and the value of g if the plus sign be taken. The following formula for the current c is useful—

$$c=\sqrt{\frac{h^2+g^2}{r^2+q^2l^2}}v_0e^{-hx}\sin\left(qt-gx+\tan^{-1}\frac{g}{h}-\tan^{-1}\frac{lq}{r}\right). \quad (3)$$

I showed in tables how good signalling was affected by changes in the values of the constants and specially by alterations in l and s. There was nothing very new in my Paper, but it enabled the non-mathematical man to understand some of the discoveries of Mr. Heaviside. At that time I saw no easy way of calculating how the introduction of detached equidistant contrivances caused discrepance from the idea of continuously distributed properties.

In much that follows, lq will be so large compared with r that, taking $s=0$, we have $h=\frac{r}{2}\sqrt{\frac{k}{l}}$; $g=q\sqrt{kl}$. If s is small but not negligible, g is as before, but

$$h=\frac{1}{2}\left(r+\frac{sl}{k}\right)\sqrt{\frac{k}{l}}.$$

As for other uniform distribution of properties, it is only necessary here to speak of those which may immediately be put in the above shape. For example, besides having merely r and l in series in the line, we may have something of the nature (mathematically) of k_1 farads per mile, so that instead of $r+lqi$ we have $r+lqi+1/k_1q_1$ or $r+qi(l-1k_1q^2)$. This is as if we had merely the resistance r and an inductance $l'=l-1/k_1q^2$.

Again, instead of the leakance s which is the reciprocal of a resistance R, let us have also something of the nature of an induc-

* Paper read before the Physical Society. A short account of the discussion which followed the reading of this Paper appeared in our issue of March 11th, p. 902.

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tance L, say, and assume R to be small relatively to Lq. Then instead of s we have

$$\frac{1}{R+Lqi}=\frac{R}{L^2q^2}-\frac{i}{Lq}.$$

Thus the common expression $s+kq$ becomes $\frac{R}{L^2q^2}+qi\left(k-\frac{1}{Lq^2}\right)$.

For preliminary calculations it is generally sufficiently correct to assume R/L^2q^2 to be zero.

We may now consider that the telephone line has, per mile, a resistance r, an inductance $l'=l-1/kq^2$, a leakance $s=0$, and a capacity $k'=k-1/Lq^2$. It will be found desirable in almost all cases to have l' so large that we may take $h=r/2\sqrt{k'/l'}$ and $g=q\sqrt{k'l'}$. Assuming these conditions to exist we have, very nearly,

$$c=\sqrt{\frac{k'}{l'}}v_0\epsilon^{-\frac{1}{2}rx\sqrt{k'/l'}}\sin(qt-qx\sqrt{k'l'}).$$

For a line of, say, L miles in length, the amplitude of the arriving current is a maximum if $\sqrt{l'/k'}=\frac{1}{2}rL$. In fact, the arriving current is the sending current divided by ϵ. It will be found that in practice we never have so small a value of h as this gives, and we generally try to make h as small as possible. We can approximate to the above conditions by inserting contrivances at equal distances in the line. I will take a few examples. I prefer just now to consider a cable in which I have recently taken an interest: $r=18$ ohms per mile, $k=0{\cdot}055\times10^{-6}$ farad per mile, $s=0$, $l=0$. I take q to be 5,000 (that is, a frequency of 800).

1. This cable with no contrivances, $h=g=\sqrt{kqr}/2=0{\cdot}04975$. So that if x is 1 mile, $\epsilon^{-hx}=0{\cdot}9513$. That is, there is an attenuation of 5 per cent. per mile.

2. Let $l'=l=0$. That is, there is neither inductance nor capacity inserted in the line. Now let there be an inductance leak to earth which causes k' to be $0{\cdot}01375\times10^{-6}$. Then $h=g=\sqrt{k'qr/2}=0{\cdot}024875$, so that $\epsilon^{-h}=0{\cdot}97513$, or there is an attenuation of 2·55 per cent. per mile. The approximation to this is by an inductance to earth of L henrys per mile, where $0{\cdot}055\times10^{-6}-1/Lq^2=0{\cdot}01375\times10^{-6}$, or L=0·972 henry. When I use an inductance to earth I generally prefer to put it in series with a condenser. Thus, instead of an inductance of 0·972 henry, I would use an inductance of 1·012 henrys in series with a condenser of 1 mfd. This enables the line to be tested more easily. Instead of an inductance leak of 0·972 henry per mile we may insert $0{\cdot}972/m$ henry every m miles. As m gets greater the discrepance from the continuous conditions gets greater. The problem to be solved, later, is in all cases to find the discrepance for a particular value of m and what therefore is the most convenient distance by which contrivances ought to be separated.

3. Suppose $l'=-0{\cdot}09112$ and $k'=-0{\cdot}0125\times10^{-6}$. These values will cause c to be a maximum if the distance is 300 miles. It will be found that they mean a capacity of $0{\cdot}439\times10^{-6}$ farad per mile in series with the line and an inductance leak of 0·5925 henry per mile. Here $g=0{\cdot}16775$ and $h=\frac{1}{2}\sqrt{k'/l}=0{\cdot}00033$. This means an attenuation of 0·333 per cent. per mile when q is 5,000. Now when q is taken as 3,000 or 4,000 the attenuation is 0·64 or 0·53 per cent. per mile.

The approximation to these conditions is (*a*) a contrivance every m miles consisting of a capacity of $0{\cdot}439/m$ microfarad in series with the line and an inductance leak of $0{\cdot}5925/m$ henry; or (*b*) a contrivance every m miles consisting of a capacity of $0{\cdot}439/m$ microfarad in series with the line between two inductance leaks each of $1{\cdot}185/m$ henrys; or (*c*) a contrivance every m miles consisting of two condensers in series, each of the capacity $0{\cdot}878/m$ microfarad, the point of junction being put to earth by an inductance of $0{\cdot}5925/m$ henry. It will be found that as m is smaller and smaller the line with detached contrivances approximates more and more to the line with continuous properties.

Detached Contrivances.—Suppose we have contrivances at the equidistant places A, B, &c., m miles apart. There is a contrivance whose terminals are A and A_0, another whose terminals are B and B_0, &c. Between A_0 and B we have the standard cable. Let the currents in the line at A, A_0 and B be c, c_0 and C. Let the voltages at these points be v, v_0 and V. Let $V/C=v/c=\rho$. Knowing the nature of the contrivance we can calculate v_0 and c_0 from v and c. It is also known that

$$V=v_0\cosh mn+\frac{r+lqi}{n}c_0\sinh mn,\quad C=c_0\cosh mn+\frac{n}{r+lqi}v_0\sinh mn,$$

where $n=\sqrt{(r+lqi)(s+kqi)}$. Putting V/C or ρ equal to v/c, we have a quadratic to calculate ρ and therefore V and C.

I am in the habit of writing $c=1$, meaning $c=\sin qt$, and then $v=\rho$. Whatever the contrivance may be, $\frac{V}{C}=\rho=\frac{\alpha+\beta\rho}{a+b\rho}$, where α, β, a and b are given in value; they are usually complex unreal quantities. Solving for ρ and finding C we have two answers, C_1 and C_2 say. In general $C_1C_2=1$, and if $\frac{1}{2}(a+\beta)$ be called P, $C=P\pm\sqrt{P^2-1}$. Now P is very easily evaluated, and therefore C.

Examp'e.—(1) If our contrivance is a resistance r_1 in series with the line $c_0=c=1$, $v_0=r_1+\rho$. Thus if r_1 is an ohmic resistance R in series with a capacity K and an inductance L, $r_1=R+Lqi+1/Kqi$. This is a very simple case, the simplest form of which is that of Mr. Pupin, a mere inductance coil in the line. The trouble in such a case is that the whole telephonic current passes through the coil and there is considerable ohmic loss of energy. It is to be remembered that the value of R to be taken in any such case may be many times the ordinary resistance, because c^2R is taken to be the total loss of power, and this is due to hysteresis, eddy-currents, &c., as well as mere ohmic loss.

2. Again, taking a case already mentioned; the contrivance consists of two equal resistances r_1 in series with the line and a resistance leak to earth r_3 from the point of junction of the other two. It is easy to show that $c=1+\frac{r_1}{r_3}+\frac{\rho}{r_3}$ and $v_0=2r_1+\frac{r_1^2}{r_3}+\rho\left(1+\frac{r_1}{r_3}\right)$, and it follows that

$$P=\left(1+\frac{r_1}{r_3}\right)\cosh mn+\left(\frac{n}{r}r_1\left(1+\frac{r_1}{2r_3}\right)+\frac{1}{2r_3}\frac{r}{n}\right)\sinh mn.$$

It may be well to work out one example. In the above-mentioned cable $r=18$, $k=0{\cdot}055\times10^{-6}$, $s=0$, $l=0$; take $q=5{,}000$,

$$n=\sqrt{rkqi}=0{\cdot}07036\ (45^\circ),\quad \frac{n}{r}=0{\cdot}003909\ (45^\circ),\quad \frac{r}{n}=255{\cdot}8\ (-45^\circ).$$

Let us place contrivances at $m=4{\cdot}263$ miles apart. I choose this distance because $mn=0{\cdot}3$ (45°), and this happens to be given in Prof. Kennelly's table, which tells me that

$$\cosh mn=1{\cdot}0007\ (2^\circ.35'),\quad \sinh mn=0{\cdot}29994\ (45^\circ.51').$$

To imitate the continuous case given above we need an inductance leak of 0·5925 henry per mile or $L=0{\cdot}5925\div4{\cdot}263$ every 4·263 miles. Hence $r_3=Lqi=694{\cdot}7i$. Now r_1 is a condenser of capacity $K=\frac{0{\cdot}878}{4{\cdot}263}10^{-6}$, so that as $r_1=1/Kqi$, $r_1=-971{\cdot}13i$. Inserting these values in the above formula, I find $P=-0{\cdot}05384-0{\cdot}068078i$, and $C=1{\cdot}057\ (183^\circ.54')$ or $0{\cdot}946\ (-183^\circ.54')$. That is, there is an attenuation or increase of 5·5 per cent. in 4·263 miles or 1·3 per cent. per mile. Observe how different this is from the effect of the continuous distribution.

As another case, a most important one, consider the standard subterranean cable $r=88$, $k=0{\cdot}05\times10^{-6}$, $s=0$, $l=0$.

I. Without contrivances $h=g=\sqrt{rkq}/2$. If $q=5{,}000$ (a frequency of 800), $h=0{\cdot}1049=g$. There is an attenuation of 11 per cent. per mile. It is to be observed that notes of frequencies 1:2 are attenuated in the proportion 1: $\sqrt{2}$. This is probably good, because it is known that the graver notes of speech need to be of greater intensity for distinct hearing. But the changes in phase are also as 1: $\sqrt{2}$, whereas for good hearing they ought to be as $\sqrt{2}$:1. Using this cable with no contrivances it is found in practice that there is good telephonic speech to a distance of 40 miles. When $q=5{,}000$ a current 1 is reduced to 0·015 or $\frac{1}{66}$ of itself in 40 miles. If $q=6{,}000$ (a frequency of 930) a current of 1 is reduced to 0·01 with a lag of 2·3°; whereas if $q=4{,}000$ (a frequency of 640) a current 1 is reduced only to 0·0238, but it has a lag of 215°. In fact, the two lags in actual time are as 22 to 29. If, then, we find such attenuations and lags in any case we may infer that good telephone speaking is possible.

II. I will first give examples of a tuned circuit, that is, very perfect transmission of one musical note of frequency 800. Keeping to the contrivance which has two condensers in series, each of capacity K in the line and an inductance leak of L henrys to earth from the point between the condensers, it is easy to write out the general expression for P in terms of m and r_1 and r_3 (at all events when mn is small), and it may be studied. Now for any particular m find the values of r_1 and r_3 which will cause P to be nearly 1 (0°) and therefore C to be nearly 1 (0°). I have already explained that we have no right with the above formulæ to get a really constant current like this, but we have a right to approach it very nearly. If $m=1$ mile, then K=0·5917 mfd. and L=0·8324 henry. If $m=2{\cdot}755$ miles, K=0·2273 mfd. and L=0·3692 henry. Even when m is as much as 5·51 miles, a very considerable distance for such a cable, I find that I can use values of K and L which cause the attenuation to be comparatively small.

We see that by means of contrivances placed at considerable distances apart we can tune a long circuit so that it will transmit a current of one frequency, just as if the line were a mere ohmic resistance. I do not know whether practical men see great value

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in having this power. It may be important to inventors. It is well, however, to say that when we have such a line, unless the contrivances are rather close together, the circuit is really a tuned one, tuned to a particular frequency and not good for the transmission of other frequencies.

III. Isolated contrivances. When m is so great that cosh mn and sinh mn are practically equal, calculations are particularly easy. Thus, taking the case in which $q=5{,}000$, $r=88$, $k=0{\cdot}05\times10^{-6}$.

We have

$$\frac{r}{c}=\rho=\sqrt{r/kq}\,i=593\ (-45^\circ)=419{\cdot}3\ (1-i)=\alpha-\alpha i=\alpha-\beta_1 i,\ \text{say.}$$

1. If in the middle of a very long line we merely insert an inductance leak to earth of L henry; $L=\frac{\alpha}{q}=\beta=0{\cdot}11725$ gives the best effect. This multiplies the received current by 1·414 and causes a lead of 45°.

2. An inductance of L=0·11725 henry in series with the line and a leak to earth which is a condenser of capacity $1\div\beta_1^2$ farads (in the present case 0·532 mfd.); this causes the current to be multiplied by 1·414 and to get a lead of 225°.

3. An inductance of 0·11725 henry in series with the line and no leak to earth. This multiplies the received current by 1·414 and it creates a lag of 45°.

IV. Returning to the contrivance consisting of two equal condensers in series with the line and an inductance to earth from the point between the condensers. For good telephonic speech it is evident that the inductance ought to be small, otherwise there is too much dependence on frequency; there is some tuning. We want k'/l' to be small and nearly constant and $k'l'$ to be small also. We cannot effect both these objects, but we can obtain fairly good speaking by compromise. Thus, let $k'=-0{\cdot}05\times10^{-6}$ and $l=-0{\cdot}128$, so that K=1/3·2 mfd. and L=0·4 henry. Thus if m is 1 mile, $r_1=-320i$ and $r_3=2{,}000i$. I find that if $q=5{,}000$, C=0·9704 (24°.3), it $q=4{,}000$, C=0·9647 (35°). This is, with a frequency 800 there is an attenuation of 3 per cent. and a lag of 24° per mile, whereas with a frequency of 640 there is an attenuation of 3½ per cent. per mile and a lag of 35°. We get practically the same results by continuous formulæ.

Practical men will now see their way to easy calculation of the effect of placing any kind of contrivance in a circuit, and I need not give any more examples. It is to be remembered that condensers suitable for telephonic purposes are very cheap, a few shillings per microfarad, whereas inductances are expensive. Also, it has to be remembered that when the whole telephonic current passes through an induction coil, its resistance becomes of very serious importance, for the cost of coils of similar construction is proportional to the 3/2 power of L/R if L is the inductance and R the resistance of the coil.

Appended to the Paper is a table of the values of sinh r (45°) and cosh r (45°) to supplement that published by Kennelly.

RAILWAY ELECTRIFICATION,

At the present time the subject of railway electrification is one of the most important topics in engineering circles. The following abstract of a lengthy discussion which took place a short time ago at a meeting of the American Institute of Electrical Engineers should therefore prove of interest to electrical engineers in this country. The discussion was in connection with a Paper by Mr. C. T. Hutchinson on "The Three-phase Installation in the Cascade Tunnel of the Great Northern Railway Co," of which an abstract appeared in our issues of January 14th & 21st.

President STILLWELL remarked that the three-phase system had been in use in Italy and in Switzerland for a number of years, and, since 1904 on what might be called a large scale, on the Valtellina line. From 1890 until recently but little attention had been paid in the United States to the practical application of the polyphase motor to railway purposes. It had received during that period careful study, but the conclusions reached were negative, so it was not introduced in commercial service. In the United States at the present time there were three different systems operating electric traction of the heaviest kind—namely, the direct-current, the single-phase and the three-phase systems. All these were doing their work not only successfully, but in a manner that showed a marked improvement over the steam locomotive operation that they had superseded. The steam railroad managements of the country were beginning to awaken, and were asking which was the best system for general railway work. It was here that one of the functions of the Institute came in. In the U.S.A. there was no government commission to decide general standard specifications and to pass on the claims of various systems before adoption, as, for example, in Germany. He was always glad, therefore, to have this subject presented, because there was nothing within the scope of the Institute that was of greater technical interest or that compared with it in commercial importance.

Mr. W. S. MURRAY, as a single-phase man in other fields, said that, so far as the Cascade Tunnel was concerned, he was heartily in agreement with Dr. Hutchinson's chosen method of electrification. The author stated that traction developed by motors of the three-phase type admitted of 3 per cent. or 4 per cent. greater adhesion than in the case where single-phase motors were used. Now, the single-phase motor was admittedly heavier than the three-phase motor of the same capacity, and, therefore, if it lacked adhesion in its torque developing characteristic, which statement was by no means accepted by all, the deficiency was taken care of by its excess weight. A frequency of 25 cycles was also applicable to single-phase installations, but it was true that the use of three-phase apparatus assured less costly generators. This saving, however, was offset in the case of single-phase installations by less costly switchboards. He agreed with Dr. Hutchinson that, in regard to mechanical clearance, ¼ in. was ample for all practical purposes, and that the yard proposition on two overhead wires was not practicable; this was true of main-line tracks where high speeds and many switches were involved. He supported the author's views in regard to simplicity, capacity and reliability of the induction motor, but regretted that its electrical characteristics did not conform to those required by the general traction problem. It was to the alternating-current series motor what the direct-current shunt motor was to the direct-current series motor. The direct-current shunt motor had disappeared for ever on all traction lines, and he did not believe that it could reappear under the cloak of alternating current.

Mr. E. B. KATTE thought the reasons for adopting a three-phase system over the whole mountain division were quite obvious, but he was surprised to note that this same system would probably have been used if only a 4 mile tunnel section was to have been considered. Without going into figures, it would seem that a direct-current system with storage batteries would have made unnecessary the use of steam locomotives in starting electric trains, and at the same time would have relieved the power station from the sudden inrush of current, thus securing better regulation at the water wheels. And further, by adopting multiple-unit control for the locomotives, two or more at the head of a train could have been operated with one-half the number of men. He asked the author why the earth wire was finally omitted. When the transmission line of the New York Central was designed, similar provision was made for an earth wire, but after further consideration it was left out, for the reason that the poles were of steel and each carefully earthed to a large copper place set in permanently wet ground, and it was believed that each pole would act as a lightning rod and thus protect the line. However, on the Great Northern line the poles were wooden and the insulator pins did not seem to have been earthed, consequently if an earth wire was ever necessary, these would appear to be conditions under which it would be most valuable.

Mr. BION J. ARNOLD was surprised at the excessive friction of the Mallet compound locomotives, given as an average of 46 lb. per ton. Ordinarily the friction load for steam railway trains was estimated at 6 lb. per ton on level straight track. This excessive friction was probably due to the greater number of cylinders, reciprocating parts and extra weight of the valve motion of these engines; and it indicated that some of the advantages of these immense engines were offset largely by this excessive friction. The author had adopted a method which gave him a single speed for his electric locomotives and resistance was used when starting. Such practice would not do in case the power were produced by a steam power plant on a railroad of any great magnitude, and a different conclusion would have to be drawn as to the method of control to be adopted in case the three-phase system were made applicable to a large railway system.

Mr. F. N. WATERMAN said there was one interesting property of induction motors which was not exhibited in the present instance, because only one train was operated—namely, the action of moving trains as flywheels to keep down the peaks or to minimise the fluctuations of output of the central station. This was illustrated on the Valtellina line. With only one train running the ratio of maximum to average ordinate of the output curve was about 3·5 to 1; the average run was short, requiring frequent acceleration. With four to six trains on the line the ratio of maximum to average output fell to 1·7 or 1·8 to 1, giving a load factor of 55 to 60 per cent. The reason why the ratio of maximum to average was a favourable as 3·5 to 1 with single-train operation was the employment of cascade control for most of the trains. The remarkably favourable results on the Italian State railways were unquestionably due to the peculiarity of induction motors that they ceased taking current if the frequency fell by the amount of their slip, and returned current if it fell to a greater extent. The water wheels driving these generators fell off in speed some 5 per cent. as full load came on, while the average slip of synchronously running trains was less than 1 per cent. Hence, as the shock of starting a train came upon the power house the frequency fell, and it had to fall only 1 per cent. entirely to relieve the station of other loads. A further fall would cause the moving trains to return energy to the line and help supply the starting current. This momentary relief of the station resulted in the high load factor noted. This property of induction motors should be of great value where a small number of trains was operated. Of course, relief of the power house by this means was only momentary; whether it would be of consequence at all in such a proposition as the author was dealing with was perhaps problematical. He had had some calculations made showing the effects of tandem control of three-phase motors in comparison with the series-parallel control

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of the New York Central locomotives. It was impossible to include a computation for the single-phase locomotive, because sufficiently accurate information was not available. The table showed that the tandem control with two speeds—a method that left the entire equipment available for either kind of running—was at least not inferior to the New York Central locomotives, employing four motors and their three groupings, in respect of maximum draught on power house or total energy consumption, but was rather better. If handled on the basis of constant-current input, which was not the custom in direct-current practice in America, he believed the three-phase locomotive would show rather a noticeable advantage when the application of the three-phase motor to railroad work had received the same thorough study and development as given to the direct-current motor.

Comparisons of Three-phase and Direct-current Locomotives.

Type of locomotive.	Total train wght. (tons).	Net train wght. (tons).	Distance. Feet.	Time. Sec.	Speed max. miles per hour.	Kilowatts. max.	Kw.-hours.	Watt-hours per ton-mile. gross.	Watt-hours per ton-mile. useful
New York Central (weight 95 tons)	435	340	27,300	426	58·4	1,320	110·0	49·4	62·8
Valtellina 2 speed type (weight 68 tons)	408	340	27,300	426	58·5	1,660	104·0	49·1	59·4
Valtellina 3 speed type (weight 68 tons)	408	340	27,300	425	58·5	1,660	91·5	43·5	52·3
New York Central.....	265	170	29,800	403	60·5	1,800	82·0	54·9	85·5
Valtellina 2 speed type	238	170	29,800	404	59·5	1,660	71·0	52·8	74·0
Valtellina 3 speed type	238	170	29,800	402	59·5	1,660	60·0	44·7	62·5

From a mechanical point of view he was much interested in the motors of the Italian State railways. The clearance used there between rotor and stator was 2 mm. (about $\frac{1}{12}$ in.), and the wear of the bearings in some 60,000 miles of operation was about 0·3 mm. The reason for such a result was that the collector rings were outside the bearings, leaving it only necessary properly to proportion the spiders to have virtually the entire interior of the rotor for bearings and lubricating means.

Mr. J. H. Davis compared the conditions at Cascade Tunnel with those encountered on the Belt Line Railroad of the Baltimore & Ohio, where direct-current electric traction had been used for 14 years—this being the first installation of electric locomotives for heavy traction purposes in the United States.

Mr. L. R. Pomeroy had obtained particulars of a road test of a Mallet locomotive over the section described in the Paper—namely, from Leavenworth to the Cascade Tunnel summit—a distance of 32·4 miles, with an average grade of 1·35 per cent. and a limiting grade of 2·2 per cent.; also from a neighbouring road having similar physical conditions, an actual coal record for a period of six months, of individual classes of locomotives, representing 156 locomotives making 1,382,092 miles, and consuming 174,121 tons of coal, as follows:—

No.	Class.	Engine-miles.	Tons of coal.	lb. per 1,000 ton-miles	lb. per engine-mile.
55	2-8-2 simple	291,070	33,418	191	230
6	2-8-2 compound	81,150	10,275	175	251
24	2-8-0 simple	299,036	33,931	345	227
71	2-8-0 compound	710,836	96,479	306	271
156	.....	1,382,092	174,121	...	...

Some figures of the test referred to were as follows: Distance, 32·4 miles; running time, 4 hours; total time, 7 hours; average speed, 8·1 miles per hour; coal used per trip, 23,000 lb.; coal per square foot of grate per hour, 74·03 lb.; coal per 1,000 ton-miles, 896 lb.; average weight hauled, 810 tons; average number of cars per train (all loaded), 21; average grade, 1·35 per cent.; maximum grade, 2·2 per cent.; indicated tractive force, 60,000 lb.; type of locomotive 2-6-6-2 (L2), Mallet; total weight of locomotive, 225 tons. From the foregoing data the speaker made a few deductions. A train with a trailing load of 2,500 tons over the section of road on which the test was made would require about 5,750 kw.-hour at the rail per trip. Assuming a modern steam generating station, the coal used per trip at 15 miles per hour would be about 5 lb. per kilowatt-hour (at the rail), or a total of 28,750 lb. With the same tonnage per train under steam conditions at 15 miles per hour three steam locomotives would be necessary. Increasing the speed of the steam train from 8·1 miles per hour to 15 miles per hour reduced the tonnage about 30 per cent. per locomotive, giving a total weight, including locomotive, of 725 tons per locomotive. The coal consumption of the three steam trains then became at 717 lb. per mile 68,832 lb., the difference in favour of electricity being 58 per cent. Taking a basis of 50 per cent., the speaker showed that the annual coal saving for the 156 steam locomotives would equal $348,242. As the Mallet type of locomotive claimed to be 30 per cent. better than the above locomotives, this amount might be reduced 30 per cent. to $243,769; adding the saving in water ($25,000) the net saving became $268,769. This amount capitalised at 5 per cent. represented $5,375,380, which sum alone, not figuring on other savings, such as train crews, reduction in train-mileage with the same tonnage, and the advantage of a great increase in capacity, showed that such a mountain section came very near being a situation where one could accomplish by electrification what was now impossible under steam conditions. Approximate figures from three railroads which showed separately in the annual reports the coal per locomotive-mile for freight and passenger service, based on the total coal for the year, gave the consumption per horse-power-hour as 12·30 lb., 12·86 lb. and 14·0 lb. for passenger service, and 9·64 lb., 11·20 lb. and 10·0 lb. respectively for freight service; while from individual road tests it was found that the coal consumption frequently was from 4 lb. to 8 lb. per horse-power-hour. It was not quite fair, therefore, to the electric side to base the comparative costs on a road test without adding a liberal amount to cover this "contingent" feature.

Mr. W. N. Smith thought the objection to two trolley wires was partly obviated by the slow speed of 15 miles per hour. In his opinion this was the salvation of the wheel-trolley contact system adopted. But even slow speed could not mitigate all the disadvantages of two trolley wires of opposite polarity. It was in respect to the trolley problem that the single-phase system was likely to be regarded as superior for some time to come. Future development in the perfection of the moving contact would probably be in the way of the wide roller type with pantagraph mounting, as distinct from the narrow trolley wheel or the sliding shoe; for the sliding shoe, widely used for high-speed work at the present time, seemed susceptible of further improvement, if wear and tear at high speeds and heavy currents were to be overcome. Speeds of 20 to 30 miles per hour might sometimes be thought advisable on a mountain grade of this type, and he suggested that the next locomotives to be built for this electrified section, or a similar one, would be fitted either with pony wheels or with side rods for coupling to motors placed on top of the frames, or possibly with both of these contrivances. The increased flexibility of locomotive design from the mechanical standpoint, which was consequent upon placing the motor on top of the frame and using side rods and jack shafts, and the general mechanical uniformity with the frames and running gear of existing steam locomotives, would make an electric locomotive appear more like a standard piece of machinery to the railroad operating man than had hitherto been the case. The great advantages would be the raising of the centre of gravity, the ready standardising of mechanical parts independently of electrical equipment, and the ability to use the same arrangement of frames and running gear for either direct-current, single-phase or three-phase motors. With such construction safe speeds were not limited to 15 miles per hour. Without it, track maintenance and liability to derailment might continue to be as disadvantageous to the electric locomotive at high speeds as they had been in the past. In spite of the objections that had been urged against the term "continuous capacity," as applied to railway motor specifications, the author apparently took it for granted that it was bound to survive; and it was to be hoped that its evident applicability to the specification of locomotive motors would lead to a more universal recognition of its appropriateness in specifying the smaller sizes of railway motors.

Mr. F. S. Denneen said that the chief reason for selecting the direct-suspension type instead of the more elaborate catenary type, now so popular, was the greater mechanical and electrical simplicity of the former.

Mr. W. I. Slichter mentioned that the principal characteristic which differentiated American from European railway installations was size. American trains were about three times as heavy as the European trains, and the heavy traffic over single-track roads required that every operation must be performed with the utmost reliability. In the locomotives under consideration, as the tractive effort had to be applied gradually, steadily and continuously, any scheme of double-speed connection, such as concatenation or changeable poles, was undesirable, as in these it was necessary to cut out at least a portion of the motors while the change was being made.

Mr. E. F. W. Alexanderson remarked that railway motors of the ordinary type were in most cases limited in capacity by the temperature rise in service; this was substantiated by the fact that there was allowed a higher temperature than that found economical with stationary machinery. The continuous capacity of such motors of the closed type was usually about one-third of the capacity for one hour, whereas the continuous capacity of the Great Northern motors with forced ventilation was 79 or 74 per cent. of the hourly capacity at 500 volts and 625 volts respectively. In attempting to meet the Great Northern requirements it was immediately apparent that a motor of any reasonable size would run too hot unless forced ventilation were used. It was naturally attempted to make the artificial cooling as efficient as possible by taking advantage of the structure of an alternating-current motor with distributed windings, thus bringing the air into intimate relation with the active parts. In order not to waste space in the length direction of the motor—which had already been encroached upon by the double gearing—the air was led through holes or channels running longitudinally through the core. This system of ventilation proved successful, and tests showed that the continuous capacity with forced ventilation was practically the same as the hourly rating on a standard basis without ventilation. The weight efficiency of the three-phate railway motor was often referred to. It might, therefore, be of interest to compare the Great Northern motor with two other well-known locomotive motors—the Detroit River tunnel locomotive (a freight locomotive of the same weight and mechanical design provided with four motors of the double-geared type), and the Simplon,

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a well-known three-phase locomotive. In the accompanying table was shown the comparative figures for a stationary three-phase motor of the same dimensions. All three induction motors had practically the same armature peripheral speed, and the weight per horse-power was favourable. The Simplon motor was favoured by a small air-gap, but handicapped by being wound for high voltage. The comparison of the four-motor types showed a relative consistency and also indicated the great possibilities of the inductive motor for high-continuous output.

—	Detroit River tunnel, 600 v., d.c.	Great Northern, 625 v., 3 phase.	Simplon, 3,000 v., 3 phase.	Stationary motor, 550 v., 3 phase.
Weight	8,330·0	12,200·0	22,000·0	11,500
Air gap	...	0·125	0·059	0·050
Peripheral speed, ft. per min.	2,450·0	3,440·0	3,250·0	3,550·0
H.P. hourly—75° rise	300·0	550·0	1,100·0	...
Weight per H.P.	29·5	22·0	20·0	...
H.P. continuous—75° rise...	...	400·0	...	...
Weight per H.P. (continuous)	...	30·5	...	...
H.P. continuous—40° rise	...	260·0	...	330·0
Weight per H.P. (40° rating)	...	47·0	...	35·0

Mr. C. L. DE MURALT thought that what the author brought out principally was that the efficiency of the three-phase system was extremely high. There was no other system that would show the same efficiency under the same conditions. Some engineers claimed it was not good practice to use two trolleys. It was not an operating feature at all; it was a matter of suitable design and proper location of overhead line. Once these were taken care of, the road would operate with two overhead wires just as well as with one. There was hardly any difference in maintenance either, because the maintenance cost was made up of labour rather than of material.

Mr. C. TOWNLEY said that, with reference to uniform torque, their observations on single-phase locomotive performances did not support the view that the so-called pulsating torque of that motor was practically in evidence. The comment of a prominent steam railroad engineer on the question of constant speed was that the conditions which affected the operation of trains on schedules and which caused delays were many of them entirely foreign to any question of traction. Various and diverse influences caused delays, requiring trains to make up time if they were to be maintained on schedule. Therefore, an inflexible and a uniform speed was undoubtedly somewhat of a disadvantage, even though the running time and operating conditions indicated that ordinarily it was desirable to maintain a uniform speed when the trains were running.

Mr. C. P. STEINMETZ mentioned that, in addition to its use on a mountain division, another application of the induction motor would be for very high speed passenger service. At speeds of 50 or 60 miles an hour or above, the air friction produced a considerable part of the train resistance; there was a decrease of the difference between the power required to run on a level track at a constant speed and the power of acceleration, and, therefore, an approach to the same conditions as running on a mountain division. For general railway work, however, as at present carried out in America, the three-phase locomotive was not as well suited as the direct-current locomotive or the single-phase locomotive, for the reason that the direct-current series motor or the alternating-current commutator motor could directly replace the steam locomotive in present railway operation, while the three-phase induction motor locomotive was not at its highest efficiency, when operating on a railway system under existing conditions. The method of operation must be rearranged to a constant-speed service. Whether the constant-speed operation of the railway would be disadvantageous, or advantageous, over the present variable-speed method, required further consideration.

Mr. F. J. SPRAGUE (communicated) remarked that the Cascade Tunnel installation was one of three in America of almost identical requirements, but each was characterised by a different electrical system. Two, the Sarnia single phase and the Cascade three phase, were in operation, while the Detroit Tunnel direct-current locomotives had been fully tested. In each case the steam locomotive could only be used under the maximum disadvantages. None of these installations represented normal trunk line requirements. He had for nearly three years made a study of such a trunk line, presenting, perhaps, the most difficult operating problem he had encountered. He referred to a stretch of nearly 140 miles on the Sacramento Division of the Central Pacific Railroad, over the Sierra Nevada Mountains. The section was normally single tracked, with sidings every few miles, raising the aggregate trackage to something over 200 miles. The physical conditions were such as to present extreme difficulties to double tracking, although second tracking was being added for a part of the distance. There were nearly 32 miles of snowsheds and tunnels, and in winter the snowsheds formed practically continuous tunnels. The grades were severe, there being a rise of about 7,000 ft. in 83 miles in one direction, with a ruling grade of 2·4 per cent., and the amount of curvature was startling. Over this division practically the entire freight and passenger traffic from the Union Pacific Railroad for Central California passed. Freight trains, often over ½ mile in length, and with 2,000 to 2,500 tons trailing load, were operated in both directions. These trains required as many as four consolidated locomotives, or two of the heaviest Mallet compounds. The running speed was sometimes as low as 7 miles an hour, and the schedule speed for the division was seriously interfered with by opposing traffic. Coupled with this freight operation was passenger operation in both directions, in trains up to nearly 400 tons trailing load, way trains, "limited" Pullmans, and fast mail trains, operating at double the freight speeds, and with coasting speeds as high as 50 miles an hour. This division was approaching the limit of steam capacity, especially when considered in relation to the balance of the system, and the question was whether such a division could be operated electrically, and, if so, what could be gained thereby. Would the object be economy in fuel? Such alone would not warrant electrification, although the general line of investigation of railroads operated by electricity showed about 50 per cent. in coal economy. If carried out, electrification would be primarily for the purpose of increasing capacity, and thereby effecting ultimate economy. The investigation of the possibilities of electrification on this road had been conducted on a plan somewhat different from that ordinarily taken. It was not deemed wise first to decide upon a system, but rather to ascertain the costs of locomotives by various systems which could perform a service determined as essential to effective operation, and then to collate all the facts, advantageous and otherwise, affecting capital cost and cost of operation, after which the best system to meet the existing conditions could be determined. If asked what system would probably be indicated, he must frankly say that he did not know. That electrification was possible he did know, and that such could be successfully carried out he did not doubt, with increased capacity and general economic results.

Mr. MAX TOLTZ took exception to the author's figures for the rail resistance, given as 6 lb. per ton. Dynamometer tests gave 6·5 lb. to 14·25 lb. per ton. In the tunnel, with its soot and wet rails, the resistance used to be over 10 lb. per ton. The rail resistance of the Mallet locomotive was stated to be 47 lb. per ton, computed from ammeter readings. This figure was much too high, and was probably due to the air pump action of the pistons in the cylinder.

Mr. C. T. HUTCHINSON, in reply, merely answered the questions that had been asked. The earth wire was omitted, as there was no lightning on that side of the mountain. In regard to the high frictional resistance of the Mallet locomotives, the tests were carefully made by competent observers, and he was sure were accurate expressions of the conditions that existed. He did not pretend that the internal losses of the Mallet, when operating under its own steam, were represented by those figures; there was no direct comparison between the two conditions.

SHORT-CIRCUIT LOSSES IN ALTERNATING-CURRENT COMMUTATOR MOTORS.

BY A. FRAENCKEL, DR.ING., AND B. J. M. LANE, B.SC.

Summary.—Results of experimental researches on the losses due to the short-circuit currents in alternating-current commutator motors are given. These show a rapid decrease of the loss with increasing speed, other conditions being equal. An explanation of this phenomenon is given, and oscillograms are shown from which the decrease of the short-circuit current with increasing speed, and for a given short-circuit E.M.F., is deduced. The influence of the short-circuit currents on the line pressure and current is illustrated.

Since alternating-current commutator motors have been in use much trouble has been experienced owing to the currents which are induced by the pulsations of the main field linked with the armature coils undergoing commutation. These currents not only cause sparking at the brushes and give rise to considerable losses, but they also cause a phase displacement between flux and current, and consequently diminish the torque of the machine for a given current value.

A large number of devices have been designed in order to diminish these currents, the chief tendency being towards the use of commutating fields. By these means the short-circuit currents may be reduced to a limited extent, and heavy sparking avoided; but since a commutating field of proper magnitude and phase cannot be obtained for all speeds and working conditions, there still remain at nearly all load conditions short-circuit currents causing additional losses.

An experimental research on these losses was published by Prof. Bragstad and Mr. S. P. Smith in THE ELECTRICIAN, 1906 (Vol. LVII., p. 996). In this Paper it is shown how the losses depend upon the E.M.F. induced in the short-circuited coils by the pulsations of the main field and the drop of pressure between brush and commutator, the experiments having been carried out for one definite armature speed. The losses were determined by taking the difference between the power delivered from the mains to the exciting coil, firstly when no brushes were on the commutator, and secondly when the brushes were on and placed in the neutral zone. In both cases the armature E.M.F. in the axis of the stator exciting winding and due to flux pulsations had the same value.

In carrying out similar experiments to those mentioned, the

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authors of the present Paper found that the losses not only depend upon the E.M.F. induced in the short-circuited coils, and upon the brush contact resistance, but that for a certain brush resistance and induced E.M.F. they vary to a great extent with the speed of the machine. The present investigation is intended to explain this phenomenon, and includes a series of experimental results and oscillograms that have been obtained.

Firstly we will consider theoretically the phenomena that occur.

Theoretical Considerations.- For the sake of simplicity, let us initially deal with the case in which *the brush width is equal to that of one commutator segment*, so that for a parallel winding only one coil can be short-circuited, or for a series winding p coils, p representing the number of pairs of poles.

The differential equation for the short-circuit is

$$e = ri + L\frac{di}{dt},$$

where e = E.M.F. induced by the main field,
i = current in the coil,
r = total resistance of circuit,
L = self-induction coefficient of the coil for the stray flux.

While the self-induction coefficient does not vary much, and may practically be regarded as constant, the resistance r varies greatly with the relative position of brush and segments. In fact, r consists of three parts, the resistance of the coil R_s, the resistance of the two connectors between the coil and the

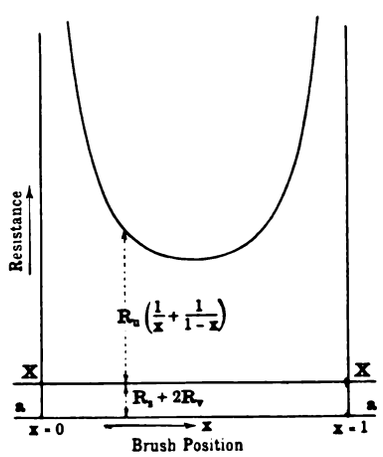

Fig 1.

commutator and the contact resistance at the brush surface. The latter consists of two parts, corresponding to the two segments 1 and 2.

Let R_K = specific brush-contact resistance,
F_u = contact surface between brush and commutator,
$R_u = \frac{R_K}{F_u}$ = contact resistance for total brush surface,
$F_{u1} = x \times F_u$ = the fraction of the brush surface covering segment 1,
$F_{u2} = F_u - F_{u1} = F_u(1-x)$ = fraction of brush surface covering segment 2,

The total resistance is thus

$$r = R_s + 2R_r + R_u\left(\frac{1}{x}+\frac{1}{1-x}\right),$$

where x varies from 0 to 1 for the different positions of the brush on the segments. *Supposing now that the armature is at rest* so that x is constant, and that the induced E.M.F. varies according to a sine law; then, if R_u and L be regarded as constant, the short-circuit current will also be a sinusodial function of time and vary with the same frequency as the induced E.M.F. Actually the E.M.F. $L\frac{di}{dt}$ for the line frequency is so small compared with the ohmic drop of voltage that its influence on the phase and magnitude of the current may be neglected and the latter may be regarded as being in phase with the induced E.M.F.

Thus, if E is the effective value of the induced E.M.F., the loss due to the current in the short-circuited coil is

$$\frac{E^2}{R_s + 2R_r + R_u\left(\frac{1}{x}+\frac{1}{1-x}\right)}.$$

For the different positions of the brush the resistance $R_u\left(\frac{1}{x}+\frac{1}{1-x}\right)$ varies as shown in Fig. 1, being infinite for $x=0$ or 1 and a minimum for $x=\frac{1}{2}$, the minimum value being $4R_u$. If we plot a second abscissa, $a-a$, whose distance from the first is equal to R_s+2R_r, then the ordinates between $a-a$ and the curve give values for the total resistance. Thus, for the different positions of the brush the losses will be shown by a curve having the same form as that shown in Fig. 2.

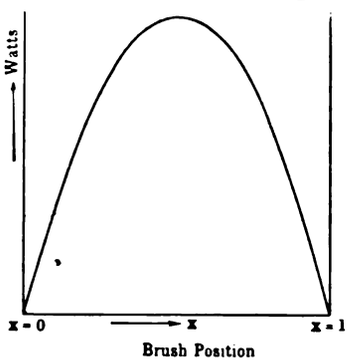

Fig. 2.

If the value R_s+2R_c is small, then the loss may be written in the form $\frac{E^2}{R_u}x(1-x)$, and in this case the curve in Fig. 2 will be a parabola. Thus it is seen that for different positions of the brush at standstill the losses vary considerably, the mean value being about two-thirds of the maximum.

It may be noted that the supposition that the brush contact resistance remains constant is not correct, as we shall see later on. However, for an analytical treatment no other supposition is practicable.

If now the armature rotates, the short-circuit of every individual coil lasts for only a short time, T, which is determined by the width b of the brush and the circumferential velocity of the commutator v_K. $T = \frac{b}{v_K}$. During this short time the E.M.F. induced in the short-circuited coil by the field pulsations varies from $e_1 = E_{max.} \sin wt$ to $e_2 = E_{max.} \sin w(t+T)$, as shown in Fig. 3; and, since T is a small fraction of the time of

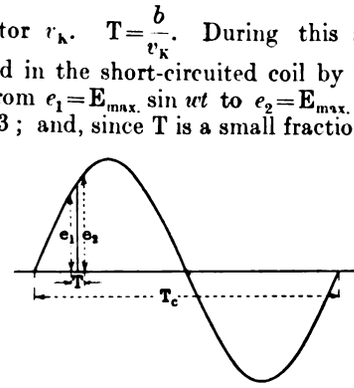

Fig. 3.

the period T_c, we may regard the induced voltage as being constant over the short-circuit period and equivalent to the mean value of e_1 and e_2. The short-circuit current will in this time increase from zero to its maximum value, and fall to zero again, having thus a far higher frequency than when the armature stands still. Consequently the effect of self-induction in this case cannot be neglected. If we had only ohmic resistance the current would follow the same law as in the case of the armature being at rest and the brush gradually brought into different positions with respect to the segments, so that the losses would follow the same parabolic law, the maximum loss taking place at the middle position of the brush with respect to two segments. The maxima of the different currents would follow a sine wave according to the sine wave of the induced E.M.F., and the mean loss would remain constant. The effect of

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self-induction is that the currents will increase more slowly, and will not be able to reach their maximum values when the brush contact resistance is a minimum—*i.e.*, after half the time of short-circuit has elapsed. When the currents have reached their maxima, then the contact resistance is already higher. Consequently the maximum currents and the losses will decrease. In order to show this effect we must integrate the differential equation.

Let t represent the time from the beginning of the short-circuit. Then $t = Tx$, where x has the same meaning as before, and

$$r = R_s + 2R_c + R_u\left(\frac{1}{x} + \frac{1}{1-x}\right).$$

The E.M.F. of self induction $= L\frac{di}{dt} = L\frac{di}{T dx}$,

and so $$e = i(R_s + 2R_c) + R_u\left(\frac{1}{x} + \frac{1}{1-x}\right)i + L\frac{di}{T dx},$$

or $$\frac{di}{dx} + \frac{i(R_s + 2R_c)T}{L} + \frac{iR_uT}{L}\left(\frac{1}{x} + \frac{1}{1-x}\right) = \frac{eT}{L},$$

where e, as shown, may be regarded as constant and equal to

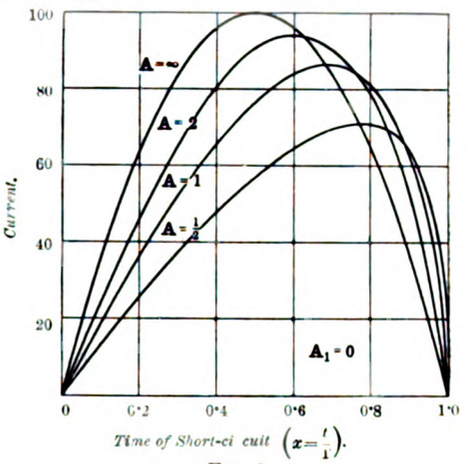

FIG. 4.

the mean of the two momentaneous values at the beginning and at the end of the short-circuit.

Let $$\left(\frac{R_s + 2R_c}{L}\right)T = A_1$$

and $$\frac{R_uT}{L} = A.$$

then $$\frac{di}{dx} + i\left\{A_1 + A\left(\frac{1}{x} + \frac{1}{1-x}\right)\right\} = \frac{eT}{L}.$$

The solution of this equation is*

$$i = \epsilon^{-A_1 x}\left(\frac{x}{1-x}\right)^{-A}\int_{x=o}^{x=x}\frac{eT}{L}\epsilon^{A_1 x}\left(\frac{x}{1-x}\right)^{A} dx.$$

where ϵ is the base of the natural logarithm. The value of i may be determined by a point to point method if values for A and A_1 are assumed, and we take the different values of x from zero to unity. A and A_1 are proportional to the time of short-circuit, or inversely proportional to the speed. A number of curves have been calculated, firstly when $R_s + 2R_c$ was neglected—*i.e.*, $A_1 = 0$, and secondly when $R_s + 2R_c = \frac{1}{2}R_u$, or $A_1 = A/2$. The curves in Fig. 4 correspond to a constant value for e, and are calculated for values $A = \infty$ (standstill), $A = 2$, $A = 1$ and $A = \frac{1}{2}$. They represent conditions for the first case, while corresponding curves are shown in Fig. 5 for the second case. From these curves the loss at any moment may be calculated, since this is equal to ri^2, r being the instantaneous value of the total resistance. If the mean loss W over the short-circuit period is plotted as a function of $\frac{1}{A} = \frac{L}{R_uT} = \frac{L}{R_u}\frac{v_k}{b}$, it will be seen how the loss decreases with the speed. This is shown in Fig. 6. For an infinite speed the loss would be nil.

* "Electrical Review," 1900, p. 211. Arnold Die Gleichstrommaschine, Bd. I., p. 419.

It is, however, to be expected that the actual losses will decrease more rapidly than those determined from the calculation, since the brush-contact resistance is not constant, but increases with decreasing current-density. As seen from the calculation, the maximum current and the corresponding density decrease with increasing speed. If now the higher resistance corresponding to the smaller density is taken into account, the maximum current will be less than that calculated, and the total loss diminished.

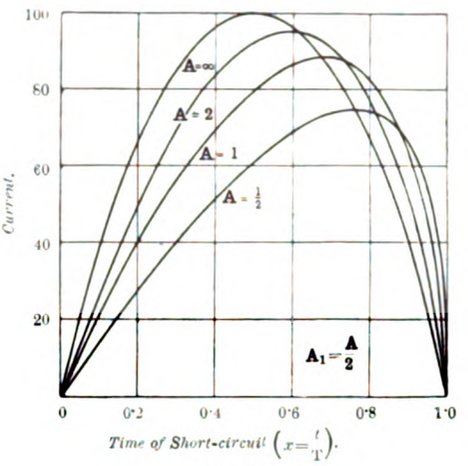

FIG. 5.

Considering now the cases where *the brush width is greater than that of one segment* and more than one coil are simultaneously short-circuited, the mutual induction must be taken into account. To treat these cases analytically would lead us to extremely complicated equations. However, we may consider them simply in a general way as follows: The internal currents in consecutive coils are displaced by an interval, T_1, corresponding to that which one segment requires to pass a given point, T_1 being determined by the width β of the segment and the circumferential velocity v_K of the commutator. $T_1 = \frac{\beta}{v_K}$. If we assume $\beta = b/2$, T_1 will be just half the short-circuit time of one coil, and while the internal current in one coil increases, the current in a neighbouring coil decreases, and vice versa. Thus the resultant E.M.F. induced by self and mutual induction does not vary with the period of the current in the coil, but pulsates with a higher frequency depending on the time T_1, the resultant being less than the E.M.F. due to self-induction alone. The result is qualitatively the same as in the case considered previously, with the exception that the apparent self-induction is smaller.

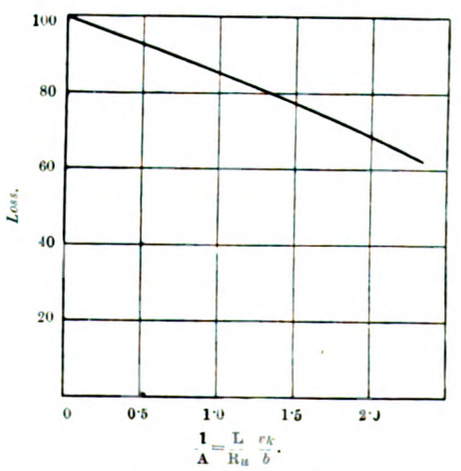

FIG. 6.—CALCULATED LOSS-CURVE FOR A CONSTANT BRUSH CONTACT RESISTANCE.

(*To be concluded.*)

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SOME PHYSICAL PROPERTIES OF CRYSTALLINE SILICON.*

BY C. I. ZIMMERMAN.

It has been estimated by Clarke† that the element silicon constitutes 28 per cent. of the earth's crust. It exists in the form of its oxide, SiO_2, and this oxide constitutes 60 per cent. of the earth's crust. The importance of knowing the various properties of silicon, which can now be obtained in a relatively pure state in any quantity desired, cannot, therefore, be under-estimated. Not only might such information be of great value in finding valuable applications for the element, but it would probably lead to the correlation of many properties which the various elements and many compounds have in common.

The author then gives a brief summary of the various physical properties of this element, including its atomic weight, specific gravity, molecular state, tenacity, tensile strength, melting point, vapour tension, specific heat, optical properties, and goes on to discuss its magnetic and electrical properties as follows:—

St. Meyer‡ published some data on the magnetic behaviour of silicon. For all practical purposes it is non-magnetic. Silicon-iron alloys will decrease in magnetic susceptibility until the silicon content increases to 30 per cent. Above 30 per cent. of silicon, the silicon-iron alloys are practically non-magnetic. The electrical properties nad constants of silicon are exceptionally interesting because they are quite different from metallic conductors.

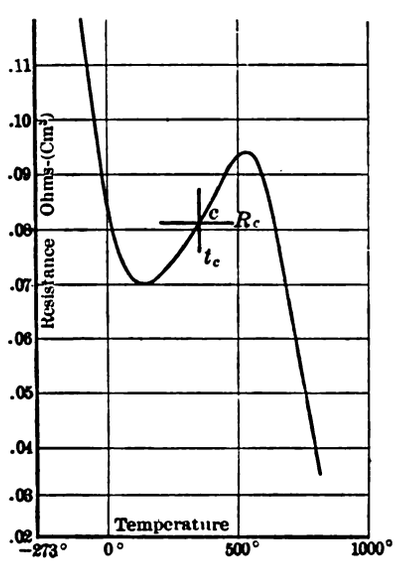

FIG. 1.—RESISTANCE-TEMPERATURE CURVE SILICON ROD NO. 1.

$Res = R_c + m[K^2(t-t_c)-(t-t_c)^3]$ or
$Res = R_c[1+nK^2(t-t_c)-n(t-t_c)^3]$.

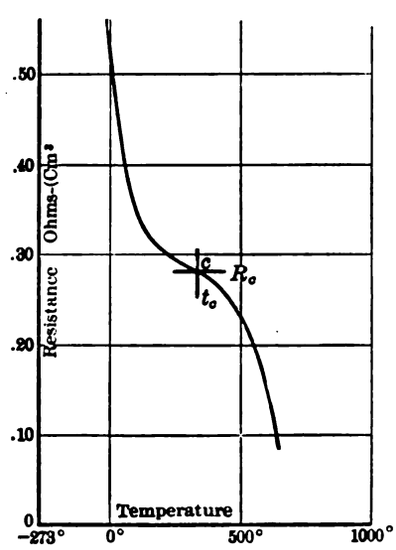

FIG. 2.—RESISTANCE-TEMPERATURE CURVE. SILICON ROD NO. 2.

$Res = R_c + m[K^2(t-t_c)-(t-t_c)^3]$ or
$Res = R_c[1+nK^2(t-t_c)-n(t-t_c)^3]$.

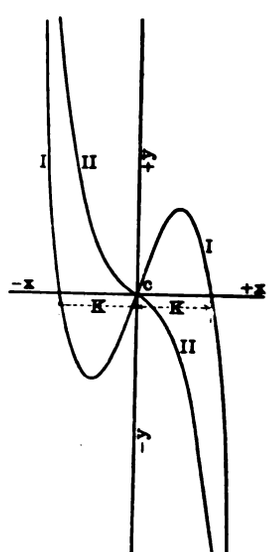

FIG. 3.—CUBIC CURVES.

$Y = m(K^2 \times - \times^3)$

Curve 1 $\begin{cases} m = 0.2 \\ K^2 = 30 \end{cases}$ Curve 2 $\begin{cases} m = 0.02 \\ K^2 = -3 \end{cases}$

For instance, as regards thermo-electric properties Heath§ found that the junction of silicon and metals exhibits high thermo-E.M.F.s when heated. The magnitude and the direction of the E.M.F. generated will vary greatly in different specimens. Sometimes the current will flow in one direction across the hot junction and sometimes in the opposite direction. A single specimen may have positive and negative spots. This peculiar ability of a given substance to exhibit high thermo-electric forces in different directions at the contact with a metal or other conductor is not new, nor is it characteristic of silicon alone. It is quite a common phonomenon among mineral substances, and was investigated to some extent 25 years ago. Miss Francis G. Wick¶ and Dr. L. W. Austin have published some results on the thermo-E.M.F.s of silicon-metal contacts. They have stated that the usual direction of current flow is from silicon to copper through the hot junction. My own observations are just the reverse. The usual direction is from the copper to the silicon across the hot junction in a copper-silicon couple. I have tested this out on 40 or 50 different specimens of silicon which covered a wide range of physically and chemically different samples. I have also tried a number of alloys of silicon against a metal and have found that in nearly all of the cases the silicon was the positive side of the hot junction. The few specimens which did not follow my above described usual thermo-electric direction at ordinary temperatures, reversed their effect when the temperature of the silicon itself was raised considerably above the temperature at which the first observation was made. There was no reversal of direction in what I have called my normal specimens even when they were raised to a very much higher temperature than that which reversed the abnormal specimens. Further work on this line is in progress.

The characteristic unilateral or asymmetric conductivity which is observed at the contact surface between almost any two heterogeneous conductors is quite marked at the contact surfaces between silicon and metals. The current will pass across a silicon-metal junction much more readily in one direction than in the other. If the area of contact between silicon and a metal be varied the degree of unilateral conductivity for a given current flow will also vary. Hence if an electric circuit contains a piece of silicon held between two metal contact pieces, and if the areas of contact on each side of the silicon are different, that circuit will be a unilateral conductor. If an alternating current be then passed through this circuit which possesses asymmetric or unilateral conductivity, there will be a tendency to stop one half-wave and to pass the other half-wave. G.W.Pickard* was probably the first person to note that this effect could be utilised for wireless telegraph waves when silicon was one of the rectifying elements.

Extensive use of the silicon rectifier has been made in wireless telegraphy.† By a proper disposition of silicon rectifiers and of electrical condensers the energy of the short oscillatory trains of waves caught by an aerial can be stored in the condensers and subsequently discharged through a telephone receiver or through a galvanometer. Without rectification and without any means for storing the energy caught by the aerial the telephone receiver will not detect the waves. The condenser may be the aerial itself, or the telephone receiver coil. I have constructed some exceedingly sensitive wireless receiving circuits based upon the use of two or more of such crystal rectifiers with electrical condensers. Ordinarily only one such rectifier is used in commercial receiving circuits, and in such cases only a part of the energy of the oscillatory waves can be detected. The direction of the first half-wave of a strongly damped oscillatory train makes a great difference in the sensitiveness of a receiver containing only one silicon detector or rectifier. In this case much of the energy and also the highest E.M.F. of the damped waves comes in the first pulse. There is no thermo-electric action in the silicon detector. It is an interesting phenomenon, still to be explained, that the thermo-electric and rectifying actions of silicon-metal contacts and other

* Abstract of a Paper read before the American Electrochemical Society.

† F. W. Clarke, "The Data of Geochemistry," U.S.G.S. "Bull.," 330, 31 (1908).

‡ St. Meyer, "Weid. Ann.," 69, 236 (1899).

§ Austin, "Bull." Nat. Bur. Standards, August, 1908.
Schrauf and E. S. Dana, "Am. Jour. Science," 8, 255 (1874); Rose, "Pogg. Ann," 142, 1 (1871); Friedal, "Ann. Chem. Phys.," 17, 79 (1869); Friedal, C.R., 78, 508 (1874).

¶ F. G. Wick, "Phys. Rev.," 25, 382.

* G. W. Pickard, U.S. Patents 836,531, 877,451, 888,191.

† G. W. Pickard, "Elec. Rev. and West. Elec.," February 20, 1909.

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similar "crystal rectifiers" are usually such that the current flows through the rectifying contact in opposite directions in the two different cases. No doubt there is a simple explanation for this relation. Just as there are numerous substances which, when placed in contact will produce high thermo-electric forces when the junction between the two of them is heated, so there is a long list of substances which show a marked rectifying action like that which silicon exhibits. Carbon and tellurium show these thermo-electric and rectifying effects to a marked degree when in contact with other conducting substances. The list of conducting mineral substances which show this same effect is too long to be given here. Almost all of them show this to a more or less marked extent.*

When a current of electricity flows across a conducting silicon plate, which lies perpendicular to the direction of a strong magnetic field, the current in the plate will take a different course than when the strong magnetic field is not present. The path of the current tends to be rotated more and more as the magnetic field increases. In silicon this effect is quite marked.† It varies greatly with different samples of silicon and is roughly related in magnitude to the thermo-electric forces. Dr. Smith‡ has investigated the Hall effect quite extensively in silicon and other substances. In silicon he finds the Hall effect is a reversible affair, like the thermo-electric and rectifying properties and that they are closely related.

The electrical resistance of silicon also shows some exceptionally varied and interesting results. Two years ago Dr. C. P. Steinmetz§ in a lecture on "Conduction," gave some results on the relations between temperature and electrical resistance. He classified electrical conductors in a general way and stated that the resistance of certain specimens of cast silicon seemed to give an intermediate link between pyro-electrolytic and metallic conduction. Miss F. G. Wick‖ investigated the electrical resistance of some rods of silicon, similar to those which Dr. Steinmetz discussed. The results showed that cast silicon varied widely in its resistance characteristics in inffierent specimens. Some specimens showed a negative temperature coefficient through the range of temperatures which they studied, whereas other specimens showed a temperature coefficient which was at first positive and afterwards negative, and still others showed a change from negative to positive and then back to negative characteristics. Cast silicon rods were used in their measurements In Figs. 2 and 3 are shown curves plotted from experimental data which I have obtained from two specimens of silicon rods which were cut from homogeneous masses of slowly cooled, relatively pure and coarsely crystallised material. The temperature range covered was 190°C. to 800°C. The composition of these rods I give below:—

Rod No. 1. Impurities present.		Rod No. 2. Impurities present.	
Fe	0·32%	Fe	—
Al	0·14%	Al	—
C	trace	C	—
Ca, Mg, Mn	trace	Ca, Mg, Mn	—

In Figs. 2 and 3 there exists a cubic relation between the co-ordinates of the curves. In order to show this cubic relation more plainly I have drawn two curves in Fig. 3 from the equation of a cubic curve having the formula

$$y = m(K^2x - x^3)$$

In curve 1, $m = 0{\cdot}02$ and $K^2 = 30$. In curve 2, $m = 0{\cdot}02$ and $K^2 = -30$.

In curve 1 of Fig. 3 the factor K is equal to the horizontal distance between the centre of the cubic curve and the points at which the curve cuts the axis. The cause of the marked difference in the specific resistance of the two rods is not yet definitely known. It may be due to the difference in the chemical composition alone, but it is probably due to a difference in the physical condition of the molecular aggregates in the two samples.

BOOKS RECEIVED.

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"Mathematical and Physical Papers." Vol. IV., "Hydro-dynamics and General Dynamics." By the Right Hon. Sir Wm. Thomson, Baron Kelvin. (Cambridge: University Press.) 18s.

* For interesting and valuable data, *see* Pierce, "Phys. Rev.," March, 1909; also Pickard's article, "El. Rev.," February 20, 1909.

† F. G. Wick, "Phys. Rev.," August, 1908.

‡ Dr. Smith, *loc. cit.*, results as yet unpublished. Phys. Labs., University of Wisconsin.

§ Dr. Steinmetz, "Conduction," "Trans." A.E.S., 11, 105-113 (1907).

‖ F. G. Wick, "Phys. Rev.," July, 1908, 27, 11, "The Electrical Resistance of Silicon at Various Temperatures."

COMMUTATION PHENOMENA AND MAGNETIC OSCILLATIONS OCCURRING IN DIRECT-CURRENT MACHINES.*

BY G. W. WORRALL, M.SC.

(*Concluded from page 185.*)

Summary.—In the first part of this Paper the author, after discussing the theory of commutation, describes a research on the influence of contact resistance, speed, commutating E.M.F. and width of commutating pole on commutation, the phenomena being studied by means of the magnetic oscillations recorded by search coils on the pole shoes. The cause of the difference in behaviour of the positive and negative brushes is also investigated. The latter portion of the Paper is devoted to an examination of the magnetic oscillations occurring in various parts of the machine.

Influence of Speed on Commutation.—It has already been pointed out that the natural period of commutation is but slightly influenced by the speed. The reason for this may be seen from the following considerations: At a given time after the commencement of short-circuit the contact resistance to the forward segment is increased, while that to the rear segment is reduced by an increase in speed. Such a change in the resistance will diminish the natural period of the coil, but not in proportion to the speed, while the available period is diminished in proportion to the speed, and the ratio of the available to the natural therefore diminishes as the speed increases. At a certain critical speed therefore the ratio is unity, and this is the critical sparking speed. Fig. 11 shows a series of records of the oscillations occurring in coil 5 P on the pole-shoe obtained by varying the speed of the machine. The negative peak moves to the left as the speed is diminished, and hence occurs earlier. At a speed of 640 revs. per min. the peak occurs just before the contact mark, which latter was adjusted to the commencement of the short-circuit;

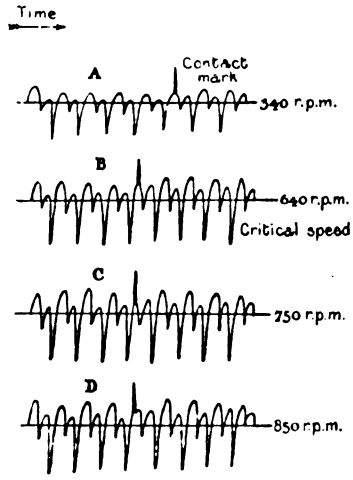

FIG. 11.

hence at this speed commutation was completed by a current rush, and when the speed exceeded this value the natural period exceeded the available and sparking took place. In order to make quite sure that the improvement of the commutation at the lower speeds was due to a change in the available period of the coil, the machine was run with the poles not excited, and the armature current supplied from an external source. The records obtained exhibited the same characteristics as those in Fig. 11. This critical no-sparking speed of 640 revs. per min. was quite definite even to a few revolutions, and could readily be determined by gradually increasing the speed until sparks appeared. Although the available period increased as the speed was diminished, the magnitude of the commutation peaks was but slightly reduced, and in relation to the contact maker moved to the left, or if the position of the peak be considered as fixed, the contact maker moved to the right in the direction of time—*i.e.*, the extension of the available period occurred at the end of commutation, or in other words, the natural period remained nearly constant, and maintained the same relation to the commencement of commutation.

Influence of Commutating E.M.F. on Commutation.—The E.M.F. may be induced in the short-circuited coil by its movement either in a portion of the main magnetic field or in the field due to commutating poles. If the induced E.M.F. be constant or follow a known law the way in which the current varies may be expressed by the differential equation—$L\frac{di}{dt} = r_2 i_2 - r_1 i_1 + e_c$, where e_c = commutating E.M.F.

* Abstract of a Paper read before the Birmingham local section of the Institution of Electrical Engineers.

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The E.M.F. should be sufficiently large during the early part of the short-circuit period to accelerate the commutation at the commencement. The effect of the acceleration in reducing the natural period and the maximum rate of change may be readily seen from Figs. 12 and 13. The various records in Fig. 12 were obtained by shifting the brushes forward by steps of one or more segments. The magnitude of the negative oscillation gradually diminishes and the peak moves to the left—that is, occurs earlier—as the brush lead is increased. At the same time the positive oscillation is considerably increased. When the lead is such that there is a relatively large E.M.F. induced in the short-circuited coil at the commencement of short-circuit a rush of current takes place at the first contact with the approaching segment, and the contact may be so heated that the continuity of contact

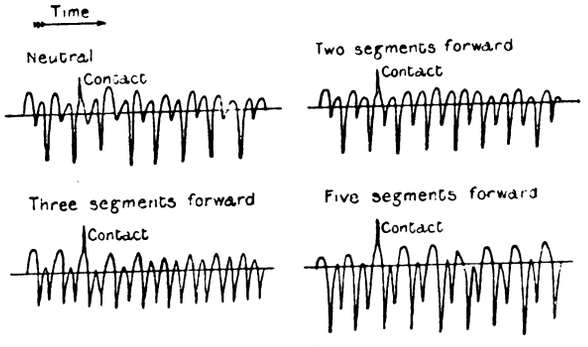

FIG. 12.

is broken and a spark occurs at the rear tip. If the E.M.F. be so large at the end of the commutation period as not merely to reduce the current flowing through the forward segment to zero, but to reverse its direction, a spark occurs at the forward tip. The common conception of an induced short-circuit current in the coil can only hold in the latter case above described; unless the current in one of the segments be actually reversed no current can flow across the brush surface, for the effect of the commutating E.M.F. when of normal magnitude is simply to increase the current in the rear segment and diminish it in the forward segment.

In the records given in Fig. 13 the commutating E.M.F. was induced by means of commutating poles. The width of each pole was 2¾ times the armature tooth-pitch. The commutating poles were separately excited and the field was varied from a minimum for no sparking to a maximum for no sparking. Such variation of the field

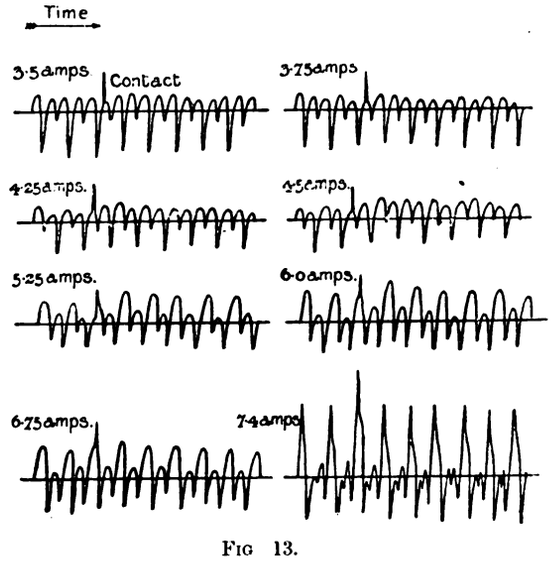

FIG 13.

produced effects similar to those obtained by shifting the brushes above described. The short-circuit current at the end of commutation is clearly shown by the large peak above the zero line. The presence of the commutating poles increases the self-induction of the coil, and therefore the natural period is increased; hence, if the natural period be correct without commutating poles it may be too long when commutating poles are fitted. In such a case a commutating E.M.F. is required to compensate the increased natural period.

The presence of the commutating pole, however, not only increases the self-induction of the short-circuited coil, but also increases the armature reaction flux in the commutating zone. This latter must be opposed by an equal flux from the commutating pole before any flux is available to generate the required commutating E.M.F. The two fluxes oppose but do not cancel one another in the commutating pole air-gap. The effect of such opposition is to spread out the fluxes in much the same way as the flux of two permanent magnets with similar poles presented to each other.

The surface of the commutating poles remains constant, but that of the armature varies as the teeth move past the pole face. Such variation gives rise to a corresponding change in the magnitude of the armature flux opposed by the commutating pole flux; thus when the commutating pole flux is equal to the minimum value of the armature flux, the periodic increase of the latter enters the commutating pole-face and induces an E.M.F. in a coil wound round the commutating pole shoe. As the pole flux is increased this magnetic oscillation is diminished, and the excess of the commutating pole flux over the armature reaction flux enters the armature and generates a commutating E.M.F. This latter flux is also subject to an oscillation owing to the movement of the teeth, which induces an E.M.F. in the search coil above referred to. The armature reaction oscillation, however, although diminished in magnitude continues to exist, for whatever be the magnitude of the commutating pole flux the two opposing fluxes remain independent of each other. The two oscillations, being produced by opposing fluxes, are approximately 180 deg. out of phase with each other.

Thus the resultant oscillation exhibited by coil 9 P on the commutating pole shoe forms a convenient method of studying the nature of the field in the commutating pole air-gap. In Fig. 14 are given the oscillations recorded corresponding to various commutating pole currents between the two extreme sparking limits. On record A the main oscillation is due to the armature reaction flux, the slight indent in the oscillation indicates that the commutating pole flux is greater

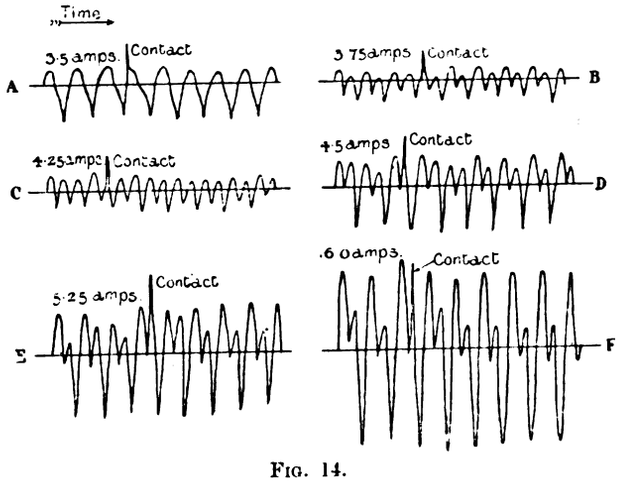

FIG. 14.

than the armature flux. The indent grows and in record B is about one-half the magnitude of the main oscillation, while in record C the original indent is larger than the original main oscillation. This may be seen by the position of the contact maker relative to the two oscillations. As the commutating pole current is increased, the oscillation of the commutating pole flux rapidly grows until in record F the original indent becomes the main oscillation, and the original oscillation almost an indent.

These records were taken at the same time as those given in Fig. 13, and hence each record given in Fig. 14 shows the condition of the field in the commutating pole air-gap, while the corresponding record in Fig. 13 shows the nature of the commutation obtained. A comparison of the two sets of records shows that for no sparking a slight commutation E.M.F. was required, but that there was a large range before the maximum permissible E.M.F. was reached. That the oscillations were not due to interference on the part of the other commutating pole was shown by the fact that a similar series of results was obtained when the other commutating pole was removed. In this case the minimum value of the commutating pole current for no sparking was but slightly greater than when two poles were fitted, but the maximum value was double.

This clearly shows that the commutating pole flux fulfils two functions: firstly, to oppose the armature reaction flux in the commutating zone; and secondly, to provide a commutating E.M.F. The first acts as pole against pole, the armature flux is not cancelled but only opposed. Each commutating pole deals with the pole-strength of the armature on its own side, and is not influenced by the presence or absence of the other pole. The commutating E.M.F., however, must be of approximately the same magnitude whether there be two poles or only one, and hence if the E.M.F. be generated in one side

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only of the short-circuited coil the flux generating it must be doubled. Hence, when the commutating flux is small compared with the opposing flux, the ampere-turns required per pole are only slightly greater when only one pole is used than when two are in use, while when the commutating flux is large compared with the opposing flux, the ampere-turns required are practically double. Hence the use of one pole may effect a considerable saving in copper, and the range of commutation is greatly increased.

Width of the Commutating Pole.—Fig. 15 shows the E.M.F. curve recorded in coil 2 A wrapped round the middle of an armature tooth. A is the curve recorded when the width of the commutating pole is 2¾ times the armature tooth-pitch. The two extreme peaks, P and Q, in the commutating zone are due to the flashing of the flux across the slot, one as the coil enters under the commutating pole, and the other as it leaves. Between these two peaks two others, R and S, occur due to the commutation pulsation. The one to the left occurs in the tooth when to the rear of the slot being commutated, and to the other when it is in front. The four peaks are alternately above and below the zero line, and are of the same order of magnitude. The position of the inner peaks is fixed by the commutation conditions, but the distance apart of the outer peaks may be varied by varying the width of the commutating poles. If the width were so adjusted that the two outer peaks were superposed on the inner ones the four peaks might be made practically to disappear. In order to ascertain if this were possible narrow commutating poles were fitted, equal to 1¾ times the tooth-pitch, and the position of the brushes slightly adjusted so that the two left-hand peaks were superposed. The magnitude of the commutating pole current was also slightly reduced, and record B in the same figure was also obtained. If the oscillation in the tooth be neutralised the losses will be reduced and the efficiency of the machine increased. In the experiment only one commutation oscillation was neutralised, but if the width of the pole had been further reduced the other oscillation could have been neutralised

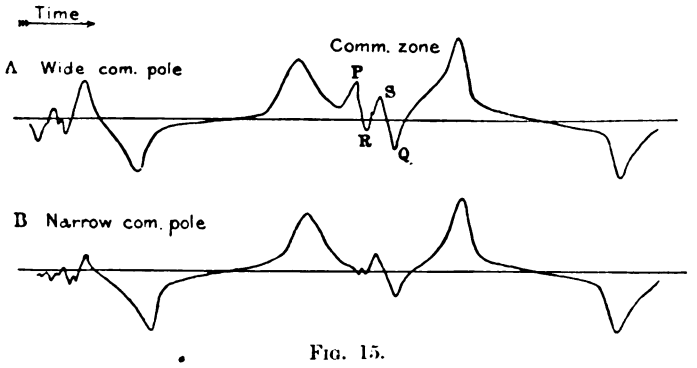

Fig. 15.

in the same manner. The velocity of the coil side relative to the flux is greater during the flash than when the slot is under the pole-face, hence the flux required would be less, and the ampere-turns could be reduced.

Cause of the Difference in Behaviour of the Positive and the Negative Brushes.—No law appears to hold which could be applied to all conditions of running, and to all brush materials, but the general observed result is that the negative brush is much more sensitive than the positive to change in temperature, current density, &c. Two observations in this direction were repeatedly made in this research—viz., that the warm brush vibrated very considerably when negative—but the same brush ran quite smoothly when positive, and that the surface of the negative brush was very much more highly polished than that of the positive. The vibration was entirely prevented by laying about six thicknesses of copper foil, each 0·035 mm. thick, on the forward tip, and a strip of copper on the rear tip, the metal being held in close contact with the brush by means of a copper clip; the metal was insulated from the carbon by very thin strips of mica. Both brushes were fitted in this way for the sake of uniformity.

The reason was thought to be as follows: The heat generated at the brush contact surface caused that surface to expand slightly, and the forward tip, being shielded from all draughts by virtue of its position, was subject to the greatest expansion, and actually lifted from off the commutator. The lifting was not continuous, but periodic; as a cold segment came under the tip, the latter came into contact with the commutator, but when the segment was heated by the current the tip was lifted off again. Thus a high-frequency vibration was set up which was communicated to the whole brush. The heat generated at the tip was not readily conducted away by the carbon, but the superior conductivity of the copper strips carried the heat away, and the large surface of the clip served to radiate it. The polished surface of the negative brush was due to its high temperature. This theory was fully substantiated by the following experiments:—(1) A brush polished up and in use for some time without the metal cooler was observed to have a band of brown nearly half the width of the brush on the forward part of the contact surface; slight sparking also took place. The metal cooler was then fitted, and after about two hours' running, the band of brown was found to be entirely rubbed away, while a new band appeared down the middle of the brush. No sparks were visible at the tip, but at the side of the brush about the middle an occasional spark appeared. The brush vibrated very considerably without the cooler, but with the cooler it ran quite smoothly, and the running was observed to improve as time went on. (2) With a very weak commutating pole field the current commutated very irregularly even with the cooler used in experiment (1), and a brown band 3½ mm. wide formed on the forward tip of the contact surface. When the field was strengthened regular commutation was obtained, and the brown band was rubbed away. (3) The commutating field was weakened as in experiment (2) and the brown band again obtained. The thickness of metal on the forward tip was then trebled, and regular commutation was obtained with the same commutating field, and the brown band was rubbed away. No sparking took place in either case when regular commutation was obtained.

From experiment (1) it is evident that with the cooler the brush was running on the two tips and the centre was not in proper contact with the commutator, and it may be concluded that without the cooler the forward tip was in bad contact with the commutator. It thus appeared that the surface of the brush expanded, but the cooler cooled the tips, thereby causing the curvature of the surface to be less and the tips to come into contact with the commutator. Experiment (2) shows the same effect; when the commutating field was weak the high inductance of the armature, owing to the presence of the commutator poles, caused the current to commutate very slowly, and consequently the forward portion of the brush surface carried a heavy current. This made the tip hotter than when there were no commutating poles, and hence the expansion took place, the bad contact at the tip caused the brown appearance and made the commutation irregular. When, however, the field was increased, the current density at the brush tip was reduced and the tip ran cooler. In experiment (3), when the tip was cooled by the extra metal, it was also kept in contact with the commutator and the brown band was polished off.

The observation that the negative brush was more highly polished than the positive may be considered in conjunction with another observation—*i.e.*, that the brushes after being freshly ground up would not take a good polish until current flowed through them. This was due to the warming effect of the current. Hence the degree of polish depends upon the temperature of the brush surface, and since the polish on the negative brush was better than that on the positive, it follows that the negative brush is hotter than the positive. The highly polished surface will make better contact, and hence the contact resistance of such a surface will be lower. Thus it is that the resistance of the negative brush is lower than that of the positive and the natural period is greater.

The difference in temperature between the two brushes is accentuated by the manner of commutation, but if the difference in temperature is the cause of the difference in commutation, the former phenomenon must be due to a cause entirely outside the phenomena of commutation. In order to ascertain this the following experiment was carried out: A carbon brush of the same material and shape as was used in the other experiments was placed on a thick piece of brass, and bedded down on to it by several thicknesses of copper foil. A slit was cut in the brass and foil, and a thermocouple was introduced into it so as to touch the carbon surface. The couple was composed of copper and constantan, separated from each other up to the joint by a thin strip of mica, and laid between two sheets of asbestos. The other element in the thermocouple was placed in a vessel of water in which a mercury thermometer was placed. The whole apparatus was carefully screened from draughts. Current was passed through the apparatus from carbon to copper, and also from copper to carbon. In the former case the carbon corresponded to a negative dynamo brush, and in the latter to a positive dynamo brush. Readings were taken for a series of currents in both directions (Fig. 16), and it will be seen that the difference in temperature is increased as the temperature rises.

The temperature of the actual commutator brush was also measured when the machine was running. The brush normally negative was fitted with a thermocouple on the forward tip as near to the contact surface as possible. The couple was in contact with the carbon and covered by a thick layer of asbestos, the whole being clipped on by a copper clip. The rise of temperature obtained when the brush was negative was 19·4°C.; the polarity was then reversed, and the

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temperature gradually dropped until a rise of 15·2°C. was obtained. The temperatures measured are, of course, less than the actual temperatures of the contact surface owing the low heat conductivity of the carbon brush. The divided brush was afterwards put into position, and the temperature rise of the forward tip measured in the same way and found to be 14·8°C., which is slightly less than that obtained when the full surface brush was in position. This shows the possibility of reducing the temperature by improving the current distribution, although in doing so the actual area of the brush may be reduced. The explanation of this phenomenon lies somewhat outside the domain of electrical engineering, and the author had no opportunities of extending the experiments in this direction, but it is evident that this physical fact is the basis for the whole of the phenomena associated with the polarity of the brush. Evidence of the expansion of the brush contact surface was also observed by Mr. Lane in connection with some experiments on an alternating-current commutating motor, in which he also adopted the author's brush-holder and cooling device.

The importance of keeping the front tip of a brush cool cannot be over-estimated, for in it lies to a very great extent the secret of successful commutation. The overload capacity of a machine can be very greatly increased if the brush-tip be kept cool. The metal case in which the brush is usually fitted is not sufficient unless the case almost touches the commutator, and is in very good contact with the carbon. Since carbon is a very bad heat conductor, any artificial method of cooling must necessarily be deficient, and the best way to avoid a hot tip is to increase the rate of commutation during the early stages of short circuit. This can be effected by the proper distribution of resistance as already shown, or by a commutating E.M.F. The former method, however, has the advantage of greatly increased stability of the brush. When the tip lifts to any considerable extent,

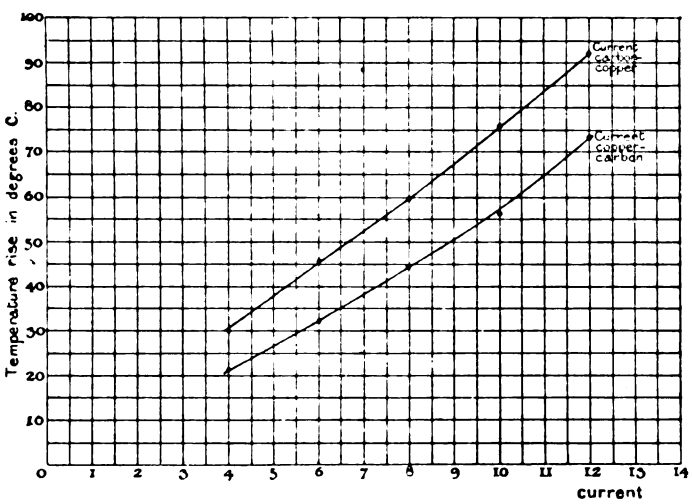

Fig. 16.

as was the case when no cooler was employed, the brush is exceedingly unstable and vibrates considerably. If the brush be high as in an ordinary plunger-holder, or attached to a rigid arm, as in a finger-holder, the vibration may be considerably multiplied.

Magnetic Oscillations Occurring in the Machine Parts.

Magnetic Oscillations in the Main Poles.—The shape of the E.M.F. waves recorded in coils 1 P to 4 P on the pole-tips was not found to vary with varying conditions of running, and hence the oscillations may be assumed to be entirely due to the teeth. Table I. gives the values of the oscillating flux expressed as a percentage of the maximum flux entering the coil. The load increases the magnitude of the oscillations, especially in the trailing tips. The presence of the commutating poles increases the oscillations in coils 2 and 3, but has practically no effect on those occurring in coils 1 and 4. This is probably due to the flux from the commutating poles. The "back pressure" of the commutating pole flux deflects the armature reaction flux more into the trailing tip of the main pole, while the commutating pole flux is in turn deflected into the leading tip. The extreme tips being already saturated are not influenced by this action. The coils 6 P, 7 P, and 8 P, each of 60 turns, showed but very slight oscillations on open circuit. This shows that only the flux generated by the outer layers near the pole-shoe is influenced by the teeth, and this flux crosses to the armature by way of the pole-tips. On load the oscillations in these coils were considerably increased

Table I.—*Flux Oscillations in Main Pole-tips.*

Coil.	Open circuit.	Percentage flux.	
		Full load without commutating poles.	Full load with commutating poles.
1 P Trailing tip ..	1·40	2·17	2·10
2 P ,, ..	2·54	3·55	4·35
3 P Leading tip ..	2·10	3·00	3·28
4 P ,, ..	0·97	1·24	1·25

Table II.—*Flux Oscillations in Main Pole-shoe (Coil 5 P.)*

	Per cent. flux.
Open circuit	0·015
Full load without commutation poles	0·022
Full load with commutation poles	0·022

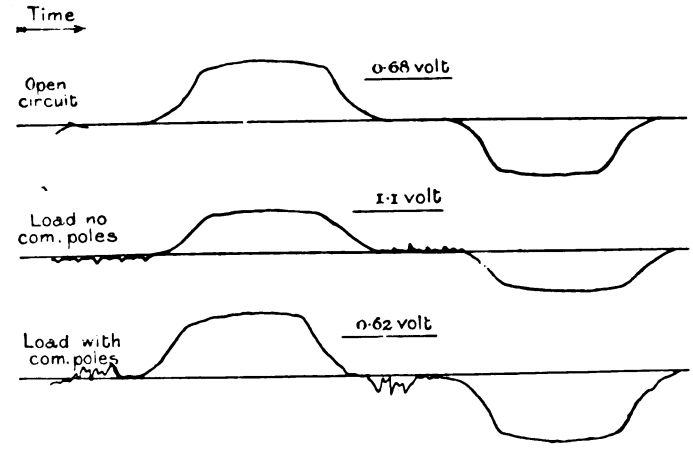

Fig. 17.—Coil 1A.

by the presence of the commutation oscillations. Coil 7 P, however, showed a greater increase than coil 6 P. This was due to the path taken by the oscillations—*i.e.*, through the tips and the outer layers of the exciting coil and then back through air, the major portion thus avoiding the solid limbs and yoke. It will be remembered that the coil 6 P was directly on the iron, while coil 7 P was over the exciting coil (Fig. 1).

Table II. gives the values of the oscillating flux in coil 5 P under various conditions expressed as a percentage of the flux when the machine is stationary. The flux in coil 5 P, when the machine was stationary, was measured ballistically and found to be $2{\cdot}68 \times 10^6$ lines. The flux oscillation is considerably increased by load, and is practically uninfluenced by the presence of commutating poles. This

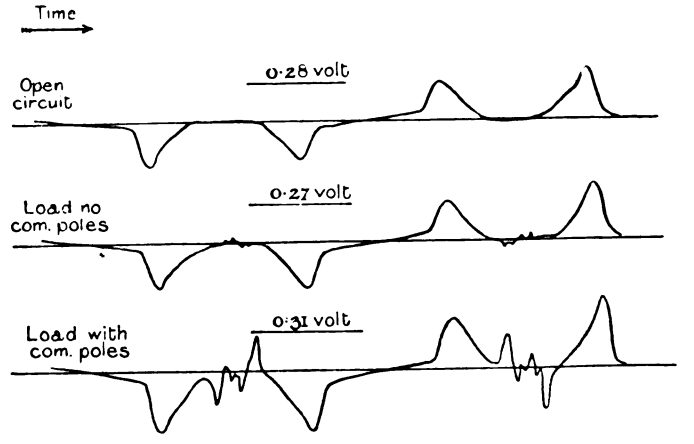

Fig. 18.—Coil 3A.

shows that although the magnitude of the peak is considerably reduced by the commutating poles, the actual value of the flux change is unaltered. This is due to the fact that whatever be the nature of commutation, the total current change remains unaltered.

Magnetic Oscillations in the Armature.—The E.M.F. waves recorded in the four coils on the armature under various conditions of running are given in the Paper. Figs. 17 and 18 herewith show the waves for coils 1 A and 3 A, whilst Fig. 19 shows to a larger scale the part of the wave generated in the commutating zone. The commutation oscillations are very marked, and the difference in magnitude between alternate peaks due to the positive and negative brushes respectively is clearly seen. No oscillations were induced in any of the search coils in the commutating zone on open circuit.

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The E.M.F. peaks induced in coil 1 A gradually increase as it approaches the commutating zone, and diminish again as it leaves it. When the coil is actually in the commutating zone, it links one-half the total flux induced by the current in the short-circuited coil, except that portion that crosses the slot below the tip; the E.M.F. peak at this instant is therefore nearly equal to the self-induction or "reactance" E.M.F. per conductor of the short-circuited coil, while the other peaks give the magnitude of the E.M.F.s induced in the adjacent coils. The records for the coils 2 A and 3 A consist of four principal peaks, two successive ones in one direction and two in the opposite direction. The first two are produced by the commutation of the top and bottom coils in the slot ahead of the tooth by the positive and negative brushes respectively, and the second two are due to the commutation of the coils in the slot immediately to the rear of the tooth. Here again the difference in magnitude between the oscillations due to the positive and negative brushes will be noticed. The remaining peaks are due to the stray flux from the short-circuited coils entering the neighbouring teeth.

Results and Conclusions.

(1) The natural period of the short-circuited coil may be varied by varying its contact resistance, or by properly disposing the resistance over the brush surface. (2) Sparking depends upon the relation of the natural period to the available period. (3) The maximum rate of change of the current during commutation may be reduced by reducing the natural period, and at the same time the overload capacity of the machine as regards sparking will be improved. (4) The maximum rate of change may also be reduced by accelerating the commutation during the early portion of the short-circuit period by means of a commutating E.M.F., and this has the same effect as reducing the natural period of the coil. (5) The ampere-turns necessary on the commutating poles may be reduced if the flash across the slot be used to generate the commutating E.M.F.

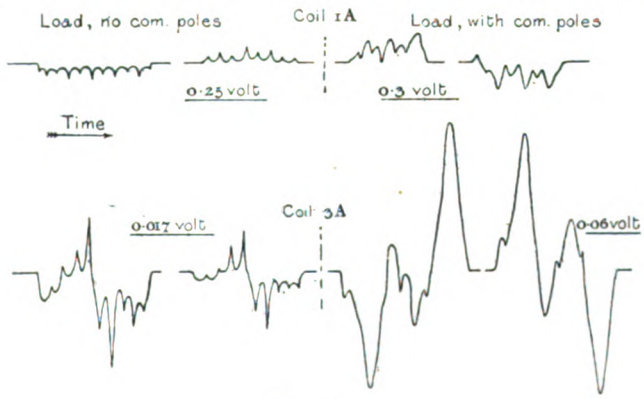

Fig. 19.

The E.M.F. generated in such a manner possesses approximately the correct wave shape, and the magnetic oscillations in the armature teeth during commutation are thereby reduced. (6) If only one commutating pole be fitted, the ampere-turns necessary are less than when two are in use. (7) The commutating pole flux fulfils two functions: (1) to generate the commutating E.M.F., and (2) to oppose or press back the armature reaction flux. (8) The negative brush is hotter than the positive; the higher temperature causes the negative to take a higher polish than the positive, thereby reducing its contact resistance. The lower contact resistance increases the natural period, and renders the negative brush more liable to sparking than the positive. (9) The higher temperature of the negative brush causes it to expand more than the positive. The forward tip is generally the hottest part of the brush surface, because it is shielded from draughts. The forward tip is alternately heated and cooled as the segments pass under it, and vibrates with the frequency of the segments. This vibration renders the brush unstable, and the commutation irregular. (10) The forward tip may be cooled, the vibration avoided, the commutation made regular, and the sparking limit raised by a piece of metal in good contact with the brush at the forward tip and provided with a relatively large radiating surface. (11) The results in (10) may also be obtained by preventing the rush of current at the end of commutation, either by reducing the natural period of the coil or by accelerating the commutation during the early stages by means of a commutating E.M.F. (12) The vibration of the forward tip of the brush causes a minute arc to be periodically set up between the carbon and the commutator, which causes a brown band to form on the brush and a deposit on the commutator.

This research was carried out at the Technische Hochschule at Karlsruhe, Baden.

REQUIREMENTS FOR AN INDUCTION MOTOR FROM THE USER'S POINT OF VIEW.*

BY W. B. NYE.

The author discusses this problem not as an engineer, but from the point of view of that large class which pays the bills, and to which the motor is but a means to an end. The prime requisite from a manufacturer's point of view is continuity of operation. To secure continuity of operation and ease of repair, former-wound impregnated coils should be used. Impregnation of coils is suggested because in many industries motors are subjected to moisture, steam, fumes, either acid or alkaline; dust, which may be organic, and which by its decomposition affects the insulation. Impregnation renders the coils much more immune to these conditions.

However good the motor may be, sooner or later repairs will be necessary, and in that case a former-wound coil is much more easily put in place than any other type. Coils should be made accurately to size, so there may be no difficulty in placing them in the slots, and there should be good mechanical connection between coils, as lack of this often leads to open-circuiting. It is also desirable to have a good terminal board, and preferably flat, flexible copper leads, so as to do away with soldered or screwed terminal connections. It would also be well to use particular care in the quality of the insulation on the copper bars in the rotor where they pass through the slots, as this would reduce the amount of labour in repairs. It is to be hoped that some better scheme may be devised for connecting the conductors to the outside rings, as bolts corrode, and it is seldom possible to remove them without twisting them off, which again occasions delay.

Bearings should be long, well designed, and filled with the best quality of babbitt. Great care should be given in designing the channels for the oil-rings to travel in, so there may be no chance for the ring to catch; and the sight-feed or overflow pipe should be piped away from the bearings, so that inspection may be given it regularly.

Shafts should be stiff, and the motor so designed as to permit of considerable overhang of the driving pulley. There is a tendency on the part of designers to increase the diameter of the driving pulley, narrowing the face in order to reduce the overhang; but at the speed at which most motors run, these large driving pulleys occasion difficulty in getting down to such speeds as are common in mill practice. In fact, the motors which so far have come under my notice have practically all had to be equipped with smaller, wider pulleys than those sent with them. This condition might as well be realised, and the motor designed for this service.

My experience has been mainly with a group drive, hence there is a chance of continual slow growth in the power requirements, and for that reason the motor should be capable of standing up to the load, even if in excess of its name-plate rating. A motor, therefore, should be designed to stand at least 25 per cent. continuous overload without undue heating, and should be so designed as to permit of good ventilation and a ready access of the air jet in cleaning out.

Controllers, and particularly switches, should be of the oil-immersed type, doing away with fuses, thus meeting the requirements both as to fire hazard and to life, from contact with the average open-jaw switch. Experience shows that auto-transformers for use in connection with induction motors have almost invariably been too small, and after considerable trouble in endeavouring to start the motor, it has been necessary to secure larger ones. Designers may well consider this point and be more generous in their provision of capacity in these most necessary appurtenances. The user can well afford to pay a little more for a well designed motor containing some reserve in capacity and ability to stand hard usage.

In the business in which I am interested (paper manufacturing), we have not thought it wise to take up the application of the individual motor to the individual machine, although this has been developed quite fully by electrical engineers. We have so far made use of group-drives, so arranging the groups as to make use of but a few standard sizes, of which we always keep one or two in reserve for use in case of emergency. The standard group might be said to be that driven by a 100 H.P. motor, of which we have twenty, and for which we constantly hold two extra motors in reserve, one of them on trucks ready to be hurried to any point required. In this way, should anything occur to a motor, it can be removed, and a new one slipped in its place, with the loss of but a few moments, and the repairs made in the shop at leisure. This same practice holds good for all sizes up to 150 H.P., above which this scheme is not practicable.

* Abstract of a Paper read at a joint meeting of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers.

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Editorial, Publishing and Printing Offices,

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(ONLY ADDRESS.)

Tel.: Holborn **6363** (Two Lines). *Tels.*: ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The forty-ninth issue of the Supplement will be published (Gratis) with the number of "THE ELECTRICIAN" for May 27.

The "INDUSTRIAL SUPPLEMENT" is holed for filing or hanging, and filing covers can be supplied for holding 6 or 12 issues.

ELECTRICITY IN MINES.

HERBERT SPENCER was never tired of pointing out that the interference of the State with the liberty of the subject was increasing and ought to be diminished, and that the happiness of the human race was likely to be inversely proportional to the number of Government inspectors. Nobody nowadays believes in all this: on the contrary, there seems to be a well-rooted belief that without the help of the authorities it is almost impossible for us to tell what is for our good. Consequently, we accept from time to time, as meekly as is possible, such codes of rules as are inflicted on us from above, though they often run to such length that much careful study is needed for their interpretation. The infinite multiplication of wiring rules is a case in point, and a nuisance that might well be abated, even to the irreducible minimum, by the adoption of the Rules of the Institution of Electrical Engineers

It seems now that the Home Office is of opinon that the Regulations relating to the Use of Electricity in Mines require revision; either they do too little and are defective, or they do too much and need modification. Or more probably still, they do the wrong thing, and need correction. Such is the result of the interference of the State. It will be admitted that the use of electricity in mining work has been attended with very hopeful results. There is no sphere of work falling under the head of the engineering aspects of electricity which has of late years met with a more encouraging expansion. As to the class of plant that has been put in, this varies, no doubt, from good to bad. Certainly no sort of finality has been reached. There is, and will long remain, much that is debatable as to methods and appliances; but a premature codification or too rigid application of general principles might prove very undesirable. Evolution has played its very important part; in

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other words, experimental errors have been corrected gradually, and much that seemed at first likely to be suitable to the needs of the case has been replaced by something else that has been shown by experience to be better. The type of cable has sometimes led to failure, and the lead-covered cable seems to be falling into disrepute in this underground work. Armoured cables, carefully chosen, are preferred. Such points are, doubtless, of the greatest importance; but they are precisely the sort of thing which cannot be dealt with under any kind of regulation imposed from above. The aim and object of all engineering work is to approach as nearly to the ideal as is humanly possible, and never, if only from business motives, to be in favour of petty economies. This can only be done if a fairly free hand is given to those to whom the responsibility is entrusted of carrying out the work, and they stand to lose or gain in the long run in proportion to their success or failure.

The aim of the Home Office is, doubtless, to secure immunity from the two sources of disaster which may be classified under the heads of shock and explosion. Safety from shock is supposed to result from establishing satisfactory "earths"; how and where this is to be done is the problem, and there is, of course, at the moment no one recognised method that is practised to the exclusion of all the others. Sometimes the cables are earthed at the top of the shaft; or, again, in the sump at the bottom; or, again to the rails forming the track. All of these plans require discretion and experience. The rails may be resting on an insulating layer of subsoil, in which case the "earth" formed by such rails may be actually a source of danger; and in case of any discontinuity in the armouring of the cables danger may arise in another way. Experience is a far more useful ally than any number of regulations, and the short time during which colliery work has had the advantage of electrical auxiliaries has already taught us much. The human element, too, is by no means negligible, and of the 1 per cent. of the total fatalities which is attributable to electricity a large proportion have been of such a nature that they could hardly have been avoided by any preventive system, short of the useful one by which we are content to learn most things. As has been well said, the school of experience is the best one, but it is a pity the fees are so high. In the early days of telegraphy large numbers of birds used to kill themselves by flying against the wires. Now they seem to have learned better; and every living thing learns in the same way—man himself included. Complaints are often made that it is not easy to find men who have had much experience in the every-day work of a colliery installation, and that in consequence it is necessary to engage men who have yet to learn some of the elements of such work. This is probably true enough, but though there may at the moment be a shortage in the supply of such men this is not likely to be the case for long. Such troubles, therefore, as are traceable to this cause are certain to pass away.

The second point at which the regulations would be likely to aim would be the provision of means for lessening the risk of explosion. This is notoriously a very difficult and obscure problem. Methods that are suitable in one pit are quite insufficient in another. Some pits are so fiery that it may at present seem well to leave them almost out of account, as the most perfect devices might well fail, even if installed with the utmost care. Local conditions are in these cases all important, and any general conditions intended to cover such cases would only err on the side of excessive rigidity. The precise mechanism by which explosions are caused is not altogether as certain as is sometimes supposed, and the parts played by coal dust, moisture, and inflammable gas are not at all clear. The one and only remedy that has been suggested has been to enclose everything. This is a move in the right direction, if a certain amount of latitude is allowed for the interpretation of the conditions of the special case. It is often the method of enclosing the switch or motor that is more important than the mere fact of enclosing it; the case of Davy's safety lamp is a classical instance of this.

We make no claim, of course, that we should be allowed to go on our way without let or hindrance. It is too late in the day for such a plea to be of any avail, even if it were desirable. But we do urge that as free a hand as possible should be given to those who are in a position to avail themselves of the benefit of their experience. Anything that can be done towards placing the responsibility definitely on the right shoulders we should heartily welcome; but a sub-division of such responsibility among a variety of officials, no one of whom is clearly in intimate contact with the work, or has sufficient technical knowledge to understand the problems involved, is clearly to be deprecated. If the authorities work with such points in view it is needless to say they will have our entire approval.

OBITUARY.

MAJOR P. CARDEW, R.E.

We sincerely regret to record that Major Philip Cardew died at about noon on Tuesday last. He underwent a serious operation in November last for a tumour behind the nose, and never really recovered from its effects. He has, in fact, been sinking since that time.

Philip Cardew was born on September 24, 1851, and passed out with honours from the Royal Military Academy, Woolwich, in 1871, being awarded the Pollock gold medal as the most distinguished cadet of his year.

He was placed in charge of the military telegraphs at Bermuda in 1876, and in 1877 he joined the Submarine Mining Service, being a year later appointed assistant instructor, and in 1883 instructor, in electricity at Chatham. In 1888 Major Cardew was appointed electrical adviser to the Board of Trade, which post he held until 1899, when he resigned in order to take up consulting work in partnership with Sir W. H. Preece, K.C.B., and his sons, thus forming the well-known firm of Preece & Cardew. The firm were consulting engineers for many electricity supply and tramway undertakings, and, in connection with this consulting practice, Major Cardew made a journey on behalf of his firm to Sydney (N.S.W.) to report upon the municipal electricity undertaking. He was also engaged in many important arbitrations. During Major Cardew's tenure of office at the Board of Trade the development of electricity supply for lighting, tractive power, and other purposes was developed, and regulations and numerous other important questions settled. It was during that period that the rules for

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safeguarding underground pipes from electrolysis by stray currents from electric traction systems, and which have proved so beneficial, were drawn up.

Major Cardew was a director of the London, Brighton and South Coast Railway, which has lately had the distinction of being the first to adopt the single-phase electric system for the working of its suburban lines. He was the author of many inventions and improvements, among the more important of these being :—A system of vibration telegraphy, which has been extensively used for field telegraphs since 1881, as it enables communication to be maintained through a very defective line ;

MAJOR P. CARDEW, R.E.

a voltmeter, working by the heating of a fine wire in a compensating tube ; a safety device for transformers ; and a system of regulating the fall of potential in the return circuit of electric tramways and railways. Major Cardew was the author of numerous Papers, among which may be mentioned one on "The Application of Dynamo-electric Machines to Railway Rolling Stock," published in March, 1881 ; and one on "Electric Railways," read before the Society of Arts in March, 1901.

SIR WILLIAM HUGGINS, K.C.B.

We regret to record the death, on Thursday, May 12th, of Sir William Huggins, K.C.B., F.R.S. The deceased was 86 years of age. Though by no means intimately connected with electrical work, Sir William Huggins is deserving of honour by all scientists on moral grounds alone, for he was one of those who without being forced by the spur of obligation followed science for its own sake alone. In his observatory which he erected at Tulse Hill in 1856 he carried on, in conjunction with Lady Huggins, his work on astronomical spectroscopy, a field of research which had been made possible by the discovery by Kirchoff of the true significance of the Fraunhofer lines. A full consideration of Huggins' work is not within the scope of THE ELECTRICIAN, but we may mention that besides scientific, he also received, though somewhat tardily, official recognition. He was made K.C.B. in 1897, and a member of the Order of Merit on its foundation. He had been elected a Fellow of the Royal Society in 1865, and received from them the Royal Medal in 1866, the Rumford Medal in 1880, and the Copley Medal in 1898. He succeeded Lord Lister, as president of the Society, in 1900. He was also an honoured member of many foreign learned societies.

THE ELECTRICAL EQUIPMENT OF SMITH'S DOCKS, MIDDLESBROUGH.

The electrical equipment of the shipyard and graving docks of Messrs. Smith's Docks Co., Middlesbrough, presents many features of interest. About 18 months ago the Company, acting on the advice of its consulting engineer, Mr. J. Mitchell Moncrieff, decided to re-claim a portion of the foreshore of the River Tees covering some 16 acres of ground near Middlesbrough. The choice of the site was determined by a scarcity of dry docks on the Tees capable of dealing with the largest ships calling at Middlesbrough and by a plentiful

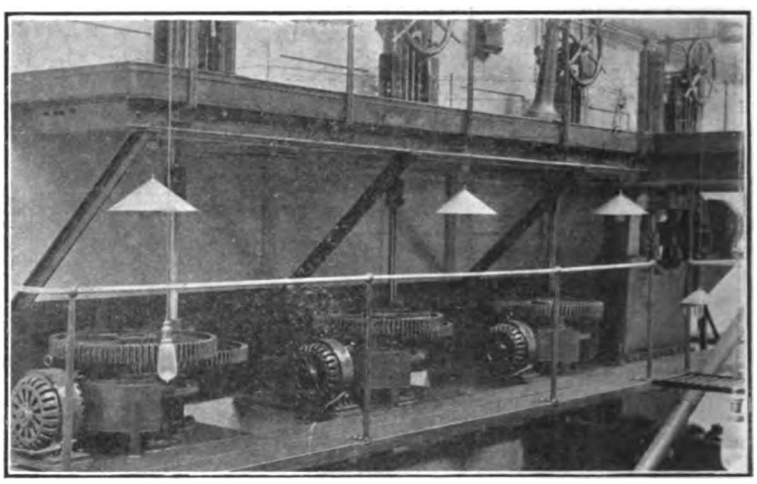

FIG. 1.—VALVE CONTROLLING GEAR.

supply of engineering material and labour. The work was carried out by Messrs. John Aird & Co., and includes a shipyard with offices, fitting, machining, wood-working and blacksmithing shops and two dry docks, one 550 ft. long and 67 ft. wide, and the other 450 ft. long and 61 ft. wide, both being 26 ft. deep at high-water mark of ordinary spring tides.

Full advantage has been taken of the economy and convenience resulting from the electric drive, all the machinery employed being

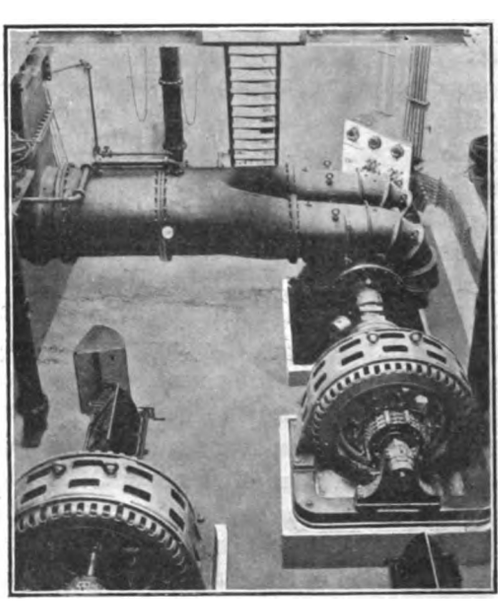

FIG. 2.—VIEW OF UNDERGROUND PUMP ROOM.

operated, and all the lighting effected, by this means. The dock is provided with a large travelling jib crane, built by George Russel & Co. This crane has a capacity of 25 tons at 42 ft. radius, 15 tons at 70 ft. radius and 10 tons at 90 ft. radius. It is fitted with an auxiliary hoisting gear for lifting loads up to 5 tons at a rate of 100 ft. per minute. The lifting speed with a 25 ton load is 20 ft. per minute, and for the lighter loads is proportionately greater. The crane is equipped with four Westinghouse motors of 48, 20, 20 and 15 H.P. for hoisting, derricking, slewing and travelling respectively,

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which, with the exception of the travelling motor, are mounted in a cabin on the rotating frame, the travelling motor being mounted on the crane carriage and controlled from the cabin on the rotating frame at such a height as to command a good view. Each of the motors is fitted with an electromagnetic brake, and the hoisting and derricking gears are also equipped with an automatic, mechanical and foot or hand brakes. The crane receives its power from a number of plug boxes placed along the track through a flexible armour-covered cable.

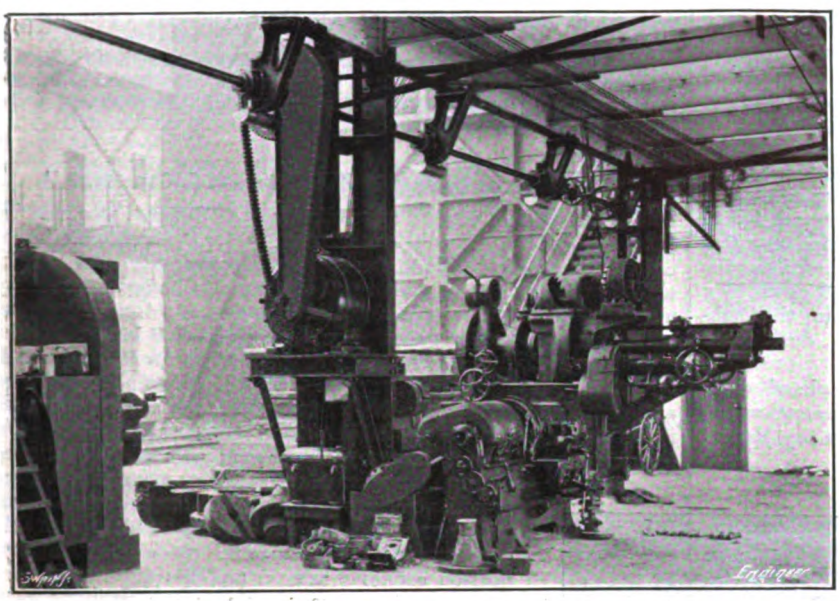

FIG. 3.—SHAFT DRIVEN BY MOTOR AND CHAIN.

Near the entrance to the docks is an underground pump room, which contains the pumping plant, consisting of two main twin Worthington pumps with 48 in. diameter suction and delivery pipes connected direct by flexible couplings to two 400 H.P. Westinghouse slip-ring motors operated by liquid starters. A view of these pumping sets is given in Fig. 2. There is also a 12 in. Worthington low lift pump used for draining purposes. The pump has a capacity of 2,000 gallons per minute against a maximum head of 45 ft. when running at 760 revs. per min., direct connected to a 35 H.P. Westinghouse squirrel-cage motor. A small priming pump is driven through a chain drive by a 4 H.P. motor. An appliance of this kind is necessary in such an installation in order to re-charge the pumps should they happen to lose their water through the emptying of the dock.

The main pumps are designed for a constant output of 42,000 gallons per minute at a speed of 295 revs. per min., but an official test shows that this figure was exceeded by 10 per cent., the docks being emptied in a correspondingly shorter time. On this test, the maximum pump efficiency is given as being 84 per cent., and the load on the motor at this point was only increased by 16 per cent. when working at the lowest head.

The gears for the emptying and discharging valves can be operated either electrically or by hand. A portion of these gears is shown in Fig. 1, the gears being driven by eight 4 H.P. motors, each provided with automatic cut-out gear to prevent any possibility of the valves jamming. The switchboard controlling the various motors receives a 440 volt three-phase supply direct from the sub-station, and consists of five polished white Sicilian marble panels, on which are mounted the necessary switches, fuses and both indicating and integrating instruments. A telegraph gear is provided for the convenience of the docks master in controlling the operation of the pumps. The capstan equipment of the docks consists of five capstans, each with a haulage capacity of 5 tons at a speed of 40 ft. per minute and 1¼ tons at a speed of 120 ft. per minute. The capstans are operated by three-phase motors, three being placed at the entrances to the docks and one at the end of each dock.

The shipyard, which is on the Middlesbrough side of the dry docks, is capable of accommodating 18 large steam trawlers at one time. Near the yard is a gut for berthing ships, while their machinery is under repair, and immediately in the rear of the yard is a machinery shop 220 ft. long by 140 ft. broad, containing a mould, lathe and two furnaces, suitable for angle iron 48 ft. long and plates 25 ft. long heated by two gas producers manufactured by the Gas Power Co.

A fine set of rolls, 15 in. in diameter by 30 ft. long, made by James Bennie & Sons, has together with other machines, been removed to this machinery shop. The set is driven by a 75 H.P. Westinghouse slip-ring motor operated by a liquid controller for rolling, and 25 H.P. Westinghouse squirrel-cage motor for lifting the rolls. The joiners' and blacksmiths' shops, the former covering an area of 130 ft. by 70 ft. and the latter 111 ft. by 70 ft., will, when fully equipped, contain 30 fires, a large ground fire, a Roots blower driven by a 15 H.P. alternating-current motor, and a 5 cwt. Massey power hammer driven by a 20 H.P. alternating-current motor, which are at present in a temporary shed near the fitting and machine shops. All these machines are individually driven, and among them are a 30 ft. plate edge planing machine and a large roll 2 ft. diameter by 17½ ft. long, each driven by a 20 H.P. motor, while outside are a punch and shears 1½ in. by 1½ in., driven by a 20 H.P. motor mounted on the top of the machine. A ⅝ in. joggling machine, geared to a 40 H.P. motor, a plate straightener with rolls 5½ ft. long, driven by a 50 H.P. motor, and a horizontal bending machine, driven by a 20 H.P. motor mounted on the machine, all the motors, both here and in the temporary shed, being protected by wooden casings.

In the machinery shop it is interesting to note the method of driving the two lines of shafting, which run practically the whole length of the building. Each line is driven by two 30 H.P. motors through short lengths of chain drives; one is illustrated in Fig. 3 with half the gear case removed; but by disconnecting the coupling joining the two halves of the line shaft each half can be driven by one motor. There are also two large shafting lathes, each 30 ft. long, driven from the main shafting, a large horizontal machine driven by a 10 H.P. motor, and a medium-sized vertical boring machine driven by a 5-20 H.P. squirrel-cage motor, the speed variation being obtained by special motor winding connections. The vertical boring machine is illustrated in Fig. 4.

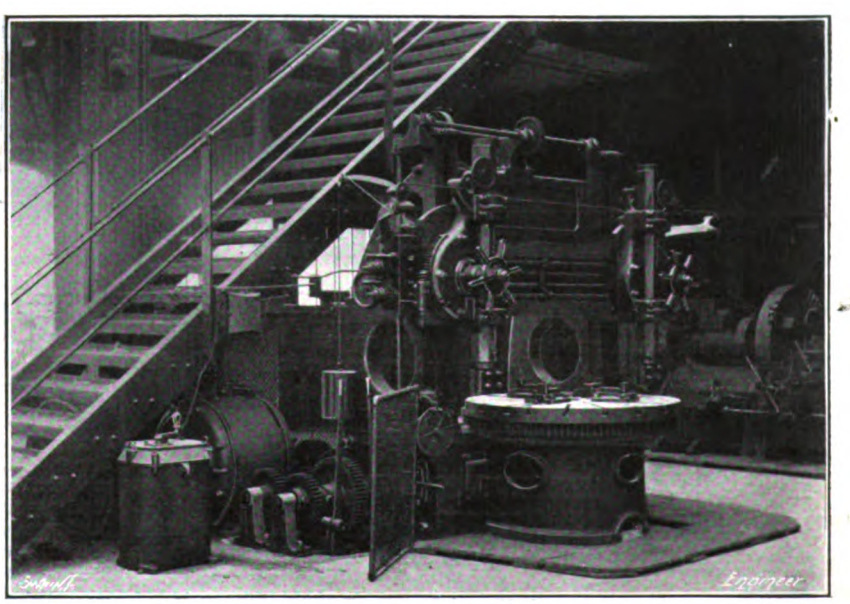

FIG. 4.—ELECTRICALLY-DRIVEN VERTICAL BORING MACHINE.

A sub-station in a corner of the shop contains two 60 kw. motor-generator sets supplying direct current for lighting the docks and works and two distributing switchboards, one with eight panels for alternating current controlling the air compressor motor, the cap-

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stans, fitting shop and the motors of the motor-generator sets; the other five panel direct-current board controlling the generators and lighting circuits.

The main alternating-current panel contains an automatic oil switch and an ammeter and voltmeter, whilst each of the other alternating-current panels contains an oil switch, ammeter and an integrating wattmeter, and each of the direct-current panels a two-pole switch, porcelain-handle fuses and ammeter, whilst the generator panels also are provided with voltmeters and voltmeter plugs. All circuits which lead from the station to the outside circuits are protected with choking coils and lightning arresters, which will be noticed in Fig. 5. A 22 k.v.a. 440/220 volt single oil-insulated self-cooled transformer is installed in the station for supplying the lighting when the direct-current sets are not running, and also a compressor for furnishing air at 100 lb. pressure to the pneumatic tools. This machine, driven from a 120 H.P. slip-ring motor on the gallery above, is operated by an automatic liquid starter controlled by the variation of air pressure in the air receiver. Power is fed to this station at 440 volts from the main sub-station situated near this shop, at which three-phase power at 3,000 volts, received from the Cleveland & Durham Electric Supply Co., is transformed down by a 500 k.v.a. oil-insulated self-cooled transformer. From this sub-station circuits are also run direct to the pump house, dock crane and shipyard.

The whole of the electrical installation has been completed under the supervision of Mr. C. W. Fairweather, consulting electrical engineer to Smith's Docks Co., and the wiring carried out by Messrs. Warren, Beattie & Co., of Middlesbrough.

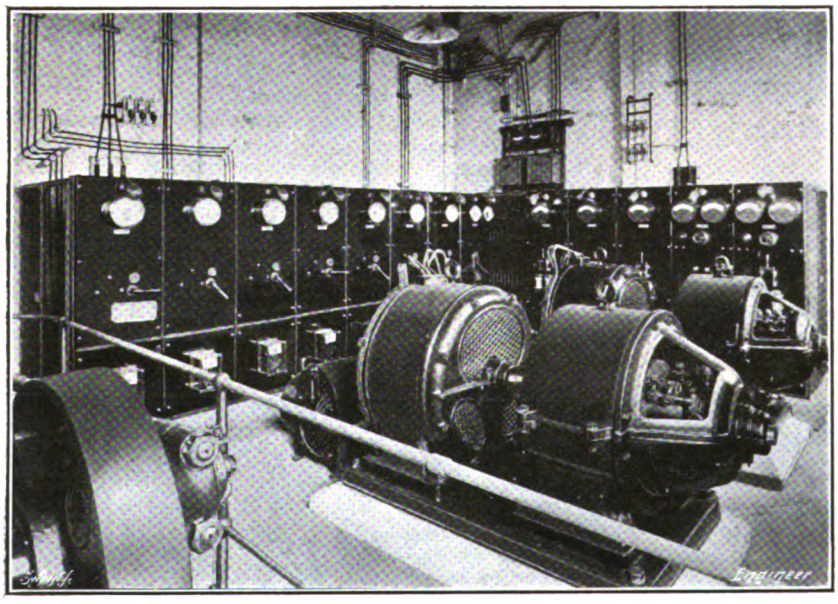

FIG. 5.—VIEW OF SUBSTATION.

With the exception of the capstans, the whole of the electrical apparatus for the above installation was supplied by the British Westinghouse Electric & Mfg. Co. to whom we are indebted for the particulars here given.

PHYSICAL SOCIETY.

At the meeting held on April 22nd, Prof. H. L. CALLENDAR, F.R.S., President, in the chair, Mr. W. A. SCOBLE read a Paper entitled

"Further Tests of Brittle Materials under Combined Stress."

A former Paper described tests on cast iron, which is the brittle material which is most commonly employed in engineering practice. The cast iron yielded somewhat, and it was necessary to assume a redistribution of stress before fracture. Then the maximum principal stress appeared to be the best criterion of strength. The tests described in the present Paper were made on hardened cast steel, which material was selected because it obeys Hooke's Law to fracture. The specimens were $\frac{3}{4}$ in. diameter and 30 in. effective length, and were tested under combined bending and torsion. As it was not possible to ensure that the hardened bars were of exactly equal strengths, a bar was first fractured under combined loading, then one portion was tested under bending alone, and the other part in simple torsion. Thus each bar afforded independent evidence on the law of failure. Neither the maximum shear stress nor the maximum strain was constant at fracture, but the results indicated that the maximum principal stress is the best criterion of strength for a brittle material under combined stress. In general, the hardening did not affect the strength of a bar to resist bending, but it doubled the torque which was required to cause failure.

Dr. RUSSELL asked the author for a definition of a brittle material.

Mr. R. S. WHIPPLE asked what were the advantages of hardening in vitriol.

Mr. SCOBLE, in reply, said a brittle material was one which did not yield before fracture, although cast iron, which was usually classed as brittle, yielded to a slight extent. Tool hardeners found that hardening in vitriol was preferable to hardening in oil.

A Paper on

"The Magnetic Balance of MM. Curie and C. Cheneveau,"

by C. CHENEVEAU, with an appendix by A. C. JOLLEY, was read by Mr. A. C. JOLLEY. This balance is intended for the determination of the coefficient of specific magnetisation, susceptibility and permeability of feebly paramagnetic and diamagnetic bodies. The body under investigation is suspended from one arm of a torsion balance, which measures the force exerted on the body when it is placed in the non-uniform field of a permanent magnet. The torsion balance is formed by a horizontal rod suspended by a long fine platinum wire and carrying at one end a hook from which the substance under investigation can be suspended in a small enclosing glass tube. On the other end of the torsion arm a copper sector is fixed which moves between the poles of an auxiliary magnet and thus provides efficient damping. A second branch arm is also provided, upon which may be placed suitable counterweights to balance the specimen. The suspension carries a mirror, and the movements are read on a translucent scale in the ordinary way. The magnetic field is that of a large circular permanent magnet mounted in such a way that the vertical gap may be made to describe a semicircle of radius equal to the length of the torsion arm, and the movements of this magnet are controlled by the observer at the screen by means of cords. An empty containing tube is first mounted on the balance, and the maximum deviation of both sides of the zero is obtained by bringing up the magnet towards each side of the specimen. The tube is now filled to a given mark with a known mass of pure distilled water and the variations observed as before. The water is now replaced by a known mass of the substance to be examined occupying the same volume or the same vertical height, and again the deviations are observed. The Paper indicates how the value of K may be calculated from these observations. Experiments have been performed with various metals and alloys, and the results are tabulated and discussed in the Paper.

Mr. A. CAMPBELL said that for certain experiments, and in the construction of certain instruments it was essential to know that the materials used were non-magnetic; and he thought the author's instrument would be useful. It was very difficult to obtain non-magnetic brass.

Mr. W. DUDDELL asked if the specimens used were specially cleaned, as the oxides and sulphides of many metals were magnetic. It would also be necessary to keep them clean to get trustworthy results.

Mr. D. OWEN expressed a doubt as to the accuracy of the results attainable by this apparatus used as described by the authors in the Paper. Theory required that the specimens of the standard substance and that under test should be exactly equal in size and shape, and similarly situated in the variable magnetic field when the observation of maximum force is taken. In many ways this condition might be departed from in the experiments described. The size of the test-tube used to hold the specimen was a considerable fraction of the interpolar space, and, excepting in the case of liquids, it would be difficult to ensure identity of form of the samples in the correlated pair of experiments. Absence of coincidence between the axis of rotation of the magnet and the axis of the torsion wire would cause an error of position varying with the deflection of the balance arm. Again, the magnetic pull parallel to the balance arm would cause movement of the specimen to an extent depending on its susceptibility and its density, though the effect was likely to be very small. These causes might account for the authors' observations of apparent dependence of K on the mass and length of specimen.

The authors were also asked whether they had any experimental data as to the independence of K with respect to temperature.

Dr. RUSSELL regretted that the author had not explained more fully how the magnetisation of the specimen under test was maintained uniform. Any lack of uniformity would seriously affect the accuracy of

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the results. He thought that the great discrepancies found by Mr. Jolley in the apparent value of the coefficient of the specific magnetisation of copper for specimens of different lengths must be due to an uneven distribution of the magnetic field. When the specimens were very feebly magnetic he considered that it was legitimate to make the assumption that the intensity of the magnetisation was proportional to the field. He did not see, however, how the balance could be employed to test strongly magnetic substances. He suggested that the specific magnetisation of water might vary largely with temperature. It was interesting to find that the discrepancies between the calculated and the observed values of the inductance of a certain brass conductor had been traced to the magnetic qualities of the brass. In his opinion errors in the computed values of inductance standards, due to the permeability of the conducting material differing from unity by a very small fraction, would in general be negligible.

The SECRETARY read a letter from Dr. C. V. DRYSDALE in which he stated that Mr. Jolley's experiments with the magnetic balance proved its value, both scientifically and commercially, as a means of rapidly estimating the composition and purity of alloys and other materials. The instrument enabled the magnetic qualities of materials to be obtained as easily as the specific gravity measurements which are usually employed as an aid to practical analysis, and it formed a kind of magnetic hydrometer which gave the specific magnetisation instead of the density of the substance as compared with water. The displacement principle of Poisson and the derivation of the force as the slope of potential were both of great importance, and an apparatus such as the author's, which showed the practical application of these principles, was welcome.

Mr. C. W. S. CRAWLEY drew attention to the fact that if the brass rods were cut with steel shears they would be rendered magnetic. Brass tubes prepared by drawing through steel dies were generally magnetic. He asked if the variation of the value of K for copper was due to impurities.

Mr. R. S. WHIPPLE asked if the author had performed any experiments on wood or ebonite, and, if so, with what results.

Mr. JOLLEY, in reply, said he could fully endorse Mr. Campbell's remarks concerning the difficulty of obtaining non-magnetic brass which seemed to be quite rare. In reply to Mr. Duddell's point concerning the cleaning of the specimens, a fair amount of care was taken to keep the specimens clean; they were handled with ivory forceps, and in most cases they were bright new samples of rod and wire, which to the eye certainly did not seem in any way oxidised; and if any such oxide or other salt were present, unless it were very highly magnetic it would not be sufficient in quantity to account for the high values of K generally obtained. Mr. Owen raised a point in connection with the theory, which would be of importance if the maximum deflection were obtained with the specimen in the interpolar gap, but, as a matter of fact, the maximum deflection as indicated in the Paper was always obtained when the specimen was considerably out of the gap of the magnet, and consequently the position of the specimen did not become so important. An excellent datum was, however, provided by the damping sector, which had to be accurately between the poles of its magnet for perfectly free rotation, and when this was so the tube was rightly centred relatively to the gap of the deflecting magnet. No experiments had been made either as to side pull, which, however, in feebly magnetic bodies must be very slight indeed, or as to temperature. With regard to the uniformity of magnetisation of the specimen raised by Dr. Russell, he believed that some experiments on this had been made by MM. Curie and Cheneveau, but the point would have to be referred to M. Cheneveau before anything definite could be said. With regard to Mr. Crawley's point as to the cutting of the specimens and the presence of iron from the tools employed in manufacture, they had no special method of cutting the lengths and had to resort to the usual workshop processes. The experiments with acid treatment showed that although in some part the magnetic quality was a surface effect, this was by no means accountable for all, and the amount of magnetic material left on the surface from tooling was far too small to account for the values of K found. With regard to copper, the value of K certainly was due to impurity, but it was considered that the magnetic balance gave indications of the presence of such impurity with far greater reliability than any chemical test for such minute quantities. In reply to Mr. Whipple, both wood and ebonite had been tested, but not tabulated. In both these cases the results were variable, and it was practically impossible to free the material from the effects of tooling; in any case, the results always showed the specimens to be very magnetic.

CORRESPONDENCE.

NOMINATIONS FOR THE COUNCIL OF THE I.E.E.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Along, I presume, with other members of the Institution, I have received a letter signed by Mr. W. A. Chamen asking for my "vote and interest" on behalf of Mr. H. Faraday Proctor for the forthcoming election of the council of the Institution of Electrical Engineers.

I think that, with certain safeguards, the practice of the Institution nominating members for the election of the council is one that has many advantages, but I am strongly of opinion that the innovation of circularising the general body of the members in favour of a particular candidate, however eminent that candidate may be, is one that cannot be too strongly condemned, and I sincerely trust that for the well-being of the Institution the present unfortunate attempt to influence the members by circular may receive such a set back as may prevent any recurrence of it in the future.

If this practice is allowed to take root and grow, then I fear it will cause a rivalry between the members of the various local sections with regard to representation on the council, that will seriously detract from the usefulness of the Institution.

I do not say that the method adopted by the council of putting forward a bare list of the names necessary to fill the vacancies on the council is an ideal one, but I think that in nominating three prominent members of local sections they have taken a step in the right direction, and one that is likely to commend itself to the general body of the members.

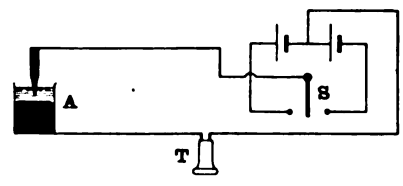
I have no personal feeling with regard to Mr. Faraday Proctor, who, I believe, would make an extremely good member of Council, but I do think that this attempt to influence members is one that will seriously affect the influence of the Institution, and I trust, therefore, that it will not receive the support of the general body of the members.—I am, &c.,

Liverpool, May 14. THOS. L. MILLER.

TELEPHONE RELAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: After listening to Mr. S. G. Brown's interesting Paper on "A Telephone Relay," read before the Institution last Thursday, it occurred to me that the effects which his new microphonic contact exhibits were, to a certain extent, analogous to those I had noticed in some recent experiments. The apparatus I was using at the time consisted of a modification of the well-known "wheel coherer"—the invention, I believe, of Sir



Oliver J. Lodge—in the form of a very fine steel needle, mounted on a vertical adjustment screw, and so arranged that its point was capable of dipping into a cup of mercury placed underneath.

The surface of the mercury was covered with a layer of oil, and the apparatus was connected up to a telephone receiver and a pair of dry cells fitted with a reversing switch. A represents the steel-mercury combination, T the telephone and S the two-way reversing switch.

On screwing down the steel point it was found that the steel apparently pierced the surface of the mercury for quite an appreciable distance before any current flowed through the telephone receiver, due to the presence of a thin film of oil—the passage of a current could, of course, at once be detected by breaking the circuit.

If now the switch S were left on the right-hand contact—*i.e.*, with the steel negative—it was found that, with the steel adjusted as above, whereas no current was flowing at first, a weak one very soon started, and gradually increased in value till there was quite a loud click in the telephone on breaking the circuit. On now raising the steel a very minute distance it was discovered that the arrangement was very sensitive to movement of the steel, and that very large fluctuations in current followed minute variations in the position of the steel.

If, however, the switch were thrown over to the left, so as to make the steel positive, the effect entirely disappeared.

The influence of different oils was tested, but among those tried ordinary glycerine seemed about the best. The phenomenon was quite a stable one, and could easily be reproduced at will immediately the point was made negative.

It seems that in action this greatly resembles Mr. Brown's microphonic contact, and that possibly the oil plays a more important part in the working than he seems to make out—at

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least, from what he says in the appendix, viz., that its function is merely to promote a slight oxidation of the surfaces of the osmium-iridium alloy of the contacts.

The general impression created by the statements in the Paper seems to be that the action of the microphone is explained by the passage of electrons across the air-gap; but how can this be the case if the air is excluded by oil? Of course, the electrons might as well flow across oil as air, but when one considers that the majority of oils are good insulators—*i.e.*, that there are very few free electrons in any given volume—this does not seem to be a very plausible explanation.

I should be glad if a good explanation could be given of this action, as it would most probably fit both phenomena since they seem so allied.

Whether the apparatus that I have described above would have any use in connection with telephone relays remains for further experiments to decide, but the fact that both pieces of apparatus "work best" when the point is negative seems significant.—I am, &c.,

Muswell Hill, N., May 10. PHILIP R. COURSEY.

EFFICIENCY OF SHORT SPARK METHODS OF GENERATING ELECTRICAL OSCILLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue Mr. Galletti gives an estimate of the efficiency of transference of oscillatory energy from the primary to the secondary of a generating set. The argument on which the calculation is founded is as follows: (1) With the secondary not coupled to the primary the power input P_1 is equal to the wastage W_1 in the primary. (2) With the secondary coupled to the primary, the power input P_2 is equal to the wastage W_2 plus the power U transferred to the secondary. Taking $W_1=K_1i_1^2$ and $W_2=K_2i_2^2$, where i_1 and i_2 are the primary currents in the above two tests, we get $P_1=K_1i_1^2$ and $P_2=K_2i_2^2+U$.

By assuming that (*a*) $P_1=P_2$ and that (*b*) $K_1=K_2$, Mr. Galletti obtains the efficiency $U/P_1=(i_1^2-i_2^2)i_1^2$. Even if assumption (*a*) be allowed, exception must be taken to assumption (*b*), as K_1 and K_2, the effective resistances of the primary in the two tests, being resident almost wholly in the spark, undoubtedly depend on the currents i_1 and i_2. As a fact, if $i_2<i_1$ then $K_2>K_1$, and the proper expression for the efficiency is $(K_1i_1^2-K_2i_2^2)/K_1i_1^2$. If K_2 be taken as only twice K_1 in Mr. Galletti's case, where $i_1=2i_2$, the calculated efficiency falls from 75 per cent. to 50 per cent., a figure near to that obtained by us. It would be interesting to know on what grounds your correspondent bases the questionable premises underlying his calculation.—We are, &c.,

South Western Polytechnic Institute. W. H. ECCLES.
May 14. A. J. MAKOWER.

TEMPERATURE COEFFICIENT OF COPPER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the correspondence which has appeared in your last two issues, occasioned by your review of our book on "Electric Cables: their Construction and Cost," it appears that the original subject has been dextrously displaced by a discussion on the merits of the temperature coefficient recommended by the Engineering Standards Committee.

This recommendation is contained in paragraph No. 4 of the Committee's revised report, and reads: "Resolved that the average temperature coefficient of 0·00238 per degree Fahrenheit be adopted for commercial purposes."

This, as it stands, can only mean that the Committee recommend the use of so-called "logarithmic" coefficients, and, therefore, for example, the coefficient for a difference of 28°F. will be the natural number corresponding to the logarithm

$$28(\log 1{\cdot}00238)=0{\cdot}02890692;$$

that is,

$$R_{32\,F.}=\frac{R_{60\,F.}}{1{\cdot}06883}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (i.)$$

It is, however, usual for commercial purposes to adopt a temperature resistance equation of the form

$$R=r(1+\alpha t).$$

But the above resolution cannot be concerned with this form, because no mention is made as to the standard temperature, and we should therefore be led into chaos, since we have, for example

$$R_{70}=R_{60}\{1+0{\cdot}00238(10)\}=1{\cdot}0238R_{60},$$

and again—

$$R_{60}=R_{70}\{1+0{\cdot}00238(-10)\} \text{ or } R_{70}=1{\cdot}02438R_{60}.$$

However, this being the resolution of a Standards Committee, and finding that the preceding three resolutions specifically mention 60° F. as the standard temperature, one is tempted to fill in the void of paragraph 4, thereby obtaining the formula $R_t=R_{60}\{1+0{\cdot}00238(t-60)\}$, which would meet the case of 99 per cent. of electrical resistance tests (60°F. being the standard temperature for comparison except in the limited field of submarine cables) *providing* the coefficient 0·00238 is correct. This formula gives

$$R_{32}=\frac{R_{60}}{1{\cdot}0714}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (ii.)$$

Now, I understand that Messrs. Clark, Forde and Taylor give as the result of their experiments

$$R_{32}=\frac{R_{60}}{1{\cdot}06665}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (iii.)$$

whilst the table given in our book (p. 89) shows

$$R_{32}=\frac{R_{60}}{1{\cdot}0632}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (iv.)$$

Which of these four coefficients best meets the case of commercial copper conductors must be decided from everyday practice, and not from a few experiments.

The two coefficients derived from the E.S.C.'s recommendations are ridiculously high, and can be at once discarded. With regard to the coefficient given in our book, I have found this to be reliable in all cases and it is used, I understand, by the majority of cable manufacturers. Messrs. Clark, Forde and Taylor's coefficient I have always found to be too high, although I believe it is used by one or two cable firms—one of which, however, repeatedly obtains inaccurate results when the temperature difference is at all appreciable.—I am, &c.,

Old Charlton, Kent, May 14. F. O. HOWE.

SWITCH AND TRANSFORMER OILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the discussion of Messrs. Mellis and Digby's Paper on Switch and Transformer Oils, published in THE ELECTRICIAN, April 29th, Mr. Pollard claims that alkali in a transformer oil would not be detected by phenol phthalein when the oil was shaken up with water.

It is true that the free alkali in soaps may be estimated by taking advantage of the fact that phenol phthalein is unaffected by the soaps of alkali metals in "alcoholic" solution. In aqueous solution, however, the case is totally different since hydrolysis takes place liberating free hydroxyl ions (*see* Lewkowitsch I., 56, and Mellar's "Chemical Statics," 212), which react strongly alkaline to phenol phthalein.

The same is true of alkaline carbonates and alkali salts of naphthenic and sulphonic acids, sometimes present in oils. Accordingly, exceedingly minute traces of alkali, whether present as carbonate, soap or combined with petroleum acids, can readily be detected in the aqueous extract by phenol phthalein, when oils containing these compounds are shaken up with "water."

Imperial Oil Works, Salford, JAS. ED. SOUTHCOMBE.
May 10.

We have submitted the above letter to Mr. Pollard, from whom we have received the following reply:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Southcombe's assertion, in his letter dated the 10th inst., that I claim "that alkali in a transformer oil would not be detected by phenol-phthalein when the oil was shaken up with water" is not warranted by any statement of mine.

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In replying to the discussion I said "It seems to be generally taken for granted that the alkali in oil invariably exists as hydroxide. This is very far from being the case; and, consequently, when phenol-phthalein is used as an indicator considerable traces of alkali escape detection."

The following particulars of recent experiments prove that a comparatively large quantity of sodic carbonate (Na_2CO_3) in aqueous solution gives no indication of alkalinity with phenol-phthalein:—

1. In 10 cc. of neutral distilled water (having a specific conductance of somewhat less than three reciprocal megohms) cochineal gave a sharp and distinct reaction with 0·00003 gm. of sodic carbonate, added in aqueous solution: methyl orange gave a distinct change of tint with the same quantity of sodic carbonate; whilst phenol-phthalein required 0·0004 gm. of sodic carbonate before giving a feeble indication.

2. In 20 cc. of extremely faintly acid distilled water (specific conductance, four reciprocal megohms) 0·00006 gm. of sodic carbonate gave a decided reaction with cochineal; but 0·0008 gm. of sodic carbonate was required by phenol-phthalein.

3. In 20 c.c. of distilled water, of approximately the same quality as that used in experiment No. 2, cochineal gave a sharp indication with 0·95 c.c. of solution of sodic carbonate containing one part in ten thousand; whilst phenol-phthalein took 12·75 c.c. In this experiment the solution of the carbonate contained a large proportion of the faintly acid distilled water.

Mr. R. T. Thomson's researches on indicators quoted by Sutton (volumetric analysis) and Crookes (select methods) go to show that phenol-phthalein is not a suitable indicator of alkalinity when "soda exists as hydrate along with sodium carbonate if the proportion of carbonate is large"; that in the estimation of alkali existing as carbonate and bicarbonate phenol-phthalein requires tedious boiling with carbonates of fixed alkalis; that it gives results considerably too low if sodium silicate is present, and "for the estimation of soda in borax is utterly useless."

Soap is hydrolysed by water to only a very limited extent (Wright and Thomson, "Journ." Soc. Chem. Ind., IV., 630); and Mr. Southcombe's opinion, that "exceedingly minute traces of alkali," whether present as carbonate, soap, &c., can be readily detected in the aqueous extract by phenol-phthalein, does not exactly coincide with that of other investigators.—I am, &c.,

F. Ernest Pollard.

28, Victoria-street, Westminster, May 17.

PAUL'S NEW UNIVERSAL TESTING SET.

Up to within a few years ago the mains engineer was a member of that numerous class whose lot, like that of the Gilbertian policeman, was not a happy one. Although we do not wish it to be supposed that we consider nocturnal calls and midnight wanderings to investigate the results of a meandering pickaxe to be exactly an ideal condition of livelihood, yet matters are better in at least one respect than they used to be.

The respect to which we refer is in regard to testing sets. At one time a fully equipped mains engineer required to be followed by a transport train carrying the necessary instruments. Now, however, compactness is the fashion, and he can practically carry unaided all the instruments he is likely to require. This advance has been made possible by the concentration in one box of all the testing equipment which it is necessary to use on such occasions, and much ingenuity has been expended by various makers in obtaining this condition, with the result that some very interesting instruments have been designed.

Among the latest of these, and certainly not the least interesting, are the direct-reading "Unipivot" universal testing sets made by Mr. Robt. W. Paul. These sets are made in two patterns, the first of which is shown in Fig. 1. This pattern is capable of dealing with pressures between 0·0001 and 600 volts in nine ranges, with resistances between 0·00001 to 10 ohms in four ranges, and between 0·01 and 600 megohms in seven ranges, with currents between 0·000001 and 120 amperes, and with power up to 72 kw.

Dealing with the external features, the set is fitted in a strong teak case with detachable lid, lock and leather handle, and may be used on a table or other support, or a removable tripod can be supplied for outdoor use. The internal parts are highly insulated, and all electrical and mechanical details are carefully designed, the movement and switches being mounted on separate metal base-plates, supported from the ebonite front of the instrument. The terminals are plainly marked and widely spaced, they are ebonite covered to prevent accidental shocks, and there are no other external live parts. The ebonite front is fitted to the case with watertight joints; there are no openings to admit dust, draughts or moisture to the working parts, nor do any parts project when the case is closed.

The essential parts of the set comprise a direct-reading microammeter capable of being connected across a universal shunt, a series resistance for use when measuring pressures and insulations,

Fig. 1.—"O" Pattern Universal Testing Set.

two small series resistances for use when measuring millivolts, also a resistance equivalent to that of the universal shunt which is substituted for it when measuring millivolts. Two standard shunts, having their resistances adjusted to decimal parts of an ohm, are used for measuring currents by the drop at their potential points, which is read at the millivoltmeter terminals.

The microammeter is of Mr. Paul's well-known "Unipivot" construction, shown in Fig. 2, which it is claimed requires neither levelling nor setting in any particular position, and is unaffected by vibration or external fields. The movement of the pointer is quick and dead-beat and without frictional error. The single pivot on which the

Fig. 2.—The "Unipivot" Construction.

coil turns is protected from injury during transit, being lifted entirely from the jewel on depressing a plunger, either by hand or by closing the lid of the instrument; this plunger may be locked down by giving it a slight turn, and is automatically locked on closing the lid. An external adjustment provides for setting the pointer to zero should this become necessary.

All connections between the instrument and the rest of the set are controlled by a double-pole switch, shown in the centre of Fig. 3, which minimises any risk of damage by wrong connection. Further, should the negative pole be in error connected to the positive terminal of the instrument, this switch still makes it possible to read

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both the current and voltage without altering the leads—an arrangement which is certainly an advantage when there is not much time to spare. Further, all the advantages of a centre-zero instrument are obtainable with a long scale of 120 divisions. This switch makes it possible to read quickly with accuracy the current and voltage on both sides of a three-wire system.

As shown in Fig. 3, the connection inside the instruments consist of two parts, that to the left of the diagram dealing with pressures and insulations, and that to the right with millivolts and current. The various parts of the instrument are g, the microammeter, having a resistance of 60 ohms, and reading from 0 to 120 micro-amperes; s, the universal shunt, having a total resistance of 600 ohms and seven shunt powers—viz., 1, 2, 5, 10, 50, 100 and 500; and r, a resistance of 20,000 ohms, designed to withstand pressures up to 600 volts.

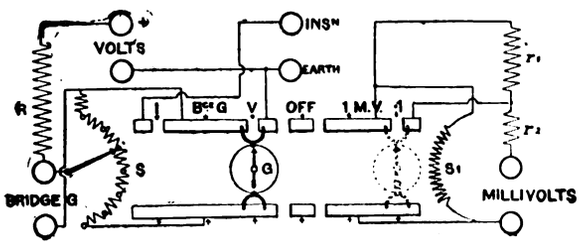

FIG. 3.—CONNECTIONS INSIDE THE TESTING SET.

Pressures applied to the terminals marked volts are read off directly on the scale, the ranges being 0·02 to 2·4; 0·04 to 4·8; 0·1 to 12; 0·2 to 24; 1 to 120; 2 to 240; or 10 to 600 volts, according to the positions of the shunt switch, which are marked with the corresponding values. An extension of five divisions at the upper end of the scale renders it possible to read pressures a little above the nominal range. For direct pressures above 600 volts an external volt box may be used.

To measure insulation the resistance under test is connected between the terminals marked Insn. and Earth. The double-pole switch is placed on v, and the deflection obtained when the test pressure is applied across 20,000 ohms. The double-pole switch is then thrown over to I, and the deflection obtained when a suitable shunt power is used with the insulation under test in circuit. Multiplying the deflection by the shunt power and dividing the testing pressure

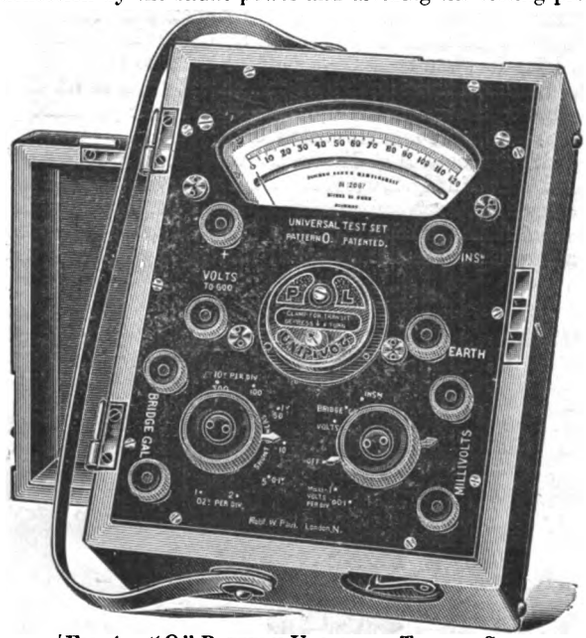

FIG. 4.—"O" PATTERN UNIVERSAL TESTING SET.

by the product gives the number of megohms. The maximum insulation readable in megohms is the same as the testing voltage available, which may be furnished either from the mains or by a portable battery. Two separate terminals, marked bridge G, render the microammeter and its shunts separately available as a sensitive galvanometer set, for use with the Wheatstone bridge or in fault localising by Murray or Varley loop tests.

The parts shown on the right of the diagram (Fig. 3) are: S_1, a resistance of 600 ohms, replacing the universal shunt so as to maintain the resistance of the microammeter circuit at its original value; and r_1 and r_2, series resistances bringing the total resistance between the millivolt terminals to either 1,000 or 100 ohms. When the double-pole switch is in the position shown by the dotted lines in the diagram, the scale reads from 0·1 to 12 millivolts; the second position giving a range from 1 to 120 millivolts. The same change-over arrangement as that mentioned above is available in this case also.

Currents are measured by one of two standard shunts, not shown in the diagram, which is joined in the circuit in which the current is to be measured; owing to the high internal resistance of the millivoltmeter, the shunt may be, if necessary, used at a considerable distance from the set, as the error due to the leads is negligible. Shunt A has a resistance of 0·1 ohm, and is used for measuring currents from 0·001 to 0·12 amperes on the lower, or 0·01 to 1·2 on the higher, millivoltmeter range. Shunt B has a resistance of 0·001 ohm, with ranges for current measurement from 0·1 to 12, or 1 to 120 amperes. Both shunts are conveniently packed in the lid of the instrument, and additional shunts may be provided, if required, for measuring up to 2,400 amperes. Very small currents may be measured at the bridge galvanometer terminals. When measuring power in a continuous-current circuit, the pressure and current may be measured in rapid sequence by turning the double-pole switch, without the necessity of changing the external connections.

Small resistances, from 10 ohms down to 0·00001 ohm, may be measured by joining them in series with one of the standard shunts and passing through them a small steady current, say between 0·1 and 10 amperes, and comparing the fall of potential across them by means of the millivoltmeter. Owing to the high internal resistance of the millivoltmeter, heavy potential connections are unnecessary. This method is suitable for measuring resistances of armatures, transformers, rail bonds, coils and similar low-resistance circuits. For measuring the temperature of electrical or other machinery, or of flues or furnaces, thermo-couples are supplied by the maker for use in conjunction with the millivoltmeter portion of the set. For use in accurate resistance measurements from 0·1 ohm to 111,000 ohms by means of the Wheatstone bridge, and for fault locating by the Murray or Varley test, the necessary additional accessories can be fitted in one case with the universal testing set without detracting from its portability. No separate ammeter is needed when using the set for locating faults by fall of potential method. When used

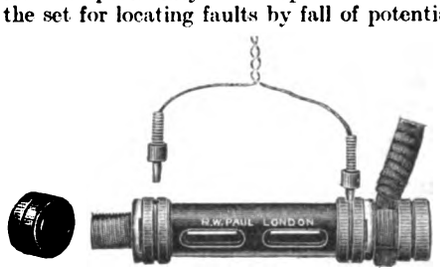

FIG. 5.—SPECIAL FORM OF TERMINAL.

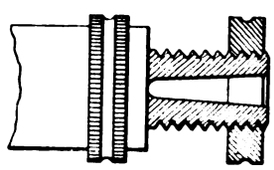

FIG. 6.—VIEW OF CONNECTION USED ON SHUNT.

as a ballistic galvanometer for comparing capacities the microammeter gives a complete throw across the scale for 100 microcoulombs, and it is frequently used in this manner for locating discontinuities in underground cables.

The second pattern testing set (Fig. 4) is similar to that described, but the scale is longer, and each division corresponds to one-fifth of a microampere. This improvement involves the use of a larger and more powerful moving coil system, the resistance of the moving coil being 350 ohms and that of the shunt 2,500 ohms, while the two series resistances in the millivolt circuit are of 500 and 5,000 ohms respectively. Further, the resistance between the volt terminals is increased to 100,000 ohms, giving an advantage in locating high-resistance faults by the fall of potential method, while an additional terminal enables this to be reduced to 20,000 when it is required to use the instrument for low-resistance work. It will therefore be seen that this pattern instrument is considerably more sensitive than that described above.

One detail of this instrument is worthy of special attention. The instrument is fitted with a translucent dial, while a hole in the back of the box permits the insertion of a special fitting containing a 2-volt lamp. In this way the scale can be illuminated at night. When not in use this lamp can be packed away in a brass case in the lid of the box.

To allow the connection of all sizes of cables to the larger shunts a special form of terminal is used, which we illustrate in Figs. 5 and 6. It consists of a copper pillar slotted out on a taper and tapped on the outside to take a circular milled head nut. The cable is inserted between the jaws of the taper and the nut screwed down until good contact is made. In this way good contact is always ensured.

We had the pleasure of inspecting one of these sets the other day, and must congratulate Mr. Paul on the results he has obtained. The set weighs only 15 lb., and is so well balanced that there seems no possibility of its ever catching its carrier in that exceedingly weak portion of the anatomy just behind the knee. This disadvantage was a feature of certain other sets. As will be seen from our illustration, the set is designed for mounting on a tripod.

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SPARK-GAP PHENOMENA.*

BY J. M'WHAN, M.A.

Summary.—The author describes phenomena observed in connection with a solid dielectric placed between the terminals of an induction coil or influence machine. Experiments on the repulsion of the dielectric, the characteristics of the brush discharge, the influence of low pressures, &c., are described.

In a recent note to the Royal Society of Edinburgh,† Dr. Dawson Turner remarks on a peculiarity observed by him in the behaviour of an induction coil spark-gap when a piece of mica, glass, sulphur, ebonite, &c., is placed between the terminals, near or against the + one. The surprising variety of the phenomena exhibited on the interposition of a solid dielectric plate between the two poles of such a coil (or between the poles of an influence machine) may make the following observations (carried out in the University of Göttingen) of some interest. The observations in question were made during the course of an inquiry into the causes of the Lullin effect (according to which a thin dielectric plate interposed between two sparking terminals *not* opposite to one another is, as a general rule, perforated at the negative pole). A motor-driven influence machine whose terminals were connected through a battery of Leyden jars in cascade to a specially designed spark-gap, which allowed of any three dimensional motion of the electrodes being accurately measured and of any desired form of electrode being inserted, was used. A second spark-gap, fitted with standard spherical electrodes was connected in parallel with the first. By adjusting this second gap just to spark synchronously with the first, the P.D. of the first could easily be deduced. This method was found preferable to the use of an electrometer. Within certain limits for the dimensions of the dielectric, sparking may often be induced by placing it near or against the positive pole; and the opposite effect may be obtained by setting it at or near the negative pole. [This experiment, however, and most of the others described, will time and again *seem* to fail, owing to non-fulfilment of some one of the many limiting conditions. Thus the P.D. may not be near enough to the spark potential for free air, the dielectric may be too thick or too thin, or too broad, &c.] Even at the negative pole, however, it may be observed that if a dielectric plate be suddenly dropped vertically between the poles, a violent discharge at once takes place, and, curiously enough, more easily as a rule when the plate is so thin as to be easily ruptured by the discharge. The whole phenomenon, and particularly the violence of the discharge, is most strongly marked when, at the instant of the plate's fall, the terminals of the coil are giving off the characteristic brush discharge. Again, if the dielectric be so set up that it is at right angles to the lines of the electrodes and can be moved freely in the direction from one electrode to the other, some interesting results may be noted. Thus, if each electrode is spherical, motion of the card in the direction from the + electrode to the — electrode results in a great facilitation of the spark, while motion in the opposite direction distinctly acts as a deterrent. A little paddle-wheel, whose paddles are made of the dielectric in use, may be set up so that the paddles when rotating pass, at the lowest point, between the electrodes from + to — and provoke a steady stream of sparks. The converse of this experiment—the "quenching" of an already sparking gap by rotation in the opposite sense—is more difficult to perform, but usually can be got to succeed with a little patience. The same results are to be observed when each electrode is fitted with a conical cap, or point. But if one be spherical and one conical, an important difference comes in, for now the direction of motion for provocation of a spark is found to be *always* towards the conical electrode, no matter whether it be + or —. Also the dielectric itself is in this case under a continuous and very sensible repulsive force tending to drive it towards the spherical electrode, again quite independently of the polarity of the electrodes. There are, of course, limiting conditions to the above experiments, for example, if the angle of the conical electrode be increased indefinitely until the cone degenerates into a plane surface, the preference of the spark for that electrode naturally diminishes. It may also be noted that when a discharge followed by perforation of the dielectric has once been induced by motion of the dielectric, the difficulty of provoking a second spark discharge becomes still greater than formerly: on examining the apparatus in the dark it is usually easy to discern the faint lines of an almost silent discharge threading the hole from electrode to electrode.

Repulsion.—Doubrava has pointed out‡ that in general any dielectric plate set between discharging electrodes experiences a definite force tending to displace it in the direction of one of the electrodes. He declares, however, that "the experiment only succeeds when the electrodes are sufficiently separated to give a crackling brush discharge." This is not the case. Repulsion effects on all kinds of plates are observable even when the electrodes are speaking freely (*through* the plate, or round its edge) or discharging by the so-called "silent" discharge. In the present instance, dielectric plates (16 cm. × 16 cm.) were suspended midway between the electrodes by a fine silk bifilar suspension from insulators on the ceiling. The suspension was about 15 ft. long, a length sufficient to permit of even very small forces producing sensible deflections, and the plate itself was screened off from draughts. In the case of metal plates, however, which were also found to exhibit repulsion phenomena, one thread can conveniently be replaced by a fine copper filament leading to an electroscope screened from electrical action by fine wire gauze.

In general it was found that when the electrodes were of similar shape and size, discharge between the electrodes resulted in a strong repulsion of the plate in the direction from the + to the —. Preconceived theories of this repulsion, such as that of a possible hydro-electric excitation of the surface of the plate by the discharge, are upset when we employ electrodes of different shapes. Thus, if the sphere and cone be again used, it does not matter which is + and which —: the repulsion is always violent, and in the direction from the conical electrode to the spherical one, regardless of polarity. If the electrodes are not opposite one another, then, on reaching the sphere, the plate is rotated through a considerable angle. If the plate is not allowed to touch either electrode, but is tested immediately after the discharge, it shows always the sign of the conical electrode. When the electrodes are similar, it shows always the sign of the repelling electrode, *i.e.*, +. Another curious phenomenon occurs in the case of similar electrodes, *e.g.*, spheres. Let the plate be repelled against the — electrode, and remain there

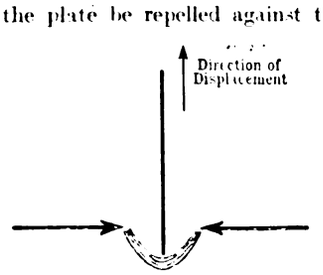

FIG. 1.

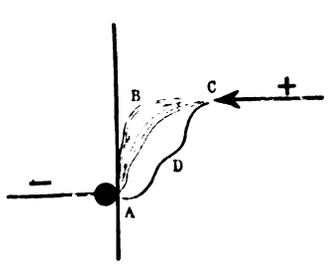

FIG. 2.

during discharge. If the electrodes are not opposite one another, it will again show rotation, but this time of the opposite sense to that mentioned above. That is to say, it behaves as if attracted simultaneously by both electrodes, but with the — electrode in predominance. This effect could not be obtained with metal plates: it may hence be inferred that different parts of the dielectric plate are in this case in different electrical conditions as regards charge.

If the plate be light enough, and the electrodes placed so near the edge of the plate that the path of least resistance for the discharge is round the edge of the plate instead of through it, a considerable horizontal displacement of the plate in the direction of its own length may take place, as shown in Fig. 1. Observed in the dark, the phenomenon is a very beautiful one, the rays of the discharge appearing like luminous elastic strings attempting, in a contractile effort to straighten out, to pull the plate aside—in fact, like luminous Faraday lines of force. The electrification of the plate is slight, and practically indeterminate as regards sign.

Brush Discharge.—When a dielectric is placed between two electrodes excited to a potential sufficient to produce the brush discharge, examination in the dark reveals some interesting details. The discharge is seen to be made up, as in ordinary cases, of a bundle of luminous threads, each pursuing a quite independent path; but at one part of their course these threads converge, and pass almost wholly through one point. This point lies *on* the dielectric (usually on the + side), is brilliantly illuminated, and is found to be in every case *the site of the perforation* consequent on the exciting of the electrodes to spark potential. Although, however, the point of concentration of the rays usually determines the point of perforation, the spark does not, except in simple cases, follow the path of the brush discharge. Fig. 2 illustrates a typical case of this, ABC being the path of the brush, ADC the approximate spark-path. The point of concentration A is common to both paths. In this case a hole made in the card between the electrodes would have no appreciable effect on the path of the brush.

Some remarkable "dark-space" phenomena can also be easily

* Abstract of a Paper read before the Royal Society of Edinburgh.
† "Proc." Roy. Soc. Edin., 1908-9, Vol. XXIX., p. 414.
‡ "Wiedemann Annalen," Bd. VIII., p. 476.

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observed or photographed. Fig. 3 gives an example: the observer is looking from above on to the spark-gap below. The + side of the card for the whole distance between the electrodes is strongly illuminated: from the — (conical) electrode proceeds little more than a point of luminous discharge—between that and the card all is dark. The rays from the + (spherical) electrode have the peculiarity of lying entirely in one horizontal plane: they, too, after bridging about one-half the gap between card and electrode, vanish abruptly, the end of the discharge being perfectly straight and regular. If, now, the card be moved slowly towards the anode, a change takes place in the character of the brush. Fig. 4 is a side view showing that change. At a certain stage in the motion, the horizontal brush suddenly splits into two brushes, each uniplanar; and as the card continues to approach, these continue to diverge, each making at any time the same angle as the other with the plane of the electrodes. Many varieties of these experiments can be designed by making holes at various points in the plates between or outside the electrodes, or by bending the plate itself into various shapes.

An attempt was made to observe the influence of low pressures in air and other gases on these phenomena, and on the Lullin effect. A strong glass bell-jar was accordingly made to contain the spark-gap and a contrivance for supporting or suspending the dielectric. The dimensions of the jar were approximately: height, 40 cm.; average thickness, 1 cm.; mean inside diameter, 25 cm. It was made in two parts for convenience of access to the interior. In the first experiment the air was exhausted to a pressure of about 4 mm. Hg and a spark passed. Instantly the lower half of the jar split, with a loud report, from top to bottom. Lehmann has observed the same phenomenon when working on discharges through gases in large vessels. The danger of breakage is, however, not entirely confined to *large* vessels. After the bell-jar had broken, it was

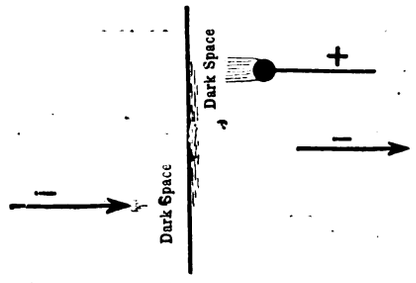


FIG. 3.

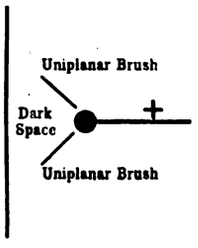


FIG. 4.

decided to abandon the idea of getting the special spark-gap bodily into the vessel. A cylindrical glass tube, 14 cm. in length and 5 cm. inside diameter, was taken instead. The ends were open, but could be closed by two plane slabs of glass, bored to allow stout pieces of copper wire (which were to do duty as the electrodes) to enter, and the whole was rendered air-tight with sealing-wax. This stood successfully the first and second discharges, but on the third the lower end of the tube was completely shattered.

In experiments as described above, the vagaries common to most electrostatic experiments performed in the free air of a laboratory are of course prominent, especially during adverse atmospheric conditions; and results on occasion display such consistent inconsistency as to baffle serious consideration. For this reason only a few phenomena, substantiated beyond reasonable doubt, have been quoted. These should be sufficient, nevertheless, to draw attention to the complete absence of a theory regarding the presence of dielectrics in a spark-gap, which will deal satisfactorily with all cases. The further surprising divergences met with when the dielectric has imposed upon it a drop or drops, of various shapes and sizes, of wax, stearine, &c., make the problem still more difficult.

ELECTRICAL CONVEYOR FOR WAREHOUSING PARCELS.

In busy cities, particularly those concerned in the textile industries, an enormous amount of lorry traffic with comparatively small parcels exists. In Manchester, for example, thousands of loads daily of yarn bundles, piece goods and the like are conveyed by lorries to and from warehouses in the city. One finds similar conditions with textiles, provisions, light hardware and so on in the City of London, and in Birmingham, Liverpool, Glasgow, Nottingham and elsewhere.

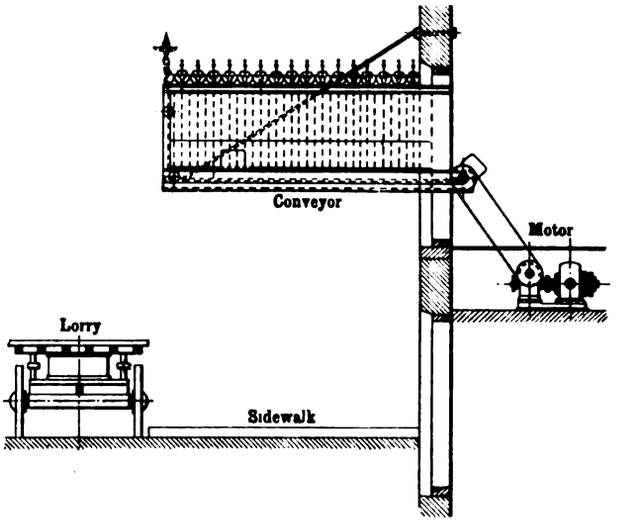
The usual practice is to build important warehouses with a frontage to a main thoroughfare, and with one or more of the other sides abutting upon a narrow side street or alley, into which the lorries draw up and from which the lorry man unloads by throwing his parcels through a window or down a shoot. The result is that during working hours these by-streets are practically impassable for pedestrians, while in London and Manchester, for example, one often sees long trains of lorries waiting for hours for their turn to unload. Then, again, there often is congestion at one side of the warehouse and comparative idleness at the front. The Corporation authorities very properly veto any such unloading as will inconvenience the general public in main streets.

One of the leading shipping houses in Manchester, who were urgently in need of additional loading and unloading facilities, recently invited Mr. T. Roland Wollaston, of Manchester, to devise a means whereby they might load and unload from and to their main frontage in Peter-street, with the result that the device, which is the subject of this notice, was designed, patented and has proved of great utility.

It was from the first recognised that the authorities would not sanction anything of the nature of an ordinary elevator hanging over the footway, nor, on the other hand, could anything which involved a high degree of skill or care on the part of the lorry man be considered. One had also to remember that any such contrivance must not unnecessarily disfigure the handsome elevation of the warehouse.

Now, permanent awnings, such as one may see at the entrances of most hotels and public buildings, are ornamental and useful as shelters, while, if fitted as cantilevers, they present no footway obstruction.

The device comprises a permanent awning of this type, with arched roof, and sheet-iron bottom, projecting out from a window of the building and across the footway, so that the front is plumb with the



GENERAL ARRANGEMENT OF CONVEYOR.

curbstone. Within the hollow trunk so formed runs a lattice conveyor belt which extends just so far within the building as is necessary for the convenient reception of the parcels. The front of the awning towards the roadway is provided with a large opening which, when the apparatus is idle, is closed by an ordinary roller-shutter door, operated and locked from within. The lorryman has simply to throw his parcels haphazard through the opening, when they fall upon the belt and are conveyed and delivered inside. The belt is driven through a Renold chain and worm-reducing gear from an ordinary Crompton direct-current electric motor. At the preliminary trial of this apparatus 600 10 lb. bundles of yarn were unloaded in 25 minutes, the rate being nearly double the highest recorded at the back of the building where similar bundles are thrown across the narrow footway through open windows.

The apparatus embodies one or two somewhat novel constructional features. The local authorities insist upon a minimum of 10 ft. of headroom under the awning, which is somewhat higher than one would wish for the lorryman's convenience in throwing in. Therefore it was necessary to keep the upper side of the travelling band as low as possible, or, in other words, to keep the end rollers or wheels small in diameter. Now an ordinary conveyor belt of cotton or leather, 5 ft. wide and to carry 10 lb. bundles, would have to be very substantial, and would not turn easily over rollers, say, 6 in. in diameter. It would be heavily stressed thereby and would absorb much power uselessly. Similarly a lattice belt formed of timber or iron slats and of the above width, carried on pitch chains, would necessarily be very heavy. The actual belt is formed of Ewart's

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patent pitch chains at either side, running over end sprockets about 5 in. in diameter. Alternate links of these chains are prepared to carry pins in the ends of the slats which are composed of the metallic conduit tube commonly used for electrical wiring. These tube slats, about ¾ in. outside diameter and pitch 3½ in. apart, are very light, sufficiently strong, and present a smooth surface unlikely to damage fragile goods.

A reversing switch enables the conveyor to work either inwards for unloading or outwards for loading.

The following are approximate details:—

Width of conveyor	5 ft.
Opening for parcels	5 ft. by 2 ft. 9 in.
Speed of belt	40 ft. per minute.
Rating of motor	2 H.P.

THE JAPAN-BRITISH EXHIBITION.

The interest of engineer visitors to the Japan-British Exhibition naturally centres in the Machinery Hall. Although this is not filled with exhibits to the same extent as on the occasion of the Franco-British Exhibition, still, the show of general engineering, mechanical and electrical apparatus is well worth inspection. The Japanese section of the hall is confined to one leg of the U, which letter the hall resembles, and the remainder is devoted to British exhibits.

Japan is essentially a country of earthquakes; consequently one may expect to find the study of seismography reduced to a science. Judging by the fine examples of seismographs at the entrance to the Japanese portion of the hall this is certainly the case. The Imamura seismoscope is displayed together with a number of records taken on it. Also the Omori tremor recorder and a collection of seismograms. The instruments utilise electricity in a portion of the recording mechanism, and we hope to return to a more detailed description of them later. At the time of our visit to the Exhibition the stand was unattended and no particulars could be procured.

The Imperial University of Japan exhibits a large collection of portfolios containing drawings by the students. The electrical engineering portfolio gave full details of a direct-current generator. Beyond a section of a Japanese centrifugal pump and examples of a wood-testing machine, there does not appear to be anything further of engineering interest in the Japanese section.

The feature of the British section is the textile machinery exhibit which has been made by a number of Lancashire manufacturers. Prominent among these is the display by Platt Bros. & Co., who have installed machinery which shows practically the whole of the operations performed on cotton from the bale to the finished goods—both fine and coarse. This machinery is grouped on each side of the central aisle in the Machinery Hall. Electric driving has been adopted and the one-half of the machines is belted to countershafting driven by a polyphase motor, the other half being operated in a similar manner by a direct-current motor. The alternating-current motor is a 40 H.P., 525 volts, 50 ∿, 575 revs. per min., slip-ring machine, and is connected to the shafting by three cotton ropes. A weft ring frame is driven by a 15 H.P., 962 revs. per min. motor, which drives the main shaft through a Hele Shaw clutch. This latter is provided to give smooth starting so as to avoid "breaking down the ends." Included on the stand driven by the alternating-current motor is a spinning mule which makes a difference of 15 amperes to the load, when the mule is drawing out. The direct-current motor is a 60 H.P. machine, running on 500 volts at 600 revs. per min. It drives the bale opening, breaking and blowing machinery on the other stand. The exhibit is quite the most interesting collection of textile machinery demonstrating progressive stages of cotton manufacture that we have seen.

There is a good collection of electrical exhibits which include Chloride accumulators, Linolite, Float Battery lamps, Sturtevant fans, Dugdill pendants, Maxim lamps and Western Electric telephones. Electromotors (Ltd.) have a display of their standard direct-current machines, both as motors and dynamos. The exhibit also includes a motor generator supplied at 500 volts from the Exhibition network and delivering current at 250 volts within the Machinery Hall.

The General Electric Co. have a brilliant display of Osram lamps, which are shown in sizes from 2 to 400 c.p., and they are also making a special demonstration of "Striplite," which has been designed to comply with the L.C.C. requirements for showcase lighting.

The heavier machinery exhibits are provided by Armstrong, Whitworth, Vickers, Sons & Maxim and the Thames Ironworks & Shipbuilding Co. These firms show models and photographs of ships built for the Japanese Navy and parts of guns, gun carriages, Maxims, &c. Armstrong, Whitworth have put down some large machine tools, a lathe, boring mill, shaper and slotter, each of which is driven by independent electric motors. Vickers also make a good show with various types and sizes of electric motors, both alternating current and direct current and suitable controlling gear. Mounted high above the stand is the barrel of a 12 in. gun.

The general illumination of the Exhibition is, of course, entrusted to electric lamps, and at present the outlining of the buildings is still done with carbon lamps. Metal filament lamps are, however, to be seen in large numbers throughout the various buildings and stalls. We shall return to a more detailed account of the electrical features of the Exhibition in an early issue.

SIEMENS WORKS AT WOOLWICH AND DALSTON.

We have received from Messrs. Siemens Bros. & Co. a well-illustrated description of their works at Woolwich and Dalston. The former of these, as is well known, was established in 1864, and until 1904, when the dynamo and motor branch was transferred to Stafford, was the scene of all this firm's manufacturing activities in this country. At the present time the works are fully employed in making submarine cable, as well as cables for electric light and power purposes. Further, there are well-equipped cabinet-making shops as well as shops in which instruments, railway signalling apparatus and batteries are turned out. In connection with all these operations there is a very complete testing department, while

FIG. 1.—PART OF INSULATING TAPE SHOP.

the whole works are supplied with electric power from a private power house containing five 300 H.P. engines. Some new photographs of these works are given herewith.

The Dalston works are, as is well known, a comparatively recent outlet for the firm's activities in manufacturing Tantalum lamps. They were opened in 1908, and contain on the ground floor a general packing and despatching department, as well as a receiving department and fitting stores. The rest of the works is devoted to the manufacture and storage of Tantalum lamps, ventilating, heating and transforming machinery being situated in the basement, while out-buildings on the south side contain the necessary generating station for the supply of light, power and other auxiliary machinery. Special precautions are taken to protect the buildings from fire, a system of sprinklers and fire alarm indicators, under the control of the company's fire brigade, being installed.

The many processes involved in the manufacture of Tantalum lamps are carried on to a certain extent simultaneously, but the following description illustrates approximately the manner in which the lamps are built up and completed for sale. A Tantalum lamp consists essentially of three parts, namely, the "foot," the filament and the glass bulb. The "foot" is made up of flanged sealing-in tube with leading-in wires, and the "spider" or filament support. The flanged tubes are formed in the following manner: A glass tube is cut up into suitable lengths and these are inserted into a specially designed revolving machine, one end of each tube being brought into contact with a gas flame. When sufficiently hot a device is pressed into the tube so as to form a flange or funnel, and the flanged tube is then complete. The copper leading-in wires are finished off by being brazed on to short pieces of platinum wire,

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which, in turn, are brazed on to copper electrodes. The "spider" consists of a small glass rod, on which two buttons are worked up, a radial set of copper wire arms being inserted into each button while hot. The various component parts of the "foot" are now assembled in the shop, where they are put together in a specially constructed machine. The portions that have to be melted together

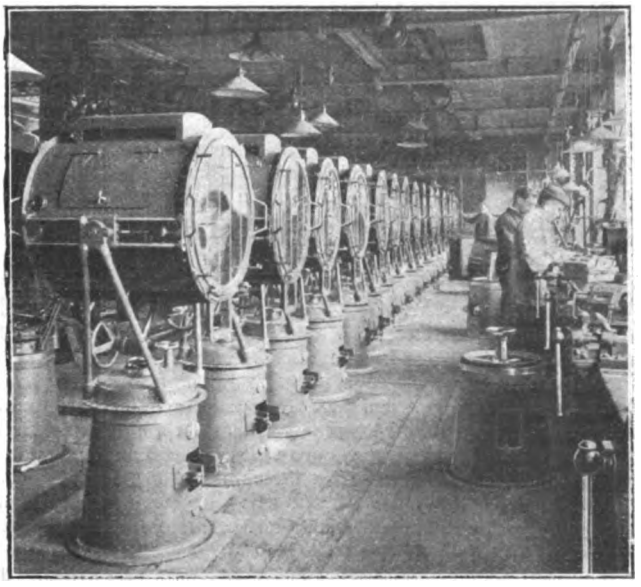

FIG. 2.—PART OF FITTERS' SHOP.

to make the "pinch" are gradually heated in the gas flames until they are sufficiently hot, when they are squeezed or pinched together, an operation requiring great care.

The "foot," being completed, is now ready to go to the winding room. Here the copper arms of the "spider" are pulled into shape and the hooks are made on which the tantalum wire is wound. The operator measures off suitable lengths of tantalum wire, one end of which is pinched into the tube which has been formed at the end of one of the copper electrodes; the wire is then wound round the arms of the spider and the other end is pinched into the second electrode.

The filament being now wound on the "foot," the next operation is that known as "sealing-in," by which the complete foot is melted into the bulb. But the bulb has previously been stemmed for exhausting, a small hole having been blown in the bottom of the bulb, to which a piece of stemming or exhausting tube has been joined on, an operation requiring some skill, as it is at this point that the lamp is finally sealed to form the "pip."

The first operation involved by sealing-in is to cut off the neck of the bulb evenly, and at the right distance from its shoulder, so that the filament will occupy its correct position in relation to the shape of the bulb. This having been done effectually, the "foot" is placed in the bulb, with the flanged part of the tube about ¼ in. up the neck; this point is then brought into a gas flame and rotated on a special machine, so as to obtain even heating, the bulb neck being melted thoroughly on to the flange, thus making absolutely an air-tight seal. The sealed-in bulb is then placed in an annealer and allowed to cool slowly.

The next process is that of exhausting the air from the bulb. The lamps are sealed on a vacuum pump by the stemming tube being connected, firstly, to the rough or "fore" vacuum pump, which exhausts the greater part of the air, and then to the fine or finishing vacuum pump.

When the vacuum has reached a certain degree current is passed through the filament, in order to drive off any occluded gases. During this operation also the lamps are subjected to great heat by means of so-called "heating caps," with the object of driving off any air which may be adhering to the inside of the glass bulb. Finally, the current is switched off and the lamp is sealed off by means of a small pointed gas flame, the "pip" end of the lamp being formed by this means.

This operation concludes the general manufacturing processes, but the lamp has yet to go through an important series of tests before being finished off for sale. The first test is for vacuum. This is carried out by means of an induction coil in a dark room. The operator holds the lamp in the hand and connects the leading-in wires to one or other of the secondary terminals of the coil. All lamps showing any sign of glowing, which indicates a poor vacuum, are tested for continuity of circuit, and are then placed on a frame for "running," *i.e.*, the current is passed through them to make them incandesce for a considerable period. The vacuum is tested again in the manner already described, and any lamps which show signs of faultiness are discarded.

FIG. 3.—INSTRUMENT SHOP.

The next process to which the lamps are subjected is that of testing voltage and candle-power. This is carried out in the photometer room, where the candle-power is read off on a scale against a standard lamp, and the voltage and current are measured simultaneously by instruments.

When the lamps leave the photometer room they are sorted into groups, according to the voltages indicated by the previous tests,

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They are then sent into the capping and finishing room to be capped, cleaned and stamped with voltage marks, &c. Those that have to be obscured are taken to another room, where they are inserted in a machine specially devised for this purpose.

Although the lamps are now complete, it is considered desirable to make further tests, as they are subjected to another vacuum test, this time with an oil transformer having a secondary pressure of 10,000 volts. They are then placed again on circuit to test for continuity and equality of light, in order to make sure that no lamp of the wrong voltage or candle-power has been passed through. Finally, they are sent to the wrapping shop and thence to the store, where generally they do not remain long before entering the packing and despatching department.

The Dalston works, of which we regret we are not in a position to give any illustrations, are supplied with power from two 165 H.P. 220 volts Belliss-Siemens sets contained in a separate building. Alternating current at a pressure of 200 volts is generated by means of two motor-alternators, this arrangement being selected as the tests made on the lamps are therefore more stringent than if continuous current were used. Continuous current is supplied from a battery.

THE MOTOR APPLIED TO BREAKDOWN WORK.

An interesting example of the way in which the electric motor can be easily and quickly applied to the rectifying of accidents is shown by a case which recently occurred at Blackburn. The machinery which was driving the Struan Mill in that town, belonging to Messrs. John Yates, broke down about a fortnight ago, on Friday, April 29th,

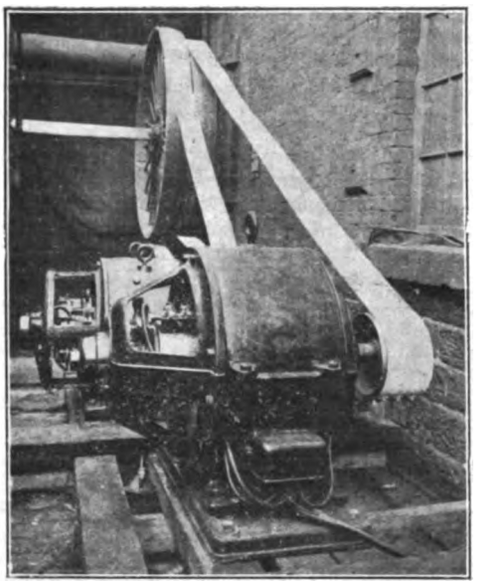

FIG. 1.—TWO MOTORS RUNNING IN PARALLEL AND DRIVING THE SAME SHAFT.

to be exact. On that day one of the teeth on the second main pinion wheel on the main shaft of the mill broke, with the result that the big fly spur wheel became jammed by the broken bits and three of its teeth were also broken off. The resulting damage was that all the bearings and gearing were smashed, the shaft was strained, and the mill, which contains 820 looms, was brought to a standstill.

A consultation was at once held as to how soon the mill could be again set running, for the firm were engaged on several important contracts, and every day's stoppage meant a serious loss. The owners were informed that the repairs would require a period of at least three weeks. On account of this lengthy time they, therefore, communicated with the electricity department of the Blackburn Corporation, with a view to discovering whether electric power could be obtained temporarily from the mains. We are glad to be able to say that this arrangement was quite possible; while the speed with which Mr. P. P. Wheelwright, engineer and manager of the Blackburn electricity department, and his staff worked to get things going again reflects great credit on all concerned. This very practical example of the way in which the electric motor can be quickly applied to all classes of work should not be without its effect upon the directors of the Struan Mill, and doubtless other cotton manufacturers both in Blackburn and the surrounding neighbourhood will now see much virtue in the new arrangement.

Mr. Wheelwright received information of the affair at noon on the Saturday, and by Monday morning a motor was installed in the top shed of the mill, and was driving 100 looms out of the 820, being connected to the shafting through a belt and a large temporary pulley. On Tuesday morning another motor had been put down, also driving 100 looms, while the following morning the third motor had enabled another 100 to be re-started.

This desirable state of things was not reached without considerable difficulty, as the motors themselves had to be brought into the shed in parts and built up, while a switchboard had to be erected, as well as the necessary wiring operations effected. This having been done successfully, on Thursday morning 250 looms out of the 400 in the bottom shed were re-started by connecting up two motors with the driving shaft. In this connection we may call attention to an ingenious arrangement which was adopted for this purpose. The electricity department did not possess a motor of sufficient capacity to drive 400 looms at the right speed. They, therefore, employed two smaller motors whose normal speeds and capacities, however, were different. This difficulty was got over by carefully adjusting pulleys on the shaft, and more exact adjustment was obtained by slightly speeding up one motor and slowing down the other, the two motors being run in parallel, driving the same shaft. By this means 250 looms were quickly set running and have been working satisfactorily since. Fig. 1 shows this interesting arrangement, and Fig. 2 one of the other drives.

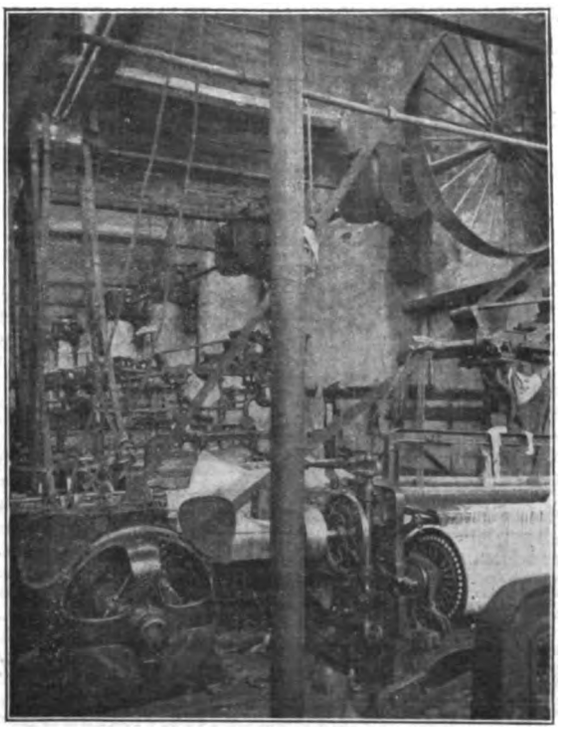

FIG. 2.—MOTOR ARRANGEMENT IN THE STRUAN MILL, BLACKBURN.

It should also be noted that overtime has been worked on 350 looms for two hours every evening. The Corporation electricity department have, therefore, been successful in arranging for the mill to work at its full capacity in spite of the breakdown.

We must congratulate both Mr. Wheelwright and his staff for taking such good advantage of an opportunity for showing the possibilities of the application of the electric drive to textile work. As our contemporary, the "Blackburn Weekly Telegraph," remarks: "Certainly the affair seems to open up wide possibilities in the direction of running mills by electric motor power," and we hope that this point will be duly appreciated.

LEGAL INTELLIGENCE.

Tramway Assessment Appeal.

Sheriff Gardner Millar, Glasgow, heard an appeal last week of the Lanarkshire Tramway Co. against the valuation of £18,826 placed by the assessor of railways on the company's lines in the county. After hearing the parties, the Sheriff fixed the valuation at £15,725, with no costs to either side.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT.

The Council of the University of Manchester require an assistant lecturer and demonstrator in the department of physics. Applications to the Registrar by June 13.

The professorship of physics at University College, Reading, will shortly become vacant. Particulars from the Registrar.

A junior lecturer and demonstrator in physics is required at the University of Sheffield. Salary £150 per annum. Applications to the Registrar by June 1.

Australasia.—The Victorian Minister of Railways (the Hon. W. Billson) has made an important announcement in regard to the electrification of the suburban railway system.

He said there was only one policy that should be followed, and that was the policy initiated by New South Wales Government in Sydney of the electrification of the means of transit between the city and its suburbs. He was convinced that that system must be introduced in Melbourne without delay, and he intended to make an earnest effort to get the Government and Parliament to approve of the electrification of the whole of the suburban system.

Austria-Hungary.—Budapest Tramways Co. intend to increase the capacity of their generating station from 6,500 kw. to 13,000 kw. The company are said to contemplate additional capital expenditure of £187,500.

Prague Municipality have voted £62,500 for the construction of electric tramways.

Birmingham.—The report of the Electric Supply committee for the year ended March 31 states that the total units generated were 29,079,276, against 24,406, 227 in 1908-9.

For lighting and power 12,254,931 units of low-tension current were supplied, against 10,796,024; 4,677,922 units of high tension current were supplied for power, against 1,827,794; and for traction 12,146,423 units, against 11,782,409 units. The receipts were £186,345, compared with £175,896 in 1909. Private lighting and power output again show a satisfactory increase (34·13 per cent.), but the receipts only show an increase of 7·8 per cent. owing to lower prices for current. The revenue account is also debited with £4,257. 4s. 1d. in respect of new meters. In 1908 the Council obtained sanction to a loan of £4,000 for meters, but the L.G. Board only granted a period of five years for the repayment of the loan. Having regard to the shortness of the period and the consequent heavy payments for sinking fund, the committee decided to purchase meters out of revenue. The sanction to the loan will not be acted upon, and the amount spent on new meters during the past 2½ years has been transferred to revenue account. A sum of £1,520. 6s.6d. for service switches installed on consumers' premises is also included, as it has been decided to pay for these fittings out of revenue rather than apply for a loan, seeing that only a short period would be granted. In addition, the revenue account contains special expenditure amounting to £12,110. 3s. 2d., in respect of the reconstruction of Dale End station and offices and alterations at Water-street and Parker-street stations; also £2,351. 11s. in respect of plant abandoned at Parker-street substation. The balance (£93,588. 2s.) represents the gross profit, and after meeting all charges for interest and sinking fund there remains £19,255. 10s., of which £9,000 has been placed to renewals fund, leaving a surplus of £10,255. 10s., which it is proposed to pay to credit of improvement rate. The net increase in lamp connections (lighting only) amounted to an equivalent of 13,378 16 c.p. lamps, against 24,691. The net increase in motors connected amounted to 5,720 H.P. (4,267 kw.), against 4,869 H.P. (3,632 kw.). The total length of new mains laid during the year was 20,680 yards, against 29,316 yards. The work of installing additional plant at Summer-lane station and various substations is approaching completion, and it is necessary, in view of the steady growth of the output, to make provision to continue the installation of additional plant. According to estimates prepared by the engineer (Mr. R. A. Chattock) by the end of 1914 the demand may reasonably be expected to reach 27,000 kw. To meet this increased demand it is proposed to instal 11,000 kw. of generating plant at Summer-lane station, bringing its generating capacity up to 31,500 kw. This addition will complete the equipment of the station. The original estimate of the capacity of the station was 26,500 kw. The installation of 5,000 kw. of additional plant is rendered possible by the adoption of exhaust steam turbines. There will also be available at Water-street station generating plant of a capacity of 2,000 kw. giving in 1914 a total generating capacity for the whole undertaking of 33,500 kw. The extensions proposed also include the building of a small sub-station at Harborne, and its equipment with 400 kw. of distributing plant. Applications have been made for a supply of current in this district, and the prospects justify the erection of a sub-station of this size. The estimated cost of the extensions proposed (including £1,000 for Harborne) is £143,250.

The great development in the work of the department has compelled the committee to consider the question of relieving the city electrical engineer of some of his various duties. At present Mr. Chattock also acts as manager of the department, and the committee do not propose to alter this arrangement, but to appoint a secretary, who, under the engineer, shall take control of the commercial, secretarial and accountancy sides of the undertaking. The committee do not think that they are likely to obtain the services of a man having the necessary experience for less than £600 per annum, and they recommend that they be authorised to make the appiontment at this salary.

Blackburn.—The borough electrical engineer (Mr. P. P. Wheelwright) is preparing a scheme for the electric lighting of Corporation and Queen's Parks.

Bolton.—The borough electrical engineer and tramways general manager (Mr. A. A. Day, A.M.Inst.C.E.) has reported to his committees on the results of the past year's working as follows:—

The revenue was £60,527. 18s. 6d. (1·21d. per unit sold), works cost £21,837. 1s. 6d. (0·414d.), and total cost £26,749. 18s. 6d. (0·513d. The capital items paid out of revenue came to £2,715. 8s. 9d. (0·055d.), interest absorbed £8,563. 3s. 2d. (0·171d.), sinking fund £14,583. 12s. (0·292d.) and depreciation £4,664. 8s. (0·094d.). The inclusive cost was £56,252. 8s. 3d. (1·125d.) and the gross profit £34,941. 9s. (0·799d.). The percentage of operating cost to revenue was 44·19, the amount brought forward was £2,680. 6s. 1d., and the nett profit was £8,119. 5s. 4d. (0·162d.). The average price obtained was 1·18d. per unit. £6,000 was devoted to relief of rates; the gross capital is £359,690 and the nett capital £242,557.

The revenue of the tramways department was £122,528. 1s. 3d. (11·134d.) per car-mile, and operating costs were £72,436. 18s. 5d. (6·582d.), the percentage of operating costs to revenue being 59 per cent. The traffic expenses were £28,406. 13s. 10d. and the general expenses £7,375. 14s. 11d., repairs and maintenance came to £16,724. 17s. 8d., and power cost £19,947. 12s. 2,641,292 car-miles were run, and 27,018,149 passengers carried. £7,866 was paid in relief of rates. The gross capital expenditure is £504,694 and the net capital is £375,248.

Brighton.—For the year ended March 31 the revenue of the tramways department was £51,358, compared with £47,809 in 1908-9. The number of passengers carried shows an increase of nearly 750,000. The net profit was £1,190, against a deficit of £2,420. The cost of repairs and renewals to permanent way increased from £3,459 to £4,005 owing to the great charge for maintaining the wood-paving.

Bulgaria.—Philippopolis Communal Authorities will shortly invite tenders for the provision of electricity supply and electric tramways.

Colwyn Bay.—The Council have obtained sanction to a loan of £2,500 for cable extensions to Old Colwyn.

Cornwall.—Camborne Council have been informed by Cornwall Electric Power Co. that the company propose to erect a power station at Hoyle and electric current will be transmitted from there by overhead cables to the Dolcoath and other mines.

Dundee.—The receipts of the tramways department for the past year amount to £61,233, compared with £61,869 for 1908-9. The number of passengers carried was 16,836,571, compared with 16,988,331.

The Scottish Office have granted increased borrowing powers for the electricity department to the extent of £50,000.

East Ham.—To encourage private arc lighting among consumers who provide their own installation and lamps, the Electricity committee have decided that, instead of metering the current, a fixed charge of 5s. per lamp per quarter is to be made for each arc lamp installed, and a fixed rate per hour for each hour the lamps are burning during the quarter, this amount to be measured by an ordinary clock meter. The scale is as follows:—

For ordinary enclosed type lamps in series: Up to 6 amps. 1d. per lamp per hour, 7 amps. 1·2d., 8 amps. 1·4d. For open type of flame arc lamps: Four in series, up to 10 amps. 1d. per lamp per hour, 12 amps. 1·2d.; three in series, 6 to 8 amps. 1d.; for double carbon single lamps, up to 3½ amps. 1·4d.; for double carbon single lamps, up to 4 amps. 1·5d. On the hire system the present inclusive charge of £2. 2s. per lamp per quarter is to be reduced to £1. 11s., and the present charge of 2½d. per lamp per hour for all hours in excess of 800 per annum is to be reduced to 2d. The reductions come into operation on July 1.

Exhibition.—A Smoke Abatement Exhibition will be held at the Victoria Skating Rink, Glasgow, from Sept. 16 to Oct. 8. The exhibition is being organised by the Corporation, and the exhibits will include appliances for lighting, heating and cooking without smoke.

The Corporation decided to hold the exhibition in consequence of reports by experts and by special committees appointed by the Corporation to consider the matter. The charge for space for exhibits will be very low, and electrical energy and gas will be supplied free. Further particulars from the Exhibition Office, 270, Sanchiehall-street, Glasgow.

Fatality.—An Accident occurred at Messrs. Moore & Co.'s Blantyreferme Colliery, Uddingston, on Friday last, resulting in the death of a roadsman named Bellingham.

A runaway hutch had knocked out a prop supporting an iron girder, which fell, and in its descent split the electric cable running along the wall. Bellingham, anxious to clear the obstruction, made to move the girder, which, however, had become charged, and he was instantly killed.

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Fulham (London).—The Electricity committee have had under consideration suggestions for increasing the demand for electricity, including (a) the free wiring of consumers' premises, and (b) the introduction of metal filament lamps for outside shop lighting at fixed annual charges.

At present there are about 22,000 houses in the borough, but only about 3,000 consumers (including flats) connected to the mains. The suggestion is that the Council should agree to wire for approximately six lights per house or flat, and supply the necessary plain fittings (free of charge), current being supplied through prepayment meters. The wiring would be done by local contractors at schedule rates according to specification. The system of wiring to be adopted would depend largely on circumstances. When surface wiring is unavoidable, the engineer (Mr. A. J. Fuller) advises the adoption of the "Stannos" principle of metal sheathed wiring as being a safe, neat and reliable method. The estimated capital cost of wiring and supplying fittings for six lights, including a transformer, is £3. 3s. per consumer. The committee think that only when the landlord accepts responsibility for all renewals (other than those necessitated by ordinary wear and tear) can the supply of the requisite lamps be included in the scheme, and, failing an undertaking by the landlord, the tenants will be required to provide their own lamps. Where this undertaking is obtained, and after allowing for repayment of principal and interest (extended over 10 years), and providing for renewals of lamps and repairs, the committee are of opinion that the basis of charge may safely be fixed at 5½d. per unit, but where the owner declines to give the undertaking, and the provision and renewal of lamps is not included in the scheme, the charge should be 5d. per unit. It has been ascertained, as a result of preliminary circular and canvas in four streets, that about 112 new consumers may be expected to at once adopt the electric light if this system is introduced.

The Council adopted the committee's recommendation to provide for wiring 500 houses at a total estimated expenditure of £2,000.

The committee have also reported with regard to the proposed introduction of a less powerful outside shop lamp at a fixed annual charge according to candle-power, that for all practical purposes this would be an extension of the present arc lamp rental scheme, and would supply the demand which is said to exist for a less powerful illuminant at a lower fixed charge. The suggestion is that the Council should arrange to supply fix, maintain, clean and renew a suitable outside lantern with 13 in. reflector globe and bracket for fixing to shop facia (the customer providing his own wiring up to the bracket), the lighting being by metal filament lamps of either 100, 200, 300 or 400 c.p., at following fixed charges: (*a*) A fixed charge of £1. 3s. per lamp installed, irrespective of candle-power, to be paid on lamp being fixed: (*b*) a quarterly payment in advance, according to power of lamp installed, as follows: 100 c.p. size, two winter quarters at 15s., £1. 10s., two summer quarters at 5s. 6d., 11s., annual inclusive charge, £2. 1s.; 200 c.p., size, £2, £1. 12s., and £3. 12s.; 300 c.p. size, £3, £2. 2s., and £5. 2s.; 400 c.p. size, £4, £2. 12s., and £6. 12s. (The above charges include current for 870 hours at 3½d. per unit, less 2½ per cent. discount, one new lamp per annum, 7s. per lamp per annum for cleaning, repairing, &c., and 2s. per lamp per annum for sundries.) The present form of arc lamp rental agreement is to be adapted to apply to these lamps, and it has also been arranged that all current supplied in excess of 870 hours per annum be charged as follows: 100 c.p. lamps ½d. per hour, 200 1d., 300 1½d., 400 1½d.

German East Africa.—A hydro-electric generating station with a capacity of 52,500 kw. is to be established at Pangani Falls for the production of fertilisers from atmospheric nitrogen.

Hastings.—Existing gas lamps in streets in which electricity supply mains are laid are to be converted to electric lamps. The gas lamps affected number about 250 and £600 has been provided for carrying out the work of conversion.

Ipswich.—The salary of the electrical engineer and manager of the electricity department (Mr. F. Ayton) has been increased from £500 to £600 a year.

The Rural Electricity Supply Co. have been informed, in regard to the proposal to supply electricity in bulk in Pakefield, that the Council can only supply to a company authorised to supply energy, and they would be prepared to supply a company possessing such powers with current in bulk delivered at an agreed point at the borough boundary at 3d. per unit

Light Railways.—Application is being made to the Light Railway Commissioners for an order to amend the Llanelly and District Light Railways Order, 1907, by reviving certain powers and extending the time for the construction of certain light railways. Objections to the Secretary of the Light Railway Commission.

Limerick.—At a recent meeting of the Corporation it was decided to call in a consulting engineer to report on the plant and the working of the municipal electricity undertaking.

Middlesbrough.—The borough electrical engineer (Mr. H. M. Taylor) has presented his report for the year ended March 31.

Mr. Taylor states that it is the second year's trading under the agreement with the Power Co., and the figures show a substantial improvement on the previous year, in spite of bad trade and high coal prices. The gross revenue shows an increase of £1,271 for an increase in generating and distribution costs of £4,820. Included in these costs is £1,436 for repairs and maintenance to buildings, plant, cables, &c. There is an item of £1,392 (0·19d. per unit) for rents, rates and taxes, an increase of £133. The total costs stand at 1·22d. per unit sold, against 1·26d. The gross profit is £8,406, against £7,617. The profit is £1,301, against £1,277, although there was an increase of £765 in capital charges. The number of consumers has increased by 144, or nearly 15 per cent., and the number of equivalent 30 watt lamps by 11,911, or 11 per cent. The increase in the number of consumers is the greatest which they have had in any year since the undertaking was started.

Newcastle-on-Tyne.—It was recently reported to the Tramways committee that there was a profit of £15,136 on the past year's working of the tramways, against £7,558 in 1908-9.

The traffic income was £272 less, but for electric lighting there was a slight increase (£5,570 against £5,446), and rents also showed a slight increase. Total income was 203,948. 15s. 3d., against £204,123. 1s. 6d. Expenses had been brought from £122,609 in the previous year to £117,593. Traffic expenses were £58,286. 15s.9d., against £56,912.18s.2d. and general expenses £19,318, against £21,272. Repairs and maintenance was £23,751, against £27,924. In permanent way charges there was a saving of £2,000. Power expenses came to £14,563, against £14,947. On the lighting branch they had spent £1,673, against £1,533. The gross profit was £86,355, against £81,513. 6s. 10d. £32,231. 9s. 11d. was required for interest, rents,compensation to electric supply company, and contributions to superannuation fund came to £2,504. 8s. 8d., and income tax £700. 5s. 9d. They had to pay £36, 835. 1s. 6d. as sinking fund and £1,537. 18s. to the Corporation towards liquidating the debt due on old horse cars. There was left a net profit of £15,136. 5s. 9d. to be carried to reserve and renewals account.

Peterhead.—The Council have granted permission to Messrs. Jas. Simpson & Son to lay an underground cable between their works and the new Post Office buildings, for supplying the latter with electricity.

Provisional Order Revocation.—The Board of Trade have revoked the Bromley Rural District Electric Lighting Order, 1903, as from May 7.

Railway Working Agreement.—The working agreement between the London & South-Western Railway and the Great Western Railway Companies, foreshadowed at the last meetings of shareholders of these great undertakings has become an accomplished fact, and it is anticipated that the public, and also traders, will considerably benefit by the new arrangements now being formulated by the companies.

Rochdale.—The total receipts of the electricity department for the year ended March 31 were £22,085.

Total expenses were £9,579. After paying interest (£2,652), sinking fund instalments, &c. (3,652), and other charges the balance (£5,171) was carried forward, against £4,830 in 1909. 4,012,994 units were generated; 2,124,487 units were supplied for traction and 1,420,852 sold to private consumers. The total maximum supply demand was 1,415 kw. for traction and 827 kw. for lighting.

The borough electrical and tramways electrical engineer (Mr. C. C. Atchison) states that the increase in the units sold is practically all due to electricity supplied for power, and this, together with more satisfactory working of the plant, accounts for about half the saving in total costs, the other half being due to reduced prices for coal, the net result being that the department turned out a larger number of units than during the previous year at a less total cost. The reduced charges for lighting and power were in operation for the full period, and the estimated reduction of income (£700) was borne out when the reduction made in the power schedule is taken into account. The tramways item, however, of £250 has been materially exceeded, amounting to over £350 this year. During 1909 the Electricity committee succeeded in having a resolution passed by the Council that an amount equal to 1 per cent. of the capital expenditure should be charged to revenue account annually for depreciation before showing any surplus. The benefit of this action has been shown this year, when, instead of taking the £4,000 which the committee offered for relief of rates, the Council took £5,000, leaving only £505 to go to reserve. This first instalment for depreciation amounts to £973. The reserve fund stands, with the addition of £505, at £6,763. During the first two and a half years of working £5,543 was obtained from the rates, but since then the department has succeeded in producing a net surplus each year, out of which it has to date assisted the rates by a total of £17,350. As the surplus, plus depreciation, amounts to over 6 per cent. for 1909-10, there is a possibility that the committee may reduce the prices charged, but coal is likely to increase in price, and, with all additional power tending to reduce the average income per unit, the committee may not be disposed to cut down its possible surplus.

Rotherham.—Extensions of electric supply mains are to be made at an estimated cost of £620.

South Africa.—The Transvaal Commission who have recently been considering the subject state in their report that they approve of the establishment of large power generating concerns under effective control.

The Commission are of opinion that the gold industry will benefit considerably, that the coal industry will not on the whole be prejudicially affected, and will probably benefit to a large extent ultimately, that the Central and South African Railways will benefit from the general indus-

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trial expansion, and that the agricultural industry should benefit for the same reason.

The Government bill for regulating the supply and use of electrical energy, which was read a second time in the Transvaal Legislative Assembly on April 13, proposes the formation of a Board to be called the Power Undertakings Board, who will inquire into every application for a supply of power and grant licences to suppliers of power. The bill further provides that power supply companies must state in their applications for licences the minimum amount of power they will be willing to supply to one purchaser, their proposed area of supply, &c. The licence is to state that every applicant for power within the area must be supplied, and it will contain a schedule of prices, subject to revision after 10 years and each succeeding five years, that profits are to be divided in the proportions of 75 per cent. to the licensee and 25 per cent. to the consumers. Certain mine owners' stations, from which it is not proposed to supply outside consumers, are excluded from the scope of the bill. The maximum period for licences is 37 years. The bill as introduced will enable the Victoria Falls Power Co. to supply in the Johannesburg municipal area, but Johannesburg Corporation are seeking to get the bill amended so as to prohibit companies from supplying in the municipal area without the Council's consent, except for operations directly connected with mining.

It is stated that the Victoria Falls & Transvaal Power Co. are about to proceed with the construction of the power station at Vereeniging for supplying electric power to the mines of the Western Rand, and negotiations for the starting of industrial undertakings in the vicinity of the works are taking place.

Southampton.—The tramcar sheds at Shirley depot are to be extended at a cost of £127.

The tramways manager (Mr. H. F. Street) reports that the "Barber" radial axle truck has been tried, and its behaviour round curves exceeds his expectations. He has every reason to hope that this truck will be a vast improvement on anything that has been put on the market in recent years. Others were being made suitable for short car bodies, and he hoped to be soon in a position to advise the purchase of one of these.

The Corporation have agreed to enter into a contract for the electric lighting of certain lamps in the main road of Swaythling.

Spain.—An application has been lodged with the Public Works Department by the Compañia Madrilaña de Urbanizacion for a concession for constructing and working a combined steam and electric railway in the vicinity of Madrid.

Torquay.—The Board of Trade have intimated that they will not renew the licence (which expires on Oct. 31) for the Tramway Company surface contact system of tramways. It is probable that the overhead system will be ready for substitution by that date.

Wireless Telegraphy Notes.—Under the provisions of the International Radio-Telegraphic Convention of Berlin, as from May 15 all French wireless telegraph stations will be open to receive home and international communications for or from ships at sea. The following stations in France are open day and night: Boulogne, Ushant, Porquerolles, S. Marie de la Mer (Marseilles), Fort de l'Eau (Algiers), Ajaccio (Corsica), Brest, Cherbourg, Dunkirque, Lorient and Rochefort, which, although naval stations, will receive public messages only from 7 a.m. until 10 p.m. Boulogne is a specially equipped station, with apparatus for determining the position of ships at sea. The rates for messages transmitted to ships at sea have been fixed at 40c. a word, except in the Mediterranean stations, whence messages for vessels plying regularly between France, Corsica, Algeria and Tunis are accepted at 15c. a word, and from vessels at sea to those stations at 10c. a word.

We are advised from America that a Wireless Corporation has been formed (the Continental Wireless Telephone & Telegraph Co.) to establish commercial coast-to-coast wireless transmission. The existing undertakings which have mutualised their interests are the Collins, the Clark, the Pacific and the Massie Wireless Telegraph Companies. Mr. A. F. Collins, who is described in the document sent us as "the inventor of the wireless telephone," is a director; Mr. F. T. Davis is president, Mr. Walter W. Massie is vice-president, and Mr. F. E. Clark is general manager. The company is stated to be capitalised at $5,000,000. It will operate from Newark, N.J.

Wireless Telephony.—It is announced by "Le Journal" (Paris) that within a few weeks three of the principal French warships will be provided with wireless telephone equipments.

Wakefield.—An inquiry was held here last week into the application of the Council for sanction to borrow £7,150 for extensions of the electricity undertaking.

The town clerk (Mr. W. W. GREENHALGH) explained that the money was required for additional plant to meet the increasing demand for electrical energy for lighting and power. The number of consumers was increasing steadily

The inspector (Mr. H. Ross HOOPER) pointed out that the L.G. Board were not likely to sanction any further loan until the deficit had been cleared off.

The TOWN CLERK replied that that was due to the new assessment of the works, the abnormal advance in the price of coal last year and the economy in consumption by consumers owing to the extended use of metal filament lamps.

Evidence was given by the electrical engineer (Mr. H. A. Nevill), but the Inspector desired further information with regard to the allocation of accounts, &c., and the inquiry was adjourned.

West Ham.—The Electricity committee report that the whole of the points between the Port of London Authority and the Corporation as to the supply of electric current have been settled, and the consent of Woolwich Council or the approval of the Board of Trade is alone necessary. The principal question outstanding is the payment to be made to Woolwich for their consent.

Wimbledon.—An inquiry was held last week into the application of the Council for sanction to borrow £5,800 for extensions of the electricity undertaking.

Woolwich.—London County Council have agreed to permit electric cables being laid through the new Woolwich subway for 21 years for supplying electricity to North Woolwich, in consideration of the payment of £50 per annum.

The Electricity committee have decided that the word "power" includes all purposes to which electrical energy may be applied other than its use either directly or indirectly for lighting. Consumers who use motors for driving gas compressing plant are to be charged 4d. per unit.

Workhouse Lighting.—Aberdeen Parish Council have asked the Poorhouse committee to report as to whether any saving would be effected by taking the supply of electricity for the poorhouse from the Corporation.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., **post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.**

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding **that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable** and of little value for **Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.**

TENDERS INVITED.

BARNES Urban District Council invite tenders for supply of 4,000 yds. of 0.25 0.25 1.25 sq. in. triple concentric cable, paper insulated, lead sheathed and jute served, suitable for a working pressure of 660 volts, manufactured in strict accordance with the British Engineering Standards committee's specifications. Tenders to the Clerk to the Council, High-street, Mortlake, by noon Tuesday, June 14. See also an advertisement.

Tenders are invited by July 6 for the supply of cordless switchboards to the Postmaster-General's Department in SOUTH AUSTRALIA. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

NEWPORT (Mon.) Electricity committee invite tenders for supply and erection of two 400 kw. motor-generators, three-phase to d.c.; one 600 kw. motor-generator, three-phase to single-phase; and one 'bus-bar three-wire booster. Specifications, general conditions and form of tender from the borough electrical engineer and tramways manager, Mr. H. Collings Bishop, Town Hall, Newport, Mon. Tenders to the Town Clerk by first post May 31.

COVENTRY Electricity committee invite tenders for supply, delivery and erection of a 1,250 kw. turbo-alternator, complete with surface-condensing plant, &c., four water-tube boilers (straight

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tube type) and two fuel economisers. Specification, general conditions and forms of tender from the engineer and manager, Mr. Geo. Tough, and tenders to the Town Clerk, Hay-lane, Coventry, by first post May 30.

SOUTHAMPTON Corporation invite tenders for supply of a 1,000 kw. steam generator, boiler, alternator and motor alternator. Particulars, specifications and forms of tender from the borough electrical engineer, Mr. H. F. Street, electricity works, Western Shore, Southampton. Tenders to the town clerk, Mr. R. R. Linthorne, Municipal Offices, Southampton, by May 24.

CROYDON Corporation want tenders by 11 a.m. May 26 for lighting the two isolation pavilions and additions to the administrative block of the Borough Hospital, Waddon. Specification, &c., from the Borough Engineer.

DARLINGTON Electricity committee want tenders by May 25 for a cooling tower, electrically-driven centrifugal and air pumps and a boiler feed pump. Specifications, &c., from the Borough Electrical Engineer.

The LIVERPOOL Overhead Railway Co. require tenders by 10 a.m. June 7 for 12 months' supply of electrical fittings, insulating tapes, iron and steel, ironmongery, oil and grease, packings, &c. Forms of tender, &c., from 31, James-street, Liverpool.

BATLEY Corporation require tenders by noon June 1 for a lighting and traction switchboard for the electricity works Specifications, &c., from the Borough Electrical Engineer.

BERMONDSEY (London) Council require tenders by 10 a.m. May 27 for Midland and Scotch coal for the electricity works. Forms of tender from the Town Clerk.

Tenders are invited up to June 14 for supply of 100 party line common battery telephone wall sets, 10 party line common battery table sets, 100 switches, common battery, single extension and intercommunication, and 3,000 telephone protectors to the Postmaster-General's department in VICTORIA. Tender forms and specification at the Commonwealth office, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, BRISBANE (Queensland), will receive tenders until noon June 22 for supply of copper wire and accessories, covered wire, iron wire, insulators, ironwork and sal ammoniac and zinc for batteries. Local representation is necessary.

Tenders are invited up to June 7 for supply of one frame, main distributing, to the Postmaster-General's department in WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W.

Tenders will be received (up to 11 a.m. June 6) at the Royal Arsenals, SPEZIA and NAPLES, for supply to the Italian Naval Authorities of electric lamps and lamp stands in two separate lots. The total estimated value of the contract is placed at 32,009 lire (about £1,280), and a deposit of 1,880 lire (about £74) will be required to qualify tenders for lot 1, and a deposit of 1,330 lire (about £53) for lot 2. Only manufacturers of electric lamps will be allowed to tender. Applications for certificates of competency to the Director of Naval Construction at Spezia, Naples, Venice or Taranto not later than May 21. Copies of the specifications, conditions of tender, &c., may be seen by British firms at 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Tenders have been received by Newport (Mon.) Corporation for a turbo-alternator from Willans & Robinson, General Electric Co., Dick, Kerr & Co., C. A. Parsons & Co., the British Thomson-Houston Co. (Jas. Howden & Co.) and the British Westinghouse Co. The tender for 1,500 kw. turbo-alternator and condenser by Willans & Robinson and General Electric Co. has been accepted.

Bootle Council have accepted the following tenders:—

Chloride Electrical Storage Co., automatic reversible traction booster (£424); Whipp & Bourne, automatic reversible current breakers and traction feeder breakers (£141), and shunt regulating resistances and switches (£52); Jas. Scott (Ltd.), rewinding balancers (£79) and circulating pump (£120); Bruce Peebles & Co., two dynamos (£295); Kelvin & James White, switchboard instruments (£54).

Woolwich Electricity committee have accepted the tender of Ferranti Limited for the annual supply of a.c. meters for use in Eltham. The British Thomson-Houston Co. have submitted a new type of meter which the committee desire to test under actual working conditions.

Richmond Council have accepted the tender of James Simpson & Co. at £115. 10s. for an electrically-driven pumping plant for the Petersham Well.

Yarmouth Council have accepted the tender of John Baker & Co. for 30 steel tramway tyres at £1. 14s. 6d. each.

Chichester City Council have accepted the tender of the local electric light company for wiring the new schools.

Malvern Council have accepted the tender of the British Thomson-Houston Co. for meters for five years.

BUSINESS NOTICE.

For the convenience of their customers in the south-west London district, the Hart Accumulator Co. have opened a branch at 36, Victoria-street, Westminster, S.W., with Mr. W. Howard Tasker as their representative. The branch is in telephonic communication with the company's works at Stratford.

Plant for Sale.—A 240 kw. Howden-Crompton direct-coupled generating set is advertised for sale in another column. Particulars from Messrs. W. E. Moulsdale & Co., 24, Chapel-street, Liverpool.

Patents Development.—The proprietors of the following patents desire to enter into arrangements by way of licence and otherwise for exploiting and developing the same in this country:—

No. 17,601/1901, for "Improvements in apparatus and devices for controlling electric currents"; No. 15,243/1903, for "Improvements in means for automatically regulating electric currents generated by dynamos"; No. 16,962/1902, for "Improvements in electrical switches or cut-outs"; No. 17,314/1905, for "Improvements in automatic regulators or rheostats for electric currents." Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

Patent No. 10,187/05, for "Improvements in electric couplings." Applications to Messrs. G. F. Redfern & Co., 15, South-street, Finsbury London, E.C.

CATALOGUES, &c.

MATERIALS FOR TELEGRAPH AND TELEPHONE LINES.—Messrs. Siemens Bros. & Co., Caxton House, Westminster, S.W., have forwarded a copy of the March issue of their pamphlet No. 11, "Iron Poles, Insulators and Materials for Telegraph and Telephone Lines." This is one of the largest and most complete publications of its kind, comprising 124 pages, containing descriptions and illustrations of line materials and appliances to meet requirements in all countries. The pamphlet has been divided into six sections, dealing respectively with Siemens iron poles, insulators and stalks, brackets, arms and fittings, stay tighteners, tools and bolts and screws.

The introduction to the iron pole section is of special interest, in that it traces the evolution of the various types of Siemens poles which are listed, from the tubular iron pole, with buckled plate, which was originally designed and patented in 1863 by Sir William Siemens, down to the present time. Interesting particulars of a great variety of poles are set out. The insulator and stalk section contains, besides examples of telegraph and telephone insulators, which have been designed to meet the requirements of practically every Government and telegraph company, a large selection of porcelain reels and knobs, which find useful application in all branches of the electrical industry. The section dealing with brackets, arms and fittings contains every conceivable form of device to meet the existing practice of securing insulators and stalks. The remaining sections give all the accessories and tools that are required for the erection of land lines.

The pamphlet is coded throughout, and is provided with a comprehensive system of cross references, so as to facilitate the drawing up of specifications and schedules for lines and the necessary materials required.

"Installation News."—The May issue of "Installation News" contains an article on "Conduit Clauses in Specifications," in which some useful information is given. A hint on connected-up motors should also interest wiremen.

BANKRUPTCIES, LIQUIDATIONS, &c.

The examination took place at Bristol last week of Robert Edward Joy, electrical engineer, 143, Cheltenham-road, Bristol.

Gross liabilities £649. 5s. 6d., and unsecured debts £602. 10s. 10d.; net assets £87. 18s. 6d., deficiency £514. 12s. 4d. Debtor began business in 1907 without capital. He admitted that he had contracted all his present indebtedness with a knowledge of his insolvency, of which he was aware about three years ago. He had made no net profit during the last two or three years. Claims are to be sent to Mr. F. I. Clark, 26, Baldwin-street, Bristol, by June 3.

An application for the discharge of Ernest Roberts (trading as Roberts Bros.), electrical engineer, 21, North Parade, Bradford, will be heard on June 21 at the County Court House, Manor-row, Bradford.

The Automobile Electric Lighting Synd. (Ltd.) and the Polkey Automobile Electric Lighting Synd. (Ltd.) are being wound up voluntarily, and meetings of creditors will be held at Mr. A. R. Lancaster's, Queen's College, Birmingham, on May 24.

The Lepel Wireless Synd. (Ltd.) is being wound up voluntarily and Baron von Lepel and Mr. A. Holt have been appointed liquidators.

A meeting will be held on June 27 at 79-81, Queen-street, London, E.C., to receive an account of the winding up of the Electric Tramways Construction & Maintenance Co. (Ltd.)

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

*Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

March 8, 1910.

5,735 Docking. Pendants for electric lamps.*
5,747 Adams. Insulating cups for telegraph, telephone and other electric wires.
5,766 Hirst & Brook. Time-limit overload devices for actuating the no-volt release devices of circuit-breakers and motor starters.
5,801 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Electromagnetically actuated electric switches.*
5,818 Patterson. Electric safety lamps for use in mines or other like places.
5,822 Davidson. Thermopiles or thermo-electric couples.*
5,823 Fanning & Nellis. Electric switching mechanism.*
5,835 Neudorffer. Insulating wall boxes for electric apparatus.*

March 9, 1910.

5,896 Taylor. Obtaining continuous currents from alternating-current circuits.
5,917 Siemens & Halske Akt.-Ges. Rectifier for high-tension alternating currents. (Date applied for, 28/5/09.)*†
5,926 Bennett. Sockets of incandescent electric lamps.
5,934 Johnson. (Chemische Fabrik Griesheim Elektron, Germany) Production and maintenance of long electric arcs. (Addition to No. 11,060/09.)

March 10, 1910.

5,965 Jandus Arc Lamp & Electric Co., Jones & Castell-Evans. Arc lamps.
5,985 Smith, Green & Glover. Alternating-current induction motors.*
6,035 Petersson. Charging electric resistance furnaces. (Date applied for, 2/6/09.)*†
6,065 Ely & Foster Arc Lamp & Engineering Co. Electric water heaters.

March 11, 1910.

6,124 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H., Germany.) Alternating-current commutator electric motors.*
6,125 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H., Germany.) Regulation of electric frequency converters.*
6,132 Brooker & Hooper. Locking device for electric lamp-holders.
6,160 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Electric switches.*

March 12, 1910.

6,190 Bishop. Locking nuts on insulator attachments of telegraph poles and for other like uses.
6,191 Ewart. Electric lamp-holders and lamp caps for same.
6,207 Bastian. Electrically heated appliances or apparatus.
6,212 Meguin & Co. A.-G. Electromagnetic apparatus. (Date applied for, 12/3/09.)*†
6,256 Landi. Electrical speed indicator.*
6,272 Allmanna Svenska Elektriska Actiebolaget. Single-phase commutator machines. (Date applied for, 2/8/09.)*†
6,292 B.T.-H. Co. & Wedmore. Protective or indicating devices.

March 14, 1910.

6,312 Hall. Automatic generation of electricity for motor cars.
6,353 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Electric switches.*
6,397 Wolfram Lampen Akt.-Ges. Support for incandescent filaments. (Date applied for, 13/3/09.)*†
6,402 Akt.-Ges. Brown, Boveri & Cie. Driving of single-phase motors. (Date applied for, 18/11/09.)*†
6,403 Akt.-Ges. Brown, Boveri & Cie. Driving of electric rail vehicles. (Date applied for, 1/4/09.)*†

March 15, 1910.

6,431 Hall. Terminal ends of electric cables.
6,432 Hall. Electric generators for motor cars.
6,433 Hall. Electric wiring for supplying current for motor cars (conduit system).
6,526 Capitaine. Incandescent lamps. (Date applied for, 9/12/09.)*†
6,531 Sunderland & Pillinger. Electric control of engines, dynamos and batteries.
6,535 Barnard & Edwards. Controlling devices for electric motors.*
6,536 Bleckly. Multiple arc lamps.*
6,553 Jevons & Green. Electric welding.

March 16, 1910.

6,589 Staniar & Clegg. Supporting electric wiring conduits in position.
6,594 Turnbull. Balancing apparatus for three-wire and the like electrical-distributing systems.*
6,595 Waterhouse. Electric light pendant fittings.*
6,596 & 6,597 Schott & Gen. Electrolytic apparatus having a liquid annular anode. (Addition to No. 14,288/09. Date applied for, 30/3/09.)*†
6,624 Zweigbergk. Dynamo-electric machines.
6,633 Field & Ferranti. Circuit-breakers and the like.
6,634 Loring. Dynamo-electric machines of the homopolar type.
6,653 Bosch. Magneto-electric ignition machines. (Date applied for, 18/5/09.)*†
6,654 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Automatic telephone exchanges.*
6,658 Salzer. Holders for the filaments of incandescent electric lamps. (Date applied for, 19/3/09.)*†
6,667 B.T.-H. Co. & D'Arcy. Electric energy meters. (Addition to No. 6,565/09. Date applied for, 20/9/09.) Comprised in No. 6,565, dated 20/9/09*
6,668 B.T.-H. Co. & Wedmore. Protective devices for electrical transmission and distribution systems. (Date applied for, 18/10/09. Comprised in No. 17,031, dated 18/10/09.)*

March 17, 1910.

6,681 Dixon. Electric trolley heads.
6,704 Charlton. Systems of electric wiring and apparatus relating thereto.
6,706 Marshall. Machines for the manufacture of flexible metallic tubes or for armouring insulated electric and other cables.*
6,719 Bridge. Make-and-break contact devices for electric circuits.*
6,743 Boot & Tarrant. Electrically-operated signalling for railways or tramways.
6,746 Gatinaud. Electric accumulators.*
6,768 Stora Kopparbergs Bergslags Aktiebolag. Electric furnaces and the method of charging the same. (Date applied for, 19/3/09.)*†
6,782 Compagnie four la Fabrication des Compteurs et Materials d'Usines a Gaz. Recording galvanometers and other instruments operating with a very small turning moment. (Date applied for, 15/5/09.)*†
6,791 B.T.-H. Co. (A.E.G., Germany.) Regulating valves and the like.
6,792 B.T.-H. Co. & Wedmore. Electric circuit interrupting devices and the like.

March 18, 1910.

6,814 Fuller, Moore & Fuller. Electric road lamps.
6,825 Neave. Controllers for electric motors.*
6,865 Pizzuti & Ferrari. Shortening electric waves.*
6,867 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Motor controllers.*
6,868 Konecke. Three-phase current arc lamp. (Date applied for, 19/3/09.)*†
6,870 Anger. (Walter Everett Anger, U.S.) Sparking plugs.
6,871 Williams-Ellis. Calculating devices for electrical quantities.
6,875 Siemens & Halske Akt.-Ges. Semi-automatic telephone exchanges. (Date applied for, 18/3/09.)*†
6,876 Damaskinos. Telegraphic relays.
6,881 Tucker. Current collectors for overhead electrical tramways and light railways.
6,894 B.T.-H. Co. (G.E. Co., U.S.) Electric measuring instruments.
6,895 Petersen & Sem. System for use in long-distance telephony. (Date applied for 25/3/09.)*†

SPECIFICATIONS PUBLISHED.

1909 Specifications.

5,418 B.T.-H. Co. (G.E. Co., U.S.) Controlling electric circuits.
5,427 Addison. Switch for use with electric transformers.
5,459 McClelland & Ferranti Limited. Maximum current indicator for electricity.
5,685 Hughes. (Murray.) Wireless electric fog signalling apparatus.
5,955 Twigg. Electric sparking plugs.
6,049 Hope. Metal casings of electric fuse boards.
6,111 Ghadiali. Totally de-energising overhead dangerous electrical wires the moment they snap.
6,477 Lancashire Dynamo & Motor Co. & Stelling. Rotors of alternating-current dynamo-electric machines.
6,770 Twaites. Electric accumulator.
6,936 Westinghouse Metal Filament Lamp Co. (Lederer.) Metal filaments for incandescent electric lamps.
6,956 Siemens Bros. Dynamo Works & Kloss. Starting of electric induction alternate-current motors.
7,106 Moser. Synchronous alternating-current machines with automatic regulation of the tension or pressure. (Addition to No. 6,103/09.)
7,410 De Daillens & Joris. Portable electrically-driven drilling machines.
7,471 Jaburg. Arc lamps. (Date applied for, 28/3/09.)
8,025 Baker. Electric switches.
8,077 Sedgwick. Electric lamp holders.
8,345 Mosep. Self-regulating alternating-current additional machine or booster. (Date applied for, 11/7/08.)
8,351 B.T.-H. Co. (G.E. Co., U.S.) Electric incandescent lamp-making machines.
8,582 Marconi & Marconi's Wireless Telegraph Co. Transmitters for wireless telegraphy. (Addition to No. 20,119/07.)
9,035 Higgins & Sheridan. Electric signalling systems for railways.
9,094 Kennedy-McGregor. Electric circuit closers.
9,194 Cottier. Locking electric incandescent lamps to their holders.
9,427 Monasch. Means for producing phase displaced electromagnetic oscillations. (Date applied for, 21/4/08.)
9,693 Joel. Portable electric lamps. (Addition to No. 11,106/08.)
9,706 Hirst & Krause. Electric fan motors.
9,996 Brock. Joint for tramway or railway rails and the like.
10,175 Von Ugrimoff. Electrical sliding contacts.
10,348 Brampton & Osborne. Conduit fittings. (Addition to No. 8,601/09.)
10,594 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric distribution systems.
10,607 Key Engineering Co. & Andrews. Conduits for electric conductors.
10,663 Brazil & Cooch. Protective devices for alternating-current systems. (Cognate Application, 22,551/09.)
10,739 Pugh & Bull. Junction fittings of metallic conduits for electric conductors. (Post dated 6/5/09.)
11,154 Patterson. Galvanic batteries. (Date applied for, 26/4/09.)
11,326 Eccles & Hadfield. Trolley retrievers for electric cars.
11,765 Lecler. Openwork or armatures for reinforced concrete structures. (Date applied for, 18/5/08.)
11,842 Cowper-Coles. Regenerators for use in the electro-zincing process.
12,286 Hall. Magneto-electric ignition apparatus for use with the ignition systems of internal-combustion engines.
12,335 MacDiarmid & Bates. Electric switches.
12,507 Ruthenburg. Electrodes for electric furnaces.
12,709 Electrolytic Alkali Co., Connor & Stubbs. Electrodes for electrolytic purposes.
12,744 W. T. Henley's Telegraph Works Co. & Nichols. Electrical fuse carriers.
12,774 McLean. Brush-holders for dynamo-electric machines.
12,917 Mavor & Mavor & Coulson. Controlling the speed of bodies driven by alternating-current electric motors.
12,970 Le Blanc. Systems for electrically controlling searchlights from a remote point.
13,010 Johnson. Electrical torsiometer.
13,041 Siemens Bros. Dynamo Works & Kloss. Suppressing electric currents due to harmonics in the wave-forms of alternating-current dynamo-electric machines.
13,059 Crafton & Johnson & Phillips. Alternating-current generators.
13,129 Monnier. Distributing box for underground cables with multiple electrical conductors. (Date applied for, 6/6/08.)
13,655 B.T.-H. Co. & Richardson. Switchboards for electrical installations.
14,165 Millauro. Arc lamps. (Post dated 25/3/09.)
14,209 Pickford. Telephonic transmitters and the like.
14,244 May. Telephone system.
15,032 Kozesnik. Third rail electric railway systems.
15,317 Prott. Electric motor.
15,389 Hindley, Hindley & Stanford. Electric ignition apparatus for internal combustion engines.
15,421 B.T.-H. Co. & Dawson. Current-collecting devices for dynamo-electric machines.
15,578 Kennedy-McGregor. Electric switches.
15,851 Siemens Bros. & Co. & Ferreira. Electrical mercury switches operated by a vehicle passing along a railway.
16,004 Bluemel, Bluemel, Bluemel & Shill. Electrically-controlled pneumatic dispatch tubes, cash railways and the like. (Addition to No. 3,770/08.)
16,170 Hunt & Sandycroft Foundry Co. Alternating-current dynamo-electric machines.
16,631 Akt.-Ges. Brown, Boveri et Cie. Control of dynamo-electric machinery in electric lighting installations worked with accumulators. (Date applied for, 14/9/08.)
17,137 Foss. Sound intensifiers for telephone mouthpieces and the like.
17,353 Berry. Electrical heating apparatus.
17,450 Fessenden. Wireless signalling. (Date applied for, 8/3/09.)
17,653 Mueller. High-tension magnetos. (Date applied for, 4/8/09.)
17,664 Mueller. Magneto-electric machines. (Date applied for, 25/2/09.)
17,824 Fuller. Electric dry batteries.
17,909 Geiger. Arc lamps.
18,005 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Electric control of clocks.
18,534 Bosch. Multiple distributor for electric ignition apparatus. (Date applied for, 20/7/09.)
18,950 Clement. Telephone exchange system.
19,057 Kelvin & James White, Chetwynd & Clark. Magnetic compasses.
19,111 Friedrich. Regenerating electric accumulators.
19,210 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
19,263 Edwards. (German.) Fusible cut-outs for electrical apparatus.
19,424 Trentmann. Electric lighting devices for life buoys.
20,003 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke Ges.) Adjustable transformers for polyphase electric alternating currents.
20,311 Bloxam. (Geb. Siemens & Co.) Arc lamps.
20,413 Dusseris. Electric switching devices for controlling electro-magnetic clutches.
20,656 Bosch. Current distributors for the ignition devices of internal combustion engines. (Date applied for, 7/4/09.)
20,832 Weinert. Carbons for arc lamps.
20,841 Kingsbury. (Western Electric Co.) Selector switch.
20,842 Kingsbury. (Western Electric Co.) Automatic selective switching apparatus.
20,882 Jenkins. Electric hand lamps.
20,922 Justice. (Kunsch & Jaeger Ges.) Photographic recording apparatus for galvanometers, oscillographs and the like.
21,113 Crompton & Co., Macfarlane & Burge. Electrical regenerative control apparatus and systems. (Date applied for, 3/3/09.)
21,222 Skinner. Iron poles for telegraphs, telephones and the like.
21,374 Geb. Siemens & Co. Electrodes for arc lamps. (Date applied for, 5/10/08.)
21,763 Allgemeine Elektricitats Ges. Centrifugal pumps and the like. (Date applied for, 24/9/08.)
22,273 Meszaros, Fawns & McCracken. Metallic filament lamps.
22,385 Howe & Taylor. Electric switches and the like.

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22,479 Bosch. Insulation of windings in electrical apparatus. (Date applied for 12/12/08.)
22,768 Christoph & Klein. Arc lamps.
23,177 Isaacson. Magneto-ignition apparatus.
23,863 Schmeltz. Charging electrical accumulators or secondary batteries.
24,185 Siemens & Halske Akt.-Ges. Electric signalling installations. (Date applied for, 21/10/08.)
24,306 Allgemeine Elektricitats Ges. Continuous-current motor generators or transformers. (Date applied for, 22/10/08.)
24,632 Walden. Electrically reset gravity escapement.
24,771 Waterhouse. Combination coupling for electric conductors.
24,812 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Telephone exchanges.
24,892 Brampton & Osborne. Conduit fittings for electrical and other purposes, and the manufacture of same. (Date applied for, 10/4/09.)
25,028 Moloney & Ross. Telephone transmitters.
25,259 Burton. Electric insulators.
25,445 Nordentoft. Electric fuses.
25,733 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke Ges.) Electric fuse fittings. (Addition to No. 8,263/09.)
25,883 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Telephone exchanges.
25,962 Siemens Bros & Co. (Siemens & Halske Akt.-Ges.) Electrical mercury switches. (Addition to No. 6,037/05.)
27,033 Milton. Generating alternating currents. (Date applied for, 30/1/09.)
27,103 Bosch. Carbon holders in magneto-ignition apparatus, current distributors or the like. (Date applied for, 27/7/09.)
27,245 Fried. Krupp Akt.-Ges. Regulating devices for direct-current dynamos. (Date applied for, 18/3/09.)
27,446 Rawlings. Tumbler switches. (Date applied for, 7/1/09.)
27,472 Falk, Stadelmann & Co. & Charles. Means for holding globes or shades in the galleries of electric light, gas and other fittings.
27,560 Timar. Electromagnetic igniting device for arc lamps.
27,757 Navarro. Supports or insulators for carrying electric conductors or cables.
28,184 Sterling Telephone & Electric Co. (Telephon Fabrik Akt.-Ges. vorm. J. Berliner.) Electric switches.
28,363 Siemens & Halske Akt.-Ges. Telephone exchanges. (Date applied for, 5/12/08.)
28,362 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Telephone exchanges.
28,825 Siemens & Halske Akt.-Ges. Telephone exchanges. (Date applied for 12/12/08.)
29,491 Chemische Fabrik Griesheim-Elektron. Manufacture of anhydrous caustic soda. (Date applied for, 23/12/08.)

COMPANIES' MEETINGS AND REPORTS.

ALLGEMEINE ELEKTRICITATS GESELLSCHAFT.—The annual report states that business is satisfactory, but prices have been affected by keen competition. Producing costs have been reduced owing to lower prices of raw materials and to improved methods of manufacture. The value of the work executed by the machinery department between July 1, 1909, and March 31, 1910, was 11,000,000 marks (£550,000) in excess of that for the previous corresponding period, and establishes a record. Electrical locomotives, both for passenger and goods transport, are in course of construction, and are of various sizes up to 1,800 H.P. A system of power transmission for very high voltages has been perfected, and a new factory for this work is already partly in use. The turnover in small motors has increased considerably, and this department is being enlarged. The output of the turbine works showed an increase over last year of 50 per cent., and this department now employs over 3,000 workpeople. The cable works at Oberspree were well employed, and the output showed an increase of 6,000,000 marks. The cable works have to meet the demand for higher voltages, and 30,000 volts may now be considered normal, but by no means indicates the probable limit. As several departments are badly situated for enlargements, a new factory is in course of erection, and will be completed about the end of the year. The incandescent lamp works show an increase in output owing to the growing demand for metal filament lamps, though there is still a steady demand for carbon filament lamps. The total turnover of the undertaking for the first three quarters of the current year has declined slightly compared with last year owing to a decrease in orders from the Berlin Electricity Works, but orders on the books at present are 18,00,000 marks in excess of those at this time last year. The land at Henningsdorf has been laid out for new works.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—The gross receipts during 1909 were £1,938,887. 13s. and the working expenses £1,207,222. 6s. 2d., leaving £731,665. 6s. 10d. Adding £12,839 brought forward, £24,099 interest, &c., the total was £768,603. 18s. 8d. After paying the annuity to "City Company" (£70,660) and interest on debenture stock and preference dividends, and the 6 per cent. interim dividend on ordinary shares, the balance was £80,972. 17s. 3d., and the directors recommend a final dividend on the ordinary shares at the rate of 6 per cent. (less tax), which will absorb £70,625, leaving £10,347. 17s. 3d. to be carried forward. The total length of the combined tramways is 332 miles of single track. The great development of traffic makes some form of relief necessary. Applications were made last year by Buenos Ayres Western Railway Co. for a concession for an underground line from Plaza Once to Plaza Mayo and the Port, and by other parties for concessions for the construction of other underground railways. In these circumstances the company considered it advisable to apply for a concession for the construction of certain subways. The National Government granted a concession to the Buenos Ayres and Western Railway and the Municipality granted to the Anglo-Argentine Co. the concession for constructing subways near the surface, and the Western Railway will, therefore, construct their tunnels at such depth as will not interfere with any of the proposed subways. The contract concluded with the Municipality authorises the construction of three lines of an aggregate of over 10 miles to be worked by electric traction in conjunction with the company's existing system. The company is to pay to the Municipality a tax of 6 per cent. of the gross receipts of the subway traffic. No new taxes are to be imposed by the Municipality during the term of the concession. The concession for the whole undertaking of the company, including all lines recently acquired, is fixed at 80 years from March 18, 1910. The directors have arranged to purchase the Metropolitano tramways, which are at present held on lease, and in order to provide funds for the construction of the subways, the purchase of the Metropolitano tramways, &c., the directors ask for power to create and issue £6,000,000 5 per cent. debenture stock, to rank after the existing 4½ per cent. debenture stock, and to increase the second preference share capital by £500,000 and the ordinary share capital by £1,500,000. It is also proposed to increase the dividend on the first and second preference shares respectively from 5 to 5½ per cent.

BARNSLEY & DISTRICT ELECTRIC TRACTION CO. (LTD.)—The total revenue for 1909 amounted to £9,043. 12s. 9d. and expenditure to £7,141. 2s. 5d., leaving a profit of £1,902. 10s. 4d. Adding £196. 4s. 5d. brought forward, the total is £2,098. 14s. 9d. £200 has been placed to depreciation and reserve and £350 to sinking fund for redemption of loans and debenture stock, and after paying the preference dividend for the year (£1,320) the balance (£228. 14s. 9d.) has been carried forward. The net result is £150. 0s. 4d. better than in 1908, although the receipts from traffics and parcels show a decrease of £406. 0s. 8d., due to strikes in the coal trade and bad weather. The expenses show a reduction of £683. 10s. 11d.

CITY OF BIRMINGHAM TRAMWAYS CO. (LTD.)—The directors' report for 1909 states that they have decided to recommend the shareholders to equalise the amount paid on the whole of the ordinary shares by returning £4 per share upon each ordinary share upon which £5 has been paid. This payment will be made out of profits, and will leave a liability of £4 per share on all the ordinary shares. After providing £12,000 for debenture interest and £12,083. 6s. 8d. for preference dividend, the surplus on the past year's working was £38,516. 16s. 9d. Deducting £2,104. 14s. for interim dividend at the rate of 5 per cent. on the ordinary shares for the June half-year, there remains £36,412. 2s. 9d. The directors recommend an ordinary dividend at the rate of 5 per cent. for the last six months and a bonus of 5 per cent. (making 10 per cent. for the year), and the payment of £24,188 (£4 per share in reduction of paid-up capital of £5 per share upon 6,047 ordinary shares), £5,910. 0s. 9d. being transferred to reserve. The traffic receipts, compared with the previous year, show an increase of £3,360. 14s. 5d., and receipts from advertising and interest on investments show an improvement of £4,019. 9s. 11d. A reduction of £4,246. 15s. 7d. has been effected in the cost of maintenance of tramways and payments to local authorities. The price payable by Handsworth Council (£72,174) for the company's Handsworth undertaking has been received. The Council are under obligation to grant a lease of the cable tramway to the company from the date of purchase to June 30, 1911. An agreement has been entered into with the Council for the operation of through services from Birmingham, through Aston, to the terminus of the Perry Barr route in Handsworth, and from Aston, through Handsworth, to West Bromwich, when the cable line is electrified, and the Villa-road line reconstructed and open for traffic. Notice has been received from Yardley Council of its intention not to exercise its option to purchase the electrical plant at the Yardley power station. The company have protested against the charges made by Birmingham Corporation for repairs to permanent way of Bristol-road tramway. The lease of the tramways provides that the decision of the City Surveyor is to be final on all questions or differences that arise under the lease in regard to value, repair and construction. The company applied to the Corporation to appoint an independent person as arbitrator, but the Corporation refused to depart from the terms of the lease. The Corporation has acknowledged the claim made against it for loss of traffic receipts arising out of the delay in completing the reconstruction of the Bristol-road line and £540 has been paid. The working of the company's undertaking by the joint committee continues to show satisfactory results and the arrangement has been further continued.

ELECTRIC SUPPLY CORPN. (LTD.)—At the meeting last week the chairman (Mr. J. Stone) said that in future the company would depend solely on its own earnings, as the final payment under the guarantee had been made. Originally it was estimated that at the expiration of the guarantee the company would be earning 5 per cent. on its shares, but that would not be accomplished for several years, although the table of progress showed a steady advance. Soon after the flotation of the company the electrical supply business was revolutionised by the introduction of metal filament lamps, and that upset their calculations, which were based on the carbon lamp. Their view, that the metal filament lamp was benefiting the company by bringing the light within the means of small consumers, had been verified by the results.

FELTEN & GUILLEAUME-LAHMEYERWERKE, A.G.—The directors' report for 1909 states that all their factories were kept well employed throughout the year, but owing to the general fall in prices of electrical machinery the results were comparatively poor. The gross trading profit was M.13,993,100 (£699,655), compared with M.14,618,900 (£730,945) in 1908, while the net profit was £181,200, against £256,400. The dividend is 6 per cent, against 8 per cent. in 1908.

LEAMINGTON & WARWICK ELECTRICAL CO. (LTD.)—Capital expenditure during 1909 was £798. 1s. 5d. in respect of mains, &c., for supply of electricity in Warwick and other equipment. The accounts show a credit balance of £5,504. 16s. 9d. from the tramways and electricity supply. Deducting expenses (£1,281. 2s. 5d.), interest and provision for renewals, there remains £2,458. 15s. 5d. Adding £282. 16s. 5d. brought forward, the total available for distribution is £2,741. 11s. 10d. The directors recommend a dividend at the rate of 2 per cent. on the ordinary shares. The unsatisfactory weather during the year had an adverse effect on the traffic receipts. The number of installations connected at Dec. 31 was 206 (exclusive of tramway load), and was equivalent to 7,870 8 c.p. lamps, compared with 7,402 8 c.p. lamps in 1908.

MUSSELBURGH & DISTRICT LIGHT & TRACTION CO. (LTD.)—The accounts for 1909 show an available sum (after providing for deben-

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ture interest and including £131 brought forward) of £3,811. The directors recommend the transfer of £2,000 to reserve and renewals fund and carry forward £1,255. This would permit of a dividend of 2½ per cent. on the preferred shares, and the directors hope this will be paid towards the end of July.

PARA ELECTRIC RAILWAYS & LIGHTING CO. (LTD.)—The chairman (Sir W. Evans-Gordon) stated at the meeting last week that the receipts from the tramways had been better by £17,300 and the receipts from the lighting increased by £3,400. Working expenses of the tramway were £24,300 less and the working expenses of the lighting part were £8,000 less. Since Nov. 30 the working expenses had been further reduced, so that for the four months of the current year, compared with the corresponding period of the previous year, they were well under 50 per cent. for both tramways and lighting. There had been a great improvement of the electric lighting branch, and he thought a further extension was certain to take place in connection with the use of electrically-driven fans and pankahs. Once the people used pankahs they found it impossible to do without them, because they gave such an increased amount of comfort in a country where is was hot all the year round. They had earned enough to enable them to pay a dividend upon the ordinary shares at the rate of 7½ per cent. They were now clear of the arrears of preference dividend, and the directors considered the position so satisfactory that they would be quite justified in paying an interim dividend later on on these shares for the first half of the current year.

REUTER'S TELEGRAM CO. (LTD.)—The directors' report for 1909 states that the balance for distribution amounts to £4,992. 6s. 9d., including £693. 18s. 10d. brought forward. An interim dividend of 2½ per cent. has been paid, and the directors now declare a dividend of 4s. per share (2½ per cent.), making a total distribution (tax free) of 5 per cent. for the year. £256. 14s. 9d. is carried forward.

SAO PAULO TRAMWAY, LIGHT & POWER CO. (LTD.)—The gross earnings during 1909 were $2,439,485, operating expenses and maintenance charges $846,626, net earnings $1,592,859, less taxes, &c., $71,986, bond interest $300,000 and dividends $973,866, surplus $242,005, provision for renewals $150,000, transferred to profit and loss account $92,005.

WOKING ELECTRIC SUPPLY CO. (LTD.)—At the meeting last week the chairman (Mr. John Ashby) said that the total revenue for the year (£13,837) was between £600 and £700 less than in 1908; but the expenditure was also nearly £300 less, owing largely to a reduction in cost of coal and to other economies effected. After meeting debenture interest and preference dividend, they were able to pay a dividend of 5 per cent. on the ordinary shares, to place £1,000 to reserve and to carry forward £617. 15s. 6d. Their customers were increasing at a greater ratio than at any time in the previous history of the company. On the whole the directors were satisfied with the report, and they considered the business of the company was in a healthy and satisfactory state. They were pushing their business in Chertsey and Addlestone, where they started doing work last year. At Chertsey they had opened a shop where the residents could obtain particulars as to cost of wiring, &c. They had been approached by towns where they had no powers to supply, and asked if they would supply current in bulk for distribution by the local authority or a local company. They were considering that proposal. They had put the matter into the hands of their co-director (Mr. Bowden). They had been asked to go to Cobham, but they should not incur further capital expenditure unless they could satisfy themselves that they would receive a fair and adequate return on it.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

DE LAVAL IGNITER CO. (LTD.) (109,408)—Reg. May 3, capital £1,500 in £1 shares, to carry on the business of manufacturers of and dealers in dynamos, electric motors, switchboards, resistances, general switchgear appliances, controllers, accumulators, &c., and to adopt an agreement with R. E. Bentley. Private company. R. E. Bentley is first director. Reg. office, 64A, Broad street, Birmingham.

HARPIN & CO. (LTD.) (109,290.)—Reg. April 20, capital £2,500 in £1 shares (1,500 6 per cent. cumulative preferred), to take over the business of electric lighting and power engineers carried on at Birmingham and Dudley as John H. Harpin & Co. Private company. First directors, F. C. N. Holloway, J. H. Harpin and P. T. Holloway. Reg. office, Bank Chambers, 47, Temple row, Birmingham.

NEW AFRICAN CONCESSIONS SYND. (LTD.) (109,342.)—Reg. April 29, capital £50,007 in £1 shares, to acquire the undertaking of the African Concessions Synd., to carry on the business of suppliers of electric light, heat and power, builders and constructors of public works, &c. First directors, W. A. Wills, Hon. R. J. Delays Tollemache, A. H. D. Cochrane, W. Praeger and P. S. Inskipp.

J. H. WALLACE & CO. (LTD.) (109,264.)—Reg. April 27, capital £5,000 in £1 shares, to carry on the business of hydraulic and general consulting engineers, electricians, manufacturers of and dealers in electrical and other machinery, &c. Private company. First directors, J. H. Wallace (chairman), J. F. Sickman, F. E. Greenwood, W. L. Bowker and J. Perry.

STATUTORY RETURNS.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—Return to Feb. 18 gives capital as £7,000,000 in £539,920 ordinary stock, £3,230,040 preferred ordinary stock and £3,230,040 deferred ordinary stock. All stock taken up. £7,000,000 paid. Mortgages and charges, nil.

HASTINGS & DISTRICT ELECTRIC TRAMWAYS CO. (LTD.)—Capital in return to March 29 is £500,000 in £5 shares (50,000 preferred). 40,000 preferred and 28,235 ordinary shares taken up. £5 per share called up on preferred. £200,000 paid. £141,175 considered as paid on the ordinary. Mortgages and charges, £250,000.

LEICESTERSHIRE & WARWICKSHIRE ELECTRIC POWER SYND. (LTD.) Return to Dec. 21 gives capital as £20,000 in £10 shares, 1,990 shares taken up. £10 per share called up on 1,470 and nil on 520. £17,740 paid (including payments in advance of calls). £40 remains in arrears. £20. 12s. 1d. paid on 10 shares forfeited. Mortgages and charges, £2,250.

LONDON ELECTRIC SUPPLY CORPN. (LTD.)—In return to March 11 capital is £1,050,000, in 200,000 ordinary shares of £3 each and 90,000 preferred shares of £5 each. 111,000 ordinary and 69,840 preferred shares taken up. £632,360 paid, including £160 on 160 shares forfeited. Mortgages and charges £387,355.

NEW ARC SYND. (LTD.)—According to return to Jan. 12 capital is £6,000 in £1 shares. 5,557 shares taken up. £1,557 paid. £4,000 considered as paid. Mortgages and charges, nil.

NORTHALLERTON ELECTRIC LIGHT & POWER CO. (LTD.)—In return to March 9 capital is £6,500 in 2,900 preference shares of £1 each and 12,000 ordinary shares of 6s. each, of which 1,151 preference and 4,561 ordinary shares have been taken up. £2,519. 6s. has been received. Mortgages and charges, £5,400.

RHYMNEY VALLEY & GENERAL ELECTRIC SUPPLY CO. (LTD.)—Return to Feb. 9 gives capital as £5,000 in £1 shares (2,500 preferred). 2,101 shares taken up. £1 per share called up on 930 ordinary and 2s. on 354 preferred. £955. 14s. paid, leaving £5. 6s. in arrears. £817 considered as paid on 817 shares. £4. 8s. paid on 80 forfeited preferred shares. Mortgages and charges, £900.

TURNERS & MANVILLE (LTD.)—Return to Feb. 22 gives capital as £50,000 in £1 shares. 20,012 shares taken up. £10,621 paid. £9,391 considered as paid. Mortgages and charges, nil.

MORTGAGES AND CHARGES.

HINDHEAD & DISTRICT ELECTRIC LIGHT CO. (LTD.)—Issues from March 7 to April 9 of £950 debentures, part of a series of which particulars have already been filed.

PAIGNTON ELECTRIC LIGHT & POWER CO. (LTD.)—Issue on April 13 of £400 debentures, part of a series of which particulars have already been filed.

THOMAS L. SCOTT & CO. (LTD.) Particulars of £3,500 debentures, created Aug 20, 1909, have been filed, amount of present issue being £2,500. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

CITY NOTES.

MEMORANDA (May 18).—**Bank rate 4 per cent. (since March 17, 1910). Price of silver,** 24⅞d. per oz. **Consols** 81⅞—82 **for money; 81⅞—82⅛ for account. Consols Pay Day, June 1; Stock and Shares Continuation Days, May 25 and June 8; Ticket Days, May 26 and June 9; Pay Days, May 27 and June 10; Mining Shares Carry Over Day, May 24.**

PRICES OF METALS (London).—*Copper*, cash, 56⅛; three months, 56⅜. *Lead*, English, 12⅝—13¼; foreign, cash, 12⅝—12¾; three months, 12¾—12⅞. *Spelter*, 21⅝—22¼. *Tin*, English, 149—151; foreign cash, 150¼; three months, 151¼. *Iron*, Cleveland, cash, 49/7, and three months, 50/6.

BERGMANN ELEKTRICITATS-WERKE (A.G.) (BERLIN).—The turnover for the past year was 37,586,500 marks (£1,879,325), against 23,031,600 marks (£1,151,580) in 1908. An increase of capital (8,000,000 marks) has been decided on, bringing the capital to 29,000,000 marks.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the five weeks ended April 1 was 743,651 compared with 693,472.

CASTNER KELLNER ALKALI CO. (LTD.)—An interim dividend at the rate of 12½ per cent. is announced for the six months ended March 31.

COMPANIES STRUCK OFF THE REGISTER.—The following were struck off the Register of Joint Stock Companies on May 10:—

Electrical Bleaching Co., Electrical Regulating & Lighting Synd., Electrical Supplies, Rubber & Ebonite Co., Electric Lamp Regenerating Co., Electric Railways Co., Electro-Voelker Synd., Hillgrove & Armidale Electrical Corpn., McGuire Mfg. Co., Meyra Electric Co., Sulphides Reduction Co (New Process) (reg. March 27, 1902).

HOLSWORTHY GAS & ELECTRIC LIGHTING CO. (LTD.)—At the statutory meeting last week the chairman (Mr. W. T. Kivell) said that they hoped in a fortnight's time to be in a position to place the contract for the installation of electric light plant in Messrs. Christy & Co.'s hands.

OLDHAM, ASHTON & HYDE ELECTRIC TRAMWAY (LTD.)—A dividend has been declared of 7s. per share, making 6 per cent. for the year (the same as for each of the last five years).

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have ordered a further issue of $1,500,000 7 per cent. cumulative preference stock of the *Mexican Light & Power Co. (Ltd.)* to be quoted in the official list.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	May 6	222	+ 8	18	3,888	+ 92
Anglo-Argentine	,, 13	47,005	+ 10,107	19	832,852	+ 83,206
Ayr Corporation	,, 14	230	— 4	52	14,325	— 104
Baker St. & Waterloo Ry.	,, 14	3,260	+ 150	19	65,100	+ 1,390
Barnsley	,, 6	177	+ 13	18	3,069	+ 129
Barrow	,, 6	250	+ 41	18	4,103	+ 411
Bath Electric Trams, Ltd.	,, 11	707	— 71	19	13,410	+ 1,146
Birmingham Corporation	..	..	..	..	..	..
Birmingham & Midland	April 29	810	+ 2	17	13,738	+ 235
Blackburn Corporation	May 11	967	— 173	‡7	7,013	— 965
Blackpool and Fleetwood	..	..	..	..	..	..
Bolton Corporation	..	..	..	..	..	..
Bombay	April 15	2,829	+ 388	15	41,297	+ ‡ 2,735
Bournemouth Corporation	May 11	1,462	— 112	6	9,143	— 1,248
Bradford Corporation	..	..	..	..	..	..
Brighton Corporation	,, 15	981	+ 144	§6	5,377	— 640
Bristol Trams & Carriage	,, 13	5,356	+ 25	52	297,277	— 210
Burnley Corporation	,, 14	1,227	— 8	19	23,950	+ 552
Burton Corporation	,, 15	266	+ 31	§6	1,628	— 44
Bury Corporation	..	..	..	..	..	..
Calcutta Tramways Co.	,, 14	₹50,096	+ ₹2,008	19	₹990,730	+ ₹34,408
Camborne-Redruth	,, 14	114	— 5	19	2,222	— 69
Cardiff Corporation	..	..	..	..	..	..
Cavehill	,, 6	82	— 1	18	1,309	+ 132
Central London Railway	,, 14	5,692	+ 234	19	105,118	+ 974
Charing C., Euston & H'stead	,, 14	3,655	— 225	19	72,495	— 685
Chatham & Dist. Lt. Rys.	,, 12	762	— 26	19	14,439	+ 499
City & South London Rly.	,, 15	3,133	+ 142	19	62,311	— 32
City of Birmingham	,, 6	2,834	+ 145	18	50,582	+ 2,721
Colchester Corporation	,, 11	163	+ 12	19	3,063	+ 444
Cork Electric Trams Co.	..	..	..	..	..	..
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	,, 6	414	+ 60	18	7,265	+ 741
Dover Corporation	..	..	..	..	..	..
Dublin & Lucan Railway	,, 13	125	— 20	19	2,234	+ 17
Dublin United	,, 13	5,112	— 221	19	96,885	+ 2,932
Dudley-Stourbridge	,, 6	735	— 39	18	12,671	— 467
Dundee Corporation	,, 11	1,134	— 30	†52	60,531	— 627
East Ham Council	..	..	..	..	..	..
Exeter Corporation	,, 13	283	— 19	6	1,802	— 205
Gateshead & Dist. Trams	,, 6	983	+ 30	18	17,113	— 267
Glasgow Corporation	,, 14	18,294	+ 683	†50	848,638	+ 3,907
Glossop Trams	..	..	..	..	..	..
Gloucester Corpn.	,, 11	259	— 17	6	1,537	— 35
Gravesend-Northfleet	,, 6	185	— 7	18	3,382	+ 107
Great Northern & City Rly.	,, 14	1,436	+ 44	19	28,602	— 354
Gt. Northern, Piccadilly, &c.	,, 14	5,690	— 25	19	114,850	+ 4,660
Greenock & Port Glasgow	,, 6	623	+ 70	18	9,739	+ 1,306
Hartlepool Tramways	,, 6	234	+ 22	18	3,765	+ 168
Hastings Elec. Trams Co.	,, 12	822	— 103	19	15,384	+ 208
Hong Kong	,, 14	$8,928	+ $197	19	$163,462	+ $14,653
Huddersfield Corpn.	,, 14	1,685	+ 128	6	10,679	+ 255
Hull Corporation	,, 14	2,603	+ 277	6	16,489	+ 375
Ilford District Council	..	..	..	..	..	..
Ilkeston District Council	,, 11	116	— 5	6	692	— 89
Ipswich Corporation	..	..	..	..	..	..
Isle of Thanet Co.	..	..	..	..	..	..
Jarrow	,, 6	121	+ 8	18	2,004	+ 106
Keighley Corporation	,, 12	168	..	6	973	— 36
Kidderminster & District	,, 6	85	— 6	18	1,557	+ 40
Kilmarnock Corporation	,, 7	145	— 8	51	7,366	— 213
Lanarkshire Trams Co.	,, 12	1,378	+ 132	19	25,329	+ 2,596
Lancashire United	,, 11	1,198	— 115	19	23,188	— 206
*Leamington	,, 6	134	— 22	18	2,581	— 60
Leeds Corporation	..	..	..	..	..	..
Leicester Corporation	..	..	..	..	..	..
Leith Corporation	,, 14	594	+ 57	52	30,635	+ 3,752
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	,, 7	11,010	+ 235	18	193,398	+ 4,702
Liverpool Overhead Rly.	..	..	..	..	..	..
Llandudno&ColwynBayRy.	,, 13	160	— 15	§23	3,378	+ 111
*London County Council	April 30	40,744	+ 5,147	¶4	172,901	+ 18 429
London United	May 14	5,816	— 342	19	108,109	+ 6,405
Lowestoft	..	..	..	..	..	..
Maidstone Corporation	..	..	..	..	..	..
Manchester Corporation	..	..	..	..	..	..
Mersey Railway	,, 14	2,229	+ 124	19	38,392	+ 930
Merthyr	,, 6	195	— 8	18	3,421	— 215
Metropolitan Dist. Railway	,, 14	10,727	+ 709	19	205,768	+ 20,045
Metropolitan Elec. Trams	,, 6	7,189	+ 1,076	18	122,592	+ 22,690
Middleton	,, 6	292	— 37	18	5,012	— 430
Nelson Corporation	,, 14	138	+ 7	§6	857	— 70
Newcastle-on-Tyne Corp.	..	..	..	..	..	..
Newport (Mon.)	..	..	..	..	..	..
Northampton Corporation	,, 13	453	— 21	6	2,755	— 210
Oldham, Ashton & Hyde	,, 6	651	— 6	18	9,503	— 139
Oldham Corporation	..	..	..	..	..	..
Perth (N.B.) Corporation	..	..	..	..	..	..
Perth (W.A.) Elec. Trams	,, 13	1,437	+ 95	19	29,918	+ 2,179
Peterborough	,, 6	101	— 2	18	1,790	— 37
Portsmouth Corporation	..	..	..	..	..	..
Potteries	,, 6	1,876	+ 131	18	30,980	— 170
Preston Corporation	,, 11	674	— 52	6	4,094	— 361
Rotherham Corporation	,, 12	589	— 3	6	3,558	— 118
Rothesay	,, 6	85	— 23	18	1,331	— 20
Salford Corporation	..	..	..	..	..	..
Sheerness	,, 6	44	— 1	18	764	— 14
Sheffield Corporation	..	..	..	..	..	..
Singapore Trams	,, 14	$9,830	+ $13	19	$190,415	+ $4,720
South Metropolitan	,, 6	757	+ 4	18	13,221	+ 711
South Staffs	,, 6	847	+ 53	18	14,408	— 118
Southend Corporation	,, 11	414	+ 19	6	2,521	— 110
Southport Tramways	,, 6	247	— 18	18	4,355	+ 105
Stalyb'dge,Hyde,&c., Jt.Bd.	..	..	..	..	..	..
Sunderland Corporation	,, 15	1,129	+ 83	7	6,738	— 495
Sunderland District	,, 11	400	— 32	28	11,418	— 954
Swansea Trams	,, 6	1,041	+ 127	18	17,665	+ 1,944
Swindon Corporation	,, 11	129	+ 4	..	..	..
Taunton	,, 6	40	+ 2	18	711	+ 89
Tynemouth and District	,, 6	163	— 1	18	2,795	+ 236
Tyneside Trams Co.	,, 11	382	— 20	19	7,218	— 358
Wallasey District Council	,, 14	897	+ 16	§6	5,384	— 595
Walsall Corporation	,, 14	546	+ 54	19	10,018	+ 516
Warrington Corporation	..	..	..	..	..	..
West Ham Corporation	,, 5	2,361	+ 113	5	11,523	— 401
Weston-super-Mare	,, 6	61	— 28	18	790	— 40
Wolverhampton Co.	,, 6	413	+ 18	18	7,209	+ 148
Wolverhampton Corpn.	,, 11	846	+ 75	6	5,080	+ 264
*Worcester	,, 6	265	— 12	18	4,388	+ 54
Wrexham	,, 6	89	+ 2	18	1,668	+ 9
Yorkshire W.R. Trams	,, 16	1,327	+ 110	20	24,032	..
Yorkshire Woollen District.	,, 6	1,005	+ 88	18	16,892	+ 1,687

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	NAME.	Price Tues., May 17	Rate per cent. Yielded.	Dividend Due.	Business 6 Days to May 17. Highest.	Business 6 Days to May 17. Lowest.
		Electricity Supply.		£ s. d.			
10	6/0	Boarnemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9½	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	9¼—10¼	5 17 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅛—7¼	6 7 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7 —7¼	4 13 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 9	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾—4⅛	5 14 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 17 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —100	4 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101⅛—103½	4 7 0	..	102¼	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¾—4⅛	5 3 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜—4⅛	5 9 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11½—12	5 16 6	Feb, Aug	11⅛	11⅞
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	12⅞	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 —103	4 7 6	Jan, July	101¼	99½
5	..	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¼—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7⅜—8	6 0 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾—11½	5 6 6	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103 —106	4 5 0	Jan, July	..	..
St.	4½%	†Do. Second Deb. Stock	98 —101	4 9 0	May, Nov	100½	100
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4⅞	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5¼	4 15 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7⅛	5 6 8	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅞—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94½—96½	4 3 6	..	..	..
St.	4%	Kensington & Knigtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —99	4 1 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4¼—5½	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	92 —94	4 4 0	Jan, July	93½	..
5	2/6	Metropolitan Electric Sup. Ord.	3¾—4⅛	5 6 0	April, Oct	4	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4½—4¾	4 12 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	97 —99	4 11 0	June, Dec	..	..
5	4 0	Newcastle Elec. Supply Ord.	4¼—4½	4 5 0	Feb, Aug	..	..
5	5%	Do. 5 per cent. non Cum. Pref.	4½—4¾	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	99 —101	4 19 0	..	..	..
10	9/0	Notting Hill Electric Ord.	11¾—12¾	5 17 6	March	12¼	11
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8½—9	5 11 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¼—7⅛	4 16 9	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	85 —88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1⅜—2⅛	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3⅛	6 11 0	April	..	..
St.	5%	Do. 5% 1st Mort. Stock (red.)	100 —103	4 17 6	..	102½	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—¼	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	2⅛	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	99¼	..
5	2/6	Urban Electric Supply Ord.	⅛—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8¼—8½	5 13 0	Mar, Sept	8⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5¼	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	96¼	..
1	..	Bath Elec. Trams Pref. Ord.	⅜—⅝	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—½	6 13 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	83 —86	5 5 6	Jan, July	83	..
10	6%	Bristol Tramways & Carriage Ord.	6¼—7	8 11 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7¼—7½	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅞ —1⅛	..	June, Dec	..	..
10	3%	Do. 6 per Cent. Cum. Pref.	3¼—3½	7 15 0	Feb, Aug	..	..
St.	5%	Do. 5 Cent. Perpetual Debs.	90 —93	5 7 6	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	66 —71	6 7 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	71 —73	5 3 6	Feb, Aug	73	71½
St.	4%	Do. 4 per Cent. Pref. Stock	85 —88	4 11 0	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	53 —55	3 12 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	102½	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	95 —98	4 2 0	Jan, July	95¼	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4½—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	34 —35	3 10 0	Feb, Aug	34½	..
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	106 —108	4 12 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —105	4 15 0	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1933)	100 —103	4 17 6	Feb, Aug	101	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	93 —100	4 0 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 —98	4 2 0	Jan, July	97	96¼
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3¼—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	70 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅜—1⅝	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2¼—2⅝	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	68 —72	5 11 0	Jan, July	69¼	68
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅝—¾	..	..	..	..
1	..	Do. Deferred	⅛—¼	..	April	¼	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	5 11 6	Feb, Aug	¾	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 —100	5 0 0	Jan, July	..	..
St.	1%	Metropolitan Railway Consolidated	44 —44½	2 5 0	Feb, Aug	44⅛	43⅞
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	67½	66
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90½	89½
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	86½	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	93	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Tues., May 17	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business 6 Days to May 17. Highest.	Lowest.
		Electric Railways and Tramways— *Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	91 —93	3 15 0	Jan, July	92	91½
St.	..	Metropolitan District Railway Ord.....	24¼—24½	..	Feb, Aug	24½	23½
St.	..	Do. Extension Pref. (5 per Cent.).....	68 —70	..	Feb, Aug	69½	68½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	72½	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	76	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	101 —103	3 17 0	Mar, Sept	103	101
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	142 —144	4 3 3	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto.....	96 —98	4 1 0	Jan, July	..	..
1	..	Potteries Electric Traction Ord.	½—¾	..	April, Oct	¼	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	½—¾	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	..	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	½—¾	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	67 —71	5 12 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	58 —63	7 18 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% 1n.bds. withcoups	38 —40	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds.....	100½—101½	4 18 6	..	101½	..
..	4½%	Do. 4½% Bonds with coup. 5	88 —90	4 18 0	..	90	..
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	97 —99	4 1 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	¼—¾	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1¾—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	78 —81	5 11 0	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101 —103	4 7 0	..	..	..
1	..	Aron Electricity Meter Ord.....	½—¾	..	..	..	..
1	7½d.	Do. 6% Cum. Pf.	¾—1	6 8 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.....	5 —5½	3 15 6	April, Oct	..	..
1	0/7½	Do Pref.....	1⅞—1⅞	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7	7 3 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.....	5¾—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	¾—⅞	..	Feb, Aug	99	98
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	98 —100	6 0 0	..	..	98½
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	58 —61	6 11 0	Jan, July	59	57½
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	25 —29	15 10 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.....	9½—10¾	6 3 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	5¼—5½	4 11 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	102½—104½	4 6 0	Nov, May	..	..
1	1/9	Castner-Kellner Alkali Co.....	2¼—2½	5 3 9	May, Nov	2¾	2½
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	104 —107	4 4 0	Feb. Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	¾—¾	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	¾—1	7 0 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	¾—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	¾—¾	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¾—1¼	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	¾—1	6 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	1⅛—1⅛	5 5 3	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United (" A " Sh.) (£3 pd.)	⅞—⅞	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1¼	9 3 0	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅞—1	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1¼—1½	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)..	73 —76	5 18 0	Jan, July	..	..
2	..	Electric Construction Co.....	¾—1	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1⅛—1⅛	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs ..	61 —66	6 1 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7¼—8½	6 1 6	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	12 —12½	5 5 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 3 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 3 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Works....	14½—15½	6 9 0	Feb, Aug	..	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10¼—10½	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97½—99½	4 0 6	April, Oct	..	..
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	No.	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—¼	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1¼	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	30/0	Telegraph Construction & Maintenance..	32½—34½	5 17 0	Mar, July	34½	33½
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 11 0	..	2⅜	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1⅛	4 4 3	..	⅛	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	107 —110	4 11 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	101 —103	3 7 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 —107	4 4 0	June, Dec	105	104½
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	105 —109	4 12 6	..	107	..
10	8%	J. G. White & Co. 6% Cum. Pref	9½—10½	7 12 0	..	..	..
1	..	Willans & Robinson Ord.....	¾—1	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1¾—2½	9 0 0	Apr, Oct	1¼	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	65 —75	5 6 8	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3¾—3¾	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100 —102	4 18 0	June, Dec	..	..
St.	15/0	Anglo-American	60 —62	5 18 0	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	101½—102½	5 17 6	F,My,Ag,N	102½	101½
St.	25/0	Do. Deferred	20½—21	6 0 0	F,My,Ag,N	21	19
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	85½—87½	4 11 6	Jn,Ap,Jy,O	..	..
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 12 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3½—3¾	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable.....	13½—13¾	6 3 6	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½% Rg.Db.(rd.).	100 —102	4 18 0	June, Dec	..	..
St.	65/0	†Eastern Ordinary .....xd and bonus	134 —137	5 2 0	Ja,My,Jy,O	136	..
St.	17/6	†Do. 3½ per Cent. Pref. Stock.....	85 —87	4 0 6	Ja,My,Jy,O	86½	85½
St.	4%	Do 4 per Cent. Mort. Deb. Stk. (red.)..	101 —103	3 17 6	May, Nov	..	..
St.	6/6	†Eastern Extension .....xd and bonus	12½—13¾	5 5 0	Ja, Ap, Jy, O	13½	12¾
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101½	3 18 6	May, Nov	99¾	..
10	26/0	G.N (of Copenhagen), with Coupon 79 ..	30½—31½	6 0 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt.Db.(red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European	52½—54½	5 19 0	May, Nov	54½	..
100	$1½	Mackay Companies Common	86 —91	4 18 6	Ja,Ap,Jy,O	..	..
100	$1	Do. Preference	77 —80	5 0 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜—⅝	..	April	..	..
100	4%	†Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	98 —100	4 0 0	June, Dec	..	..
2½	1/3	†West Coast of America	1¼—1½	4 0 0	May	..	..
100	4%	Do. 4 per Cent. Debs.....	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	¼—½	..	May, Nov	..	..
10	6/0	†Do. 6 per Cent. 1st Pref.	8½—9½	6 11 3	May, Nov	..	..
110	9/0	Do. 6% 2nd Pref. Ex 9/- on a/c of arrs	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.....	101 —103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph.....	13¾—14½	4 18 0	Mr,Jn,O,D	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	101 —103	3 17 6	June, Dec	..	..
—	4%	Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	—	—	—

Share	Last Dividend	NAME.	Price Tues., May 17	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business 6 Days to May 17. Highest.	Lowest.
		Telephones.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	139 —141	5 13 6	..	141	..
	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	93 —95	4 4 6	Jan. Jul.	..	..
St.	4%	Do. 4% Cons. Bonds 1936	104 —105	3 14 6	..	..	..
	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99½—101½	4 18 6	Mar, Sept	..	..
5	3/0	Chili Telephone	7⅞—8⅛	4 15 9	August ..	..	..
1	0/7½	Monte Video Telephone Ord.....	½—1	7 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	½—¾	5 14 6	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	104 —105½	5 15 6	Feb, Aug	105	..
St.	6%	Do. Def. Stock	123½—125½	4 15 6	Feb, Aug	124½	124
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 10 6	Feb, Aug	10½	10
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 10 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.....	5¼—5½	4 11 0	Feb, Aug	5⅛	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)....	97 —99	3 11 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	98½—100½	3 19 6	Jan, July	98½	98
	4½%	New York Telephone Co. 30 yr. Bnds.....	98 —99	4 11 0	..	..	..
		Oriental	1⅛—1⅜	4 15 0	April, Oct	1⅛	1⅛
1	1/0	Do 6 per Cent. Cum. Pref.	1⅛—1⅛	4 11 0	April, Oct	..	..
1	0/7½	Do. 4 per Cent. Red. Deb. Stock.....	86½—88½	4 10 6	Jan, July	88½	..
St.	4%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100 —102	4 8 0	Jan, July	..	..
St.	4½%	United River Plate.....	7½—7¾	5 9 0	July	7¾	..
5	3/0	Do. 5 per Cent. Cum. Pref.	5¼—5½	4 9 0	June, Dec	..	..
5	2/6	Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan, July	..	..
St.	4½%						
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2⅞—3⅛	8 18 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10¼—11	5 9 0	Sp,DcMrJu	..	..
10	3/0	Do. 6 per Cent. Pref.	13¼—13½	4 8 0	Sp,DcMrJu	13⅜	13⅛
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4¼—4½	5 2 6	April, Oct	4⅜	4⅛
		Do. 5% Cum. 2nd Pref.....	4⅞—4⅞	5 5 6	Jan, July	..	..
		Do. 4% Deb. Stock	90½—92	4 7 0	June, Dec	91½	91
		Do. 4½% Deb. Stock	96 —98	4 12 0	..	97¼	96½
St.	4½%	Auckland Elec. Trams. 5% Deb. (red.)....	105 —107	4 13 6	Jan, July	105½	..
		Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	6⅞	..
		Do. 5 per Cent. Cum. Pref.	5 —5½	4 15 0	May, Nov	..	..
		Do. 4½ per Cent. Db. Prov. Certs.....	101 —103	4 6 6	Jan, July	102½	..
		British Columbia El.. Rly. Df. Ord.	142 —147	5 9 0	Mar, Sept	..	..
		Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	123½	..
St.	6%	Do. 5% Cum. Perp. Pref. Stock.....	109 —110	4 11 0	Jan, July	109½	107½
St.	5%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
		Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	105	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	103 —105	4 6 0	..	104½	103½
		Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	99¼	..
		Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	..	..
		Calcutta Tramways (1 to 137,610).....	4¼—4½	4 2 6	Mar, Sept	..	4¼
		Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	Jan, July	4⅞	..
		Do. 4½% 1st Deb. Stock (red).....	99 —102	4 8 0	Jan, July	..	..
		Cape Electric Tram Shares	¼—⅜	..	..	..	..
		†City of Buenos Ayres Trams Co. (1904) Sh.	5⅞—5⅞	4 9 6	F,My,A,N	5⅞	..
		Do. 4 per Cent. Deb. Stock.....	97 —100	4 0 0	June, Dec	..	..
		Colombo Tr. & Ltg. 5% 1st Mt. Db.....	94 —97	5 2 6	May, Nov	..	..
		Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..	..
		Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	95 —98	5 2 0	Feb, Aug	..	..
		Kalgoorlie Elec. Trams Sh.	⅞—1	..	..	..	..
		Do. 5 per Cent. "A" Deb. Stock.....	96 —98	5 2 0	Jan, July	..	..
		Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	..	..
		Lisbon Elec. Trams. Ord.	1⅛—1⅛	4 0 6	July	..	..
		Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	5 5 3	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
		Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
		Manaos Trams and Lt. Co. 5%, Debs.	88 —87½	..	..	88¼	..
		Manila Elec. Ry. $1,000 Gold Bonds.....	95 —97	5 2 6	Feb, Aug	..	..
		Mexico Trams Co. Com. St.	130 —132	4 16 6	..	..	..
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	95¼—96¼	5 4 3	..	96	95¾
		Do. 6% 50 yr. Mort. Bds.....	99 —100	6 0 0	..	99¼	99½
		Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	101½	..
		Perth Elec. Trams Ord.	¾—1	5 14 0	May	..	..
		Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
		Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5¼—5½	5 2 6	..	..	..
		Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	..	..
		Ric Janeiro Tram. Lt. & P. Co.....	95½—97¼	4 2 0	..	96½	96
		Do. 30 yr. Gold Bnds.	97½—98½	5 1 0	..	98½	97½
		Do. 50 yr. Mt. Bnds	86½—87½	5 14 6	..	87½	86½
		Sao Paulo Tramway, Light & Power Co. $100 Stock	147 —149	5 8 6	..	..	..
		Do. 5 per Cent. 1st Mt. $500 Db.	102 —104	4 16 6	June, Dec	102½	..
		Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5¼—5½	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.....	10½—11	5 9 0	..	..	..
St.	4½%	Do 4½ per Cent. Deb. Stk. (red).....	95 —97	4 12 6	Jan, July	96½	..
		Do 5 per Cent. 2nd Mort. Deb. Stock..	96 —98	4 18 0	..	97¼	..
		Calcutta Elec. Supply Ord.	6¾—7	5 14 0	April, Oct	6¾	..
		Canadian Gen. Elec. Co. Com. St.....	110 —114	6 3 0	..	113½	112
		Do. 7% Cm. Pf. Stock	118 —121	5 15 6	..	..	..
		Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
		Elect. Development Co. of Ontario.....	82 —85	5 16 0	..	82	..
		Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
		Indian Elec. Sup. & Trac. Co.	1⅛—1⅛	..	..	..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	¾—1	..	..	..	..
		Do. 6 per Cent. Cum. Pref.	7 —8	8 0 0	April, Oct	8⅛	..
		Kaministiquia Power Co.5% Gold Bnds..	102 —104	4 16 6	..	..	..
		Madras E. S. Corp. Ord.....	2¾—3¼	..	..	..	..
		Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock.	92 —94	5 6 9	..	..	..
		Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84½—85½%	5 17 6	..	84½	..
		Mexican Lt. & Power Co. Com. St.	79 —81	4 18 0	..	80½	80½
		Do. 7% Cum. Pref. St.	102 —104	6 16 6	..	102½	101½
		Do. 5% 1st Mort. Gold Bnds.	87½—90½	5 12 0	..	90½	90
		Montreal Lt. Ht. & Power Co. Cap. St.	135 —140	4 15 6	F,My,A,N	..	..
		River Plate Electricity Co. Ord.	2 —2½	3 11 0	April	..	..
		Do. 6 per Cent. non-Cum. Pref.	1½—1¾	5 4 0	May	..	..
		Do. 5 per Cent. Deb. Stock	103 —105	4 15 6	Jan, July	..	..
		Rosario Ele. Co. Ord.	8½—9	..	..	..	..
		Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
		Do. 2nd Pref.	8½—8¾	6 14 6	..	..	..
		Shawinigan Water& Power Co.Ca.	101 —103	4 7 6	..	..	..
		Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	107½	..
		Do. 4½ Per Con. Mt. Db. St.	99½—101½	4 8 6	..	101½	..
		Toronto Power Co. 4½% Db. St.	101 —103	4 7 6	..	..	..
		Victoria Falls Power Co. Pref.(1 to 808,000)	¾—1⅛	5 6 6	Jan, July	..	..
		Do. (808,091 to 1,700,000)	¾—1	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,671. [No. 7, Vol. LXV.] FRIDAY, MAY 27, 1910. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Temperature Coefficient of Copper.

IN our Correspondence columns during the last two or three weeks some reflections have been cast upon the temperature coefficient of copper adopted by the Engineering Standards Committee, and just as we were going to press last week we received a letter from Mr. F. J. O. HOWE, pointing out certain supposed anomalies. This letter appeared in our last issue, and in case it should be thought that the allegations are irrefutable, we think it well to make some further reference to it. Mr. HOWE, after starting with logarithms—which may very well be dismissed from the question as immaterial to the issue—remarks that no standard temperature is mentioned by the Engineering Standards Committee in their resolution adopting a coefficient of 0·00238 per degree F. He therefore adopts 60°F. as the standard temperature, and is surprised that he obtains some discordant results. Now, since Mr. HOWE is no amateur, we should have thought he would have known, in common with those engineers who are concerned with submarine cables, that the temperature implied by the Engineering Standards Committee is the one that is universally adopted as the starting point for temperature coefficients, namely, 32°F. The correct formula involves the square of the temperature; but for commercial purposes the Committee thought it sufficient to adopt 0·00238 as a mean value, and consequently a simple straight line law is the result. Thus the formula for the resistance R_t at temperature $t°$ in terms of the resistance at 32 F. is

$$R_t = R_{32}\{1 + 0{\cdot}00238(t-32)\}; \quad . \quad . \quad . \quad (I.)$$

or, if an observation at 60° F. is in question,

$$R_{60} = R_{32} \times 1{\cdot}00664. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (II.)$$

HAVING worked out a wrong result from the Engineering Standards Committee's coefficient through a wrong assumption, Mr. HOWE points out that it differs from what he understands to be Messrs. CLARK, FORDE and TAYLOR'S result, namely,

$$R_{32} = \frac{R_{60}}{1{\cdot}00665}.$$

This is practically identical with the result (II.) given above; and, indeed, it would be curious if it were not; for surely it is common knowledge that the temperature coefficient obtained by Messrs. CLARK, FORDE and TAYLOR was adopted by the Engineering Standards Committee, and we believe we are right in saying that the figure has been verified by any number of independent measurements. We think our readers will agree that Mr. HOWE'S statements are rash in the extreme, and if the contents of the book recently reviewed in our columns are of the same character, we can only say that the letter in question gives very good support to the review so adversely criticised by "A Lover of Fair Play," whose criticisms would have been better left unwritten.

Free Trade *versus* Protection.

AT the meeting last Monday, organised by the National Electrical Manufacturers' Association to discuss the comparative effects of Free Trade and Protection upon the electrical industry, the audience was not quite so large as might have been expected, but there is no question that all were keenly interested. Although the sympathy of the meeting seemed to lean toward Protection, a good deal of support was given to Free Trade. Mr. J. E. KINGSBURY, in opening the discussion, as will be seen in another column, laid stress upon the advantages of keen competition, which necessarily resulted in the highest possible efficiency. He remarked that the extent of the imports that we desired to exclude amounted to only about 10 per cent. of the home consumption, and although we might

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exclude this proportion, and might have our home market more to ourselves, there was a possibility that our foreign market would become less and our output as a whole diminished. To a large extent the argument was one of the general good against that of a section of the community. Mr. HUGO HIRST, on the other hand, spoke as one who had suffered from the present state of things. He laid stress upon the desirability of the country being more of a producer and less of a consumer. Under proper conditions there was no reason why the great bulk of the population should not be producers, with great advantage to the country as a whole. Also, Protection would mean a larger output and thus diminished costs.

WE think that the impression left on the minds of many of the audience was that much of the argument of both sides consisted simply of expressions of opinion, whereas it would be very desirable, if possible, to produce facts. Perhaps at the adjourned meeting we may be told how much of the present position is really due to competition at home and how much to competition from abroad. Also, it would seem, if Mr. KINGSBURY is right in his 10 per cent., that the maximum increase in output under Protection would be about 10 per cent., which is not very much, and this is on the assumption that our exports are not reduced by retaliation. There is not much doubt that in past days, when other countries were not producers, we had nothing to lose by Free Trade. The position at present is by no means so clear. Unfortunately, the subject is exceedingly complex, and we doubt whether more than a small proportion of those who have the subject at heart have sufficient knowledge of political economy to enable them to arrive at any clear judgment. It is also, perhaps, a little doubtful whether any discussion will change many minds. Nevertheless, we welcome the step taken by the National Electrical Manufacturers' Association, and we hope it will result in a clearer understanding of the case.

Dolter Surface Contact System.

OF all the troubles from which surface contact systems have suffered, that of live studs has been the most persistent. A system may work perfectly in theory, and it may appear that such a thing as a live stud is almost an impossibility, and yet in practice this trouble is very liable to occur. This is, doubtless, the reason why so many systems have failed. The latest to suffer in this direction is the Dolter. It appears that live studs have been noticeable at Torquay to a larger extent than the Board of Trade think desirable. Certificates have been issued from time to time permitting the system to continue in use, but with the intimation that the conditions must improve. Some little time ago a certificate was issued by the Board of Trade for one year, with the proviso that if matters did not improve within the first six months of that time no further certificate would be granted. This period has now expired, but, unfortunately, there has not been the desired improvement, and consequently the Town Council are considering what are the best steps to be taken. It is to be regretted that this result should have ensued, as in certain towns a surface contact system offers very marked advantages from the æsthetic point of view.

Electric Traction in the Hoosac Tunnel.—The "Electrical Review and Western Electrician" states that plans are under consideration by the Boston & Maine Railway for the elimination of coal and oil burning locomotives in the Hoosac Tunnel in Massachusetts. Should the change be made, a power plant will be established near South Adams, the tunnel will be lighted and ventilated by means of electricity, and only electrical engines will be used to draw the trains through the tunnel.

Electricity Meter Approved by the Board of Trade.—On May 21st the Board of Trade approved meter No. 307,722, deposited at the Board of Trade on Nov. 14, 1908, by Messrs. Siemens Bros. Dynamo Works (Ltd.) and known as the Siemens-Schuckert Alternating Current Meter, Type W10, and the means provided for fixing and connecting such meter, described in the specification and instructions deposited with the Board of Trade and dated and numbered May 7, 1910, and H. 6,284.

Automatic Telephony in Chicago.—According to the "Electrical Review and Western Electrician," the Subway Telephone Construction Co., which recently obtained the telephone franchise of the Illinois Tunnel Co., propose to instal a complete automatic telephone system in Chicago, the system to be in operation by June, 1911. With regard to the charges, the Company state that after 10,000 telephones have been installed, the prices for unlimited service in the business districts will be :—10,000 to 15,000 telephones, 7s. per month ; 15,000 to 17,500 telephones, 14s. per month ; 17,500 to 20,000 telephones, 21s. per month ; and 20,000 telephones and over, 28s. per month. It is stated that the charges will not at any time exceed 16 guineas annually for telephones in business establishments and £10 annually for instruments in private residences.

Magnetisation Curves for Small Iron Wires.—In a recent issue of the "Physical Review" Mr. J. A. Veazey describes an investigation of the magnetisation curves for a sample of iron wire one mil in diameter, the experiments being made with the object of obtaining an idea of the relative magnitude of the molecules, or groups of molecules, constituting the elementary magnets of which a large magnet is thought to consist. If the magnetisation curves showed changes indicative of sudden alteration of magnetic flux in the wire the inference would be that the groups were of the order of one mil in magnitude. The apparatus used was a modification of that employed by Ewing. The curves obtained were perfectly smooth, and the conclusion reached is that the elementary magnets, of whatever kind they may be, are less than one mil in order of magnitude.

Long Lived Tungsten Lamp.—According to the "Electrical World" a 250 watt tungsten lamp in the bakery of the Arlington Hotel, Hot Springs, on April 11th closed its unusual career after having burned continuously for 24 hours a day since October 7, 1908, thus accomplishing the extraordinary life of over 13,000 hours. On one of the three known occasions when the lamp was extinguished it was turned out for the inspection of the members of the Arkansas Public Utility Operators' convention in session at the hotel, and although its long life at that time occasioned much interest, it continued burning 11½ months more, finally having its filament separated by an accident to the 8 H.P. steam engine driving a dish-washing machine near by. This engine was mounted but 6 ft. away from the lamp, and was operated a number of hours each day during the life of the lamp. On the date mentioned the belt came off the engine and the latter ran away. When the excitement had subsided the lamp was found to be extinguished.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Balik Papan—Kwandang	Nov. 1, 1909
Malta—Tripoli	April 20, 1910
Para—Pernambuco	April 25, 1910
Mosambique—Majunga	May 3, 1910
Suakim—Jedda	May 6, 1910
Bonny—Duala	May 6, 1910
Madagascar—Reunion	May 12, 1910
Reunion—Mauritius	May 20, 1910

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Royal Commission on Mines.—The King, on the recommendation of the Home Secretary, has approved of the reconstitution of the Royal Commission on Mines for the purpose of an inquiry into the health and safety of persons employed in metalliferous mines and quarries. The new commission will consist of Sir Henry Cunynghame, K.C.B. (chairman), Mr. R. A. S. Redmayne (Chief Inspector of Mines), Dr. J. S. Haldane, M.D., F.R.S., Mr. J. S. Ainsworth, M.P., Mr. R. M. Greaves, Mr. R. A. Thomas (General Manager of the Dolcoath Mine, Cornwall), Mr. R T. Jones (Secretary of the North Wales Quarrymen's Union), Mr. W. Lewney (Secretary of the Furness Iron Ore Miners' and Quarrymen's Union), and Mr. U. Lovett (Secretary of the National Union of Quarrymen). Mr. T. E. Bettany and Mr. G. W. Chrystal, of the Home Office, will act as joint secretaries of the Commission.

Statistics of Cable Breakdowns.—In a recent issue of the "Electric Railway Journal," Mr. H. C. Stott, of the Interborough Transit Co., gives the following record of high-tension cable breakdowns on the 11,000-volt distribution system of that Company from January, 1904, to January, 1910.

Year.	Miles of cable.	In joint.	In bend.	In cable.	External causes.	Total.
1904	330	1	0	1	1	3
1905	351	0	0	1	0	1
After Earthing the Neutral.						
1905	351	0	1	1	0	2
1906	353	3	0	3	5	11
1907	353	1	0	0	5	6
1908	368	1	0	0	4	5
1909	371	3	0	1	5	9
Total		9	1	7	20	37

NOTE.—External causes include mechanical injury, steam leaks and burning of the armouring by other cables.

"The Central."—The current issue of this journal is a "memorial number" devoted to the life and work of Prof. W. E. Ayrton, who died on November 8, 1908. The issue is divided into parts, the first, describing Prof. Ayrton's life, being written by Mr. Maurice Solomon. The second on "Prof. Ayrton and His Work," is written by Prof. T. Mather, F.R.S., who is certainly qualified on all counts to undertake such a task. The third is not the least useful, for it consists of a full list of Prof. Ayrton's publications between 1870 and 1907. The number is illustrated by photographs of the subject of the issue at various times of his life. No electrical engineer will deny the great influence which Prof. Ayrton had on the progress of the profession, and thus to have in a compact form a record of his achievements is an advantage which cannot be over estimated. We congratulate the compilers on the work they have done. Although this issue is complete in itself we gather that there is more to follow.

Obituary.—JOHN OLDHAM.—Sad and unexpected news comes from the River Plate. We have been so accustomed to regard Mr. John Oldham (Manager of the River Plate Telegraph Co., and since 1874 representing the Western Telegraph Company's interests in Argentina and the Plate) as a permanent institution that the news of his sudden death on April 18th comes as a shock. He first left England for the Plate in 1865, and resided in Uruguay and Argentina up to the day of his death, with infrequent journeys home. He was always an acceptable negotiator with the Governments on his Companies' behalf, and quite recently he had almost seen the completion of the negotiations of the direct cable between Europe and Argentina. Mr. Oldham was greatly respected and possessed many friends, with whom we join in tendering our sincere condolences to his family.

Mr. Oldham was born near Manchester in 1836. He was associated with the earlier days of telegraphy, having served the old United Kingdom and the British and Irish Magnetic Telegraph Companies. He subsequently had some experience at Henley's factory at Woolwich, and ultimately was selected by Mr. Matthew Gray to undertake the establishment of the Monte Video-Buenos Ayres communication, partly by cable and partly by a hundred miles or so of land lines over a country not the most convenient for transit, nor then by any means safe, owing to the frequent troubles and recurring revolutions amongst the neighbouring Republics. Mr. Oldham personally superintended the whole of this difficult and dangerous work from the first. He was a Chevalier of the Order of the Rose.

ALFRED NUTT.—It is with great regret we record the death of Mr. Alfred Nutt, head of the well-known firm of London publishers, which sad event occurred under distressing circumstances on Monday. Mr. Nutt was with his son in Paris taking a stroll on the banks of the Seine, when his son, who was in a light vehicle, was accidentally precipitated into the river. Mr. Nutt, a powerful swimmer, went to the rescue, but was caught by the current and drowned. His son was saved. Mr. Nutt had a remarkable grasp of all matters relating to technical literature, and was the sheet anchor of booksellers and book readers in search of works of a technical and special character in all languages.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

As already announced in these columns, the 15th Annual Convention of this Association will take place at Glasgow from June 14th to 17th inclusive. The meetings in Glasgow will be held at the Institution of Engineers and Shipbuilders in Scotland, Elmbank-crescent, where there will be a reception room for transacting the business of the convention. It is requested by the Council that members, delegates and visitors (including ladies) will register their names on arrival. They will then be handed distinctive badges, and can obtain any papers to which they may be entitled. These badges will only be obtainable after registering, and are supplied free of charge. They should be worn throughout the convention.

The convention proper will open at 10 a.m. on Tuesday, June 14th, when the Lord Provost of Glasgow (The Hon. A. McInnes Shaw) will welcome the members of the Association. Mr. W. W. Lackie, chief electrical engineer of the Glasgow electricity department, will then deliver his presidential address. A Paper on "Commercial Progress," by Mr. A. C. Cramb, chief electrical engineer of Croydon, and Mr. H. Collings Bishop, chief electrical engineer of Newport (Mon.), will be read and discussed. At 1:15 p.m. the Tramways and Electricity Committee of the Glasgow Corporation will entertain the members and delegates (including ladies) to luncheon at the City Chambers. After lunch, brakes will leave the City Chambers to visit the Springburn sub-station of the electricity department, the Pinkston power house of the tramways department and the Port Dundas electricity works of the electricity department. In the evening a reception and conversazione will be held at the City Chambers by the Lord Provost, Magistrates and Town Council of the City of Glasgow. On Wednesday, June 15th, the members present at the meeting will leave Glasgow at 8:25 a.m. by special train for Edinburgh. A meeting will be held at 10 a.m. in the Free Gardner's Hall, Picardy-place, Edinburgh, when the Right Hon. the Lord Provost of Edinburgh will welcome the convention to that city. A Paper on "Steam Turbines and Condensing Plant," by Mr. F. A. Newington, chief electrical engineer of Edinburgh, will be read and discussed, as will also one on "Mixed Pressure Turbines," by Mr. Ashton Bremner, chief electrical engineer of Burslem. At 1:15 p.m. members and delegates (including ladies) will be entertained to luncheon by the Corporation of Edinburgh at the Music Hall, George-street. In the afternoon a visit will be paid to the works of the electricity department in Macdonald-road. On the Thursday, meetings will be held in the Rankine Hall of the Institute of Engineers and Shipbuilders, Glasgow. A discussion will first take place on the "Advantages of Continuous Records of Costs and Steam Consumption." This will be opened by Mr. Geo. Wilkinson, chief electrical engineer of Harrogate, and Mr. C. E. C. Shawfield, chief electrical engineer of Wolverhampton. There will also be a discussion on the "Cheapening of the Cost of Mains and Services," which will be opened by Mr. S. E. Fedden, chief electrical engineer of Sheffield, and Mr. S. J. Watson, chief electrical engineer of Bury. In the afternoon the St. Andrew's Cross power station of the electricity department, the Coplawhill works of the tramways department, and the generating station of the Govan electricity department will be visited, or alternative visits may be paid to the electricity works at Partick, the power station of the Clyde Valley Electric

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Power Co., at Yoker, and the shipbuilding works of Messrs. Beardmore (Ltd.) at Dalmuir. A special visit will be arranged for the ladies of the party to Rouken Glen. In the evening the annual dinner of the Association will take place at the Windsor Hotel, Glasgow. On Friday the annual general meeting of the Association will be held in the Rankine Hall of the Institute of Engineers and Shipbuilders.

Special arrangements are being made for the ladies accompanying members to visit places of interest in both Glasgow and Edinburgh, while the following works will be opened for the inspection of members during the time of the convention: Messrs. Mavor & Coulson, Babcock & Wilcox, Craigpark Electric Cable Co., Bruce Peebles & Co., and the electricity works of the Greenock and Paisley Corporations.

We are, as usual, making special arrangements for giving full reports both of the Papers and discussions at this convention, and our issue of June 17th will contain an account of the proceedings up to the close of the meeting on Thursday, June 16th.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Dr. A. Fraenckel and Mr. B. J. M. Lane conclude their article on "Short-circuit Losses in Alternating-current Commutator Motors."

Mr. F. Fernie contributes an article on "Electrolysis of Underground Mains."

The National Electrical Manufacturers' Association held a meeting on Monday last, when the comparative effects of Free Trade and Protection upon the electrical industry were discussed.

The programme for the Convention of the Incorporated Municipal Electrical Association at Glasgow has been issued.

We conclude our account of the new generating station of the Westminster Electric Supply Corpn.

The report of the proceedings of the Board of Trade and of the Light Railway Commissioners for the year 1909 is abstracted in another column.

The Board of Trade have refused to grant further certificates for the use of the Dolter system at Torquay.

Legal.—The Court of Appeal yesterday (Thursday) allowed the appeal of Eccles Corporation against the judgment of Mr. Justice Eve dismissing their action for an injunction to restrain Salford Corporation from authorising the South Lancashire Tramways Co. to run over a portion of tramway track in Eccles.

Mr. Justice Grantham and a special jury yesterday (Thursday) commenced the hearing of an action brought by a builder against Marylebone (London) Borough Council for damages for injuries by electric shock alleged to have been received in consequence of the negligence of the Council's servants in not cutting off electric current from a cable laid through a house which was being rebuilt by plaintiff.

INSTITUTIONS AND SOCIETIES.

Royal Society of Arts.—The Council of this society have elected the Hon. Theodore Roosevelt a life member under the terms of the by-law which empowers them to elect annually not more than five persons who have distinguished themselves by the promotion of the society's objects. The first American member of the society was Benjamin Franklin, who was elected in 1755.

National Electrical Manufacturers' Association.—A meeting of this Association will be held at Caxton Hall on Monday, June 6th, at 8 p.m., when the discussion on "The Effect of Free Trade or Protection on the Electrical Industry" will be resumed. Mr. E. Garcke will open the discussion. Admission will be by visiting card.

The Institution of Civil Engineers.—In consequence of the death of His Majesty King Edward VII., the council have decided that the conversazione shall not be held this year. The eighteenth "James Forrest" lecture will be delivered at the Institution on June 22nd, at 8 p.m., as already announced.

Illuminating Engineering Society.—At the meeting on Monday last the report of the council for the session 1909-10 was presented. In this it is mentioned that the membership of the society now exceeds 220, and the results of the first session are considered satisfactory. Prof. S. P. Thompson, F.R.S., remains as president, and the council has been increased by the addition of Dr. W. Eccles, Mr. A. H. Stokes and Mr. A. H. Seabrook.

New Building of the Institution of Civil Engineers.—We have received from the secretary a copy of a pamphlet giving details of the new Institution building which is to be erected at the corner of Great George-street and Princes-street. The premises will occupy an area of some 21,000 sq. ft. On the ground floor will be situated the council and committee rooms, the reading rooms and general offices. The first floor will be occupied chiefly by the lecture theatre, the great hall and the main library, the apartments being arranged and connected together in a convenient manner for the reception of large numbers of people. Further library accommodation will be afforded on the second floor, where also will be a writing and smoking room for the members. Provision for the general service of the premises, including the heating and ventilating apparatus, extra cloak rooms, &c., and for storage, will be made in the basement and on the third floor. It is confidently anticipated that the new premises will lend themselves satisfactorily to the purposes of the society and the needs of its members; and an interesting feature in the construction of the building will be the introduction of the timbers and certain other products of various parts of the British Empire, which may serve to symbolise in some degree the close relationship of those who constitute the Institution of Civil Engineers in all parts of the world.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 27th (to-day).

Physical Society of London.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda: (1) "On an Oscillation Detector actuated solely by Temperature Variation of Resistance," by Dr. W. H. Eccles. (2) "Exhibition of a Resonance Transformer," by Mr. A. Eagle. (3) "The Limitations of the Weston Cell as a Standard of Electromotive Force," by Dr. S. W. J. Smith.

MONDAY, May 30th.

Railway Signal and Telegraph Engineering Institute.

7:30 p.m. Meeting at St. Marylebone Church Institute, Central Hall, 59 and 60, Paddington-street, W. Paper on "Automatic Switches, Relays and Signals," by Mr. F. W. R. May.

TUESDAY, May 31st.

The Faraday Society.

8 p.m. Meeting in the Rooms of the Chemical Society, Burlington House, Piccadilly, W. Papers on (1) "Some Practical Experiments of the Sheradising Process," by Mr. J. W. Hinchley. (2) "Note on the Composition of Eutectic Mixtures," by Mr. C. H. Desch. (3) "Relations between Critical Temperature, Boiling Point, and Expansion Coefficient of Phosphorus Pentachloride," by Mr. E. B. R. Prideaux. (4) "Thermic Reactions in Vacuo." Parts I., II., and III. by Messrs. F. E. Weston and H. R. Ellis. Demonstration of (1) "Apparatus for Rapid Determination of the Resistance of Liquids." (2) "Apparatus for the Determination of Specific Resistance of Oil," by Messrs. C. V. Biggs and W. P. Digby.

WEDNESDAY, June 1st.

Royal Institution.

3 p.m. Meeting at Albemarle-street, Piccadilly, W. Lecture on "The Constitution and Internal Structure of Alloys," by Mr. W. Rosenhain (Lecture II.).

THURSDAY, June 2nd.

Röntgen Society.

8:15 p.m. Meeting at 20, Hanover-square, W. Papers on "Practical Observations on Everyday X-Ray and Electrical Work, Filtration of Rays, Measurement of Rays, Rapid Stereoscopic Method, &c.," by Dr. H. Pirie and on "Recent Improvements in Radiographic Technique," by Dr. R. Knox. A new Form of Apparatus for Producing Rythmical Variations in the Strength of Electrical Currents will be shown by Dr. Hampson.

SATURDAY, June 4th.

Royal Institution.

3 p.m. Lecture on "Electric Heating and Pyrometry," by Prof. J. A. Fleming, F.R.S. (The Tyndall Lectures.) (Lecture I.)

The Corps of Electrical Engineers (London Division).

Commanding Officer, Col. R. E. B. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, May 30th, "A" Company.—Recruits' infantry drill, 6 to 6:45 p.m. Company drill, 7 to 9:30 p.m.

Tuesday, May 31st, "B" Company.—Company Drill, 7 to 9:30 p.m.

Wednesday, June 1st.—Gymnasium, 8 to 9:30 p.m.

Thursday, June 2nd, "C" Company.—Recruits' infantry drill, 6 to 6:45 p.m. Company drill, 7 to 8:30 p.m. Technical drill, 8:45 to 9:45 p.m.

Friday, June 3rd, "D" Company.—Recruits' infantry drill, 6 to 6:45 p.m. Company drill, 7:15 to 8:30 p.m. Technical drill, 8:45 to 9:45 p.m.

Saturday, June 4th, "Drill Cup Competition."—Drill Parade at Headquarters 3:30 p.m. Dress:—Service dress with putties. Arms will be issued at 3:30 p.m. Equipment to be worn:—Belt, Frog, Haversack and Water Bottle.

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STANDARDISATION OF FUSES.*

BY H. W. KEFFORD.

Summary.—After pointing out the desirability of standardisation, the author gives particulars of tests on a number of representative types of fuses up to a capacity of 50 amperes, and discusses the ratio between the rated current and the normal fusing current. He then considers the general regulations for the construction and operation of standard fuses and describes a non-interchangeable fuse system. He refers to the testing of fuses, and finally puts forward some suggestions as the basis of a specification for standard fuses.

The standardisation of electric fuses and the enforcement of more stringent regulations with regard to their design and use would contribute greatly to the increased safety of electrical installations and would put the manufacture of this class of apparatus on a more uniform and scientific basis. The difficulties to be overcome before a standard system of fuses can be brought into general use are certainly numerous, but delay renders the problem more and more complex. If we would foster the popularity of electrical applications and the prosperity of the industry we must create and maintain confidence in the safety, reliability and convenience of electrical power by every possible means. In addition to contributing largely to the attainment of this end, the standardisation of fuse design would undoubtedly conduce to economy in manufacture and result finally in a reduction of cost. Up to a certain point it is a very simple matter to determine the behaviour of a fuse when blown under working conditions, and this fact renders still more inexplicable the retention of many types which are wholly inadequate and of others which are needlessly elaborate. In the present Paper the subject is dealt with from a practical rather than academic point of view, the object being, if possible, to suggest a few lines along which certain essential questions may be tackled. Up to the present time the tests referred to have been confined to low-tension fuses up to a normal carrying capacity of about 60 amperes, but it is hoped to continue the experiments on fuses of much larger capacity.

The complete specification of a line of fuses will embrace (*a*) a definition of the "marked" or "rated" current in terms of the "limiting" current (also called the "normal fusing" current); (*b*) a standard range of rated-current values and voltages; (*c*) a definition of one or more points on the "time-overload" curve of each fuse; (*d*) regulations as to non-interchangeability, temperature rise, freedom from deterioration and perfect operation under all conditions; (*e*) specifications for the standard method of carrying out short-circuit, temperature rise and overload tests.

Rated Current.—As is well known, the chief characteristic of a fuse for quantitative purposes is its "time-overload" curve and the asymptotic current value of this curve to which the name "normal fusing current" has been given, but which will be referred to in this Paper as the "limiting current." The strict definition of this is the minimum steady current which will produce fusion after an infinite time interval, but for practical purposes we might substitute with advantage a definite time interval—say four hours. The limiting current or limiting overload is the one fundamental quantity to which any definition of rated current should refer. An appropriate way of defining the rated or marked current of the fuse is as follows: A fuse which is rated at R amperes must fuse within four hours when carrying a times its rated current, but must be capable of carrying $a-\alpha$ times its rated current for at least four hours without fusing. If L amperes is the limiting current, the rated current R amperes must lie between L/a and $L/(a-\alpha)$.

The values chosen for a and $a-\alpha$ depend on a large number of practical considerations, and should also be selected with a view to facilitating the application of the above definition in factory and test house. Thus the difference α between the two values may be looked upon as a measure of the accuracy with which the specified conditions can be attained in manufacture. The latter point recalls the fact that the Wiring Rules of this Institution require that no fuse shall carry more than 200 per cent. overload without fusing (*i.e.*, $a=3{\cdot}0$), whereas the rules of another recognised authority in this country restrict the permissible overload to 50 per cent. ($a=1{\cdot}5$). The writer has recently heard of suggested modifications to the overload regulation from two independent sources, one of which was a proposal to permit an overload of 300 per cent. ($a=4$), while the second authority was of the opinion that the permissible overload should be even less than 50 per cent. if manufacturers could work to a narrower limit. If, as may be assumed, the smaller overload is the one dictated by considerations of safety, irrespective of manufacturing limitations, whereas the higher figure is based on a compromise between what is desirable and what is present practice, these figures furnish one of the most striking arguments for the need of a system of non-interchangeability for fuses of small capacity. This point will be dealt with more fully later in the Paper. The regulations for enclosed fuses by the Underwriters' Association in the United States, which have been framed with the co-operation of manufacturers, fix the values of a and $a-\alpha$ at 1·25 and 1·10 respectively, but these figures were only decided upon after manufacturers had endeavoured to work to a smaller value of α than 0·15, as specified above. These close limits are in marked contrast with the figures quoted above.

The results of an experimental investigation of the properties of current commercial types of fuses should give a reliable and useful indication of the possible values of a and $a-\alpha$, the limits between which the ratio (limiting current)/(rated current) must lie, and it becomes a relatively simple matter to determine whether this ratio should have the order 4 or 1·5. In drawing inferences from such tests due weight must be given to the many other properties which are closely connected with the ratio a, and observations must be made of running temperature, voltage drop, behaviour when blowing on overload and short-circuit and general reliability and safety.

A table in the Paper summarises some tests carried out on a representative variety of fuses in common use; a few of the fuses tested are illustrated in Fig. 1. A distinctive letter has been given to all fuses supplied by one firm and the various sizes and types are

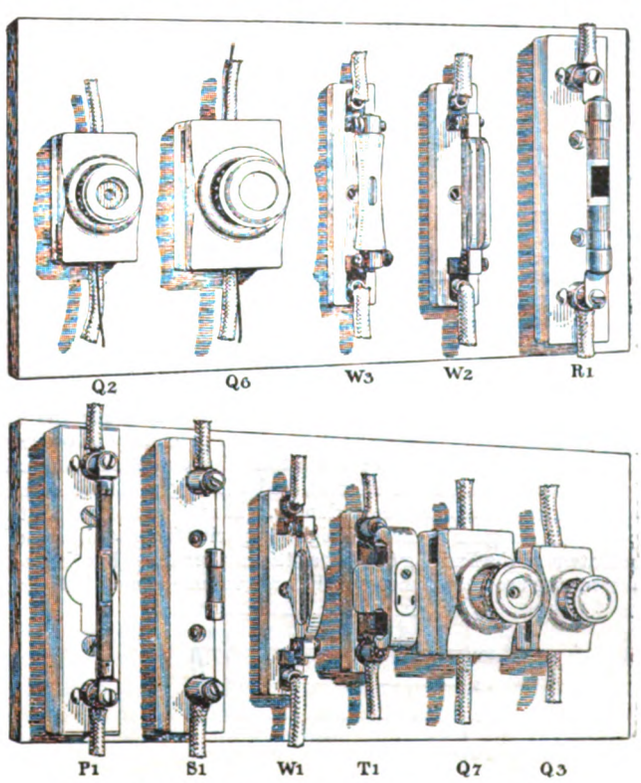

FIG. 1.—SOME REPRESENTATIVE TYPES OF FUSES TESTED.

denoted by a number which follows this letter. A few particulars of the tests on the fuses illustrated are given in the table herewith. Fig. 2 illustrates typical curves of voltage drop, while Fig. 3 shows the watts losses corresponding to the voltage drops plotted in Fig. 2.

Before proceeding to make any deductions from these results, the

Symbol of fuse.	Rated current.	Rated max. voltage.	Limiting current / Rated current		Watts lost at	
			$a-\alpha$ min.	a max.	Rated current.	Rated current $\times a-\alpha$.
P_1	4	500	1·25	1·50	2·290	4·15
Q_2	6	250	1·67	2·00	1·390	6·95
Q_6	6	500	1·50	1·67	1·890	4·80
*R_1	4	550	0·75	1·00	—	2·87
†S_1	4	250	1·50	1·75	0·328	8·20
‡T_1	6	250	2·67	3·00	0·466	9·01
W_1	6	250	2·00	2·33	0·729	7·61
W_2	6	250	2·33	2·67	0·714	10·33
W_3	6	250	2·00	2·33	0·883	10·50

* Dangerous on short-circuit. Case burnt on continuous overload.
† Case burst on all short-circuit tests and frequently on overload tests.
‡ Behaved irregularly on overload, and continuous arc often formed.

* Abstract of a Paper read before the Birmingham local section of the Institution of Electrical Engineers.

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author considers one or two points which may serve for general guidance. Taking first the case of a bare fuse wire stretched between two terminals, let us assume that a line of fuses, all of equal length, is to be designed. It will be found that the voltage drop is proportional inversely to about the square root of the limiting current. Owing to the desirability of preventing the pressure drop across the fuse becoming excessive, the same value of a is not advisable for large and small fuses; it may be desirable to increase the value of a as the normal working current diminishes. In the case of fuses of the totally enclosed type, we have also to consider the effects of the increased cooling facilities and capacity for heat of the fuse enclosure. Owing to the large radiating surface, the size of wire for a given limiting current is reduced, and the drop of volts may therefore become large if the length of the fuse is not reduced or a metal

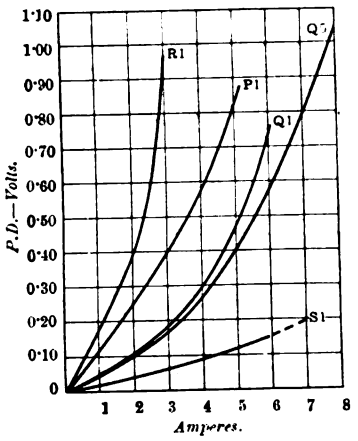

Fig. 2.—Pressure Drop across Fuses, rated at 4 amperes.

adopted which has a low melting point. If the fuse is very short, on the other hand, conduction and dissipation of heat from the terminals will play an important part and exercise a similar influence in increasing the voltage drop and power loss. In order to reduce these two quantities to economical and safe limits, it becomes necessary to rate the smaller fuses at a lower percentage of the limiting current. Since well-designed fuses of the enclosed type may be made very much shorter than a corresponding open-type fuse for the same voltage, advantage should be taken of this possibility in order still further to reduce the losses; the alternative course of using a low melting-point metal is far inferior, and the larger volume of metal required may prove a source of danger. It may be noticed that it is open to the designer to rate the higher capacity fuses at the same low percentage of the limiting current as the smaller sizes; but this, again, involves the use of an unnecessarily large volume of metal, a proceed-

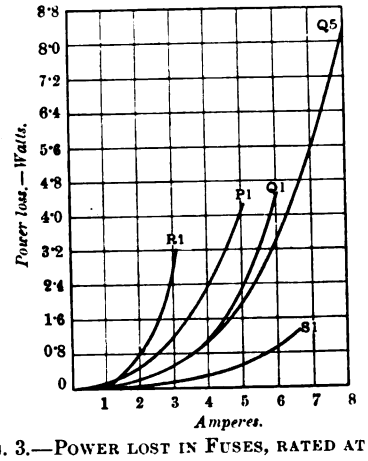

Fig. 3.—Power lost in Fuses, rated at 4 amperes.

ing to be avoided as much as possible, particularly for fuses carrying heavy currents and liable to severe short-circuits. From a purely utilitarian standpoint it is probably correct that small fuses should carry higher overloads than fuses of large capacity, and all that might be said from this point of view may be best summed up by considering a 5-ampere fuse capable of carrying 10 amperes, and a 100-ampere fuse permitting a continuous load of 200 amperes.

The most important factor in determining a standard value or values for the ratio a=(limiting current)/(rated current) is the maximum safe overload to which an electric circuit may, on the average, be subjected; the results arrived at from this consideration can, if necessary, be modified to meet the limitations of manufacture. The possibility of more economical utilisation of the apparatus protected is a natural consequence of adopting fuses which restrict within narrow limits the overload which may be imposed on a circuit. For fuses up to 50 amperes a maximum permissible continuous over load of 25 per cent.—as in the United States—is not wholly desirable, since most circuits and apparatus should be designed to withstand this amount of overload without injury, and, further, even the best system of non-interchangeability would fail and the circuits be overfused if users and wiremen found that they could not overload circuits to more than 25 per cent. even for short periods. Fuses run normally at only 20 per cent. under the limiting current must of necessity have fusible metal of low melting point if the running temperature is not to be unduly high; for reasons of equal importance, the use of such metals is bad.

Nearly all the metals used for fuses suffer oxidation if run at temperatures much above that corresponding to 50 per cent. of their limiting current, although if silver be employed the rated current may certainly be as much as 65 to 70 per cent. of the limiting current without the occurrence of any deterioration. The permissible overloads corresponding to a rating 50 and 70 per cent. of the limiting current are 100 and 43 per cent. respectively, and the large difference in these overload capacities is of interest as showing the superiority of a non-oxidising metal like silver if it is desired to reduce to a minimum the possible overload. Assuming, as will be afterwards shown, that copper and silver are the only metals suitable for standardised fuses, we can take as a rational basis

Copper.—Minimum value of $a=2{\cdot}00$.
Silver.—Minimum value of $a=1{\cdot}43$.

Attention may be drawn to Fig. 4, which shows the approximate variation of temperature of a bare copper fuse wire with increasing currents up to the melting point and limiting current. The dotted curve is for silver fuse wire. The rapid rate at which the temperature rises after about 50 per cent. of the limiting current has been passed is noteworthy, and has an immediate bearing on the subject of rating.

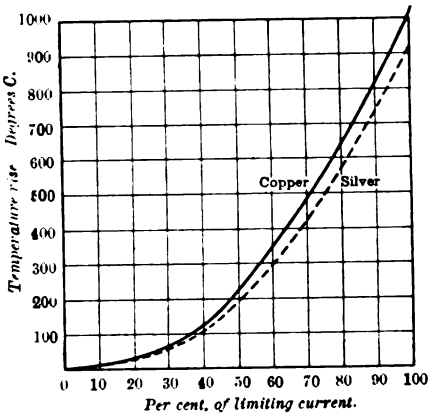

Fig. 4.—Approximate Temperature Rise of Copper and Silver Fuses in relation to the Percentage of the Limiting Current

Standard Rated Current Values and Voltages.—An excellent plan seems to be the adoption of a standard voltage of 500 for all sizes, and the addition of a range of small capacity fuses for 250 volts for use on lighting circuits where small size and cheapness are important and very severe short-circuit conditions do not often occur. In proposing a standard range of rated currents the important point is to reduce the number of sizes to a minimum while providing for all current values with a reasonable margin of overload capacity. A convenient subdivision is with steps differing by multiples of 5 amperes, giving, say, 5, 10, 15, 20, 30, 40 and 50-ampere sizes. At least one smaller capacity than 5 amperes is required, and since 4 and 6 amperes are standard values with a large number of manufacturers, a satisfactory completion of the range will be to adopt multiples of 2 amperes up to a value of 6 amperes, the complete standard line becoming 2, 4, 6, 10, 15, 20, 30, 40, 50 amperes.

Definition of Points on "Time-current" Curve.—The main object in defining further points on the "time-current" curve, in addition to the limiting current, is to ensure that the fuse will give adequate protection against very heavy overloads or short-circuits, and to restrict within limits its sluggishness of action or "time element." From a practical point of view a regulation of this kind is useful, because compliance with it can be readily checked, and it may be so framed as to eliminate the use of too large a mass of fusible metal and other faults of design. In order to be of real value such a regulation should require that a fuse shall melt within a fixed time—say, 1 minute—when loaded with a certain multiple of its limiting current—say, double that value.

(To be concluded.)

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SHORT-CIRCUIT LOSSES IN ALTERNATING-CURRENT COMMUTATOR MOTORS.

BY A. FRAENCKEL, DR.ING., AND B. J. M. LANE, B.SC.

(*Concluded from page* 233.)

Summary.—Results of experimental researches on the losses due to the short-circuit currents in alternating-current commutator motors are given. These show a rapid decrease of the loss with increasing speed, other conditions being equal. An explanation of this phenomenon is given, and oscillograms are shown from which the decrease of the short-circuit current with increasing speed, and for a given short-circuit E.M.F., is deduced. The influence of the short-circuit currents on the line pressure and current is illustrated.

Experimental Results.

In order to verify this theory experiments were carried out showing how the losses depend on the speed, and how the brush contact resistance is influenced by the current-density and

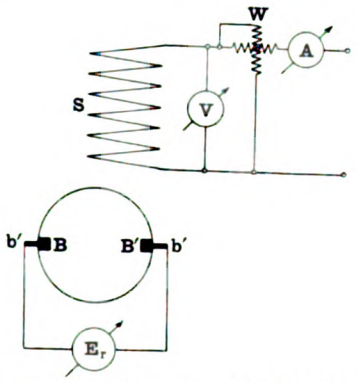

Fig. 7.—Bi-polar Scheme of Experimental Machine.

speed. Oscillograms were taken showing instantaneous values of short-circuit currents and corresponding induced E.M.F.s The experimental determination of the short-circuit losses was carried out by measuring the power supplied to the exciting coil, firstly when no brush was on the commutator, and secondly when the brushes were on and placed in the neutral zone, the main flux being the same in both cases.

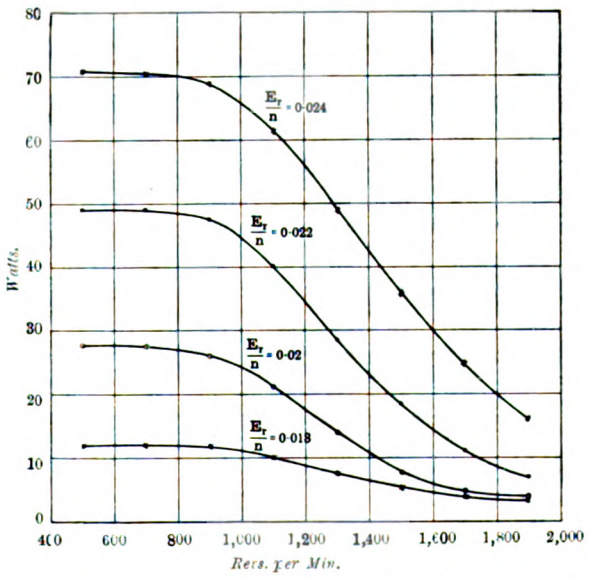

Fig. 8.—Curves of Short-Circuit Losses for two "Z" Carbon Brushes on Commutator and in the Neutral Zone.
Dimensions of each brush surface = 10 × 26 mm.

There are two ways of measuring the flux. Consider the armature of an excited two-pole machine as being driven by means of an auxiliary motor. There is a resultant E.M.F. between two brushes placed in the axis of the exciting winding, and this E.M.F. is proportional to the main flux and to the frequency of its pulsations. Another resultant E.M.F. may be obtained between two brushes placed in the neutral zone, this E.M.F. being proportional to the flux and the speed. The former may be expressed as follows

$$Ep = \frac{\pi}{2\sqrt{2}} \cdot \frac{N}{a} \cdot c \cdot f \cdot \phi_{max.} 10^{-8} \text{ volt},$$

while the latter is

$$E_r = \frac{1}{\sqrt{2}} \cdot \frac{p \cdot n}{60} \cdot \frac{N}{a} \cdot \phi_{max.} 10^{-8} \text{ volt},$$

where N = total number of armature conductors,
$2a$ = number of parallel circuits of the armature,
c = frequency of the exciting current,
p = number of pairs of poles,
$\phi_{max.}$ = maximum value of the flux pro pole,
n = revolutions per minute.

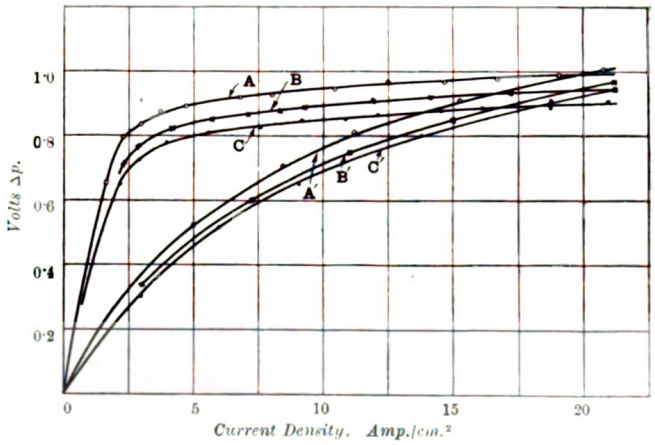

Fig. 9.—Curves showing Voltage Drop over Brush Contact Resistance.

It is seen from the above that Ep is dependent upon the factor f. This factor is dependent upon the field distribution and upon the form of the windings. For a sinusoidal distribution of the flux and a distributed armature winding f is equal to $2/\pi$. However, it is quite evident that the short-circuit currents will have an effect upon the field form, and consequently f will change in value. The short-circuited windings are concentrated and superimpose a field differing in form from that produced by the distributed exciting winding. Thus the relation between flux and voltage will not be constant. On the other hand, E_r is quite independent of the field distribution, and depends only upon the total value of the flux ϕ. Thus in the following we shall deal with E_r. This method cannot be used at standstill because E_r is zero, but this disadvantage does not come into consideration, since at standstill the losses

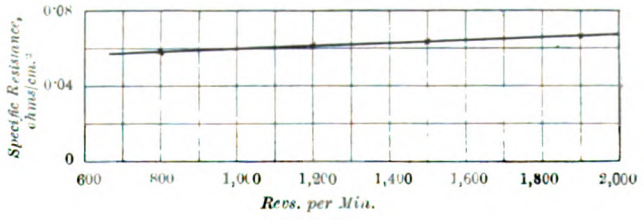

Fig. 10.

vary greatly with the position of the brush relative to the segments, and strong heating of commutator and brush occurs so that no exact measurements can be made.

The experimental machine consisted of a four-pole 5 H.P. repulsion motor having 99 commutator segments. The width of each segment = 4·5 mm., and the mica width = 0·5 mm. The armature was provided with a wave winding, so that two armature turns were lying between neighbouring segments. The stator winding was distributed in 24 slots, there being a total number of 36.

A diagrammatic sketch of the experimental machine is given in Fig. 7. The two main brushes are represented by B, B′, and the exciting coil of the stator by S. The brushes were of "Le

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Carbone" make, "Z" quality, and had a contact surface of 10×26 mm. The test brushes b, b', which had a width about equal to the insulation, were used throughout to measure the voltage E_r. In order to obtain the same value for the induced E.M.F. in the short-circuited coils for different rotor speeds, all that is necessary is to keep the value E_r/n constant, n being the revolutions of the rotor per minute. Since the width of one brush is equal to that of two segments, the number of short-circuited turns in series between the tips of one brush is a lways $S_K = 4$, or generally $S_K = \frac{b}{\beta} \cdot \frac{P}{a} \cdot \frac{N}{2K}$.

where K = number of commutator segments,
b = width of brush,
β = width of commutator segment.

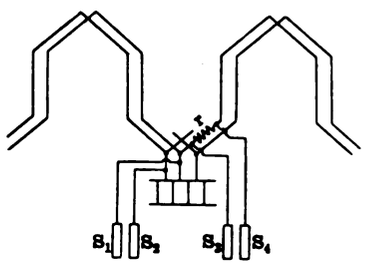

FIG. 11.

The effective E.M.F. induced in one short-circuited coil is $E_1 = \pi \sqrt{2} c \Phi_{max.} 10^{-8}$ volt, and consequently the total E.M.F. induced in the coils between the tips of one brush is

$$S_K E_1 = E = \frac{\pi}{\sqrt{2}} \cdot \frac{N}{K} \cdot \frac{b}{\beta} \cdot \frac{p}{a} \cdot c \cdot \phi_{max.} 10^{-8} \text{ volt.}$$

Since the E.M.F. measured at the search brushes was $E_r = \frac{1}{\sqrt{2}} \cdot \frac{pn}{a60} \cdot N\phi_{max.} 10^{-8}$, it follows that $E = \frac{E_r}{n} \cdot k$, where k is a constant and equal to

$$\frac{60 \cdot c \cdot \pi \cdot b}{\beta K}.$$

In the case under consideration c was equal to 50, and consequently $E = E_r/n \cdot 190$.

In the first instance the main brushes were removed from the commutator, and for a constant value of E_r/n the rotor was driven at different speeds by means of an auxiliary motor. For

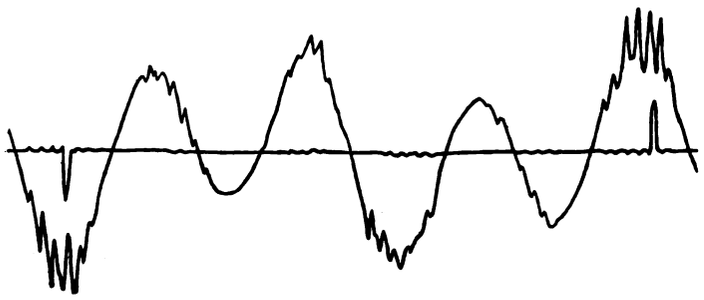

FIG. 12.

each speed the watts supplied to the exciting winding were measured, these values giving the iron losses, and the copper losses in the exciting coil. The main brushes were placed on the commutator and in the neutral zone, the position of which had been previously carefully determined. The watts supplied to the exciting winding were measured as before, E_r/n having the same value. The differences between these readings gave values for the watts lost due to the circulating currents in the short-circuited coils after the necessary correction had been made for the stator copper losses.

The short-circuited coils lie in a plane to which the exciting axis is perpendicular, and consequently these circulating currents can exert no torque effects.

In order to eliminate the effects of change in temperature of the brush over the range of values for E_r/n and the consequent changes in contact resistance, it was found necessary to provide the brushes with a number of layers of metal foil pressed on the edges of the brush and as near to the commutator as possible. By this means the heat generated could escape more readily, so that expansion and consequent lifting of parts of the brush from the commutator were avoided. With the adoption of this device it was found that any small

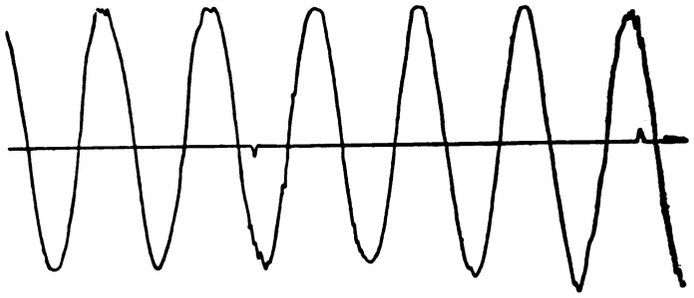

FIG. 13.

temperature changes which took place within the limits of the experiments did not affect the readings. The condition of the commutator surface was apt to change somewhat, and it was found convenient to have a cleaning pad continually rubbing on the commutator.

The values for the losses obtained are plotted in Fig. 8 as a function of the speed for the four different values of E_r/n

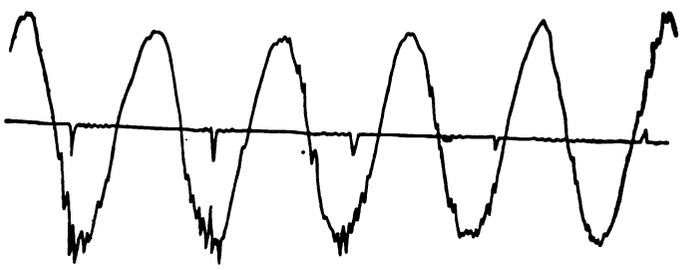

FIG. 14.

= 0·024, 0·022, 0·02 and 0·018, corresponding to effective values for the short-circuit E.M.F. E equal to 4·5, 4·18, 3·8 and 3·42 volts. At a voltage of 4·5 sparking was apt to take place. These curves clearly demonstrate the effect of the speed. Readings for very low speeds could not be obtained on account of the swinging of the instruments and general instability of the working. The losses assume practically a constant value

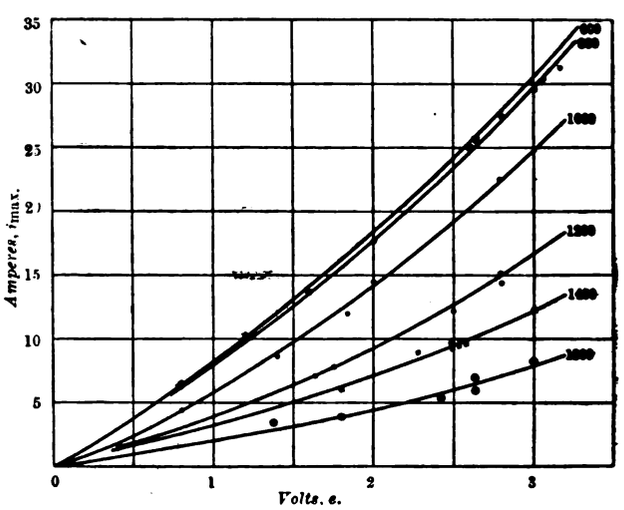

FIG. 15.—CURVES TAKEN FROM OSCILLOGRAMS SHOWING MAXIMUM VALUES OF SHORT-CIRCUIT CURRENTS AND CORRESPONDING VALUES OF e.

below a speed of 800, while for higher speeds they fall rapidly to low values. The calculated curves do not fall so quickly as those derived experimentally. This is due, as shown, partly to the fact that the contact resistance varies with the current-density, and therefore both curves cannot be directly compared,

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since it is not known what value of R_u should be taken in the calculation.

Experimental results showing the *relation between brush contact resistance and current-density* have already been given by various investigators, the brush generally being placed on a slip-ring. In order to investigate the effect of the discontinuous contact surface of a commutator, the authors carried out experiments under the working conditions. The brushes were placed on the commutator, which was short-circuited by a heavy band of copper wire. A current at 50 periods was passed through the brushes, and the pressure between the brushes measured. Since the copper band over the commutator had an exceedingly small resistance, the drop of pressure in this part of the circuit was negligible, and the pressure between the brushes practically equal to the drop at the brush surfaces. By measuring effective values of current and pressure, we obtain the relation between the effective current-density and the effective resistance. The specific resistance is the ratio of the voltage drop $\triangle p$ at one brush to the current-density. It is interesting to compare the instantaneous values of the current-density and voltage drop. For this purpose calibrated oscillograms were taken. The results are represented by curves in Fig. 9. Curves A, B and C show the effective voltage drop as a function of the effective current-density for one brush for speeds of 1,900, 1,200 and 800 revs. per min., and they have the same character as those taken with direct current. Curves A′, B′ and C′ show the instantaneous values of the voltage drop as a function of the instantaneous current-densities for the same speeds as before. These curves are similar to those obtained when the brushes are placed on slip-rings,* but while with slip-rings the speed has practically no influence, this is not the case with a commutator. The contact resistance increases for a given current-density with the speed, which may be due to the insulating layers between the commutator segments. Fig. 10 shows how the resistance changes with the speed, the effective current-density being 15 amperes per square centimetre.

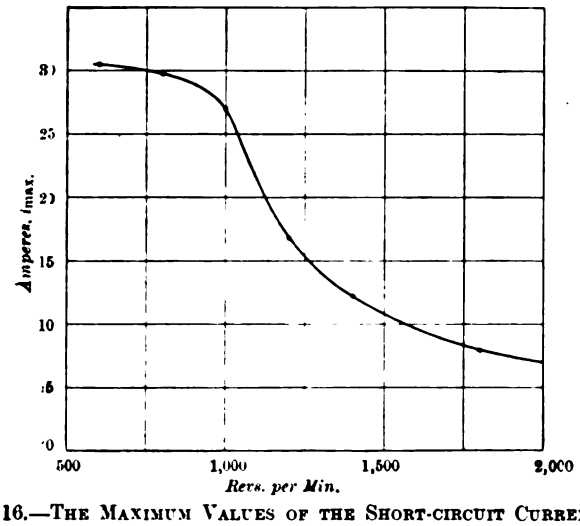

FIG. 16.—THE MAXIMUM VALUES OF THE SHORT-CIRCUIT CURRENT FOR A VALUE OF THE INDUCED VOLTAGE $e=3$.

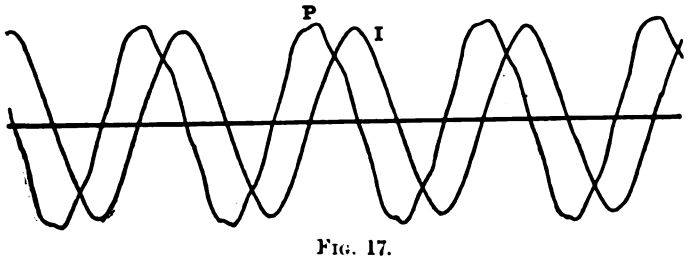

FIG. 17.

OSCILLOGRAPH RECORDS.

Oscillograms have been taken which exemplify extremely clearly the conditions prevailing during a short-circuit period. By means of slip-rings and a small non-inductive resistance it was possible to obtain records of the E.M.F. induced in any armature coil under consideration, and of the current produced in it so soon as it was short-circuited by the brush. The arrangement was as shown in Fig. 11. Two adjacent segments were connected to two slip-rings, S_1 and S_2, on which brushes were lying, the brushes being connected to the oscillograph, which in this case recorded the pressure between these segments. A small resistance, r, was placed in one coil, and its ends connected to two other slip-rings, S_3 and S_4, these being in connection with the second strip of the oscillograph. This gave a record of the short-circuit current. Figs. 12, 13 and 14 show examples of the curves of pressure and current obtained under different conditions. The current is only recorded at the moment when the coil is under short-circuit. The pressure wave has a compound form, since it is the induced E.M.F. in a coil which rotates in an alternating field. There is a main wave whose form and strength depend upon the main flux and the speed, and the ripples are due to the mutual induction of the short-circuit currents in the neighbouring coils. At the moment when the coil under consideration is in short-circuit the pressure measured at its segments falls rapidly, being only equal to the drop between the brush and the two segments. The instantaneous value of the induced voltage at the moment of short-circuit can, therefore, only be estimated by drawing a mean curve between the peaks. The scale of the oscillograms was taken, and for the different values of the instantaneous induced E.M.F.s the corresponding maxima of the short-circuit currents $i_{max.}$ were measured. These are shown in Fig. 15, $i_{max.}$ being plotted as a function of e for six different speeds, and it may be seen that $i_{max.}$ decreases rapidly as the speed increases. This decrease is shown clearly in Fig. 16, where for a constant value of $e=3$ volts the maximum values of the short-circuit currents are plotted as a function of the speed. This curve has quite the same character as those obtained for the losses, this

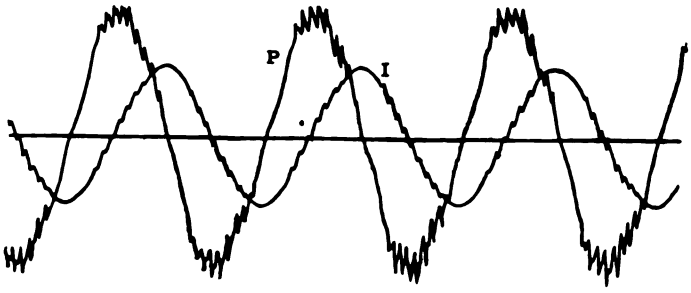

FIG. 18.

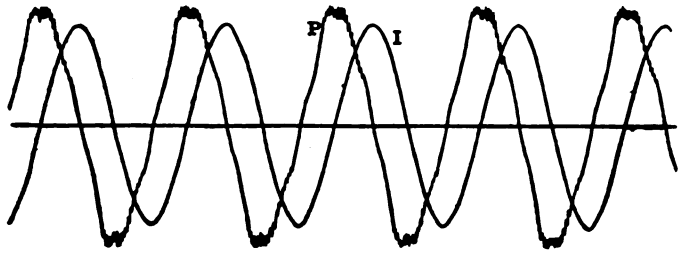

FIG. 19.

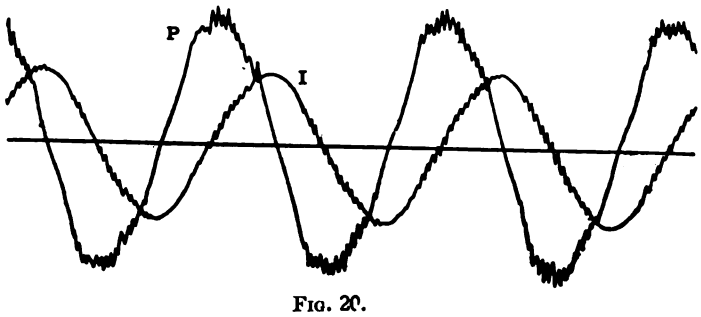

FIG. 20.

* Arnold, "Die Gleichstrommaschine," Bd. 1., S. 348.

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fact again affording evidence of the correctness of the loss curves.

It is also interesting to note the *effect of the short-circuit currents upon the primary current and voltage*. This is shown in the oscillograms 17, 18, 19 and 20. The first gives the pressure and current of the exciting winding when no brush is on the commutator. The current is lagging something less than 90 deg. behind the pressure. The second shows the same relations when one brush is on the commutator, the value of E_s/n being 0·022 or E=4,2 volts, and the speed 760. There are very distinct ripples in both current and pressure waves, this being due to the flux pulsations produced by the short-circuit currents. The ripples have their maxima approximately when the pressure is a maximum. Fig. 19 shows the curves for the same value of e, but for a speed of 1,900. The ripples in the current curve have disappeared, while those in the pressure curve still exist, but to a much smaller extent than in the previous case. Finally, Fig. 20 shows the conditions where there are two brushes on the commutator, the speed being 1,250.

The authors wish to express their thanks to Prof. Arnold for placing at their disposal the apparatus in the Electrotechnical Institute, Karlsruhe in Baden.

ELECTRICAL EXHIBITS AT THE BRUSSELS INTERNATIONAL EXHIBITION.

The Brussels Exhibition will perhaps be more notable for the excellence of its engineering exhibits than for any other reason, and it is not surprising that electricity should play an important part in introducing a considerable element of novelty in much of the machinery and apparatus displayed. There are many circumstances which render the exhibition particularly convenient from the manufacturers' and buyers' point of view, its central position and easy accessibility from all parts of Europe being an advantage not easily over-estimated. There is little doubt, moreover, that the arrangements which the authorities have made are infinitely better than are usually expected in large exhibitions, and most of the exhibitors admit that the allotments and preparations for their plant have been carried out with the utmost fairness and completeness. The Exhibition, too, has, in some cases for the first time, come under the direct authorisation of the various States, and the importance of this will have been appreciated particularly by the British exhibitors, while the magnificent arrangement of the German section is a monument to the value of the practical interest of an energetic government.

Except for the German exhibits, practically all the engineering plant and machinery are situated in one large machinery hall consisting of five bays, of which the end one is reserved for a complete battery of boilers for supplying steam to the generators. The German machinery is for the most part displayed in special departments of the German section, and is self-contained in every way, being totally independent of the main exhibition, even for the supply of electrical power.

In the large machinery hall most of the generators used for supplying electrical power to the machines and for all purposes for the exhibition are located, steam being delivered from the boilers in the adjoining bay through pipes laid for the most part underground. The boilers, of which there are 10, were all manufactured by De Neaver and are fitted with underfeed mechanical stokers. The conveying plant for automatically delivering the coal from the outside supply to the boilers, and for taking the ashes away and depositing them where required, is verying eniously arranged and is electrically operated. The coal bunkers are some distance behind the boilers and are let into the ground with the mouth flush with the ground level. The coal is tipped into them and is dropped, as required, into the buckets of the conveyor beneath by means of sloping shoots, and the conveyor rises above the ground, when clear of the bunkers, to the level of the top of the boilers. The buckets then proceed parallel to the axes of the boilers until level with the front, when they turn at right angles and run the whole length, descending at the other end, and returning underneath the floor level in a subterranean passage, so that the ashes from the boilers may be tipped into them. The buckets then rise to just underneath the coal delivery buckets, thus forming a complete chain to the coal bunkers, the ashes being discharged by means of a tip and shoot. The whole gear is driven by an electric motor, and in spite of the many turns, works extremely well, swivelling buckets being used, as is, of course, necessary on account of the corners. There are four forced-draught fans driven by electric motors in the chamber underneath the boilers, and these deliver air into a main pipe, which, by means of valves, discharges into the furnaces as required.

Continuous current is supplied for the exhibition at 230 and 460 volts, while there is also a 460 volt alternating-current supply available. Current is taken to the main switchboard from the various generating sets which form part of the exhibits, and this switchboard is erected on a raised platform at the top of the machinery bays, extending the width of two of them. Alongside the switchboard, and extending the width of the remaining bays, are two large balancers, each machine running at 230 volts for supplying this pressure between the inners of a three-wire system. The output of each machine is about 150 kw., while there are also two motor generators, the motor running at 5,000 volts and the generator delivering direct current at 230 volts. The switchboard is excellently fitted up and is an exhibit of the Ateliers de Construction Electrique de Charleroi. It follows the construction now almost invariably adopted on the Continent, all the meters being at the back of the board so that the dials are flush with its front.

Of the generating plant, the most important perhaps is a 1,000 kw. turbo-alternator of Messrs. Brown, Boveri, which is almost constantly running. The alternator is of the usual totally enclosed type, with an opening at the top, and its voltage is 460, three-phase. The turbine runs at 2,500 revs. per min., and the air and circulating pumps for the condenser, which is erected underneath the turbine, are driven by a three-phase motor. Part of the current from the alternator is taken through a static transformer, where the voltage is raised to 5,000, this pressure being employed to operate a 400 kw. motor-generator, which supplies direct current at 460 volts. This set runs remarkably smoothly, in spite of its high speed, 2,400 revs. per min., and the Morganite brushes work quite sparklessly. Messrs. Brown, Boveri also have an exhibit of their patent system of train lighting, which is now in operation on some trains in this country. A very compact switchboard of one panel is erected to control the alternator, transformer, and motor generator circuits, and the high-tension cables are brought to a brick chamber which has been built in the condenser pit, forming a model central station high-tension chamber.

All the other generators actually supplying current are reciprocating sets, except those in the German section described later, the majority of them being of the horizontal compound or tandem compound type, so universally adopted in Belgium, which country has hitherto been somewhat conservative in the matter of steam turbines. One of the most interesting of the reciprocating engines is a tandem machine manufactured by Bollinckx of 1,000 H.P. fitted with Bollinckx valve gear, this engine being employed for driving a Lahmeyer direct-current generator, the diameter of the armature being about 10 ft., while the same manufacturers exhibit a self-contained 100 H.P. suction gas plant, with the engine driving a small dynamo through belting, magneto ignition being employed. Among the other large generating sets is a compound, side-by-side Thirau engine, driving a 500-volt direct-current dynamo of the Compagnie Internationale d'Electricité, with an output of 500 kw. at 220 revs. per min. There is, further, a tandem compound 600 H.P. engine of Carels Frères well-known construction, employed for driving a direct-current generator, and, incidentally, it may here be mentioned that the 1,000 H.P. Diesel marine reversing engine recently built by this firm, which it was intended to exhibit, has not been erected. This will, no doubt, occasion considerable regret among many visitors who had expected to see this much talked of machine.

In view of the great interest now taken in the use of gas engines for central stations, the exhibit of Messrs. Cockerill, of Seraing, of a 2,500 H.P. horizontal gas engine, with a pair of tandem cylinders, is noteworthy. It is, however, not designed for electrical drive, and at the time of writing its erection was not completed; but it will, no doubt, be a source of attraction to electrical engineers as indicating the strides made in the construction of this class of engine. Messrs. Cockerill also show on their stand a 1,750 kw. turbo-generator of the Parsons type, with separate high and low-pressure cylinders; but at the time of writing this was not in operation.

There are a number of other generators, the most notable alternator being for 4,000 volts, 50 frequency, and 340 amperes, constructed by the Ateliers de Construction de Charleroi, and driven by a side-by-side compound steam engine of the Société de la Meuse. The same firm also exhibit a small 100 kw. six-pole, direct-current machine at 460 volts, belt driven from a tandem reciprocating engine; whilst there are several of similar type by other firms which call for no special comment.

At the Franco-British Exhibition the absence of overhead elec-

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trical travelling and other cranes was generally remarked, but this will not be the case with the Brussels Exhibition. In each of the bays in the Machinery Hall there is at least one crane, and these naturally were of great service during the erection of the machinery. Except in one case they are all operated by direct current, two bare copper wires being run just above the top crane girders, and the current collected by short spring collectors. None of the travellers is of British manufacture, the chief exhibitors being the Ateliers de Construction Electrique de Charleroi, with a crane lifting 25,000kg. and Bergmann's, of Berlin, who, of course, have additional plant in the German section, while the Oerlikon Co. are the manufacturers of the only three-phase motor crane in the building.

In the bays adjoining the large generators the machine tools are located, and these form one of the most complete exhibits of the machinery section; and it is satisfactory to note that England is well represented in this particular. The adoption of electric drive is very marked, the large majority of the machines being self-contained. Messrs. J. Butler & Co., of Halifax, besides the ordinary types of machine tools, have one or two novelties worthy of note. Chief among these is a motor-driven bar cutting machine for cutting off bars from 2 in to 8 in.. in diameter. The bar is clamped in a vice close to the tool (two vices being employed for long bars), and the tool is fixed in a disc which revolves in a large bearing forming part of the body of the machine. The tool works gradually toward the centre by means of a feeding arrangement, and a small pump is employed to provide the soap and water or other lubricant, so that the attendant does not have to look after this. This machine is specially adopted for motor drive, since a variable speed motor may be employed with a constant gear ratio. The speed of cutting can be increased for small bars, and, as the centre is approached, with large bars.

(To be Concluded.)

NEW GENERATING STATION OF THE WESTMINSTER ELECTRIC SUPPLY CORPORATION.

(Concluded from page 226.)

In our last issue we described the arrangements for obtaining condensing water from the river, and also the strainers which have been installed. Fig. 5, herewith, gives a view of the latter. The Bailey & Jackson rotary strainers will be noticed on the right-hand side of this illustration, and the suction boxes containing the grids for preventing large foreign matter entering the pumps in the upper left-hand corner.

In connection with the method—briefly referred to last week—for preventing air pockets in the condensing water pipes, it may be explained that separate 1½ in. vacuum pipes are led from all the high points of this pipe-work into a vacuum tank on the roof of the station and at a height of 70 ft. above the condensers. To this tank the vacuum pump previously mentioned is connected. Each vacuum pipe thus forms a barometric leg in which the water rises, and all air is collected in the vacuum tank. To prevent any water from accumulating in this tank a barometric drain pipe is provided. The arrangement, which is due to Messrs. Kennedy & Jenkin, is of considerable interest.

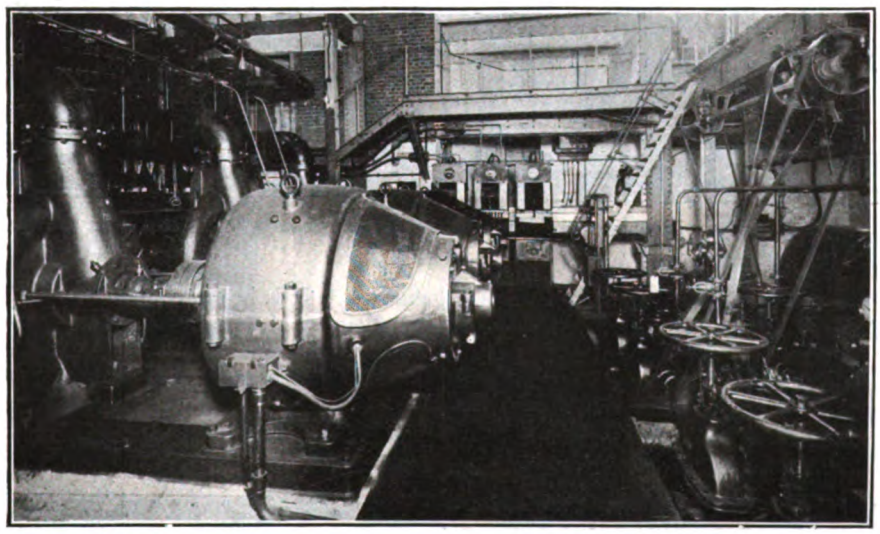

Fig. 5.—View of Strainers and Refs Roturbo Pumps.

The vertical-spindle electrically-driven turbine pumps supplied by Messrs. W. H. Allen, Son & Co. afford an interesting example of the advance made in recent years in the application of this class of pump to power station work. From considerations of practical utility, the arrangement of the pump and motor, with the axis of rotation vertical and direct-coupled, is one that obviously has much to commend it, as it enables the pump to be placed at as low a level as may be desired, thus avoiding the troubles so often encountered when a centrifugal pump has to work with a considerable lift on the suction side. The electric motor can also be placed on the engine or pump room floor level in an easily accessible position and well away from all risk of damage from water, &c.

In the early days of electrical driving this arrangement of the plant was attempted, but met with little success owing chiefly to difficulties experienced with the balancing of the vertical forces and from objectionable shaft vibrations, also difficulties in connection with bearings. It is interesting, however, to note that, as a result of the much greater experience which has now been obtained in the running of shafts at high speeds, and the better knowledge available in the design of both shafting and bearings, the old difficulties have completely disappeared, with the result that this arrangement of the plant is destined to become one of very wide application.

In the present instance the plant consists of three pumps with motors and switchgear, the complete equipment having been designed and manufactured by Messrs. W. H. Allen, Son & Co. at their works at Bedford. The smallest of the three pumps is a hot-water pump capable of delivering 100 gallons per minute against a head of 45 ft., with an efficiency of 60 per cent. when running at 1,600 revs. per min. It is placed in the basement of the building below the water level of the hot-water sump, and is direct-coupled through a length of about 12 ft. of shafting to an electric motor of 2·8 kw. situated on the engine-room floor level. The motor armature runs entirely in ball bearings, the top-most bearing being of the ball-thrust type and carrying the weight of the armature. At about the floor level and within the motor casing is a flexible shaft coupling, which is capable of transmitting rotational forces only, or, in other words, permits of 5 deg. of relative freedom. Situated immediately below this coupling, in an extension of the motor housing, is a ball-thrust bearing, designed to carry the weight of the shafting and the pump impeller. The various lengths of shafting are connected by ordinary flange couplings and supported laterally by ordinary white metal bearings in halves.

The pump is of the turbine type, having one impeller and one set of diffuser blades, both of special bronze. The spindle is of steel and encased in bronze liners, and the bearings of white metal. An automatic hydraulic balancing device is employed to carry the weight of the rotating parts of the pump and a part of the weight of the vertical shafting. The pump casing is of cast iron and contains the usual collecting chamber and suction and discharge branches all in one casting. The whole of the interior of the pump is easily accessible for inspection and repair without disturbing the fixing of the casings.

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The second pump is a well-water pump designed to deliver 100 gallons per minute against a head of 100 ft., with an efficiency of 61 per cent. when running at 1,600 revs. per min. This pump is of the two-stage turbine type, and is situated in the basement, its motor of 5·6 kw. being on the boiler-room floor level. The design of the motor, shafting and bearings is similar to that described above, the length of shafting between pump and motor being about 10 ft. The pump casing is of cast iron, made in sections accurately registered together and held by tie bolts through the flanges of the outer sections. In the upper part of the casing is a water-cooled collar-thrust bearing, which is provided for registering accurately the position of the impellers in the casing.

The third and most interesting pump of the series is a centrifugal boiler feed pump, of the six-stage turbine type, the general design and arrangement being very similar to that of the pump last described, excepting for the greater number of impellers. It is designed to deliver 100 gallons of water per minute against a head of 485 ft. when running at 2,200 revs. per min. and with an efficiency of 61 per cent. This pump, which is illustrated in Figs. 8 and 9, is direct-coupled, as in the previous cases, to a 22·8 kw. shunt-wound motor through a length of 8 ft. of shafting. It is interesting to record that this set on test gave an efficiency of 63 per cent. under the specified conditions. The pump stands upon a foundation block about 33 in. above the floor of the basement, and the motor stands on the pump room floor level.

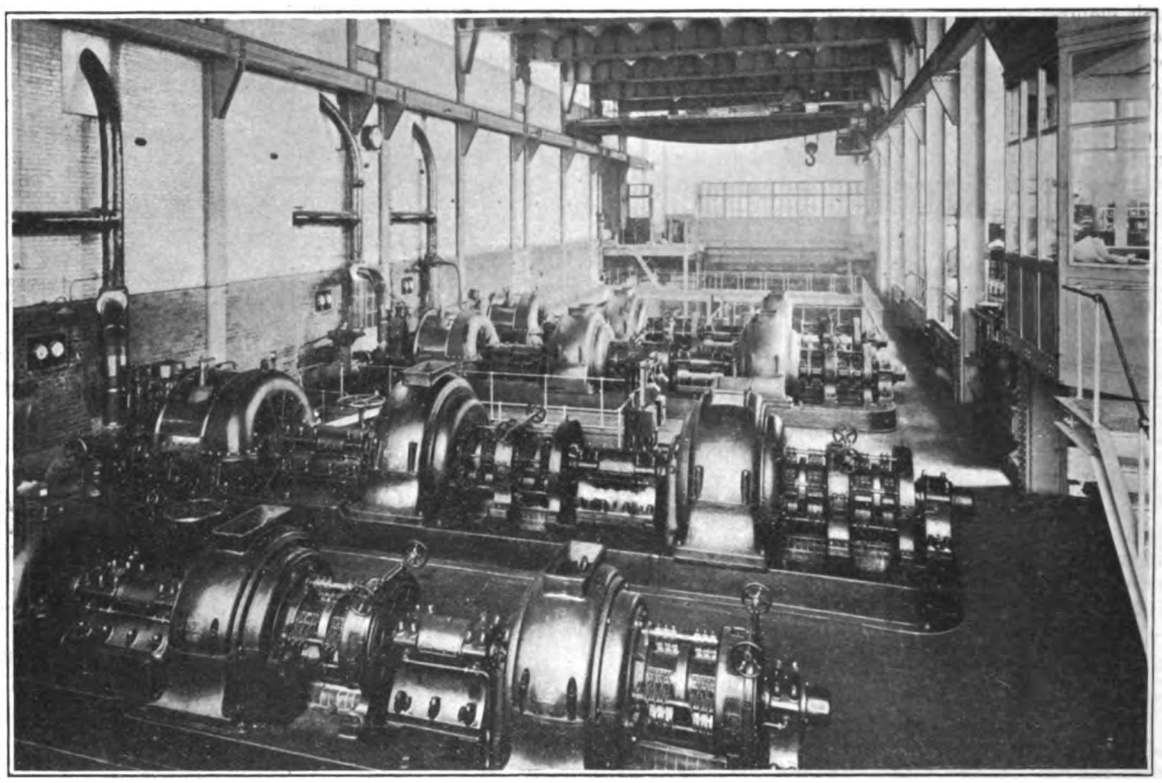

Fig. 6.—Engine Room at the Horseferry-road Station of the Westminster Electric Supply Corporation.

Pipework.—The arrangement of the steam pipes can be seen from Fig. 3 in our last issue. It may be mentioned that the main piping consists of 7 in. weldless steel, the flanges being riveted on; whilst in the case of smaller steam pipes the flanges are screwed on. A Babcock & Wilcox separator, 20 in. in diameter by approximately 2 ft. 9 in. overall, is provided in the steam main, and Hopkinson-Ferranti valves with cast steel

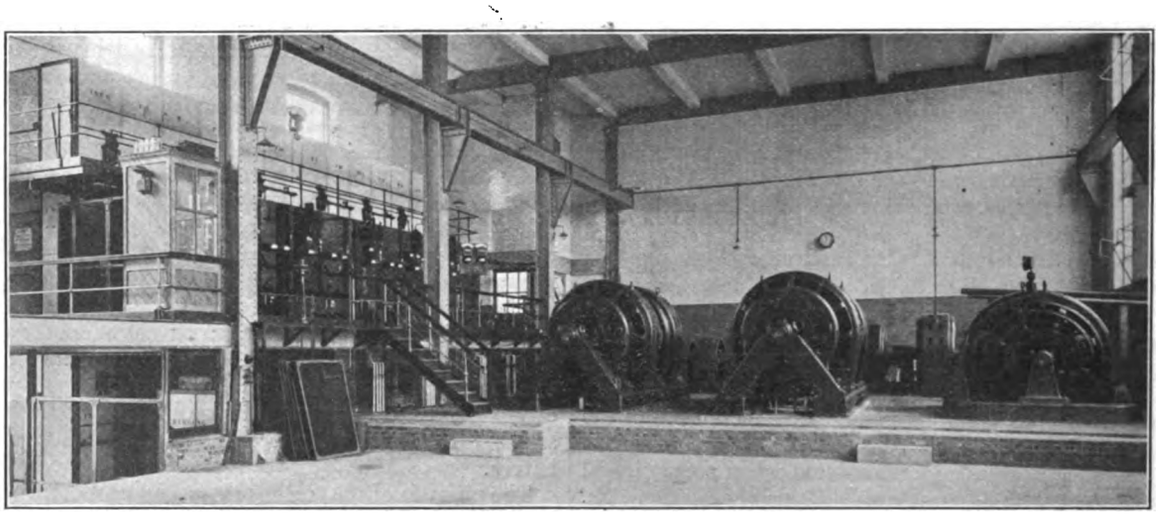

Fig. 7.—View of Motor-generator Room and High and Low-tension Switchboards.

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bodies and nickel alloy working parts are employed. The branches to the balancers and generating sets are of 4 in. and 6 in. diameter respectively.

The atmospheric exhaust pipes from the 300 kw. balancers are 10 in. in diameter, and those of the 1,000 kw. sets 14 in. in diameter. The main atmospheric exhaust pipe, as will be noticed from Fig. 3, referred to above, increases from 14 in. to 24 in.

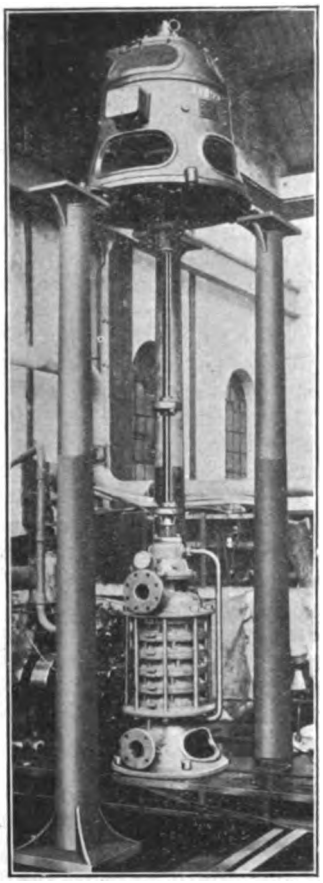

FIG. 8.—ELECTRICALLY-DRIVEN SIX STAGE CENTRIFUGAL BOILER FEED PUMP ON TEST PLATE OF MESSRS. ALLEN, SON & CO.

Engine Room Plant.—The main generating plant comprises three 1,000 kw. turbines, supplied by Messrs. Howden Bros., each coupled to two 500 kw. continuous-current generators (1,220—1,088 amperes at 410—460 volts) of Messrs. Siemens Bros. Dynamo Works' manufacture. In addition there are two 300 kw. steam balancers of the same type as the main

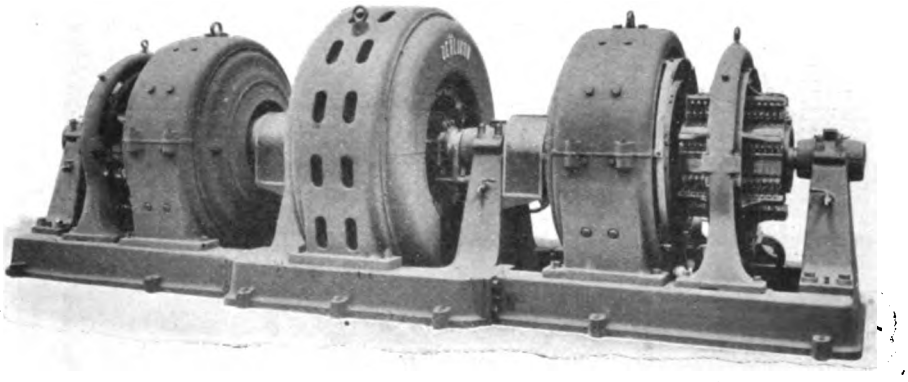

FIG. 10.—OERLIKON MOTOR-GENERATOR.

sets; each driving two 150 kw. generators at 200—230 volts pressure, whilst the dynamos for supplying the two outer conductors of the three-wire system run, as stated above, at 410—460 volts. A view of the engine room, with one of the balancers in the foreground, is given in Fig. 6. The turbines are of the Zoelly impulse type, and the larger sets run at 1,850 revs. per min., and the steam consumption guaranteed by the manufacturers, with 150 deg. superheat and a 28½ in. vacuum (barometer 30 in.), was as follows:—

Full load.	¾ load.	½ load.	¼ load.
17·1 ...	18·4 ...	20·8 ...	27·4 lb. per kw.-hour.

The corresponding figures for the 300 kw. plant are:—

19·56 ... 21·75 ... 25·75 ... 36·75 lb. per kw.-hour.

In each case the plant can take an overload of 25 per cent. for half-an-hour and 40 per cent. for 3 minutes. The turbines were also specified to give normal full load when running non-condensing and exhausting direct to atmosphere.

As mentioned above, each turbine is direct coupled to two dynamos in tandem, this arrangement being considered by the

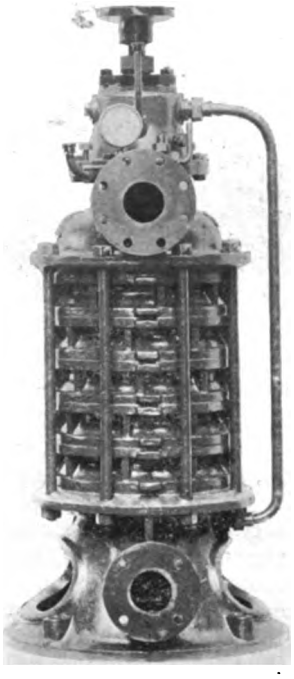

FIG. 9.—SIX-STAGE CENTRIFUGAL BOILER FEED PUMP OF MESSRS. ALLEN, SON & CO.

engineers to be more reliable at the present time than single generators of double output. Particular attention has been paid by Messrs. Siemens to compensating the armature reaction, two commutating poles, as well as a distributed compensating winding on the main poles, being provided. We noticed when we visited the station last week that the carbon brushes which are used ran sparklessly. As will be seen from Fig. 6, each commutator is divided into two distinct parts, and the connections between the two parts are arranged to act as a fan for ventilating the interior of the commutators. The machines themselves are ventilated by fans on the armature shaft, the hot air being discharged through an opening at the top of the frame.

The machines are self-excited and the pressure is regulated by hand, an adjustable rheostat being inserted in the field circuits.

The condensers, which are situated beneath the turbines, are of the "Contraflo" type, and were supplied by Messrs. Willans & Robinson. The air pumps (Edwards type) are electrically driven, and we may here mention that all electric motors in the station, with the exception of three pump motors of Messrs. Allen, Son & Co.'s manufacture, have been supplied by the Rees Roturbo Co.

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Careful provision has been made for keeping account of all water used and for ascertaining the cause of any undue consumption. Lea recorders are employed for the air pump discharge and for the make up water; a Kennedy meter measures the feed water and a Venturi meter enables the amount of condensing water to be ascertained. Three "Aero" recorders (Stone's patent) indicate the level of the water in the storage tank on the roof, in the "treated water" tank and in the hot well respectively. The "make up" water is obtained from a well in the station, the public water supply being used only as a stand-by.

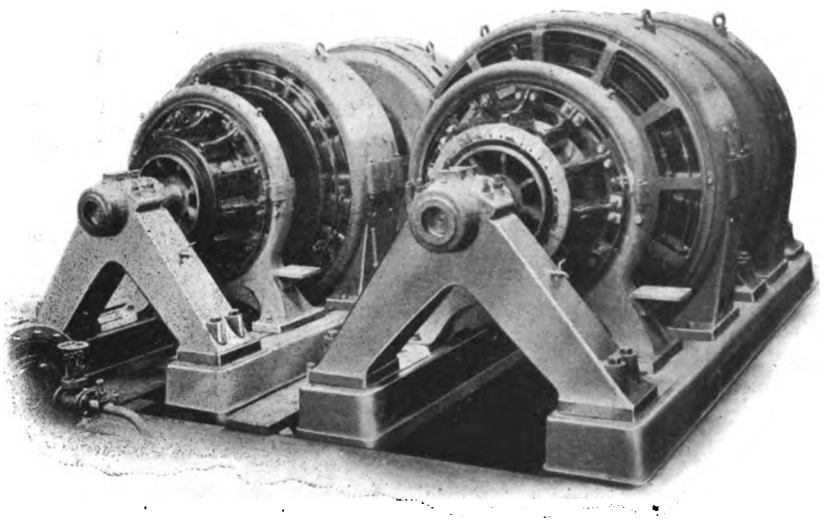

FIG. 11.—VIEW SHOWING D.C. ENDS OF OERLIKON MOTOR-GENERATORS.

A 25-ton electric crane by Messrs. Marshall, Fleming & Co., of Motherwell, spans the engine room, and one of similar size is installed in the motor-generator room.

Among the accessory plant, attention may be called to an electrically-driven Lacy-Hulbert air compressor, which has been found very convenient for cleaning the generators, economiser tubes, &c.

boosters have been installed in the motor-generator room. The pressure of these boosters is regulated by hand from the main switchboard gallery in the engine room. The five end cells of each battery can also be used for regulating purposes.

As continuous current is supplied from the Horseferry-road station on the three-wire system at a declared pressure of 400 volts across the outers, it is evident that the batteries act as a stand-by; but, of course, they would usually only be capable of dealing with a small part of the load. In this connection it may be mentioned that the Houses of Parliament are supplied from this station, a special panel on the switchboard controlling the supply. The batteries also serve as a stand-by for the various motors driving the auxiliary plant in the station.

Motor-Generators.—Undoubtedly one of the most interesting features of the new station of the Westminster Electric Supply Corpn. is the large motor-generator room, which is situated above the main engine room, and is of about the same size as the latter. Whereas, however, provision has been made for installing steam plant to a total capacity of 6,600 kw., the motor-generator room can accommodate, if ever required, transforming plant to the extent of 15,000 kw.

At present two 1,000 kw. Oerlikon motor-generators and a 500 kw. machine of the same type for balancing purposes have been installed, together with a 500 kw. B.T.-H. motor-generator which was used at the Millbank-street station and has been transferred to the new station. Electrical energy is supplied to this plant at 6,000 volts 50 cycles from the Grove-road station of the Central Electric Supply Co. The motor-generators are operated in parallel with the main steam plant installed on the ground floor, so as to obtain the most economical results.

The motor-generators can stand an overload of 25 per cent. for half an hour and a 40 per cent. overload for three minutes, whilst they run sparklessly from no load to 40 per cent. overload without shifting the brushes. They are also so built

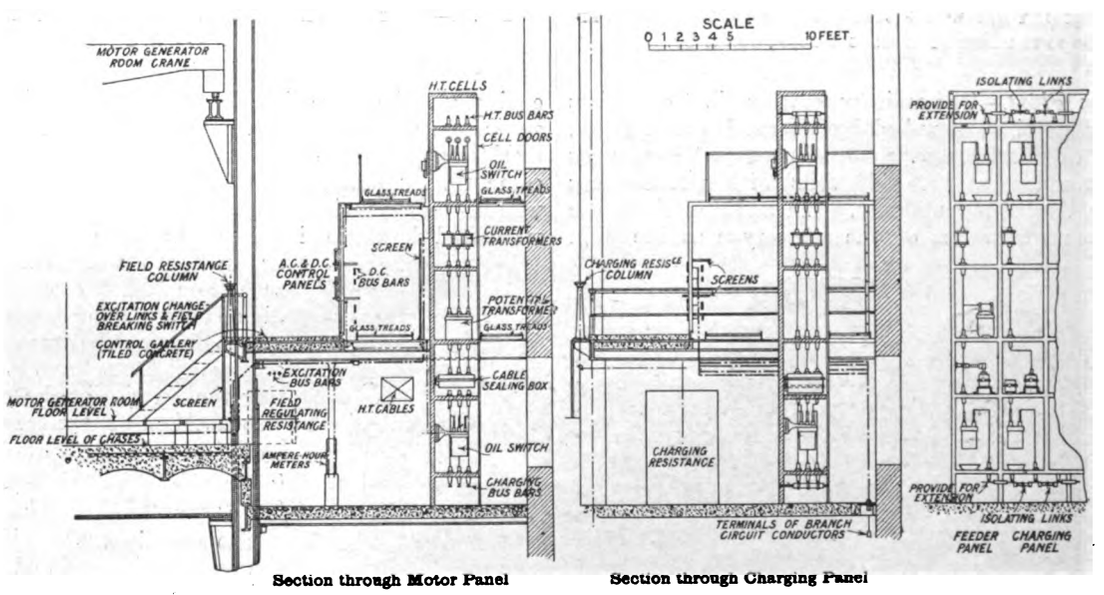

FIG. 12.—SECTIONS THROUGH H.T. SWITCHBOARD.

Batteries.—Two storage batteries, each containing 100 cells, are installed in a room adjacent to the motor-generator room. The normal capacity of the batteries, which have been supplied by the Tudor Accumulator Co., is 2,100 ampere-hours on the one-hour rate, and they are capable of discharging at 1,200 amperes for two hours, or 950 amperes for three hours. For charging and discharging the cells in each battery two B.T.-H. that when running at normal speed they can be switched on to a short-circuited system (due to failure of the supply or defective cables). This they have to do with a current equal to 40 per cent. overload and about 20 volts to start with, the pressure to be raised by regulation (separate excitation) from this level up to the normal. Even under these conditions the machines have to remain practically sparkless.

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In the view of the motor-generator room given in Fig. 7 the two 1,000 kw. Oerlikon generators will be noticed, whilst the machine on the right-hand side of the illustration is the 500 kw. B.T.-H. motor-generator. In the background the balancer is just discernible; whilst Figs. 10 and 11 show further views of the Oerlikon machines.

The direct-current Oerlikon generators are of the auxiliary pole type, and the commutator is equipped with shrink rings of a design similar to that adopted with most Oerlikon turbo-generators. The Λ spread bearings have been adopted to obtain the greatest possible stability of the machine and also to give easy and comfortable access to the commutator.

The three-phase motors are equipped with the well-known Oerlikon pole type of rotary resistances, which represent a specially strong mechanical job and permit very gradual and steady starting up without any outside apparatus. The stator coils are embedded in seamless micanite tubes filled with compound, as described in our issue of August 30, 1907, and the rotors are bar-wound.

Switchgear.—This comprises a low-tension three-wire continuous-current switchboard in the engine room and high and low-tension switchboards in the motor-generator room. Practically the whole of the control, however, is carried out from the switch gallery in the engine room, the switches and instruments for the main generators, balancers, batteries, boosters and low-tension feeders being located on this switchboard.

The arrangement of this board is on standard lines, but attention may be called to the fact that aluminium rod has been largely used for the connections behind the panels, the leads to the generators being also of aluminium rod. This allows of a very neat arrangement, and minimises the risk of fire. Duplicate 'bus bars are provided, so that the pressure on individual feeders can be varied; whilst section switches allow of each 'bus bar being divided into two independent halves.

From this switchboard, which is on a gallery at one side of the engine room, as will be seen from Fig. 6, connections are run to the low-tension switchboard in the motor-generator room, a view of the high and low-tension boards installed in that room being given in Fig. 7. The high-tension gear is of the standard B.T.-H. type, the British Thomson-Houston Co. being the contractors for the whole of the switchgear. Provision is made for the necessary switching in connection with the high-tension feeders from Grove-road station and the three-phase induction motors of the motor-generators. The switches are enclosed in fire and arc-proof cells of the usual construction. A section through the high-tension switchgear is given in Fig. 12.

In conclusion, we desire to express our indebtedness to Messrs. Kennedy & Jenkin, the consulting engineers to the Westminster Electric Supply Corpn., for giving us facilities for obtaining the information contained in this article, and to Mr. G. Horley, engineer at the Horseferry-road station, for kindly explaining the various features of the plant.

THE HELSBY WIRELESS TELEGRAPH AND TELEPHONE SYSTEMS.

The wireless apparatus which this company has installed in its experimental station at the Crystal Palace consists of a simple and practical form of spark station, with, in addition, a pair of portable earth-conduction sets for telegraphy and telephony. The two systems are absolutely independent of one another, so that it is possible to use the earth-conduction telegraph or telephone for local communications in the immediate neighbourhood of the spark station.

The details of the instruments have evidently been very carefully thought out, with the result that their design is very workmanlike and their operation exceedingly simple and rapid. In the spark station, for instance, the change over from sending to receiving, or vice versa, is done by a single master switch, which controls five separate circuits simultaneously, and the apparatus is built up in sections, each of which is completely

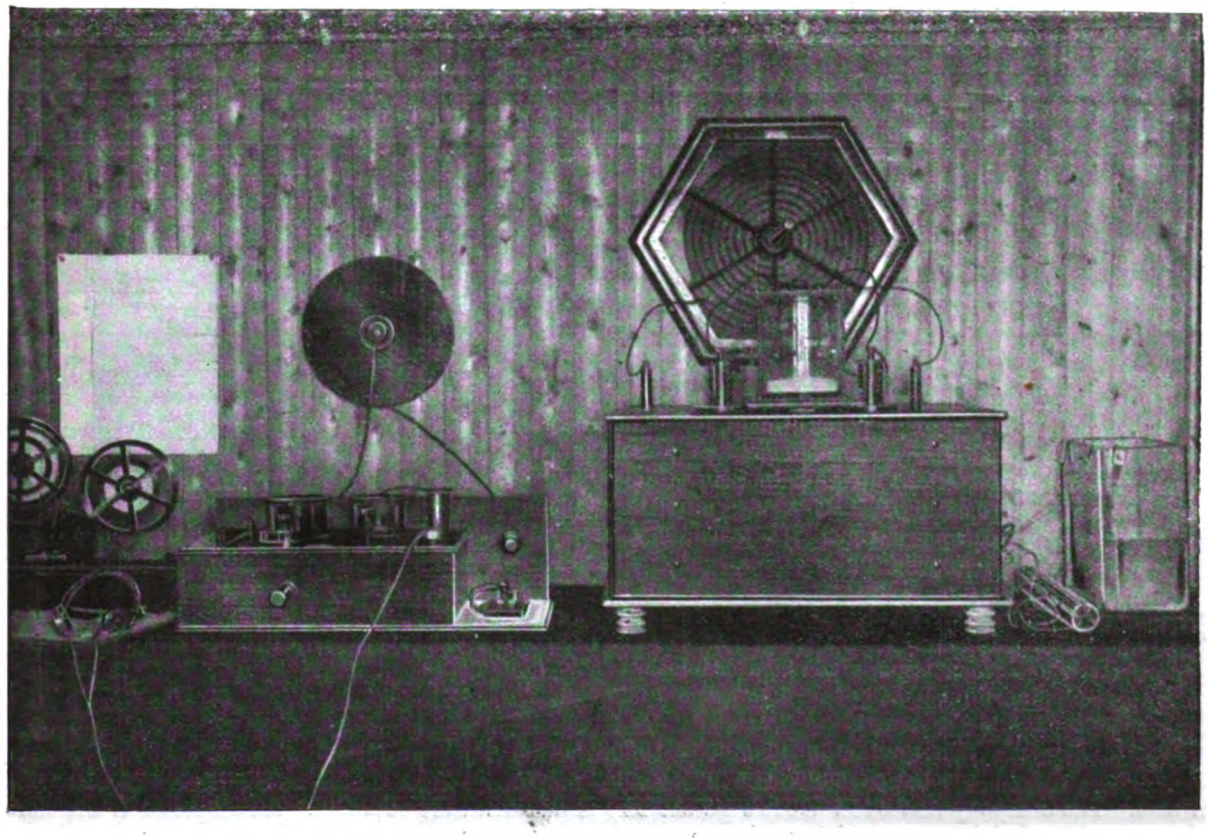

FIG. 1.—COMPLETE SPARK STATION APPARATUS. LARGE SIZE.

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wired, the connections between them being made by plug contacts. It is by attention to such details as this that telegraphic instruments are evolved from experimental apparatus.

The spark apparatus has a transmitting set consisting of an induction coil, or high-tension transformer, connected to an oscillating circuit containing a multiple spark-gap of original design; substantially constructed condensers of modern type, with relief gaps to prevent overloading; and a flat spiral inductance, which forms the primary of the high-frequency transformer, and transmits the electrical energy generated in the spark circuit to the aerial from which it is radiated. The spark-gap is a multiple one having four fixed and four moveable arms, the latter being attached to horizontal arms mounted on a vertical axis. The Company also owns Webb's patent for a transmitter capable of giving a very high spark rate.

The apparatus is constructed in sections of convenient size, each case being arranged to fit into its proper place on the top of the section below it. There are no external terminal screws, all connections being made by plugs and flexible. It is the careful attention which has been bestowed on these and other important details which gives the whole apparatus its exceedingly practical and commercial character.

The receiving apparatus, the main control switch and the ammeter and voltmeter for the supply circuit are all contained in, or mounted on, a single case of a size which can be placed conveniently on a small table. The receiver has a tuneable circuit capable of giving sufficient freedom from interference for practical working. Here, again, as in the transmitter, the apparatus is characterised by the simplicity of the arrangements and the absence of all temporary connections.

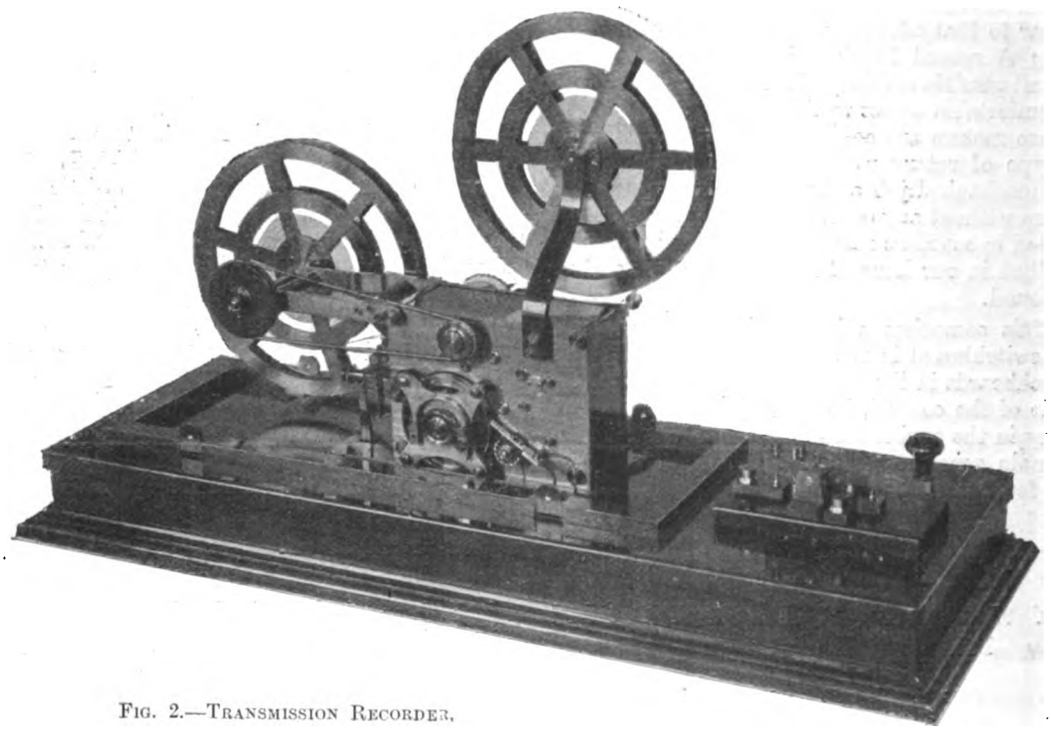

FIG. 2.—TRANSMISSION RECORDER.

An ingenious recorder forms part of the transmitting plant, and is actuated directly by the sending key, the connections being so interlocked that everything which the operator sends is automatically recorded. An inspector is therefore able to check the working of the station and ensure that the regulations of the International Convention are complied with.

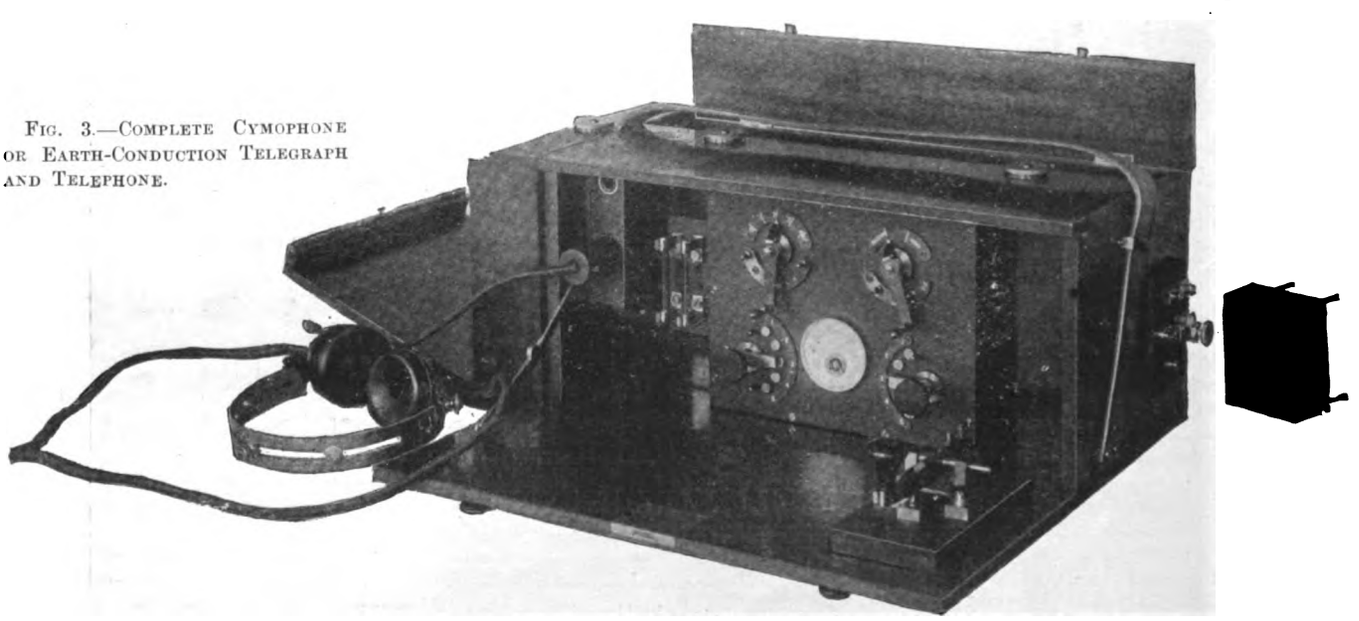

FIG. 3.—COMPLETE CYMOPHONE OR EARTH-CONDUCTION TELEGRAPH AND TELEPHONE.

The Cymophone, which is the name given to the earth-conduction system, is a very portable instrument, weighing only from 10 lb. to 15 lb. complete. Two earth connections are used at each end, the instrument being inserted in the line between

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them. Speech is clearly transmitted even when the length of the base lines is only a small fraction, say $\frac{1}{15}$, of the distance between them. The power is taken from a small 6-volt accumulator, and is converted into suitable impulses in a circuit containing inductance and capacity. Telegraphy is, of course, possible with the same power and bases to considerably greater distances than telephony.

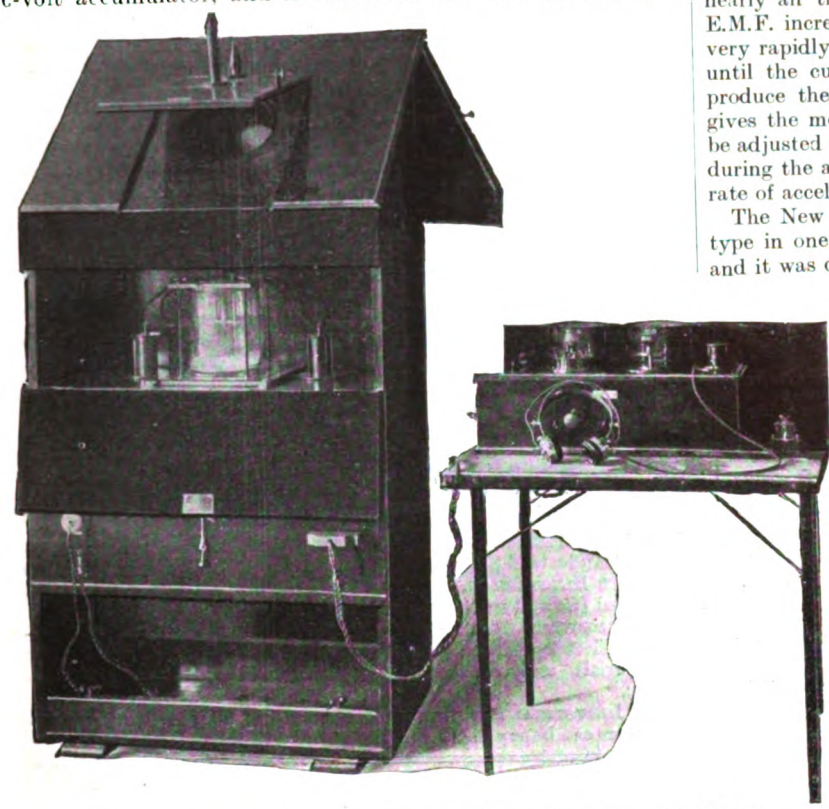

FIG. 4.—TRANSMITTER AND RECEIVER OF SPARK STATION. SHIP TYPE.

TWO-MOTOR DRIVE FOR WEB ROTARY PRINTING PRESS.*

BY S. H. SHARPSTEEN.

The drive for a web printing press may be considered in two parts, the primary or productive drive and the secondary or starting drive, which operates the press at approximately $\frac{1}{20}$th to $\frac{1}{30}$th of the production speed. The ratio of make-ready to production speed applies to newspaper work. Magazine web press production speeds are usually much lower.

When the requirements of the secondary drive for a web printing press are properly understood it is quite an easy matter to produce the desired results. For instance, a Hoe quad newspaper printing press requires approximately 30 H.P. to operate at a maximum production speed of 24,000 newspapers per hour. At such times the main shaft runs at about 200 revs. per min. The press can be threaded with paper when the mainshaft operates at 10 revs. per min., or $\frac{1}{20}$th of the maximum production speed; but $\frac{1}{30}$th of the maximum speed, or about 7 revs. per min., might be more desirable for the first running speed when the question of keeping down the paper waste due to breakage at the start is considered, and especially if the secondary drive brings the press to this speed in a jerky manner. As the power necessary to drive the press is almost in direct proportion to the speed, it would seem that a 2 H.P. motor should be large enough for the secondary drive, but the large starting friction requires a 5 H.P. motor with a normal speed of about 1,000 revs. per min. Thus it is seen that the size of the motor for the secondary drive is determined by the starting torque required.

Next, as to means for preventing rapid acceleration. Field control and multiple series connection of armatures will not here be considered, but the bridged or shunted armature, as shown in Fig. 1, offers a very satisfactory solution of the problem. The effect of the shunt resistance is to maintain the E.M.F. across the brushes at an almost constant value, which is but a fraction of the total E.M.F. The current taken from the mains remains practically constant as long as the starter handle is on the first notch. At the first instant nearly all the current goes through the motor. As its counter-E.M.F. increases, due to the increase of speed, the current falls off very rapidly and more and more goes through the shunt resistance until the current through the armature falls low enough just to produce the torque required by the press. The shunt resistance gives the motor a drooping speed torque characteristic, which can be adjusted to fit the case in hand. By keeping resistance in shunt during the acceleration period the normal speed is reached at a low rate of acceleration and without jerks.

The New York "American" installed a drive of the two-motor type in one of its press rooms in New York City some years ago, and it was claimed to be the first two-motor web press drive, using standard motors, with independent connection of the secondary drive. The secondary drive did not use the shunted armature scheme, and, therefore, it was more difficult to secure the proper start. It was started by the same controller arm that was used on the primary drive, thus requiring a controller of special design. However, there is no good reason why the secondary drive should not be started with a standard combination starter and a speed controller of the same rating as the motor, this starter being placed close beside the starter for the primary drive and having the armature bridge or shunt added. When the primary drive is in use the secondary drive may continue to run free until the speed of the press drops to a point where it would again take hold.

By the use of a first-class armature speed controller with a reasonable number of points or steps it is an easy matter to bring a press to production speed with the primary drive and control without breaking the paper after the secondary equipment has made a successful start. It is a little more economical of space to have two special motors mounted together on one base (or the secondary motor may be placed upon the primary motor, allowing the former to drive through the shaft of the primary motor) than to have the two standard motors, each on its own base and separately connected to the press.

Summing up, it may be said that a satisfactory drive for a web printing press may be made up of standard apparatus as follows: For starting, a standard motor with the usual starter and a low resistance grid or wire resistance connected across the armature, as shown in Fig. 1, should be used. The motor should be large enough to produce the initial torque without requiring excessive current. For running at the normal speed a standard motor may be used, this motor being fitted with the standard starter and armature speed controller; a field rheostat with a 10 per cent. range may be added to the equipment where desired.

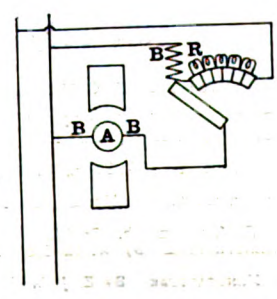

FIG. 1.—BRIDGE CONTROL.

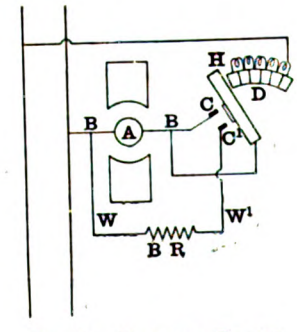

FIG. 2.—DYNAMIC BRAKE.

If a dynamic brake is wanted it may be arranged for by placing two contact pieces on the controller arm of the primary drive, as shown in Fig. 2, where A represents the armature, B and B the commutator brushes, to which are attached two wires W and W¹ connecting in the brake resistance BR, when the arm H leaves the controller dial D and is forced back upon the brake contact brushes C and C¹. An emergency stop may be had by running a push button circuit around the press, connecting the buttons in multiple and connecting the ends of the circuit to the no-voltage release coil on the starter and controller in such a manner that the coil will be short-circuited when a button is pushed and the no-voltage release allowed to act.

* Abstract of an article in the "Electrical World."

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STANDARDISATION OF FUSES.

It is surprising that in the course of its most excellent work the Engineering Standards Committee has not touched on the question of fuses. At present this subject is in a somewhat chaotic state. Beyond the requirement that a fuse is to blow when the current exceeds the normal value by a certain amount, nothing is very fixed. What this amount should be is left largely to individual fancy, or to the rules one may care to select. Thus the Wiring Rules of the Institution of Electrical Engineers state that no fuse shall carry more than 200 per cent. overload without fusing, whereas the Phœnix rules do not permit nearly so much overloading, allowing merely a modest 50 per cent. Since these figures are by no means limiting values, it will be admitted that in rating alone there is much latitude.

The question of rating, however, is only one of the factors involved in completely specifying a fuse. Elsewhere in our present issue will be found an abstract of a Paper on this subject read by Mr. H. W. KEFFORD before the Institution of Electrical Engineers, in which the author gives the following headings for a complete specification:—(*a*) A definition of the "marked" or "rated" current in terms of the "limiting" current; (*b*) A standard range of rated-current values and voltages; (*c*) A definition of one or more points on the "time-overload" curve of each fuse; (*d*) Regulations as to non-interchangeability, temperature rise, freedom from deterioration, and perfect operation under all conditions; and (*e*) Specifications for the standard method of carrying out short-circuit, temperature rise, and overload tests.

Mr. KEFFORD's Paper shows very clearly the present lack of uniformity. The subject is not altogether free from

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difficulties. From the point of view of safety it is desirable that a fuse should not be capable of carrying two to three times its rated current for an indefinite period. On the other hand, if the overload is made small, the fuse must have a low melting point, or be run at a somewhat high temperature, which is often undesirable. Apart from any fire risk due to high temperatures, most metals tend to oxidise if so run. In all cases, however, a distinction must be drawn between large and small fuses. Although an overload of twice the rated current or more may be quite harmless in house circuits, it would be undesirable in large power circuits. Here we come also into the field of the circuit breaker, with which a time element may be combined. In the ordinary fuse there is always something of a time element, but it is doubtful whether any attempt should be made to increase this beyond a modest figure. A large mass of fusible metal is undesirable, particularly in dealing with short-circuits.

Certainly, present practice in fuses for house wiring is of an elementary kind. Such fuses can generally be renewed by anyone, being of the exposed wire type, which means that they may be replaced by any sized fuse that seems to meet the case, or even by a copper "wire" if the circuit is troublesome, thus eliminating all protection. Since branch circuits are now fairly standardised, there is no reason why a standard fuse should not be made which would be applicable to all ordinary house wiring, but it would have to be enclosed and not interchangeable. Notwithstanding Mr. KEFFORD'S opinion that it is unimportant whether a blown fuse is easily recognised or not, we think this is a point which should be borne in mind. Certainly, the average consumer, whose electrical knowledge will not usually go beyond the replacement of a fuse, should not be compelled to search through his distribution board to find the faulty circuit.

In some branches of the industry standardisation may bring about a harmful result, or at least it may impede development. In regard to fuses, however, it appears to us that the subject is essentially one that lends itself to standardisation with great advantages. The manufacturer would gain because he would know what was expected of him, and the number of sizes might be cut down to a minimum. On the other hand, the user would know that the fuse made by A. and rated at, say, 50 amperes, would give about the same result as the similarly rated fuse made by B.; whereas this is by no means the case at present.

REVIEWS.

(Copies of the undermentioned work can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 8*d*. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Hydro-electric Developments and Engineering. By FRANK KOESTER. (London: A. Constable & Co.) Pp. xxv.—442. 21s. net.

A rapid glance through the 440 quarto pages of this well-printed and beautifully illustrated book gives one the impression that it is a very valuable publication, but a deeper study tends to modify this opinion in some slight degree. Some parts are good and useful, but others are rather weak and a few even misleading. Thus, the author's way of treating the stability of dams is certainly open to grave objection. He assumes that the dam has a moment of stability equal to the product of its weight into the horizontal distance between its centre of gravity and the outside edge. This is wrong, as it would imply that the specific pressure at the outside edge might be infinite without crushing the material to powder. The correct way of calculating the stability moment is, as every civil engineer knows, to take as the horizontal distance a length appreciably less (something like two-thirds) of the distance of the centre of gravity to the outside edge. A dam designed in the way suggested by the author would certainly be less safe than he assumes.

On pages 15 and 16 some quite unnecessary instructions are given to the engineer who is called upon to design a power plant. He is told what staff he is to employ, down to the tracers, and how he should shift them from one office to the other, what size the drawings should be, how blue prints should be made and filed, and other things which each engineer will best settle for himself. There is also evidence in this part of the book of rather careless revision of figures. Thus, Galileo is cited as having made a certain pronouncement in the year 1830, whereas 1630 is, of course, meant; on page 14 a certain quantity of coal is given as 6 million tons, when obviously 600 millions are meant; and in some places the sense of the text is somewhat obscure. For instance, in the following passage, occuring on page 136, when dealing with different types of turbines: "During the operation much erosion was observed, and the turbines lost their efficiency, due to the increase of clearance between the runner and the guides. As these turbines are fed by glacier water, which in the summer contains much sand, the erosion still continued during the winter months, when the water is entirely free from same."

A very good feature of the book is the bibliography which is given at the end of every chapter, and which contains a large number of references to literature on the subject treated in the chapter. The general scheme of the book is convenient for its practical use. In the first part we find all those matters connected with the transformation of the waterpower into electric power; in the second the transmission of the currents, and in the third are given numerous examples of European and American works. In the first part we find chapters on Dams, Headraces, Penstocks, Power Plant, Turbines and their Governors, Generators and electrical equipment generally. The second part treats of the Line and Sub-stations, including transformers and converters; whilst in the third part eight different hydro-electric works are very fully described and illustrated by perspective views, plans and elevations.

In the chapter on Testing Turbines some information is given which makes one doubt the accuracy of American methods. The author distinguishes between what he calls the "European" method of testing the efficiency of turbines and the Holyoke tests. By "European" he evidently means an accurate method, for he gives from a German technical paper a table in which the efficiency guaranteed by the Holyoke staff is contrasted with that found by Prof. Pfarr for the same turbine when he tested it in Germany. In this table the turbine comes off rather badly, the efficiency found by Pfarr being about 10 per cent. lower; and in commenting on this the author says rather naively: "For these reasons, guarantees for such tests must not be accepted by the power-plant designer; he should accept only such guarantees as are made in the power plant itself." The sentence is a little obscure, for guarantees are not "made in the power plant," but the meaning seems to be that the tests as made at Holyoke do not give the true efficiency, and this interpretation of the author's meaning is corroborated by what follows, namely, "However, as the Holyoke tests are used in many respects as a standard in American practice, a brief description," &c.

What the author has to say on Pelton wheels is very interesting, and the illustration prepared from an instantaneous photograph on page 151, showing how all the velocity is taken out of the jet by the bucket and the water is quietly dropped, makes one understand how it is that such a wheel can work with high efficiency.

The best part of the book is that dealing with the line, and here the author's bias in favour of American methods is a

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positive advantage, for in matters of line construction admirable pioneering work has been done by American engineers. The author deals with many essential points, both from a technical and a commercial point of view. Thus, the limiting transmission voltage at which dissipation of energy by what he calls the "corona effect" becomes serious is discussed with reference to Lyndon's Paper of a year ago, and a formula is given which is as follows:—

$$\text{Kilovolts} = 148(r+0{\cdot}07)\log_{10}\frac{D}{r}$$

D being distance between wires and r the radius of a wire in inches.

The statics of lines are fully discussed and useful information is given on many Continental and American methods of constructing towers for high-tension lines. As regards total cost of towers and insulators, an interesting problem presents itself. With a short span we have lighter and shorter towers, cheaper foundations, but more cross-arms and insulators, and also more labour in erection per mile of line than with a long span. The length of the span, then, influences certain costs in opposite ways, and there must be a particular length of span for which the total cost becomes a minimum. This problem is fully discussed by the author in the light of practical experience, and a close study of what he has to say on the subject will repay the labour bestowed on it. The line is a very important item in the total cost, and a vital item in the success of the whole undertaking, and for these reasons it is right that in a work as that under review the line should receive special attention. The author has duly appreciated this, and given us a most useful treatise on the subject of high-tension lines. The third part of the work, dealing with existing plants, will also be welcomed by engineers. The works selected are representative of good modern practice, and may, therefore, serve as examples for new designs, modified, of course, to suit special local conditions.

GISBERT KAPP.

ELECTRIC CABLES.*

ELECTROLYSIS.

BY F. FERNIE.

(*Continued from page 190*).

Summary.—The author first considers the general phenomena of electrolysis as observed in the neighbourhood of electrical networks. He then discusses in more detail the corrosion of lead-covered cables and armoured cables, and the effectiveness of earthing. Another cause of deterioration is electric osmose, which causes an accumulation of moisture at the negative conductor if there is any flow of current through the insulation. Finally, the causes of faults and measures for preventing them are considered. Faults may be classified into those of manufacture, those caused during laying, and those developed after the cables are laid. The last class is due to a number of causes, such as mechanical injuries, electrolysis and electric osmose, chemical action, overloading and decentralisation, high temperature, abnormal pressures and static discharges. Another cause of trouble is the accumulation of gas in manholes, causing explosions. The various ways in which gas may accumulate are considered and the remedies to be applied.

Armoured cables laid direct in the ground generally suffer more or less from electrolysis. Joints should be lead wiped and the armouring should be bonded on to the lead. However, with the most efficient bonding, a heavy fault current (to which such cables are peculiarly liable) will always cause some corrosion, owing to the resistance of the lead and armouring. Insulating joints undoubtedly limit the fault current, but will often increase the corrosion on the faulty section. Stoneware boxes have been used and boxes made of glass have been suggested. Wooden or ebonite bushes in the glands of an iron joint box should never be used; they always get wet and act as partial conductors. Bonding and earthing are not an absolute preventative; when a fault occurs part of the current may readily prefer to travel through 3 in. or 4 in. of soil on to some large pipe rather than by a circuitous path to earth along the lead. Also, simultaneous faults on a positive and negative cable may easily cause a heavy earth current between the two cables, the current taking a short cut via some pipe rather than the path provided for it. Steel armouring apparently often protects the lead from corrosion. It is sometimes found in practice that the armouring is pitted and eaten away along its whole length, but the only place where the lead is at all attacked is where the armouring has absolutely disappeared. In all cases *partial* measures are the least effective. Thus, earthenware or stoneware ducts are the very worst kind in relation to electrolysis. They act as partial insulators, rapidly absorbing moisture and becoming in effect electrolytes when only a slight difference of potential is applied. Those with metal joints are worst of all, as the joints act as partial earth plates. Cement joints, unless allowed to remain uncovered to set for at least 48 hours cannot be made watertight, and they also behave as electrolytes, and electrolytic corrosion may occur at every such joint. However high the resistance of a shunt to a circuit may be, some proportion of the current will flow through it, so that however well bonded and earthed a network is, if there are alternative paths for the current, they will be used, and, if these paths are electrolytic, corrosion will occur at the anode.

The problems most likely to arise are those connected with old networks, which probably incorporate a variety of methods of cable laying. The proper course to pursue and the best method of "nursing" such networks must vary in every case. An example of very extensive electrolysis occurring in practice may be quoted. A lead covered and braided cable, forming the positive main of a 460 volt three-wire system, was laid "solid" in an earthenware trough, in very wet heavy soil. It was surrounded by refined bitumen and supported on wooden saddles, which had been boiled in pitch and oil. After about two years' service, it was found that a length (about 50 yards) between two service joints (where the lead was discontinuous) was asunder. The leakage current was measured from both ends and the total was 0·25 ampere. On digging out this length, the cable was found to be almost completely destroyed. In some places, for continuous lengths of 3 ft. and more, not a vestige of metallic copper or lead was to be seen. These metals were replaced by a pale green salt (or salts) of copper (partly oxy-cloride), and a white salt of lead. A section showed these salts occupying exactly the relative positions and bulk of the metals in the sound cable, while the paper insulation was sodden, and in many places white in colour. The bitumen was generally good, but in patches it was brown in colour and friable. No action appeared to have occurred at the saddles. The troughing was cracked along its whole length, and was sodden with water. The cable had been well laid and was quite central in the trough, and not touching it anywhere.

This example shows that bitumen and stoneware are not necessarily insulators. The continuous and uneven crack in the troughing was similar to those caused in concrete by electrolysis. It is probable that if this cable had had its lead *efficiently* earthed, most of this damage might have been avoided, but as the fault was one that probably broke down very slowly, it would have been on some time before being located, and hence have involved the risk of damaging the lead at some distant point. Actually the lead on either side of the insulating joints was quite sound. Had the cable been laid in an insulating duct with isolated lead, the fault would have been noticed during a periodical inspection of the manholes, as soon as the lead became "alive," long before all this corrosion could have taken place.

A negative fault on a three-wire system nearly always damages the nearest gas or water pipe, the pipe being the anode of the circuit. Nearly all the fall of potential occurs within 5 or 6 ft. of the fault, since the fall of potential at any point near an ordinary fault in soil, plotted against distance follows a logarithmic law.

To give some idea of the conductivity of the soil in towns, it may be mentioned that between two stations in Glasgow

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1,580 yards apart the earth resistance was found to be about 0·05 ohm.*

In mines there is great difficulty in obtaining a satisfactory earth, and it is partly for this reason that leadless cables are largely used. Trolley rails are not electrically continuous and the specific resistance of sandstone and shale is of the order 500,000 ohms per cubic centimetre, whilst coal may be as much as 50 thousand million ohms per cubic centimetre. If continuous currents are used, the safest method, *as far as electrolysis is concerned*, would appear to be to use concentric cables, the outer conductor being bonded on to the lead and armouring at the generator. The lead and armouring must be continuous throughout. No serious difference of potential can exist between the lead and the outer, and any fault affecting the inner must cause a short-circuit, which will blow the enclosed fuses. The armouring and lead can, of course, be "earthed" as well as possible to comply with the rules. It should and can be made impossible for the inner conductor to become earthed at any part of the installation without melting a fuse. Whatever type of cable is used, the armouring is chiefly relied on for an "earth" in mines.

Electric Osmose.

If an electric current be passed through a solution, containing two electrodes separated by a porous partition, there will in general be an increase in the volume of the liquid in the cathode compartment, and a decrease in the anode compartment, the liquid appearing to travel with the current. This phenomenon is called electric endosmose, with reference to the cathode.

Thus whenever a continuous electric current flows through a solution contained in a porous body, as soil, brickwork, earthenware, &c., or which is spread over an insulating surface, as a film of moisture on rubber or glass, then, in general, there will be an accumulation of moisture at the negative pole, and the neighbourhood of the positive pole will tend to become dry.

Prof. Haldane Gee† has shown how water is conveyed through blocks of concrete and plaster of Paris, and accumulates at the cathodes; some of the blocks were broken in half, after the passage of a current, and the halves next the cathode were found to have a lower resistance than those next the anode. Electrical endosmose is said to cause the destruction of overhead line insulators on traction systems, since "water is drawn between the iron bolt and the insulating material and is forced through from the positive metal of the bolt to the negative metal of the hanger."‡ On any earthed system of continuous-current mains, electric osmotic effects are sure to be noticed.

The first recorded instance was on the St. Pancras mains, which were bare copper strip strained in culverts. Here metallic sodium and potassium were formed at leaky insulators, and a number of bad explosions occurred. The same effect is common with all three-wire culvert systems, and often with "negative" switches, fuse boxes, &c., mounted on damp walls. The insulator must first become leaky, and this may be caused by a film of condensed moisture and dirt on it, but often part of the insulator is short-circuited by spiders, spider's webs, or flies getting under the petticoat. If it be a "negative" insulator the leakage current will be maintained by electric endosmose, which will keep the surface wet. The salts or metals formed are the result of the electrolysis of the water in the soil. If it be a "positive" insulator the leakage current will automatically cease, since there is no reservoir of water at the "positive" pole (the conductor) to keep the leakage surface wet. The "positive" conductors in a bare copper strip system always have a better insulation than the "negative," although a very high value can be maintained on the negative conductors too, if they are systematically tested, and all faults removed. Glazed stoneware insulators, supporting a negative conductor, sometimes become impregnated with salts, right through their substance, if the leakage has been going on for some time, and they have then to be renewed.

If the bare end of a wire connected to the negative side of a three-wire system be stuck into apparently dry ground, moisture collects around it almost immediately. The great trouble with 3-wire systems is to preserve the insulation of, negative conductors as, at exposed surfaces of porcelain, &c. there always tends to be set up leakage over the surface; and with lead covered wiring for instance, this is probably one of the main causes of failure.

As stated previously, there cannot be any electric osmotic effect on lead-covered cables, so long as the lead sheath is intact, but the question is one of great interest in connection with leadless cables. Before any such effect can be exerted there must be a leakage current through the insulation. Now, with high-class rubber insulation, the real leakage current *through* the insulation is practically nil, most of the observed current when testing, itself almost infinitesimal, being regarded as an absorption current, which gradually dies away.

Thus, before any electric osmotic effect can take place, the insulation resistance of the cable must fall; this may perhaps be caused by the absorption of water, which does take place with rubber and vulcanised rubber to some extent. If it be supposed that what may be called the "normal absorption" of water by the rubber does not much affect the insulation resistance, the deleterious action of condensed water could perhaps be explained if the water "normally" absorbed held some substance in solution, because this solution in contact with pure water would exert an osmotic pressure and tend to dilute itself by sucking in pure water, and thus an abnormal quantity of water might be absorbed.

Rubber is a colloid substance, and colloids "freely form addition products with such bodies as alcohol and water. . . . The process of absorption of water is often accompanied by considerable increase of volume. . . . Many solid colloids and solid solutions of colloids and water can be used as solvents for mineral salts and acids . . . the ionic mobility and the diffusivity are then very little less than in liquid aqueous solutions of equivalent strength."*

Rubber does swell up to some extent when soaked in caustic alkali for a few weeks, and it seems probable that it does behave to a very limited extent like the colloids referred to above, such as gelatine. This behaviour would explain the fall in insulation resistance, and, in the case of a "negative" cable, electric endosmose would, by forcing more water into the rubber, maintain the leakage current, and perhaps cause the formation of the big blisters containing alkaline liquid sometimes observed.

"Positive" faults on rubber cables drawn into underground ducts are less numerous than "negative," and their presence on ordinary straight lengths of cable may perhaps be accounted for by the fact that the liquid conveyed by electric osmose is not always forced in the direction of the current, but in some cases its direction is determined by the nature of the solution, whether acid or alkaline. Thus it has been found† that proteid dissolved in water reverses the direction of its motion, according as the liquid is made acid or alkaline; an acid reaction caused the particles to move with the electric current, which corresponds to the liquid moving against the current; with the liquid alkaline, the particles moved against the current, and hence the liquid would move with the current. Now a positive leakage current will produce, or tend to produce, an acid solution at the cable, and it is possible that this may reverse the direction of the electric osmotic flow of liquid, or at any rate largely neutralise it. So that instead of a "positive" cable tending to dry itself, as it will when the solution is alkaline (for example, the case of a thoroughly saturated "negative" cable changed to "positive") it may actually tend to suck in water.

(To be continued.)

* Lackie, *Proc.* I.E.E., p. 128, Vol. XXXV.
† *Proc.* I.E.E., Vol. XLI., p. 455 *et seq.*
‡ *Proc.* I.E.E., Vol. XLI., p. 485 (Cunliffe).

* W. C. D. Whetham, "Theory of Solution," Chapter XIV.
† "Transactions" American Electrochemical Society, Vol. X. (Carl Hering).

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THE EFFECT OF FREE TRADE OR PROTECTION UPON THE ELECTRICAL INDUSTRY.

On Monday evening last an interesting meeting, promoted by the National Electrical Manufacturers' Association, took place at Caxton Hall, Westminster, when a very interesting discussion upon the above subject ensued.

The Chairman (Mr. H. W. BUTLER), before calling upon Mr. Kingsbury and Mr. Hirst to open the discussion, stated that the reason why the National Electrical Manufacturers' Association had decided to promote the meeting was because the Association existed for the purpose of dealing with questions of general commercial interest to the trade, and was a platform where all members of the industry could discuss the various questions of policy which were a benefit to the trade as a whole. The Association as an Association was not able to take sides, and therefore no resolution would be put, and, further, it could not be responsible for any opinions expressed. He understood that the remarks of Mr. Kingsbury and Mr. Hirst had been prepared quite independently, and therefore could in no way be taken as answering one another.

THE CASE FOR FREE TRADE.

Mr. J. E. KINGSBURY, in opening the discussion on behalf of Free Trade, said that one of the effects of Free Trade was that the electrical industry of Great Britain had a higher efficiency than any in the world. In no protected country could the engineer extend his horizon beyond the frontier, or devise the use of the most suitable instrumentalities, regardless of their birth-place. In no protected country could he exercise his choice, except at a cost which was in addition to the value. In the sale of their material our engineers and contractors had been unhampered, and the nation had added nothing to the price. For some years past efforts had been made to misrepresent the operation of Free Trade by the development of an idea that the free tradesman required the engineer to limit his range of vision and the purchaser to fetter his freedom. The speaker asked which was the truer patriotism, to extend the benefits of the industry and add to the nation's profits, or to retard the development of industry and add to the nation's loss.

With regard to the electrical industry in particular our Free Trade policy had permitted us to apply at once any advance made elsewhere, and to give the industry a start on the most practical lines. As soon as the demand became large enough we abandoned imports and manufactured for ourselves. Thus we were able to make a start at once in any application, not originated by ourselves, and were able to adopt the most suitable instrumentalities to obtain the benefits of successful improvements at a small cost. On the other hand, Protection would have delayed us for years, and have enormously increased the cost. Protected countries were behindhand in the development of enterprise originated in other countries, while we were able to develop and adopt them without delay.

As regards our progress it had been pointed out that we were exceptionally backward as compared with protectionist countries. This was not the case, as in the United States, which was a particularly electrified nation, the electrical products in 1904 were 6s. 10d. per head of the population, while ours in 1907 were 6s. 2d., those being the years most nearly available for comparison. Our progress was in reality substantial, and lack of progress in any department could be readily accounted for by our errors. Free Trade had helped us, while with Protection our case would have been deplorable. Now that the industry was established these arguments were just as forcible.

As regards the protectionist argument that Protection made the foreign manufacturer sure of his own market, that he was thereby able to organise, with confidence, a supply for that market, and could arrange for the surplus to be exported, the difference between individual firms and the industry as a whole was not recognised. An individual foreign manufacturer was, in spite of Protection, open to the competition of other manufacturers in his own country. Protection, it was true, reduced the area of competition, but it did not reduce the actual competition. With regard to unemployment, nothing could be said as to the beneficial effects of Protection in this respect. There had been more extensive reductions of labour in the United States and in Germany, within recent years, than in this country.

One argument, the speaker thought, much in favour of Protection was its educative influence; but he thought that to start a factory for the purpose of serving as a school was an expensive form of education, and when maintained by protective tariff the amounts paid in advance would most likely be very serious.

The large amount of attention given to the profits of manufacture and the small amount of attention given to the purpose of manufacture could not be readily explained. A small agricultural community that placed a restriction on the importation of the best and cheapest spade was taking a measure that must react upon its own development. It would pay the community better to develop its resources by imported spades and pay for the education of artificers from its surplus crops, rather than to set those artificers to work to produce imperfect or unnecessarily expensive spades which would retard the progress of its manufacture. The value of the article in use should be the prominent consideration. Its use should be encouraged, and yet the principle of Protection was to discourage its use by delay or excessive cost. He had only called that spade a spade metaphorically. It might be called an electrical implement. Such an improvement which might now be imported from abroad in a finished state could not be placed at once upon the market if manufactured at home. For a year or two, say, the buyers of the improved apparatus were going to be asked to pay a royalty on what our heads had not devised or our hands fashioned. The proposal was that the nation should fine such purchasers for buying foreign wares, but the purpose of the fine was that we should get the benefit by restriction as much as possible to our own sources of supply. The effect of such restriction must be that the nation would lose in efficiency, the advantages of the possible economy could not be so widespread, and the demand would not assume proportions to justify economical manufacture at so early a period. Thus the home manufacture was likely to be delayed rather than accelerated by protective measures.

With regard to the question of dumping, a term which was identified only with national commerce, nothing could be said against the principle of leaving to the buyer the exercise of his individual will, but he thought it would be unbecoming to a great commercial nation with a world-wide trade for any section of its traders to endeavour to limit the freedom of the individual by the correction of a public sentiment based on national prejudice. If such principles had governed British commerce in the past, Great Britain would not be a great commercial nation, and if they were allowed to operate in the future Great Britain would cease to be a great commercial nation. In discussing such a subject at a time when there was not enough work to go round it was well to remember that what they were talking about was not the effect of Protection applied to electrical work alone, but rather what was going to be the position of the electrical industry if Great Britain gave up Free Trade and adopted Protection generally. If we were asked to adopt Protection so as to limit the freedom of action of those to whom we were selling, and other industries were being asked to do the same, it should be recognised that by their adhesion to those principles fetters were being prepared for the trade and the nation as well. It was all very well to adopt Protection. If they believed it was for the general welfare, they could do nothing less, but had all precautions been taken to assure themselves that it was for the general welfare? Where would the profit be if they procured their home market, and thereby reduced it to insignificant proportions?

In regard to the position of the home market in 1907 we imported roughly 20 per cent. for our consumption, a figure which might be divided by two to indicate the imports which were new or advantageous and those which competed with our standard manufactures. The novelties were wanted to maintain our efficiency and promote the use of accompanying manufactures of our own. Our grievance then was that 10 per cent. of our electrical consumption was imported and could have been made by ourselves. It amounted to a little over three-quarters of a million pounds. Did the case seem quite a strong one to put before the electorate? Was there not danger that some of them at least might remind us that the retention of our home market might possibly result in the ruin of our export market?

Our exports must grow, but we had keen and alert competitors. Every advantage at our disposal must be used. Free Trade was the greatest advantage of all. To our electrical exports we must look for developments, and we were asked to discard the weapon which we knew gave us our advantage in cheap production and promoted that over-sea trade which facilitated the exchange of our manufactures for others' products. And in place of the weapon which had proved its utility we were invited to adopt this protective armour of the middle ages whose deadly weight would crush us with more celerity and greater certainty than any other nation. The dependence of the electrical industry upon the general trade and commerce of the nation could not be questioned, and it was to be regretted that more attention was not given to such points and less attention bestowed on minor questions which, whilst making appeals to individual interest or sympathy, had much less effect on the real settlement.

Amongst the many other arguments for Protection it was often urged by moderate men who did not recommend Protection as a

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good in itself that a tariff might be useful as a basis of negotiation and to permit retaliation. Could we say that any of our active competitors were so poorly equipped electrically that the operation of a retaliatory tariff was likely to lead to a reduction in their duties of any item which would facilitate our exports to them? They would agree the answer was No! In that event Protection as a retaliatory measure was useless to the electrical industry as it was equally useless in other respects.

It must be recognised that a difficulty existed in reaching a conclusion within the industry itself. A conclusion was more easily reached if the interests of the nation were considered. There could be no question then what was the interest of the industry. On foreign trade questions we adopted for ourselves a policy which we thought best. Other nations did the same, and were in no way influenced by our arguments. In such a progressive industry as ours, in which all cultured nations took an active interest, it was not reasonable to suppose that anyone could produce the best of everything. We had much that others could take with advantage to themselves. They shut their doors. Should we also shut ours? In the case of anything which benefited us it would be a mistake, and our Free Trade policy prevented our making such a mistake.

We must sympathise with the trader who found his sales affected or the profits reduced by imports from a country from which his own products were rigidly excluded, but if we legislated for hard cases we should start on the road to ruin. The operation of Free Trade was eminently fair. It might deal out hardship with one hand, but it promoted prosperity with the other. The trade returns of Great Britain, the condition of the population of Great Britain (in spite of all deputations and detractions) clearly demonstrated the wisdom of our fiscal policy. Whether it were regarded from that larger standpoint or from the more definite interests, the speaker thought it would be seen that the electrical industry only required to use its right arm and to make the most of its opportunities under the policy of freedom of trade.

Those who were not quite so satisfied as the speaker that Free Trade was essential to the progress of our industry could at least have no doubt that the effect on the electrical industry of the continual decrying of our powers which accompanied the agitation for Protection was extremely detrimental. If they had so little confidence of their powers in open competition there could be no surprise that others had even less. The best and strongest firm could not afford to lose goodwill. Now Great Britain's loss in goodwill in the last few years had been serious, entirely from the deprecatory arguments of the protective agitation. It would have been more serious but for the fact that our customers, our friends and our competitors had not taken us quite so seriously as we had taken ourselves. Unless they were satisfied that Protection was a real necessity, unless even they believed that the electorate could be convinced of that necessity, it was a mistake to continue the agitation for Protection.

The Case for Protection.

Mr. H. Hirst, in opening the discussion on behalf of Protection, said it appeared to him to be a very peculiar thing that although we grumbled at our present position as manufacturers individually around our firesides and on political platforms, electrical manufacturers as a body had been reluctant to express their views. Yet if our own and other industries were collectively to make known their opinions, and if the demands of the majority were heard, what a tremendous help it would be to statesmen of both political parties in their endeavour to do the greatest good for the greatest number. On the other hand, the most direful and misleading results could follow indecision and halting counsels on the part of industries like our own. When one industry shouted loudly for a continuance of Free Trade, and other industries, which needed Protection, remained silent, the result was bound to be harmful to the country. It might safely be stated that the indecisive results of the last election on the subject of Tariff Reform were largely due to the loud and insistent voice with which the cotton industry clamoured for Free Trade. Yet other industries of this country had a perfectly good and fair reply to give to the cotton spinners, and as that subject had now become one of general interest to the country he took this opportunity of suggesting a reply to what we had been told from Lancashire and Yorkshire. Mr. Hirst then briefly showed that the cotton industry was already naturally protected by the British climate, and that the cotton spinners' argument for Free Trade was really favourable to Protection.

Before proceeding with the discussion of the actual subject of the evening, the speaker showed that we were discussing "Protection and the Electrical Industry," not the electrical "trade." Speakers on this subject were not always careful to distinguish between trade and industry. Too many people in this country had got into the way of coupling "trade" and "industry" as if they were convertible propositions. But they were nothing of the kind. As a matter of fact, good "trade" might very conceivably be the absolute enemy of "industry," and in that case it would necessarily prove detrimental to the aims and ideals of Tariff Reformers. If trade was to be profitable in proportion to its volume, it was essential that it should busy itself only with the import of such commodities as the land was incapable of growing or producing, and with the largest export of such commodities as the land could and did produce. Was not, therefore, the vital question, Under what conditions can we produce cheaply? If you could establish such conditions as would enable the country to produce cheaply you could turn 80 to 90 per cent. or more of the inhabitants of this empire into producers. If you looked after the producer the consumer was automatically looked after, because consumers would then practically be also producers. But if the legislator kept only in view the consumer and neglected to force his country to produce up to the limits of its physical capacity, if, in short, he neglected to protect the producer and allowed outside forces to limit the field within which he could profitably work, that legislator was limiting the benefits of legislation to the smallest number of citizens instead of extending them to the greatest number. The Free Trader argued frequently as if the country were divided into two numerically equal sections, the producer and the consumer. But in an industrial country like ours, if it was to maintain a high state of efficiency, each consumer should also be a producer, though the nature of the production might vary.

The speaker maintained that Great Britain compared with its competitors had drawn nearest to this ideal state of efficiency at the close of that period of Protection which culminated in 1846. She was the chief producer amongst civilised nations. For a time the repeal of the Corn Laws appeared to have had the effect which its champions alleged as their guiding motive, to wit, the expansion of our power of production by the reduction of its cost. But the student of history who examined the facts with an impartial mind could only conclude that the results we obtained were snatched in spite of Free Trade. They certainly received a check as soon as other nations had the opportunity of so organising their economic forces as to place themselves in a position to challenge our industrial supremacy. It seemed that three factors, which were rarely mentioned, but which must be quite familiar to such an assembly as this, worked together to ensure our brilliant success as a producing country in spite of Free Trade, and these causes were operative until about the early eighties. These were Continental revolutions, steam, and the opening up of new markets.

In 1889 or 1881 Great Britain was at the zenith of her industrial power. Scarcely any engineering enterprise of any sort was set on foot in any country unless there were English brains, industry and capital at the back of it. How was it that in the short span of one generation our supremacy as a distributing nation was seriously challenged? How came it that in so many industries where we were leading we had either been caught up or overtaken, and that instead of being supreme we now occupied a secondary position? In discussing this point the speaker confined himself to the argument that under Tariff Reform or Protection we should be able to produce in very much larger quantities and by doing so we should be able to produce much more cheaply.

These two vital effects of Protection seemed to him all important. Engineers knew that in arriving at the cost price the quantity produced was a much more important factor in keeping the price of production lower than any advantage which a Free Trade country might have by somewhat cheaper raw material or cheaper labour. It stood to reason that a manufacturer who had a market of 60 millions of inhabitants secured to him, who had the advantage of preferential treaties with other countries and who could whenever he chose use for any surplus the markets of the Free Trade country, had invaluable points for producing cheaper than a manufacturer of a Free Trade country. In a secure market the outlay of works could generally, from the beginning, be a most efficient one. There could be standardisation or confinement to specialities, and, except in a period of depression, the manufacturer in a Protected country was sure of a continuity of orders. All these factors, again, tended to cheapen production, to the making of quick and big profits which attracted capital, and these profits seemed to be fairly divided between the state, the manufacturer, the workpeople and the investing public.

On the other hand, a man who started electrical works in England to-day realised that, to a great extent, he was entering on a gamble. It was very easy for him to build his works too large from a dividend point of view, or again he might make them too small for the work which might come to him, but it would be a very clever man who could exactly apportion his outlay to the work he could obtain. In this country the science of industrial economics was to a great extent

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in an anarchical condition. We had no school of thought. Free Trade had produced a condition of intellectual drought. We were too apt to take for our pattern all that was done in other countries whether suitable for our conditions or not. Every manufacturer, small or large, was expected not only to copy the work of every manufacturer in every other country, but even if he set himself out to attempt this hopeless task it would not help him much unless he could show the man who had the order to give that he had in his works or elsewhere the exact machines which his customer might imagine were indispensable for the fulfilment of the order. The speaker could hardly suppose that the most dogmatic Free Trader would deny that our power to produce as cheaply as Germany under such conditions was possible.

We must, therefore, realise this fundamental and principal fact—that by producing regularly and in large quantities we could produce cheaper, and we were better able to supply our own colonial and foreign markets. If it were not so, the so-called advantages of our geographical position, most favoured nation clause, the best transport organisation for shipment to and from abroad, would have enabled us to have still kept the lead, but all these advantages failed us one by one as soon as our industrial position was being challenged by our competitors, simply and solely because we could not under our present conditions produce as cheaply. Every other reason put forward seemed mistaking cause and effect.

The principal reasons hurled at us for our decline were the absence of water power in this country, the backwardness of technical education, the lack of inventions, the apathy of British capital, labour troubles, dearer commodities. Mr. Hirst dealt with these points in order, and pointed out that the presence of water power was counteracted by the great capital expenditure necessary to erect hydro-electric stations. In early days our technical education was good enough for our purpose, but as long as our education was confined to learning what others were doing for the purpose of making the same things and selling them below their selling price (not necessarily below their producing price), and as long as we neglected the means which would enable us to produce cheaper to get below the cost of production of our competitors our technical education had no incentive to improve, and any amount of technical colleges would not improve our education when the incentive was missing. Under such conditions technical education was bound to advance at a rate which was never known before for the good reason that there would be a better market than ever for intelligence trained to cope with the technics of what will then be a profitable industry. But as things were to-day why should the foreman of our works, for example, send his boy to Birmingham University? He could afford to do it, but why should he when he saw that a draughtsman, a scientifically-trained engineer, got less than the wage of a shop foreman. The latest development in electric railways had reached us partly from Germany, partly from America. Well, it was a fact that in these countries several manufacturers combined some five or six years ago to experiment in electric railway traction. They formed an experimental company with a capital of £100,000. That was a bold, but doubtless a sound enterprise. Why was no such enterprise forthcoming in this country? The simple reason was that under similar conditions an English syndicate would have had no guarantee that any railway company in this country would have given them an order. There were electrical companies which had been most successful in Germany and America and which had established large works in this country. These companies had practically unlimited capital, they had at their disposal the best brains and experience available for this industry. From time to time such companies had sent us some of their best men who had done as good work in this land as they ever did in their own land, but what had been the result? It was no secret that without exception the financial results of these enterprises had been anything but satisfactory to the parent companies abroad. Now, if lack of technical education was the cause of our decline, why was it that these branch factories, equipped as they had been with the best technical and commercial men which our competitors could produce—why could they not make adequate profits? He thought it was fair argument that no amount of mere technical education would improve our present condition.

Some people were fond of casting in our teeth that we had not been fruitful in new inventions. It was perfectly plain that the manufacturer who worked in a protected country under such conditions as he had described had much more chance of meeting with his due financial reward than any manufacturer who had to get along under present conditions in Free Trade England. A great deal had been said of late about the influence of capital being always held ready to further industry abroad, while the apathy of the British capitalist was severely blamed for the backwardness of industry in this land. His experience was that you could always get capital if you could show good dividends. But we could not in this country show attractive dividends, and for this reason we were deprived not only of the immediate but also of the potential help of capital. We were told that if we had Tariff Reform we should have more trouble with labour. He could not agree with that view. It was a favourite argument with Free Traders that unprotected countries' commodities were dearer, but electrical engineers and manufacturers knew that the prime factor in determining cost prices was the quantity that could be produced. If we only had a duty of 10 per cent. foreign competing firms would well understand that that figure could be varied, and in that case they would be placed in the same position of insecurity in our market in which we were to-day. Under such conditions they would probably in organising their works be more careful to avoid over-production. They would not organise for working our market as they did now. Hence, instead of sending us an unknown quantity of foreign products and for ever depressing our prices, some of these competitors would doubtless start works here, which, of course, would be to the benefit of the working man and the State in general. The manufacturer, on the other hand, would not have any reason to grumble, because he would no longer be liable to be taken at an unfair advantage. The net result would be that we could turn out from our existing works continuously larger quantities, securing regular profits, giving regular employment and at the same time be able to reduce our cost of production. Assuming that last year we imported eight to ten million incandescent lamps, under a tariff of only 10 per cent. the bulk of those lamps would never have been imported, but would have been manufactured in the existing English workshops, many of which last year were running short time. The cost of production would have been reduced by at least the amount of the duty. Nobody would have been a penny the worse, but the factories would have made some profit and employment would have been larger and more regular to say nothing of the attendant advantage of a bigger wage fund for distributing among British operatives, which, of course, meant an increased power of expenditure in the home market for the benefit of every other industry.

In conclusion, he would put one question. Could our country be equally prosperous and equally secure if it ceased manufacturing altogether? If, in short, we were to buy all we wanted? It was possible that under such a system some people provided with capital and well found in experience might grow yet richer. But the effect of such conditions on, firstly, employment, second, on the national wealth, would be disastrous. Our rich stores of coal, iron, &c., were natural wealth, but of what value would they be to us if we made up our minds to let them lie in the ground? The nation which elected to follow out a Free Trade policy to its logical conclusion would be equally annihilating its powers of exchange. Grave as such a condition would be, the evil would not stop there. A nation which deliberately stopped manufacturing, that was using its material resources to the best effect, would be taking the shortest and directest route to national suicide. Those who came as he had into personal daily contact with many of the manufacturers of Germany, France and America, and discussed with them international commercial relations, knew full well that our competitors fully recognised it as a natural and necessary step that we should protect our industries. Now, as so great a portion of the world was still undeveloped and so many industries were in a state of germination and growth there was still time to put our houses in order, and march side by side with our German, French and American friends in the cause of civilisation. If we hesitated we encouraged them to increase their factories as well as their reliance upon the British market. So the day might come when any attempt to do what we could do now would be regarded as a direct disturbance of their national and vested interests which would be correspondingly resented. Thus it was his view that in the best interests of the country, as well as the electrical industry, manufacturers and workers should be protected now while it could be done with the good will of the nations.

DISCUSSION.

Mr. J. A. Raworth said that the subject under discussion was very restricted in its scope. He had undertaken to speak on the side of Free Trade as applied to the electrical industry, and he was not going to run Free Trade down, but back it up. He was born a Free Trader, bred a Free Trader, and he was afraid he was going to die of Free Trade. Mr. Hirst had taken out of his mouth one of the arguments which he was going to put before them. He was brought up in Lancashire, and knew the cotton trade almost as well as he knew the electrical engineering trade, and he knew perfectly why they did not want what was called Protection. They wanted Free Trade, but he pointed out that no great nation ever got into a position which entirely over-clouded all other nations in the way of trade and commerce and manufacture without being protected in some manner or other. In the first instance they were protected by the sea, secondly by the fact that they had all the coal worth having, having a 30 ft. seam in Staffordshire; next that they had the best climate for spinning cotton, and that Lancashire had the best brains and the best trained operatives ever produced by any country in the world. They

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were protected by their position. Mr. Kingsbury did not take any notice of that; he called it Free Trade, and so it was to a certain point. He, the speaker, went into this business in the year 1878, and they had about four years of Free Trade, and he was making money about as fast as he could put it by. Then a proposal was made, he thought by Mr. Chamberlain, to protect the municipalities from the electrical engineers, and this was done under a bill which was set forth as being specially brought forward to foster the electrical industry. During the next six years everything was perfectly stagnant. In those five or six years, if they had had the Free Trade Mr. Kingsbury talked about, they would have been in a position when they could have gone ahead and carried everything before them. He knew that a good deal of money had been subscribed and a good deal squandered. Nevertheless they had not a fair opportunity, and because they had not got Free Trade the Germans were able to handicap them and get into the premier position. They made tramways as well as electric lighting apparatus, and he thought that most of them knew that 90 per cent. of the tramway machinery in this country had come from America. Turning to the question of investment: Not a single penny was being invested at the present time in any tramway undertaking in England, simply because they were still labouring under that old Tramway Act of 1870, which was made for the purpose of dealing with the horse traffic. His view about the case was that if they had left them to Free Trade and had given them the opportunity of dealing with the Corporations or local authorities and making their own terms they would have been all right. But if trade was interfered with in that manner trouble was sure to result.

Mr. E. W. Cowan feared that the division was too deep rooted to be even modified by the night's discussion. They were all agreed that the industry was sick, and he supposed they were all agreed that it was folly to stand idle under such circumstances. What was the disease? The production of electrical apparatus required the combination of certain necessary factors—viz., labour, capital, enterprise, ability of the entrepreneur, &c. Was capital receiving to-day in the electrical industry a "living" wage? Was enterprise receiving a "living" wage? The answer to both those questions was in an emphatic negative. That was the disease the industry was suffering from at the present moment. They might diagnose it as being "destructive competition." The disease originated in the environment of free imports, and it would continue its destructive course in that environment. A tariff on electrical imports only would afford relief, but there was not the remotest chance of a tariff being imposed upon electrical imports alone. The essential difference between the free importer's conception of "duties" and the Protectionists was that the latter believed the gain to some industries to be an absolute gain and the former regarded it only as a differential gain—*i.e.*, the gain to some counting loss to other producers. Nearly all the differences between the two views depended upon the root difference. Could they agree upon some compromise which was consistent with each side maintaining its own conception of the resultant effects of duties? He suggested that they should unite in banishing from the industry the rigid application of the doctrine of *laissez-faire*. Freedom in internal trade and freedom in international trade were both good things. But it was possible to have too much of a good thing. Competition was an excellent thing, but the electrical industry was getting a little more than was good for its economy. Could they not each go their own way in the matter of tariffs and unite upon that other ground? They could never have united action without sacrifice of some of their own particular notions, and without union they could do little. Therefore he said never mind the State, but let them voluntarily co-operate to (1) eliminate destructive competition, and (2) attain higher economy by the regulation and organisation of production. They did not need the assistance of the State to eliminate destructive competition, but they did need the co-operation of electricity supply works engineers and their committees and Councils and of consulting engineers. The support and co-operation of the consumers was, in his mind, essential to success. It should be realised that they were not combining to secure monopolistic profits, but to put their house in order for the benefit of those who used electricity and electrical apparatus, as well as for their own benefit.

Mr. G. Harland Bowden said there were certain firms which were successful organisations inasmuch as they obtained a certain percentage of such work as might be going; but, nevertheless, the electrical industry in this country could not be said to be in a flourishing condition. Putting aside prejudice, the electrical industry in protected countries was in a good condition, employing a greater number of men, who, it had been proved, were earning higher wages than those employed in this country. Taking the iron and steel industry, which was so dependent on electrical machinery for its process, steel manufactured in Pittsburg was sold at 20 to 30 per cent. lower than that manufactured in this country simply to get hold of the market. That steel should have a tariff on it. As to the numerous manufacturing firms who were erecting works abroad, and who were bound to erect them for the purpose of maintaining their markets on the other side of the wall, by putting a tariff on the products of those works one would get the works back to this country and thus increase employment.

Mr. Bennett Fitch said that the necessity of Tariff Reform was the most important question of the day. The main argument used by Free Traders was: "See how we have prospered under Free Trade. Why should we make a change, considering we have done so well and increased our wealth more in proportion than any other country?" As one who had followed the question from the early sixties, he desired to point out that the cause of our national prosperity at that time, previously and for some years later, was entirely due to our development of engineering and mechanical knowledge, every other country in the world being outsiders of those important points in those days. Men in this country invented the railway system and carried it out for many years all over the world. This country possessed further advantages by the fact that coal and iron were developed far in advance of other countries, and, being near the sea, reduced the cost of carriage, and consequently cheaper material than in other countries. A very clear explanation of the advantages this country possessed was shown in Meyers' Encyclopedia, published in Germany in 1849, in which the predominant position of this country was set forth. This country had command of every market in the world in those days, with no competition in any shape or form. The fact that this country was then able to supply cotton and woollen goods to all the world at the cheapest rate was due to our machinery improvements in the forties. Inventions in those times enabled one young girl to carry out work done by two or three men, with the result that for several years there was a great deal of unemployment, which, however, soon cleared away when our cheap supply of cotton, woollen and other goods enabled this country to supply the world without practical competition.

Mr. E. Garcke asked the chairman whether it was not possible to adjourn the meeting, as it would be very beneficial to hear the replies of Mr. Kingsbury and Mr. Hirst. Full justice could not be done to the question if they attempted to close the discussion.

The Chairman (Mr. H. W. Butler) thought Mr. Garcke's suggestion an admirable one.

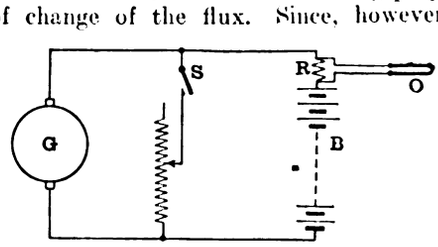
Upon a show of hands it was decided to adjourn the meeting until June 6th, at 8 o'clock, at Caxton Hall.

CORRESPONDENCE.

COMMUTATION PHENOMENA IN D.C. MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In Mr. Worrall's Paper recently read before the Birmingham Local Section of the Institution of Electrical Engineers, a method of examining commutation phenomena is described in which the pulsations of flux due to commutation are recorded by means of search coils suitably arranged on the pole shoes, the E.M.F.s. induced in the search coils being proportional to the rate of change of the flux. Since, however, the flux



pulsations occur in the axis of the main field, corresponding E.M.F.s will be induced between the main brushes by reason of the rotation of the armature in the pulsating flux.

We have been able, by means of the arrangement shown in the figure herewith, to obtain the flux pulsations due to commutation, and also the flux pulsations due to the armature teeth, without in any way disturbing the normal operation of the machine. The special feature of the method is that the E.M.F.s induced between the main brushes by the flux pulsations are directly proportional at any instant to the magnitude of the pulsating flux, and not to its rate of change.

A continuous-current generator is shown at G, and a battery, B, of E.M.F. equal to the generator terminal pressure is arranged in opposition. Some convenient load is connected across the terminals of the machine and battery. The load can be adjusted and also, by means of the switch S, entirely disconnected as required. A small non-inductive resistance, R, is placed in the battery circuit and forms a shunt for the oscillograph circuit O. The current due to any pulsating E.M.F. which may occur superposed on the main terminal voltage circulates through the battery and machine, and this is the only current through the resistance R since the steady pressure of the machine is balanced by the steady pressure of the battery. If the switch S is opened and the brushes placed in the neutral position, the pulsations so obtained are due to the armature teeth, and due also to the fact that the number of commutator segments is not indefinitely large. If the switch S is closed, and the machine loaded, the pulsations due to commutation are obtained superposed on the pulsations due to the teeth, &c.

If the test is carried out on a motor the compensating battery may be dispensed with, and the pulsating E.M.F.s separated by connecting the oscillograph circuit to the secon-

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dary of a current transformer, inserted in the armature lead. In order to avoid undue saturation of the transformer core, a direct current should be sent from a low voltage battery through a second opposing primary winding, in series with which a coil of high self-induction is connected.

We have tried the method on several machines, and have observed the various effects. The optical arrangements of the oscillograph used were, however, not suitable for instantaneous photographs.—We are, &c.,

J. D. COALES.
T. F. WALL.

Birmingham, May 7.

PROF. FLEMING'S LECTURES IN TELEGRAPHY AND TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of May 6th you published the answers to a Paper set by Prof. Fleming on a recent course of lectures. These answers do not seem to be quite accurate.

In Question II. I make Z_0 nearer $571\angle 43°23'$ than $573\angle 43°23'$, and the receiving end P.D. $= 0{\cdot}144\angle 103°16'$ vector volts, the received current $= 0{\cdot}252\angle 146°38'$ vector milliampere, and consequently the answer to Question III., $I_2 = 0{\cdot}117\angle 65°44'$.

Also in Question IV. I make the "smooth" attenuation constant nearly 0·0339 instead of 0·032.

It would be interesting to know how the published results were arrived at.—I am, &c.,

E. P. ELWIN.

Anerley, S.E., May 17.

We have submitted the above letter to Mr. Dyke, from whom we have received the following reply:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Elwin's criticism of my solutions to Dr. Fleming's examination paper, the differences referred to in the answers to Questions II. and III. are very small and quite negligible in view of the use of the approximate formulæ for long lines. In Question IV. the "smooth" attenuation constant is certainly more nearly 0·034 than 0·032.

With regard to your correspondent's question as to how the results were obtained, I am afraid that a detailed solution of each question would occupy too much of your space, but I think that sufficient indication of the methods used has been given to enable those who attended Dr. Fleming's lectures to follow the work.—I am, &c.,

G. B. DYKE.

University College, London, May 24.

KEY SPRING CONDUIT.

The risk of damaging the insulation of wires in threading them through conduits, especially where sharp bends and elbows have to be negotiated, is so well known that any conduit system whereby this danger can be removed would be welcome. Such a system was shown, in its embryo stage, at the Manchester Electrical Exhibition

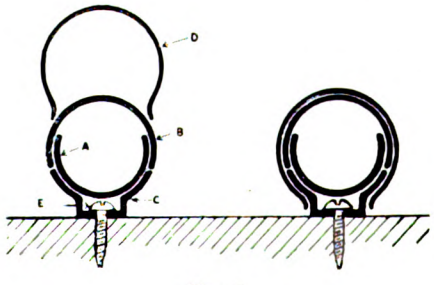

FIG. 1.

about a year and a half ago, and is now being placed on the market in an improved form by the Key Engineering Co., of 4, Queen Victoria-street, E.C.

The Key Spring Conduit, as it is called, is divided into two circular sections, each slightly greater than a semicircle. The bottom section of the troughing (A in Fig. 1) is supported upon the wall or ceiling on a simple bracket, C, screwed or nailed to the support, and is held temporarily in position by a spring clip (*see* Fig. 2). After the wires have been laid in place the cover B is sprung over the troughing, forming a complete circular conduit. Finally, the spring clip D is sprung over the complete conduit and edges of the bracket, thus rigidly holding the respective sections together, as shown on the right-hand side of Fig. 1.

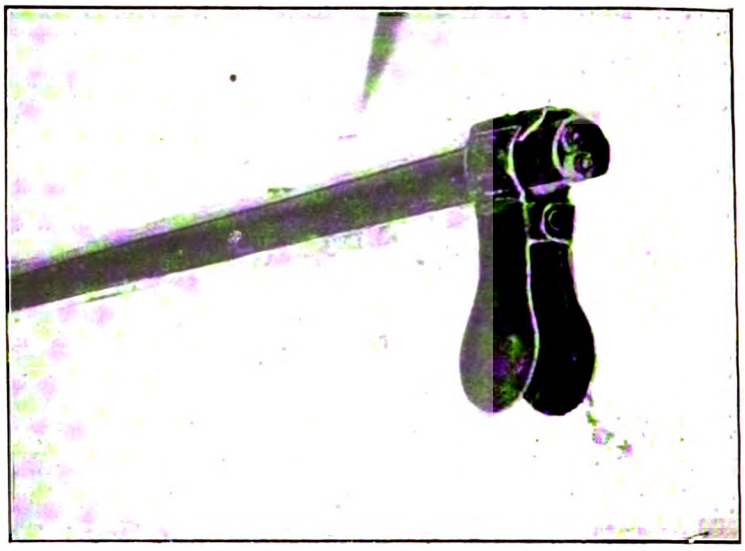

FIG. 2.—TEMPORARY CLIP FOR SUPPORTING THE TROUGHING AND WIRES.

It may possibly be thought that the arrangement shown in Fig. 1 is complicated. It must, therefore, be explained that in practice it is generally much simplified by the omission of the wall bracket C and the spring clip D. In this case small holes are punched in the inner section of the conduit A, and the latter is fixed directly on the

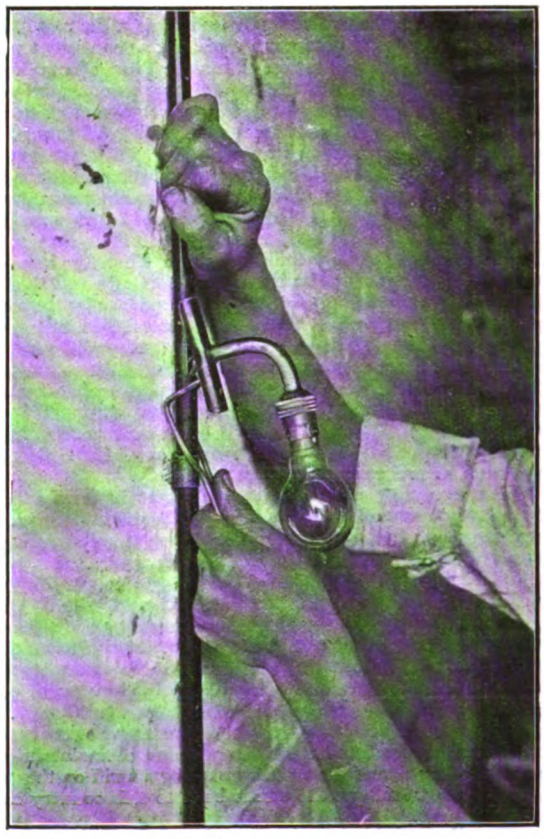

FIG. 3.—USE OF SPECIAL KEY FOR REMOVING COVER OF CONDUIT.

wall or ceiling by means of screws or nails. The conduit is shown in its simple form in Fig. 4.

Although the Key spring conduit is not water-tight, the overlap of the cover prevents the direct access of water. Also, it is claimed that condensation of moisture is prevented owing to the free evaporation provided. In this connection it may be mentioned that

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owing to the conduit being constructed in two halves it is possible to enamel the interior very effectively, thus preventing the likelihood of the formation of rust to damage the wires.

Whilst it is practically impossible to pull the cover off without a tool, it is quite a simple matter to remove it by the special key provided for this purpose. The method of removal is clearly shown in Fig. 3. This illustration also indicates the simple process of attaching fittings by means of standard nipples and steel clips, which latter may be sprung on to the conduit at any point. If it is desired at

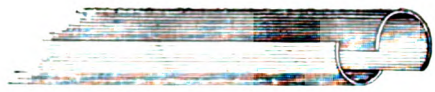

Fig. 4.—Key Spring Conduit.

any time to alter the position of the fitting, this can be very easily done by merely removing a short length of the cover and shifting the fitting and clip to the position required. It is evident that the fixing of pattrasses, ceiling roses, &c., is much simplified by the Key system. A ceiling rose fitting is shown in Fig. 5. It may be thought that a fitting which can be so easily sprung into position and so easily removed would be liable to slide out of position. This, however, is not so, and a weight of 112 lb. hanging from one of these spring fittings has not displaced the latter. A great advantage of the spring conduit system is that all wiring of fittings, &c., can be done on the bench before the wires are laid in the conduit.

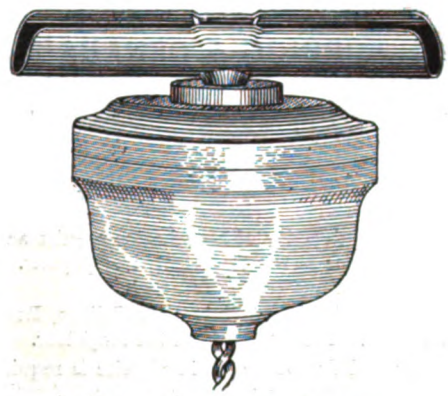

Fig. 5.—Ceiling Rose Fitting.

An effective system of bonding adjacent lengths of conduit has been adopted where electrical continuity is desired, copper rivets being expanded in newly-punched holes in the troughing. A simple screw punch is provided for cutting a clean hole in the exact position required; one of the special bonding pieces illustrated in Fig. 6, and in which the copper rivets are already fixed, is then riveted to the conduit, a special riveting tool being provided by the Key Engineering Co.

Bends and tees are constructed on the same principle as the conduit—that is to say, they are built up of two circular steel sections

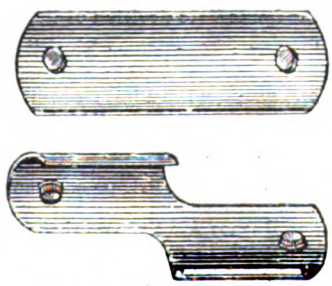

Fig. 6.—Bonding Pieces.

which are sprung together. It is also worth remembering that Key inspection fittings can be used with ordinary draw-in systems. A tee piece for such a purpose is illustrated in Fig. 7.

To show the rapidity with which the Key spring conduit may be installed, it may be mentioned that at the Manchester Exhibition, starting with bare walls, a complete installation, consisting of 20 ft. of conduit, a right-angle bend, a switch, a single-light fitting, a three-light fitting and a pendant fitting were installed by a wireman and assistant and all lights turned on in under two minutes (not including the wiring of the fittings, done previously).

There is no doubt that the possibility of having all wires accessible for examination at any time should bring the system into favour with consulting engineers, whilst the many other advantages possessed by it, such as the possibility of using smaller conduits (since

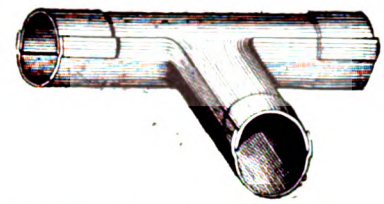

Fig. 7.—Tee for use with draw-in system.

the wires have not to be drawn in), the ease with which the position of fittings may be altered and the saving in labour, are likely to appeal to wiring contractors generally.

LEGAL INTELLIGENCE.

Société Indusdrielle des Telephones v. Nussbaum.

On Tuesday Mr. Justice Grantham and a special jury commenced the hearing of an action, brought to recover £782. 5s. 9d., balance of money alleged to have been received by defendant as agent for plaintiffs. The debt was practically admitted, and defendant paid into court £600, the amount disclosed by the accounts, but he counterclaimed in respect of breach of contract and loss of commission on business which he failed to secure owing to the conduct of plaintiffs. Under these circumstances defendant took the position of plaintiffs and sought to prove his counterclaim.

Mr. Lewis Thomas, K.C., for defendant, said plaintiffs had not carried out their work according to contract or to time, in consequence of which defendant had suffered damage by loss of orders. In one case the contract was that English pig lead should be used for covering cables, but it was found that Spanish lead was used. Plaintiffs, however, protested, while admitting the use of the Spanish lead, that they derived no advantage from it. They attributed the substitution to the difficulty in obtaining supplies of English lead. Some of the telephone wires had to go underground in conduits and others overhead. In regard to the former it was found that the cables had too large a diameter, and in regard to the latter some of them were too heavy and did not comply with London County Council's regulation which was that no aerial cable should exceed 1 lb. in weight per foot. There were also constant complaints of delay in delivery, and in consequence the National Telephone Co. declined to place a second order until the first was executed. Thus defendant lost much business and a large amount of commission which he would otherwise have received. For this he claimed, together with money spent by him for the company and expenses incurred owing to their failure to complete orders to time.

Mr. Nussbaum said he had been in business in England for 25 years. He had, since he first did business with plaintiffs, worked for them only, and had done business to the extent of about 1,000,000fr. a year. There was a written agreement in 1891 with plaintiffs' predecessors, and he went on upon the terms of the old agreement. He had London offices and a salary of £120 a year and commission. He had been in touch with the National Telephone Co. for years, and since 1904 he was in a position to place their orders where he liked. He introduced the National Telephone Co. to plaintiffs, and the result of the introduction was an arrangement by which plaintiff company should get the orders, they having stated that they would be able to deliver three miles of cable per week. Mr. Léauté, a gentleman connected with the company, said that they were getting new plant for indiarubber-covered cables. He placed a large amount of orders with them, but they did not execute them to time. If they had carried out their contracts to time his commission upon the orders would have amounted to £1,500 a year, but he did not get more than half that amount. He claimed for this lost commission. On no single occasion were the goods delivered by plaintiffs to time. The complaints were forwarded to plaintiffs. Mr. Nussbaum detailed a number of complaints which he had had occasion to make to plaintiffs in respect of the manner in which they had carried out orders forwarded to them. He had been requested by Mr. Léauté, of the French company, to retain his agency until the current contracts were finished. He consented, and stated that there would have to be an alteration in the terms of the arrangement after that. As late as March and April of last year the company had communicated with him as their agent. They wrote to him with reference to orders executed for telephone fittings.

In cross-examination by Mr. Montagu Lush, K.C., witness said that he could not do other business because he was still engaged with plaintiffs. He had, however, been in negotiation with several firms with a view to business, but they all told him first to finish his affairs with plaintiffs. He had been doing business with the Société before 1890. He first bought from them telephones as a merchant, which he sent out to Australia. From 1891 to October, 1908, he only did business with the

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Société Générale and the Societé Industrielle. It was one of the terms of his engagement with the French company that he should remit all money received by him for the company within a week or two, and he continued to do so down to 1908. He had in his employ a clerk who falsified his accounts and forged an endorsement to a cheque, and that threw his accounts into some confusion. The difficulty which arose with regard to the French company's accounts was not due to that, but to the confusion into which the company's affairs had got. Plaintiffs ought to have found out that his clerk was a forger. He had kept the £600 as a guarantee Plaintiffs had broken the contracts several times and he could not get any satisfaction from them. so he thought he ought to have a guarantee that they would finish the contract then running. The £600 was paid into the bank, and he told them that he would pay it into court.

Mr. DUDLEY STUART, of the National Telephone Co., gave evidence as to the orders which had been given through defendant to plaintiffs and the manner in which they had been executed.

This closed defendant's case, when his Lordship invited counsel to consult him in his private room. The consultation lasted over an hour, and in the result Mr. Lush, on returning into court, thanked his lordship for the opportunity which he had afforded the parties of arriving at a satisfactory arrangement.

His LORDSHIP said he was glad the parties concerned had come to an amicable settlement under which a portion of the £600 paid into court would be paid out to defendant. Plaintiffs were naturally incensed, but they had acted in a straightforward manner, and defendant had unfortunately acted hastily. The letters which had passed convinced him that defendant was an honest man and that plaintiffs were acting honourably by him. He thought plaintiffs had acted fairly and honourably in the way they had treated defendant, and that the defendant was wise in accepting the settlement.

Aberdeen Station Hotel Co. (Ltd.) v. Aberdeen Corporation.

In the Bill Chamber, Edinburgh, last week, counsel applied on behalf of plaintiff company (in liquidation) to have the Corporation of Aberdeen interdicted from cutting off the supply of electrical energy to the hotel. The Corporation had threatened to stop supply because the company were in arrears with their payment of rates.

Counsel for complainers (Mr. CRURIE STEUART) said the Corporation were seeking to secure a preference over other creditors, although they were an unsecured creditor; and he submitted that the note should be passed for the trial of the case, and that interim interdict should be granted.

Mr. CHREE, for the Corporation, said the proposal was to interdict his clients from taking a statutory remedy for the recovery of the rate. Sec. 23 of the Aberdeen Corporation Act, 1907, gave them power to cut off supply to anyone in arrear. It was not a matter of controversy that the complainers were in arrear, because the usual half-yearly account rendered in January had not been paid. A liquidator was not in the same position as a trustee in bankruptcy, because nothing was vested in a liquidator, who merely managed for the company, which continued to occupy the premises in his person. They did not object to the note being passed, but they did object to interim interdict being granted, except on consignation of the amount due, which was £125.

Lord CULLEN said there was an obligation on the Corporation to supply electricity so long as the consumer was not in arrear. The moment the consumer got into arrear the obligation fell. His lordship refused the note

Liability for Colliery Explosions,

In the Outer House of the Court of Session (Edinburgh), last week, Lord Salvesen allowed proof in three actions brought against Archibald Russell (Ltd.) by the representatives of three miners killed by an explosion. Mrs. E. Tonner (or Tait) sued for £1,000 for herself and £1,250 for her children; Mrs. P. M'Millan (or Adams) claimed £1,000 for herself and £750 for her children; and Mrs. M. M'Vey (or Hunter) sued for £1,000 for herself and £250 for her child. The miners were killed in consequence of an explosion of gas which took place in the Virtuewell seam of Forniegair Colliery, near Hamilton, belonging to defenders. Pursuers' alleged that the explosion was caused by a spark from the trailing cable of an electric coal-cutting machine, which cable one of the men was engaged in lengthening at the time of the accident. Defenders, who denied negligence and pleaded contributory negligence, stated that they believed the explosion was due to deceased (one Francis Tait) lighting his pipe either with a match or by opening his lamp. Smoking and the use of a naked light in that section of the pit were strictly prohibited. They denied that sparking could take place as suggested, but stated that if it did the spark was due to the negligence of Adams or otherwise of Hunter in failing to switch off the current at the gate-end box before proceeding to lengthen the trailing cable.

Lord SALVESEN said he had come to the conclusion that this was a case in which he should exercise the discretionary power which he had of dispensing with issues and appointing the case to be tried before the Lord Ordinary without a jury. He was the more disposed to do so as he thought there was no class of case in which a jury was more liable to go astray than that which related to operations underground, of which they had generally no personal experience. The danger of miscarriage was increased (1) because of the highly technical evidence which would be given as to the proper system of working electric coal-cutting machinery, and (2) because of the legal controversy with regard to the application of the various special rules relating to the particular pit.

Eccles Corporation v. South Lancashire Tramways Co.

In the Court of Appeal yesterday (Thursday), before the Master of the Rolls and Lords Justices Farwell and Kennedy, plaintiffs' appeal was heard from a judgment of Mr. Justice Eve dismissing an action for a declararion that Salford Corporation were not entitled to authorize defendants to use plaintiffs' tramways, or any part thereof, and for an injunction to restrain defendants from running cars over a short section of plaintiffs' tramways within the borough of Eccles. The facts of the case were reported in THE ELECTRICIAN for 24 Dec., 1909 and 28 Jan., 1910.

At the conclusion of the arguments of counsel, their lordships allowed the appeal, holding that what Salford Corporation had done in granting the licence to defendant company to run over the sectinn of the line in question without the consent of the Board of Trade was *ultra vires*. The appeal was, therefore, allowed, and the relief claimed granted, with costs. Plaintiffs undertook not to enforce the injunction for a month.

Wheeler v. Marylebone (London) Borough Council.

Mr. Justice Grantham and a special jury yesterday (Thursday) commenced the hearing of this action, brought by plaintiff (a builder) for the recovery of damages for personal injuries alleged to have been sustained through the negligence of the Council's servants.

Mr. DRAKE, K.C., in opening the case, said, that plaintiff was re-building a house in Devonshire-place, and running through the vaults of the house was an electric cable. The housebreakers employed by Mr. Wheeler gave the Council notice to cut off the electric current, but one day in April, 1908, Mr. Wheeler saw what he thought to be an old lead pipe and went to cut it away with a chisel and hammer. After two or three blows on the pipe an explosion occurred, a sheet of flame lit up the place and plaintiff was violently thrown against the wall (some 4 ft. away) and was severely injured. Plaintiff's left hand was badly burned, the nail of his thumb was burned off and his clothes were damaged; he had received a severe shock and was under medical care for some time.

Evidence for the plaintiff was taken, and the hearing adjourned.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the position of borough electrical engineer at Salford. Salary £500 per annum, rising to £700. Applications to the town clerk, Mr. L. C. Evans, by June 13. See an advertisement.

The Council of the University of Manchester require an assistant lecturer and demonstrator in the department of physics. Applications to the Registrar by June 13.

The professorship of physics at University College, Reading, will shortly become vacant. Particulars from the Registrar.

A junior lecturer and demonstrator in physics is required at the University of Sheffield. Salary £150 per annum. Applications to the Registrar by June 1.

A test room assistant, well up in a.c. and d.c. work, is advertised for.

Mr. A. J. Abraham, resident engineer at Lanark County Council's electricity works at Cambuslang, has been appointed clerk of works of the Aberdare electricity supply scheme.

Mr. W. K. Thomson has been appointed manager of the electrical department of Messrs. Renton, Holdsworth & Co., Sheffield.

Acton.—The position of the electricity undertaking was again discussed at the last meeting of the Electricity committee, and, after a lengthy debate, it was resolved "That the position of the electricity undertaking demands the immediate decision of the Council."

Argentina.—The "Review of the River Plate" states that the plans of the National Tramway Co. for the conversion of La Plata horse tramways to electric traction have been approved.

New telegraph land lines, 556 km. (345 miles) in length, are to be constructed in Argentina.

The Compañia Electricidad de la Provincia de Buenos Aires have purchased for $1,000,000 (paper) the electric power plant which supplies current in Mar del Plata.

The Belgian Legation at Buenos Aires report that Cordoba Province and the Andes districts import 15 million francs value of electrical materials per annum. Germany supplies the demand in the ratio of 491 per 1,000, the U.S.A. 98 per 1,000 and the U.K. 312 per 1,000.

Australasia.—The placing of the telephone lines underground at Ballarat was recently commenced.

The Defence Department have applied to the Minister for Public Works for an order authorising the erection of cable from Melbourne to transmit current for electric lighting at the Maribyrnong cordite factory. The line will traverse Footscray and part of the shire of Braybrook.

Malvern (Victoria) Council have obtained the necessary authority from the Governor in Council to construct a tramway in Glenferrie-road, and notice of a resolution to take further steps was recently given by Coun. Thomson.

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Emu Bay Council are considering the relative merits of gas and electric lighting for use in the town of Burnie (Tasmania). Mr. G. H. Lofts has prepared a preliminary report. The secretary of the Hobart Gas Co. has submitted an estimate intended to show that the cost (with renewals) of a 60 c.p. inverted incandescent gas light, with gas at 6s. 8d. per thousand, for 1,500 hours, would be £1. 16s. 6d., for upright mantle £2. 5s., for 50 c.p. metal filament electric lamp £2. 18s., and for 50 c.p. carbon filament lamp £6. 13s. 6d., current in both cases costing 6d. per unit.

On the other hand, Mr. Percy Rosling estimates that the cost of equivalent lighting would be as follows: Inverted gas burner £1. 16s.; upright burner £2. 5s., metal filament electric lamp £1. 15s. 3d.

With a view to expediting the proposed construction of an electric tramway from Melbourne to Williamstown, a poll has been taken at Williamstown to ascertain the probable demands which would be made for purposes other than traction in the event of a supply being provided for private consumers as well as for tramway purposes. Those in favour of the lighting proposition were: Property owners 632, out of 842 approached, occupiers 691, out of 898. Eleven factories will take electric power and 424 occupiers will take supplies for lighting.

Queensland Government has granted a further loan of £8,000 (making £33,000 in all) for the construction of Rockhampton Corporation's tramways. The Finance committee reported about a year ago that the cost would be increased 20 per cent. owing to the increased rate of customs duty on such material as had to be imported, to the substitution of heavier rails, &c.

Barking.—The electrical engineer (Mr. H. Howard) has prepared a report upon three alternative schemes for the extension of the generating station or the removal of the plant to a new site. Mr. Howard has been instructed to report upon laying an underground cable through Faircross Estate to Upney.

Belfast.—A report has been prepared by the general manager of the tramways (Mr. Andrew Nance) in which certain extensions of the tramway system are recommended.

Borough Polytechnic Institute (London).—A special course of six lectures and practical demonstrations on the "O.S." wiring system, using "Stannos" wire, will be given by Mr. Chas. Rawlings on Monday evenings from 7:30 to 10, commencing May 23. The course is only open to journeymen wiremen

Cardiff.—The Parliamentary committee have been instructed to report upon a proposal to extend the tramway service to Llandaff and Whitchurch.

Clitheroe.—The Board of Trade have deferred the revocation of the electric lighting order (1904) for a year, and intimate that it will be revoked at the end of this period unless evidence of the Council's intention to put the order into force be forthcoming.

East Budleigh (Devon).—The Parish Council have decided to call in an electrical engineer to report upon the lighting of the village.

Edinburgh.—The Electric Lighting committee will supply electrical energy for the new Slateford-road tramway at 1¼d. per unit for the first year.

The engineer (Mr. F. A. Newington) has been asked to report upon the proposal to extend the mains to the Barnton Park estate, where a number of householders have agreed to take current and to guarantee to use a certain amount of current for three years. It is also expected that residents in Blackhall and neighbouring districts will avail themselves of the opportunity of taking current.

Electricity in Flour Mills.—The flour mills of Mr. J. Rymer at Kilvington, near Thirsk, have been provided with an electric lighting and power installation. The generating plant was supplied by Siemens Bros. Dynamo Works and the installation work was carried out by Messrs. Reddin & Sons.

Electricity in Mines.—We have received from the "Colliery Guardian" a reprint of a Paper by Prof. W. M. Thornton on "Electricity in Mines." The pamphlet forms one of a series of Coal Trade Pamphlets issued by our contemporary at 1d. each, by post 1½d.

Electricity in Mining.—At the meeting of the Waihi (N.Z.) Gold Mining Co. last week the chairman (Mr. A. M. Mitchison) said that during the year the hydro-electric scheme for generating power at Hora Hora Rapids had again been the subject of negotiations, and the company had been successful in obtaining a concession for the use of the water. Having regard to the length of time required for the completion of hydro-electric works of that nature, a careful examination of all the aspects of the case was made and it was decided to again apply for the concession. In all the circumstances they felt confident that the Hora Hora electric power would allow further economise to be effected, and they hoped, moreover, that the development of one of the many sources of water power in New Zealand would be of service to the Dominion.

Fleetwood.—The demand for electrical energy for lighting and power is increasing so rapidly that extensions of the generating plant and mains will have to be considered.

Glasgow.—The Electricity committee propose to extend the electric supply cables to the Scottish Exhibition of National History, Art and Industry, where current will be supplied at 2d. per unit for lighting and 1d. for power. It is anticipated that the annual revenue will be £4,600.

Grays.—44 Nernst lamps are to be replaced by metal filament lamps of 100 c.p. and 200 c.p.

Hadleigh.—The Parish Council have asked Southend Council to extend the tramways into this district.

Hampstead (London).—On the recommendation of the Electricity committee the salaries of the following officers are to be increased:—Mr. George H. Cottam, chief electrical engineer, from £775 to £825 per annum; Mr. Egerton Sayer, chief assistant, from £365 to £390 per annum; and Mr. John Leadbeater, chief indoor assistant, from £325 to £360 per annum.

Havana.—The President of Cuba on Saturday last inaugurated the new telephone system of Havana, owned by the Cuban Telephone Co. (Ltd.)

Huddersfield.—The Corporation are negotiating with Linthwaite Urban Council for the purchase of the Linthwaite tramway lines, and an offer of £4,000 has been made for the track. Should the purchase be completed the track will be doubled.

India.—"Indian Engineering" states that the power house at the East Indian and Bengal Nagpur junction at Asansol is to be extended to supply current for lighting the East Indian Railway offices and staff quarters at Asansol.

The services of Mr. A. E. McCloskey, of the engineering department of the G.P.O., in England, have been loaned for two years to the Bombay, Baroda and Central India Railway Co., and he will act as assistant electrical engineer in the company's telegraph department at R.600 (£40) per month.

During the absence of Mr. R. E. Pigott on six months' leave, his duties as chief electrical engineer of the B.B. & C.I. Railway will be performed by Mr. H. B. Saxby, who will also continue to occupy his present position as electrical engineer of the Ragputana-Malwai State Railway.

The electrical equipment for the E.I. Railway coal yard at Howrah has been ordered from England.

Kettering.—The salary of the electrical engineer, Mr. W. A. Walker, has been increased by £50 per annum.

Lapland.—The Swedish Parliament has voted £1,204,000 for the erection of an electric power station near the Porjus Falls, in the Lule river, Lapland, to supply power to the railway between Kiruna and Riksgraensen (on the northern frontier). Electric power will also be used in the district of the falls for reducing iron ore into pig-iron.

Leicester.—The Rural Council will sanction the proposal of the Corporation to supply electricity in Oadby and other parts of the rural area.

Light Railways.—The report of the proceedings of the Board of Trade and of the Light Railway Commissioners up to Dec. 31 last has been issued.

On Dec. 31, 1908, nine light railway orders were before the Board of Trade awaiting confirmation; eight were confined in 1909, and one is still held over. During the past year 13 fresh orders were submitted to the Board by the Light Railways Commissioners for confirmation, and after hearing objections the Board confirmed eight of the orders, the remaining five being under consideration on Dec. 31, but three of these have since been confirmed. The 16 orders confirmed in 1909 authorised 68 miles of line, at an estimated cost of £300,399. Since the date of the last report the Treasury have conditionally agreed to make free grants (aggregating £26,913) in aid of three light railways.

The report of the Light Railway Commissioners states that a total of 599 applications for orders to authorise light railways (including 98 applications for amending orders) have been made since the commencement of the Light Railways Act, 1896. In respect of 379 applications (13 in 1909 and 366 in previous years) orders have been submitted to the Board of Trade for confirmation; four other applications, in respect of which orders are under settlement, have been approved, and 199 applications have been rejected or withdrawn. The decisions with respect to 8 applications have been deferred, and 9 of the 10 new applications made in November last remain to be considered. Upon examination of the lists of orders granted the Commissioners find a large number of light railways the need for which has been established at public inquiries held by them, and for which orders have been confirmed by the Board of Trade, but of which the construction has not (so far as the Commission is informed) been proceeded with, and as to a large proportion of which the powers have already lapsed. Whereas 46 light railways, with a length of 375 miles, in class A. (lines on lands acquired, mostly steam motive power), and 54 light railways with a length of 326 miles in class B. (lines on public roads, mostly worked by electric power) have been constructed, the powers given by the orders have not been carried into effect in the case of 61 schemes with a length of 765 miles in class A. and of 35 schemes with a length of 210 miles in class B. These powers have finally lapsed for 33 schemes (421 miles) in class A. and for 24 schemes (138 miles) in class B. The chief difficulty in proceeding with schemes already authorised has been in finance, while the failures enumerated above have had the effect of deterring other proposals. In relation to lines of class B., experience has shown that the absence of any provision under the Act of

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1896, for "submitting to Parliament" proposals which are required to be so submitted in accordance with the Act, renders the procedure unavailing, and practically unavailable, in many cases. To what extent, and in what way, the policy of the Act should be revised must present a difficult problem; but the Commissioners draw attention to the marked success of the system adopted in Belgium, under which a total length of more than 2,000 miles of light railways, constructed with moneys raised on national credit, is already being worked without loss to the State, while a further length of some 2,000 miles has been projected.

Manchester.—At the Corporation meeting on Wednesday Ald. Holt moved, as an amendment to the motion for the adoption of the estimates of the Electricity committee, that the committee should add £5,000 to their contribution in aid of the city rates. The amendment was, however, rejected.

On the motion to adopt the estimates of the Tramways committee, Mr. Lofts moved an amendment that the estimate of £82,537 for renewals and depreciation be reduced by £25,000, and that amount paid to the city fund. He urged that there was already a large reserve fund of £471,865, which was ample to meet all contingencies, with the sum which would be added if his amendment were accepted. This amendment was also defeated.

Municipal Telephony.—The manager of the Hull municipal telephone department (Mr. T. Holme) has presented his annual report for the year ended March 31.

Gross receipts were £11,670, increase £1,078 compared with 1908-9, and after paying expenses there was a gross profit of £4,823, increase £380. The amount transferred to loan repayment was £1,994, against £1,786, making the total carried to loan repayment account £5,668, to temporary sinking fund £1,948 and to reserve fund £3,380, total £12,166 after deducting cost of diverting Post Office junction circuits. The Government royalty for the year was £1,188. Capital expended is £60,315, compared with £57,858, increase £2,456. During the year 1,620 yds. of underground conduits were laid, extending the system by 154 miles of metallic circuit. The total conduits now laid measure 37 miles, and the underground mileage equals 4,050 miles of metallic circuit.

In regard to overhead construction, the capital expended during the year had (the report continues) been incurred in joining up additional subscribers and extending the overhead routes by the erection of 27 poles. The total overhead mileage is now 581 miles of metallic circuit, and the number of poles erected is 1,370. The cost per station now stands at £20·58, compared with £21·42.

The chairman (Ald. J. BROWN) said this was the fifth annual report, and was the best of the five. They had made a profit since they began of £10,782. They had reduced the subscription of telephone users by about one-half, and yet were able to show a satisfactory financial result. That showed the great mistake that had been made on the part of the municipalities who had not installed their own telephone system. He thought it was a credit to the city that they had carried the system out so satisfactorily. They had not only done well for themselves, but they had done well for the Government. They had been told recently that the Government could not make either the telegraph or telephones pay, so they might take a leaf from Hull's book.

The report was adopted, the net profits being carried to revenue account

National Electrical Manufacturers' Association.—A meeting was recently held in Manchester to form a northern section of this association.

The meeting was well attended, and it was resolved that the section should be formed. Mr. B. Longbottom was elected hon. secretary and the following firms have since joined the association:—E. Brook (Ltd.), H. T. Boothroyd (Ltd.), Clarke, Chapman & Co., Evered & Co., Liverpool Electric Cable Co., Bertram Thomas and Wright & Wood. Several other firms have since sent in applications, and the result is that a strong section of the association is formed which will deal with local matters directly. In consequence of opinions expressed that the association should be more national in character a revision of the bye-laws has taken place.

Obituary.—The death is announced of Mr. Geo. Bremer, who was for over 20 years chief country representative of Mr. G. Braulik.

Rugby.—The chairman of the Electric Light committee (Mr. Dewar) made a statement at the last meeting of the Council as to the financial position of the electricity undertaking.

He said that the committee were satisfied with the progress of the undertaking, and had directed that £500 further of the available balance in the net revenue account be transferred to reserve, making this £1,000, and a balance in hand of £631. 3s. 3d. The total capital spent was £14,190, and £3,150 had been repaid, so that the net capital was £10,850, against £11,318 last year. The total revenue for the year was £3,670, an increase of £167. The introduction of metal filament lamps was largely accountable for the smallness of the increase. Total expenses were £2,059, and the gross profit £1,600. Interest absorbed £410, repayment of capital £575, discount and bad debts £180; the net profit was £299. The number of consumers had increased from 329 to 381.

Spain.—The Societa Anon. Tranvias de Valladolid has been granted permission to electrify its lines.

Sunderland.—On Wednesday the Corporation adopted a recommendation of the Electricity committee to substitute electric lamps for 266 existing gas lamps upon the route of the electricity mains.

SPECIAL NOTICE.

NOW READY.—Vol. LXIV. of "THE ELECTRICIAN" (1,035 pages) bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "THE ELECTRICIAN" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

The cost for conversion will be £465. 10s., and the annual cost of lighting and maintenance will be the same as hitherto paid for gas.

Torquay.—In reference to the attitude of the Board of Trade towards the local tramways, which are worked on the Dolter surface contact system, it must be remembered that the Dolter system has been employed under provisional certificates granted by the Board.

Although the working of the tramways, both for speed and smoothness of running, has been satisfactory to the Council, yet the defective studs per month reported to the Board have been considerable, though the number of "live" studs has not been in excess per mile per week of that obtaining in other places where surface contact systems are in operation. Representations made by my Council to the Board of Trade from time to time, expressing satisfaction with the working of the tramways, have resulted in the certificate being re-issued half-yearly, but on the occasion of the last renewal (in October, 1909), after again considering the representations of the Council on the subject, an order sanctioning the use of the Dolter system was issued by the Board for a further period of 12 months with an intimation that it was granted on the understanding that if no substantial improvement was shown by the returns in regard to live studs during the next six months the company would then have notice that at the end of the remaining six months no further sanction would be given to the use of the Dolter system. As stated in our last issue (p. 256) the Board have now intimated to the company and the Council that, as there has been during the last six months no substantial improvement in the working of the system, as shown by the large number of defective studs still obtaining on the tramways, they will not further renew their sanction to the use of the system, and the Council are considering this ultimatum in conjunction with the company. We are informed that the discontinuance of the present means of propelling the trams will be much regretted locally, as the fact that the cars would be driven by a surface contact system of electric traction had great weight with the Council in consenting to the original introduction of tramways into the town.

At the meeting of the Corporation on Monday, the chairman of the Tramways committee (Mr. E. Pike) made a lengthy statement as to the present position. With reference to the number of live studs, the company had made a return for 12 months showing that there were from 40 to 60 a month, and when it was considered that there were 6,000 or 7,000 studs, that was only 1¼ per mile per month. That did not seem many, but in the opinion of the Board of Trade it was too many. As to dead studs, that was a large item. It might be calculated as anything from 1 in 4 to 1 in 6, and it was here that the flashing took place. The committee had done everything in their power to get the existing defects rectified. They would be sorry to see the present system done away with. The tramway company said they had done everything possible. The only way to keep down live and dead studs was to have a patrol and stud repairer every quarter of a mile, and a staff of men in the sheds for making and repairing the studs, and that, from the company's point of view, was an impossibility. The company offered to adopt for the proposed extension the trolley system. The present tramways, regarded as a commercial undertaking, did not pay, and the company wanted to equip something that would pay, and he did not know that the Council would put any obstruction in their way so long as the new system did not disturb the amenities of the town. There were two courses open to the company; one was to give up the undertaking, the other to go to arbitration. The Council wanted neither. He doubted whether the public would agree to give up the trams. The company were carrying 10,000 passengers at 1d. fares per day. The committee were told that the present system of trams cost 9d. per mile to run, against average receipts of 7d. They were told that they would get a better service with the overhead system, and that there would be a reduction in cost of current. Last year the company paid the Corporation £5,500 for current, and their income was about £15,000. He moved that the matter be sent back to the committee with instructions to make the best arrangements they could with the tramway company, who would do the very best for the Council and the town.

Mr. J. SMERDON said if they could get from the company their bottom price for their system they would be able to consider whether it was desirable to purchase it.

The motion was carried.

Tottenham.—The Metropolitan Electric Tramways (Ltd.) have informed the Council that negotiations are proceeding in connection with the Tottenham and Walthamstow light railway.

Transvaal Power Scheme.—In the directors' report of the Tweefontein Colliery (Ltd.) it is stated that arrangements have been practically concluded with the Transvaal Hydraulic Power Synd. in regard to the erection of a large electric power station and chemical factory on the colliery company's property. Under the terms of the arrangement, a minimum of 25,000 tons of small coal and second-class coal (the latter of which at present is not being mined) per month would be purchased for the power station

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Uruguay.—A bill has been introduced in Parliament to grant Mr. Edwin Steer a 90 years' concession for the construction of the Ferrocarril Expreso Eléctrico Montevideo-Buenos Aires and for carrying out other public works and equipping a hydro-electric generating station. The railway will extend from Montevideo to Colonia, whence a steamship service will connect with Buenos Aires.

Watford.—In view of the fact that Bradford and Leeds Corporations have obtained Parliamentary powers to employ railless traction systems, the Council consider it desirable that the construction of the proposed light railways in Watford be deferred.

Negotiations are proceeding with the North Metropolitan Electric Power Supply Co. as to supply of electricity in Munden and Hansteads.

West Ham.—Tenders are to be invited for wiring the new boys' department of the West Silvertown School.

Westhoughton (Lancs.).—The Council have authorised Atherton Council to supply electricity to certain persons in this district.

Wimbledon.—Councillor Dudley Stuart, M.I.E.E., has been appointed chairman of the Electric Lighting committee in succession to Ald. A. Holland, J.P., resigned.

Winchester.—The Assize Courts magistrates' room and the offices of the County Treasurer are to be wired, and the question of lighting the Court Hall is also under consideration.

Wireless Telegraph Notes.—Interesting developments are stated to be taking place in the establishment of a wireless telegraphic service in the Straits Settlements and in Venezuela. With regard to the former, plans are in progress to connect Singapore, Hong Kong, Bangkok and Yokohama. The company interested is an American one, and seeks a 25-year licence for the sole right to conduct wireless telegraph business, giving the Governments the privilege of purchasing at the end of 10, 15, 20 or 25 years. The company propose to instal at Hong Kong a station equal to their station in New York, which will be capable of communication with Yokohama and Shanghai on the north and Singapore on the south. As regards Venezuela, the Government has arranged for international telegraphic communication between Colombia, Ecuador, Peru and Venezuela. The Director of Telegraphs of Venezuela has been instructed to communicate with the Government of Peru with a view to extending the inter-continental service to Bolivia, Chili, and thence to the Argentine Republic. The Government of Venezuela, in connection with the Compania Anonima de Navegacion Fluvial y Costanera de Venezuela, has decided to establish wireless stations of the De Forest system at Pampatar, Coche and Araya (Margarita Island), and on board the "Venezuela" of the Navegacion Co.

The new service of time transmission by wireless telegraphy from the station on the Eiffel Tower, Paris, was duly inaugurated at midnight on Monday, signals being repeated at 2 minutes and 4 minutes past the hour, with (it is stated by "The Times") satisfactory results, the range being between 4,000 and 5,000 kilometres.

The Electrical Engineers (London Division).—The second annual athletic sports of this Corps were held on the London County Athletic Grounds at Herne Hill on Wednesday evening last.

These sports are in the nature of trials for the Territorial championships which are held later on in the year. Last year the Electrical Engineers came within one point of winning the championship for the highest aggregate of points obtained in the Territorial sports, and if the results of the other evening's events are to be relied upon, they should do just the necessary amount better this year. The times showed a great improvement, while the keenness of those entering was certainly better. A championship cup, presented by Major A. E. Le Rossignol, which is to be held by the company obtaining the greatest aggregate of marks on the events undertaken, was won by "C" Company with 28 points, "A" Company being second with 21 points.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Belfast.—The accounts of the electricity department for the year ended March 31 have been issued, and show a net profit of £11,040, against £8,282 in 1908-9.

Birmingham.—The accounts of the electric supply and tramways department (abstracted in our last issue) were submitted to the Council on Tuesday.

Mr. ELLAWAY, chairman of the Electric Supply committee, moved that authority be given for the provision of additional plant and the provision of a sub-station at Harborne at a total cost of £143,250. In 1907 (he said) they had voted a certain sum for prospective extensions to meet requirements for the three succeeding years. The committee now sought to make preparation for a further period. None of the work for which authority was sought would come into commission before the autumn of next year, but they had to get the sanction of the L.G. Board, and some portion of the machinery would require six months to build. The output of the department had been growing by leaps and bounds, especially for lighting and power. The increase in 1907 was 1,750,000 units, in 1908 2,500,000, in 1909 3,000,000 and last year 4,500,000 units. The forecast of the committee had been exceeded. While their capital had been increased by about 15 per cent., the output had increased about 50 per cent., and during the three years 1908-10 they would have paid £20,000 to rates, besides £16,000 to renewals fund and £62,000 for writing off obsolete plant. They had also made concessions to consumers in reduced charges equal to about £11,000.

The resolution was agreed to and the committee were authorised to appoint a secretary to the department at a salary of £600 per annum.

The chairman of the Tramways committee (Mr. HARRISON BARROW) thought the results of the past year's working of the tramways very satisfactory. The gross revenue from the city lines showed an increase of £13,791, and outside the city of £4,022. The receipts per car-mile had increased from 11·13d. to 11·63d. Economy had been effected in the use of electric current by affixing meters to a number of cars, and it was proposed to see what further could be done. The reduction in the hours of employés increased the expenditure nearly £8,000. The surplus to be transferred to relief of rates was £32,914, compared with £29,490.

Blackburn.—The traffic receipts of the Corporation tramways for the year ended March 25 were £55,613 (against £56,569 in previous year), parcels receipts £1,616 (against £1,477), and total receipts £59,285 (against £60,132).

Working expenses were £37,742, against £43,503; and the gross profit was £21,543, against £16,629. Interest absorbed £6,831, repayment of loans £6,080 and contributions to sinking fund £7,983. The net profit was £453, against a loss of £4,804 in 1908-9. The car miles run were 1,065,451 (against 1,132,023), the passengers carried 10,439,450 (against 10,737,528), and the receipts per car mile 12·59d. against 12·04d.

Brighton.—At the meeting of the Corporation last week the report and accounts of the tramways department for the year ended March 31 were approved.

Coun. BUTT-THOMPSON, chairman of the Tramways committee, said the year's revenue was £51,359, against £47,809 in 1908-9, an increase of £3,550. Total expenses were £37,069 against £36,670. There had been an increase in cost of renewals, and a slight increase in wages. Permanent way cost £4,005 compared with £3,549. The car mileage run increased by 21·101, and they had carried 724,992 more passengers. There had been a trading profit of £14,289, an increase of £3,151, and the net profit was £1,190, compared with a loss of £2,420. The total debt was £246,756, and the reserve fund £4,613. 18s. 10d.

The report of the engineer and manager (Mr. Wm. Marsh) states that there were 10 broken axles, compared with 25. There are 71 of the largest size in use, some of which have been running 3½ years, but not one of these has been broken. Increasing their diameter to 4⅜ in. appears to have had the desired effect. Price of current has been reduced from 1·5d. to 1·35d. Total revenue per car mile was 10·99d. (against 10·34d.) and working expenses (including power) were 7·86d. (against 7·93d.). Current used per car mile was 1·71 (1·7) units.

Burton-on-Trent.—The capital expenditure of the tramways department at March 31 was £106,000, an increase of £360 on the year.

The year's revenue was £14,044 (against £14,183), in addition to £932 £926) from the Midland Railway Co. for running powers. The trading deficit was £1,756 (£1,747). £1,496 has been placed to reserve, compared with £1,000 in the previous year. Total receipts per car-mile (exclusive of M.R. cars) were 7·87d. (7·97d.), and operating expenses were 6·27d. (6·37d.). Units used per car-mile on Corporation cars were 1·27 (1·26). Miles run 428,219 (425,843).

Crewe.—The income of the electricity department for the year ended March 31 was £7,899, including £4,111 from sale of current by meter and £3,588 from public lighting.

The expenses came to £3,733, and included £2,179 cost of generation, £164 for distribution, £379 for public lighting, £428 for rents, rates and taxes, and £500 for management expenses. The gross profit was £4,166, and after taking into account interest, &c. (£136), and paying interest on loans (£1,248), sinking fund and loan instalments repaid (£1,834), there was a balance profit of £1,220, of which £500 was transferred to reserve, £500 in relief of rates and £683 to meet expenditure in excess of loans sanctioned. Capital expenditure is £55,058, increase £903. 10s. on the year. 745,345 units of electricity were generated: 301,743 units were supplied for public lighting and 334,532 sold to private consumers. There are 34 arcs and 743 incandescent posts for public lamps, and the maximum supply demanded was 440 kw.

Devonport.—At the meeting of the Electric Power committee last week the chairman (Ald. J. B. Love) stated that the gross profit for the year ended March 31 was £7,467. 18s. 10d., and after paying interest and sinking fund the net profit was £1,010. 19s.

Ald. LOVE said the trams on the extension lines were stopped for over nine months of the year, which meant a drop in the sale of current of 122,717 units, representing £715. 12s. In spite of this, by extended business in other directions, the income had reached within £217. 14s. 11d. of that of 1908-9. A saving of £627 had been effected in the cost of generation as a result of the use of mechanical stokers. 42 new consumers and a number of extensions were added during the year, representing an equivalent of 2,875 8 c.p. lamps. In 24 cases the work of installation was carried out by direct labour of the department, and 18 by local contractors. The sale of current to the Devonport & District Tramway Co. produced £5,384. 4s. 2d.; Plymouth, Stonehouse & Devonport Tramway Co., £2,353. 8s.; private consumers (in Devonport) £4,153. 12s. 5d.; in Stonehouse, £3,889. 5s. 11d. The committee have placed the £1,010. 19s. to reserve and renewals fund, and have

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decided to recommend the Council to reduce the price of current for lighting by ¼d. per unit (from 4d. to 3¾d.) The reduction represents £450 per annum.

Exeter.—The accounts of the electricity undertaking for the year ended March 31 show a surplus of £2,736. 18s. 8d.

About 100 new consumers were connected during the past year, and the units sold (1,413,762) increased by 43,500. The revenue from general lighting showed little change owing to increasing use of metal filament lamps. The accumulated profits and reserve amount to £7,416. In the past year's accounts 5 per cent. was allowed for depreciation of machinery, 2½ per cent. on mains and services, 6 per cent. on transformers and motors, and 5 per cent. on meters, instruments, stores and tramway generators.

The surplus on the tramways is £463. 19s. 2d., after wiping out the deficiency of £131. 7s. 10d. on the previous year. The car miles run were 424,873. £463. 19s. 2d. was placed to reserve and renewals.

Georgetown (Penang).—The report for 1909 of the engineer and manager of the municipal electric supply and tramways departments (Mr. Orlo V. Thomas) states that the capital expenditure of the electricity department during the year was $58,746 (£6,609).

It is stated that the generating station was 8 in. under water on Sept. 15, during the memorable floods, and the station had to be temporarily shut down. Additions to the plant, &c., during the year included a 300 kw. Allen-Westinghouse steam dynamo, a Babcock boiler to evaporate 8,500 lb. of water per hour, condensing plant, pipework, a Weir boiler feed pump and Ledward-Körting ejector condenser and pipework and Westinghouse switchboard extensions. All the remaining 16 c.p. carbon lamps used for street lighting were replaced by 50 c.p. metal filament lamps, and at the end of the year there were 43 arc and 369 50 c.p. metal filaments in use for public lighting. Total units sold were 674,140 (compared with 562,322 in previous year); revenue was $113,230 (£12,739), increase $19,013 (£2,139); expenditure was $67,633 (£7,606), increase $1,878 (£211). Generation and distribution costs were 8·04 cents (2·17d.), a decrease of 1·29 cents (0·348d.); and total costs 10·03 cents (2·708d.), decrease 1·67 cents (0·45d.). After meeting capital charges there was a net profit of $1,961 (£221).

Capital expenditure of the tramway department during the year was $18,665 (£2,100). Revenue was $65,382 (£7,355), compared with $69,579 (£7,828). Operating, power and general expenses were $60,265 (£6,780), an increase of $5,081 (£572). Gross profit was $5,117 (£576). The net deficit was about $9,000 (£1,025). The electrical equipments of the cars, supplied by the British Thomson-Houston Co., have given great satisfaction, and none of the motors have failed. 2,040,047 (2,236,097) passengers were carried and 281,413 (285,771) car-miles run.

Grimsby.—The total capital expenditure of the electricity department at March 31 was £102,318, an increase of £2,454 on the past year.

The annual receipts were £19,487, including £8,993 from sale of current by meter, £3,926 from the G.C. Railway, £3,044 from the tramway company, £1,190 from sale of current to the Admiralty and £1,714 from public lighting. Total expenses were £9,380. Allowing £63 for bad debts, the gross profit was £10,043, and after meeting interest (£3,276) and instalment of loans (£2,879), there was a net profit of £3,867, against £3,184 in 1908-9. 2,350,869 units were sold (893,660 for private lighting and power, 748,892 to the G.C. Railway in bulk, 501,321 for traction, 132,920 for public lighting and 74,076 to the Admiralty). The equivalent of 84,705 8 c.p. lamps is connected for private lighting and 1,665 for public lighting; total 86,370 8 c.p. against 78,934. 106 new consumers were connected during the year, the largest number added in any year since the start of the undertaking. The maximum load was 1,248 kw., against 1,225 kw.

In his report, the borough electrical engineer (Mr. W. A. Vignoles) states that there was an increase of 9 per cent. in the units sold for private lighting, and, as the increase in the number of lamps connected was in about the same proportion (9½ per cent.), it is evident that the majority of the consumers have now changed from carbon to metal filament lamps. The increase in the demand for energy for power was equal to 36 per cent., against 24 per cent. in 1908-9. There are 162 motors, representing an aggregate of 1,065 H.P. connected. Of these 33 (aggregate 395 H.P.) are supplied with electricity on the time-switch or restricted-hour system. Total generation costs were equal to 0·607d., an increase of 0·015d., mainly due to increased cost of repairs, and the total working costs were 0·921d., an increase of 0·046d., chiefly attributable to increased rates and taxes. £500 has been allocated to relief of rates, and the balance of the net profit (£2,259) has been transferred to reserve.

Mr. Vignoles states that the amount sanctioned by the L.G. Board for mains and services has now been expended, and an application for sanction to a further loan will shortly have to be made. At the recent inquiry the inspector intimated that money borrowed for services in future would have to be repaid in 15 years, and under these circumstances Mr. Vignoles thinks his committee should consider the question of paying for services out of revenue.

Huddersfield.—The accounts of the electricity supply department for the year ended March show capital expenditure £225,641 (increase £19,401).

The total amount borrowed is £214,515, and the amount of loans repaid and accumulated redemption fund is £65,654. The annual revenue was £32,963 (compared with £31,614), gross profit £13,133 (£12,014), and net surplus £711 (£550). Units sold were 3,829,681 (2,462,046). There are 3,200 (2,843) consumers and 294,824 (244,163) equivalent 8 c.p. lamps connected.

South Shields.—The Council are recommended to increase the salary of the tramways manager (Mr. L. E. Harvey) from £250 to £300, and then by annual increments of £25 to £350 per annum.

The report and accounts of the working of the tramways department for the year ended March 31 last have been issued.

The traffic revenue was £29,062 and the total receipts were £29,777. The working expenses came to £18,895 and the gross profit was £10,882. Interest required £5,748 and sinking fund £3,484, and the net balance (£1,650) has been transferred to reserve. 7,273,776 passengers were carried and 807,317 car-miles run. The gross capital expended is £171,863. The number of units of energy consumed was 1,070,343 (1·326 per car mile) and the bill for electric current shows a reduction of £917. 10s. 4d., a portion of which was due to the use of meters upon cars.

West Hartlepool.—The total revenue of the electricity department for the year ended March 31 was £15,538, including £14,340 from the sale of electric current from private and public lighting.

Working expenses were £8,650 and gross profit £6,888, and after paying interest (£2,476) and sinking fund, &c. (£3,297), there was a net profit of £1,128. The year's expenses were increased by £250 additional for coal owing to the Durham coal strike and by £284 law charges in connection with the arbitration proceedings re the Kitson clause. There are 724 lighting consumers (against 687) and 69 power consumers (54), a total of 793 (741), representing the equivalent of 123,275 8 c.p. connected (113,116). There are 223 motors, of an aggregate of 1,957 H.P., against 211 motors of 3,863 H.P. 2,387,222 units were generated; 1,998,508 units were sold to private consumers and 59,685 were supplied to the public lamps (39 arcs and 26 incandescents). The total maximum supply demanded was 1,070 kw. Works costs were 0·75d. per unit sold (against 0·81d.) and the total costs (including interest and sinking fund) 1·61d., against 1·68d. The load-factor was 21·96, against 23·89 per cent.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

HAMMERSMITH (London) Council invite tenders for supply of h.t. sub-station switchgear. Specification, from of tender, &c., from the borough electrical engineer, Mr. G. Gilbert Bell, 85, Fulham Palace-road, Hammersmith, W. Tenders to the town clerk, Mr. H. Thompson, by 4 p.m. June 1. See also an advertisement.

Tenders are invited by July 6 for the supply of cordless switchboards to the Postmaster-General's Department in SOUTH AUSTRALIA. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for supply of 1,470 opalescent arc lamp globes to the city of MELBOURNE. Specification, form of tender, &c., from the agents of the City Council (Messrs. McIlwraith, McEacharn & Co. Propty., Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon June 8. See also an advertisement.

Tenders are also invited for supply of 941,000 arc lamp carbons to the city of MELBOURNE. Tender form, specification, &c., from the agents (Messrs. McIlwraith, McEacharn & Co. Propty., Ltd.), Billiter Square-buildings, London, E.C., to whom tenders by Friday, June 17. See also an advertisement.

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Tenders are invited up to July 19 for supply and delivery of 4,200 telephone sets (as per schedule No. 231) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

BARNES Urban District Council invite tenders for supply of 4,000 yds. of 0·25 0·25 1·25 sq. in. triple concentric cable, paper insulated, lead sheathed and jute served, suitable for a working pressure of 660 volts, manufactured in strict accordance with the British Engineering Standards committee's specifications. Tenders to the Clerk to the Council, High-street, Mortlake, by noon June 14.

NEWPORT (Mon.) Electricity committee invite tenders for supply and erection of two 400 kw. motor-generators, three-phase to d.c.; one 600 kw. motor-generator, three-phase to single-phase; and one 'bus-bar three-wire booster. Specifications, general conditions and form of tender from the borough electrical engineer and tramways manager, Mr. H. Collings Bishop, Town Hall, Newport, Mon. Tenders to the Town Clerk by first post May 31.

COVENTRY Electricity committee invite tenders for supply, delivery and erection of a 1,250 kw. turbo-alternator, complete with surface-condensing plant, &c., four water-tube boilers (straight tube type) and two fuel economisers. Specification, general conditions and forms of tender from the engineer and manager, Mr. Geo. Tough, and tenders to the Town Clerk, Hay-lane, Coventry, by first post May 30.

The LIVERPOOL Overhead Railway Co. require tenders by 10 a.m. June 7 for 12 months' supply of electrical fittings, insulating tapes, iron and steel, ironmongery, oil and grease, packings, &c. Forms of tender, &c., from 31, James-street, Liverpool.

EDMONTON Guardians want tenders by 9 a.m. June 2 for supply of three-phase electric motors and accessories and cable connections for the workhouse, Upper Edmonton. Form of tender from Messrs. May & Hawes.

MIDDLESBROUGH Corporation want tenders by June 2 for stores for 12 months, including electric lamps, i.r. tubes, iron and steel, belting, oils, &c. Specification from Mr. R. V. Thompson, 42, Commercial-street, Middlesbrough.

EALING Corporation require tenders by noon July 4 for supply and erection of surface condensing plant, &c., at the electricity works. Specification, &c., from the Borough Electrical Engineer, Town Hall, Ealing.

MANCHESTER Electricity committee want tenders by 10 a.m. June 7 for 12 months' supply of stores, including carbons, dynamos, brushes, iron and steel, asbestos and rubber goods, oils, &c. Forms of tender from the Town Hall.

MANCHESTER Tramways committee want tenders by 10 a.m. June 7 for special (permanent way) track work. Specification from 55, Piccadilly, Manchester.

BATLEY Corporation require tenders by noon June 1 for a lighting and traction switchboard for the electricity works. Specifications, &c., from the Borough Electrical Engineer.

ST. ANNES-ON-THE-SEA Council require tenders by noon May 28 for a fuel economiser. Specification, &c., from the Electrical Engineer.

LEICESTER Corporation want tenders by noon June 9 for an extension of engine room, &c., at tramway power station. Specification from the Borough Surveyor.

Tenders will be received by Mr. G. T. Moore, 1 and 2, Foster-place, Dublin, until June 4 for electric installation at 67, Sackville-street, DUBLIN.

Tenders are wanted by 6 p.m. May 31 for new electric lift at Beckett Hospital, BARNSLEY. Plans, &c., with Messrs. G. Moxon & Son, 26, Church-street, Barnsley.

CORK Electric Tramways & Lighting Co. (Ltd.) require tenders for steam boiler, with superheater and electrically-driven feed pump.

Tenders are invited up to June 14 for supply of 100 party line common battery telephone wall sets, 10 party line common battery table sets, 100 switches, common battery, single extension and intercommunication, and 3,000 telephone protectors to the Postmaster-General's department in VICTORIA. Tender forms and specification at the Commonwealth office, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, BRISBANE (Queensland), will receive tenders until noon June 22 for supply of copper wire and accessories, covered wire, iron wire, insulators, ironwork and sal ammoniac and zinc for batteries. Local representation is necessary.

Tenders are invited up to June 7 for supply of one frame, main distributing, to the Postmaster-General's department in WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W.

SYDNEY (N.S.W.) Council require tenders by 3 p.m. May 30 for switchboard for Pyrmont power house, and by 3 p.m. July 17 for house service fuse boxes. Specifications from the City Electrical Engineer, Queen Victoria Markets-building, Sydney.

COPENHAGEN Corporation want tenders by noon June 2 for supply of two 1,000 kw. converters or motor-generators. Specification, &c., from Elektrisk Station, Gothersgade, 30, Copenhagen.

The ITALIAN STATE RAILWAYS Department require tenders by June 5 for supply of seven electric motor pumps. Tenders to 16, Via Ludovisi, Rome. Only firms on Departmental list may tender.

Tenders will be received on June 10 at the Post Office, rue de Grenelle, PARIS, for supply of telephone cable.

The Military Telegraphs Department, PARIS, want tenders by June 14 for supply of 100 Morse instruments.

The Ministry of Public Works, Constantinople, want tenders by June 28 for a tramway concession for SALONICA.

Tenders will be received (up to 11 a.m. June 6) at the Royal Arsenals, SPEZIA and NAPLES, for supply to the Italian Naval Authorities of electric lamps and lamp stands in two separate lots. The total estimated value of the contract is placed at 32,000 lire (about £1,280), and a deposit of 1,880 lire (about £74) will be required to qualify tenders for lot 1, and a deposit of 1,330 lire (about £53) for lot 2. Only manufacturers of electric lamps will be allowed to tender. Applications for certificates of competency to the Director of Naval Construction at Spezia, Naples, Venice or Taranto not later than May 21. Copies of the specifications, conditions of tender, &c., may be seen by British firms at 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Bristol Corporation have accepted the following tenders for annual stores, &c.:—

Sykes & Sugden, joint and junction boxes, £213. 13s. 1d.; General Electric Co., meters, £546. 4s.; Bruce Peebles & Co., 500 kw. converter for Underfall Yard sub-station, £1,230; Union Electric Co., Ship Carbons (Ltd.) and Oliver Arc Lamp (Ltd.), for arc lamp carbons at schedule prices estimated to amount in the aggregate to £655. 5s. 1d.

Heston and Isleworth Council have accepted the following tenders: W. Lacey, extension of engine room; Browett, Lindley & Co., 250 kw. generating set, &c. (British Westinghouse dynamo and British Thomson-Houston switch panel); Babcock & Wilcox, steam piping and Weir pump; Körting Bros., condensing plant; and Selson Engineering Co., machine tools.

London County Council have received nine tenders for wiring Camden-street schools, St. Pancras, N.W., the amounts varying from £206. 19s. to £552. 19s. The second lowest tender, that of E. Lawrance & Sons, at £251, has been accepted.

Southend Council have accepted the tender of the Railway & General Engineering Co. for 100 renewable manganese plates for the repair of rail joints at £1. 15s. each; and that of Nalder Bros. & Thompson for 66 current limiters at 15s. each.

Hampstead (London) Council recently placed an order with Willans & Robinson for a 350 kw. disc and drum type turbine, and Norwich Corporation for a 500 kw. turbine. Both machines are intended for working both with exhaust and high-pressure steam.

Llandudno Council have accepted the tender of the Chloride Electrical Storage Co. for re-plating batteries and for supply of paper and vulcanised cable, &c., at £501. 10s.

Southwark Electric Light committee are continuing their existing arrangements with the Union and the Sloan Electric Companies for supply of arc lamp carbons at £2. 18s. per 100 pairs, less discount.

Smethwick Education committee have accepted the tender of H. W. Ludlow for wiring work at the technical school.

The East Indian Railway Co. have ordered a milking booster from the Lancashire Dynamo & Motor Co., and electrically-driven high-lift pumps for their electrical department from Greenwood & Batley.

Government Contracts.—The following tenders have been accepted by Government Departments:—

Admiralty, Edison & Swan Co., Evered & Co., General Electric Co., and W. McGeoch & Co., lampholders; India Rubber, Gutta Percha & Telegraph Works Co., gutta percha. *War Office.*—Craven Bros., electric cranes; Lancashire Dynamo & Motor Co., motors, &c.; Siemens Bros. & Co., extension of electricity supply; Foote & Milne, electric lighting of R.A.M. College, Millbank. *India Office.*—Siemens Bros. & Co., cables and electrical stores. *G.P.O.*—Creed & Co., telegraph apparatus; Johnson & Phillips and Western Electric Co., paper core cable; General Electric Co., electric light fittings. Peel-Conner Telephone Works and Gent & Co., telephones; T. Bolton & Sons, British Insulated & Helsby Cables, Elliott's Metal Co., R. Johnson & Nephew, Shropshire Iron Co., F. Smith & Co., and J. Wilkes, Sons & Mapplebeck, h.-d. copper wire; A. Sauvee & Co. and Spencer & Co., endless band conveyors for new G.P.O. building, London, E.C.

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Commonwealth Tenders.—The following tenders have been accepted by the Postmaster-General's Department :—

Victoria.—Western Electric Co. for 52 pair cable; British Insulated & Helsby Cables, five 100 line switchboards; Drew & Poole, 100,000 porcelain insulators; R. Johnson, Clapham & Morris, g.i. wire; J. A. Newton & Co., telegraph switches, ebonite tubes and ear pieces, coin attachments, howlers and open-circuit condenser telephones; Lawrence & Hanson, metal filament lamps, "Linolite" carbon filament lamps and T.H. screw socket carbon lamps.

New South Wales.—W. T. Henley's Telegraph Works Co., switchboard cable; India Rubber, Gutta Percha & Telegraph Works Co., Q and I detectors; J. A. Newton & Co., dry cells; Lawrence & Hanson, conductor cords.

Queensland.—International Electric Co., condensers; Western Electric Co., wall and table telephones; J. Paton & Co., table telephones.

BUSINESS NOTICES.

On and after June 22 the Newcastle stores and offices of the Edison & Swan Co. will be at Swan's Buildings, St. James-street, Leazes Park-road, Newcastle-on-Tyne. Mr. H. Smith will remain manager of the branch.

The partnership between Jas. D. and John H. McCarthy and Geo. H. Nicholls (trading as G. Nicholls & Co.), electric and gas fitters, &c., Goldsmith-avenue, Portsmouth, has been dissolved. Debts by Messrs. J. D. and J. H. McCarthy.

The partnership between Fredk. W. Richardson and Johan D. Carlmark, electrical engineers, &c., High-street, West Bromwich, has been dissolved.

The partnership between F. W. Bridges and G. D. Smith has been dissolved, and Mr. Smith's business will be carried on, as hitherto, at the same address, 125, Finsbury-pavement, London, E.C.

Plant for Sale.—An 80 kw. Willans steam dynamo is advertised for sale.

Demand Indicators for Sale.—Torquay Corporation advertise for sale a number of demand indicators of various sizes from 3 amperes upwards, which may be inspected at the electric lighting station.

Lamp Agency.—A firm of British metal and carbon lamp manufacturers, at present able to produce 300,000 lamps per annum, and capable of extension, advertise that they desire to arrange with a wholesale factor house to take practically exclusive output.

Patents Development.—The proprietors of the following patents desire to enter into arrangements by way of licence and otherwise for exploiting and developing the same in this country :—

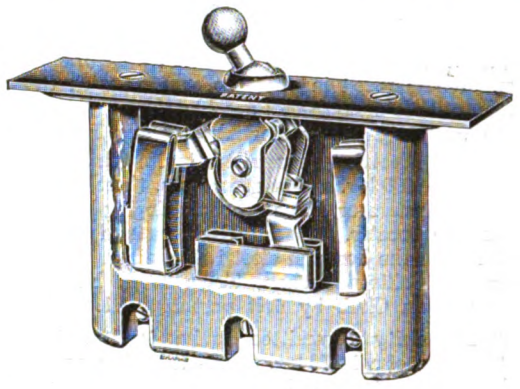
No. 17,601/1901, for "Improvements in apparatus and devices for controlling electric currents"; No. 15,243/1903, for "Improvements in means for automatically regulating electric currents generated by dynamos"; No. 16,962/1902, for "Improvements in electrical switches or cut-outs"; No. 17,314/1905, for "Improvements in automatic regulators or rheostats for electric currents." Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

Patent No. 10,187/05, for "Improvements in electric couplings." Applications to Messrs. G. F. Redfern & Co., 15, South-street, Finsbury London, E.C.

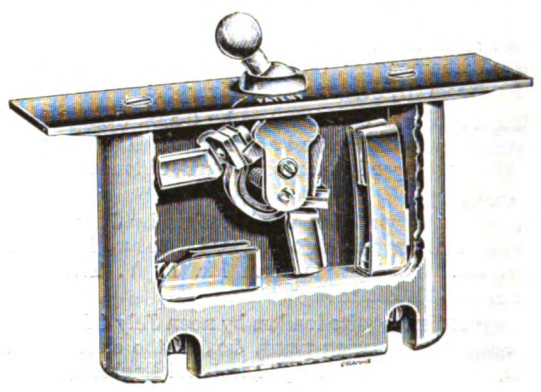
No. 12,210/1901, relating to "Electrostatic Separators." Applications to Messrs. Cruikshank & Fairweather, 65 and 66, Chancery-lane, London, W.C.

Patent Amendment.—Notice is given that Herr Willy Roos, engineer, of 368, Offenbacherlandstrasse, Frankfort-on-the-Main, Germany, seeks leave to amend the specification of letters patent No. 12,135/1907, granted to him for "Improvements in magneto-electric ignition apparatus." Particulars of the proposed amendment are set out in the "Illustrated Official Journal (Patents)" of May 19, and notices of opposition must be given at the Patent Office 25, Southampton-buildings, London, W.C., within one calendar month of that date. The agents for the applicant are Messrs. Cruikshank & Fairweather (Ltd.), 65 and 66, Chancery-lane, London, W.C.

"Klymax" Panel Switch.—Messrs. A. P. Lundberg & Sons have sent us a sample of their new two-way panel switch of 5 amps. capacity. This is a new type for flush work, to meet a demand for a narrow-pattern switch of minimum dimensions (the sample is purposely broken through to show construction). Considerable economy in space, labour and material is, it is claimed, obtained by its use. The switch movement adopted and the arrangement of the contact springs and blades are quite novel. Mica and porcelain are employed for insulating the current-carrying from other metal parts. The switch is supplied in two types, single-way and two-way, which are identical in size. All moving parts are enclosed in a porcelain casing, and the fixing lugs are covered by a brass front plate $3\frac{13}{16}$ in. by 1 in. Special fronts of other materials are also fitted to requirements. The method adopted allows the articles to be grouped into very small space, and one front plate of comparatively small dimensions can be made to serve for a number of switches. The break is quick and long, the contact arms being of the efficient knife-blade type entering double-contact springs. The switches can be fitted into suitable iron boxes to meet requirements. When



double-pole and intermediate switches are required, these are simply and neatly obtained by coupling the knobs of two single or two-way switches respectively by a short cylinder piece. Two-pin wall



connections of various gauges can also be arranged on the same porcelain parts, enabling combination sets to be made up in minimum sizes.

Tubular Osram Lamp.—We learn from the General Electric Co. that they are now making tubular Osram lamps of 16 c.p. similar to that shown in the accompanying illustration, for use on circuits of pressures between 100 to 125 volts, the price being 3s. 6d. The company anticipate a considerable demand for this new shape of lamp, as it is particularly adaptable to many popular fittings now in demand.

General Electric Co.'s Stand at the Japan-British Exhibition.—In the company of a number of pressmen, we paid a visit on Wednesday last to the General Electric Co.'s stand in the machinery hall at the Japan-British Exhibition. The opportunity has been taken to make a grand display of Osram lamps, and amongst the most interesting of the exhibits shown in this connection is a board on which are fixed a number of types of Osram lamps in candle-powers varying from 1 to 1,000, thus giving an idea of the wide range and general adaptability of this type of lamp.

We understand that on Whit Monday the stall was a great attraction to visitors and that the sale of Osram lamps is likely to materially benefit thereby. Another interesting exhibit, which is to be used in connection with Osram lamps, is a special line of glassware, by which it is claimed proper distribution of the light is obtained, while all glare is prevented. We have often spoken of the importance of this question, and are pleased to see that such a well-known firm as the General Electric Co. is taking the matter up in so thorough a fashion. The bait used in drawing the general public is an exhibit somewhat similar, but on a smaller scale, to that employed at the Olympia Exhibition in 1905. The mounting of Osram lamp filaments is carried on in full view of the public, who are mightily interested in the various processes, and there

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are certain examples of glass-blowing, such as pigs, which also attract attention. The stand is surmounted by a sign displaying the benefits of Osram lamps, which is visible from the entrance to the Machinery Hall, and on Wednesday afternoon by far the greatest crowd was to be found round the General Electric Co.'s stand. We wish the company every success in their endeavours to gain the benefits of electric lighting for the public.

CATALOGUES, &c.

CHEAP ELECTRIC COOKING.—Messrs. F. A. Wilkinson & Partners forward a leaflet dealing with their economic electric cooker. The cooker is neat and compact, and is specially adapted for use with ordinary household utensils.

KALKOS TINNED TUBE WIRING SYSTEM.—The Sun Electrical Co. have forwarded a catalogue dealing very fully with the Kalkos system of wiring, which is now well known; its wide application shows that its merits are becoming fully appreciated among contractors and supply engineers. We advise our readers to procure a copy of the catalogue and to study the recent improvements that have been made.

METAL PARTS AND SUNDRIES.—The Specialities Supply Co., of Bermondsey, London, have put down plant by means of which they are able to turn out cheaply and quickly stamped, pressed or spun metal work of all kinds, as well as light gauge brass and copper tubes and nickel cases and boxes for scientific instruments and similar goods. The demand among electrical manufacturers for this class of work is large, and manufacturers will therefore be interested in the prices at which the Specialities Supply Co. can offer them.

EDISWAN ELECTRIC FANS.—At an appropriate moment the Edison & Swan United Electric Light Co. issue a catalogue illustrating and describing their electric fans. These are made in several types suitable for ceiling, wall, desk and porthole work.

THE IDEAL HOME.—From the South Metropolitan Electric Light & Power Co. comes a pamphlet giving an account of their Ideal Home at Catford. Illustrations of the various rooms furnished and apparatus employed are given, and the pamphlet is of general interest. The distribution of the pamphlet amongst prospective consumers should be of service to supply undertakings generally.

BANKRUPTCIES, LIQUIDATIONS, &c.

With reference to the notice appearing in our last issue (p. 257) regarding the voluntary liquidation of the Lepel Wireless Synd. (Ltd.) we are asked to state that the Lepel Wireless Synd. was only a subsidiary company, and that the contracts and business of that company will be carried on, as before, by the parent company (the Anglo-German Wireless Synd., Ltd.), the owners of the patents of the Lepel system of wireless telegraphy.

A receiving order has been made against Wm. Hy. Trentham, consulting engineer, 39, Victoria-street, London, S.W. The first meeting of creditors will take place on June 3 at Bankruptcy-buildings, London, W.C., and the public examination on June 28.

John Filmer Davie, electrician, lately of 10, Gt. Castle-street, London, W., has been adjudicated bankrupt.

The affairs of the Phosphor Bronze Co. (Ltd.) having been put in order, a dividend is to be paid to the creditors of the company. Claims to Mr. S. P. Child, 8, Frederick's-place, Old Jewry, London, E.C., by June 7.

Adjudication Annulled.—The adjudication has been discharged and the receiving order rescinded in the case of Edwd. Wm. Barton-Wright, electric therapeutic specialist, 1, Albemarle-street, Piccadilly, London, W., the judgment upon which the bankruptcy proceedings were based having been set aside by the High Court.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

March 19, 1910.

6,957 TAYLOR & SCOTSON. Control of electric supply systems.
6,962 BELLEM & BREGERAS. Driving of magneto-electric machines for starting internal combustion engines. (Date applied for, 25 3 09.)*†
6,964 SIEMENS & HALSKE AKT.-GES. Connections for semi-automatic telephone exchanges. (Date applied for, 20 3 09.)*†

March 21, 1910.

7,019 TANNER & CLAREMONT. Electric appliances. (Date applied for, 8 4 09. Comprised in No. 27,858, dated 8 4 09.)*
7,048 TODD. Magnetic brakes for tramway and other vehicles.
7,082 JUILLAC. Mast for use in wireless telegraphic apparatus. (Date applied for, 27 3 09.)*†
7,093 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Automatic telephone exchanges.*
7,096 BARKER. Magnetos for ignition purposes of internal combustion engines.

March 22, 1910.

7,141 TAYLOR. Limiting the flow of current on a short-circuit.
7,154 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Electrical signalling apparatus.*
7,184 JACCHIELLO. Producing high-frequency oscillating currents.*
7,201 B. BURTON. Manufacturing metal filaments for electric incandescent lamps.
7,211 B.T.-H. CO. (G.E. Co., U.S.) Telephone systems.*
7,212 B.T.-H. CO. (G.E. Co., U.S.) Insulators for high-tension transmission systems.

March 23, 1910.

7,214 FISH. Arc light candle.
7,216 MCGINNESS. Trolley-head protector.
7,224 & 7,225 SMITH & DEAKIN. Electrodeposition of metals.
7,248 HALL. Electric ignition apparatus.
7,260 LAMB, CROWLEY & KELVIN & JAMES WHITE. Transmitting mechanism.
7,266 SIEMENS BROS. DYNAMO WORKS & LYDALL. (Siemens Schuckertwerke G.m.b.H., Germany.) Single-phase commutator motors. (Addition to No. 2,303 08.)*
7,276 NEWTON. (John Forrest Kelly, U.S.) Circuit-controlling devices.*
7,292 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Electric frequency convertors.*
7,297 BRITISH WELDING CO. (Dellwik Fleischer Wassergas Ges., Germany.) Welding joints.*
7,302 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controllers for alternating current motors.*
7,318 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Starting switches for polyphase alternating-current induction motors.*
7,322 REINEKING. Short-circuit detectors.*
7,331 MADDEN & HOUSKEEPER. Preparation of conducting filaments. (Date applied for, 31 3 09.)*†
7,332 HOUSKEEPER. Electric contact devices. (Date applied for, 31 3 09. Addition to No. 7,331 10.)*†
7,336 SLADEN. Electrical connecting devices.

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

694 B.T.-H. CO. (A.E.G., Germany.) Alternating-current dynamo-electric apparatus. (Addition to No. 23,288 02.)
2,147 TAYLOR. Electric accumulator sub-stations fed from alternating-current systems. (Cognate applications, 2,335 09 and 5,623,09.)
4,034 DE MARTIS. Electric batteries.
4,162 BROWN. Telephony.
6,069 BRUCE PEEBLES & CO. (Braestad & La Cour.) Electric motor-converters.
6,177 PARSONS, STONEY & LAW. Electric power transmission systems.
6,405 GROTE. Electric switches.
6,447 WILLIAMS. Enumeration of telephone calls.
6,504 WILSON & WILSON. Metering and transforming electrical energy.
6,564 B.T.-H. CO. (G.E. Co., U.S.) Electric motor control.
6,565 B.T.-H. CO. & D'ARCY. Electric energy meters.
6,566 ALLGEMEINE ELEKTRICITATS-GES. Control of electric motors. (Date applied for, 18 3 08. Addition to No. 22,481 07.)
6,673 B.T.-H. CO. (G.E. Co., U.S.) Speed indicators for electric motors.
6,674 B.T.-H. CO. (G.E. Co., U.S.) Electric resistance units.
6,675 ALLGEMEINE ELEKTRICITATS-GES. Polyphase relays. (Date applied for, 19 3 08.)
6,752 CHILDS & HILL. Electrical generating sets.
6,820 REID. Electric furnaces. (Date applied for, 22 8 08.)
6,836 ALLOM. Electric light reflectors for concentrating light.
6,849 RIZZO. Solenoid brakes for electrically driven carriages.
6,877 SIEMENS BROS. & CO., RIBER & IRELAND. Hand-operated magneto-electric machines.
6,916 WALKER. Generation, storage and use of electric power.
7,058 SHEPHERD. Rendering constant the voltage of dynamos for electric lighting and charging.
7,060 CROMPTON & CO., MACFARLANE & BURGE. Rotary electric transformers and motor-generators.
7,114 B.T.-H. CO. (G.E. Co., U.S.) Electric motor control.
7,141 DURANT & DURANT. Portable electric safety lamps.
7,187 HANDCOCK, DYKES, RAWLINGS & DIESELHORST. Sheathing of electrical conductors.
7,193 BRYANT & IVINSON. Electrical apparatus for medical and other purposes and articles to which such apparatus may be applied.
7,230 B.T.-H. CO. (G.E. Co., U.S.) Systems of electric motor control.
7,408 HYDRAULIC ENGINEERING CO. & ELLINGTON. Electric capstans.
7,424 STONE & CO. & DARKER. Secondary batteries.

COMPANIES' MEETINGS AND REPORTS.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—At the meeting last week Mr. E. Boulnois stated that the principal item included in the expenditure of 1909 (£42,500) was for extensions of mains. The total length of mains at the end of 1909 was nearly 255 miles. The demand for current for power had increased considerably. In view of the demand in the northern district of Calcutta it was imperative that the company should take steps to supply current, particularly as jute mill owners were considering a proposal to combine and establish their own plant. Mr. B. M. Jenkin (their consulting engineer) approved the proposal to erect a new station, but thought it advisable to carry out the work gradually. The question of lighting the streets electrically had been further considered by the municipality, and it was understood they had decided, as an experiment, to light 6 miles of streets in that way.

CALLENDER'S CABLE & CONSTRUCTION CO. (LTD.)—Mr. Hy. Drake, who presided at the meeting last week, said the value of the business done by the company during 1909 showed a considerable reduction compared with that of recent years. The results, however, could not be considered other than satisfactory.

Mr. T. O. CALLENDER (managing director) said 1909 was a year full of trouble and disappointment. It had been a period of the greatest possible trial to the management and to the board to get such a result as they had obtained. Various causes brought that about. Probably the first was the metal filament lamp, but they were beginning to find the advantage of that lamp, and it was really going to do them, as cable makers, all the good that they anticipated. Then, again, there had been an absolute want of confidence throughout the country which had hit them very hard. No one who had money was prepared to sink it in lighting schemes, tramways, or any companies using electricity, these having, unfortunately, been the prey of a good many people during many years past, with the result that no new enterprises were started and the business to be done was simply the extension of existing mains.

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Things were better now than in 1909. They had already experienced a distinct improvement in the demand for cables, both at home and abroad. Their German company had been quite satisfactory. After due consideration it had been thought advisable to extend further the scope of the trade of the company by pushing a purely engineering business.

CAPE TOWN CONSOLIDATED TRAMWAYS & LAND CO. (LTD.)—The accounts show a debit balance of £941. 9s. 7d. for 1909, which, added to £1,228. 6s. 6d. brought forward, makes a total debit of £2,169. 16s. 1d. The Camps Bay tramways have worked at a loss of £1,559. 13s. 4d., a slightly improved result compared with 1908, which showed a loss of £2,232. 11s. 3d.

CITY OF BIRMINGHAM TRAMWAYS CO. (LTD.)—At the meeting last week Mr. E. Garcke said the position of the company might be described as unique. Notwithstanding that their lines were being gradually taken over by the local authorities, and that they were exposed to increasing competition from municipal tramways, their traffic receipts increased and their net profits showed an improvement compared with 1908. The total receipts were £172,031, against £164,607, and the net profit (after paying interest and preference dividend) was £38,516, compared with £35,977. They proposed to declare a dividend of 5 per cent. on the ordinary shares and a bonus of 5 per cent., making 10 per cent for the year.

DEUTSCH-UBERSEEISCHE ELEKTRIZITATS (A.-G.)—The directors' report for 1909 states that the share capital was raised from 72,000,000 marks (£3,600,000) to 80,000,000 marks (£4,000,000), and the debenture stock from 15,000,000 marks (£700,000) to 70,000,000 marks (£3,500,000). It is proposed to further increase the capital by 10,000,000 marks. The gross profit for the year was increased from 15,077,900 marks (£753,895) to 17,631,200 marks (£881,560) and the net profit from 7,648,100 marks (£382,400) to 8,113,500 marks (£405,600). The dividend, which has been 9½ per cent. since 1906, is raised to 10 per cent.

FIFE TRAMWAY, LIGHT & POWER CO. (LTD.)—At the meeting on Monday the chairman (Mr. Wm. Low) said that with little over half their tramways running for less than two months, the earnings were such that the Tramway Company was able to pay a dividend to that company amounting to £1,111. 2s. 8d. The contractors (Messrs. Balfour, Beatty & Co.) were entitled to the thanks of the shareholders for the satisfactory result attained. Their company had agreed to acquire all the shares of the Fife Electric Power Co. The directors were satisfied with the position of the Power Company's business, and they felt sure that it would make a substantial contribution to their revenue this year. The Power Company's plant at Townhill had been largely extended, and overhead transmission lines and underground cables were laid to enable it to cope with the tramway and other additional business. Sub-stations have been built at Cowdenbeath and Lochgelly, and coupled up to supply cables so as to conveniently supply Cowdenbeath and Lochgelly. The Parliamentary powers they had sought were likely to be granted. The Fife Electric Power Co. had made an arrangement with the Wemyss Tramways Co. whereby the latter was to take from the Power Company the whole of its supply of electricity, both for the existing Wemyss tramways and for any extensions that might be constructed.

IMPERIAL TRAMWAYS CO. (LTD.)—The directors' report for 1909 states that the gross receipts of the Middlesbrough, Stockton and Thornaby electric tramways amounted to £49,670. 3s. 10d., compared with £50,904. 19s. 8d. for the previous year. The number of passengers carried was 9,834,213, against 10,014,056. The net profit was £16,142. 1s 2d., compared with £16,871. 14s. The directors regret that by the non-receipt of income from their investment in the London United Tramways the Imperial Co.'s revenue account suffered depletion to the extent of £21,111, and that they are consequently precluded from recommending any dividend on the company's preference and ordinary shares. The net revenue account for the year shows an available amount of £16,747. 1s, and after payment of debenture interest for the year (£12,740. 12s. 6d.) there remains £4,006. 8s. 6d., which the directors consider it expedient should be carried forward.

KALGOORLIE ELECTRIC POWER & LIGHTING CORPN. (LTD.)—Owing to the destruction by fire of the greater part of the machinery of the Great Boulder Proseverance Gold Mining Co. (one of the corporation's largest consumers), the demand for power was not so large as in 1908, and the increased cost of fuel and water, also a reduction in the maximum price received for power, together with the extra expense incurred in handling the firewood in consequence of wood strikes, considerably reduced the profits of the trading for 1909. The preference dividend has been paid, and £4,000 placed to reserve for depreciation and renewals. In view of the larger amount of power required by the Great Boulder Perseverance Co. for their new plant, to put the corporation into a position to supply additional power under other contracts and maintain the usual standard of reserve orders have been placed for another unit of plant.

POTTERIES ELECTRIC TRACTION CO. (LTD.)—Total receipts for 1909 were £108,182. 3s. 6d. Traffic receipts (£91,931. 14s. 1d.) show a decrease of £398. 13s. 8d., and working expenses a decrease of £5,136.7s. 2d. Deducting expenses (including £12,157. 13s. 10d. for interest), there remains £26,169. 15s. 8d., or, with £1,121. 3s. 11d. brought forward, £27,290. 19s. 7d., compared with £21,780. 18s. 6d. The directors recommend that £2,000 be placed to reserve for depreciation, £7,000 to general renewals account, and, after paying the preference dividend (£12,250), a dividend of 2 per cent. on the ordinary shares (4,900). £1,050. 19s. 3d. is carried forward. During the year £8,996 was expended on the improvement, renewal and repair of the permanent way, of which £5,406 was charged against revenue and £3,590 to general renewals account. Further important work is in contemplation for the improvement of the permanent way, and additional provision for this purpose out of the year's profits is recommended.

TYPEWRITING TELEGRAPH CORPN. (LTD.)—The report for the 13 months ended Dec. 31 last states that the balance to debit and profit and loss account has been increased by £321. 13s. 9d. The corporation has not been in a position to pay debenture interest since June, 1907, and the directors regret that they are obliged to recommend the shareholders to pass a resolution for the liquidation of the company.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

"CEDES" ELECTRIC TRACTION (LTD.) (109,698.)—Reg. May 18, capital £2,000 in £1 shares, to carry on the business of electricians, electrical engineers, manufacturers of and dealers in motors, carriages, tramcars, locomotives, &c. Private company. Reg. office, 15, Cockspur-street, London, S.W.

ELECTRO CHLORINATION SYND. (LTD.) (109,699.)—Reg. May 18, capital £50,000 in 48,000 preferred ordinary shares of £1 each and 40,000 deferred ordinary shares of 1s. each, to acquire and lay down a working plant for the reduction of ores and the refinement of metals by new processes in chlorination and electrolysis, to carry on the business of miners, smelters, metal workers, &c., and to adopt an agreement with H. W. Couzens. Reg. office, 39, Victoria-street, Westminster, S.W.

MORTGAGES AND CHARGES.

GELL TELEGRAPHIC APPLIANCES SYND. (LTD.)—Mortgage, dated April 29, to secure £1,600, charged on certain patents and inventions and the syndicate's general assets. Holders. C. M. Gonne, Mrs. J. Gonne and H. Gonne.

LANCASHIRE DYNAMO & MOTOR CO (LTD.)—Issue on March 21 of £100 debentures, part of a series of which particulars have already been filed.

NORTHWOOD ELECTRIC LIGHT & POWER CO. (LTD.)—Particulars of £5,000 debentures, created April 6, have been filed, the amount of present issue being £1,725. Property charged, company's undertaking and property. No trustees.

CITY NOTES.

MEMORANDA (May 26).—**Bank rate 4 per cent. (since March 17, 1910). Price of silver,** 24⅛d. per oz. Consols 82⅛—82⅜ for money and for account. **Consols Pay Day, June 1; Stock and Shares Continuation Days, June 8 and 27; Ticket Days, June 9 and 28; Pay Days, May 27 and June 10; Mining Shares Carry Over Day, June 7.**

PRICES OF METALS (London).—*Copper*, cash, 55⅞; three months, 57⅛. *Lead*, English, 12⅜—13⅛; foreign, cash, 12⅛; three months, 12⅝. *Spelter*, 22. *Tin*, English, 149½—151½; foreign cash, 150⅝; three months, 151⅞. *Iron*, Cleveland, cash, 49/10½, and three months, 50/9½

COMPANIES STRUCK OFF THE REGISTER.—The following were struck off the Register of Joint Stock Companies on May 24:—

Automatic Telephone Co. (1903), British Electric Separating Co. (reg. April 20, 1904), Carbon (New) Synd., "Everyday Electricity" Publishing Co., Garcin Renault Electric Cars & Accumulators, Kryptol Synd., Northern Electrical Supply Stores, Reliance Electric Co.

HINDHEAD & DISTRICT ELECTRIC LIGHT CO. (LTD.)—At the meeting last week a balance dividend was declared at the rate of 6 per cent., making 5½ per cent. for 1909.

METROPOLITAN DISTRICT RAILWAY CO—The following changes have been made consequent upon Sir George Gibb's appointment as chairman of the Road Board: Mr. Albert H. Stanley has been elected a director and appointed managing director; Mr. J. Carter, late secretary, becomes assistant to the managing director; and Mr. W. E. Mandelick, secretary of the Underground Electric Railways Co. of London and of the Allied Tube Railways, has also been appointed secretary of the District Railway.

SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)—The accounts for the 18 months to Dec. 31 last show a loss of £949, before making provision for depreciation.

SOUTH STAFFORDSHIRE TRAMWAYS (LESSEE) CO. (LTD.)—The accounts for 1909 show, after providing for debenture and loan interest, a loss of £1,493, converting the credit balance brought forward into a debit of £986.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed June 10 a special settling day in and have granted a quotation to a further issue of £2,500,000 4½ per cent. first and general mortgage 30-year bonds (London issue) of the *New York Telephone Co.* Quotations have also been granted to 70,000 £5 fully-paid ordinary and 14,000 £5 fully-paid 6 per cent. cumulative preference shares and £700,000 5 per cent. first debenture stock of the *Para Electric Railways & Lighting Co. (Ltd.)*. The committee have been asked to appoint special settling days in and grant quotations to scrip for £250,000 5 per cent. debenture stock of the *Metropolitan Electric Tramways (Ltd.)* and scrip, fully and partly paid, for £250,000 5 per cent. first mortgage debentures of the *Vera Cruz Electric Light, Power & Traction Co. (Ltd.)*.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	May 13	213	− 9	19	4,101	+ 83
Anglo-Argentine	„ 20	43,650	+ 4,863	20	876,502	+ 88,069
Ayr Corporation	„ 21	269	− 5	1	269	− 5
Baker St. & Waterloo Ry.	„ 21	3,795	+ 715	20	68,895	+ 2,105
Barnsley	„ 13	170	..	19	3,239	+ 132
Barrow	„ 13	253	+ 37	19	4,354	+ 448
Bath Electric Trams, Ltd.	„ 18	1,161	+ 161	20	14,571	+ 1,307
Birmingham Corporation	„ 21	7,706	+ 1,227	7	49,632	+ 621
Birmingham & Midland	„ 6	841	+ 44	18	14,580	+ 279
Blackburn Corporation	„ 15	1,385	+ 352	‡8	8,398	− 593
Blackpool and Fleetwood	„ 21	1,352	+ 966	..	..	..
Bolton Corporation	„ 22	2,890	+ 520	8	17,378	− 1,164
Bombay	April 21	2,789	+ 215	16	44,085	+ 2,950
Bournemouth Corporation	May 18	2,142	+ 644	7	11,286	− 604
Bradford Corporation	„ 21	6,461	+ 1,627	8	36,852	+ 445
Brighton Corporation	„ 22	1,253	+ 358	§7	6,631	− 282
Bristol Trams & Carriage	„ 20	7,967	+ 2,530	20	112,112	+ 12,652
Burnley Corporation	„ 21	1,567	+ 336	20	25,517	+ 888
Burton Corporation	„ 22	327	+ 66	§7	1,955	+ 22
Bury Corporation	„ 22	1,516	+ 358	§7	8,662	− 517
Calcutta Tramways Co.	„ 21	₹49,520	+ ₹1,948	20	₹1,010,250	+ ₹36,356
Camborne-Redruth	„ 21	177	+ 62	20	2,399	− 7
Cardiff Corporation	„ 14	2,107	+ 76	7	13,237	− 634
Cavehill	„ 13	71	− 36	19	1,380	+ 96
Central London Railway	„ 21	6,737	+ 971	20	111,855	+ 1,945
Charing C., Euston & H'stead	„ 21	4,840	+ 1,005	20	77,335	+ 320
Chatham & Dist. Lt. Rys.	„ 19	1,068	+ 317	20	15,507	+ 815
City & South London Rly.	„ 22	3,031	+ 78	20	65,372	+ 46
City of Birmingham	„ 13	2,755	− 34	19	53,337	+ 2,687
Colchester Corporation	„ 18	259	+ 105	20	3,322	+ 550
Cork Electric Trams Co.	„ 19	557	+ 243	20	8,931	+ 1,489
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	„ 13	376	+ 19	19	7,641	+ 761
Dover Corporation	„ 21	270	+ 70	7	1,427	− 13
Dublin & Lucan Railway	„ 20	205	+ 59	20	2,439	+ 76
Dublin United	„ 20	6,197	+ 951	20	103,082	+ 3,945
Dudley-Stourbridge	„ 13	678	− 93	19	13,348	− 564
Dundee Corporation	„ 15	702	− 7	†52	61,233	− 635
East Ham Council	„ 21	1,027	+ 330	¶7	7,532	+ 189
Exeter Corporation	„ 20	403	+ 102	7	2,210	− 103
Gateshead & Dist. Trams	„ 13	952	− 36	19	18,065	− 303
Glasgow Corporation	„ 21	19,500	+ 1,181	‡51	868,138	+ 5,389
Glossop Trams	„ 21	129	+ 7	20	2,216	− 119
Gloucester Corpn.	„ 18	355	+ 102	7	1,892	+ 67
Gravesend-Northfleet	„ 13	178	− 18	19	3,551	+ 89
Great Northern & City Rly.	„ 21	1,304	− 59	20	29,906	− 413
Gt. Northern, Piccadilly, &c.	„ 21	6,940	+ 1,370	20	121,790	+ 6,030
Greenock & Port Glasgow	„ 13	613	+ 45	19	10,382	+ 1,351
Hartlepool Tramways	„ 13	226	+ 11	19	3,992	+ 179
Hastings Elec. Trams Co.	„ 19	1,314	+ 446	20	16,728	+ 654
Hong Kong	„ 21	$8,994	+ $1,455	20	$172,456	+ $16,109
Huddersfield Corpn.	„ 21	2,168	+ 550	7	12,847	+ 815
Hull Corporation	„ 21	2,975	+ 645	7	19,464	+ 1,020
Ilford District Council	„ 24	781	+ 274	7	3,836	+ 162
Ilkeston District Council	„ 18	165	+ 47	7	859	− 42
Ipswich Corporation	„ 21	555	+ 185	7	2,793	+ 126
Isle of Thanet Co.	„ 21	776	+ 302	†32	10,715	+ 483
Jarrow	„ 13	118	+ 1	19	2,122	+ 106
Keighley Corporation	„ 19	237	+ 74	7	1,211	+ 37
Kidderminster & District	„ 13	80	− 17	19	1,637	+ 23
Kilmarnock Corporation	„ 21	162	+ 5	1	151	− 6
Lanarkshire Trams Co.	„ 19	1,493	+ 239	20	26,822	+ 2,805
Lancashire United	„ 18	1,489	+ 213	19	24,678	+ 17
*Leamington	„ 13	131	− 35	19	2,712	− 96
Leeds Corporation	„ 21	8,572	+ 884	7	51,176	+ 3,016
Leicester Corporation	„ 21	2,904	+ 641	..	..	..
Leith Corporation	„ 21	605	− 21	1	538	− 88
Lincoln Corporation	„ 21	159	+ 34	8	907	+ 44
Liverpool Corporation	„ 14	10,879	+ 248	19	204,277	+ 4,950
Liverpool Overhead Rly.	„ 22	1,627	+ 303	21	27,965	+ 735
Llandudno&ColwynBayRy.	„ 20	440	+ 253	§24	3,818	+ 364
*London County Council	„ 7	40,802	+ 5,407	¶5	213,703	+ 23,837
London United	„ 21	10,174	+ 3,372	20	118,283	+ 9,777
Lowestoft	„ 21	208	+ 44	34	5,068	+ 386
Maidstone Corporation	„ 21	249	+ 71	7	1,238	− 123
Manchester Corporation	„ 21	17,093	+ 2,114	7	110,466	+ 1,302
Mersey Railway	„ 21	2,079	+ 165	20	40,471	+ 1,096
Merthyr	„ 13	188	− 15	19	3,609	− 230
Metropolitan Dist. Railway	„ 21	12,485	+ 2,475	20	218,254	+ 22,520
Metropolitan Elec. Trams	„ 13	6,831	+ 573	19	129,422	+ 23,262
Middleton	„ 13	283	− 74	19	5,295	− 554
Nelson Corporation	„ 21	185	+ 50	§7	1,042	− 20
Newcastle-on-Tyne Corp.	„ 21	3,930	+ 190	¶7	27,609	− 1,452
Newport (Mon.)	„ 21	900	+ 261	21	5,436	+ 273
Northampton Corporation	„ 20	733	+ 231	7	3,489	+ 21
Oldham, Ashton & Hyde	„ 13	520	− 55	19	10,022	− 194
Oldham Corporation	„ 22	2,090	+ 190	7	15,518	− 1,009
Perth (N.B.) Corporation	„ 15	94	+ 20	§52	8,076	+ 113
Perth (W.A.) Elec. Trams	„ 20	1,477	+ 103	20	31,395	+ 2,287
Peterborough	„ 13	112	+ 4	19	1,902	− 32
Portsmouth Corporation	„ 21	2,437	+ 590	7	13,687	− 900
Potteries	„ 13	1,707	− 60	19	32,687	− 230
Preston Corporation	..	..	..	..	..	..
Rotherham Corporation	„ 19	800	+ 213	7	4,358	+ 94
Rothesay	„ 13	89	− 16	19	1,420	− 36
Salford Corporation	„ 23	5,693	+ 1,145	†8	34,974	+ 506
Sheerness	„ 13	43	− 2	19	807	− 16
Sheffield Corporation	„ 22	6,732	+ 1,105	¶8	49,903	+ 3,510
Singapore Trams	„ 21	$9,647	+ $246	20	$200,062	+ $4,966
South Metropolitan	„ 13	723	− 63	19	13,944	+ 648
South Staffs	„ 13	790	− 23	19	15,197	− 140
Southend Corporation	„ 18	732	+ 350	7	3,253	+ 239
Southport Tramways	„ 14	255	− 31	19	4,610	+ 74
Stalyb'dge, Hyde, &c., Jt. Bd.	„ 21	990	+ 245	¶7	5,010	− 857
Sunderland Corporation	„ 22	1,332	+ 229	8	8,070	− 267
Sunderland District	„ 18	551	+ 141	29	11,970	− 813
Swansea Trams	„ 13	1,025	+ 64	19	18,719	+ 2,007
Swindon Corporation	„ 18	170	+ 51	..	..	..
Taunton	„ 13	35	+ 3	19	750	+ 92
Tynemouth and District	„ 13	170	− 6	19	2,986	+ 229
Tyneside Trams Co.	„ 18	539	+ 144	20	7,757	− 213
Wallasey District Council	„ 21	1,169	+ 265	§7	6,553	− 329
Walsall Corporation	„ 21	719	+ 232	20	10,737	+ 748
Warrington Corporation	„ 19	421	+ 66	7	2,659	+ 57
West Ham Corporation	„ 12	2,296	− 14	6	13,819	− 421
Weston-super-Mare	„ 13	62	− 45	19	853	− 84
Wolverhampton Co.	„ 13	388	− 15	19	7,597	+ 133
Wolverhampton Corpn.	„ 18	1,275	+ 553	7	6,355	+ 817
*Worcester	„ 13	240	− 34	19	4,628	+ 21
Wrexham	„ 13	87	− 8	19	1,756	+ 2
Yorkshire W.R. Trams	„ 22	1,876	+ 758	21	25,908	..
Yorkshire Woollen District	„ 13	938	+ 29	19	17,830	+ 1,716

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name	Price Wed., May 25	Rate per cent. Yielded.	Dividend Due.	Business 8 Days to May 25. High-est.	Business 8 Days to May 25. Low-est.
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9½	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½—9¾	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	9½—10¼	5 16 0	Feb, Aug	10¼	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7¾—7¾	6 7 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7 —7¼	4 13 0	Mar, Sept	..	..
St.	4%	Charing Cross (W. End & City) El. Sup. Co.	100 —103	3 17 9	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¼—4¼	5 18 6	Feb, Aug	3⅛	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4¾	4 17 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —100	4 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101⅛—103½	4 7 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¼—4¼	5 3 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3¾—4¼	5 9 6	March	3⅞	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	102	..
10	9/0	City of London Electric Lighting Ord.	11¼—11⅝	5 18 0	Feb, Aug	11⅞	..
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	12⅛	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	124	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 —103	4 7 6	Jan, July	..	..
5	5%	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7⅛—8	6 0 0	Feb, Aug	7⅝	7⅝
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾—11⅛	5 5 0	Mar, Sept	11⅛	11⅛
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103 —106	4 5 0	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	98 —101	4 9 0	May, Nov	100½	99½
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4¾	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	5⅜	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7½	5 6 8	Feb, Aug	7	..
5	6%	Do. 6 per Cent. 1st Pref	5¾—6¼	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94¾—96½	4 3 6	..	..	..
St.	4%	Kensington & Knghtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —99	4 1 0	April, Oct	98½	98
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅝—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4¼—5¼	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	92 —94	4 4 0	Jan, July	94	93
5	2/6	Metropolitan Electric Sup. Ord.	3¼—4¼	5 6 0	April, Oct	4	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¼—4¾	4 12 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	97 —99	4 11 0	June, Dec	..	..
5	4/0	Newcastle Elec. Supply Ord.	4¼—4¾	4 5 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾—4¾	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	99 —101	4 19 0	..	..	..
10	9/0	Notting Hill Electric Ord.	11¾—12¼	5 17 6	March	..	..
5	4/6	Oxford Electric Ord.	6¾—7	5 0 0	March	6¾	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8¼—9	5 11 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¼—7¼	4 16 9	Feb, Aug	7⅛	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	85 —88	3 19 6	Jan, July	87½	..
5	..	Smithfield Markets Electric Sup. Ord.	1¼—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3¼	6 11 0	April	..	..
St.	5%	Do. 5 % 1st Mort. Stock (red.)	101 —104	4 16 0	..	103	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—¼	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	1	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	99½	98½
5	2/6	Urban Electric Supply Ord.	¼—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	7¾—8¼	5 17 0	Mar, Sept	8¼	7¾
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5¼	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97½	96½
1	..	Bath Elec. Trams Pref. Ord.	⅜—⅝	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	6 13 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock	83 —86	5 5 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6¼—7	8 11 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7¼—7½	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅞—1⅛	..	June, Dec	..	..
10	3%	Do. 6 per Cent. Cum. Pref.	3¼—3½	8 0 0	Feb, Aug	3¼	3¼
St.	5%	Do. 5 Cent. Perpetual Debs.	90 —93	5 7 6	April, Oct	91½	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	66 —71	6 7 0	May, Nov	68½	67½
St.	3%	Central London Ordinary Stock	71 —73	5 3 6	Feb, Aug	72	..
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	86½	..
St.	2½%	Do. Deferred Stock	53 —55	3 12 0	Feb.	—	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	96 —98	4 2 0	Jan, July	96	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	33 —34	3 12 0	Feb, Aug	35¼	34
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	98 —100	4 0 0	May, Nov	99	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	8½	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 —98	4 2 0	Jan, July	97	96
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1½	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3¼—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	70 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅜—1⅝	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9¼—10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2¼—2½	..	Jan, July	2¼	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	68 —72	5 11 0	Jan, July	70½	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅞—1	..	..	..	..
1	..	Do. Deferred	⅝—¾	..	April	⅞	..
1	0/6	Do. 5 per Cent. Cum. Pref.	¾—⅞	5 11 6	Feb, Aug	¾	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 —100	5 0 0	Jan, July	98½	..
St.	1%	Metropolitan Railway Consolidated	44 —44½	2 5 0	Feb, Aug	45	44½
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	67½	66
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90½	89
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	87½	86½
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87½	86½
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	93½	92½

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Wed., May 25	Rate per cent. Yielded.	Dividend Due.	Business 8 Days to May 25. High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	91 —93	3 15 0	Jan, July	91½	..
St.	..	Metropolitan District Railway Ord.....	24 —24½	..	Feb, Aug	24⅜	24⅛
St.	..	Do. Extension Pref. (5 per Cent.).....	69 —71	..	Feb, Aug	69⅜	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	..	..
St.	3%	Do. 3 per Cent. Consolid. Rent-charge	75 —77	3 18 0	Jan, July	75½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.....	101 —103	3 17 0	Mar, Sept	..	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	142 —144	4 3 3	Jan, July	143½	142
St.	4%	Do. 4 per Cent. Ditto.....	96 —98	4 1 0	Jan, July	97⅛	..
1	..	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅛—⅜	6 14 0	Feb, Aug	⅛	..
..	5%	Do. 5% Prior Lien Bonds.....	100½—101½	4 18 6	..	101⅜	101
..	4½%	Do. 4½% Bonds with coup. 5	89 —91	4 19 0	..	90½	89
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	97 —99	4 1 0	..	98¼	98⅜
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	⅛—⅜	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	78 —81	5 11 0	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101½—103½	4 7 6	..	..	..
1	..	Aron Electricity Meter Ord.....	⅛—⅜	..	..	..	..
1	7½d.	Do. 6% Cum. Pf.	⅜—⅝	6 8 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.....	5⅛—5⅜	3 14 3	April, Oct	5⅞	5⅛
1	0/7½	Do Pref.....	1⅞—1⅞	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7	7 3 0	July, Feb	6⅜	..
5	3/0	Do. 6 per Cent. Pref.....	5½—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	⅜—⅝	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	98 —100	6 0 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	58 —61	6 11 0	Jan, July	60¼	59½
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	25 —29	15 10 0	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.....	9½—10½	6 3 0	Jan, July	10⅛	9⅞
5	2/6	Do. 5 per Cent. Cum. Pref.....	5⅜—5⅝	4 11 0	Jan, July	5⅝	5⅜
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	102½—104½	4 6 0	Nov, May	..	..
1	1/9½	Castner-Kellner Alkali Co.....	2¼—2⅝	5 3 9	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	104 —107	4 4 0	Feb, Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	1	..
1	0/7½	Consolidated Electrical Co.....	⅜—½	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	⅜—½	7 0 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	⅜—½	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	⅜—⅝	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅝—1⅛	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	⅛—1⅛	5 13 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	½ —1½	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅛—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—1⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)..	74 —77	5 16 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅛—⅜	..	Jan, July	..	..
2	2/9⅓	Do. 7 per Cent. Cum. Pref.....	1⅛—1⅜	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	61 —66	6 1 0	Jan, July	61⅛	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7½—8½	6 1 6	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅞—12⅝	6 6 6	Feb, Aug	12⅛	11⅞
5	2/3	Do. 4½ per Cent. Pref.	5 —5⅛	4 3 9	Feb, Aug	5	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 3 6	Mar, Sept	106¼	..
10	15/0	India Rubber, Gut. Per., &c., Works....	14½—15½	6 9 0	Feb, Aug	15⅜	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10½—10⅝	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April, Oct	97	..
1	..	National Elec. Construction Co.....	⅛—⅜	..	April ..	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅝—⅞	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅝—⅞	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5⅛	..	..	..	..
12	30/0	Telegraph Construction & Maintenance..	32½—34½	5 17 0	Mar, July	34⅛	33
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100½—102½	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 11 0	..	2⅛	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅝—1⅞	4 4 3	..	1⅝	1⅝
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	108 —111	4 10 0	..	109½	..
St.	4%	†Do 4 per Cent. 1st Mort. Db. Sk. (red)	101 —103	3 7 6	June, Dec	102	101½
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 —107	4 4 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	105½—107¼	4 13 6	..	105¾	..
10	8%	J. G. White & Co. 6% Cum. Pref	9½—10½	7 12 0	..	..	..
1	..	Willans & Robinson Ord.....	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1⅞—2⅛	9 0 0	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	65	64
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3⅞	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100 —102	4 18 0	June, Dec	..	..
St.	15/0	Anglo-American	64 —66	5 11 0	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	104½—105½	5 15 0	F,My,Ag,N	102½	101⅛
St.	25/0	Do. Deferred	25½—25⅞	4 17 6	F,My,Ag,N	26⅛	21⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	85 —87	4 12 0	Jn.Ap,Jy,O	89¼	85½
10	6/0	Cuba Submarine Ord.....	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 12 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅛—3⅜	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	7⅞—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable.....	13½—13⅞	6 3 6	Ja,Ap,Jy,O	13⅜	..
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.).	100 —102	4 19 0	June, Dec	..	..
St.	65/0	†Eastern Ordinary .....xd and bonus	133 —136	5 3 6	Ja,My,Jy,O	135½	133
St.	17/6	†Do. 3½ per Cent. Pref. Stock.....	85 —87	4 0 6	Ja,My,Jy,O	86½	85½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	101 —103	3 17 6	May, Nov	..	..
St.	6/6	†Eastern Extension .....xd and bonus	12½—13½	5 7 6	Ja, Ap, Jy,O	13	12½
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	100⅛	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101½	3 18 6	May, Nov	99	..
10	26/0	G.N (of Copenhagen), with Coupon 79 ..	30½—31½	6 0 0	Jan, July	30⅞	..
100	4½%	Halifax & Bermuda 4½% 1st Mt.Db.(red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European	52½—54½	5 19 0	May, Nov	54½	..
100	$1¼	Mackay Companies Common	85 —91	4 18 6	Ja,Ap,Jy,O	..	..
100	$1	Do. Preference	77 —80	5 0 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛—⅜	..	April	⅛	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	98½—100½	3 19 6	June, Dec	..	..
2½	1/3	†West Coast of America	1¼—1½	4 0 0	May	..	..
100	4%	Do. 4 per Cent. Debs.....	98½—100½	3 19 6	Jan, July	99⅜	..
10	..	West India & Panama	¾—1	..	May, Nov	..	..
10	6/0	†Do. 6 per Cent. 1st Pref.	8½—9½	6 11 3	May, Nov	8⅝	8½
10	9/0	Do. 6% 2nd Pref. Ex 9/- on a/c of arrs	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.....	101 —103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph.....	13⅜—14½	4 18 0	Mr,Jn,O,D	13⅜	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	101 —103	3 17 6	June, Dec	101½	..
—	4%	Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	—	—	..

Share	Last Dividend	NAME.	Price Wed., May 25	Rate per cent. Yielded.	Dividend Due.	Business 8 Days to May 25. High-est.	Low-est.
		Telephones.		£ s. d.			
		Amer. Telephn. & Telegh. Cap. St.	140 —142	5 12 6	..	..	141 ..
		Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	..	..
		Do. 4% Cons. Bonds 1936	104 —105	3 14 6	..	..	..
		Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
		Chili Telephone	7⅛—8⅜	4 15 9	August ..	..	..
		Monte Video Telephone Ord.....	⅛—¼	7 0 0	Nov	..	..
		Do. 5 per Cent. Pref.	⅛—¼	5 14 6	May, Nov	..	..
		National Co. Pref. Stock.....	104 —105½	5 15 6	Feb, Aug	104½	..
		Do. Def. Stock	124 —126	4 15 0	Feb, Aug	124½	124
		Do. 6 per Cent. Cum. 1st Pref.....	10 —10⅜	5 10 6	Feb, Aug	10⅛	..
		Do. 6 per Cent. Cum. 2nd Pref.....	10 —10⅜	5 10 6	Feb, Aug	10⅛	..
		Do. 5 per Cent. non-Cum. 3rd Pref.....	5⅛—5⅜	4 11 0	Feb, Aug	5⅛	..
		Do. Deb. Stock 3½ per Cent. (red.)....	97 —99	3 11 0	June, Dec	98⅛	97½
		Do. 4 per Cent. Deb. Stock (red.).....	100 —102	3 18 0	Jan, July	100½	99
		New York Telephone Co. 30 yr. Bnds.....	98 —99	4 11 0	..	98½	97⅝
		Oriental	1⅛—1⅛	4 15 0	April, Oct	1⅛	..
		Do 6 per Cent. Cum. Pref.	1⅛—1⅛	4 11 0	April, Oct	1⅛	..
		Do. 4 per Cent. Red. Deb. Stock.....	87 —89	4 10 0	Jan, July	88½	..
		Telephone Co. of Egypt 4½%Db.Stk.(red.)	100½—102½	4 8 6	Jan, July	..	..
		United River Plate.....	7⅛—7⅜	5 9 0	July	7⅛	7⅛
		Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 11 0	June, Dec	5⅛	..
		Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan, July	..	..
		Financial, Investment, &c.					
		Elec. & Gen. Investment 6% Cum. Pref...	2⅞—3⅜	8 18 0	Jan, July	..	..
		Globe Telegraph & Trust	10⅛—11	5 9 0	Sp,DcMrJu	10⅛	10⅛
		Do. 6 per Cent. Pref.	13⅛—13⅝	4 8 0	Sp,DcMrJu	13⅛	..
		Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅜	5 5 0	April, Oct	4⅛	4⅛
		Do. 5% Cum. 2nd Pref.....	4⅞—4⅞	5 12 6	Jan, July	4⅞	4⅞
		Do. 4% Deb. Stock	90½—92	4 7 0	June, Dec	91½	90½
		Do. 4½% Deb. Stock	96 —98	4 12 0	..	97⅛	96½
		Auckland Elec. Trams. 5% Deb. (red.)....	105 —107	4 13 6	Jan, July	..	..
		Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	..	..
		Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 15 0	May, Nov	5⅛	..
		Do. 4½ per Cent. Db. Prov. Certs.....	101 —104	4 6 6	Jan, July	103⅛	102½
		British Columbia El.. Rly. Df. Ord.	142 —147	5 9 0	Mar, Sept	145⅛	145
		Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	124½	123⅞
		Do. 5% Cum. Perp. Pref. Stock.....	108 —111	4 10 0	Jan, July	109	108½
		Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
		Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
		Do. 4½% Perp. Con. Deb. St.	103 —105	4 0 0	..	104½	104⅛
		Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	..	..
		Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	96	..
		Calcutta Tramways (1 to 137,610).....	4⅛—4⅜	4 4 3	Mar, Sept	4⅛	..
		Do. 5 per Cent. Cum. Pref.	4⅞—5	5 0 0	Jan, July	..	..
		Do. 4½% 1st Deb. Stock (red).....	98 —101	4 9 0	Jan, July	..	..
		Cape Electric Tram Shares	⅛—⅜	..	..	..	..
		†City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 9 6	F,My,A,N	5⅛	5⅛
		Do. 4 per Cent. Deb. Stock.....	99 —101	3 19 0	June, Dec	..	..
		Colombo Tr. & Ltg. 5% 1st Mt. Db.....	94 —97	5 2 6	May, Nov	..	..
		Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	80 —83	6 0 9	June, Dec	..	..
		Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	95 —98	5 2 0	Feb, Aug	93	97½
		Kalgoorlie Elec. Trams Sh.	⅛—¼	..	..	..	..
		Do. 5 per Cent. "A" Deb. Stock.....	96 —93	5 2 0	Jan, July	..	..
		Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	..	..
		Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
		Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
		Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	88½	..
		Manaos Trams and Lt. Co. 5% Debs.	88 —89½	..	..	..	..
		Manila Elec. Ry. $1,000 Gold Bonds.....	95 —97	5 2 6	Feb, Aug	..	..
		Mexico Trams Co. Com. St.	130 —132	4 16 0	..	..	..
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	96 —97	5 2 6	..	96½	95½
		Do. 6% 50 yr. Mort. Bds.....	99⅛—100⅛	5 19 6	..	100⅛	99⅛
		Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	103	..
		Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	..	..
		Perth Elec. Trams Ord.	⅛—¼	5 14 0	May	..	..
		Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
		Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 2 6	..	..	..
		Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	..	..
		Ric Janeiro Tram. Lt. & P. Co.....	96 —98	4 2 0	..	97⅛	96⅛
		Do. 30 yr. Gold Bnds.	98 —99	5 1 0	..	98⅛	98⅛
		Do. 50 yr. Mt. Bnds	87 —88	5 13 9	..	87⅛	87
		Sao Paulo Tramway, Light & Power Co. $100 Stock	149 —151	6 13 6	..	..	..
		Do. 5 per Cent. 1st Mt. $500 Db.	102½—104½	4 15 6	June, Dec	103⅛	..
		Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
		Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5⅛—5⅜	5 2 0	Mar, Sept	..	..
		Bombay E.S. & T. 6% Cm. Pf.....	10½—11	5 9 0	..	..	..
		Do 4½ per Cent. Deb. Stk. (red).....	95 —97	4 12 6	Jan, July	..	..
		Do. 5 per Cent. 2nd Mort. Deb. Stock..	96 —98	4 18 0	..	..	..
		Calcutta Elec. Supply Ord.	6⅞—7⅛	5 11 6	April, Oct	6⅞	..
		Canadian Gen. Elec. Co. Com. St.....	109 —113	6 4 0	..	112⅛	111⅛
		Do. 7% Cm. Pf. Stock	118 —121	5 15 6	..	118½	..
		Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
		Elect. Development Co. of Ontario.....	82 —85	5 16 0	..	83⅛	..
		Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
		Indian Elec. Sup. & Trac. Co.	1⅛—1⅛	..	..	..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
		Do. 6 per Cent. Cum. Pref.	⅛—¼	8 0 0	April, Oct	..	..
		Kaministiquia Power Co.5% Gold Bnds..	102 —104	4 16 6	..	..	..
		Madras E. S. Corp. Ord.....	2⅜—3⅛	..	..	..	..
		Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	103	..
		Do. 5% 1st Mortg. Deb. Stock.....	92 —94	5 6 9	..	3⅛	3
		Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84⅛—85⅛%	5 17 6	..	85	..
		Mexican Lt. & Power Co. Com. St.	79 —81	4 18 0	..	80⅛	79⅜
		Do. 7% Cum. Pref. St.	103 —105	6 13 6	..	104	103
		Do. 5% 1st Mort. Gold Bnds.	89½—90½	5 12 0	..	90⅛	89½
		Montreal Lt. Ht. & Power Co. Cap. St.	136 —140	4 15 6	F,My,A,N	138⅛	..
		River Plate Electricity Co. Ord.	2⅛—2⅜	5 12 9	April	2⅛	2⅜
		Do. 6 per Cent. non-Cum. Pref.	1⅜—1⅜	5 4 0	May	..	..
		Do. 5 per Cent. Deb. Stock	103 —105	4 15 6	Jan, July	..	..
		Rosario Ele. Co. Ord.	8⅛—9	..	..	..	..
		Do. 6% Pref. (1-20,000)	6 —6⅛	4 12 0	April, Oct	..	..
		Do 2nd Pref.	8⅛—8⅜	6 14 6	..	..	..
		Shawinigan Water & Power Co.Ca.	101 —103	4 8 6	..	..	..
		Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	108	..
		†Do. 4½ Per Con. Mt. Db. St.	99½—101⅛	4 8 6	..	101⅛	100⅛
		Toronto Power Co. 4½% Db. St.	100 —102	4 8 6	..	..	..
		Victoria Falls Power Co. Pref.(1 to 808,000)	⅜—½	5 6 6	Jan, July	⅜	..
		Do. (803,081 to 1,709,000)	⅜—½	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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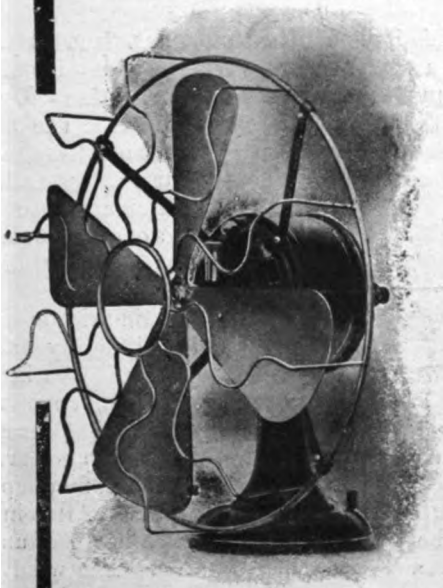

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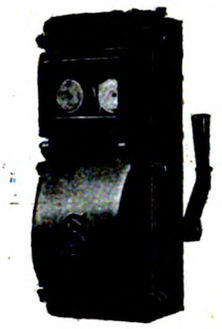

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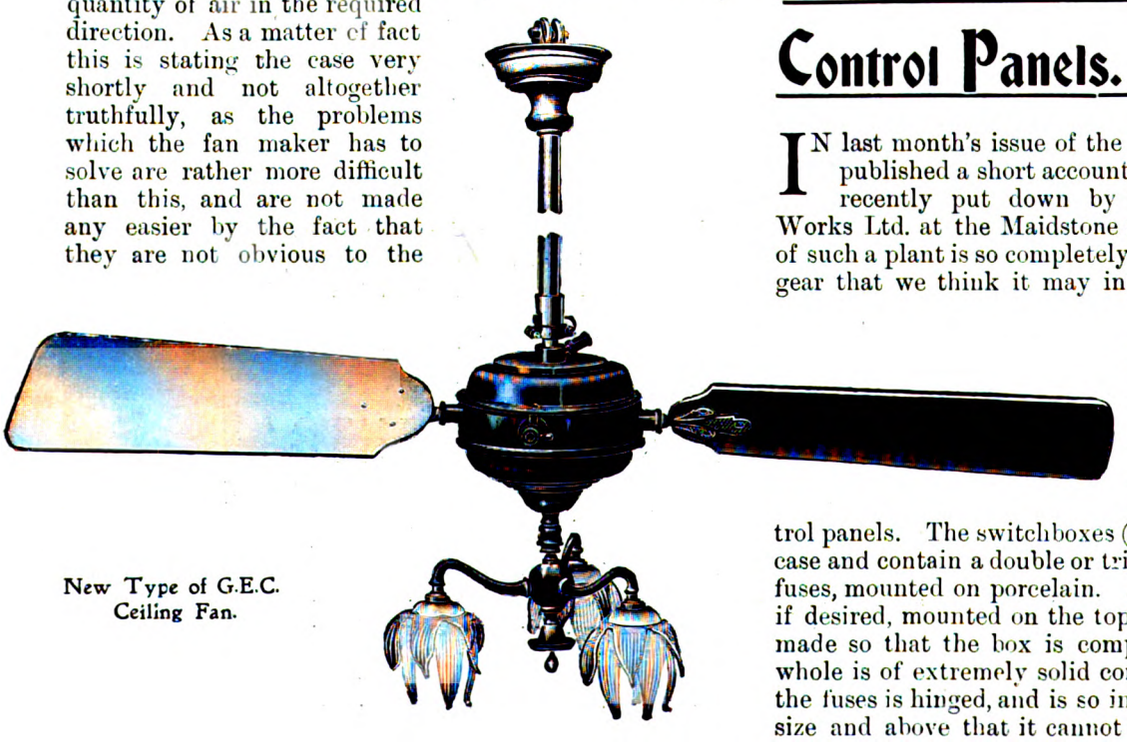
G.E.C. Fans.

AT first sight the problems which have to be faced by the fan designer would appear to be slight. It would seem that he has only to design a motor to run more or less continuously without overheating and so to arrange his blades that they distribute a certain quantity of air in the required direction. As a matter of fact this is stating the case very shortly and not altogether truthfully, as the problems which the fan maker has to solve are rather more difficult than this, and are not made any easier by the fact that they are not obvious to the casual observer. It is all very well to design fan blades which shall just churn up the air and give the false idea that they are doing something towards ventilating a room, but these revolving falsehoods are almost certainly, sooner or later, to be found out, with a result that is not likely to be pleasant to the firm that has supplied them.



New Type of G.E.C. Ceiling Fan.

The General Electric Co. have for some time been well-known makers of electric fans of all descriptons, from those suitable for standing on the desk or table and ventilating a small room to those for dealing with large quantities of air, such as are required for supplying mines and other places where no natural circulation is available. This experience is of great use to the General Electric Co., for while keeping in broad outline the same design of fans from year to year they are able to improve them in details in accordance with the demands of practice. In the accompanying illustration we show an alternating-current ceiling fan, which has been brought out this season for domestic purposes. A disadvantage, which has always attended the use of fans driven by alternating-current motors is the hum which is set up in the motor itself. To overcome this difficulty has always been the constant endeavour of fan manufacturers, and it is claimed that in this new fan the running is noiseless, and it is in fact the most silent-running alternating-current fan on the market. The lighting pendant, which is shown in the illustration, is, of course, not absolutely new as applied to fan design, but the combined fitting thus made up should have a wide sphere of usefulness. We are asked by the General Electric Co. to say that they would be pleased to show this fan in operation to any engineer calling at their show rooms in Queen Victoria-street.

The General Electric Co. have designed an electrically-driven punkah which, it is claimed, gives this flick which is so much to be desired. This is a distinct feature of the apparatus as against those placed on the market in the earlier days. It is interesting to note in this connection that a great economy in energy consumption is obtained by the use of this apparatus, which, it should be stated, is known as the "Bandy" punkah.

Switchboxes and Motor Control Panels. . . .

IN last month's issue of the Industrial Supplement we published a short account of the pumping installation recently put down by Siemens Brothers Dynamo Works Ltd. at the Maidstone sewage works. The success of such a plant is so completely dependent on the regulating gear that we think it may interest our readers to have a few particulars about some new lines of starters that this firm has recently brought out.

These comprise open, protected and totally enclosed starters, weatherproof switchboxes and motor control panels. The switchboxes (Fig. 1) consists of a cast-iron case and contain a double or triple-pole switch and cartridge fuses, mounted on porcelain. An ammeter can be supplied, if desired, mounted on the top of the case. All joints are made so that the box is completely weatherproof and the whole is of extremely solid construction. The window for the fuses is hinged, and is so interlocked in the 100-ampere size and above that it cannot be opened whilst the switch

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is closed, and, conversley the switch cannot be closed while the window is open. The fuses are of Messrs. Siemens' well-known "Zed" type, provided with an indicating device which shows at a glance when a fuse has blown. All live parts are completely enclosed, making it impossible to receive a shock accidentally when replacing a cartridge, and no arcing or flashing occurs when a fuse burns out.

The switch has a quick-break action and each pole is mounted on a seperate porcelain. The boxes are so

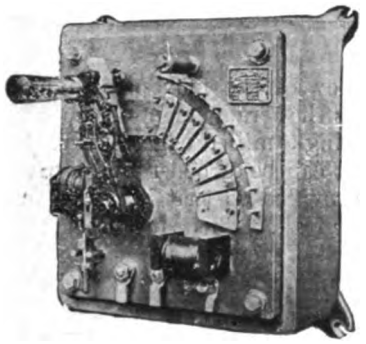

Fig. 1.—Open Type Starter with Step-by-Step Slow Motion Gear.

arranged that 2, 4 or 6 cables can be led into the box from above or below, except when an ammeter is used, in which case only two cables can be led in from the top. The boxes are stocked undrilled and are drilled to suit customers' requirements, and cable glands and packing can be supplied.

The motor starters are mounted on slate base; the contacts are renewable and of ample area and section; overload and no-voltage releases are fitted. The centre spindle is provided with a ratchet and the overload release with a pawl, and these two come into operation if the motor is switched on too rapidly and prevent further movement of the brush. A patent step-by-step slow motion gear can be fitted to these starters. In this gear the switch is moved

Fig. 2.—Weatherproof Switchbox with Ammeter.

Fig. 3.—Weatherproof Motor Control Panel.

sharply from one contact to the next, but retained at each step for a short time to enable the motor to come up to speed. The advantages of such a device as this scarcely need to be pointed out. This gear is shown in the illustration (Fig. 1).

The motor-control panels already mentioned (Fig. 3) are a combination of the switchbox and starter already described, mounted on a cast-iron pillar. They are specially constructed to withstand rough usage and bad weather.

Crompton Moving Coil Instruments.

THE question of instruments should not be without interest to the electrical engineer, for on their correctness depends the validity of all his results, both economical and technical. It will, therefore, not be inopportune to give some details of a series of instruments of the moving coil type made by Messrs. Crompton & Co. for continuous-current work.

As regards general design, it may be mentioned that great attention has been paid to standardisation. All the instruments can, it is claimed, be left in circuit continuously without heating and without affecting their accuracy. All volt indicators are designed to give either their normal or maximum reading with a current of 0·015 ampere, while in the case of ammeters a full scale reading is given when the P.D. across the instrument terminals is 0·075 volt. The indicating instruments of all voltmeters having external resistances are therefore interchangeable, and any ampere indicator can be used with any shunt. If, however, indicators are used with resistances or shunts of different rating, the scale readings must of course be multiplied by a constant.

This complete standardisation not only allows great economies to be effected in manufacture, but it also facilitates the subsequent verification of the instrument. Only one controlling spring is used, and this is entirely independent of the circuit. With regard to appearance, attention may be called to the absence of wide flanges on the back of all the instruments. This arrangement, it is

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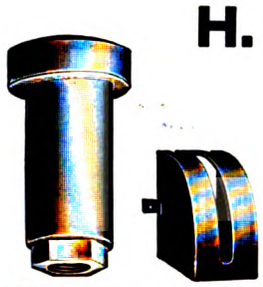

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claimed, enables longer effective scales to be used compared with the space occupied.

Electrically, the instrument consists of a horse-shoe permanent magnet with mild steel pole pieces. The pole pieces are constructed in a solid block with a pair of brass cheeks and are machined all over before being placed in the permanent magnet. The hole between the pole pieces is bored to receive the movement plug and the annular gap between the pole pieces and this core is the space in which the coil moves. The moving part consists of wire, wound on a copper former, and Fig. 1 shows the method of mounting it upon the magnet core. The parts GG are brass studs fixed in the core to centre it when placed in the pole piece block. The whole piece shown in this figure is termed 'the movement plug." The holes in the pole piece blocks, and the movement plugs, are made to gauge, so that each movement plug fits any magnet, these parts being mechanically interchangeable in all instruments.

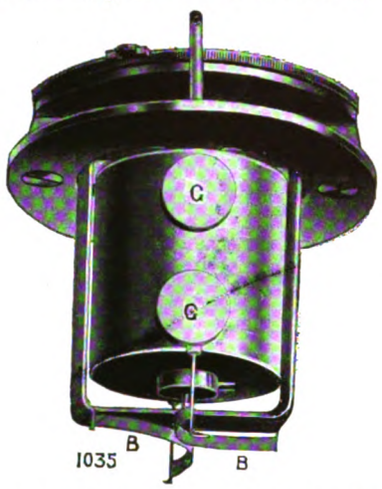

Fig. 1.—Method of Mounting Moving Coil.

Fig. 2 is a view of the movement plug seen from the front, and shows the arrangement of the controlling spring. The ring R, having a milled edge, is carried in a supporting bridge so that it can be turned round by hand. Two holes, HH, are also provided so that it can be turned by means of a pin key, or fork. This ring R carries a piece, T, to which is attached one end of the controlling spring. The zero of the instrument may be adjusted by turning the ring R in its seating. Every instrument of this class is fitted with a small detachable cover over the movement plug, by removing which any small regulation of the zero can be effected.

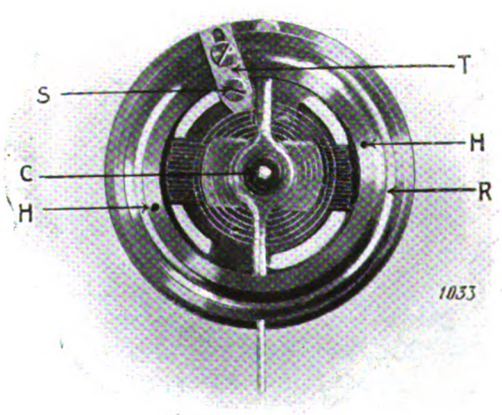

Fig. 2.—Movement Plug from the Front.

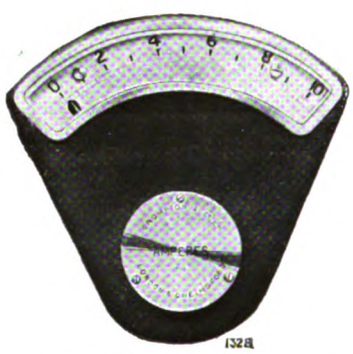

Fig. 3.—Sector Type Instrument.

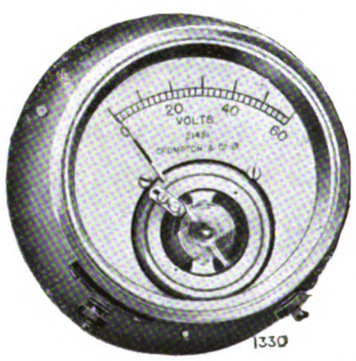

Fig. 4.—Flange Type Instrument.

Turning now to the instruments themselves, Fig. 3 shows those of the sector type, the scales being 5 in. long. They are intended principally for switchboard use, where there is not sufficient room for round instruments, or where a moving coil instrument at a somewhat lower price is required. They correspond to a 6 in. dial circular moving coil instrument, but occupy rather less space while having

Fig. 5.—Paralleling Voltmeter.

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a longer scale. Ammeters whose capacity exceeds 20 amperes are provided with external shunts, while below 150 volts the voltmeter and resistances are self-contained.

A very useful class of instrument, ammeter or voltmeter, is shown in Fig. 4. The scales are $2\frac{3}{4}$ in. long and they can be supplied either with a flange or cross-bar for fixing purposes.

Fig. 6 shows an instrument mounted in a sector-shaped case, the scale on the outer face being either 8 in. or 12 in.

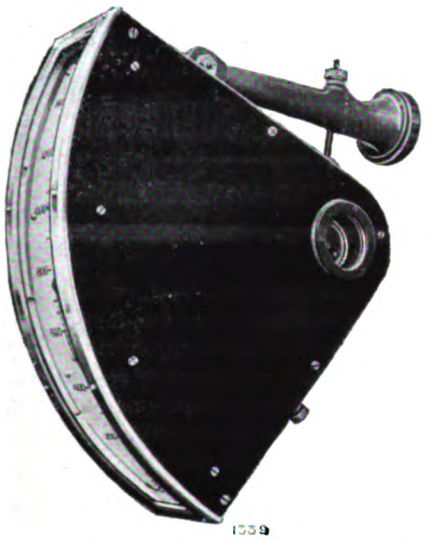

Fig. 6.—Sector Switchboard Instrument.

long. These instruments can be rigidly attached to a switchboard so that the scale is either horizontal or vertical.

Fig. 5 shows a type of instrument suitable for paralleling work. The instruments are arranged to stand the full voltage of the supply for which they are intended, and are fitted with a key so that the sensibility can be greatly increased when a balance of voltage is nearly obtained in the operation of paralleling.

Fig. 8 shows a leakage indicator for two wire circuits, which is arranged to give a continuous indication of

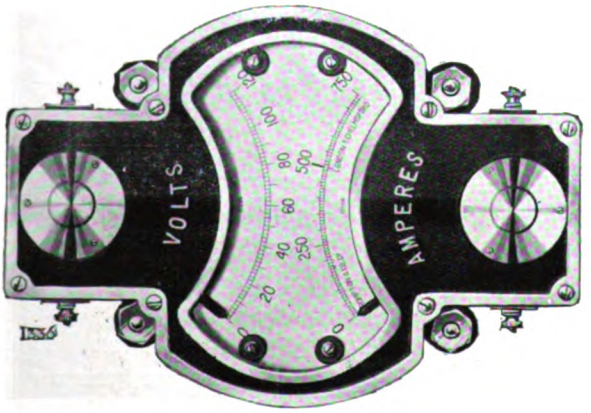

Fig. 7.—Combined Instrument for Motor Cars.

any inequality in the insulation resistance of the two mains, as required by the Board of Trade in certain installations. It also provides means of finding the actual insulation resistance of each main and the leakage current. The instrument is of the circular type and is used in connection with an external resistance. The resistance is coupled across the mains, and the indicating instrument is connected between the middle point of the resistance and earth. When coupled in this manner the indication of the pointer, and particularly any variation in the reading,

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shows the state of the insulation. The development of faults is usually preceded by unsteadiness in the readings, and the deflections of the pointer indicate by their direction in which of the mains the weakness lies. If the insulation resistance of both mains is equal, the deflection is nil, and the instrument gives no indication of the true insulation resistance. The insulation resistance of each main, however, can be separately measured, keys being provided on the instrument which allow it to be coupled in turn between each main and earth. Readings so obtained, when

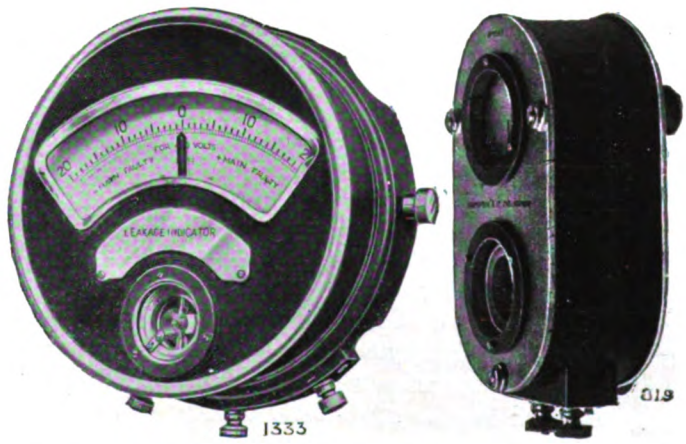

Fig. 8.—Leakage Indicator.

Fig. 9.—Instrument for verifying Ampere-Volt Indicators.

referred to a chart provided with the instrument, will give the insulation resistance. The leakage current can then be easily calculated, by dividing the voltage of the circuit by the sum of the insulation resistance of the positive and negative mains.

Fig. 7 shows an instrument which has been designed to meet the demand for a strong compact instrument for use on motor cars, launches, searchlights and other places where the available space is small. The cases are of stout cast aluminium, though cast iron can also be supplied.

An important point in connection with all electrical instruments is their correctness. The gauge shown in Fig. 9 has been designed to carry out zero and maximum reading tests. It is fitted with a moving coil movement, but has a single mark instead of a scale, and is so adjusted that the application of 0·075 volt at its terminals, or the passing of 0·015 ampere through it, deflects the pointer exactly to this mark. This instrument is so designed that it can be readily checked against a potentiometer or other standard, and is adjusted in a simple manner by turning the adjusting ring provided on the movement.

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ISSUED MONTHLY with "THE ELECTRICIAN"
Telegraphic Address: "ELECTRICIAN NEWSPAPER LONDON" Telephone No. 640 HOLBORN.

All communications should be addressed to the Editor, "The Electrician" Industrial Supplement, 1, 2 and 3, Salisbury Court, Fleet Street, London, E.C.

Copy for Text or Advertisement pages for next issue, publishing on **June 24th, 1910,** *should reach the above address by Tuesday,* **June 14th, 1910.**

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

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The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms ; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations ; to any firm of Merchants or Agents ; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings ; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

The Choice of a System. Anyone who is able to spend a few minutes in the consideration of THE ELECTRICIAN Annual Tables of Electricity Supply cannot help being struck with the varying systems which are at present used in this country. And he will doubtless also be struck by a feeling of mild wonderment as to why certain systems were chosen in certain particular cases. Why, for instance, two-phase high-tension current with sub-stations should have been selected as a fit and proper system to supply a small and congested area and why it was necessary to erect a single-phase station in a town inhabited mostly by power users. Such schemes are at best a living monument to the nearsightedness of those concerned, or, put another way, to an optimism which is scarcely likely to be justified.

In both of the more or less hypothetical cases mentioned above it would have been more economical and better engineering to instal continuous-current stations, at least, in the first instance. This has, it is true, often been done with success, but these stations are now faced with a problem which to a certain extent arises from the increasing use of metal filament lamps and the migration of the inhabitants of practically every city from the centre to the outskirts. The problem of how best to get over these difficulties is discussed by Mr. Wunder in a recent issue of the "Elektrotechnische Zeitschrift." He points out that in the case outlined above special stations would either have to be built for the supply of these districts or the present stations extended by the erection of single or three-phase generating plant. Taking 100,000 inhabitants as a basis for his calculations, the author finds it is considerably more economical to use polyphase than continuous current.

The cost of installation and current losses will in this case be about one-third less than with continuous current, while the saving in capital expenditure is also considerable. Mr. Wunder's article and results are a case of theory following after practice, and it is interesting to note that in this case at least, these two often opposing factors are in agreement. The excellent results obtained with this arrangement in many towns in this country, notably Manchester, fully bear out Mr. Wunder's theoretical investigations.

Coal Handling Problems. In the discussion on Mr. J. H. Rider's Paper read last year before the Institution of Electrical Engineers a variety of opinions were expressed on the relative advantages of waterside and "inland" stations. It is, of course, natural that every effort should be made to get the coal into the vicinity of the station as quickly as possible, but it is just as important, and should be just as natural, to ensure that the handling of coal within the station itself is effected as cheaply as possible. Present-day tendency is all towards economy, and by making certain that there is no waste of time or labour between wharf or cart, and bunkers, still more will be done towards a further reduction of working costs—a reduction which has been commenced by doing all that is humanly possible to prevent losses in the boilers and main steam pipes. Too often have we seen, and still, in fact, see, coal brought to a station in carts and then laboriously removed by hand to the bunkers instead of being mechanically handled far more quickly and in greater quantities than is possible by hand. It is true, that at many waterside or railside stations, especially the latter, arrangements are made for dealing mechanically with the fuel. Coal is tipped straight from the truck into special hoppers and fed into the boilers without being hand-touched. We feel that much more might be done, with advantage to all concerned, in this way at "inland" stations. The total annual cost, including fixed charges, of operating a small electrically-driven crane in a station consuming two or three thousand tons of coal per year should be easily less than the expense of handling by ordinary manual labour. The coal could be brought to the station in much larger units than would be possible under the old conditions and handled much more quickly. Power would be cheap and labour would be reduced to a minimum. Where the station is on the quayside some sort of telpher system can be conveniently employed. There is, of course, the financial side of the question to be considered, but even to those stations who are not able to spend a large amount of capital, the reduced working costs and thus the good return on the money paid out should specially appeal.

With coal in its commercial form a certain amount of waste is inevitable, but the less it is handled or moved from one receptacle to another the better. Each transfer from barge to cart, and cart to bunker, and bunker to boiler means a certain loss, and these should therefore be avoided as far as possible.

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Small Hydro-Electric Plants.

We are often told that the inhabitants of this country are greatly handicapped by the absence of water power. Eyes are longingly cast on Sweden, Norway, Bavaria and other places where large falls are in evidence and where, therefore, it is possible to generate energy very cheaply. It may, however, be pointed out in reply to this argument that we are much luckier than other countries in possessing an abundant coal supply. There is practically no industrial area in this country where coal is neither cheap nor plentiful, and it is to be doubted whether, even if we had large waterfalls, it would be more economical to erect stations, in the out-of-the-way places where they exist, to supply industrial areas than to use the coal and generate the power more or less where it is wanted. In fact, one authority has pointed out that there are sources of water power in this country which could be utilised if there were necessity to do so, and the fact they are not points to the conclusion that we have better means at our command.

In making these remarks we wish them to act as a prelude to our calling attention to a use to which these small streams or waterfalls might be well applied. Much has been done in Germany and America in applying the electric drive to agricultural purposes. A small stream is harnessed, and a plant erected from which the farm machinery can be easily driven, while at the same time farm buildings can be supplied with a good light. In the INDUSTRIAL SUPPLEMENT for March we pointed out that the petrol electric set formed an excellent generating plant for this purpose, but where water power is available there is no doubt that it has even greater advantages as far as the farmer is concerned. There are certainly many places in this country where water power is already used, but it is employed inefficiently, and by no means the best is got out of the plant used. An interesting example of what may be done in this way is given in a recent issue of the "Electrical World." A farmer in Utica has erected a small hydro-electric plant on his farm which supplies the owner's premises with light, heat and power. The owner has gone into the matter thoroughly, and has expended rather more capital on the project than perhaps was actually necessary, but he has got in return a highly efficient plant and one which should supply him with power very cheaply. The generator plant has a capacity of 10 kw., and supplies direct current to the farm buildings at a pressure of 230 volts. Transmission is by means of a pole line, to which is fixed insulated wire. The plant is controlled from the house by means of a simple arrangement for ifting or closing each generating station. The switchboard, being at the house itself, it is also possible to regulate the voltage from the same point without going down to the station. It may appear that the output from this generator (10 kw.) is very small, but it would be quite possible so to arrange matters that the energy generated was used for power in the daytime and for lighting at night. By so using, with a small set and the expenditure of very little capital, all the benefits of the electric drive could easily be obtained. We should like to see this example more generally followed in this country. At the present time the cry of "Back to the Land" is ever ringing in our ears, but if we are so to return, full advantage might be taken of the present resources of civilisation in getting out of the soil every possible yield.

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Hydro-Electric Pumping Plant for a Gold Mine in Brazil.

IN considering the question of gold mining in Brazil it is well to remember that waterfalls are plentiful and that power is therefore very cheap. It therefore, happens that many mines are worked at a profit which otherwise would have to be abandoned. The plant described below was supplied by the Sandycroft Foundry Co. to such a mine, and is employed for pumping water from the lower levels of the mine. Fig. 1 shows a section of the mine and the relative position of the various parts of the plant. The power water is brought along the old rego A and enters the pipe line at B. This pipe line carries the water to the power station at C, which is situated just above the river. The cables pass from the power station along the shallow adit D, down the shaft E to the pump situated at F. The water discharged by the pump passes through pipes up shaft E, and along the deep adit G, where it is discharged into the river further down, and at a lower level than the power station. The effective height of fall for the power water is 200 ft. and the amount of water available about 282 cubic ft. per minute. The pipe line is of steel of 16 in. inside diameter.

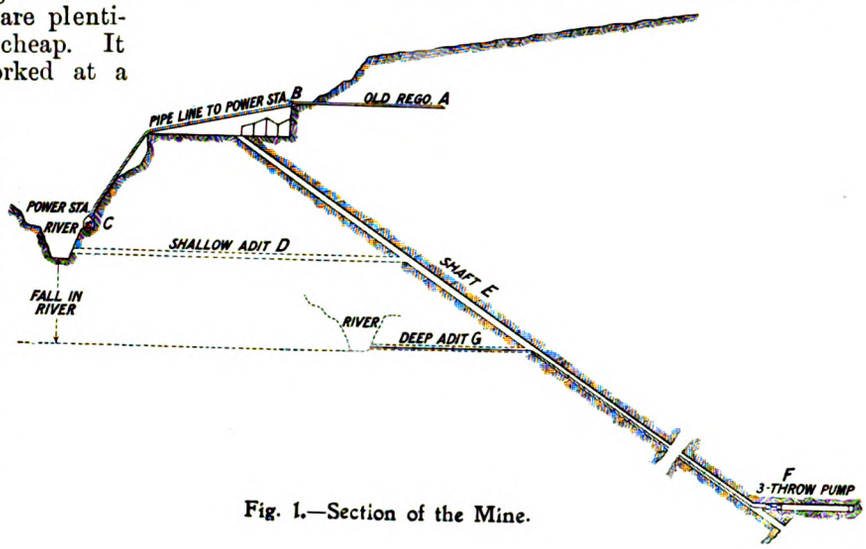

Fig. 1.—Section of the Mine.

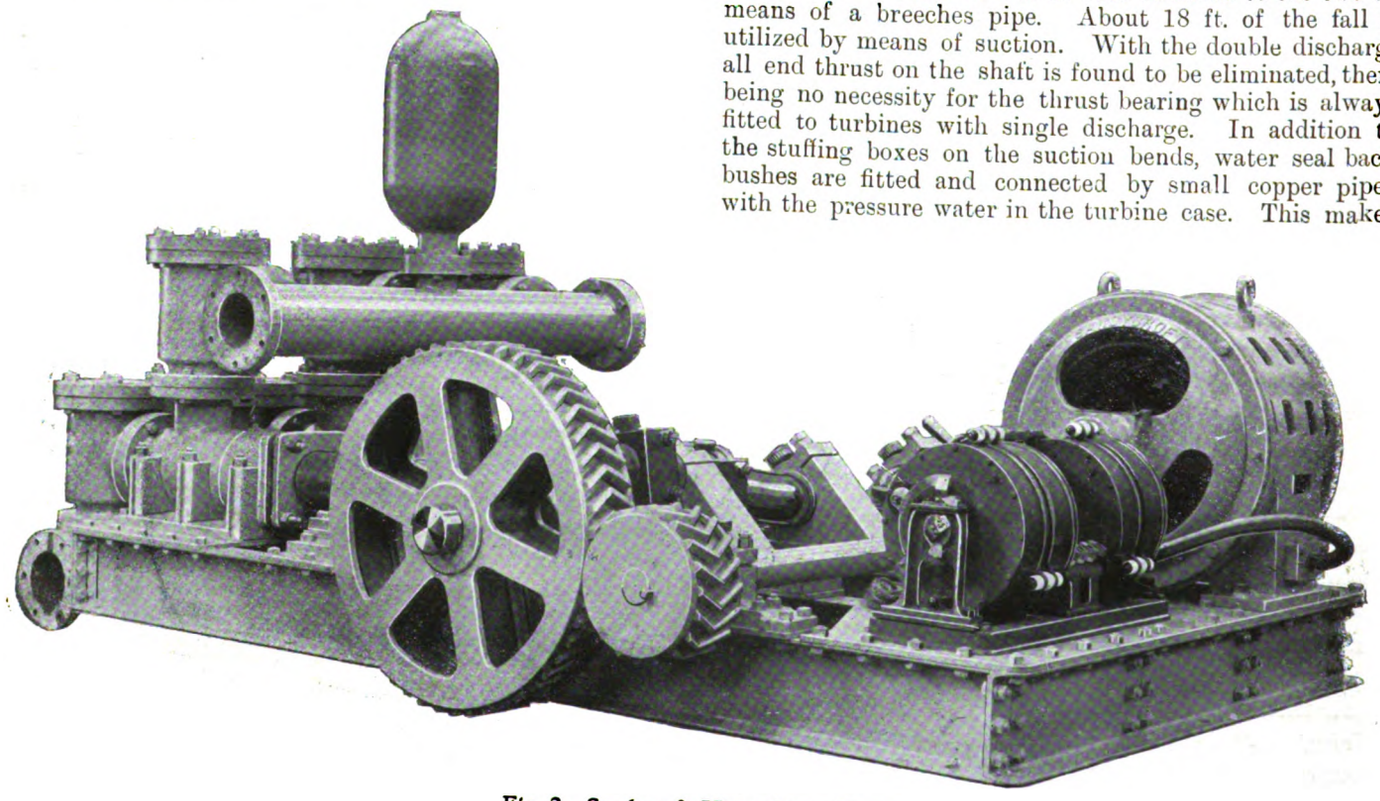

Fig. 2.—Sandycroft Motor-driven Pump.

The arrangement of the power station, which contains turbine, generator, exciter, switchboard, &c., is shown in Fig. 3. The turbine is of the "Gilkes" inward flow type, known as the double vortex. It is designed to develop 80 B.H.P. with an effective fall of 200 ft. using 282 cubic ft. of water per minute and, making 1,000 revs. per min. The outside casing is of spiral form in order that the water may have a uniform velocity inside the case. The water is directed on to the wheel by means of short movable guides of the "Francis" type, which ensure, it is claimed, a very high efficiency at all loads These guides are made of gunmetal and are actuated by means of a gunmetal ring, which, in turn, is operated by the cranks. These latter receive motion from the governor cylinder. The revolving wheel is of brass and has a dividing plate, so that half the water is discharged on each side and passes out through the suction bends. These bends are connected to a draft tube common to the two by means of a breeches pipe. About 18 ft. of the fall is utilized by means of suction. With the double discharge all end thrust on the shaft is found to be eliminated, there being no necessity for the thrust bearing which is always fitted to turbines with single discharge. In addition to the stuffing boxes on the suction bends, water seal back bushes are fitted and connected by small copper pipes with the pressure water in the turbine case. This makes it impossible for air to be drawn into the suction tubes. The turbine shaft is supported in a ring-oiled bearing, a flexible coupling being used for coupling to the dynamo. Speed regulation is attained by means of a hydraulic governor. This governor is of the hydraulic relay compensating type, which, while allowing the turbine gate to be moved over its full range from shut to open in as small a period of time as four seconds, at the same time, it is

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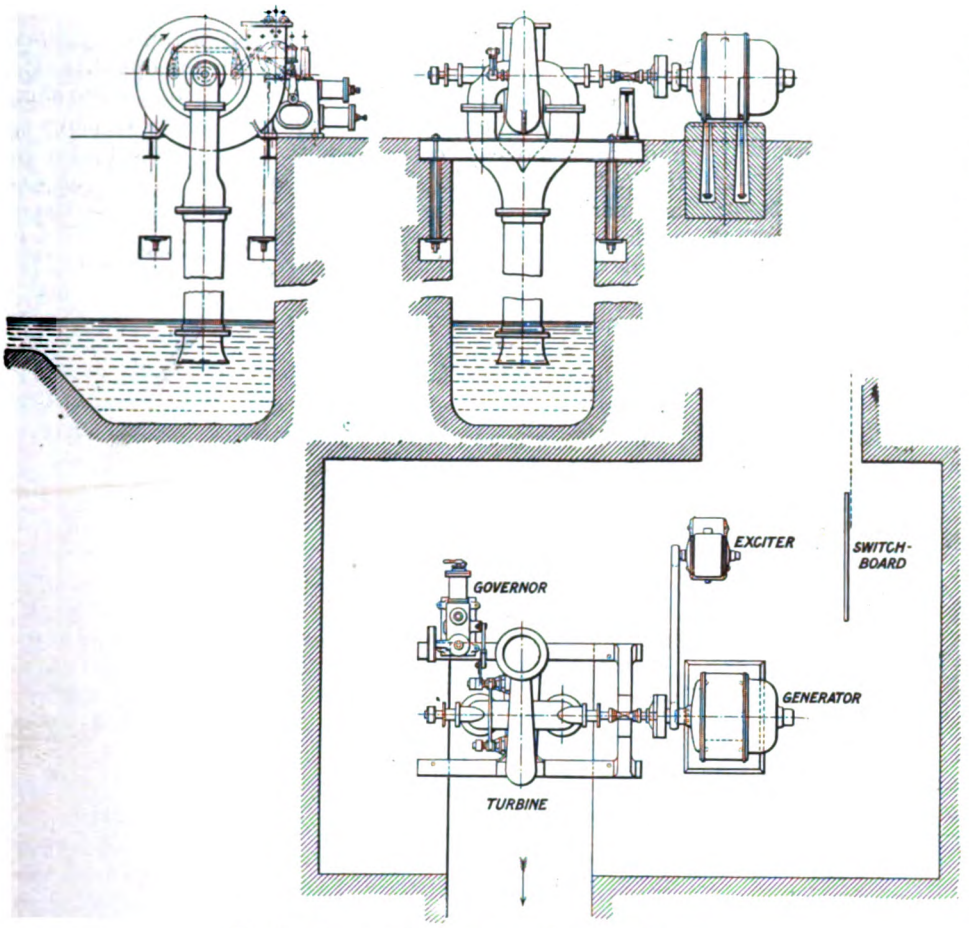

Fig. 3.—General Arrangement of Power Station.

claimed, entirely prevents hunting even when running on the lightest loads. The rotating parts of the governor are all automatically lubricated, which enables the plant to be left running for very considerable periods of time without any attention.

The generator is of the three-phase revolving-field type capable of giving out 68 k.v.a. at 550 volts, 50 cycles, when running at a speed of 1,000 revs. per min. The armature core is made up of insulated plates 0·02 in. thick, having open slots, and is wound with former wound coils of the barrel type covered with waterproof insulation. These are held firmly in the slots by strips of hard wood. The plates for the field poles are $\frac{1}{16}$ in. thick, and are riveted together and fixed to a steel hub by means of keys. The arc of the pole surface is of suitable radius to obtain a sine curve. The field is energised from a 100-volt continuous-current dynamo, which also supplies current for lighting purposes.

The switchboard is made up of one alternator and one exciter panel, the main switch being of the oil-break type with trip coils on two phases. The power is transmitted along the shallow adit to a junction box near the shaft by three bare copper conductors of 19/15 S.W.G. which are held by leather suspenders hanging from porcelain insulators; from the junction box three-core insulated cable is taken to the motor panel at the shaft bottom, it being necessary to insulate this cable as the shaft is damp. The motor panel is of the enclosed type and is fitted with ammeter, voltmeter and oil-break triple-pole switch with trip coils on two phases. The pump is driven by a "Sandycroft-Hunt" 50 B.H.P. "cascade" motor, running at 490 revs. per min. this type of machine being used as it is without slip-rings, rubbing contacts, brushgear, &c., thus eliminating the chief source of trouble found with motors working in mines. The only attention required by the machine is that necessary to keep the bearings supplied with oil. The motor is capable of starting up the pump against the full head of water and can be started up gradually by a starting switch of the enclosed liquid type, as shown in the illustration. Full load starting torque is obtained with full load current. The pump, which is shown in Fig. 2, is of the horizontal three-throw ram type, having single-acting rams of 7 in. diameter and 12 in. stroke running at 53 strokes per minute, and delivering 250 gallons of water per minute to a vertical height of 450 ft.

The bed frame is built up of steel joists and channels, thus permitting it to be easily sectionalised for transport and allowing of it passing through confined places to its working position in the mine. The first reduction gearing is machine cut, the motor pinion being of forged steel and the wheel of cast iron. The second reduction gearing, as will be seen from the photograph of the pump, is double helical machine moulded. Bent cranks are used, and the pump valves are of the mitre type. These pumps have an efficiency of between 75 and 80 per cent. at 500 ft. head. They are said to be very reliable for mining work, being specially designed for that purpose. A large number have been built by the Sandycroft Foundry Co. for mines in this country and in other parts of the world.

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Siemens Tramway Meters.

ATTEMPTS were made in the early days of tramway development to utilise ordinary meters for the purpose of recording the energy consumption of tramcars under working conditions. These attempts proving unsuccessful, Messrs. Siemens Bros. Dynamo Works, who were among the pioneers of tramway development, applied special attention to the production of a reliable tramcar meter, with the result that they have succeeded in

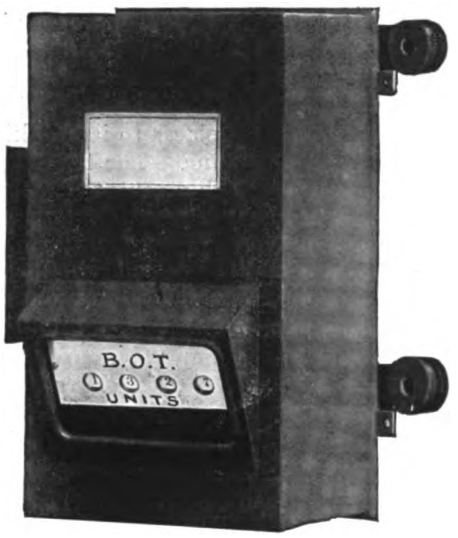

Fig. 1.—Siemens G.K.B. Meter.

putting on the market a meter which, after extensive trials under working conditions, has proved itself to be fully capable of meeting all the requirements of the situation. We illustrate, in Fig. 1, a Siemens type G.K.B. meter, and in Fig. 2 is shown the same meter with the cover removed.

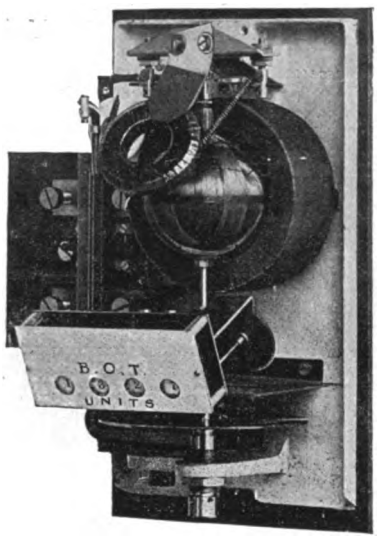

Fig. 2.—G.K.B. Meter with Cover Removed.

One of the chief difficulties was found to be in the bottom bearing. This, in the Siemens meter, has been overcome in a very ingenious manner. As may be seen from Fig. 3, the bottom pivot is not turned solid on the ends of the armature spindle, but the latter itself is drilled to form a cylinder in which is a steel piston abutting against a spring control; the bottom end of this piston is cone shaped. The bottom pivot is of highly polished and hardened steel and is held in position at the end of the piston by friction. The jewel is also spring supported from the opposite side, so that any vibration which would tend to produce chattering, causes the jewel and the pivot point to move up and down as one piece. All vibration is taken up by the top and bottom springs, thus eliminating all possibility of hammering of the jewel. Other details, as the outcome of extensive practical experience, have also been embodied in the design of the Siemens tramway meter. The li e of the meter can be safely taken as at least five years, the maintenance cost are low, and provision is made for the easy renewal of all wearing parts.

A large number of these meters are in active service in England and on the Continent, and in instances where figures are obtainable, it is seen that large economies in

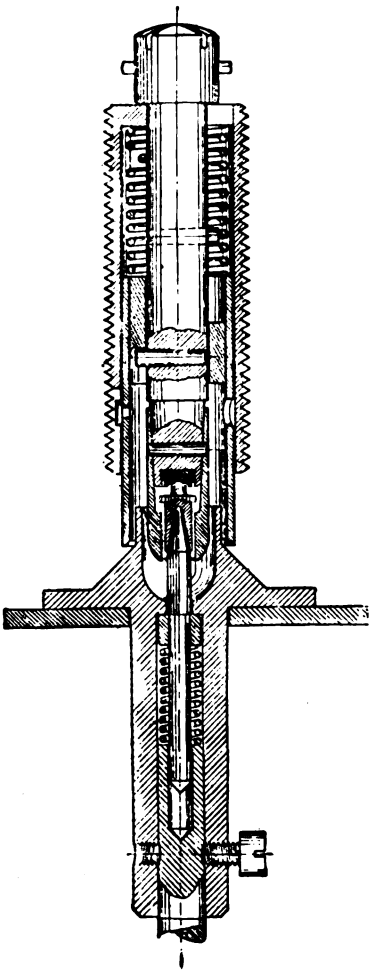

Fig. 3.—Bottom Pivot of G.K.B. Meter.

current have been effected, varying from 4 to 20 per cent., the average being in the neighbourhood of 10 per cent. Since a car meter has to deal with current to the value of approximately £200 per annum on an average, a saving of 10 per cent., namely £20, on that amount would repay the cost of the meter several times over in a single year.

The economies effected by the use of meters on tramcars afford an interesting sidelight on one phase of human nature. Without the meter the driver tends towards carelessness, towards rapid starting and still more rapid braking, all of which are operations harmful to the equipment and unpleasant to the passengers. When a meter is fitted, however, the motorman feels that he is constantly under supervision, even though it is only by an instrument, and orders his doings accordingly; with the result that the equipment is operated in a normal fashion and the passengers are no longer jerked from their seats.

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Sulzer High-Lift . . Centrifugal Pumps.

AMONG the firms who have exerted a great deal of influence on the development of the rotary pump may be justly placed Messrs. Sulzer Bros., of Winterthur. The principle on which this type of pump works is, of course, well known, the liquid being put in motion by a more or less quickly rotating impeller and then raised by centrifugal force. The shape given to the impeller, as well as that of the casing surrounding it, varies between wide limits, the ultimate design depending upon the work required from the pump.

In the high-lift centrifugal pumps made by Messrs. Sulzer Bros. the guide wheel surrounds the impeller and serves to divert the water discharged from the impeller, reduce its velocity and convert part of the latter into pressure, whereby the lift and efficiency of the pump are increased.

Great lifts are obtained by the arrangement of several impellers in series on the same shaft with their guide wheels surrounding them. In the first impeller and guide wheel the fluid is brought to a pressure or lift corresponding to the number of revolutions, from whence it passes into the second impeller and leaves the same with double the pressure; from the second wheel it passes in the same manner through a third, fourth or *n*th impeller and guide wheel, so that the final pressure or total lift corresponds to two, three, four or *n* fold of the lift of the single impeller.

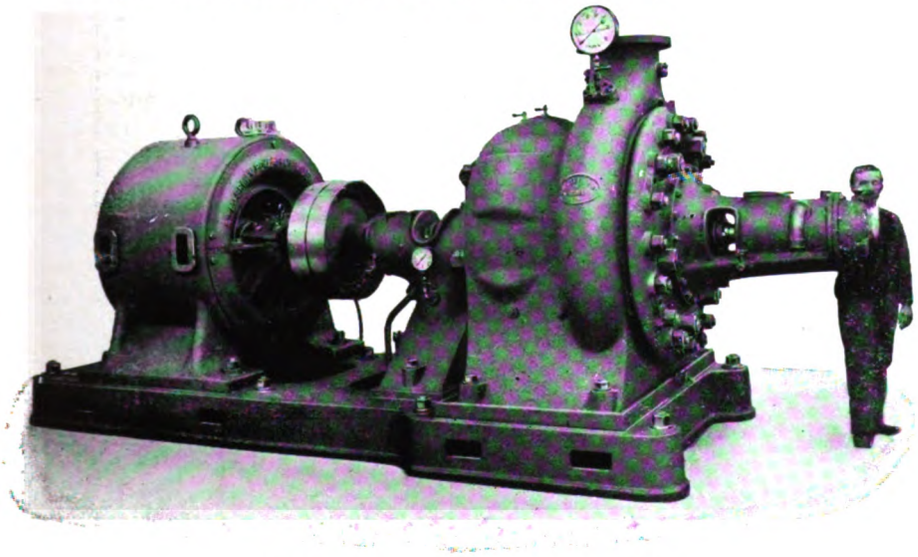

Fig. 1.—Sulzer High-Lift Centrifugal Pump.

The number of impellers arranged in one casing is further dependent on various constructive questions, especially on the quality of bearings.

In the six-stage high-lift centrifugal pump the casing consists of six annular pressure chambers, the last of which is provided with the delivery nozzle. The suction nozzle is bolted on the left side of the casing, while the other side of the latter is closed by a cover.

The pump shaft is supported on the one side in the suction nozzle and on the other in a bearing mounted on the cover. This last-named bearing, which is patented by Messrs. Sulzer Bros., is arranged in such a manner that water from the last pressure chamber leaks through around the shaft into the separate chambers of the bearing and on its way to the outlet cools the oil chamber as well as the bearing itself.

The six impellers are keyed on the shaft in pairs in such a way as nearly to eliminate the side thrust. Two impellers are surrounded by one double guide wheel, which contains the spirally shaped guide channels and the overflow openings. The circular section of the suction nozzle changes to an annular one before the first impeller, to give the fluid a uniform inlet into the first impeller. Between two pairs of impellers an intermediate piece is contained, which is provided with the overflow channels, while the suction chamber for the sixth impeller is arranged in the cover.

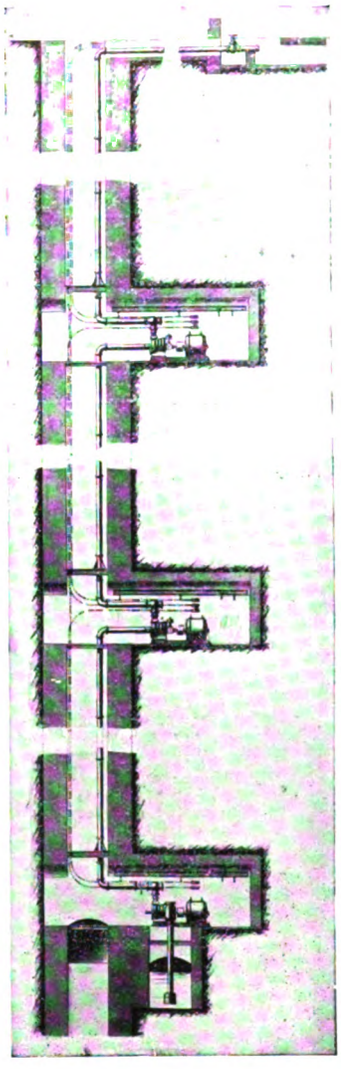

Fig. 2.—Section of Horcajo Silver Mine, showing Pumping Arrangement.

The efficiency of Sulzer pumps is quite satisfactorily high. For instance, a plant at Horcajo, in Spain, where 235 H.P. pumps are installed, an efficiency of 79·5 per cent. was obtained at a speed of 1,320 revs. per min. and a delivery of about 6 cubic metres per min. In another case a Sulzer sinking pump delivering 16 cubic metres per min. at a manometric head of 45 metres when running at a speed of 1,025 revs. per min. gave an efficiency between 83 and 84 per cent. in accordance with the conditions of working. Such a type of pump is naturally very suitable for direct coupling to the electric motors and, as may be seen from our illustrations, this combination is at present receiving a wide application. Fig. 1 shows such a set, the

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motor being of the alternating-current type and fixed on the same bed-plate as the pump. This illustration also gives a good general idea of the pump design, showing its compactness and other desirable features.

In considering the question of electrically-driven pumps, the field of application is doubtless the section to which most attention should be drawn. It will suffice to say in this connection that Sulzer pumps are now being employed for a variety of uses—uses which differ so widely as irrigation and fire extinguishing, and are found to work satisfactorily under all sorts of conditions. For instance, Sulzer pumps are actively engaged in connection with the water supply of Milan. At first three pumping stations were built for this purpose, which were supplied with alternating current from a central electric station and in which the pumps were direct coupled to motors. A fourth pumping station will be erected in the near future, in which the pumps will be driven by belt from gas engines, rather a retrograde movement on the part of the municipal authorities. Pipe wells (till now 45) are connected to many places in the middle of the town, from which the water is led to suction air chests, where it is freed of its air and from whence it is drawn directly by the pumps, the suction height reaching 8·2 metres without trouble. The largest pumping station (Fig. 3) is in Loreto. The four direct-coupled pumps draw from a common air chest. All pumps work independently of each other and deliver into a common delivery pipe. Each pump delivers 3·6 cubic metres per minute to a head of 57 metres at 820 revs. per min. The second station is located in Via Parini and contains two equally large pumps directly coupled with electric motors. The third station with only one pump is in the same street. The pump is mounted over the well, and draws directly from it. The fourth station, now in course of erection, will contain three pumps, each of which will deliver 6 cubic metres per minute to a head of 52 metres when running at 925 revs. per min.

In connection with the application of electrically-driven pumps to mine draining, it is interesting to note that one of the first plants of this kind was built by Messrs. Sulzer Bros. in 1898 for the Horcajo silver mine in Spain (Fig. 2). The plant, which since its erection has practically run uninterruptedly, delivers at an average rate of 4·8 cubic metres per minute. As seen in Fig. 2, the plant works with several pumps at various levels with a total head of 480 metres. The arrangement is such that the lowest pump draws the water from the sump and delivers it to the next pump, which latter again forces it to the following. The upper pump receives the water under pressure, so that its filling is always assured and no air can enter. The pumps all work exactly in accordance, as they have the same speed, and the same water passes through them. They are four-stage pumps with impellers of 500 mm. diameter, and deliver each 4·8 cubic metres per minute to a 130-metre head when running at 850 revs. per min. The central power station contains six Sulzer cross-compound steam engines, which at 115 revs. per min. each develops 525 I.H.P. The working steam pressure is 8 atmospheres. The six-pole alternating-current pump motors work at a terminal pressure of 1,000 volts. In consideration of greater depths to be overcome and an increased water flow, a new drainage plant was erected by Messrs. Sulzer Bros. in Winterthur for this mine in the latter part of 1903. The pumps of the new plant deliver each 6 cubic metres to a height of 130 metres at 1,310 revs. per min.

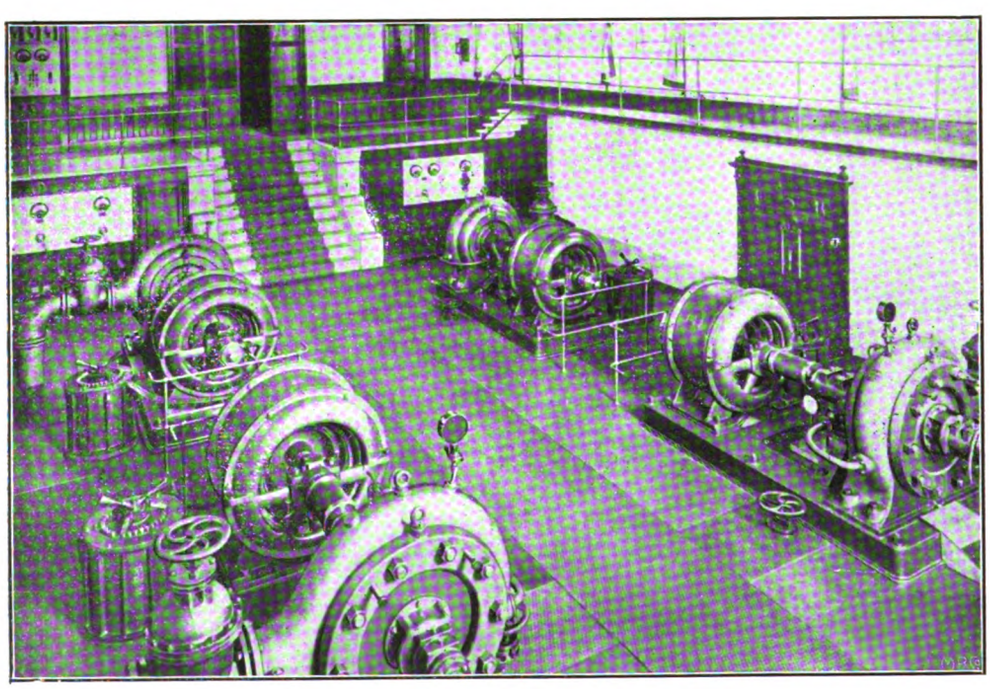

Fig. 3.—Loreto Pumping Station at Milan.

Fig. 4.—Sulzer Vertical Pump.

A more modern arrangement in which the entire head is overcome in a single lift is installed in the Victor mine at Rauxel, in Westphalia. Two four-stage high-lift centrifugal pumps are coupled in series, and deliver 7 cubic metres a minute to a head of 524 metres when running at 1,040 revs. per min. The horse-power required by each set is 570. The combined efficiency of the steam generating and pumping plant is 58 per cent.

Another important mine drainage plant is that installed by Messrs. Sulzer at Ems. Current is supplied from a central power station at a pressure of 8,000 volts, and Sulzer

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pumps were erected to overcome the large quantities of water present.

The pump chamber in the ninth level is capable of taking four pumping sets, three of which are already at work. They are six-stage 200 H.P. high-lift centrifugal pumps, each of which when running at 1,455 revs. per min. will deliver 2·52 cubic metres per minute to a head of 255 metres. Each pump is coupled direct to an asynchronous motor of 225 B.H.P. normal output at the above stated speed, taking current at 1,000 volts and 50 cycles. The motors have no slip-rings, and are provided with water-cooled ring bearings. The pumps draw direct from the water drift of the mine level by means of a common suction pipe. Later on the water will be fed under pressure from the sixteenth level by a second suction pipe. The delivery pipe is common to all pumps, and consists of a large collecting pipe with branches which leads to the surface. The great length of the piping was dependent on the location of the already existing pump chamber. Each pump works independently of the others, and according to the fluctuation in the flow of water and to season, one, two or three pumps are in operation at a time. The drainage of the not flooded ninth level downwards to the sixteenth level was accomplished by Sulzer sinking pumps. To treat with smaller quantities of water in the side or trial drift, which water must be removed without delay, the Sulzer drift pump is employed. The pump is direct coupled with an electric motor and mounted together with it on a small carriage. The current is transmitted through a flexible cable and plug contact.

The latest application of the high-lift centrifugal pumps consists in the construction of pumps with vertical shafts, which are usually coupled to alternating-current motors. These sets are employed as sinking pumps when sinking shafts. They require very little space, are self-contained and easily accessible. They can work while suspended freely, without requiring any excavations or supports in the shaft. Fig. 4 shows one of these sinking pumps, which is operated by means of a gate valve hand wheel and ammeter. The pump is of the four-stage type and capable of delivering 3 cubic metres per minute to a head of 200 metres, when running at 1,450 revs. per min., and then requires 185 B.H.P.

De Dion Bouton Engines.

A FIRM of motor car makers who, profiting by the experience gained in the construction of light engines for cars, are now manufacturing engines for the use in the larger sphere of industrial operations, agriculture and generally for all uses for which the engines formerly offered to the public were unsuitable on account of their weight, size and complication, are the De Dion Bouton (Ltd.).

Fig. 1 shows such a set of the 6 H.P. type. These sets are mounted on cast-iron stands, with pulleys revolving at 300 revs. per min., which is a suitable speed for working, by means of a belt, any kind of machinery, such as threshing machines, root-cutters, cream separators, churns, saws, planing machines, wringers, pumps of all kinds, &c.

The sets consist of a De Dion Bouton engine driving through a pinion fixed to the end of the engine shaft, a toothed wheel fast on the pulley shaft. The whole is mounted on a cast-iron stand. The carburettor is fixed on to the engine, and the timing gear is enclosed in a gear case. The battery is supplied in a special box with the sets, the coil being placed in the interior of the cast-iron stand. The single cylinder engines are cooled by thermosyphon circulation. For combinations with two cylinder engines the water circulation is effected by means of a pump.

The single cylinder engines are lubricated by splash feed. A drip feed lubricator can be fitted to these motors. This apparatus ensures the lubrication without stopping the motor. The two cylinder engines are fitted with an oil-pump, and the lubrication is automatic.

An automatic governor can be fitted to 6, 8, 10 and 12 H.P. combinations. It is not indispensable, but in most cases it facilitates the running of the engine. It is a centrifugal governor driven by pinion, and acts on the exhaust or the carburettor of the motor so as to maintain a constant speed. The adjustment for a given speed is very simple. It is only necessary to alter the tension of a spring by means of a nut.

Examples of the petrol-electric generating sets made by this firm are shown in Figs. 1 and 2. These sets consist of a vertical high-speed De Dion Bouton engine direct coupled to a dynamo. Constant voltage under varying load is maintained by an electrically-operated governor acting on a throttle on the gas inlet. The engines on these direct-coupled sets are exactly the same as those in use on De Dion Bouton cars, industrial vehicles and motor boats. The dynamos employed are bi- and four-polar with drum-wound armatures and are self-excited. The fields are self-excited, and the field connections are made direct to the brushes. Ball bearings are fitted, and these are easily accessible. The brushes are fixed in position and require no adjustment; they should be left in the same position as set until the brushes are completely worn out. The governing device, fitted on these sets, consists of a solenoid acting on a conical plunger, which is free to move in a tube. In order to make full use of the magnetic field and thereby to diminish the amount of current passing through the soleniod, this is completely encased in a hollow cylinder, which completes the magnetic circuit. This also has the advantage

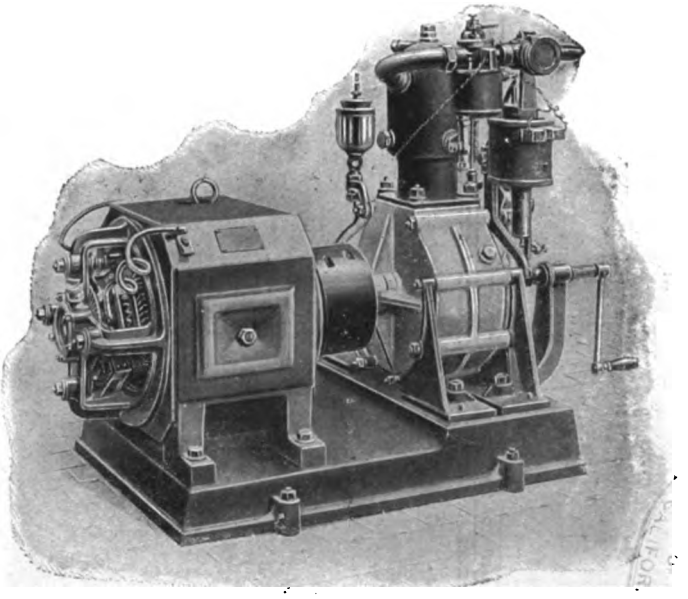

Fig. 1.—Single-Cylinder Generating Set.

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of rendering the apparatus insensible to any stray external magnetic field. The upper end of the core of the solenoid is attached by a chain to a pulley keyed on to the spindle of a throttle valve in the passage of the explosive mixture coming from the carburettor. A spiral spring is attached by one end to the spindle and by the other to a cover, the position of which it is possible to alter, consequently the tension of the spring and, therefore, the sensitiveness of the apparatus can be varied at will. It also follows that the apparatus may be still further adjusted by altering the position of the core with respect to the solenoid, this being effected by means of a series of holes drilled on the internal face of the pulley, into which the attaching pin may be inserted. The amount of energy consumed by this arrangement is about 5 watts. These sets are also made for portable purposes, and in this connection we may call attention to a patent hydraulic suspension for petrol electric generating sets which has been designed by De Dion Bouton. This system utilises the water tank as the foundation of the set. The dynamo is directly coupled to the motor, and the set is bolted to a base which floats on the water. The water ensures the insulation of vibration, and also acts as the means of cooling the exhaust gases. The dynamo set can be supplied assembled with the float, so that upon the tank being bolted down and the petrol pipe connected it is ready for immediate service. The motor and the dynamo are bolted to a float which is supported in the tank by the cooling water. Spring connections, one at each corner, keep the float central with the tank. The pump draws up the water by the pipe, circulates it round the engine, and then expels it by the pipe. Excessive heat is prevented by varying the capacity of the tank in proportion to the size of the motor, and the sides of the tank acting as radiators. Another advantage of this system is its silencing effect. To attain this the exhaust pipe is passed through the water tank; the cooling of the gases causes their expulsion at low pressure, and the noise of their final escape to the atmosphere is almost suppressed. The system is, it is claimed, a real improvement to the installation, whilst it adds nothing to its cost, as a water tank is necessary in any case, and it saves the expense of a concrete or similar foundation.

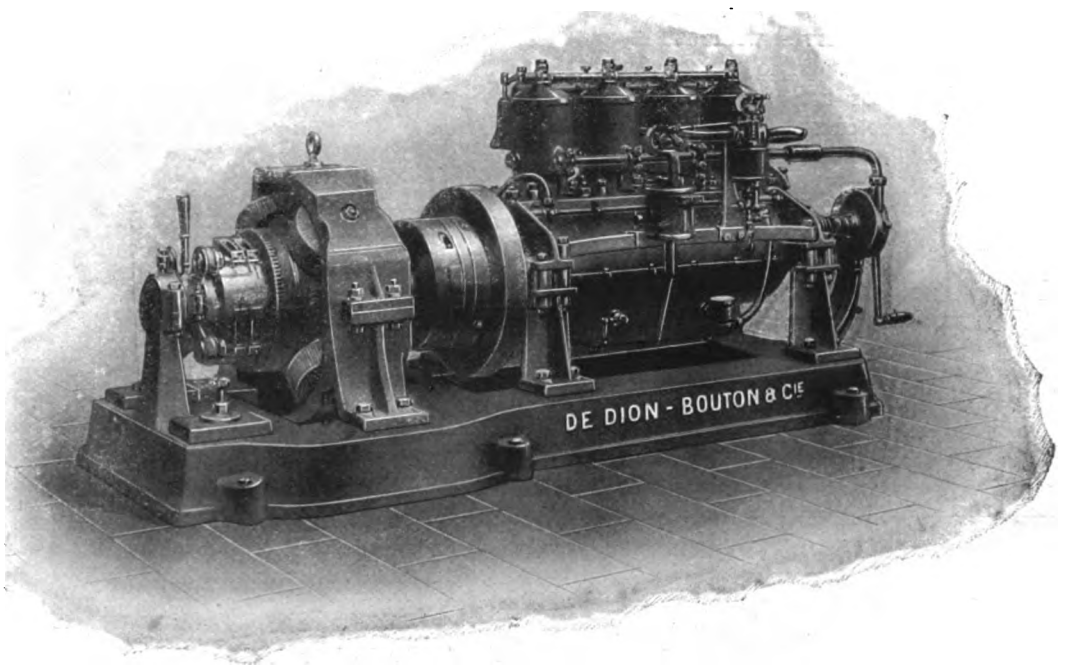

Fig. 2.—Two-Cylinder Generator Set.

The "Drum" Pump.

AS is well known, pumps, like many other things, may be divided into two main classes, centrifugal and piston. There are a certain number of pumps, however, which combine the features of both these classes. Among these may be placed the "Drum" pump manufactured by the Drum Engineering Co., of Bradford. It is claimed for this pump that it has the capacity of the centrifugal pump with the power of the ram—a very useful combination.

The pump consists essentially of a revolving piston that sweeps out the cylinder every revolution. The revolving piston dips into a revolving valve or cylindrical drum, the openings in which are so arranged that the piston passes through without appreciable slip, back pressure or undue friction. When the revolving piston moves round from the revolving valve a vacuum is formed, into which the water flows and is then forced in the front face of the piston.

The "Drum" rotary piston pump differs entirely from the ordinary rotary pump; the latter, like the direct-acting piston pump, is more or less intermittent in its action, and breaks up the flow of the fluid; the "Drum," on the contrary, passes the water through in one continuous flow without interruption, and utilises the power in the momentum of the moving column; thus the great advantage of centrifugal action is obtained without the cost of additional power. Another great difference between the "Drum" and the ordinary rotary pump is that the latter has usually two revolving working pistons, one of which is driven through the gear wheels. The "Drum" having only one rotary working piston, the friction and strain on the gear wheels and bearings of driving a second revolving piston are avoided.

The "Drum" pump is found particularly adaptable for use by contractors, dyers, brewers, paper makers, sugar refiners, soap and linoleum manufacturers, and for drainage works, docks, on board ships, and for pumping semi-fluids, chemicals, or for any purpose where large volumes are to be dealt with quickly and economically.

There are a number of different sizes of "Drum" pump, varying in capacity from 650 to 18,000 gallons per hour. They are specially adapted for direct-coupling to motors and an interesting arrangement has recently been supplied for drawing water from a river in China that is subject to great variations in level.

The pump and motor were placed in a small power house, mounted on a platform that could be raised and lowered on rails on an inclined plane on the bank of the river, so that the pump could always be placed within easy reach of the water without any risk of the motor being flooded.

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M.A.N. "Double Drive" Cranes.

NOWADAYS an increase in the hoisting speed of cranes has become a necessity from an economical point of view. In many works, especially in foundries and fitting shops, disadvantages have, however, arisen on the adoption of high speeds owing to the frequent necessity of accurately placing the load, which procedure is, of course, thus rendered much more difficult than with cranes working at low speeds.

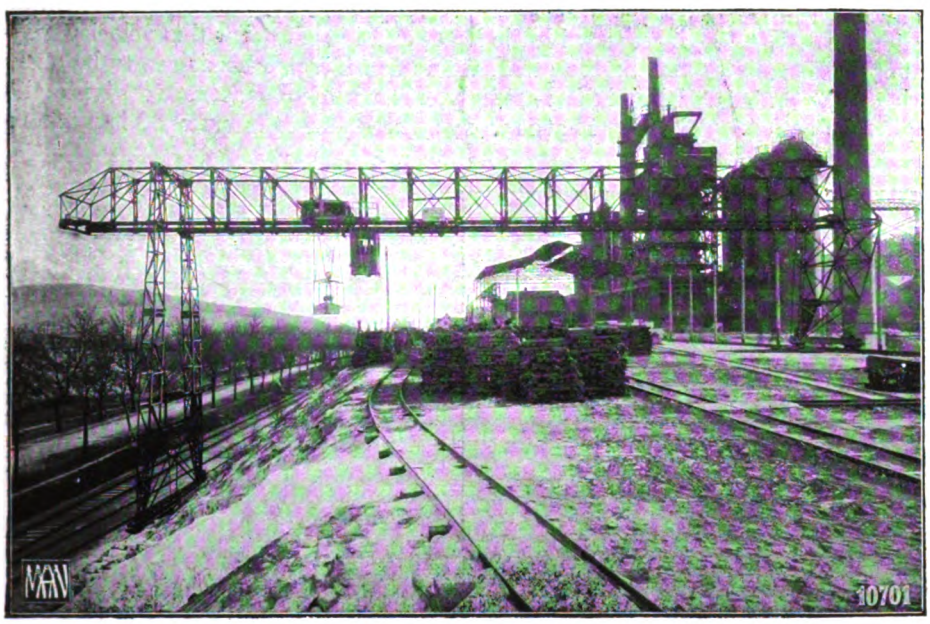

Fig. 1.—Crane for Transporting Pig Iron.

As the controllers in use render it possible to govern the speeds only within comparatively small limits, the want of an apparatus was badly felt, which—in the case also of rapid-hoisting cranes—would allow of quite a slow movement of the load in the simplest manner, without complicated speed-changing gear. The new "double drive" of the Maschinenfabrik Augsburg-Nürnberg A.G. not only, it is claimed, satisfies this want in a perfect manner, but also offers further advantages of considerable importance.

With the double drive, two electric motors work either alternately or simultaneously upon a peculiar but extremely simple driving gear, and in this way the various main speeds are obtained. Alterations in the speed are effected solely by means of the controllers—*i.e.*, without putting in action any mechanical apparatus, and this, it is argued, obviates *a priori* all errors. The main speeds obtained in this way can be graduated further by means of the regulation stages permitted by the controllers, so that a very far-reaching and extremely sensitive adjustment of the speed is ensured.

The following examples show further advantages of the "double drive." In foundries the patterns can be lifted quite slowly out of the moulds and can be transported as quickly as required. In steel works the heavy ladles can, on the one hand, be slowly moved by cranes fitted with the "double drive," and, on the other hand, the comparatively light ingot moulds and such like can be quickly shifted. Such lifting apparatus are of just as much importance also for workshops and fitting shops, where not only precise but expeditious working is required. The "double drive" is likewise advantageous for tower cranes owing to their great height.

The auxiliary hoisting gear used so much up to now for high speed for small loads becomes superfluous, and conse-

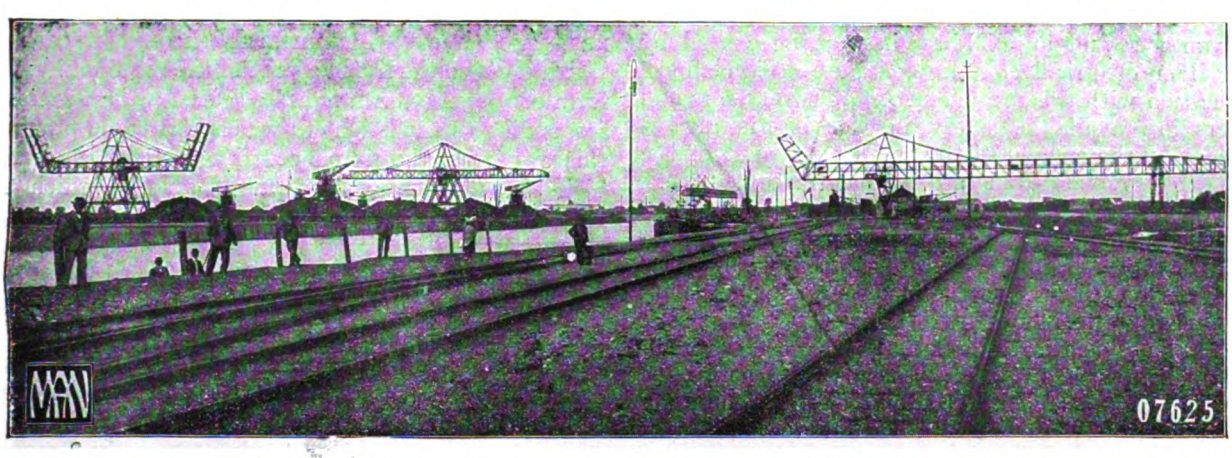

Fig. 2.—Loading Plant for Coal and Ore. Six Portal Cranes, each of 6 tons capacity with a radius of 49 ft., and four Loading Bridges, each with a capacity of 8 tons.

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quently the troublesome delay—resultant upon the presence of a second hook, which must always be previously moved out of the reach of the load—is also done away with. The general arrangement of the crab with "double drive" is simpler and more comprehensive on account of the decreased number of working parts, and the length of the crab is shorter, which means an increase in the sphere of action.

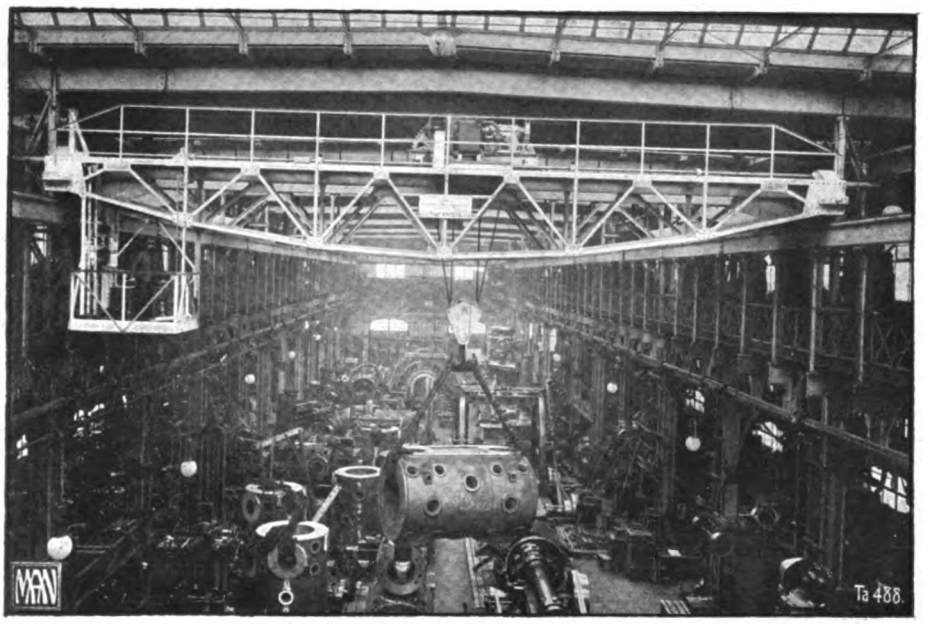

Fig. 3.—40-ton Overhead Travelling Crane with M.A.N. Double Drive.

Disadvantages and unreliability in working caused by mechanical or electrical couplings, &c., are, it is claimed, out of question with this arrangement. As two motors and controllers are available, safety in working is always ensured, for by the comparatively small extra cost of the "double drive" a stand-by is procured at the same time.

For driving the hoist of a 110-ton crab two motors of 68 B.H.P. each were used. They worked separately or simultaneously on worm gears. The centre lines of the worm wheels coincide with those of the planet gears, which drive the rope drum by means of toothed wheels (with smaller hoists one planet gear is available). The main stages of the speeds, which are varied further by means of the controller, are, for a maximum load of 110 tons, 6½ ft. per minute; a medium load of 25 tons, 26¼ ft. per minute; and for an empty hook, 46 ft. per minute. The alterations in the speed are effected solely by means of the controllers—*i.e.*, without putting in action any mechanical apparatus.

High-Lift Turbo-Pumps.

THE increasing use of the motor almost makes some type of rotary pump necessary if the full advantage of high speed is to be obtained. It is, therefore, not surprising to find the rotary pump more and more employed for a variety of uses. Among the firms who have taken up this class of work may be mentioned Messrs. Hayward Tyler & Co., whose particular brand of rotary pump we illustrate and describe in this article.

The mode of operation of this pump rests upon the following principle: A particle of water near the axis, entering the revolving wheel or "runner," is seized by its vanes, and thus compelled to take part in the rotation. Under the influence of the centrifugal force, it moves further and further from the axis until it is at last ejected near the circumference of the wheel, with an energy corresponding to a certain head. The greater the speed of revolution the greater is this energy. It is obvious that, in the case of a simple wheel, the velocity of the water discharged must increase with the head, and in order that this velocity may not be too great, where considerable heads are to be dealt with, it is necessary, for practical reasons, to divide the head. That is to say, the liquid to be pumped is made to

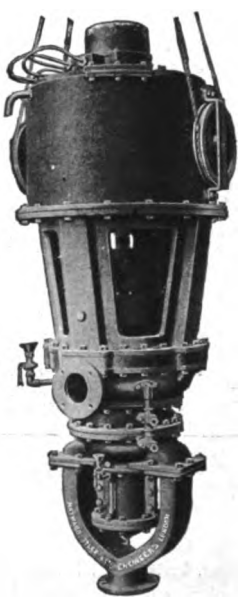

Fig. 1.—Hayward-Tyler Turbine Pump.

pass through several runners in succession, each one of which gives to the liquid a part of the required head, in the form of pressure, until it has attained a total pressure corresponding to the height to which it is to be pumped. In this way, from the simple centrifugal pump, is derived the high-pressure centrifugal pump, among which Messrs. Hayward-Tyler's pump possesses many advantages on account of its attaining the simplest and most practical solution of this subdivision of head.

The drawing Fig. 2 shows the Hayward-Tyler turbo high-pressure pump in section. There is a steel shaft (A) to which runners (B) are firmly fastened, while the guides or guide wheels (C) are attached to the surrounding casing (D), which is lined by a gunmetal liner. The liquid to be pumped enters the annular casing (E) and is then led by a stationary guide wheel to the first runner, and so on through a number of guides and runners until it at last escapes from

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the casing (F) into the discharge pipe. The intake and delivery can be set in any position by the simple rotation of the inlet and discharge casings about the axis. The shaft revolves in self-lubricating bearings (G), both of which are completely protected by a special form of construction from the entrance of the liquid pumped. Both bearings may be easily examined while running and supplied with fresh oil. The axial thrust is completely balanced, so that pistons, valves, &c., are unnecessary; the working of this balance is so exact that neither ball nor collar thrust bearings

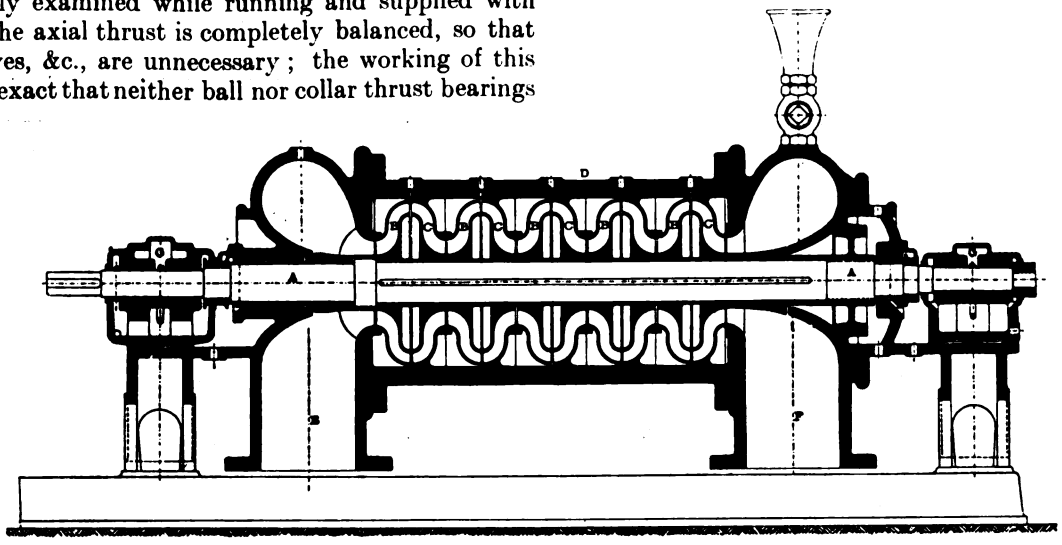

Fig. 2.—Section of Hayward-Tyler Turbo Pump.

are needed. As the liquid which is pumped flows continuously, and there are thus no fluctuations in pressure, such as are unavoidable with piston pumps, air chambers are rendered entirely unnecessary.

From a theoretical point of view, the simplicity with which the water is guided is at once noticeable. There are no avoidable losses from curvature, as the water passes through the pump by the shortest route, avoiding all unnecessary and sharp bends. This shortest route results from the fact that the necessary change in direction of flow is accomplished, half during the passage of the liquid from the periphery to the axis in the guides, and half in the passage in a reverse direction through the runner, so that the water enters and leaves the runner in an axial direction. The curves of the water channels can always be made as easy as

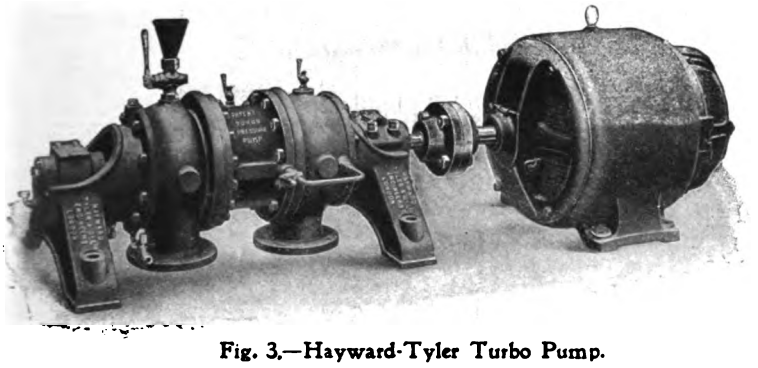

Fig. 3.—Hayward-Tyler Turbo Pump.

necessary, and this enables the losses from friction of the liquid against the sides of the channels in passing around the bends to be reduced to a minimum. Both in the guides and runners of these pumps there are vanes which guide the water throughout its entire course. The form of these vanes completely prevents the formation of whirls or eddies, and the consequent losses of power; whereas, in cases where the vanes are not continuous, the particles of the liquid, which must constantly change their direction of flow, would, beyond doubt, hit against one another, and waste a part of their velocity in eddies, so that a loss of power would result.

From a practical point of view, it will be seen that the assembling and erection of the turbo high-pressure pump are the simplest imaginable, so are not liable to derangement. The runners, each of which is separately and most carefully balanced on the shaft, can be pushed on to the smooth shaft by hand, and the pressure of a single nut, with check nut, is sufficient to fasten them firmly in position. In a similar manner the guide wheels are put into a smooth cylinder and firmly fastened in place by the end cover. The construction remains the same regardless of how many runners (2, 3, 4, 5, 6 or more) are needed, and for this reason it is easy to satisfy all requirements.

It requires only a few hours to take one of these machines apart and to put it together again, so that it is possible, without any considerable interruption of operations, to examine the condition of runners and guides and replace them if damaged. All wheels of any one machine have the same bore and external diameter, so that a mistake in erection is almost impossible, and a very small number of duplicate parts needs to be kept on hand. It makes no essential difference in the operation of the machine whether the axis

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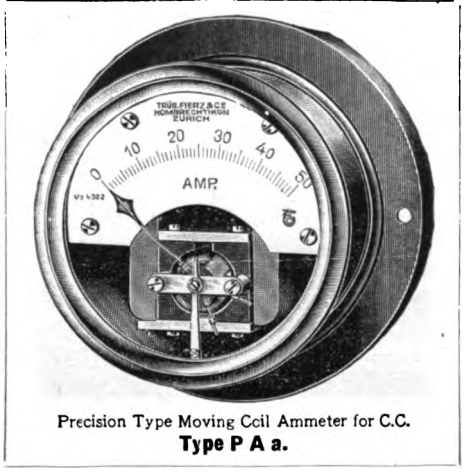

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is horizontal or vertical, the latter arrangement being more suitable for pumps used for sinking wells or shafts.

The space required is smaller, a point which is of great importance in the case of underground pumping installations. As the diameter of the runner which produces the pressure is practically the same as that of the surrounding case, the pressure which is imparted to the liquid pumped is the maximum attainable with a given extreme diameter of

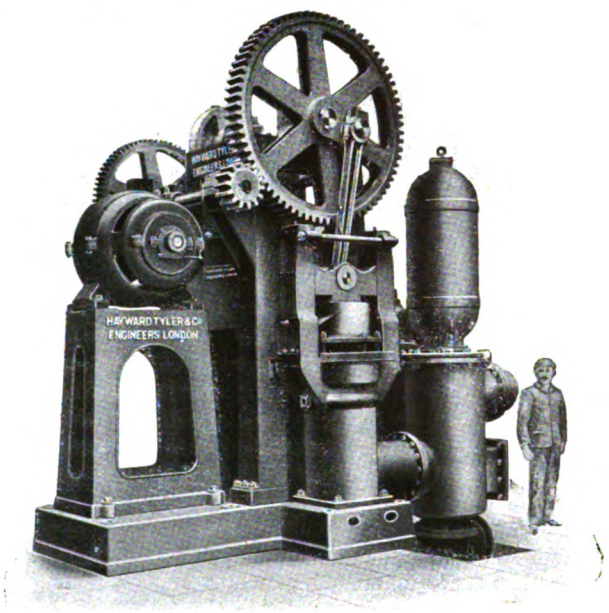

Fig. 4.—Hayward-Tyler Reciprocating Pump.

machine. Therefore each pump of this design can be built smaller and lighter than many pumps of similar design for the same head of capacity. On account of the absence of all opening and closing valves, and of the theoretically rational passage of the water through the machine, these pumps are noiseless. From the use of self-lubricating bearings, the attendance becomes extremely simple and does not require skilled labour. The machine has no moving parts which slide on each other, so that the greatest possible certainty of operation is assured, and in this respect its great superiority to the piston pump is evident. The method of operation to be chosen whenever possible is that of direct con-

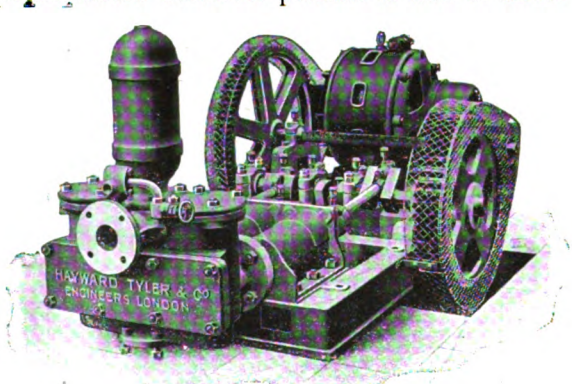

Fig. 5.—A Compact Reciprocating Pump.

nection with an electric motor or hydraulic or steam turbine. When this is impracticable, the pump may be driven by belts or ropes, or, in exceptional cases, by gearing. Messrs. Hayward-Tyler's standard types are built with special reference to the speed of electric motors.

Besides turbo-pumps, Messrs. Hayward-Tyler also manufacture treble-barrel pumps suitable for electric driving. Our illustrations show examples of these.

A New Blow-off Cock.

WE have been supplied by Messrs. James Baldwin & Co., of Keighley, with details of a new blow-off cock whose object is to elimimate all unequal expansion and pipe strains. The special feature of this blow-off cock, to which its makers have given the name of "Overall," consists in the formation of what is termed a

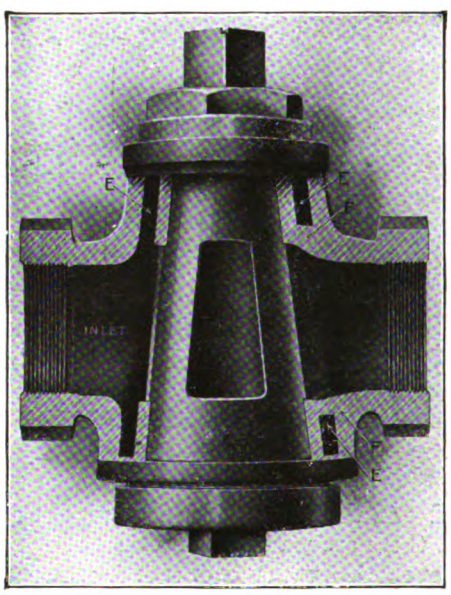

Fig. 1.—Section of Blow-off Cock.

temperature jacket, or space in the body of the cock forming an inner and outer shell, but there is only one casting. Fig. 1. shows a section of the cock. The taper plug C, which is ground in and not packed in any way, is shown in the shut position, the opening being at right angles to those in the body of the casting. It will be noticed that

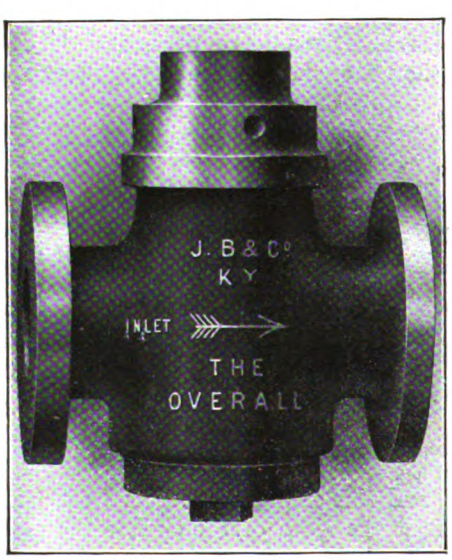

Fig. 2.—Inverted Type of Blow-off Cock.

there is a jacket or space E which extends completely round the body. There are thus an inner and an outer casing surrounding the plug, with the exception of at the parts marked F, where it is obviously necessary to have solid in order to form a partition between the inlet and outlet. Owing to this construction, the steam or other fluid at the inlet circulates in the jacket, thus maintaining the casing and the plug at an equal temperature under all

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conditions of service, and thus, it is claimed, allowing the plug to move freely and to prevent it sticking.

It is pointed out by the makers that owing to the use of plug cocks, pipe stresses and strains caused by expansion, &c., are a source of trouble and give rise to leakage. This, it is maintained, arises from the fact that the bodies of ordinary cocks are solid and consequently rigid. It will be gathered that the inlet pipe is only connected to the outer shell of this new cock, which gives rise to a certain amount of flexibility. It is only the outlet pipe which is in rigid connection with the plug.

The makers have recently carried out a test on a 2 in. cock of this type. The cock was first subjected to high pressure steam, when it was found to be perfectly tight; that is, as regards leakage. It was then allowed to cool down whilst under pressure, when it was found that the plug could be moved slowly half a turn from the shut to open and open to shut positions with a lever 8 in long. Our illustration (Fig. 2) shows an inverted plug type of blow-off cock fitted with a locking gland. These cocks are made in sizes from ½ in. upwards.

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Simplex Fans.

AT this sultry season of the year attention may be called to the cooling breezes engendered by Simplex fans which are made in all the usual types, shapes and sizes. They are neat and compact, and their general design can be gathered from the accompanying illustration.

Simplex fan motors receive the same winding for all voltages between 100 and 120 volts, also between 200 and 230 volts, and the alternating current and three-phase types are the same for all periodicities between 40 and 60 cycles per second. The outputs are, therefore, approximately proportional to the pressures and inversely proportional to the periodicities. As far as possible, the motors and fans are also wound for abnormal voltages, periodicities and speeds. Simplex direct-current motors are distinguished by their elegant design and are so constructed that they combine, it is claimed, an unusually high efficiency with low weight, great stability and small dimensions. By the application of a laminated field-frame of special form the losses are reduced and the commutation is considerably improved. All current-carrying parts are insulated in the most careful manner. The smaller types are exclusively supplied with automatic grease lubrication; in the larger

Typical Simplex Table Fan.

types either ring or grease lubrication is used. When desired, the motors can be totally enclosed, in which case the output is about 75 per cent. of that of the open-type motors.

The smaller alternating-current types of fan motors are series wound and are fitted with a highly insulated sector commutator. By the introduction of a finely laminated field-frame of special form, the losses and heating are considerably reduced, whereby a very high efficiency is attained. The single-phase commutator motors and fans can be connected to one of the three phases of a three-phase network. The regulation of the single-phase commutator motors is effected in the same way as in the case of the direct-current types. The alternating current and three-phase motors from ⅛ H.P. upwards are asynchronous motors and consist of a laminated stator, which carries the winding, and a short-circuited rotor. The starting of the alternating current single-phase motors is carried out by means of an automatic arrangement incorporated in the winding of the stator. All the alternating current motors can be at once set to work by means of simple switches.

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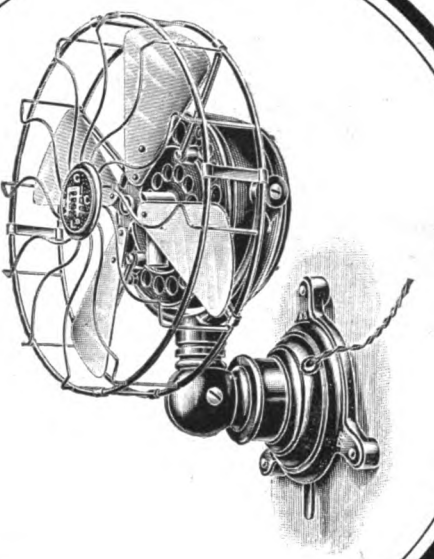

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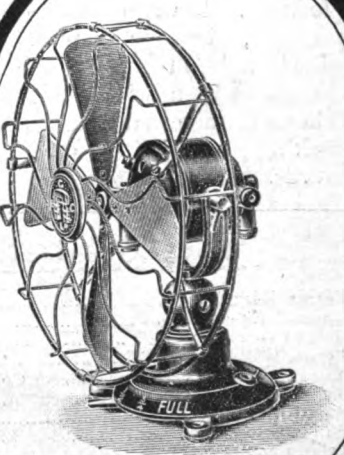

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,672. [No. 8. Vol. LXV.] FRIDAY, JUNE 3, 1910. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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SPECIAL NOTICE.

MARINE ISSUE OF "THE ELECTRICIAN," JUNE 10, 1910.

The price of the Special Issue of THE ELECTRICIAN which will be published next week will be ONE SHILLING, and copies of the Marine Section will be subsequently obtainable price One Shilling each nett, postage 3d. extra.

NOTES.

The I.E.E. Council Election.

As is already known to our readers, the Council's nominations for the election of members of Council of the Institution have this year been challenged by an outside nomination, Mr. H. FARADAY PROCTOR being selected as candidate for this purpose. Last week the election was held and resulted in the return of Mr. PROCTOR in place of Mr. J. E. KINGSBURY, the figures of the ballot for the five vacancies being as follows:—

P. V. McMahon	854	R. K. Morcom	842
S. L. Pearce	852	H. Faraday Proctor.....	696
H. Dickinson	846	J. E. Kingsbury	438

AT the outset we wish it to be clearly understood that we are in favour of outside nominations, if properly conducted, as they check any tendency for the Council to develop into a clique, of which there must always be some danger when nominations are made by a Council alone. The question arises whether it was desirable that such a step should have been taken at the present time. We think most people will have felt that it was unnecessary, as the Council's nominations gave general satisfaction. But supposing the step to have been desirable in principle, was it suitable that a provincial member should have been selected? It appears to us, and doubtless to many others, that such a selection was unjustified, having regard to the fact that three representatives of local sections had already been nominated by the Council. It must not be forgotten that chairmen of local sections are *ex officio* members of Council; there are thus six such *ex officio* members, who, together with three local section members nominated by the Council, make a total of nine out of a body of 28 vice-presidents and members who are subject to change by election. It must be admitted, then, that the provincial members have a considerable voice in the affairs of the Institution. If this proportion in the provincial representation is to be much exceeded, then the Council should be enlarged, for it is obvious that provincial members cannot attend meetings with the same regularity as those in London, and thus the working Council becomes reduced.

ALTHOUGH, of course, we have no feeling against Mr. PROCTOR, and we do not doubt that he is well qualified to serve the Institution, we must, nevertheless, take very strong exception to the way in which his candidature has been urged. A letter signed by Mr. W. A. CHAMEN, a copy of which will be found elsewhere in this issue, was sent to *selected* members of the Institution, enumerating Mr. PROCTOR'S qualifications, and pointing out among other things that he belongs, as is indeed suggested by his name, to the family of the famous Michael Faraday. Except to those who are strong believers in heredity, this seems scarcely a serious recommendation, for surely a seat on the Council depends upon personal merit quite independently of one's grandparents. This, however, is but a small matter. The important part of the letter is where members are asked specifically to vote against one particular candidate, namely, Mr. KINGSBURY. As pointed out recently in our Correspondence columns, the canvassing

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of selected members is bad enough and is highly undesirable if the dignity of the Institution is to be maintained; but when we come to definite instructions for the blackballing of a particular candidate, the whole thing savours of political warfare and cannot be too strongly condemned.

A GLANCE at the ballot figures is enough to show that a large number of papers were sent in with every name struck out except that of Mr. PROCTOR. There is much to be said in favour of issuing balloting lists which need not be returned with a full list of candidates, so that members need only vote for those whom they know, but this weapon should not be used for what may be best described as party purposes. We cannot help thinking that Mr. PROCTOR will feel a little uneasy in his seat at the Council table after the means that have been used to secure his election. If we are to have outside nominations, at least let the procedure be open and aboveboard; otherwise the final result will be far worse than with Council nominations alone, for the Institution will suffer by continual wire-pulling, and will inevitably cease to attract the most desirable elements of the profession.

Electricity Supply at Grimsby.

SEVERAL points of interest are contained in the annual report of Mr. W. A. VIGNOLES on the progress made by the Grimsby Corporation Electricity Department during the past year. In the first place, it is very satisfactory to notice that increased sales are recorded in each branch of the supply; and as the number of units sold for private lighting has increased in approximately the same ratio—9 per cent.—as the number of lamps connected, whereas during recent years the revenue did not keep pace with the growth of the connections, it is probable that the majority of consumers who are likely to adopt metal lamps have already done so. In regard to power supply, the number of units sold has increased by no less than 36 per cent. compared with the previous year's sales, but in this connection it must be remembered that a year ago the demand for power had been affected by the depressed state of trade. Attention may be called to the fact that out of 1,065 H.P. of motors connected to the mains, 395 H.P. is on the restricted hour system, 206,625 units having been sold on this basis during the past 12 months.

STATISTICS as to the operation of arc lamps for street lighting are not always easy to obtain; the figures given by Mr. VIGNOLES are, therefore, of interest. He mentions that of the 230,408 lamp-hours during which the open type arc lamps were in use, the lamps were reported "out" for 1,564 lamp-hours—that is, 0·68 per cent. of the total. The existing arc lamps, however, are to be changed to flame lamps, the cost of the alteration to be met out of the profits of the undertaking, and we do not doubt that Mr. VIGNOLES' estimate of considerably improved results as regards "extinctions" will be realised. In view of the heavy penalty attaching to "extinctions" in the recent Westminster street lighting contracts, it is not unlikely that greater attention will in future be paid to the recording and minimising of failures.

Loans for Service Mains.

As is well known, the attitude of the Local Government Board has of recent years become more critical in regard to the sanctioning of loans for electricity supply undertakings, and certain expenditure, which at one time would have been placed to capital, has now to be met out of revenue. At a Local Government Board inquiry at Grimsby some little time ago the inspector intimated that money borrowed for service mains would in future have to be repaid in 15 years. This step is only in keeping with the present tendency of the Board to restrict the period for which loans are granted and to refuse loans for small expenses. It will be remembered that loans for mains have hitherto been sanctioned for a term of 30 years; where, however, loans can only be obtained for short periods it may sometimes be preferable to endeavour to meet the expenditure out of revenue. Under the circumstances mentioned above, Mr. VIGNOLES has recommended the Committee to consider the question of adopting this course for the laying of services at Grimsby. There is little doubt, however, that such a policy must tend at times to restrict the expansion of an undertaking, especially in its early years. In this connection it will be remembered that the Board have already required that meters should be provided out of revenue, so we hope a similar policy will not be pushed too far.

Fiscal Discussion.—We are asked by the National Electrical Manufacturers' Association to draw attention to the adjourned discussion on the Comparative Effects of Free Trade and Protection upon the Electrical Industry, which will take place on Monday next at Caxton Hall, Westminster, S.W. The chair will be taken at 8 p.m. by the chairman of the Association, Mr. H. W. Butler, and the discussion will be resumed by Mr. E. Garcke.

"Illumination of Interiors."—A course of three lectures on this subject will be delivered at the East London College on Wednesdays, June 8th, 15th and 22nd, at 8 p.m., the first two being given by Prof. J. T. Morris, and the third by Prof. C. A. M. Smith. The first lecture will deal with "Principles and Daylight Illumination," the second with "Artificial Illumination by Gas and Electricity," and the third with "Illumination by Petrol Air Gas." Admission to this course is free, and application for tickets should be made to the Registrar.

Street Lighting.—In last week's issue of the "Journal of Gas Lighting" the writer of "Electricity Supply Memoranda" makes some disparaging remarks about the Jandus regenerative arc lamp and recent victories achieved by that lamp over high-pressure gas. Reference is also made to an interview with Mr. A. Denman Jones, manager of the Jandus Arc Lamp & Electric Co., which appeared a short time ago in our columns. In the correspondence columns of our present issue will be found a letter in which Mr. Denman Jones replies to the criticism of our contemporary, and gives some interesting figures.

Cable Interruptions and Repairs.

	Date of Interruption.		Date of Repair.
Assab—Perim	July 8, 1909	...	—
Balik Papan—Kwandang	Nov. 1, 1909	...	—
Malta—Tripoli	Aprll 20, 1910	...	—
Para—Pernambuco	April 25, 1910	...	June 1, 1910
Mosambique—Majunga	May 3, 1910	...	—
Suakim—Jedda	May 6, 1910	...	—
Bonny—Duala	May 6, 1910	...	May 30, 1910
Madagascar—Reunion	May 12, 1910	...	—
Reunion—Mauritius	May 20, 1910	...	—
Lattaquie—Talura	May 26, 1910	...	—

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Obituary.—ALFRED COLSON.—We regret to record the death of Mr. Alfred Colson, which occurred at Leicester on Friday last. The deceased was gas and electric light engineer to the Leicester Corporation. Mr. Colson was born in 1854, and received his early engineering education under his father, who at that time was engineer to the London & South-Western Railway. After finishing his apprenticeship he took up gas engineering in London, and held a position at one of the large metropolitan gas works. In 1872 he moved to Birmingham, becoming assistant engineer to Mr. Chas. Hunt, one of the most celebrated gas engineers of his time. In 1882 Mr. Colson was appointed gas engineer at Leicester, a position he was holding at the time of his death. During the 10 years of his office he carried out a number of extensions to the works, and generally improved the method of manufacture and distribution. In 1893 the Leicester Corporation decided to erect works for the supply of electricity. These were built under Mr. Colson's superintendence, and when they were finished he was placed in charge of the electricity supply in Leicester. Although several years ago he was offered the position of engineer-in-chief of the Gas Light & Coke Co., he preferred to remain at Leicester. He was the inventor of many patents, and his services as consulting engineer on gas questions were frequently sought.

Insulating Materials for Wireless Telegraphy.—At a meeting of the Wireless Institute, held at the Engineering Societies' Building, New York, on May 4, Mr. S. M. Hills read a Paper dealing with materials for resisting dielectric stress, mechanical rupture, flow of electricity and heat, and the action of chemicals. He gave an outline of the electrical, mechanical and chemical characteristics of air, oil, marble, hard-rubber, porcelain, glass paper, mica, wood, lava and various compositions. He stated that where the distance was not limited, dry air formed a good insulator, and compressed air could be used where high voltages were encountered. Dry oil made an excellent insulator on account of its self-healing properties. Hard rubber was apt to deteriorate with age. Marble was hygroscopic and irregular in mechanical characteristics. Porcelain was surprisingly strong mechanically, but was apt to possess unknown defects. Glass was very fragile, but its defects were visible upon superficial examination. Mica was extremely good for localities where oil or moisture would not be encountered. Wood was a good insulator when kept perfectly dry and it had good mechanical properties. Mr. R. H. Marriott remarked that hard rubber and wood were frequently used for strain insulators in the guys for wireless masts. Oak had proved good for this purpose. In some of the early stations use was made of rope for strain insulators. Porcelain compression insulators had many excellent characteristics for wireless installations. Mr. A. N. Goldsmith described the use of an insulating material of lava which could be moulded into any desired shape and then baked to form an insulator possessing excellent electrical, mechanical and chemical properties. Mr. J. J. Frank mentioned the fact that moisture was detrimental to the performance of practically all insulators. A very small percentage of moisture greatly lowered the insulating strength of oil. Solid insulators could be kept free from moisture by maintaining them at a temperature higher than their surroundings or blowing warm, dry air across them.

The Corrosion of Metals.—We understand that the Council of the Institute of Metals have decided to undertake an investigation into the causes of the corrosion of non-ferrous metals by sea water, acids, &c., and by other chemical and electrolytic reactions. A committee has been appointed for the purpose of carrying out the investigation, and at their first meeting decided in the first instance to confine their attention to the question of the corrosion of condenser tubes in marine engines and in stationary engines using foul water or subject to violent electrolytic action, such as often occur in electric power stations. Before commencing experimental research, the committee propose to have prepared an epitome of such information on the subject as is already available from previous research in the same direction. Mr. G. D. Bengough, of the metallurgical department of the University of Liverpool, has been asked to undertake this work and to become a member of the committee. On the completion of the work by Mr. Bengough it will be submitted to the committee, who will then consider what steps shall next be taken in the matter of further investigation and experimental research, with a view to elucidating the various mysteries of corrosion which are the source of so much trouble and anxiety both to users and manufacturers of articles composed of copper and its alloys. Prof. H. C. H. Carpenter, M.A., Ph.D., of the University of Manchester, whose work for the "Alloys Research Committee" of the Institution of Mechanical Engineers is so well known and highly appreciated, has kindly undertaken to act as honorary secretary to the committee. The result of the committee's researches will be at the disposal of members of the Institute of Metals, which already includes in its membership most of the leading manufacturers and users of non-ferrous metals; and, doubtless, those who have not as yet thought it worth their while to associate themselves with the Institute will, in view of the useful and most important work which it has now initiated, be anxious to join its ranks. This trouble of corrosion is one which has long given infinite cause of annoyance and anxiety to all who have to deal with non-ferrous metals, and above all to marine engineers, and it cannot fail to be a matter of general congratulation amongst engineers that the solution of the problem has now been undertaken seriously by a body so competent to deal therewith as the Institute of Metals, which comprises within its membership makers, users and scientists, and, therefore, has at its disposal information such as no other body possesses or could hope to possess.

Electricity Supply in Brussels.—According to "The Times Engineering Supplement," the extra traffic arising in consequence of the Exhibition has made an extension to the generating plant of Brussels a necessity, and it has been decided in view of the increase in connections to extend considerably the output of the station. The equipment consists of five four-cylinder tandem compound reciprocating engines of the horizontal type, each driving a 1,500 kw. alternator. The most economical load of four of these, however, is only 1,100 kw., and as the *maximum* demand for power before the opening of the Exhibition sometimes amounted to 6,600 kw., it was evident that additional plant was urgently required. After considerable discussion, it was decided to instal a 4,000 kw. turbo-alternator, and the machine was recently set to work. The normal speed of the turbine is 1,500 revs. per min., which is high for this power, and hence the machine is relatively small. There are seven nozzles, all of which are automatically opened and closed by means of the governor, being mounted on a vertical spindle, which is raised or depressed with the governor sleeve. On this vertical spindle are projections which, as the spindle descends, force the horizontal nozzle valve spindles to move inwards and thus to open the nozzles in pairs as the load increases. The speed of the machine can be raised by hand by increasing the pressure on the governor balls, and the same operation can be performed from the switchboard through a small electric motor which operates the same handwheel. There is an automatic runaway governor which shuts off steam from the turbine when the speed reaches 1,660 revs. per min. The working pressure at the stop valve is nine atmospheres (10 at the boilers), and the temperature of the steam is 325°C. The overload capacity is 5,000 kw. for one hour, and the steam consumption is 13·7 lb. per kilowatt-hour at normal load, against a guarantee of 13·8 lb. The existing steam engines take 14·3 lb. per kw.-hr., and there is already a daily saving of about 5 tons of coal, which has caused the directors to consider the question of replacing the reciprocating engines by another turbine. The alternator, the working pressure of which is 6,600 volts, is totally enclosed, except for an air inlet at the bottom and outlet at the top, and the air is drawn in from an enclosed brick chamber underneath, where it has to pass through many rows of filtering cloths before being drawn into the alternator casing, thus avoiding any possibility of damage to the insulation through dust. In accordance with the usual practice,

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the condenser is directly underneath the turbine, and the air and water circulating pumps are both driven by a 100 H.P. turbine (one on each side) at 1,400 revs. per min., the air pump being of a rotary type. The pump for returning the condensed water to the boilers is also driven by a small steam turbine at 5,000 revs. per min., but the water can also flow to waste if desired. The turbine runs excellently in parallel with the reciprocating engines, and will no doubt be the forerunner of many similar installations in some of the larger and older tramway stations.

Telephone Train Despatching on the Great Northern Railway of America.—According to the "Electrical Review and Western Electrician," the Great Northern Railway, which at the present time is using the telephone to dispatch its trains on divisions covering approximately 2,100 miles of its line, is now planning a further extension of this system. The apparatus to be installed will be the Cummings-Wray selectors and Western Electric telephones, as this style of equipment has been adopted as standard by this railway, and is now in use on the present circuits. Two hundred and ninety stations will be completely equipped for the new class of service. An interesting feature of this installation will be the placing of telephones at sidings and at stations which are not open during the whole 24 hours, 350 telephones being required. While the train crews in this way can reach the dispatcher at any time, the important fact is that the dispatcher can get in touch with the train crews waiting at any siding.

Electricity in a Gas Company's Building.—The "Electrical World" states that the new building of the People's Gas Light & Coke Co. in Chicago will be supplied with both electricity and gas for lighting purposes. The Commonwealth Edison Co. will furnish the electrical energy, and the building is being wired for about 18,500 16 c.p. incandescent electric lamps and 1,400 H.P. in electric motors for lifts and other purposes. There will be 15 electric lifts, including 14 for passengers and one for goods. These lifts will be of the recent one-to-one traction type made by the Otis Elevator Co. In addition, there will be motors to drive ventilating fans, blowers, house pumps, coal conveyers, centrifugal pumps, vacuum pumps, &c. Such a large amount of electricity will be required for the general purposes of this building that the contract for supplying it is based on the central station company's regular wholesale schedule for light and power. This schedule applies only to large users of electricity, and in ordinary cases office buildings do not fall within the rates which it provides. Tenants will have the option of using electricity or gas, or both, for lighting. The gas company itself will use gas for lighting its offices and salesrooms, as may be imagined. A portion of the building is now occupied, and temporary gas fixtures are in place. Ultimately, however, all fixtures in tenants' rooms will be combination fixtures, so arranged that the gas lighting will be indirect and the electric lighting direct. Mantles will be attached to the gas burners, of course, and it is probably the theory of the gas company that the indirect gas lighting will be pleasing to tenants and more economical than the electric light. The actual results of the experiment—that is, the proportion of tenants using the gas and electric light, respectively—will be of interest when the building is fully occupied and sufficient time has elapsed to enable the tenants to make an intelligent choice.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Dr. C. V. Drysdale contributes an article on "The Determination of the Efficiency of Direct-Current Machines" by the Hopkinson test.

We give an account of the electrical features of the main drainage scheme in Glasgow.

At the election of the Council of the Institution of Electrical Engineers last week the outside nomination (as distinct from nominations by the Council) of Mr. H. Faraday Proctor was successful.

At the meeting of the Institution of Electrical Engineers last week the Annual Report of the Council was presented.

We conclude our abstract of the Paper on "Standardisation of Fuses," read by Mr. H. W. Kefford before the Birmingham local section last week.

We give a further account of the electrical exhibits at the Brussels Exhibition.

Ventnor (Isle of Wight) Council have decided to consider the question of constructing an electric tramway in the district.

The Board of Trade arbitrator, Mr. S. Buckmaster, K.C., has given his award in the dispute between Stretford Council and Manchester Corporation as to the supply of electrical energy for abnormal traffic on the Stretford lines, caused by football matches, &c.

Extensions of the Sheffield electricity supply works are to be carried out at an estimated cost of £78,000.

Legal.—In the action Wheeler *v.* Marylebone (London) Borough Council, plaintiff recovered damages for injuries caused to plaintiff by coming into contact with a service cable in a house which he was demolishing preparatory to rebuilding.

Companies' Meetings.—At the meeting of the Anglo-Argentine Tramways Co. on Wednesday, resolutions were passed increasing the capital by £8,000,000 to provide for the construction of new subway lines in Buenos Ayres, &c.

INSTITUTIONS AND SOCIETIES.

THE INSTITUTION OF GAS ENGINEERS.—The annual general meeting of this Institution will be held in the hall of the Institution of Mechanical Engineers, at Westminster, under the presidency of Mr. J. W. Helps, Engineer and General Manager to the Croydon Gas Co., on Tuesday, Wednesday and Thursday, June 14 to 16. The president's address will be delivered at the opening of the proceedings, after which a Paper on "Public Lighting from a Municipal Point of View," by Mr. Jacques Abady, will be read and discussed. Other Papers on subjects of interest to gas engineers will be dealt with on the subsequent days.

SOCIETY OF CHEMICAL INDUSTRY.—The Scottish Section of this Society will hold their annual meeting in Glasgow from July 6th to 8th inclusive.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, June 4th.

ROYAL INSTITUTION.

3 p.m. Lecture on "Electric Heating and Pyrometry," by Prof. J. A. Fleming, F.R.S. (The Tyndall Lectures.) (Lecture I.)

MONDAY, June 6th.

NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION.

8 p.m. Meeting at Caxton Hall, Westminster. Adjourned discussion on "The Effect of Free Trade or Protection upon the Electrical Industry," to be opened by Mr. E. Garcke. Admission will be by visiting card.

THURSDAY, June 9th.

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

10:30 a.m. Congress at Dublin. (Headquarters Imperial Hotel.) Official reception; followed by the reading of Papers.

FRIDAY, June 10th.

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

Congress at Dublin. Visits to power station, &c.

PHYSICAL SOCIETY.

8 p.m. Meeting at the Imperial College of Science, Imperial Institute Road, South Kensington. Agenda: "A Galvanometer for Alternate Current Circuits," by Messrs. W. E. Sumpner and W. C. S. Phillips, and "The Positive Electrification due to Heating Aluminium Phosphate," by Mr. A. E. Garrett.

SATURDAY, June 11th.

ROYAL INSTITUTION.

3 p.m. Lecture on "Electric Heating and Pyrometry," by Prof. J. A. Fleming, F.R.S. (The Tyndall Lectures.) (Lecture II.)

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. B. Crompton, C.B.

Monday, June 6th. "A" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Technical Drill, 7 to 9:30 p.m.

Tuesday, June 7th, "B" Company.—Technical Drill, 7 to 9:30 p.m.

Wednesday, June 8th.—Gymnasium, 6 to 9:30 p.m.

Thursday, June 9th, "C" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Technical Drill, 7 to 9:30 p.m.

Friday, June 10th, "D" Company.—Recruits' Infantry Drill, 6 to 6:45 p.m. Technical Drill, 7 to 9:30 p.m.

Saturday, June 11th.—Musketry at Runemede. This course is now compulsory. Names must be sent in as soon as possible for this shoot. Next shoot after this, July 30th.

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INSTITUTION OF ELECTRICAL ENGINEERS.

At the general meeting held on Thursday evening last week at the Royal Society of Arts, the chair was taken by Mr. W. Duddell, F.R.S., who read a letter from the president, in which Dr. Kapp stated that he regretted that he was unable to be present, but he hoped to be about again in a fortnight's time.

Mr. Duddell moved that the following resolution of the Council be adopted by the Institution. "That the Council of the Institution of Electrical Engineers, in special meeting assembled, hereby record their sense of the deep loss which the British Empire has sustained through the lamented death of His Majesty King Edward VII., and their sorrow that one who spent his life for the good of his people, and to whom his subjects were affectionately devoted, has been removed from the scenes of his unremitting labours, and that a reign marked by unparalleled social, scientific and industrial progress has thus been brought to a close.

"The Council humbly beg permission to express to His Majesty King George V., the Queen Mother, and to the Members of the Royal Family, their sincere condolence and sympathy, and further to lay before His Majesty the assurance of their unswerving loyalty and devotion, and their earnest wishes that he may, with Her Majesty Queen Mary, long be spared to reign in happiness and peace over a loving and united people."

This resolution having been adopted, Messrs. W. A. Chamen, R. J. Wallis-Jones, C. S. Thomson and R. W. Hughman were appointed as scrutineers of the ballot for the election of five new members of Council. At the conclusion of the meeting the result of this ballot was declared as follows :—

P. V. McMahon	854	votes.
S. L. Pearce	852	,,
H. Dickinson	846	,,
R. K. Morcom	842	,,
H. Faraday Proctor	696	,,
J. E. Kingsbury	438	,,

The Council for the session 1910-11 will therefore be as given in our issue of April 22nd, except that Mr. H. Faraday Proctor's name must be substituted for that of Mr. J. E. Kingsbury.

In moving the adoption of the annual report of the Council, of which an abstract is given below, the chairman called attention to the more important points mentioned therein; and after Mr. Robt. Hammond had dealt with the statement of accounts for the past year, the usual votes of thanks to the Institution of Civil Engineers and the Royal Society of Arts, and to the officers of the Institution were moved and adopted.

As the scrutineers of the ballot had not completed their task, the meeting adjourned and a special general meeting was held to pass the following resolution :—

"That, in addition to the sum of £20,000 authorised by special resolution of July 29, 1909, to be expended, a further expenditure of a sum not exceeding £10,000 in connection with the Institution building on (*a*) structural alterations, furniture and fittings, and (*b*) outlays during present or future structural alterations, including ground rent, rates and taxes, less rents received or to be received from tenants in the building, be sanctioned and approved, and that the Council be authorised to make such financial arrangements (including the borrowing of money on the security of the Institution building and on the Institution property in Tothill-street) as the Council may consider necessary for the above purpose."

Mr. Hammond explained that there had been a considerable loss on the sale of securities in providing funds for the new building. This loss, he thought, should form part of the cost of providing the new building. If this were done, however, the Council's estimate was exceeded by £1,100 to £1,200. In order to obviate the need for special meetings in the future to sanction any expenditure which might have to be met within the next two or three years, the Council asked for authority to expend a sum not exceeding £10,000, although it was not expected that anything approaching this amount would be required.

The chairman then moved the above resolution, which was seconded by Mr. Kaye Gray. Mr. W. B. Esson asked Mr. Hammond for an explanation of the reason why the original estimate of the Council had increased to such an extent. In this connection he drew Mr. Hammond's attention to his (Mr. Hammond's) statement two years ago that £56,000 was to be the total cost of the new building, whereas now the Council were asking for sanction to expenditure which would bring the total cost to £80,000.

Mr. Hammond, in reply, explained that on taking over the building and going more fully into the question the Council found that drastic alterations would be required to the theatre if the members were to obtain a first-class result, which there was no doubt they desired. At the first opportunity (July 29, 1909) the Council explained the position to members and asked for sanction to the expenditure of £70,000. This sum had merely been exceeded by, say, £1,100-£1,200. In reply to Mr. W. R. Cooper, Mr. Hammond stated that the £10,000 now in question was not to be used (except approximately to the extent of the small sum mentioned) for the alterations now in progress.

No further questions being asked, the resolution was put to the meeting and passed unanimously. The adjourned annual meeting was then resumed, and the result of the ballot for the election of five members of Council was declared as above. This concluded the business of the meeting.

The following is an abstract of the report of the Council :—

Growth of the Institution.—Since the last annual general meeting, 505 proposals for election have been considered, and there have been elected 8 members, 215 associate members, 6 associates, and 233 students. To the class of members there have been transferred 39 associate members and 12 associates, to the class of associate members 28 associates and 117 students, and to the class of associates 3 students. The total roll is now 6,222, compared with 6,097 in the previous year, and is composed of 7 honorary members, 1,173 members, 2,629 associate members, 938 associates, 1,370 students, and 105 foreign members.

Among well-known members who have died since the last annual general meeting are Sir Charles Todd, K.C.M.G., F.R.S. (local hon. secretary and treasurer for South Australia from 1881 to 1906), Mr. Shelford Bidwell, F.R.S., Major P. Cardew, R.E., Mr. Hugh Erat Harrison, B.Sc., and Mr. J. Oldham (local hon. secretary and treasurer, Uruguay).

Meetings and Papers.—During the past session 15 general meetings, 2 special general meetings, and 19 council meetings have been held. There have been 45 meetings of local sections, viz., 7 at Birmingham, 7 at Dublin, 7 at Glasgow, 11 at Manchester, 6 at Newcastle, and 7 at Leeds and Sheffield. A complete list of Papers and original communications, with the places where read, is given in the report.

Scholarships.—The Council have awarded a Salomons Scholarship of the value of £50 to Brian Charles Clayton, of King's College, and David Hughes Scholarships, of the value of £50 each, to George Wood Pearce Page, of the Central Technical College, and to Archibald Davidson Peacock, of University College.

Premiums.—The Premiums for Papers and communications have been awarded as follows: The Institution Premium, value £25, to Mr. Miles Walker, for his two Papers, "Short Circuiting of Large Electrical Generators and the Resulting Forces on Armature Windings," and "The Design of Turbo Field Magnets for Alternate-current Generators, with Special Reference to Large Units at High Speeds"; the Paris Electrical Exhibition Premium, value £10, to Prof. A. Schwartz, for his Paper, "The Testing of Rubber for Electrical Work"; the Fahie Premium, value £10, to Mr. S. G. Brown, for his Paper, "A Telephone Relay"; a Premium, value £10, to Messrs. W. P. Digby and D. B. Mellis, for their Paper, "Some Properties of Switch and Transformer Oils"; a Premium, value £10, to Mr. G. W. Worrall, for his Paper, "Commutation Phenomena and Magnetic Oscillations Occurring in Direct Current Machines"; a Premium, value £5, to Mr. F. Hope-Jones, for his Paper, "Modern Electric Time Service"; a Premium, value £5, to Mr. F. H. R. Lavender, for his Paper, "Research on Metallic Filament Lamps"; a Premium, value £5, to Mr. Albert Campbell, for his original communication, "On Magnetic Testing of Iron with Alternating Current"; a Premium, value £5, to Mr. C. F. Smith, for his original communication, "The Relation between the Stator and Rotor Circuits of the Single-phase Induction Motor"; a Premium, value £5, to Mr. L. W. Wild, for his original communication, "The Production, Measurement, and Effect of Variable Wave-Form." The Council have also awarded the Willans Premium (of which an award is only made every sixth year) to Mr. J. H. Rider, for his Paper, "The Electrical System of the London County Council Tramways." Students' Premiums have been awarded to Messrs. R. C. Plowman, A. P. Young, P. J. Cottle, J. A. Rutherford, P. Kemp, W. A. Stephens, and W. H. Young.

Students' Section.—At the opening meeting of the session an address to the students was delivered by Mr. J. H. Rider on the subject of "The

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Importance of Attention to Detail." Ten meetings of the Students' section have been held in the library of the Institution, at which Papers were read and discussed. The Students' committee organised a very successful visit to Berlin in the summer of 1909. The Glasgow and Manchester branches of the Students' section have each completed a successful session, having held six and nine meetings respectively.

The Institution Building.—The structural alterations necessary to adapt the building to the requirements of the Institution have been in progress since August of last year. It is expected that the offices will shortly be transferred to the building, and that the lecture theatre, library, and members' rooms will be ready in time for the opening of the new session.

The British Electrotechnical Committee.—The British committee for 1910 is constituted as follows: The Council for the time being of the Institution, with the addition of Mr. K. Edgcumbe, Mr. S. Z. de Ferranti, Mr. C. D. Le Maistre, Mr. H. W. Miller, Lord Rayleigh, O.M., F.R.S., Capt. H. R. Sankey, R.E. (ret.), Mr. C. P. Sparks, Mr. A. P. Trotter, and Mr. E. B. Vignoles. In view of the removal to the new building it was felt that it would be an advantage to transfer the work of the committee to the Institution. The committee having given their consent, the transfer was effected in January of this year, and the work is now carried on in the offices of the Institution. During the last session the committee and its sub-committee on Nomenclature and on Symbols have held eight meetings and have made satisfactory progress.

An informal meeting of the Electrotechnical committees of the various countries will take place at Brussels next August. This will afford an opportunity for an exchange of views, and will considerably facilitate the work of preparation of the several committees for the official international meeting arranged to take place in Berlin in 1911.

Wiring Rules.—The revision in progress has been carried further than was at first intended. By the kindness of Dr. R. T. Glazebrook, F.R.S., Director of the National Physical Laboratory, tests are being made with reference to certain data in the rules. It is hoped that the revised edition will be ready before the end of the year.

Model General Conditions for Contracts.—The conditions which were issued in 1903 are under revision.

Professional Conduct.—The Council have decided to adopt the regulations relating to professional conduct recently incorporated in the by-laws of the Institution of Civil Engineers, and subject to the proposal receiving the sanction of a special general meeting of members and associate members, these regulations will be embodied in the articles of association and be applicable to members of all classes. The regulations are as follows:—

Every member of the Institution shall observe and be bound by the following regulations: (1) He shall act in all professional matters strictly in a fiduciary manner with regard to any clients whom he may advise, and his charges to such clients shall constitute his only remuneration in connection with such work, except as provided by clause 4. (2) He shall not accept any trade commissions, discounts, allowances, or any indirect profit in connection with any work which he is engaged to design or to superintend, or with any professional business which may be entrusted to him. (3) He shall not, while acting in a professional capacity, be at the same time, without disclosing the fact in writing to his clients, a director or member of, or a shareholder in, or act as agent for, any contracting or manufacturing company or firm or business with which he may have occasion to deal on behalf of his clients, or have any financial interest in such a business. (4) He shall not receive, directly or indirectly, any royalty, gratuity, or commission on any patented or protected article or process used on work which he is carrying out for his clients, unless and until the receipt of such royalty, gratuity or commission has been authorised in writing by those clients. (5) He shall not improperly solicit professional work, either directly or by an agent, nor shall he pay, by commission or otherwise, any person who may introduce clients to him. (6) He shall not be the medium of payments made on his clients' behalf to any contractor or business firm (unless specially so requested by his clients), but shall only issue certificates or recommendations for payment by his clients.

Any alleged breach of these regulations, or any alleged professional misconduct by a corporate member which may be brought before the Council, properly vouched for and supported by sufficient evidence, shall be investigated, and if proved shall be dealt with by the Council either by expulsion of the offender from the Institution or in such other manner as the Council may think fit.

Examinations for Associate Membership.—A committee has been appointed by the Council to consider and report on the question of an examination for associate membership.

Articles of Association.—As no alteration has taken place in the articles of association for the past five years, a committee has been appointed to consider and to report whether any alterations are necessary, and any suggestions which the members may desire to make will be welcome.

Electricity in Mines.—A number of suggestions were received from members and were carefully considered. A letter embodying the Council's views and recommendations was forwarded to the Home Office committee. Mr. W. H. Patchell also attended at the Home Office and gave evidence on behalf of the Council.

Electricity in Textile Mills.—A committee appointed by the Council to report on the question of electrical driving in textile mills are at present engaged in collecting the data available in collaboration with the local sections interested.

Building Fund.—The attention of members generally is called to this fund. The Council hope that there will be a large increase in the number of contributors, and they wish to point out the importance, in the aggregate, of even small annual subscriptions.

Benevolent Fund.—The committee of management report that the benevolent fund of the Institution shows a satisfactory increase for the past year. On December 31, 1909, the capital account of the fund stood at £3,500, as compared with £3,000 at the end of 1908. The donations to the fund in 1909 include one of £25 from the committee of the electrical engineers' ball. Grants in aid amounting to £77 were made during 1909. The Wilde Benevolent Trust Fund stands at £1,744. 16s. One grant in aid of £25 was made from the income of the fund during 1909.

Annual Accounts.—The report of the hon. treasurer, Mr. Robert Hammond, shows that the balance carried to the general fund at the end of 1909, being excess of income over expenditure, was £3,283. 3s. 11d., as compared with £3,253. 9s. 3d. for 1908. In this comparison no account is taken of outlays in connection with the acquisition of the Institution building. The balance-sheet shows that the total assets amount to £84,906. 17s. 3d., against which are to be set liabilities amounting to £29,081. 2s. 3d., leaving as the net assets of the Institution £55,825. 15s. This amount is almost entirely locked up in the acquisition of the lease of the Institution building, in the structural alterations, and in the expenses incurred prior to occupation.

In consequence of the acquisition of the lease of the Institution building, the constitution of the building fund account differs materially from that set out in preceding years. The investments have all been realised, and the fund has been augmented as follows: (*a*) Permanently, by transfer of £2,201. 8s. 7d. from the entrance fees fund, and by revenue from the Tothill-street property, subscriptions, donations, dividends, and sundry other items, £1,234. 7s. 5d.; (*b*) temporarily by loans, on mortgage from the Economic Life Assurance Society £26,000, from life compositions fund £5,613. 3s., and from general fund £5,582. 5s. 11d.

The general fund has increased to the extent of £3,283. 3s. 11d. during the past year, and now stands at £10,135. 10s. 8d.

Library.—The Council have now acquired 1,444 out of the 1,623 works which were reported to be wanting to complete the Institution's collection of electrotechnical literature. In addition to these, 67 new books have been purchased since May 20, 1909, and 220 books and pamphlets have been presented by members, publishers, and kindred societies. The total number of readers during the past 12 months was 614, of whom 39 were non-members.

An appendix to the report contains a list of transactions, proceedings, &c., received by the Institution.

THE INSTITUTION OF ELECTRICAL ENGINEERS COUNCIL ELECTION.

The following communication (in the style here shown) was recently sent to a number of members of the Institution:—

FORTHCOMING ELECTION OF MEMBERS OF COUNCIL OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

On or about the 18th inst. a Ballot Sheet will be issued by the Secretary, which will contain the following names of new nominees for election as Members of the Council:—

H. Dickinson, P. V. McMahon,
J. E. Kingsbury, R. K. Morcom,
S. L. Pearce,

who are the nominees of the Council, and also the name of Mr. H. Faraday Proctor, who has been nominated, seconded and supported respectively by Messrs:—

W. A. Chamen, Cardiff (Proposer) C. A. L. Prusmann, Swansea,
W. W. Lackie, Glasgow (Seconder), Walter J. Bache, Cheltenham,
H. Collings Bishop, Newport, R. A. Chattock, Birmingham,
Arthur Ellis, Cardiff, T. O. Callender, London,
H. D. Munro, Exeter, David E. Roberts, Cardiff,
E. G. Okell, Plymouth, Theodore Schontheil, Cardiff, and
Herbert T. Sully, Bristol, A. J. Hodgson, Chelmsford.

Mr. H. Faraday Proctor comes of the same family as the famous Michael Faraday. He is a member of the Institution of Civil Engineers as well as of this Institution, and is a Past President of the Incorporated Municipal Electrical Association, of which he was one of the Founders, and of which he is, since 1905, Honorary Secretary.

He is the Electrical Engineer to the Corporation of Bristol, which position he has held since 1892, having previous to that date been Assistant Engineer to the Newcastle-on-Tyne Electric Supply Company.

He has always taken a very active part in all legislative matters connected with Electrical Engineering, and is well known for his steady and continued application to whatever work lies before him.

The nomination is made in accordance with Section 45 of the Articles of Association. Although this power to nominate has existed for many years past, **this is the first occasion upon which there has been an Election,** because the number of nominees put forward by the Council has always been sufficient only to fill the number of vacancies, and no one outside the Council has hitherto put forward any other nomination.

The result is that many members of the Institution feel that they have no interest in the election of the Council, and there is not that universal feeling of loyalty to the Institution which is so very necessary to its continued success.

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The nomination of Mr. Proctor has not been made out of any feeling of antagonism to the Council, but on account of a genuine desire to further the true interests of the Institution **by giving its members an opportunity of voting by ballot for members of Council, as is the case every year in other Institutions**, and also on account of a desire to increase the provincial representation upon the Council **and particularly to place thereon a member intimately acquainted with the West and South-Western Districts of England and South Wales**.

It is strongly felt that by putting upon the Council a man possessing Mr. H. Faraday Proctor's special qualifications for the position, and one who is able regularly to attend the Council Meetings as Mr. Proctor will be able to do, not only will the existing members in the District concerned take a greater interest in the Institution, but a considerable further number of Electrical Engineers who are at present holding aloof will be induced to join.

There is some danger in districts where the use of electricity is developing greatly, as it is particularly in South Wales, that other Institutions will take the place which should be held by the Institution of Electrical Engineers.

For these reasons your vote is asked for Mr. H. Faraday Proctor.

In order to make the votes of those who wish to put Mr. Proctor upon the Council as effective as possible, **it will be necessary for them to decide unanimously upon the name of one of the other nominees which shall be struck out**, as there will be one more name upon the ballot sheet than there are vacancies to be filled.

As provincial representation is of great importance to the well-being and wide-spread popularity of the Institution, it is suggested that the names of Mr. H. Dickinson, Mr. R. K. Morcom and Mr. S. L. Pearce should not be struck out, and of the two remaining names, although it is regretted that either should have to be struck out, it is felt that as Mr. J. E. Kingsbury has already served several times as member of Council and has been a Vice-President, it would be better to put Mr. P. V. McMahon upon the Council at the present time. Mr. McMahon has not yet served in that position, and he represents Electrical Railway Engineering, of which particular branch of the profession there is so far no member upon the Council.

While, therefore, Mr. Proctor's supporters fully appreciate the services which Mr. Kingsbury has hitherto rendered to the Institution, and do not at all wish to prevent his being returned to the Council again at some other time, they feel obliged upon this occasion to suggest that his name be struck out on the ballot sheet.

You are reminded that **all members, associate members and associates of the Institution** whose subscriptions are not more than six months in arrear **are entitled to receive ballot sheets and to vote** (See Sections 36 and 45 of the Articles of Association, which are to be found with the list of officers and members issued each year). The ballot sheet must be returned at or before the Annual General Meeting on the 26th inst.

W. A. CHAMEN,
ROYAL CHAMBERS,
PARK PLACE, CARDIFF.

May 13, 1910.

THE ELECTRIC FURNACE IN THE IRON AND STEEL INDUSTRY.*

BY G. HOOGHWINKEL.

The writer proposes in the following remarks to give an idea of the results obtained with various types of electric furnaces both for smelting and refining work. This seems all the more desirable as considerable progress is being made in other countries, although the conditions are better perhaps here than anywhere else. England, and especially Sheffield, are always held up, and with ample reason, as the home of the special steels, the most modern development of the steel industry. The use of, and the demand for these special steels is increasing every day, and it is not rash to predict that in the near future most of the steel produced will be special steel containing one or several of the rarer metals, and to a chemical and physical specification varying in each case and for each special purpose, among which steels may be mentioned high speed tool steel, steel for motor cars, and perhaps aeroplanes, steel for special castings, boiler plates, steel for railway trucks, special track work, bridge girders and rails. Nearly all these steels have been manufactured in the electric furnace in various countries, and it will not be long before no steel works will be complete without one or more electric furnaces to supply the ever-growing demand for special steels at reasonable prices, and especially to definite and stringent specifications, and of exactly the same composition for repeat orders. The last-named condition is of special importance where special steels are concerned, and it is at present exceedingly difficult to obtain, even where very high prices are being paid. The writer is at present advising on a steel refining furnace for the production of a special steel entirely free from phosphorus, as it was found impossible to obtain this particular steel of always exactly the same composition.

* Paper read before the Sheffield Society of Engineers and Metallurgists. Slightly abbreviated.

A.—By far the greatest demand, however, will arise when once the various railway authorities have settled upon a new rail for main lines, the present rails being entirely unsuitable both chemically and physically to stand the great strains to which they are submitted, by express traffic, during a reasonable period. A beginning in this direction is being made in Germany, where the State Railway authorities have issued a specification for electric steel rails specifying higher figures for the physical tests and resistance to wear than is usual for ordinary basic rails, viz., a tensile strength of 99,000 lb. per square inch against 85,000 lb. per square inch. They also require a guaranteed life of 10 years for the track rails. The actual test figures obtained with both quality of rails were 119,000 lb. and 97,000 lb. respectively. An electric steel rail, made for the Metropolitan Railway of London, and tested at the Clarence Steel Works of Dorman, Long & Co., Ltd., contained carbon 0·78, silicon 0·196, manganese 0·285, sulphur 0·035, phosphorus 0·022. By the Brinell hardness test, with a 19 mm. ball and 50 tons pressure, it gave an impression 3·7 mm. in diameter. With a 2,240 lb. drop test falling 25 ft., it gave 3·56 in. deflection; second fall of 21 ft. did not break it, but broke at the third blow with 37 ft. fall.

The following results have been obtained from some 80 lb. electric steel rails rolled in the United States, carbon content 0·80 per cent.

Weight of Tup, 2,000 *lb. Distance between Bearings*, 4 *ft.*

No. of drop.	Height of drop.	Total deflection in inches.
1	20 ft.	2·5
2	10 ft.	3·5
3	10 ft.	4·2
4	10 ft	Broken.

The same may be said of steel castings produced in the electric furnace. It has been found that the chemical, physical and machining qualities of such castings are far superior to those produced in crucibles on account of the facility and safety with which any specified quality can be produced. In short the electric furnace will be found a necessity in all large steel works for the production of high-class uniform steel for different purposes in large quantities and to various specifications at reasonable prices. This is the first and most important source of demand, and the furnace will be used more often as a refining furnace, working on hot charges direct from the converter or mixer, or from a Thomas, Martin or Bessemer furnace, or on cold scrap and pig iron. As will be shown later on, for certain classes of steel, such as fine tool steel, soft steel castings, &c., the latter method is preferable.

The writer wishes to state already at this stage that the cost of electric power enters only to a certain degree into the calculations, as it is only a small fraction of the total cost of production (about 3 per cent. to 8 per cent. for hot and cold charges respectively). It seems that this point is often misunderstood by our steel manufacturers, and that it is thought that the electric furnace is destined to be used only where very cheap electrical power is available. Even with a town supply at a price of between ½d. and 1d. per unit the production of electric steel is a commercial proposition of no uncertain merit. But in the waste gases from blast furnaces and coke ovens, a cheap supply is available for operations on a large scale, and it will be found that this is quite the most economical and profitable way of utilising these waste gases, the other power requirements at the steel works being satisfied from some other source of supply. For town supply stations, and even more for power supply companies, these electric furnaces will supply an excellent load on account of their high load-factor (50 per cent. and 75 per cent. for hot and cold charges respectively). If operations could be so arranged as not to coincide with the peak loads of the supply stations, very low prices could be charged to the advantage of both the supply companies and the steel makers. At the Niagara Falls and other power centres in the States this is actually being done.

B.—The next general use to which the electric furnace will be put is the production of steel castings both for high grade and medium grade products. The electric furnaces for these purposes will be generally of smaller capacities than those referred to before. They will replace the crucible method, to which they are much superior, owing to the absence of the expensive and short-lived crucible with its inherent disadvantages of introducing impurities into the steel. In addition, the high temperature of the cast can be utilised in manufacturing ocmplicated parts. Such castings have been made now for a considerable time in Girod, Stassano, Heroult, Kjellin, and other furnaces with complete commercial success, and they are distinguished by a very long elongation value (25 per cent., with a breaking strength of 60,000 lb. per square inch) a low percentage of sulphur (0·03 per cent.), and phosphorus (0·06 per cent.) This is of particular value for such work as railway and motor car materials, light castings for flying machines, &c. The pure Lancashire and Swedish iron formerly used in the crucible furnace for this class of work cost £10 per ton, and the casting about £15 to £20 per ton.

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The cost of production of these steel castings in a 1-ton Stassano furnace at the Bonn File Works amounted to £9 per ton, including all capital charges. The reason for this difference is:—(*a*) The cheaper initial materials (scrap at 67s. per ton). (*b*) The total cost of current (at ½d. per unit), upkeep of furnace electrodes, &c., together 64s., is considerably less than the cost of crucibles, coke, wages, &c., required by the crucible furnace. Moreover, the handling of a simple pouring furnace is much easier than the separate handling of heavy and cumbersome charged crucibles. The charge of ½d. per unit for power is a fairly high one for work of this class, and electric power can be obtained nearly everywhere in England at that figure from existing electric supply undertakings. It seems, therefore, that the days of the crucible furnace are numbered, and there is no excuse for up-to-date steel works to cling to the antiquated method of the crucible furnace with all its disadvantages. It seems to the writer that this particular field is a very promising one in Sheffield, and can be approached by steel makers without any misgivings as to its commercial results, as in most of the continental plants, excellent results were obtained with untrained men.

The furnaces for this class of work should be from one to three tons capacity, and the cost of such a furnace complete varies from £750 to £1,500 for a 2-ton furnace depending on the type chosen. The requirements for a furnace of this class are different from those of the first category. The small charges required, the desirable simplicity and safety in handling by the existing non-electrical staff, the necessity of using power from existing power supply undertakings are all conditions which do not have the same importance in large installations of the first-mentioned class. A 1-ton Stassano furnace will require about 200 kw. on an average during the four hours the power is required, using about 800 units per ton of steel produced.

There are now quite 60 electric furnaces of this class at work in various countries, and there is no excuse whatever for our backwardness, at least in this particular branch of electric smelting. The production of steel castings by means of the electric furnace has been a commercial success from the very beginning, and the castings produced have been of a better quality in all respects. The plea one so often hears of "novelties which have not yet stood the test of commercial application" can in this case be answered with a list of works where castings are produced in an electric furnace at a price far below that of the products of the crucible furnace. One or more electric furnaces of this type should be installed in every iron and steel works with a pretence of up-to-dateness, and if those responsible for the commercial management of these works would call in the help of the electrician, it would be seen that first cost is in this case not such an insurmountable obstacle as it seems with most improvements with us. Not only in iron and steel works, but also in such works as naval and shipyards, locomotive and carriage works, bridge building works, machine shops, electrical works, &c., small electric furnaces producing steel for castings should be indispensable. The very materials used, such as scrap, trimmings, stampings, punchings, steel and iron borings, &c., which are always produced at such works, point to the utility of such furnaces not only as refuse destructors, but as the means for producing their own castings at a very low price, thereby making them independent of the foundries, and giving them better facilities for regulating their deliveries in accordance with modern demands for promptness.

The electrical furnace will also replace the small converter which is now often used with or instead of the open hearth furnace, *e.g.*, in shipyards. Such a converter as a rule produces a quantity in excess of the requirements, so as to prevent the converter from cooling off. The electric furnace is a combination of the cupola furnace and the small converter, and produces a superior material (less sulphur and phosphorus) from an inferior charge (60s. instead of 90s. for special pig) in smaller quantities, at a lower cost.

A further product to be made in the small electric furnace is malleable cast iron, which is now made in the cupola furnace, the crucible, the small converter and the reverberatory furnaces at higher cost, at least for small quantities (on account of high fuel charges and expensive special pig iron used). It will be necessary, however, to convince the managers of the works referred to that the two supposed bugbears, *i.e.*, heavy maintenance of the furnace and linings and heavy consumption of electrodes, are in reality quite unimportant, at least in some of the better known furnaces. A few figures taken from actual practice with furnaces producing the class of products under discussion will be given at the end of this chapter to illustrate these two points.

In fixing on a particular type of furnace it must be remembered that the initial charge to be used will be cold, contrary in most cases to the process followed with furnaces under class A. A resistance furnace, or better still, a combination furnace, will fulfil the requirements, but all the Héroult, Stassano, Girod and Rodenhauser furnaces have given excellent results for this class of work. Fairly pure materials will always be used, and if no refining but only smelting and "killing" is required, using very pure materials, a plain induction furnace such as the Kjellin will give an ideal crucible steel, as the furnaces of this class will not exceed two tons as a rule. With impure materials, where refining is required, the plain induction furnace is impracticable on account of its inherent electrical disadvantages and the difficulties of obtaining a hot and fairly liquid slag, and handling it. Another type which combines the advantages of the pure resistance furnace (easy handling and regulation) with those of the arc type furnace (adaptability to existing public supply and to all initial materials and products) is the Grönwall furnace, which uses two-phase current in two vertical electrodes, the common return or neutral being through the bottom lining of the furnace. This furnace is extremely simple in construction and requires no rotary movement on account of the vertical and horizontal effect of the two phases. The lining maintenance is very small, the latter only consisting of a rammed mixture of dolomite, or magnesite and tar. The hottest part is also in the slag, as in the other types of arc furnaces, so that refining can be carried on until the desired result is obtained. The conditions which must be satisfied by a furnace for the practical purpose under discussion are:—(*a*) Good thermal efficiency and high power-factor combined with medium output. (*b*) Easy and simple handling, regulation and repairs. (*c*) Adaptability to all kinds of initial materials, hot or cold. (*d*) Must be capable of working with an ordinary three-phase supply, and have a fairly constant energy consumption. (*e*) Must admit of using low voltage at the furnace. (*f*) Must admit of easy refining with a basic slag, even with impure materials high in sulphur and phosphorus contents. (*g*) The bath of molten metal must be homogeneous throughout, even after the refining process has been completed.

There is no type of furnace which unites all the above conditions in the same degree, and in the choice of a suitable furnace one must therefore be guided by local conditions and requirements, and it is here that the expert will have to decide and guide the decision of the works manager.

Without in the least attempting to advocate the use of any par-

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Cost of Production and Repairs in Various Furnaces of Similar Output Obtained from Actual Practice in the Production of Steel Castings.

Girod Furnace at Ugine, 2 tons.

Charge: Cold scrap, turnings and some cast iron and iron ore.
Total time required: Rated at 275 kw., 5 hours per ton of steel.

Lining repairs: (dolomite or magnesite paste)	£0	6	0	per ton
Electrodes consumption: (40 lb. ordinary retort carbon)	0	4	0	„
Energy consumption: (850 kw. hours plus 10 per cent. loss, say 960 units at ½d. per unit)	2	0	0	„
Wages (2 men)	0	4	9	„
Materials charged, say, 1 ton scrap	3	0	0	„
2 cwt. lime, 2 cwt. iron ore, ferro alloys, hammer scale	0	3	6	„
Upkeep of furnace, wear and tear of plant, ladles, &c.	0	12	0	„
Depreciation	0	1	6	„
	£6	11	9	„

Cost of furnace plant complete without power plant, £1,000. In case molten steel from a Bessemer converter, Martin or open hearth furnace is charged into the furnaces, the energy consumption and cost is reduced to one-third of the values given.

Stassano Furnace at the Bonn File Works (replacing 32 crucible furnaces *of* 6 crucibles, each of 75 lb. capacity).

Rating: 185 kw. Charge: Cold. Soft scrap, &c. Smelting period: 3½ hours. Refining period: 1 hour. Total time: 4½ hours. Daily production of cast steel, 3 tons.

Energy consumption per ton of steel, 909 units at ½d.....	1	18	0
Electrodes consumption	0	2	6
Repairs to lining (£20 per lining, 33 charges)	0	11	0
Wages (3 men)	0	8	8
Cooling water (440 gallons per ton)	0	0	5
Upkeep of furnace, wear and tear of plant	0	10	0
Materials: 1 ton scrap.....	3	7	0
44 lb. hammer scale, at 17s. per ton	0	0	4
44 lb. lime, at 12s. per ton	0	0	3
17½ lb. ferro-silicon (12 per cent.), at 150s. ...	0	1	2
9 lb. ferro-manganese (80 per cent.), at 220s.	0	0	11
1½ lb. aluminium	0	1	2
Depreciation, 10 per cent.	0	4	2
Duration, 5 hours..... Total.....	£7	5	7

This means per ton of finished castings 1·5 tons of molten steel, less 0·5 ton of scrap, say, 180s., £9.
Cost of furnace complete, £1,500.
The lining lasted an average of 70 charges.

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Kjellin Furnace at Gysinge.

1½ tons charge of cold pig iron, very pure iron ore, briquetted. Rating, 175 kw. Single-phase, 15 periods, 500 volts, P.F., 0·7. Produced crucible quality steel.

Cost per ton of steel (melting only) :—			
Energy consumption, 809 units, at ½d. (water power)...	£0	7	10
Repairs to lining	0	3	5
General expenses	0	5	7
Wages	0	7	3
Cost of casting	0	4	6
Materials : 1 ton of scrap, at 80s.	4	0	0
Flux	0	2	1
	£5	10	8

The low figure is, of course, due to the low charges for power. Interest and depreciation are also not included.

Rodenhauser Furnace at Volklingen, 2 tons Capacity.

Rating : three phase, 350 kw., 500 volts, 50 periods, 0·8 P.F. Refining only : Charge, hot from basic Bessemer convertors containing 0·08 per cent. phosphorus and 0·1 per cent. sulphur. Product : Crucible steel for castings.

Energy consumption, 390 units at 1·09d.	£1	7	0
Heating up	0	1	2
Repairs to lining (10 days, or 160 tons per lining)	0	1	6
Other repairs	0	0	10
Wages	0	2	0
Materials : 1 ton liquid steel	3	9	0
Mill scale, lime, ferro-silicon	0	4	5
Interest and depreciation (15 per cent.).....	0	1	5
	£5	7	4

Cost of complete furnace, £2,700. The cost of power per unit in this case was, of course, very high.

Héroult Furnace at La Praz, 2½ tons.

Rating : 370 kw., single phase. Charge : cold scrap. Product : crucible steel.

ticular make of furnace, the writer wishes to enumerate the particular conditions which in each type of furnace have proved to be more especially fulfilled. The conditions sub. (*a*) are better complied with the by Héroult, Girod, Grönwall and Rodenhauser furnaces than by others. Condition (*b*) is better satisfied by the Grönwall, Kjellin and Rodenhauser furnaces. Condition (*c*) by the Héroult, Girod, Stassano, Grönwall and Rodenhauser furnaces. Condition (*d*) by the Stassano, Grönwall and Rochling-Rodenhauser furnaces, and, as far as the latter condition, also the Girod furnace. Condition (*e*) by the Girod, Stassano, Grönwall and Héroult furnaces. Condition (*f*) by the Girod, Stassano, Rochling-Rodenhauser and Héroult furnaces. Condition (*g*) by the Rodenhauser, Kjellin, Frick and Grönwall furnaces.

It may be stated generally that all the furnaces using vertical electrodes through the roof of the furnace offer the disadvantages of heavier repairs to the roof lining, due to the unequal heating, and that all furnaces using electrodes have the disadvantage of heavy energy losses (over 10 per cent.) in the electrodes. One of the future modifications will certainly be in the direction of metal electrodes used at an angle of 45 deg. There are several modifications of each of these parent furnaces, but they do not offer material differences in construction, and their advantages and disadvantages are more or less the same as those of the typical furnaces from which they are evolved. Among the simple induction furnaces may be named the Frick furnace (differing only from the Kjellin furnace in the position of the coils), Colby, Hiorth and Schneider furnaces.

The resistance furnaces of the Héroult type, apart from the Girod type, are represented by the Kjellin, du Giffre, Gin and Anderson furnaces. The plain arc furnace is principally represented by the Stassano furnace. In selecting a suitable type of furnace plant in accordance with local requirements, the only guide is, of course, the expert's advice, or to await the results obtained elsewhere. The last practice, in many branches of our industries, has become something of a mania, in strong contrast to the former leading attitude of our manufacturers, and the writer would strongly plead a return to earlier methods.

C.—The third purpose for which electric furnaces should be installed is for the manufacturing of special steels, ferro-alloys, &c. Foundries, for instance, should be each provided with a 200 H.P. or 1 ton furnace to utilise their waste materials in the production of high-priced tool steel. Such works, which require expensive and homogeneous steel for special tools, razors, &c., could easily make or refine their own steel from cheap materials and thereby annually saving amounts entirely out of proportion with the first cost of one or two furnaces, and thus making themselves independent of the steel works, which, on the other hand, are not anxious for small orders of special steels. Other examples may be found in ordnance and similar works, where the broken and rejected shells can be re-smelted and turned into new ones.

Carbon steel for chisels, blades, files, extra hard steels for lathe tools, including such varieties as nickel, chrome, chrome-nickel, tungsten and other alloy steels, also case-hardened steels, will be more and more produced in the electric furnace on account of the absence of the action of the air, which permits of the production of steel without the usual overdose of manganese and silicon, and with a hard surface. A steel for shafts, gearing and springs is being produced at present at Turin in the electric furnace to the following specification :—

—	Elastic limit. tons per	Max. stress. sq. in.	Elongation. %	Contraction %	Resilience. kg.
(A) Annealed at 900°C.	41·9	50·8	18	29	14
Hardened at 800°C. and tempered at 450°C. ..	67·9	76·2	8	32	12
(B) Annealed at 900°C.	41·3	58·4	15	25	11
Hardened at 800°C. and tempered at 450°C. ...	82·5	96·5	6·5	32	6
Nickel steel (5% nickel)—					
Annealed at 900°C.	47·9	49·2	15·5	36	10
Hardened at 800°C. and tempered at 600°C.	59·7	66	9	43	13·5

There are a great many other applications of the electrical furnace for such special purposes which are suggesting themselves every day, but enough has been indicated to give an idea of the extent of these applications. The type of furnace to be used is practically the same as the types indicated under B, but generally of a smaller output, 1 to 1½ tons being a maximum. Here again simplicity in handling is the principal requirement, and the furnace must be easily adaptable to existing sources of electric supply. The cost of such a furnace will not be high, so that it seems that nothing stands in the way of a growing demand for electrical furnaces of small sizes for special work. It may be interesting to give a few results from furnaces actually in commission for this class of work, giving some figures as to cost, &c.

D.—The fourth class of electric furnace consists of the furnaces used for the reduction of iron ores. This type of furnace may be said to be more or less in the process of development, but several furnaces are at work, although the results have not been uniform. This is, of course, due to the composition of the various ores used, and therefore only some general points will be dealt with in this Paper, especially as our home industry is not so much concerned with this furnace at present, although with the rising prices of coal, and coke which are foreshadowed, the smelting of iron ores by means of electricity generated from coal even at home will become a possibility. At present, however, such countries which possess large deposits of iron ore and little coal, such as Mexico, Brazil, Canada, India, South Africa, Spain, &c., but which have ample water power, will derive immense benefits from the electrical furnace.

There are at present two different methods to be considered. The first is practically a small blast furnace combined with electric heating, and the second utilises the refining furnaces of the Stassano and Héroult type. In the latter case steel is produced directly from the ores, but the ores must be very pure and the proportion of carbon and fluxes must be carefully adjusted. The ores used at Turin at the Stassano furnace consisted of finely ground hematite mixed with a limited quantity of carbon and flux, and moulded into briquettes.

For impure ores, magnetite, &c., which are generally found in large quantities in the countries which possess little or no coal, it is more likely that a furnace of the blast furnace type will be selected. These ores are sometimes high in sulphur but free from manganese. In other cases titanium is present. The first experiments with such a furnace were made in Sweden at the Domnarfet Iron Works, and excellent results have already been obtained.

Taking an average for several casts, the production was found to be 2·44 tons of pig iron per electrical horse-power year, with a consumption of 5 kg. of electrodes per ton of pig iron produced. The cost per ton of pig iron was 35s. 8d., taking power at 50s. per electrical horse-power per year. A source of trouble was the accumulation of carbon in the smelting chamber, which had to be removed by discontinuing the gas supply through the tuyeres.

It may be taken for granted from the above experiments that with ore of over 60 per cent. iron in a 2,500 H.P. furnace, 3 tons per electrical horse-power per year may be counted upon.

The Paper concludes with a list of furnaces in operation.

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THE GLASGOW MAIN DRAINAGE AND SEWAGE DISPOSAL WORKS.

Summary.—An account is given of the electrical features included in the immense drainage scheme recently laid down by the Glasgow Corporation. Among the features of interest are electric pumping, an electricity supply station and special electrical plant for clearing the catchpit.

The third and last section of this important scheme was formally opened on May 2nd by Lord Provost McInnes Shaw.

The whole scheme, next to that of the London County Council, is the largest of its kind in the world, and there are many features of novelty about the gear for handling the sewage of the large communities embraced in the scheme. The whole aim of the promoters, the Glasgow Corporation, has been the prevention of the discharge into the river Clyde of the sewage of the city. Since the opening of the first two sections there has been a marked diminution in the intensity of the effluvia given off by the river in the warmer months of the year. The area at present embraced covers 41½ sq. miles, and includes the whole of the city of Glasgow, with the burghs of Rutherglen, Govan, Pollokshaws, Partick, Renfrew, Clydebank and the intervening portions under the county authorities of Lanarkshire, Renfrewshire and Dumbartonshire. Negotiations are at present proceeding to prevent the discharge of free sewage into the river higher up, as at Hamilton, &c., and also into the tributaries of the rivers Kelvin and Cart, the first of which flows into the Clyde inside the city boundaries and the latter a little below the boundary. The river Clyde, which has been deepened and straightened considerably during the last 60 years by the Clyde Navigation Trustees at enormous expense, is now subject to the tides, and is deep enough to permit of the largest steamers entering the Glasgow Harbour. The necessity, therefore, of preventing the Burghs of Paisley, &c., lower down the river discharging sewage without treatment is apparent.

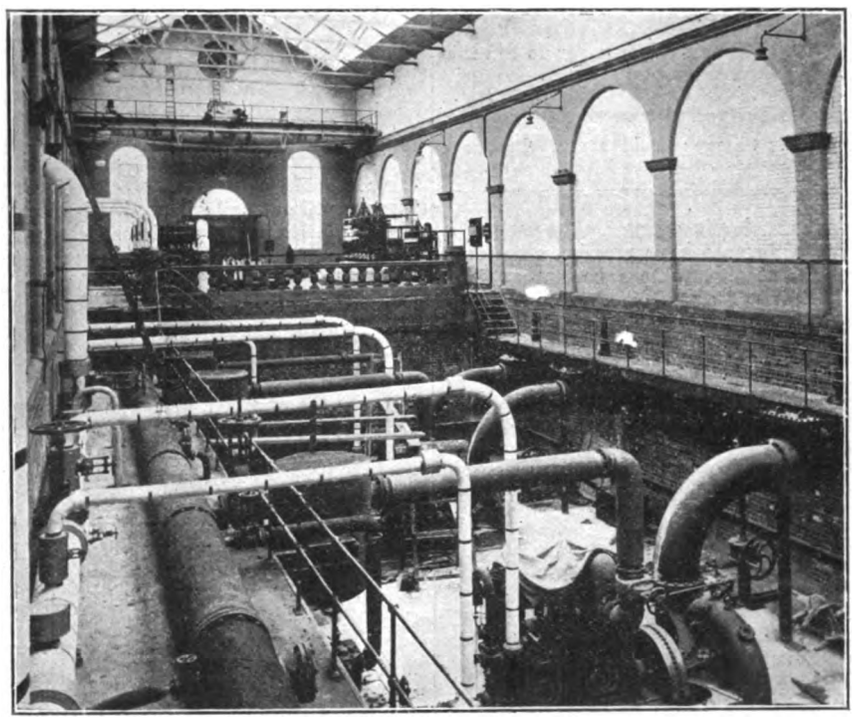

Fig. 1.—Interior View of Main Engine Room.

The first steps taken were to obtain Parliamentary sanction for the first section, that at Dalmarnock, embracing 11 sq. miles, in 1891. Subsequent additional powers were obtained between the years 1896 and 1907, and the section embracing the whole of the north side of the river, amounting to 15 sq. miles, with works at Dalmuir, 7 miles down the river from Glasgow, was opened in 1902. The last section, with works at Shieldhall, opened last month, embraces, as indicated, the remaining area on the south side of the river, covering 15½ sq. miles.

The amount of sewage and proportion of rainfall drained from the area is estimated at 250,000,000 gallons per day. For its collection some 30 miles of new sewers had to be constructed. These sewers vary in size from 2 ft. 6 in. to 10 ft. in diameter, which is the size of the main sewers entering the respective works. The gradients vary from 1 in 25 to 1 in 2,800. Their depth varies from 4 ft. above ground to 60 ft. below the surface, and they pass under railway lines no fewer than 30 times.

The main feature on the northern side was getting across the river Kelvin, and for this purpose a pumping station was put down alongside that river, thus giving the sewage a lift of 37 ft. 6 in. on the west side, whence it gravitates to the works at Dalmuir.

On the south side, due no doubt to the comparative flatness of the original country, pumping into the main sewer had also to be resorted to, and a pumping station for this purpose was put down at Kinning Park. This latter gives a lift to the sewage of 28 ft., and forces it a further 17 ft. into the main sewer, whence it gravitates to Shieldhall, 3 miles off.

Neither of these pumping stations presents anything of interest to electrical engineers, the pumps being of the steam-driven reciprocating engine type.

The sewage from Govan and Renfrew and district is pumped at the Shieldhall works by three centrifugal pumps, and is given a lift of 21 ft. to bring it to the level of the Glasgow sewage. Entering the works at Shieldhall, which lies between the river and the main road between Glasgow and Renfrew, one is struck with the enormous volume of sewage to be dealt with. On the right are the main offices and on the left are the lime agitators and precipitation tanks, while in front are the main station and treating house. The whole works are self-contained — that is, electricity at 250 volts is generated on the spot and everything is electrically driven. Another feature that strikes one is that there are no belt drives, except for the tools in the mechanics' shop.

The lime agitators referred to are three in number, and are for the purpose of keeping the lime mixture in a condition ready to be discharged into the sewage as it enters the catchpit referred to later.

For this agitating process the mixture passes into three brickwork tanks, each measuring 100 ft. by 30 ft. by 5½ ft. deep. Along each side of each tank there are gantry rails, and on these rails runs back and forward, automatically reversing at each end, a specially made four-wheeled stirring arrangement, which in travelling keeps the lime liquid in a creamy condition, it being necessary to discharge a saturated solution into the wage at the catchpit.

These travelling stirrers are driven by endless steel ropes fixed to the screens permanently, but passing over drums which are automatically reversed. These drums, of which there are three to each stirrer, are in turn driven by a 15 H.P. Rees-Parker Roturbo motor, one motor to each stirrer, through speed-reduction gear and reversing clutches on the drum shaft.

The lime mixture is conducted along concrete-lined ducts, and there are suitable penstocks controlled by small motors.

Passing on, we enter the mechanics' shop, where are the usual machine tools for repair work and an overhead 8-ton hand-operated travelling crane. There are here two 10 H.P. and one 5 H.P. motors. Next door is the boiler house, containing three Babcock & Wilcox chain-grate mechanically-stoked boilers, and an ash hoist driven by a 30 H.P. motor on to a line of shafting, and one stand-by Weir feed pump, a Claycross economiser, driven by a 5 H.P. motor, and a large fresh-water storage tank.

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Adjacent to the boiler house is the main engine room, as shown in Fig. 1. Here are three Crompton-Howden 150 kw. steam sets generating at 255 volts, the generators being of shunt-wound direct-current type. The main and feeder distribution switchboards by Lowdon Bros. are fitted with Whipp & Bourne double-pole circuit-breakers, Ferguson switches, Everett, Edgcumbe instruments and Reyrolle fuses, mounted on enamelled slate and of the usual construction. There are also an 8-ton hand-operated overhead travelling crane, two Mirrlees-Watson condensers, using the treated solution, by the way, for condensing purposes, and two air pumps.

The pumps for the Govan and Renfrew sewage referred to above are also in this room. They are of Drysdale's make, centrifugal type, driven by Howden engines. There is one 24 in. diameter for dealing with 600,000 gallons per hour, one 18 in. diameter dealing with 330,000 gallons, one 15 in. for 240,000 gallons and two 10 in. diameter. The sewage entering these is controlled through hand-operated penstocks.

Alongside the engine and boiler house is the men's messing and other accommodation fitted up in the usual manner.

Passing through the engine room we come to the iron liquor stores and tanks. These tanks are of special construction, being lined with oak, then a section of puddle, and another lining of oak, to prevent leakage and at the same time to stand the liquor's chemical action. These tanks being built in the ground necessitates the liquor being pumped into the catchpit. This is effected by a double ram suction pump by Brackett, of Colchester, driven by a 3 H.P. motor, direct coupled, situated in the adjoining oxidiser house. In this house are also the three oxidsier drums, as they are termed. The iron liquor, like the lime mixture, must be a saturated solution, and to keep it so and prevent settling or precipitation these revolving drums are necessary. The drums are each 11½ ft. long and 8 ft. diameter, and are constructed entirely of oak. The axles are also of oak and revolve on rollers. The drums are geared to a shaft which in turn is driven by either of two 30 H.P. motors through a suitable clutch gear. From the drums the liquor gravitates to the catchpit.

Adjoining is the lime store, capable of storing 1,000 tons of lime. In this store are also the four pan mixers for slaking the lime and making the mixture. They work in pairs, and are all driven by a 30 H.P. motor geared to a shaft with clutches for each pair of pan mixers. From here the lime mixture goes to the agitation tanks and back to the catchpit, which is in the house adjoining the lime store.

This catchpit is 170 ft. long, 17 ft. deep and 16 ft. wide, tapering down to a depth of about 18 in. at the bottom. A part of it is seen in Fig. 3. Along each side are standard rails on which runs a unique piece of gear of special construction and the first of its kind. It is to the design of Mr. W. D. Hamilton, the consulting engineer. At Dalmuir a man is required to sit on the travelling carriage, but as this means sitting over the open sewer all the time during a shift, the disadvantage of such an arrangement was obvious, hence this development.

As indicated in the photograph, it consists of a four-wheeled bogie carrying a bucket dredger and elevator. The sewage on entering the catchpit meets the lime mixture, which causes the solid matter to precipitate and settle at the bottom of the sloping-sided catchpit. This, therefore, requires constant clearing, obtained by the use of this special dredger. The dredger is self-contained, and after starting requires no attention. It automatically reverses itself at each end of its travel, in moving along the catchpit rails, by means of the kick lever (seen projecting downwards in line with the wheels) striking a buffer fitted at each end of the catchpit. This reverses the clutch reversing gear on the opposite side of the carriage.

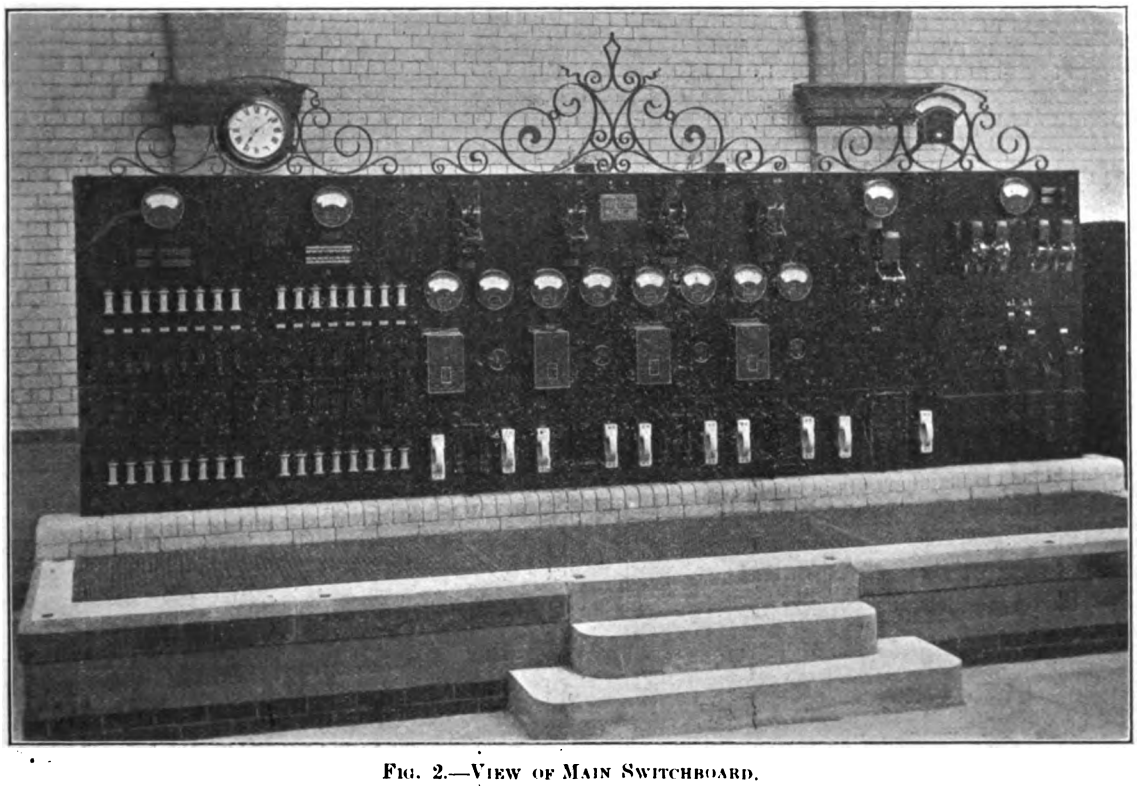

FIG. 2.—VIEW OF MAIN SWITCHBOARD.

The bucket conveyor at the same time continues elevating the solid matter and empties it through a shoot into a truck following up behind. These trucks or waggons are specially made and used for this purpose alone. They are coupled up as usual in railway practice, and move back and forth with the dredger. Being for standard gauge they are despatched all over the country with the sludge for agricultural use, but the solids obtained are used principally by the Corporation themselves on their sewage farms. Some of it is used and sold in cakes as a celebrated fertiliser.

The whole dredger, carriage and elevator is driven by a 30 H.P. motor fixed on to the carriage as seen. Current is collected in the usual way through a trolley and three wires. The starter for the motor is fixed to the back of the engine room wall, and the motor is a shunt-wound machine; hence the reason for the three wires seen in the view.

Having dropped most of the solid matter in its passage along the catchpit, the sewage is now attacked by the iron liquor,

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which enters at the end remote from the lime end. This liquor is made to spray over the sewage by means of a baffle plate.

The sewage then passes through a screening plant seen behind, and in the corner of, Fig. 3. These screens are to remove any solids unaffected by the lime. They accumulate at the screens and are removed by a stationary elevator, seen at the back in Fig. 3, and discharged through a shoot into a truck standing below.

These screens are of three different meshes, and can be removed for cleaning purposes periodically like ordinary sluices. For the hoisting of the screens on to the floor level, seen in Fig. 3, motor equipments are fitted aloft (*see* Fig. 4). Each of the grids or screens is fixed to a wire rope, which passes round a revolving drum, which in turn is made to revolve through a friction clutch. The motors driving these are of 5 H.P. and of the Rees Parker shunt-wound type. This equipment stands on a raised gallery about 15 ft. above floor level. Speed reduction is obtained through worm and pinion in an oil bath.

On this gallery are also the hand wheels operating sluices to close any screen opening when necessary.

After screening, the sewage and treated liquor passes on into the open air, and, by means of suitable brickwork channels, is led into the precipitation tanks of brickwork, 15 in number, and each measuring 400 ft. by 60 ft. wide and normally holding a depth of 8 ft. of treated sewage.

Here it is allowed to rest for a time to allow the iron liquor to purify it, after which it is pumped into two iron sludge tanks, each 115 ft. by 45 ft. by 10 ft. deep. The pumps are three in number, 9 in. diameter and of Drysdale's centrifugal type, each driven by a 20 H.P. motor. The clear liquor passes off into the river and the sludge passes through pipes 18 in. in diameter on to the specially built Corporation steam hopper barge t.s.s. "Shieldhall," by which it is taken out to the open sea and there dropped. It is said that the purified liquor thus discharged into the river can be drunk by human beings without any ill effects; in any case it is used for condensation purposes.

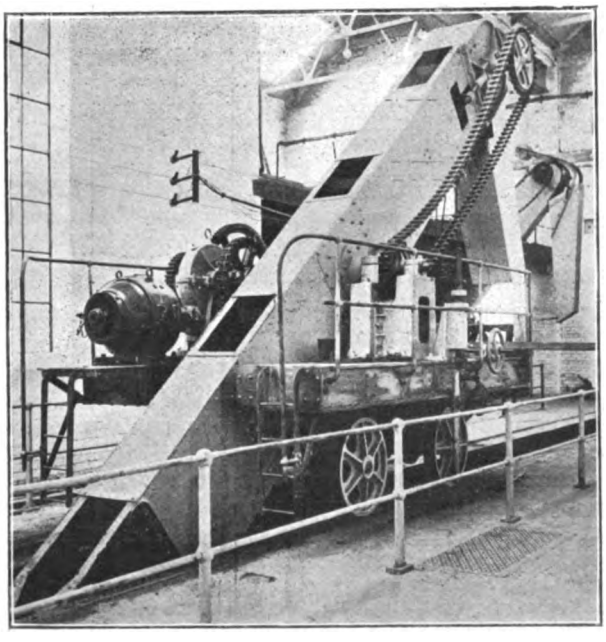

FIG. 3.—CATCHPIT DREDGER.

With the exception of the economiser and oxidiser house motors, by Wright & Wood, all the motors—some 40 in number—are of Rees-Parker make, of Wolverhampton. The starting panels, two of which are indistinctly seen in background of view Fig. 4, are by Hamilton Bros., Glasgow.

The principal engineering contractors and electricians were Lowdon Bros., of Dundee and Glasgow. Sub-contractors:—

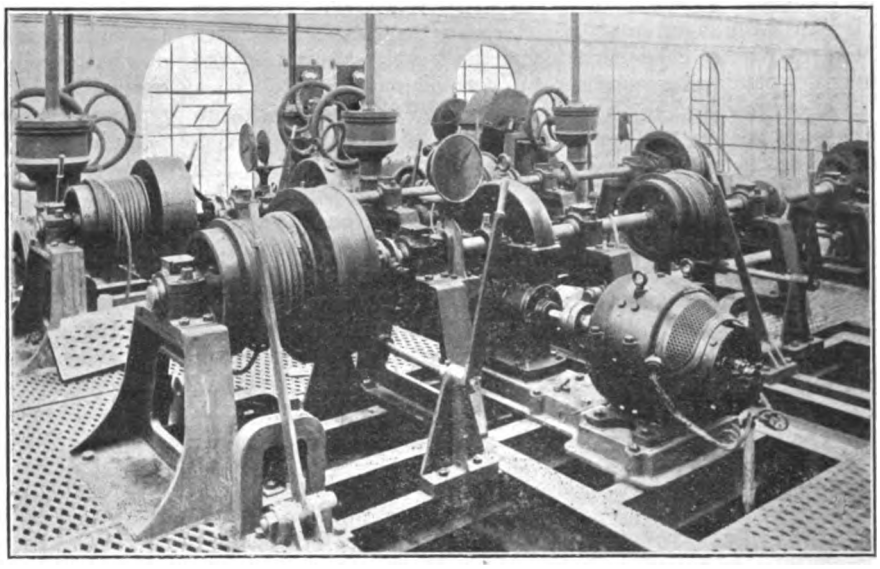

FIG. 4.—SCREENING PLANT MOTOR EQUIPMENT.

For structural ironwork of the lime agitators, mixers, &c., Barrowfield Iron Works (Ltd.), Glasgow; valves and penstocks, Glenfield & Kennedy (Ltd.), Kilmarnock; Arc Lamps in the engine room and precipitation tanks, &c., Gilbert Arc Lamp Co.

The general scheme is due to Mr. A. B. McDonald, city engineer.

The machinery buildings (sub and super-structure), sludge tanks and pump house and discharging gear, sewage disposal and treatment machinery, mechanical and electrical power and lighting plant arrangements are to the design and specification of and have been carried out under the supervision of Mr. Wm. D. Hamilton, of Glasgow, to whom we are indebted for many details.

The whole scheme, it is anticipated, involves an expenditure of £2,250,000, equivalent to an assessment rate of 7d. in the £1, but it is not anticipated that this maximum will ever be levied.

STANDARDISATION OF FUSES.*

BY H. W. KEFFORD.

(*Concluded from page 268.*)

Summary.—After pointing out the desirability of standardisation, the author gives particulars of tests on a number of representative types of fuses up to a capacity of 50 amperes, and discusses the ratio between the rated current and the normal fusing current. He then considers the general regulations for the construction and operation of standard fuses and describes a non-interchangeable fuse system. He refers to the testing of fuses, and finally puts forward some suggestions as the basis of a specification for standard fuses.

General Regulations for Construction and Operation.—While it is not desirable to specify too rigidly the constructional details to be embodied in standard fuses, yet it appears imperative that a few general principles should be laid down for the guidance of manufacturers, and one or two essential features should be demanded. As an example of the extreme necessity of this, it may be mentioned that in fuses T_5 and T_6 the fuse wire is *soldered* at each end into a small terminal plate. The distribution of the masses of metal is such that all the fuses of this type which were tested opened the circuit by melting the soldered connection; had the full rated pressure of over 500 volts been maintained, the arc, consequent

* Abstract of a Paper read before the Birmingham local section of the Institution of Electrical Engineers.

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on the separation of the wire from its terminal plate, would have spread speedily and consumed the entire fuse fitting and terminals until the circuit was broken elsewhere. In a second line of fuses (R) of the totally enclosed or cartridge type, also rated for over 500 volts maximum pressure, a solid single link of soft fusible metal is used, containing a volume of metal nearly 15 times as great as that contained in another make of cartridge fuse of the same rating. This protective device is completed as an explosive of a most dangerous kind by the provision of a number of vent holes in the metal cap at each end.

If any efforts to increase the efficiency and serviceableness of fuses are to be successful it is inevitable that bare wire fuses should be abandoned; and the logical consequence of the standardisation of small capacity fuses is the introduction of a simple method by means of which the control of the fuse capacity on any circuit is placed in the hands of competent persons only. This requirement of non-interchangeability is far-reaching in its effect on fuse design, since it involves the abolition of all fuse fittings having two exposed terminals, and in so doing leads half-way to the requirement dictated by safety—namely, that no terminals whatever should be exposed on fuse fittings intended for use in private houses or public situations.

An ideal system for safeguarding a circuit against over fusing should consist of some small separate part or adjustment which can be suitably set by an electrician either to restrict the capacity of the fitting to the present current or so as to allow a definite margin for increasing the size of fuse consistent with the dimensions of the wiring or apparatus. Although it is admitted that no non-interchangeable system will do away with the deliberate over fusing of the circuits, yet sufficient will have been attained if accidental over fusing is made impossible and an obstacle is placed in the way of using hair-pins and similar well-known substitutes for the legitimate article.

In order that the idea of non-interchangeability may be fully grasped, reference may be made in detail to what is, so far as the author knows, the only type of fool-proof fuse on the market. The loose pieces or "gauge-rings" B, B¹ (Fig. 5) consist of a steatite ring

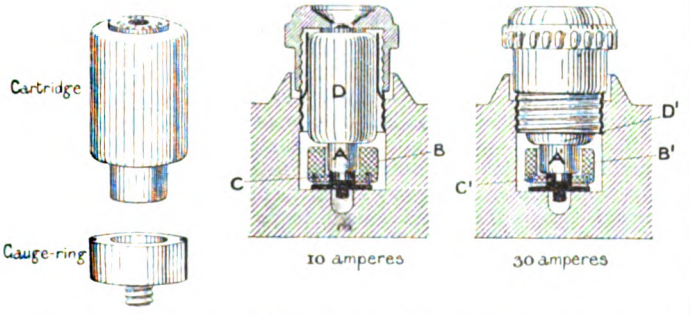

Fig. 5.—Example of Non-interchangeable Fuse System.

of constant external diameter, but having the diameter of the hole varying with the rated current. One of the terminals with which the cartridges D, D¹ make contact is situated at the bottom of the cylindrical hole in the steatite ring, and unless the stud A, A¹ is of equal diameter or smaller than this cylindrical hole, contact cannot be made. Thus B and D are gauge ring and cartridge for 10 amperes, whilst B¹ and D¹ are the corresponding parts for 30 amperes rated current. The rings B for all capacities screw interchangeably into the same terminal block, but it is evident that a cartridge, D¹, for 30 amperes will not make contact through its stud A¹ with the terminal C which lies at the bottom of a ring, B, for 10 amperes. It is, in fact, impossible to insert D¹ in a fuse fitting containing a gauge ring, B, of smaller capacity. Needless to say, each rated current has its own special diameter of stud and gauge-ring orifice.

Bare wire fuses, or rather fuse fittings, in which a conductor can be easily inserted by the user, are incompatible with protection against overloading. Two other objections of equal weight against exposed fuse wire are their liability to scatter molten or hot metal and the rapidity of corrosion unless certain non-active metals are used. The first objection holds good of all metals, but more particularly of low melting point metals, of which a larger volume is requred than if copper or silver were employed. The second objection is especially applicable to copper, which in many other respects is an excellent fusible metal.

If, on the other hand, we examine the case for fuses of the totally enclosed type, we have the following outstanding advantages: (1) The fuse wire is less liable to corrode or become injured, and therefore enclosed fuses lend themselves to exact calibration. (2) Tampering with the fuse wire is difficult, and a system of non-interchangeability is greatly facilitated. (3) If properly designed, no molten or hot matter can be thrown about. (4) Perfect operation can be obtained on heavy overloads at full voltage. (5) Less metal is required, and the weight and size of the complete fuse fitting is reduced.

The principal objections raised against enclosed fuses are mainly questions of cost, the impossibility of inspecting the fuse wire, and the difficulty of ascertaining with certainty when the fuse has blown. The first-named objection appears to be almost wholly fictitious if account is taken of the frequency with which not only the fuse wire of an open fuse is melted, but the holder itself is either cracked or so fused as to be useless. Engineers do not seem fully to recognise how much more severe in many cases is the effect of fusion produced by a heavy gradual overload at full voltage as compared with the effect of a severe sudden short-circuit. Fuses of the china holder type are often reduced to a useless condition by an overload, whereas they may withstand repeated short-circuits of a severe character without great damage. The asbestos protection now largely used, although fairly efficient when new, soon loses its efficacy after repeated blowing of the fuse, and is, moreover, frequently discarded altogether.

With regard to the deficiency of enclosed type fuses in not permitting inspection of the fuse wire or giving reliable indication of fusion, the latter is a mechanical detail which can be quite satisfactorily solved, as is shown by the arrangement adopted in a new type of enclosed fuse recently put on the market. Fig. 6 shows the design of indicator referred to. The diagrams are self-explanatory.

The demand for exposure of the fuse wire has arisen from the custom of inspecting a fuse, say of copper, either for the purpose of seeing what progress oxidation has made or to determine by its red glow or otherwise whether it was being unduly overloaded. The

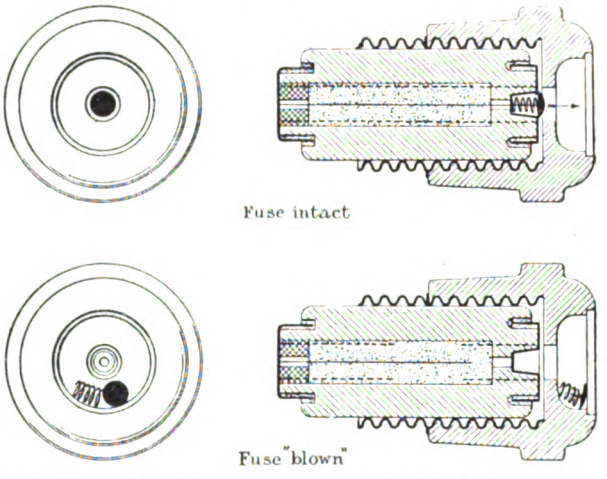

Fig. 6.—Example of Cartridge Fuse with "Self-testing" Indicator.

oxidation of a fuse is, as we have seen, harmful and unnecessary, and the rating and design of standard fuses should be directed towards minimising its occurrence; similarly a well-considered and consistent rating will in time enable the user to become familiar with the overload capabilities of a fuse of certain capacity. For fuses of the capacity under discussion a completely enclosed design is the only one which enables any set of standards to be followed or enforced with reasonable success.

Stress may be laid on four points essential to the satisfactory operation of any fuse, whether of the open-wire, tubular or totally-enclosed type; these are: (1) The volume of fusible metal should be reduced to the minimum compatible with correct rating and moderate temperature rise. (2) The fusible metal should be subdivided so that the ratio of exposed surface to cross-section does not fall below a figure depending on the design. (3) The provision of cooling arrangements adequate to extinguish the arc formed on overload. (4) In exposed wire fuses the provision of sufficiently free expansion space to prevent explosion when a short-circuit occurs. In enclosed fuses the same end must be attained by precisely opposite means, and no opening or weakness of any kind is permissible in the enclosing case.

It is interesting to notice how the fulfilment of requirement (2) naturally leads to the cartridge design of fuse, since only in this design can the proper subdivision of the fuse wire be guaranteed. The effect of neglecting proper subdivision as well as the use of too much metal is shown by photographs reproduced in the Paper. It is unfortunate that instead of attacking the problem of an enclosed fuse in an appropriate manner, some designers have considered that the simple enclosure of an open-type fuse would produce the desired end. The use of soft metals, such as tin, lead or zinc, is to be deprecated, although with very careful design successful use may be made of the non-arcing property of the last-named metal.

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When a filling powder is adopted it is important that the fuse wire and filling should be free from any mutual chemical action, even when subjected for a long time to alternate heating and cooling. Fillings containing a capsule of liquid, or any hygroscopic or moist substance, are bad in principle, and may be the cause of violent explosion or of chemical corrosion of the fuse wire. Tests carried out on a very large number of filling materials lead to the conclusion that the most suitable for use in enclosed fuses are thoroughly dry uniform powders of completely inert substance.

Tests of Fuses.—The most important tests which a fuse must pass successfully in order to demonstrate its reliability are: (1) An insulation or pressure test (*a*) between all live metal parts and earthed metal parts, (*b*) between the two opposite poles of the fitting when no fuse is in place and when a blown fuse is inserted. (2) Tests for operation with gradually increasing current at normal voltage until fusion occurs. (3) Short-circuit tests at normal voltage. In addition to the above tests, measurements should be made of the temperature rise of accessible parts of the fitting and of the voltage drop. A pressure test of at least 1,000 volts above the working pressure should be withstood without breakdown. Experience shows that under certain circumstances a risk of dangerous shock may be created by the use of hygroscopic materials like fibre, asbestos or strawboard between the terminals; leakage may occur sufficient to give a severe shock when it is thought that the operation of the fuse has rendered one terminal "dead." Test 2 is of extreme value as an indication of the behaviour of the fuse under the conditions which in practice most frequently lead up to fusion. The fuse under test should be connected in circuit with an adjustable resistance and a battery or generator giving the maximum normal voltage for which the fuse is designed. The current is increased gradually so that the fuse has time to attain approximately its steady temperature for each value of the current. This procedure is followed in three or four steps until the fuse blows. The circuit should not be opened by other means until all arcing or glowing has ceased. The formation of a continuous arc after fusion must be considered as a property even more dangerous than faulty performance under short-circuit conditions, the latter consisting generally of a violent explosion and scattering of the fuse fitting without necessarily giving rise to the great fire risk which always attends imperfect operation under gradually increasing overload. It is surprising how large a percentage of sample fuses utterly fails under this test.

The value of a short-circuit test as a criterion of the goodness of a fuse depends to a large degree upon the manner in which the term "short-circuit" is interpreted. A fuse of the smallest size may be inserted in an auxiliary circuit on the switchboard of a central station, in the closest proximity to the bus bars transmitting thousands of kilowatts, and the safety of the whole plant may be imperilled by the failure of the fuse to sever a faulty circuit cleanly and promptly. Perfect operation on short-circuit is a matter of careful design, and entails neither increased cost nor elaboration. Since fuses of all capacities are liable to be subjected to short-circuit conditions of the same severity, it is not advisable in specifying the method of carrying out short-circuit tests to differentiate between fuses for various rated currents. Thus the "standard short-circuit" should not be defined as a maximum possible short-circuit current 20 or 30 times the rated current of the fuse under test. An adequate but not too severe short-circuit test for fuses up to 50 amperes rating is provided by the following rules, which have been followed in all tests carried out by the author: (1) The source of current should be a battery having an open-circuit P.D. 10 per cent. higher than the rated maximum voltage of the fuse under test, and capable of giving 500 amperes without the terminal voltage dropping by more than 5 per cent. (2) The total resistance of the test circuit, including the fuse, should be adjusted to correspond to a steady current of 1,500 amperes produced by an E.M.F. equal to the rated maximum voltage of the fuse. (3) On closing the main switch the fuse should blow without a continuous arc being formed or any explosive violence.

The following suggestions are put forward as a basis for the discussion of a specification for standard fuses:—

1. (*a*) *Material for Fuse Wire.*—The fuse wire must not corrode or permanently change its conductivity or physical structure.

(*b*) *Non-interchangeability.*—Fuses up to 50 amperes rated current should be provided with a simple arrangement by means of which the capacity of the fuse which can be inserted by a non-technical user is restricted within definite limits.

(*c*) *Type of Fuse Recommended.*—To facilitate compliance with (*a*) and (*b*) above, and generally to render standardisation practicable and useful, an enclosed cartridge type of fuse is recommended.

(*d*) *Indication of Fusion.*—All fuses must be provided with a simple means for detecting fusion merely by inspection of the fitting.

2. (*e*) *Rating.*—The rated current marked on the fuse shall bear a definite relation to the limiting current, or least current which will produce fusion within four hours. The minimum value of the ratio a = (limiting current)/(rated current) shall be 1·54, and the maximum value shall not be higher than 30 per cent. above the minimum. In a correctly proportioned line of fuses a should decrease from the maximum to the minimum values specified, as the size of the fuse increases from the lowest to the highest capacity. This regulation is based on the assumption that silver is the best metal for fusible links, taking into consideration its permanent character, the small volume required and its "clean" action when breaking the circuit.

(*f*) *Sluggishness of Action and Time Element.*—Standard fuses shall be so rated and constructed that when loaded with 50 per cent. above the limiting current they will fuse within 1 minute. The actual time required for fusion shall be taken as a measure of the "time element" of the fuse.

(*g*) *Standard Rated Currents and Voltages.*—Every fuse shall be clearly marked with its rated current and the maximum voltage for which it is suitable. The standard rated currents and voltages suggested are as follows: *Maximum voltage*, 250.—2, 4, 6 and 10 amperes. *Maximum voltage*, 500.—2, 4, 6, 10, 15, 20, 30, 40 and 50 amperes.

3. (*h*) *Temperature Rise.*—When loaded continuously with 80 per cent. of the limiting current no exposed part of any fuse fitting shall attain a temperature exceeding 100° C. above that of the atmosphere.

(*k*) *Insulation.*—Fuse fittings shall be tested for insulation between terminals with the fusible portion removed and between the live parts and "earth" with the fusible portion in place.

(*l*) *Operation.*—Fuses shall be tested for satisfactory operation on overload and short-circuit in accordance with the specified arrangements for carrying out such tests.

LONG DISTANCE WIRELESS TESTS.*

In its quest for the most efficient wireless telegraph apparatus the U.S.A. Navy Department is now having tests made between its ships and shore stations. While the present installations are giving very satisfactory results, it has been apparent for some time that, no matter how carefully tuned, communication is not certain over any considerable distance without the necessary power behind the spark to overcome the immense amount of interference caused by the wireless apparatus on almost all seagoing vessels of any importance and through atmospheric disturbances.

Some months ago the Navy Department invited tenders for high-powered transmitting and long-distance selective receiving sets, and the National Wireless Telegraph Co., builders of the Fessenden apparatus, secured the contract and are now endeavouring to fulfil the conditions prior to the tender being finally accepted.

Roughly, the scheme is to have a high-power installation at Washington, which will be a kind of master station; the mast to be an iron structural one about 600 ft. in height and the transmitting apparatus to be rated at about 50 kw. Other naval stations will also be equipped, but to a lesser extent, with sets of about 25 kw. capacity, and the battleships and first-class cruisers will have 10 kw. installations, all of high frequency and capable of communicating a distance of 1,000 miles during either daylight or darkness. It is a well-known fact that wireless communication is many times better, possibly as much as three times, during darkness than it is in the daylight; and for a wireless company to undertake to communicate regularly in the daytime a distance of 1,000 miles is an undertaking of no small magnitude. If accomplished it will mean a great advance in the art of wireless telegraphy. The company are partly relying on the theory that with high enough frequency the effect of the sun's rays will be neutralised and communication will be the same either by day or night.

In conjunction with the Navy Department the National Wireless Telegraph Co. began experimenting last August, having installed on the U.S.S. "Connecticut" a high-frequency, 25 kw. transmitter. But, partly from the necessity of having to instal the apparatus, several decks below the main deck and having no adequate means of getting full power into the antenna due to the great loss on account of induction, the tests with the "Connecticut" have for the present been abandoned, and are now being carried on with 10 kw. transmitters, one of which is installed on the scout cruisers "Birmingham" and "Salem" and with the 50 kw. station at Brant Rock, Mass., and the Atlantic naval shore stations. These scout cruisers are admirably adapted for this work, being swift in speed and having wooden masts; the wireless station being placed in the open on the after part of the bridge, thus giving a free lead for the antenna.

A diagram of the connections of the 10 kw. Fessenden transmitter, as installed on the "Birmingham" and "Salem," is shown

*Abstract of an article in the "Electrical World."

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in Fig. 1. The motor-generator set consists of a 10 kw. General Electric, 500-cycle, 110-volt, 2,000 revs. per min. single-phase alternator driven by and directly connected to a 14 H.P., 120-volt direct-current motor. Also directly connected on the alternator and motor shaft and on the outside end of the alternator is a synchronous rotating spark-gap consisting of a hard rubber disc, 4 ft. in diameter and 1 in. in thickness, on the periphery of which is a brass band. In this, set at uniform distance from each other, are 30 brass spokes, there being a spoke for each field coil of the alternator. These spokes are 3½ in. in length, and terminate in a small brass ball on the end. The spark-gap is completed by two stationary terminals set at equal distances and opposite each other on either side of the rotating disc, being highly insulated in porcelain and contained in a frame, which also encloses the rotating part, and by means of a worm gear can be turned through a small arc so as to adjust the stationary part in proper relation to the revolving part of the gap. When so adjusted a spoke comes opposite both of the stationary terminals at the exact instant maximum potential obtains in the condenser, thus producing a discharge across the gap for every alternation, or 1,000 discharges per second. The heating prevalent with a high frequency is dissipated by the windage of the rotating member and the spark given off forms a high, pure musical note easily detected through even strong interference. The distance between the stationary and rotating part is from ¼ in. to ⅜ in. on either side, making a total gap of from ½ in. to ¾ in., but which, in fact, amounts to about 1 in. on account of the spark jumping a little before and hanging on after the spoke has passed the terminals.

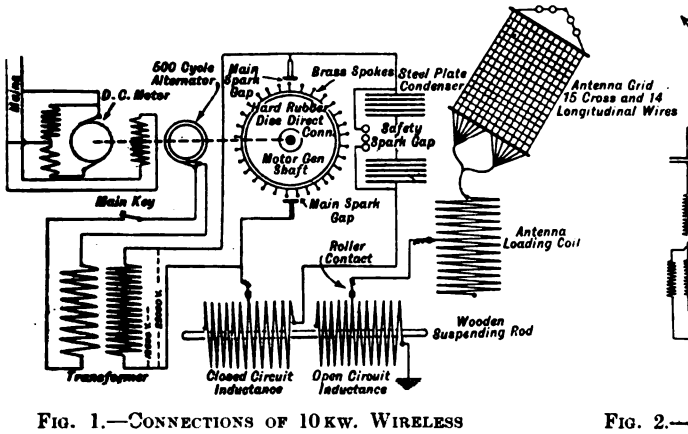

FIG. 1.—CONNECTIONS OF 10 KW. WIRELESS TRANSMITTER.

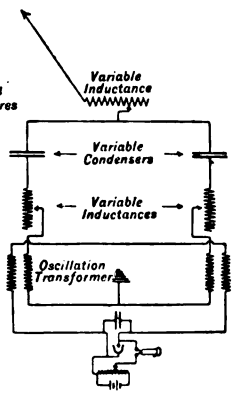

FIG. 2.—SELECTIVE RECEIVER CONNECTIONS.

The transformer is rated at 10 kw. and has oil insulation. The primary voltage is the same as that of the alternator, namely, 110 volts, and from the secondary a voltage of either 25,000 or 12,500 can be obtained. There is a choke coil at each secondary terminal to guard against kicks, and in addition the transformer is protected by an adjustable safety spark-gap connected across its terminals. The current through the primary is usually constant, a spark of one intensity being used, but, when necessary, the current is regulated by varying the field strength of the alternators. The secondary is connected directly across the terminals of the rotary gap, across which, in turn, is also connected the main condenser in series with a variable inductance.

This condenser, for a 10 kw. transmitter, is of small size, having only a total capacity of 0·09 mfd. It is made in two sections, each section being separately contained in a steel cylindrical tank about 1½ ft. diameter and 4 ft. high, suspended from an insulated wooden frame and made absolutely air tight. The condenser plates consist of steel discs, $\frac{1}{16}$ in. thick by 1 ft. diameter. The tanks are subjected to an air pressure of 250 lb., which forms the dielectric for the condenser plates. The series of plates in each tank are connected in multiple, and the two groups connected in series, the series connection being made by earthing a terminal of each condenser to the side of the tank, and the tanks being metallically connected together. The other terminal is taken through heavily insulated porcelain bushings in the top of the tanks. From the two outside terminals and from the common terminal leads are taken to three copper cylinders 1 ft. in diameter, which are adjustable and form a safety valve for the condenser against excessive charging.

The closed circuit inductance connected in series with the condenser consists of 100 turns of $\frac{1}{16}$ in. by ½ in. copper ribbon wound on a wooden cylindrical frame 18 in. in diameter and suspended on a wooden axle. Suspended on the same axle is the antennæ inductance of the same size and turns as the closed circuit inductance and movable in relation toward or from it so that the mutual inductance, and, therefore, the coupling of the two circuits, can be varied, the coupling being in all cases purely inductive. There is still another inductance made similar to the others and placed in series with the antennæ and used as a loading coil by means of which, and the inductive coupling, the wave radiated is made extremely "loose," there being practically but one wave. Each of the inductances can be revolved and by means of a wheel spring contact turns, or parts of a turn, may be obtained. All of the connections in the secondary circuit are made with 1 in. strip copper to keep down induction.

The transmitting key, placed in the primary circuit of the transformer, is of the relay and series break type, consisting of a standard telegraph key shunted by a condenser in series with an electromagnet which operates the main key in the primary. The receiver used with this set is known as the "Fessenden I. P.," or interference preventer type. It tunes extremely sharp, and the only objection to it is the somewhat lengthy time required to make the proper adjustments. The receiver connections are shown in Fig. 2. The antenna is led in singly to a variable inductance coil, after passing through which it divides into two branches and the two branches are brought to a common earth. In each branch or leg is a variable condenser and a variable inductance, the primaries and two oscillation transformers. The detector circuit is inductively coupled and contains the secondaries of the two transformers and the detector, which is of the well-known Fessenden electrolytic type, and having the usual telephones and potentiometer connected in multiple around it. The fine platinum wire is adjusted by a very fine gearing, which is graduated to show the depth of immersion in the electrolyte composed of a 20 per cent. solution of nitric acid. Shunted around the detector is a variable condenser, which acts to neutralise the effect of the inductance, and a sharper coupling is therefore obtained on the transformers.

The antenna as swung on the "Birmingham" and "Salem" is made of standard phosphor-bronze antenna wire and the grid consists of 14 of these wires run lengthwise of the ship and at equal intervals cross-connected by 15 other wires. The lengthwise wires are spaced 3 ft. apart, and the whole is suspended on two 2½ in. iron pipes. The antenna is led down into the transmitting and receiving room in the form of a loop, there being seven wires bunched to form a short fan on either side. This permits the use of either a single or looped antenna for receiving. The suspension of the whole antenna from the masts is by a hemp bridle and down-hauls at both ends and Locke high-tension petticoat porcelain insulators.

Early in March the two scout cruisers left Hampton Roads, Va., with a number of expert National Wireless Telegraph Co.'s operators on board for an extensive test, which, if successful, will mean the general introduction of high-frequency transmitters into the U.S.A. navy.

THE ORIGIN AND PREVENTION OF CURRENTS IN BEARINGS.*

BY L. ADLER.

Summary.—The author discusses the causes which lead to the presence of currents in the bearings of electric machines, and proceeds to show how the injurious effect of the same depends on the current density and bearing surface. Lastly, means are discussed whereby this nuisance can be avoided.

Amongst the various problems and phenomena brought out by the development of electric machines, and more especially of those designed for high speeds, the existence of pulsating currents through the shaft, bearings and bedplate becomes of importance. These currents make themselves chiefly felt by their injurious effects, such as pitting of the shaft and bearing, also by making the oil impure.

In normal generators and motors we can distinguish between those where the main field is produced by continuous current and those where the same is produced by alternating. We shall first consider the flux distribution in the former class. The

* Lecture delivered to the Elektrotechnischer Verein in Vienna. Abstracted from "Electrotechnik und Maschinenbau."

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flux leaving a north pole splits up into two parts, Φ_1 and Φ_2, which pass through south poles on either side, thence to return again to the north pole. From the general equation of the magnetic circuit,

$$\text{Flux} = \frac{\text{magnetomotive force}}{\text{magnetic reluctance}},$$

we have

$$\Phi_1 = \frac{\frac{4\pi}{10}AT}{\Sigma\frac{l_1}{q_1\mu_1}} \text{ and } \Phi_2 = \frac{\frac{4\pi}{10}AT}{\Sigma\frac{l_2}{q_2\mu_2}},$$

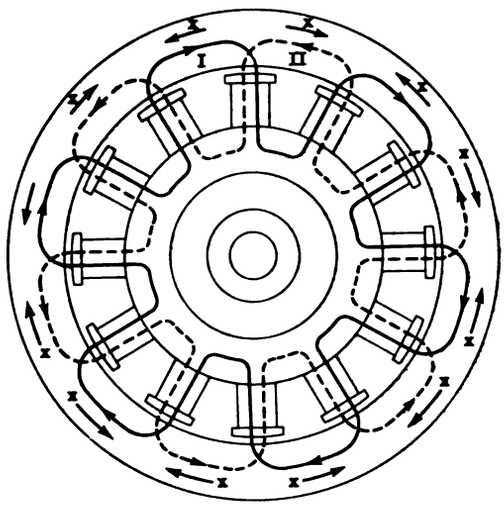
where l_1, q_1 and μ_1 denote the length, section and permeability re pectively of the several parts of the one path, and l_2, q_2 and μ_2 those of the other.

With the usual assumption that the several magnitudes $l_1=l_2$, $q_1=q_2$ and $\mu_1=\mu_2$, it is clear that with a constant M.M.F. $\Phi_1=\Phi_2=\frac{\Phi}{2}$.

In practice, however, it sometimes happens that the reluctances of the two paths are by no means the same, so that the flux is not equally distributed.

Such cases are of two kinds: (1) Those due to the construction; (2) Those due to inequalities in the magnetic circuit.

The first group is by far the more important, and the chief trouble here is due to splitting the stator. From experiments made by Punga and Hess the gap thus introduced in the case of well-constructed parts can be taken as 0·2 mm. to 0·3 mm.



$(x_I)=(x_{II})$.

FIG. 1.

To the latter group belong all such instances as are due to bad erection or faulty material, whereby the reluctance of the path carrying Φ_1 is different from that carrying Φ_2.

To represent the dissymmetry in the flux distribution mathematically we can proceed as follows:—

$$[\Phi_1]=[\Phi_1]$$
$$[\Phi_2]=[\Phi_1]-[X].$$

That is, we assume the armature flux to be equally distributed, and the part which has the greater reluctance to overcome is assumed to have an opposing flux, X, which—as will be seen later—is capable of inducing a pressure in the shaft circuit. Now, in order that a current can exist in the shaft, bearing and bedplate, the flux producing the same must be interlinked with the shaft and pulsate regularly, as in a transformer. To obtain a clearer insight into what goes on, we can imagine the lines of force to pass completely round the machine in two opposite directions, as suggested by Dr. Fleischmann, instead of the usual method of considering each pole pair by itself. The points where the opposing flux X occurs, due to the varying reluctance, comes alternately into the region of north and south pole, so that this flux will consequently fluctuate periodically, and will reach its positive and negative maximum when these critical points lie exactly between two poles. These points of varying reluctance can occur at one or more points in the machine in either one or both of the lines of force passing round the machine. Hence we have the following cases:—

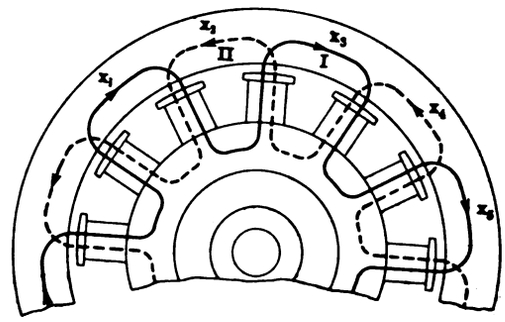
(*a*) The dissymmetry or opposing flux X occurs in both lines of force to the same degree (Fig. 1)—*i.e.*, $X_I=X_{II}$.

(*b*) The dissymmetry occurs in both lines of force, but not to the same extent (Fig. 2)—*i.e.*, $X_I \neq X_{II}$.

(*c*) The dissymmetry only occurs in one of the fluxes (Fig. 3)—*i.e.*, X_I or $X_{II}=0$.

In case (*a*) the two opposing fluxes neutralise one another completely, and no current will be induced in the shaft. In case (*b*) the current through the bearings will be proportional to the difference $X=X_I-X_{II}$. Case (*c*) is really part of case (*b*).

From these possibilities of flux variations in machines with continuous-current excitation a number of conditions for the existence of currents in the bearings can be deduced



$[x]=[(x_1)+(x_3)+(x_5)]-[(x_2)+(x_4)]$
$(x)=(x_I)-(x_{II})$

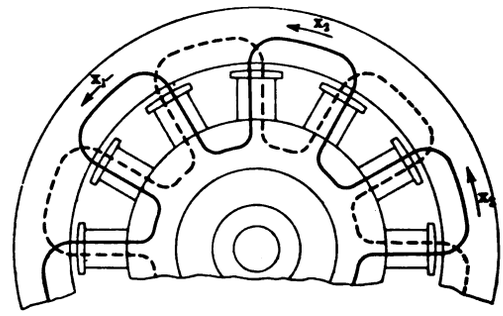
FIG. 2.

For example, if the stator is split into two halves it can be easily seen from Fig. 4 with equal X's we get case (*a*) with 6, 10, 14, 18, &c., pole machines; whilst with 4, 8, 12, 16, &c,. poles, both X's occur in the same line of force round the machine, and we get case (*c*), Fig. 5.

Hence, if the machine is split into n parts, case (*c*) occurs when the number of poles is divisible by $2n$. This gives one fundamental condition for the existence of currents in the bearings due to construction.

Again, when the stator is not round, currents in the bearings can also be set up. According to where the want of rotundity exists, case (*b*) or (*c*) can occur.

On the other hand, if the revolving magnet wheel is not round, or if the poles have not all the same length, or, again, if



$x=x_1+x_4+x_6$
$[x]=[x_1]$
$x_{II}=0.$

FIG. 3.

the distances between the several poles are unequal, none of these can give rise to currents in the bearings; for the resultant flux in the shaft in these cases does not pulsate periodically, but is continuous in one direction.

It is also interesting to see how these currents can be present when plates of different permeability are used. This results in case (*b*). As the rotor revolves the resultant flux changes its sign, and consequently fluctuates with the frequency of the machine.

Coming now to asynchronous machines, it is easily seen that the only practical difference between these and machines excited by continuous current is that in the former they occur, not only when the machine is running, but also when at rest.

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If now the points where the stator is split lie symmetrical with respect to the two lines of force round the machine, no opposing flux X can exist. Hence, with alternating fields, in addition to the three cases which occur with continuous-current excitation, there is a fourth—namely, where the position of the varying reluctances does not fall directly in either of the two lines of force round the machine, but is symmetrical to both. Thus, in a three-phase motor with split stator, one phase is generally quite symmetrical, whilst the other two are equally unsymmetrical with respect to the place where the stator is split. Under these conditions only the latter two phases can give rise to currents in the bearings. Similarly, with two-phase machines, one will generally give rise to these currents, whilst the other will not.

Though the theoretical possibility of dissymmetry in machines may be great, yet in practice only those cases are of importance where the flux and currents in the shaft assume appreciable magnitudes. Let R be the reluctance of one of the two lines of force round the machine, and r that corresponding to the existence of the flux x in the shaft (in split stators the reluctance where split occurs), then we have

$$\Phi_1 = \frac{\frac{4\pi}{10}\Sigma AT}{R}\ ;\ \Phi_1 - X = \frac{\frac{4\pi}{10}\Sigma AT}{R+r}.$$

Then the value of r/R will be a measure of the magnitude of X. The larger the diameter and the larger the number of poles in the machine the smaller r/R will be. Hence, in high-speed machines with few poles, the phenomenon of currents in the bearings will be more pronounced. The ratio r/R will also be smaller the larger the ratio of ampere-turns required for the

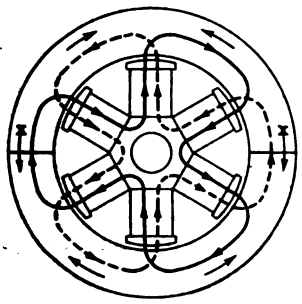

FIG. 4.

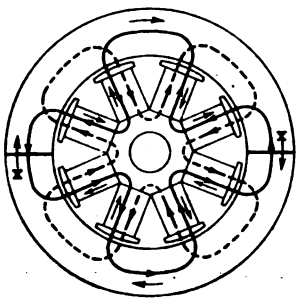

FIG. 5.

gap to total ampere-turns. Thus induction motors will be much more liable to such currents than synchronous machines, which have larger gaps.

Owing to the very varying contact resistance between shaft and bearing and bearing and bedplate (resistances of the order of 0·001 to 0·00001 ohm and less), it becomes impracticable to calculate these currents. The important factor, however, is the current density. But the magnitude of the bearing surface is also indeterminable. It must suffice, therefore, to know what magnitudes the currents and current densities in a machine can assume, and prevent the same by suitable means.

To find out the value of the current density which can cause damage, tests were made for several weeks at the works of the A.E.G. Union Elektrizitäts-Gesellschaft, in Stadslau, with various shafts and bearings through which known currents were passed. As a result of these it was found that, with ordinary soft metallic alloys for the bearing linings, harmful effects on the shaft were produced when the density exceeded 15 to 20 amperes per square decimetre of bearing surface. Since now the current density is under 15 amperes per square decimetre in most practical cases, the shaft surface will be seldom injured by these currents. This is an advantage, for it is much simpler to re-line a bearing than to turn down the shaft.

Along with the pitting of the bearing the oil loses its purity completely on account of the metallic particles set free. An investigation, however, showed that these impurities were of a mechanical nature rather than chemical.

The quite black discoloured oil has a considerably higher viscosity than pure oil, which explains why the presence of currents in the bearings is very seldom due to the warming up of the bearings.

For the purpose of measuring the currents in the bearings of a machine, the bearing was completely insulated from the bedplate by means of a sheet of presspahn, also metallic contact of the bolts was prevented by means of insulation. An ammeter was then placed between the bearing and bedplate. Care had to be taken to make the resistance of this path as low as possible to prevent these currents being diminished.

Measurements were taken on a 12-pole three-phase induction motor built for 700 H.P. at 3,000 volts, the stator of which was split. The pressure between bearing and bedplate was 1·3 volts with normal working pressure applied to stator. At rest, the current in the bearings measured 99 amperes; when running this fell to 75 amperes. This large decrease in the current when running was due to increased resistance caused by the better supply of oil between the contact surfaces than was the case when at rest. With alternating currents the variation of the resistance of the oil layer varies little with the current, whilst with continuous current the resistance falls off rapidly as the current is increased, and reaches a minimum with a current density of about 6·5 amperes per square decimetre. This characteristic property with continuous current may be due to electrolytic action. In another case of a 16-pole three-phase motor for 600 H.P. at 5,000 volts, the current in the bearings decreased from 150 amperes at rest to 50 amperes when running. The pressure between bearing and bedplate was 1·8 volts, so that the loss in energy due to these currents is only a small fraction of the total losses of the machine.

From the foregoing it will be seen that by facilitating the lubrication and improving the bearing surface the currents through the latter can be greatly reduced. As an example of this, it was found that by carefully scraping a bearing which had begun to show signs of pitting, the current was reduced from 200 to 35 amperes.

Another means adopted by certain firms for preventing these currents passing through the bearings is to provide a shunt path by means of placing a special ring on the shaft and leading the current directly to the bearing pedestal by means of copper brushes. Measurements made by the author, however, showed that, owing to the low resistance of the path through the bearings, this method only reduced the current to about two-thirds or one-half of its previous value.

The only means of preventing these currents entirely is to interrupt the circuit. Though several ways for doing this suggest themselves, the simplest and most practical is doubtless the insertion of insulation between bearing and bedplate, and also insulating the bearing bolts, if necessary. This method can also be applied to machines already in operation.

ELECTRICAL TRANSMISSION OF MUSIC.*

DEVELOPMENTS IN THE CAHILL TELHARMONIC SYSTEM.

The general features of the Cahill Telharmonic system † for generating currents of the proper frequency and amplitude at a central station, and superposing and transmitting them to numerous distant points for the purpose of producing music by means of electromagnetically vibrated diaphragms, are well known. During the past three years important changes have been introduced in the equipment, and the results now being obtained with a larger plant, which is being completed in the Cahill laboratory at Holyoke, Mass., are even better—in some ways strikingly better—than those secured with the equipment formerly in service in New York. The power and breadth of effects and the range of expression have been greatly increased. The mechanism has been simplified and the keyboard can now be manipulated by any skilled organist or piano

* Abstract of an article in the "Electrical World."

† A short description of the Cahill telharmonium was given by Sir W. H. Preece in a lecture before the I.E.E. in March, 1908. See THE ELECTRICIAN, March 20, 1908, p. 873.

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player after only a few trials, with results much more pleasing than they can obtain with the instruments upon which they have spent years in study and practice. But, notwithstanding this, the instrument has a new technique, a thorough mastery of which is not easily obtained.

Before considering the improvements in detail it may be of interest to mention what was desired in building the new plant. The ability of the New York plant to produce a wide range of orchestral timbres and to control the loudness of the note at every instant, by the human touch, was evident to all who saw and heard it; but it fell short of the inventor's ideal. Each switchboard represented a voice, but to produce the full, rich, many-voiced effect of a fine orchestra, quite a number of switchboards are required. Dr. Cahill's design contemplated five switchboards, with a large number of generators, for the New York plant, but the great expense of that pioneer work compelled a large reduction in the number of generators and the omission of three of the five switchboards. The distinctive tone and timbre of the music were there, but the full orchestral effect which the inventor desired was not. Notwithstanding these economies the original New York plant cost almost £40,000.

Another of the difficulties with the original New York plant was that on account of the interactions or reactions of the electrical circuits, the more keys of any one keyboard were depressed at the same instant (that is, the fuller the chord) the less loud each individual note became; and a point was easily reached where the loudness and strength of a chord were less than that of a single note. In the new telharmonium the circuits, switches and transformers have been reorganised in such a manner that full chords can be played on the same manual and switchboard, without any appreciable diminution in the strength of the individual notes, through the reaction of the circuits.

Persons who have heard the telharmonium, or dynamophone, as Dr. Cahill prefers to call it, have usually been surprised at the round and powerful tones which were produced from an ordinary telephone diaphragm. This responds well to powerful electrical vibrations so long as only one note is used. It also responds well for many chord effects, but there are other chord effects, particularly close chords in the bass, which if taken *fortissimo*, produce an unmusical sound—almost a growl. Dr. Cahill found two remedies for this defect. One was to produce one bass note from one diaphragm and line and another bass not from another diaphragm and line. This method obviously required a multiplication of lines and receivers, thereby involving a great increase in expense. Another remedy was to open up the chords in the bass. This method, however, involved the rearranging of the music in many cases. These difficulties have been completely overcome by a new receiver, described below, which was designed by Mr. A. T. Cahill, who is associated with his brother in the electrical work.

The new plant is much larger than the original New York plant. That plant had eight sections or panels of generators. The new plant has 24 sections in operation, with provision on the main frame and in the gearing system for others to be added later. The new sections are smaller and contain a smaller number of generators, but the individual generators, or at least those of high frequency, are much more powerful. In fact, the generators of the very highest frequency have many times the output ratings of the corresponding alternators in the New York plant. Almost the only feature of the New York equipment retained, without change, in the new plant, is the type of alternators, which are inductor machines. Even here, however, there have been changes in the details of the winding and in the shaping of the pole pieces, &c., the result of a long series of experiments.

Each panel of generators is mounted upon a steel shaft about 8·5 in. in diameter, which runs in a cast-iron shell. These shells are assembled upon a steel main frame. The main frame is approximately 65 ft. long, 13 ft. wide, and is built of 20 in. steel beams, mounted upon masonry. Great strength is apparent in the framework and foundations. The result is that the 24 high-speed shafts, before mentioned, each carrying a different group of inductors, run quietly and without any perceptible vibration.

The steel shafts, carrying the inductors, are mounted on ball-bearings of chrome-nickel steel. This feature alone is interesting, since this immense machine, with perhaps the most complicated gearing ever built, has 140 alternators, all running at high speeds on ball bearings. The saving of power in the bearings alone is estimated at more than 150 H.P.

The switchboards, even in their improved form, are of so complicated a nature that a brief description is impossible. The musical conditions are so far different from those of lighting circuits that open-circuit transformers seem to give better results than the closed-circuit transformers.

The new receiver, by which the electrical vibrations are converted into sound waves, is very different from that of the ordinary telephone. It has a much larger and heavier diaphragm—about 10 times as large and three times as thick. A more powerful magnet system is used and the disposition of the field and coils is strikingly different from that in common use. Partly as a result of the increased size and weight of the diaphragm, partly from the greatly increased strength of the magnetic system, partly from the novel disposition of the same and the novel shape of the air passages, a most striking effect is produced. A single diaphragm responds powerfully to any sound, from the deepest bass to the highest treble of the machine; to a pure tone or a highly composite tone; to a single note or to a full chord. The volume and purity of the sound is very striking.

The inventor has expressed the conviction that the most important musical effects of a large and fine orchestra can be produced electrically by the use of, say, 10 manuals, with one performer for each and a sufficient set of generators to furnish all of the necessary harmonics. The music, of course, of this electrical orchestra would not be exactly the same as that of the orchestra of bows, wood-winds, and brass. It would certainly be better in some ways; it might not be so good in others. All the musicians who have seen the new telharmonium are in love with it. And almost every person who hears it considers it as the music of a future that ought to begin at once. The new plant has cost, up to the present, about £40,000.

The inventor claims that for £60,000 a powerful plant, with eight good switchboards, can be built at the present prices of labour and material, while three good switchboards and enough generators to make a respectable beginning in a city having 200,000 or 300,000 inhabitants can be furnished for £25,000. With such reductions in cost, combined with the great improvements in the musical effects before described, the electrical music ought to come into general use at an early date.

The improvements made in the new plant may be briefly stated to consist in a great improvement in musical effects, combined with a great reduction in the cost of the plant. This reduction in cost arises chiefly from the greatly increased power of the high-frequency generators and various improvements in the generators and their gearing, a great simplification in the switchboard work, and the improved receivers by which a single receiver and a single pair of lines is made to do the work which formerly required several receivers and several pairs of lines. The improvements in musical effects arise chiefly from the greater strength of the highest notes and of the higher harmonics, the improvements in the expression devices, and the simplifying of the keyboard and switchboard work, making it much easier for a performer, familiar with the pianoforte or pipe organ, to play upon the new telharmonium.

ELECTRICAL EXHIBITS AT THE BRUSSELS INTERNATIONAL EXHIBITION.

(*Concluded from p. 273.*)

Among the other electrically-driven machines exhibited by Messrs. Butler is a planing machine suitable for work up to 6 ft. in length and 2 ft. 6 in. square. The motor is mounted on a bedplate fixed to girders at the top of the two main uprights carrying the tool. The driving is arranged by a raw hide pinion on the armature shaft, gearing into a spur wheel on the same shaft as that to which the main driving pulleys are fixed. A 15 H.P. shunt-wound motor is employed running at a constant speed of 1,000 revs. per min., and the speed of cutting is 40 ft. per minute, while the return speed is 120 ft. per minute.

There is also shown a slotting machine of 10 in. stroke, fitted with a 10 H.P. motor with variable speed ranging between 600 and 1,350 revs. per min., and also a 48 in. vertical turning and boring machine, in which a 10 H.P. constant-speed shunt-wound motor is mounted on the top of the standards forming the main framing. The different speeds are arranged by a five-speed cone pulley, and, as there are two sets of back gear, 15 different speeds may be obtained, the belt-shifting device allowing the belt to be moved from one speed to another without stopping the machine.

Messrs. B. & S. Massey, of Manchester, have an interesting exhibit of power hammers, several of which are electrically operated, this being a somewhat recent departure for this class of work. The hammer is worked by compressed air, the air being compressed by a double-acting reciprocating pump driven through spur gearing by the motor. The air is admitted at the top and bottom of the hammer cylinder, exactly as the steam in a steam hammer. A 2 cwt. hammer is exhibited, a compound-wound motor of 6 H.P.

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continuous rating at 1,000 revs. per min. being employed. For the drive a raw hide pinion is used on the armature shaft, gearing into a spur wheel, which consists of a heavy flywheel with the teeth on the periphery. The piston in the pump cylinder is operated through a forged steel crank on the flywheel and a diagonal connecting rod.

Messrs. Massey also exhibit a 5 cwt. pneumatic hammer, for which the air is supplied from a separate motor-driven compressor, being used expansively on the down stroke of the hammer. There is also a 3 cwt. stamp by the same firm, with a patent friction drop arrangement, the machine being operated by a motor fixed on the top of the guides for the falling stamp.

As might be expected, there is a good display of American machine tools, and here again one sees the electric drive very much in evidence. Among the many interesting exhibits is a shaping machine for shaping crank shafts up to 32 in., driven by a 7 H.P. motor at 1,000 revs. per min.; two milling machines, one operated by a 7 H.P. motor at 1,000 revs. per min., and the other by a 10 H.P. motor at 900 revs. per min.; a grindstone driven through gearing by a 7 H.P. motor at 1,800 revs. per min; and a turret lathe operated by a variable-speed motor of 11 H.P., with a range of from 400 to 1,100 revs. per min.

Among the other English exhibits, interesting from an electrical point of view, is that of Messrs. C. A. Parsons & Co., of Newcastle-on-Tyne, who show an example of their new type of direct-current armature for a turbo-generator, this being for a 1,000 kw. machine running at 1,800 revs. per min. and generating current at 550 volts. The object of the new construction is to reduce the large air-gap which is necessitated with surface windings, and to provide a fan action which shall keep down the temperature of the conductors. These latter are of solid copper, and are firmly fixed edgewise into slots in the armature core, the end connections being clamped by studs and plates, no binding wire being wound at all over the bars; the cause of most of the accidents with direct-current turbo-generators—namely, the breaking of the binding wire, with its consequent disastrous effects—is by this means entirely eliminated. Messrs. Parsons also show a large model of their patent compounding device for regulating the voltage of alternators on load.

Messrs. Reavell, of Ipswich, who have of recent years been very successful with their air compressors, have erected several at the Exhibition, one for belt drive, one direct coupled to a petrol engine, and one driven by an electric motor. This last-mentioned compressor is of the quadruplex type, with four air cylinders arranged at right angles, all pistons being driven from the central shaft. The output of this machine is 45 cubic ft. of free air per minute, and the motor employed is of 10 B.H.P. and runs at 440 volts. Messrs. Reavell also exhibit a small steam engine coupled to a 10 B.H.P. dynamo manufactured by Messrs. Maudsley, this being a type they have developed for ship's lighting.

In the British Industrial Hall, Messrs. Waygood exhibit one of their well-known electric double-cage passenger lifts for conveying visitors from the ground floor to the gallery. Each cage is capable of carrying seven persons, and the travel is 13 ft. 8½ in., the speed being 110 ft. per minute, with a lower speed if required. The control is by means of a car switch with a detachable handle, being arranged so that the handle returns to the off position immediately it is released. There are also exhibited a model of an automatic electric push button passenger lift and of a hydraulic lift.

Among the few stands that were completely finished on the opening day was that of Messrs. Marryat & Place, of Hatton Garden, London. This firm is showing a 10 cwt. passenger lift gear with push button controller, and arranged to operate a model four-floor passenger elevator. A car switch and rope operated lift controllor are also exhibited. As to the push button controller, a feature is its simplicity. The number of parts has been reduced to a minimum, and all contacts have been removed from the lift well, so that there are only the push buttons and door contacts at the various floors, the controlling panel and selecting switch being in the motor house.

Messrs. Hans Renold are exhibiting in the British section, in addition to many samples of their various types of chains, three complete drives, viz., a patent bearing silent chain, a bush roller, and a block chain drive. The silent chains are capable of running up to 1,250 ft. per minute, and, with special oiling provisions, even faster. Powers up to 500 H.P. can be transmitted, and larger sizes are at present being developed. The drive exhibited is provided with a shock-absorbing sprocket, for use where the driving power or load is liable to sudden fluctuations. The bush roller chains may be run up to 900 ft. per minute, and that exhibited is of 2 in. pitch, and will transmit 20 H.P. at a speed of 450 ft. per minute. The third drive shows a 2 in. pitch block chain 1 in. wide, capable of running at speeds up to 500 ft. per minute. A coal-cutter chain is amongst the exhibits, it being claimed that this chain is more durable and considerably stronger than any hitherto used for the purpose.

As previously mentioned, the German section is quite self-contained and generates the whole of the electric power required for its own purposes. At present the supply is taken care of by a type of generating set somewhat uncommon in England, but very much in use on the Continent, and particularly in Germany—a semi-portable and entirely self-contained arrangement known as a locomobile. There are two of these in the exhibition, one by the firm of Wolf, of Magdebourg-Buckau, and the other by Heinrich Lanz, of Mannheim. They are both employed for driving dynamos, and the former has a horizontal boiler with removable tubes, a superheater being placed just behind the fire tubes, and the ejector condenser underneath with the pump driven off the main shaft. There are two cylinders, each with a balanced piston valve, and there is a flywheel on each side of the crank. These flywheels also serve as belt pulleys, two dynamos placed on the floor being driven by means of belts. It is stated that the coal consumption is under 1 lb. per effective horse-power-hour, and the steam consumption less than 8 lb. per horse-power-hour, from which it is evident that the absence of piping has a very beneficial effect on the economy of the plant. The power of the machines shown at the exhibition is 650 H.P.

The exhibit of Messrs. Lanz is even larger than that of Wolf, and is said to be the largest in the world. The main details of construction do not differ widely from the machine described above, except that there is but one dynamo. This is driven direct from the main shaft, and is mounted on a platform about the level of the top of the boiler, thus forming an even more compact arrangement. A heavy flywheel is provided on the other side of the crank, and this overhangs the boiler.

Another exhibit of Messrs. Lanz, who have a very imposing display, is a four-cylinder steam engine of 6,000 H.P. for the propulsion of a torpedo boat. On the end of the shaft remote from the propeller is a direct-coupled dynamo for supplying electric power to the ship.

The exhibit of Messrs. Bergmann, of Berlin, forms one of the most remarkable features of the entire exhibition. On their stand in the main machinery hall in the German section a 10,000 H.P. turbo-alternator has been erected. This is the biggest unit in the exhibition. The steam turbine is of the single-cylinder Bergmann type, which has attained considerable success on the Continent, and the manufacture of which has recently been taken up in this country by Messrs. Dick, Kerr & Co. Its speed is 1,500 revs. per min., which is high for this large output, and hence the overall dimensions seem relatively small. There are four nozzles, whose spindles are grouped round the main stop valve spindle, and they are operated by the main stop valve handle, which is not fixed. The alternator, which is totally enclosed except for the usual opening at the top, has an output of 8,000 k.v.a., and the exciter, which is on the same shaft, has no end bearing for its armature. There is, further, a turbo-generator of 2,500 H.P. for supplying current to the German section, and a high-speed rotary converter of 1,000 kw., with a commutator and slip-rings for three-phase current at each end. Numerous small motors for all purposes and a model "remote control" switchboard are also exhibited.

In the locomotive shed, where several of the most modern of German steam locomotives are installed, Messrs. Bergmann show a motor car for suburban service, running on a normal gauge track, which, though not entirely novel, will be of much interest to many English engineers. There is a totally-enclosed direct-current motor geared to each axle suspended from the frame of the car, and the current is derived from a 50 H.P. dynamo driven by a benzine motor direct coupled and mounted on the front of the car. The engine and dynamo are enclosed in a chamber with doors at each end, so that both the engine and commutator are readily accessible. The cylinder is water cooled, the radiator being fixed just above and cooled by a fan, which is driven by bevel gearing off the end of the armature shaft. The motors are of 30 H.P., at one hour rating, and the maximum speed of the car is about 50 miles per hour, the number of passengers carried being about 40.

Among Messrs. Bergmann's other exhibits is a 30,000 kg. overhead electric travelling crane spanning one of the bays; while there is, further, an unusual type of traveller, in which the crane house is made to traverse and a revolving jib is fitted.

A new type of rotary engine evolved by the Internationale Maschinenbau-Gesellschaft, of Hanover, is also exhibited, coupled to a 170 kw. direct-current generator, and some secrecy is being maintained concerning it. There are two cylinders, exactly like the high and low-pressure cylinders of a compound steam turbine, and the steam, in fact, expands partially in one and is then delivered into the other, where it expands to exhaust pressure, a bearing being provided between the two cylinders. The remarkable point about the machine is its low speed—only 150 revs. per min.—and a very low steam consumption is claimed. Naturally, owing to the low speed, the machine is very much larger than a steam turbine set, resembling, in fact, a 500 kw. generator in outward appearance.

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With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The forty-ninth issue of the Supplement was published (Gratis) with the last number of "THE ELECTRICIAN."

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THE INSTITUTION OF ELECTRICAL ENGINEERS.

In reviewing the work of the Institution during the past session we think it may be said that the Papers presented, and the discussions to which they have given rise, have been up to the usual standard. Many Papers have been read more than once, and the advantages of an organisation which permits a Paper to be read at more than one centre have certainly been apparent. The number of original communications also has increased by, roughly, one-third, which must be considered a good sign that the Institution is attracting work of a kind which, although not suitable for discussion, is nevertheless worthy of publication.

In other directions also the Institution has been active, and in many respects these activities must be considered as important as the reading of technical Papers. In the Report we find that provision is being made for issuing another revised edition of the Wiring Rules, and to this end tests are being made at the National Physical Laboratory with reference to certain data in the rules. The Model General Conditions for Contracts are also being revised. It will be remembered that these were due in the first instance to the energy of Mr. ROBERT HAMMOND, and after careful discussion they were duly issued some years ago. Since then, however, they have remained unaltered, and now the Council appear to think that the time has arrived when

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modifications should be considered. To this end the Council have had the benefit of co-operation with the Cable Makers' Association, the Electrical Contractors' Association, the Incorporated Association of Electric Power Companies, the Incorporated Municipal Electrical Association, the National Electric Manufacturers' Association and the Tramways and Light Railways Association. It is well that all the interests concerned should have a voice in a matter of this kind, and we are glad to see that this policy of co-operation is being adopted.

Another point of interest in the annual report is that the Council have adopted the Rules for Professional Conduct recently adopted by the Institution of Civil Engineers, and we gather that the Council will seek powers to enforce these rules. This is always a point of difficulty in such matters, as rules are of very little value unless they can be duly enforced. With regard to the rules themselves, they are good so far as they go, but there are inherent difficulties in the provision of suitable rules by any Institution whose membership includes engineers of very different classes. Although it is not definitely so stated, the term "professional conduct" really refers to the practice of the consulting engineer. As the Institution of Electrical Engineers does not consist exclusively of consulting engineers, it is difficult for the Council to adopt rules which really meet the case, as other conflicting interests are to be found. The result of this is to be seen very clearly in the third rule, which practically states that an engineer, while acting in a professional capacity, shall not at the same time act as agent for any contracting or manufacturing company with which he may have occasion to deal on behalf of his clients, or have any financial interests in such business without disclosing the fact in writing to his clients. This one clause renders the rules practically inoperative on the very large question of contractors who act as consulting engineers, a question which is a most legitimate grievance on the part of engineers who are really consultants, and it renders the fact very clear that these questions can only be dealt with by an independent organisation.

Among other spheres of activity we may mention that certain points in legislation have been considered by the Council during the past year, and a committee has been appointed to report upon the question of electrical driving of textile mills. At present data are being collected, with the collaboration of the local sections interested, and in view of the report recently issued under somewhat curious circumstances by the Bradford Engineering Society we are sure that this step by the Council will be very much welcomed. It is extremely important that this question should be cleared up authoritatively.

The election of the Council for the new session has this year been marked by the unusual occurrence of a nomination beyond those due to the Council. This principle, as a principle, is desirable, but as we deal with this subject elsewhere we need say no more on this particular point.

The time is now approaching when the Institution will be moving into its new building, and will at length be provided with a home of its own. We trust that finance in connection with this new move will work smoothly, and that the Institution will be so far supported by an influx of new members as to relieve the Council of all anxiety. It is a little early yet to judge of the position accurately. At a special general meeting last week the members were asked to sanction the expenditure of another £10,000. The arguments on which this request was based were not entirely convincing, as the amount actually required was only a small proportion of this sum, and the possibility of spending the greater proportion apparently will not arise for another two or three years. We do not doubt, however, that the Finance Committee will keep a firm hold upon the expenditure. This is certainly desirable, though, on the other hand, we think it is far better that a clean sweep should be made at the start, and that the building should be put into such a state that it will meet the needs of the Institution for a good many years to come.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electric Waves. By W. S. FRANKLIN. (London: Macmillan & Co.) Pp. ix. + 315. 12s. net.

This treatise is planned to exhibit in as simple a manner as possible the principal mathematical methods at present available for handling high and low frequency alternating-current problems when the E.M.F.s and currents are not simply harmonic, and when the capacity is not concentrated. The treatise is intended for practical people and not for mathematicians; but, of course, the book will not be easy reading throughout except to those with a considerable mathematical equipment. In spite of this fact, large portions of the volume can be understood without the assistance of the differential calculus, or even trigonometry—the author makes such excellent use of mechanical analogies. Indeed it is not too much to say that the first two chapters of this book comprise the most lucid short exposition of general wave theory that the present writer has yet happened upon.

The first part of the book deals in turn with water waves, wave trains and stationary waves, electromagnetic waves, waves along and oscillations on cables, the general electromagnetic wave equations, and electric wave telegraphy. The author discusses the surgings on transmission lines and the reflection from inductive and non-inductive terminal apparatus, with exceeding simplicity. The explanation of the reduction of line losses in telegraphy and telephony by loading the line with inductance, and the reduction of distortion by leakage is similarly carried through with what may be styled a clarified Heavisidean spirit. Throughout even the mathematical part the author keeps his eye on the practical side. The development is here again based largely on the methods of Heaviside; but in the explanation of curl, divergence, vector potential and so forth, the mind of the ordinary reader is supported by ample provision of that Cartesian scaffolding which Heaviside spurns scornfully away. The chapter on electric wave telegraphy is the weak one of the book; it takes the whole of that subject in ten pages, and really might as well have been left out.

Part II. of the work is devoted to harmonic analysis. Practical analysis is represented by a very full description of the Fischer-Hinnen method of evaluating the Fourier coefficients in given non-harmonic curves. This analysis is applied to an examination of the causes of non-harmonic E.M.F.s in alternating-current generators; and allied matters such as the influence of higher harmonics upon core losses in transformers, and the influence of triple harmonics on the current and voltage, and on the power factor in three-phase systems, are touched upon. Appendixes deal with the

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practical calculation of the inductance and capacity of transmission lines, and certain smaller matters.

The work is too interesting to be left to students; it could be read with pleasure and profit by all scientific electrical engineers.

W. H. ECCLES.

The Prevention of Industrial Accidents. No. I.—GENERAL. By F. E. LAW and W. NEWELL. (New York, The Fidelity & Casualty Co.) Pp. 194. 25 cents.

"An ounce of prevention is worth a pound of cure" is a befitting text for the title-page of this handbook, to which we are pleased to extend a hearty welcome. Whilst the valuation at which human life is held differs considerably in various countries, no one will question the desirability of preventing accidents. It is interesting, but perhaps not surprising in view of German "thoroughness," to notice that the authors have turned to Germany for exact information in regard to the causes of accidents in industrial concerns. The published statistics in that country show that no less than 58 per cent. of the total number of accidents recorded are due to the negligence of employers or employés, the remainder—namely, 42 per cent.—being due to the inevitable risks of employment. As the United States have not progressed to anything like the same extent as many other countries in minimising industrial accidents, the authors remark that probably far more than 58 per cent. of the accidents that occur in the States are preventible. That an extensive field exists for preventive measures may be gathered from the following remark in the "Bulletin" of the Bureau of Labour (September, 1908): "Upon a conservative estimate, the total mortality from accidents in the United States among adult wage-earners is between 30,000 and 35,000, of which it should not be impossible to save at least one-third and perhaps one-half by intelligent and rational methods of factory inspection, legislation and control. In addition, there were approximately not much less than two million non-fatal accidents."

A large insurance company should be particularly qualified to speak with authority on means for the prevention of such accidents, and the present handbook is undoubtedly a valuable addition to the literature on this subject. The book deals with general precautions, and applies to all industries; but other pamphlets have been prepared dealing with the conditions peculiar to certain industries.

Particular emphasis is laid on the large part played by ignorance and carelessness as causes of accidents, and to the duty of employers to make strict rules for observance by employés. There are also many safety devices which can be installed at small cost. Safety devices are considered under the following heads: Steam boilers, engines, electrical apparatus, elevators, the factory and wood-working machinery. In no case is the name given of the makers of the various safety devices described, but it is stated that they will be supplied on application being made.

In the section dealing with electrical apparatus undue emphasis is, perhaps, laid on the use of rubber gloves. Thus, the recommendation that in oiling, cleaning, or adjusting any part of a dynamo, motor or transformer in service the attendant should wear rubber gloves is scarcely practicable, or perhaps we might say necessary, at any rate in the case of low-voltage machines. This also applies to the suggestion that the handles of oil cans and wipers and cleaners should be insulated. As to portable hand lamps, the authors state that the two most important points to be observed are: (1) That there shall be no metallic connection between the lamp-holder and any other metal part of the fitting; and (2) that the flexible wires in passing from the lamp-holder shall not be led through a metal tube or otherwise touch any metal part of the fitting. It will be remembered that particular emphasis was laid in the recent official notes on the Home Office Regulations on point (1) above, the majority of hand lamps hitherto used failing to comply with this condition.

Automatic elevators are by no means unknown in this country. The authors consider such installations inadvisable, and in their opinion each elevator used for passenger service should be in charge of an operator.

THE DETERMINATION OF THE EFFICIENCY OF DIRECT-CURRENT MACHINES BY THE HOPKINSON TEST.

BY C. V. DRYSDALE, D.SC.

There is probably no method of testing the efficiencies of direct-current machines which is so much used in commercial work as the Hopkinson test or Kapp's modification of it; and no method about which so little seems to be known. The method is described in practically every text book, but the writer has not met with one in which the details of the test and the analysis of the results have not been shirked. All that is usually stated is that the combined efficiency is the ratio of the generator to the motor current and that the efficiency of each machine is the square root of this combined efficiency. When we have a pair of machines of high efficiency running at approximately full load this may not be far from the truth, but with small machines, and with any machines at low loads, the conditions of load for the two machines are so different that it is absurd to assume their efficiences as equal, and it is absolutely impossible to obtain a rational efficiency curve in this manner.

In THE ELECTRICIAN of April 15th Mr. W. C. Clinton has done valuable service by calling attention to the unnatural and unequal conditions under which the two machines are run in the ordinary Kapp method, and has shown us how these inequalities may to a considerable extent be rectified by an auxiliary battery. He has also properly apportioned the copper losses between the machines, which is the only rational method.

As the matter is of some importance the following description

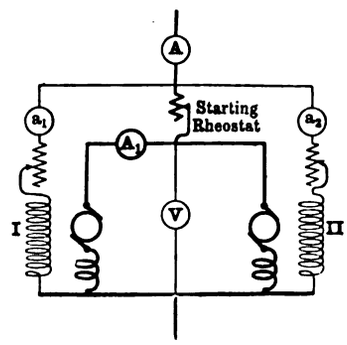

FIG. 1.—CONNECTIONS EMPLOYED.

of a simple method of carrying out the test, which seems fairly satisfactory although not pretending to be theoretically correct, may be of interest. Fig. 1 shows the method of connecting up and needs no explanation. The regulation of the currents is effected by the rheostats in the shunt fields in the ordinary manner.

If the excitation of machine I. is weakened so that it becomes the motor, we have obviously:—

$$\text{Motor input} = (A_1 + a_1)\ V.$$
$$\text{Generator output} = A_1 - A + a_1)V.$$

On the other hand, if II. is made the motor, by weakening its excitation, we have:—

$$\text{Motor input} = (A_1 + A - a_1)V,$$
$$\text{Generator output} = (A_1 - a_1)V.$$

The difference between the input and output in either case is AV, the total losses in the two machines. So far we are rigidly correct.

If the machines are of fairly high efficiency it does not require a great change of speed or excitation to produce the circulating current between the machines, and we may assume the iron and frictional losses as nearly constant and equal for each machine. If then we subtract the value A_0V, the watts when the machines are both running under equal conditions or at "no load," from the value of AV when running under any given load, the excess is approximately the sum of the C^2r losses in the armatures of the two machines. The current in the armature of machine I. is A_1, and in that of machine II.

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Motor.	Volts.	Currents. Main. A.	Coupling. A_1.	Shunt a_1.	Shunt a_2.	Total losses. V.A.	Excess. C^2R.	Armature current. I.	Armature current. II.	$A_1^2/(A_1^2+A_2^2)$.	C^2R losses. I.	C^2R losses. II.	Total losses. I.	Total losses. II.	Machine I. Input.	Machine I. Output.	Machine II. Input.	Machine II. Output.	Efficiency. η_1.	Efficiency. η_2.
I	105·0	21·0	...	2·26	2·25	2,205	...	...	...	...	...	...	1,102	1,102	2·236	...	1·10	...	...	...
	105·0	21·0	20	2·12	2·28	2,205	...	20	3·4	...	...	...	1,102	1,102	2·32	1·22	1·22	0·118	52·6	9·7
	105·0	22·5	40	1·98	2·28	2,360	155	40	21·76	0·773	120	35	1,222	1,137	4·41	3·19	3·18	2·047	72·4	64·3
	105·0	28·0	60	1·88	2·25	2,625	420	60	39·1	0·702	295	125	1,397	1,227	6·5	5·1	5·11	3·88	78·5	76·0
	104·5	27·0	80	1·83	2·25	2,870	615	80	57·1	0·663	408	207	1,510	1,309	8·56	7·05	7·05	5·74	82·4	81·5
	104·0	30·0	100	1·77	2·21	3,120	915	100	74·0	0·646	591	324	1,693	1,426	10·59	8·90	8·9	7·47	84·1	84·0
	103·0	35·0	120	1·70	2·22	3,605	1,400	120	88·9	0·645	903	497	2,005	1,599	12·53	10·53	10·53	8·94	84·1	85·0
	102·0	40·0	140	1·65	2·22	4,080	1,875	140	103·9	0·645	1,210	665	2,312	1,767	14·45	12·14	12·14	10·37	84·1	85·5
	101·0	48·0	160	1·55	2·20	4,848	2,643	160	115·7	0·657	1,735	908	2,837	2,010	16·32	13·48	13·48	11·47	82·7	85·3
II	105·75	21·0	...	2·15	2·12	2,220	...	...	16·72	...	...	...	1,110	1,110	1·11	...	1·99	0·88	...	44·2
	105·5	22·0	20	2·0	1·95	2,320	100	20	38·05	0·217	22	78	1,132	1,188	3·03	1·9	4·22	3·03	62·8	71·8
	105·5	25·0	40	2·0	1·82	2,640	420	40	61·2	0·3	126	294	1,236	1,404	5·24	4·0	6·55	5·15	76·4	78·6
	105·0	22·0	60	2·2	1·75	2,940	720	60	81·0	0·338	243	477	1,353	1,587	7·43	6·08	9·02	7·43	81·9	82·4
	104·0	33·0	80	2·175	1·70	3,435	1,215	80	109·1	0·35	425	790	1,535	1,900	9·63	8·1	11·52	9·62	84·2	83·6
	104·25	39·0	100	2·175	1·65	4,070	1,850	100	135·2	0·354	655	1,195	1,765	2,305	11·96	10·2	14·26	11·97	85·4	84·0
	104·0	45·0	120	2·14	1·60	4,680	2,460	120	161·3	0·356	877	1,583	1,987	2,693	14·23	12·24	16·93	14·24	86·1	84·1

is $A_2 = A_1 - A + a_1 - a_2$. Hence we may divide the above copper loss $(A - A_0)V$ in the ratios of the squares of the armature currents, and the copper loss in I. is $\frac{A_1^2}{A_1^2 + A_2^2}(A - A_0)V$, and in II. it is $\frac{A_2^2}{A_1^2 + A_2^2}(A - A_0)V$, which are obtained without measuring the armature resistances. The loss in each machine is then taken as half the iron and friction loss, or $\frac{A_0 V}{2}$, together with its own share of the copper loss as above obtained. We thus obtain the motor output = generator input, and thence we can calculate the efficiency of each machine separately, and plot its curve of efficiency against output.

The following table and the efficiency curves, Fig. 2, were

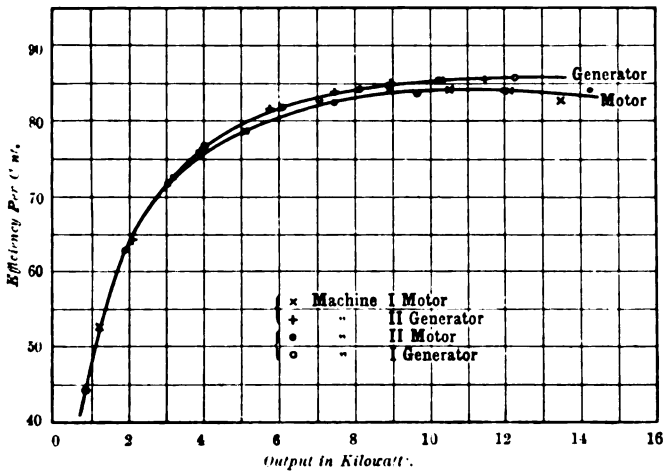

Fig. 2.—Efficiency Curves from Hopkinson Test.

obtained in the above manner by the staff and students in the evening practical demonstrations at the Northampton Institute. The tests were made on a pair of 15 kw. machines by the International Electric Co. of Liège, each being intended for 100-110 volts at 1,150 revs. per min. The mode of constructing the table will be obvious from what is said above.

It will be noticed that the two tests with machine I. and II. as motor, respectively, give four sets of points for the motor and generator efficiencies. Up to about 4 kw. all these points lie on the same curve, but above this the motor curves separate from those of the generator, until the difference is a little over 1 per cent. at about 12 kw. This difference is probably due to the fact that the motor having had its field weakened should not have had half of the "fixed" losses apportioned to it, but the mean of the two curves should be approximately correct. Previous tests on the machines had shown them to be most accurately similar in all respects.

Fig. 3 shows the result of a brake test on machine I. as a motor, taken on the writer's regenerative brake. Unfortunately it was only found possible to carry the test as far as 11 kw., but the observations agree remarkably well with the upper of the two curves in Fig. 2. In the brake test, however, the P.D. was always kept at 110 volts, while in the Hopkinson test it fell from 105 to 102 or 103 volts as the load was increased. Had the voltage been maintained, the mean curve for the Hopkinson test obtained in this way would have very closely coincided with the direct test, and this would appear to indicate that this mode of carrying out the test would be sufficiently satisfactory with machines from 10 kw. upwards in practice. This only applies, of course, to machines having a fairly horizontal speed or voltage characteristic, and not to series machines. It should be noted that considerable care was taken to have the brushes of each machine set on the neutral axis before the test commenced. It might, perhaps, be possible to obtain the required regulation of the load, without change of the field and iron losses, by regulating the brushes, but the writer has had no opportunity of trying this.

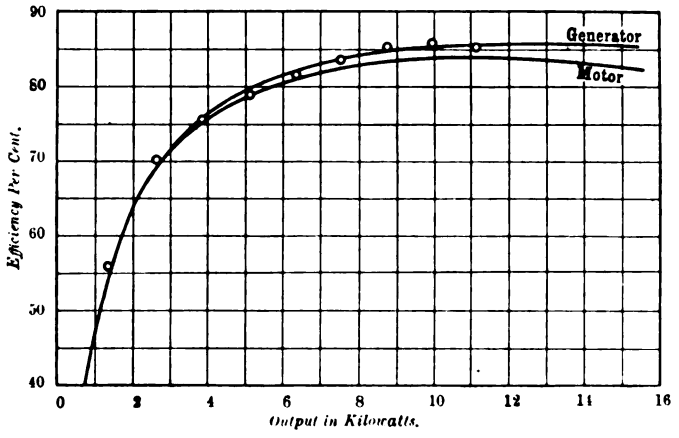

Fig. 3.—Brake Test.

The speed of the machines during the Hopkinson test varied from about 1,100 at no load to 1,200 at full load, or by nearly 10 per cent. Of course by using an auxiliary battery as Mr. Clinton suggests this could have been avoided.

In conclusion, the writer's thanks are tendered to Messrs. A. C. Jolley, H. Gerrard and A. F. Burgess, and to several students of the Northampton Institute for conducting the above tests.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"The Technical Press Index for the Period of January, 1908, to June, 1909." (London: A. Constable & Co.) 12s. net.

"Compulsory Working and Revocation of Patents." By Ernest Lunge. (London: Stevens & Sons.) 3s. 6d.

"Modern Lightning Conductors." By Killingworth Hedges. 2nd edition. (London: Crosby, Lockwood & Son.)

"Electric Power Plants." Designed by T. E. Murray. (New York: T. E. Murray.)

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RELATION BETWEEN TEMPERATURE OF ELECTRODES AND VOLTAGE OF THE ELECTRIC ARC.*

BY C. D. CHILD.

Summary.—A *résumé* is first given of previous experiments to find the effect on the electric arc produced by cooling the electrodes. Some of the experiments were repeated by the author, who found that cooling the cathode of a carbon arc raised the pressure several volts, a smaller increase occurring when the anode was cooled. The anode and cathode pressure drops were measured and both found to increase when the cathode was cooled, the principal increase being in the cathode drop. The increase in potential in different parts of the arc was approximately proportional to the potential existing before the cathode was cooled.

The theory of the electric arc, as at present held, leads us to expect that with cooled electrodes a higher P.D. will be needed to maintain the arc than with electrodes not cooled, but the experimental evidence to a large extent favours the opposite view. It, therefore, seemed worth the trouble to review what has been done on the subject and to repeat some of the experiments.

Many of the earlier experiments are of little value. Such for example as that of De la Rive (1841), who attempted to heat the arc by placing an alcohol lamp under it. Tommasi (1881) formed an arc between copper tubes, and found that when they were cooled by water passing through them the arc was very unsteady and the luminosity became less. This is one of the most satisfactory methods of examining the question, but his results are not as definite as is desired. Cross and Shepard (1885) endeavoured to heat the electrodes by protecting them from convection currents. This method is more satisfactory than some, and yet it is conceivable that the protection would alter the character of the gas sufficiently to change the P.D. Lecher (1887) used three methods for changing the temperature of the electrodes. The first was to warm the electrode with a gas lamp; the second was to wrap fine copper wire about the electrodes; and the third method was to cool the electrode by immersing it in a mercury bath, which was in turn kept cool by running water. This would apparently be a suitable method, providing that the mercury vapour did not pass into the arc.

The experiment of Hertzfeld where he blew cold CO^2 into the arc was valueless, for the reason that the change in the character of the gases and the distortion of the arc by blowing into it would produce far greater effects than those produced by cooling the electrodes. Schultze used the same method as that of Tommasi, experimenting with the arc between copper electrodes which could be cooled by passing water through them. He found that cooling the cathode raised the P.D. about 1 volt, cooling the anode raised it about 4 volts, and cooling both electrodes about 6 volts. Where an oxide is formed by the action of the arc this effect was not found. Even with iron the effect could not be shown. This was partly due to the smaller heat conductivity of the iron.

Mitkiewitz found that a current of 2 amperes could be passed through an arc with a P.D. of only 2 volts if the anode was heated in an oxy-hydrogen flame. But it is a question whether this is an arc at all and not merely the discharge produced by a hot flame. Stark and Cassuto cooled the electrodes by placing a small quantity of the substance to be examined on the top of a water-cooled jacket. They were unable to determine with certainty any change when carbon electrodes were used. With copper electrodes they found the voltage much lower when the arc was several millimetres long and no change when it was 2 mm. long. From this they concluded that with still shorter lengths the voltage would be higher with hot electrodes and that the sum of the anode and cathode drops is greater with hot electrodes than with cold ones. Malcolm and Simon using copper electrodes and small currents with arcs 4 mm. long found that the cooled electrodes required higher voltages. With currents varying from 0·4 to 1 ampere the voltage was from 20 to 5 volts higher when the anode was cool than when the electrodes were hot, and 40 to 10 volts higher when the cathode was cooled.

Of the experiments, therefore, which are least open to objection there are two sets, and these two arrive at directly opposite conclusions. Cross and Shepard using carbon electrodes came to the conclusion that cooling the electrodes lowered the required voltage, while Schultze, Clarke and Cassuto, and Simon and Malcolm, using copper electrodes, reached the conclusion that cooling the electrodes raises the required voltage. It, therefore, seemed worth while to repeat some of these experiments and to find the cause of the discrepancy.

Electrodes Cooled by Water-jacket.—The experiment of Cross and Shepard was first repeated. One of the electrodes was surrounded by a copper jacket through which water could be passed. This was made to fit tightly around the carbon, so that no steam could get into the arc. The top of the carbon extended between 1 mm. and 2 mm. above the top of the jacket, which was made out of sheet copper, so that the water would come as near as possible to the top of anode. The carbon was 12 mm. in diameter. The arc was started without any water in the jacket and allowed to run as long as possible without overheating the apparatus. It was then cooled by passing water through the jacket. The P.D. at the terminals of the arc was taken before the anode was cooled and again immediately afterwards. The water was then allowed to flow out of the jacket and the P.D. again noted.

When the cathode was thus cooled there was an increase in the P.D. of 2 or 3 volts. When the temperature increased on drawing off the water there was a decrease in voltage of about 1 volt. It was to be expected that the decrease would not be as large as the increase, since the P.D. would gradually increase, due to the burning away of the electrodes. This change was found to be practically the same for currents varying from 8 to 20 amperes and for lengths varying from 1 mm. to 5 mm., as long as the arc was quiet. With the hissing arc it was difficult to detect any change when the jacket was filled with water. When the anode was cooled, no definite change could be detected, but this may be due to the difficulty of performing the experiment properly. Practically the same effects were observed with solid and with cored carbons, but with a mineralised carbon, such as is used in the "flaming arc," no effect could be definitely determined.

These results are opposite to those found by Cross and Shepard, and to find the cause of the difference the experiment was again performed, but with the water vapour passing freely into the arc. It was found that this caused the arc to go into the hissing form, with, of course, a large decrease in the voltage. It is possible that the decrease in voltage which Cross and Shepard found was due to the change to the hissing form of the arc and not to the change in the temperature of the electrodes. This same experiment was then repeated, using mercury instead of water to cool the electrode, as was done by Lecher, and the vapour of the mercury could pass into the arc freely. It was found that there was a decrease in the P.D. of 10 or 15 volts, when the mercury reached the hot part of the anode. That this was due to the passing into the arc of mercury fumes was shown by the fact that the mercury lines began to appear in the spectrum of the arc even before the decrease in the P.D., and became very prominent at the time of this decrease.

Hollow Carbons Cooled by Flow of Water.—As far as I have been able to learn, the method employed by Tommasi and by Schultze with copper electrodes has not been used with carbon electrodes. It, therefore, seemed worth while to try their method with such electrodes. The arc was formed between a cored or solid 10 mm. carbon and a hollow carbon, outside diameter 12·5 mm., inside 4 mm., connected to a water faucet so that it could be cooled by running water through it.

In the first experiments the hollow carbon was used as cathode. It was found that the voltage always rose when the cathode was cooled. The change in voltage occurred, as nearly as one could tell, at the same time as the change in the luminosity of the cathode. The average of 10 readings gave a rise of 4·5 volts. The average of 10 readings for the decrease when the flow of water had stopped was 1·8 volts. The change in the voltage appeared to be the same for currents varying from 6 to 15 amperes, but increased somewhat as the length of the arc was increased from 2 mm. to 10 mm.

The change in P.D. is not so great when the cooled carbon is used for the anode. It is also more difficult in that case to take satisfactory readings. The arc does not become steady until a crater is formed on the anode and by the time this is done a hole is apt to be burnt through the carbon, so that water flows directly into the arc. As near as could be determined the P.D. increased about 2 volts on cooling the anode, decreasing nearly the same amount on allowing it again to become heated. With thicker carbons the effect was, of course, smaller.

Objection may perhaps be raised against this method due to the fact that the carbon was porous. It is conceivable that steam passes through the carbon and changes the arc by the introduction of a different gas. To test this, steam instead of water was passed through the hollow carbon. This was under a pressure of 5 cm. of water, and might have been expected to have a greater effect than the water, if the effect was due to the passing of the steam through the carbon. But it was found that the passing of the steam had no appreciable effect on the arc. The second test was made by inserting a hollow copper tube within the carbon rod. This would keep any water vapour from coming into contact with the carbon, but it also protected the carbon from the cooling effect of the water. However, there was an increase in voltage each time that the carbon was cooled. This was approximately 2 volts.

Effect of Heating Electrodes.—A second method of studying this

* Abstract of an article in "The Physical Review."

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problem is to heat the electrode by passing an electric current through it. It was found, however, that when the current was sent through the carbon, the magnetic field about it deflected the arc, so that any effect was masked.

Change in the Cathode and Anode Pressure Drops.—In the explanation of the arc commonly given to-day it is claimed that the fundamental difference between the arc and other forms of discharge through gases is that in the arc the hot cathode allows the electricity to pass from it with great ease. To do this the cathode must have a high temperature, and to produce the high temperature there must be an expenditure of electrical energy in its neighbourhood. The rate at which this is done equals the product of cathode drop and current. It is natural to expect that if the cathode is cooled artificially, it will require a greater expenditure of energy to maintain the needed temperature, and to do this with a given current the cathode drop must be greater. Similarly with any method of heating we should expect the cathode drop to be less.

To test this view, the cathode drop was examined by inserting a carbon pencil 1·7 mm. in diameter between the electrodes of the arc and connecting this through a voltmeter to the cathode. The arc was approximately 4 mm. long and the exploring electrode was placed as near the middle of the arc as possible. The P.D. measured in this way included both the cathode drop and half of the fall of potential through the vapour of the arc, but the method answers for getting an approximation to the cathode drop. Contrary to what had been expected, it was found that there was but a small change in the value of the cathode drop when the cathode was cooled. The anode drop was then examined and it was found that there was here a large change. In one case the total P.D. changed from 41 to 47 volts, the cathode drop from 6 to 7 volts and the anode drop from 35 to 40 volts. It is evident from this that the change in potential produced by cooling the cathode does not all occur near the cathode; and that the change in different parts of the arc is roughly proportional to the potential existing before the cathode was cooled.

In order to test this view, a shunt was placed about the arc and a point on this which had the same potential as that of the exploring pencil was connected to it through a voltmeter. While this connection was made, the cathode was again cooled. At times when this was done the voltmeter would give no reading. At other times there was a small reading in a direction indicating that the ratio of the increase to the original value was slightly greater in the cathode drop than in the remaining part of the arc, but it could be said that the change in the different parts of the arc is nearly proportional to the original potential. While this was contrary to what I had expected, it is not difficult to explain the phenomena observed. It was thought that extra energy would be developed near the cathode, so that the temperature in its immediate neighbourhood would be the same as before. It would appear that what really happens is that the bright spot on the cathode is not as hot as before and that fewer ions pass into the vapour of the arc, and consequently its conductivity is less. This view is also in agreement with the fact mentioned above that the change in potential was found to be greater when the arc was long than when it was short. It apparently follows from this that the anode drop itself depends on the ions produced at some distance from it. There are other facts which would indicate the same. For example, the anode drop becomes very much smaller when a salt is placed in the cathode, or when the cathode is a metal instead of a carbon.

Effect of Heating Anode in Mercury Arc.—Stark, Retchinsky, and Schaposnikoff found that with a carbon anode in a mercury arc the anode drop was much smaller when the anode was cold than when hot. It varied in their experiment from 12·4 volts when the carbon was bright red to 4·7 volts when it was non-luminous. In the experiment described above there was but a very small change produced by cooling the anode. Because of the difference in these results, I repeated their experiment with the conditions as nearly as possible the same as those described by them. While a small increase in the anode drop was at times found to accompany a rise in temperature of the anode, it was one of only 2 or 3 volts, and it was not possible to show definitely that it was due to the increase in temperature and not to an increase in the pressure of the gas.

This, however, would not explain the results of Stark, Retchinsky and Schaposnikoff, for in their experiments the tube containing the arc was not connected to the pump after the arc was started. There was a rise in the pressure of the mercury vapour and the increased amount of vapour *cooled off* the anode so that it became non-luminous. So that with the increase in the amount of pressure there was a decrease in the temperature of the electrode and a decrease in the anode drop. As far as the relations between the pressure and the anode drop, and between the pressure and the temperature of the anode are concerned, these were exactly opposite to that found by myself.

CORRESPONDENCE.

SHORT CIRCUIT LOSSES IN ALTERNATING-CURRENT COMMUTATOR MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The above Paper is of special interest to me in that it was commenced just as my own research on commutation phenomena was approaching completion. During that research I had discovered that parts of the brush surface expanded and lifted from the commutator, and to remedy these evils and further improve commutation I had invented the cooling device and brush holder described in my Institution Paper, the one in that portion published in your issue of May 20th, p. 237, column 1, and the other in that portion published in your issue of May 13th, pp. 183 and 184.

I communicated my results to Dr. Fraenckel and Mr. Lane, and suggested the use in their research of these inventions, as I believed that they would enable them to obtain results of a more uniform character than those which they explained they had up to that time obtained. I am interested to see from their Paper that they obtained more uniform results, and I am surprised that they have failed to refer to my brush-holder and to acknowledge me as the discoverer of the expansion of the brush surface and inventor of the cooling device, the more so as such mention and acknowledgement when they came to publish was agreed upon.—I am, &c.,

Birkenhead, May 28. G. W. WORRALL.

STANDARDISATION OF FUSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the interesting editorial on this subject in your current issue, it is evident that you have misunderstood my views on the "indication" of blown fuses. An efficient and reliable indicator is one of the most important features essential to a practical line of fuses, and in order to show what is, in my opinion, a satisfactory device, an illustration was given on page 17 of my Paper of the "self-testing" indicator which forms one of the best features of the excellent "Zed" fuses which have recently been put on the market. In designing an indicating fuse it is very necessary to avoid impairing the reliability and efficiency of the fuse, *e.g.*, an enclosed type fuse which might be safe for use in explosive atmospheres is rendered unsafe for such use if provided with an external indicating wire of the type in which fusion of the indicator wire burns or scorches a paper label. As is well known to all users of enclosed fuses having an indicator of the type just referred to, this form of indicator is very untrustworthy and often fails to perform its office; for this reason it is desirable that a fuse indicator should be self-testing, *i.e.*, should give visible indication when it is "out of order" as a fusion indicator.

I sincerely trust that after the subject of fuse standardisation has appeared and passed into space periodically for many years, the latest references to the subject may be productive of action and satisfactory results.—I am, &c.,

London, May 28. H. W. KEFFORD.

COMMUTATION PHENOMENA IN DIRECT-CURRENT MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The method of commutation investigation described by Dr. Coales and Mr. Wall in your last issue has the great advantage of simplicity, which is not possessed by the methods ordinarily used. This method, however, as the authors state, gives two kinds of oscillations foreign to the desired result, *i.e.*, tooth oscillations and those due to the fact that the number of commutator segments is not infinite. The first kind, athough independent of the load, would probably vary with the position of the brushes, while the second kind would be greatly influenced by both these factors. The second type of oscillation, however, is entirely absent in the method of investigation described in my Paper, and hence the only item

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foreign to the desired result is a constant one, and as I have shown, is readily distinguished.

This, however, is not the only difference between the two methods, for the presence of a finite number of segments would introduce variations in the observed commutation oscillations, and these could not be eliminated even if it were possible to eliminate the two foreign elements above noted.

The method suggested further involves the use of a battery, which is certainly no less burden than the wrapping of a few turns of wire on the main poles. I hope that Dr. Coales and Mr. Wall will obtain and publish some oscillograms, as I shall be very interested to see them.—I am, &c.,

Birkenhead, May 28. G. W. WORRALL.

RELATIVE COSTS OF GAS AND ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The "Journal of Gas Lighting" refers to a recent article in your paper upon gas lighting. May I trespass upon your space to reply to the remarks of the "Journal of Gas Lighting"?

The writer of the "Memoranda" column in the "Journal of Gas Lighting" asks for figures giving the relative costs of gas systems against arc lighting. Unfortuantely, he requires these to be submitted with "gracious and valiant compliance." I fear I cannot compare in grace and valour with the article criticising electric lighting, but if the writer will excuse this portion, I am most pleased to submit a few extracts for his preliminary examination.

I should like to take this opportunity of noting the courtesy that usually marks the "Journal of Gas Lighting." A specially marked copy was duly sent to me, although it was needless in this instance, as I have for some time past regularly read the "Journal of Gas Lighting" with interest. The lamps mentioned by the "Journal," "giving an efficiency of 60 candles per cubic foot of gas," are the ones I should like to take for comparison. In this connection, Mr. Herring's figures of the Scottish National Exhibition are usually quoted by gas people. His highest reading gives an efficiency of 73·6 candle-hours per cubic foot, the candle-power being taken at an angle of 20 deg. below the horizontal. Prof. Morris, on testing these lamps, found an efficiency of 48 mean hemispherical candle-power at the maker's works, which fell to 31·6 and 27·5 when tested on East London gas. (*See* "Illuminating Engineer," Vol. I., p. 630.) Mr. Bradley, in his report to the City of Westminster, gives figures varying from 38·4 to 23·6, the candle-power apparently being taken at 20 deg. to 50 deg. below the horizontal.

Prof. Morris, in his comments upon the tests, said: "What do we find it does in actual practice? The above tests show that the maximum candle-power of the lamp is in one part of London about 800 candles, but take it to another part of this city and it yields 1,250 candles, and take it to Edinburgh when it will probably yield some 1,500 c.p.; truly a most disconcerting state of affairs." I quite agree with Prof. Morris. Does the 60 candles per cubic foot usually run down to 30 in actual practice?

I do not think I need add more details of victories of electric light over the latest forms of gas, as, in the same "Memoranda" columns, it is noted that Hampstead, Harrogate and Yarmouth are changing to the latest forms of electric lighting. Surely three victories chronicled in one issue of a paper will suffice for the moment! I regret that it is not our practice to publish beforehand where the Regenerative lamps will be installed. The "Journal" will soon have opportunities of seeing the localities lit by the Regenerative arcs that have displaced high-pressure gas.—I am, &c.,

A. DENMAN JONES, Manager.
The Jandus Arc Lamp & Electric Co. (Ltd.)

Holloway, May 30.

SWITCH AND TRANSFORMER OILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Replying to my letter of the 10th inst., Mr Pollard says "Mr. Southcombe's assertion that I claim that alkali in a transformer oil would not be detected by phenol phthalein when the oil was shaken up with water is not warranted by any statement of mine."

Now, my reason for entering into this correspondence is to be found in Mr. Pollard's remarks, in replying to the discussion, "that at least 80 per cent. of the oils examined had been found to contain alkali, sometimes in slight and sometimes in very distinct traces, but had phenol phthalein been used as an indicator no doubt practically the whole of these would have been returned as neutral."

Such a statement cannot be allowed to pass unchallenged, and, as the following evidence will show, my assertion that "exceedingly minute traces of alkali, whether existing as carbonate, soap, &c., can readily be detected by phenol phthalein when the oil is shaken up with water" is strongly supported by other investigators.

The following experiments have been conducted at Liverpool University by Mr. A. B. Harris: A N/100 solution of sodic carbonate (Na_2CO_3) was made up with pure distilled water (specific conductivity $3{\cdot}1 \times 10^{-5}$ reciprocal ohms). Aliquot parts of this solution were diluted with the pure distilled water to varying concentrations of Na_2Co_3 and tested in open test tubes with three drops of phenol phthalein.

The following gives the results obtained: N/4,000 Na_2CO_3 solution (0·00013 gms. Na_2Co_3 in 10 c.c.), very distinct persistent colour; N/6,000 Na_2CO_3 solution (0·00008 gms. Na_2CO_3 in 10 c.c.), very distinct pink, persists for 12 hours; N/7,000 Na_2CO_3 solution (0·000075 gms. Na_2CO_3 in 10 c.c.), quite definite pink even after one hour; N/10,000 Na_2CO_3 solution (0·00005 gms. Na_2CO_3 in 10 c.c.), distinct colouration.

With ordinary laboratory distilled water treated in the same way as in an oil test I obtain distinct indications with N/5,000 solution (0·0001 gms. Na_2CO_3 in 10 c.c.).

Further, Glaser ("Indikatoren," p. 100) points out that even "the purest bicarbonate reacts weakly alkaline to phenol phthalein in aqueous solution."

With regard to the researches of Thomson, quoted by Mr. Pollard, in which he says that phenol phthalein is not a suitable indicator of alkalinity "when soda exists as hydrate along with sodium carbonate, &c.," I should like to point out that they do not materially influence this argument, since Thomson concerned himself with the sharpness of the end-point in titration and not with the qualitative detection of alkali. Again, Mr. Pollard appears to forget that when an oil containing soaps or alkali salts of petroleum acids is shaken with water the acid product of hydrolysis is continually removed by the oil, in which it is soluble, thus permitting hydrolysis to proceed almost to completion with the concomitant liberation of its alkali which dissolves in the water.

The results of Wright and Thomson refer to somewhat different conditions. As to the delicacy of phenol phthalein towards free alkali hydroxide, it is only necessary to point out that Dupré, quoted by Lunge (Tech. Methods), finds cochineal to be "*almost* as sensitive as phenol phthalein."

Mr. Pollard's conclusion, that "when phenol phthalein is used as an indicator considerable traces of alkali escape detection," is therefore not quite confirmed by the above-named investigators and my own experience.—I am, &c.,

Imperial Oil Works, Salford, May 27. JAS. ED. SOUTHCOMBE.

TEMPERATURE COEFFICIENT OF COPPER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your remarks on the above subject, appearing under "Notes" in your current issue, do not necessitate any alteration in my letter of May 14th. My original letter can be supplemented by the following:—

1. You state that I start off with logarithms *which can be dismissed*. In answer, I point out that it is the E.S.C. who recommend such coefficients, and if logarithms are dismissed then resolution No. 4 becomes *absolutely meaningless*; this point is admitted in your remarks, for you find it necessary to add to the resolution in question the words "in terms of the resistance at 32°F.

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2. The standard temperature for all ordinary commercial resistance measurements is 60°F. (75°F. for submarine work), and in view of this fact the E.S.C. considered it necessary, and have deliberately corrected to 60°F., the standard values of resistance of copper from Matthiessen's bases at 32°F. to form their resolutions Nos. 1 and 2; how then can you assert that it is plain that the E.S.C. "imply" (your use of this word seems regrettable when dealing with standards) a temperature of 32°F. for their resolution No. 4?

That 60°F. is the basis of tables of coefficients follows naturally from the fact that 60°F. is the standard temperature.

3. Cases are known in which engineers have had to insist, against their common sense, upon the use of the coefficient 0·00238 per degree difference from 60°F. simply "because the E.S.C. resolution reads this way."

4. The *universal* adoption of 32°F., as stated by you, is incorrect; *e.g.*, the Verband Deutscher Elektrotechniker recommend the formula $R_t = R_{15}\{1+0{\cdot}004(t-15)\}$ for copper, from which it will be seen that 15°C. (practically 60°F.) is the basis, and the coefficient is also much lower than that determined by Messrs. Clark, Forde and Taylor.

In conclusion, I greatly regret to find your remarks so personal towards the end—a mistaken help for a weak argument.—I am, &c.,

F. O. HOWE.

Old Charlton, Kent, May 28.

[In regard to the first three points raised by Mr. Howe we need add very little to our comments of last week. In our remarks we referred to submarine cable measurements, not to ordinary resistance measurements. If Mr. Howe and other engineers use a coefficient "against their common sense," they might at least use their common sense to be certain that they have not made wrong assumptions in applying that coefficient.

Mr. Howe's last statement is that the Verband Deutscher Elektrotechniker coefficient of 0·004 per degree C. (or 0·002222 per degree F.) referred to 15°C. (or 59°F.) is much lower than that of Messrs. Clark, Forde & Taylor. As explained in our last issue the latter is 0·00238 per degree F. referred to 32°F. (a fact which Mr. Howe can verify by purchasing Messrs. Clark, Forde & Taylor's pamphlet on "The Temperature Coefficient of Conductivity Copper," if he so desires) and is that adopted by the Engineering Standards Committee; it is a mean figure for commercial purposes. Now, if the resistance at 32°F. is taken as unity, that at 59°F., according to Messrs. Clark, Forde and Taylor's coefficient, is $1+0{\cdot}00238\times 27$, or 1·0642. Thus the variation per degree at 59°F. is 0·00238 in 1·0642, which gives a coefficient of 0·002236. This is practically the same as that of the V.D.E. In fact, the V.D.E. coefficient is only 0·63 of 1 per cent. lower than that of Messrs. Clark, Forde and Taylor, and in calculating a change produced by 30°F. the difference in the results by the two coefficients will be about 4½ parts in 10,000. This being so, it is surely rather an exaggeration on the part of Mr. Howe to describe the V.D.E. coefficient as being "much lower" than that of Messrs. Clark, Forde and Taylor. It is evident that for commercial purposes the V.D.E. coefficient is the same as that of Messrs. Clark, Forde and Taylor, and, therefore, necessarily the same as the E.S.C., so that Mr. Howe has scarcely chosen a good example to advance his case.—ED. *E.*]

THE ELECTRIC DRIVING OF PRINTING PRESSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Considering the grave danger to life and limb involved in a defective system of press driving, I think some protest ought to be made against the article from the "Electrical World" as abstracted in your issue of the 27th.

I do not think any manufacturer (on this side of the Atlantic) with a reputation to maintain would propose to his customers such a scheme as that outlined in the article, but there is a danger that the non-electrical customer should insist on some such cheap and shoddy arrangement, bringing in the end discredit on electrical driving in general.

Briefly, the author's scheme is to use two standard motors, one for starting and slow motion, and the other for ordinary working at full speed. These are to be operated by two standard controllers—that for the former motor having an armature diverter resistance added, that for the latter being provided if desired with dynamic brake contacts and a push-button stopping device. As the apparatus is spoken of as "standard" it is presumably legitimate to assume that no further "extras" are contemplated.

The most obvious defect is the provision of *two* handles, which at best is objectionable, but becomes positively dangerous when they are neither mechanically nor electrically interlocked. The ordinary press hand is a skilled man in his own particular work, but he does not know much about controllers. At a time of "rush" (when accidents most often occur) his attention will be chiefly concentrated on the press, and there will be great danger of his making a mistake with his two handles.

If he starts on the wrong motor he will probably have someone's fingers off. If he forgets to switch off the starting motor when done with, it will carry on the press when the main motor is switched off—perhaps for an emergency stop. The result in this case will probably be a bad jam of torn paper before the mistake is noticed.

With regard to the apparatus proposed, I noticed no mention is made of the "free-wheel" or disengaging clutch necessary in the drive of the small motor. Nor is it mentioned that ordinary starters, unless very substantially designed, have always proved unsatisfactory for the very heavy work involved in press driving.

Finally, with regard to the diagrams given, it will be seen that the armature diverter is arranged in the most inefficient manner, being placed straight across the mains when the small motor is full on. Further, the control of the main motor is all, or nearly all, effected by means of main resistance.

Recent practice has been all in the direction of increasing the proportion of field control given, one recent specification, for example, calling for as much as 3 to 1 speed variation by shunt regulation alone.

In any rotary press equipment, the cost of the whole electrical portion is very small compared with the total outlay, and still less compared with the possible cost of a breakdown, and it seems a pity that make-shift arrangements like that refered to should be seriously proposed.—I am, &c.,

Norwich, May 31. S. E. GLENDENNING.

TRAMCAR METERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I see that in your notice of the new Siemens tramcar meter you say that "attempts were made in the early days of tramcar development to utilise ordinary meters for the purpose of recording the energy consumption of tramcars." I fear that the inference would be that ordinary meters have failed for this purpose. I should be allowed to state that, with my meter, owing to the extreme lightness of the armature, I have never experienced the smallestdifficulty when using it on tramcars, and I venture to think that there is a greater number of these meters so used than of all other types put together. I notice the means Messrs. Siemens have adopted to overcome the difficulty caused by a heavy armature; mine is so light as to avoid it altogether.—I am, &c.,

Birmingham, May 31. GEORGE HOOKHAM.

Power Required by Telephone Systems.—The "Engineer" gives some information with regard to the service of the New York Telephone Co., which indicates that the handling of a million messages requires on an average the expenditure of electrical energy to the extent of 900 kw.-hours. Assuming a heating power of 13,900 B.Th.U., it may be calculated that the development of 900 kw.-hours requires 2,025 lb. of coal. Allowing for sundry power-house wastes, perhaps it would be permissible to consider an English ton as the amount actually required in practice. The telephone messages of the United States now aggregate 9,000 millions per year, so we may set down the coal required for transmission at 9,000 tons. Of course, this is only a small fraction of the tonnage required for heating purposes in the 50,000 telephone exchanges.

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HIGH-TENSION SWITCHGEAR,*

BY A. G. COLLIS.

Summary.—The author discusses recent practice in switchgear design and illustrates typical installations. In connection with switch construction, he describes a hand-operated, non-automatic, 3-pole oil switch. Instruments and the protection of circuits are also referred to.

When considering the design of a switchboard the following practical points should be remembered: (1) Simplicity, consistent with adequate protection, avoiding as far as possible the addition of unnecessary links. (2) Ease of operation and inspection. (3) Instantaneous response to the call of its duties. (4) Apparatus at high potentials placed in cells that will not, in case of fire, affect remaining gear, and arranged so that each respective gear can be inspected from the exterior, and isolated from "live" condition. (5) Inflammatory material to be avoided as far as possible. (6) Connections well spaced, to avoid short-circuits. (7) Only low-tension connections and indicators to be on the operating board and traceable at sight. (8) Liberality of design to withstand the development of abnormal conditions. (9) Sound earth connections.

The constructive portion of the board is materially affected by the space available and the conditions of service. When space, however, is limited, as at sub-stations, the design shown in Fig. 1

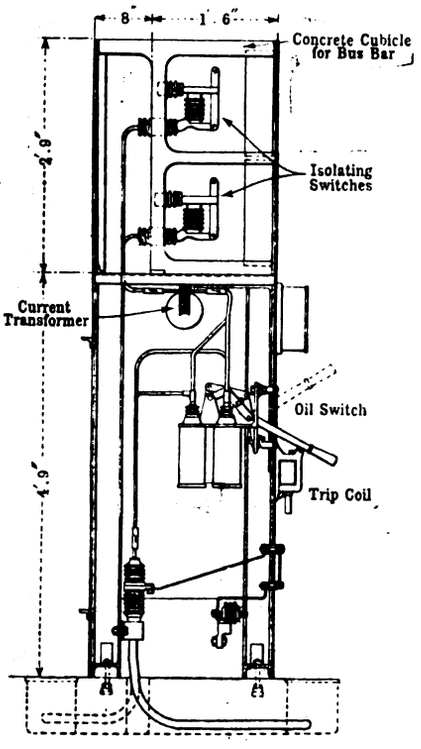

FIG. 1.—TWO-PHASE BOARD FOR 3,000 VOLTS.

will commend itself. This board controls three transformers and seven circuits at two phase 3,000 volt 50 frequency, the outer conductor being earthed. The author is personally in favour of this type of board, which may be described as "Ironclad type." It not only incorporates the points referred to above, but as iron constitutes the main construction, there is less danger, the iron being at earth potential, than with a board that consists of stone or other insulating material, which is never free from conducting mediums, such as slate with metallic veins, and stone with porosities which are hygroscopic; and, further, in the case of heavy cell fires or violent ruptures, the iron lends itself to displacement in a better manner than solid stone partitions, which could cause sonsiderable damage to their adjacent gear.

This type of board may not be adaptable for controlling units and feeders of a large central station, and for this work I prefer electrical remote control, similar to that fitted in St. Andrew's Cross Station, Glasgow. Fig. 2 shows a sectional view of this gear. This board is designed eventually to control six three-phase generators at 6,500 volts, 18 feeders, and two inter-connectors. It will be seen that the whole of the high-tension gear is situated in an adjacent room in separate compartments, and operated from the control board fixed on the gallery. Iron doors to admit of inspection of cells are shown, but preference has latterly been given to doors of uralite, which material is much lighter to handle, and is considered more in keeping with the cell structure. Another type of this class of board is shown in Fig. 3, and although I have stated I prefer electrical remote control, mechanical remote control has many advantages peculiar to itself, possibly due to space limitations, or, further, the switches being of such dimensions that the control board may be of the same width as the switch cells, without being of unreasonable length, with the additional advantage of a direct connection of each separate section. The board illustrated controls plant generating three-phase current at 6,600 volts 50 periods, and is of the "Bench type" construction, which design is very convenient, as it places the engine room in full view of the operator, this practice being almost universally adopted in power stations where the switchboard attendant is in command, controlling both the mechanical and electrical sides. At one of the largest stations in this country this method of control has been adopted, with very efficient and economical results. The success of such a scheme as this would, of course, depend largely upon the man in charge, and would probably result in disaster if the scale of wages were not increased, with the responsibility above the reported standard. I am led to understand that many of the reported failures of switchgear are due to the tendency of to-day to have cheap labour on improved systems; and, further, the tendency to place orders with the lowest tenderers not only discourages science, skill and design, but causes the omission of a large amount of actually necessary gear, resulting in breakdowns and fatalities. The author emphasises these points by quoting from the 1908 report of H.M. Inspector.

All circuits should be fitted with isolating switches, or so subdivided as to admit of attention while the section is dead, each section or circuit being in a separate compartment to prevent accidental contact with the adjacent "live" portions during repairs or inspection. Some engineers pay particular attention to this, and their ideas are further advanced by the additional precaution of inter-locked gear, so that it is impossible for a man to enter the compartment unless the circuit is dead. In many cases of electrical supply undertakings isolating switches are inserted on the 'bus bar side. This, however, does not mean that when these are in the "off" position the circuit is dead, as in the case of feeding in duplicate to a sub-station, the cable may be charged via the sub-station, which necessitates isolating switches being installed on that side of the oil switch. All isolating switches should be operated by an insulated rod or hook, and should be so mechanically constructed to resist twists as to ensure good contacts; also, if possible, earth contacts should be provided. It is preferable, in the case of a three-phase supply, to have single-phase isolating switches, as the coupling up of these switches may, owing to breakdown of insulation, place a "short" across the system, by no means an uncommon occurrence. Further, if the scheme is on a large scale, it should be sectionalised by 'bus bar switches, and this fact should be remembered by the operators. The observance of this might have minimised the extent of the disaster at Lot's-road, where the custom of running the whole station in parallel resulted in a complete shut down. Ring and duplicate 'bus bars and change-over systems have also their advantages, the design being regulated according to the conditions of the service, and the results aimed at by the supply authorities. Connections between gear should be "bare," not "insulated," in order to avoid inflammatory material, and should be cemented in porcelain sleeves when passing through partitions. All connections should preferably be clamped or coned, instead of, as is often the case, bolted or set-screwed, which causes considerable heating from imperfect contacts.

In connection with the foregoing alternating-current design, oil switch construction is exceptionally prominent. Many forms and types are now on the market, owing to the varied conditions of service, and the diversity of opinion amongst experts as to the proper form of design, more particularly on such points as the "disposition of the arc," "insulation," and "strains from explosive effects." It is necessary, however, that all these points should be incorporated, as the specialised application of one with the non-observance of the others may result in entire failure. Unfortunately, no definite data are available as to what is the breaking capacity of any switch, experience only proving that this or that form has successfully discharged duties which may, under different conditions, be totally inadequate for the purpose.

In order to demonstrate some useful points which I emphasise with confidence, I would refer you to Fig. 4, which illustrates a hand-operated non-automatic three-pole oil switch, capacity 100 amperes, at 6,600 volts pressure. It has a double break of 4 in. per pole (8 in. per phase), which length of break is consistent with its other capabilities of rupturing capacity, and for this size a smaller break is not recommended. The operating levers are fixed rigidly to the con-

* Abstract, from the "Transactions," of a Paper read before the Glasgow Technical College Scientific Society.

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tacts and move in a vertical plane. The disturbance of the oil due to the arc is thus concentrated in the same direction, and not distributed over the entire area of the oil as in other forms. The position at which the arc takes place is near the surface of the oil, at which point it is free from the sediment which is found towards the bottom of the can, where the insulation value, owing to these impurities, is proportionately less. Further, when the rupture takes place near the surface of the oil, the pressure due to the explosion of the arc is relieved by the bubbles of gas passing into the air, the dielectric strength of the switch is therefore maintained. To obtain further efficiency in dealing with "strains from explosive effects," the oil cans are lined with three-ply impregnated wood, between which and the can there is a space of $\frac{3}{8}$ in.; this not only further increases the dielectric strength, but effectively damps out the arc on rupture, the oil in this space being in a quiescent condition. This is an important point, as burning oil and failure from strains may cause heavy fires, resulting in the complete shut down of a power supply. Each phase or pole of the switch is in a separate tank, thus admitting of the inspection of a single phase without removing the tanks of the whole switch, and, in addition, is much lighter to handle. The effectiveness of the switch, again, is increased by these divisions, it being practically impossible for the arc to form between the phases, there being a possibility of this occurring when all the phases are placed in one can. The contacts are brush type, fitted with additional sparking tips, which deal with the final arc on breaking circuit. I have always advocated this type of contact except when it is mechanically unheavy currents. Instantaneous rupture is essential for dealing with short-circuits, and it will be noticed that the pressure in the brush type is in a direct line with the operating mechanism. Immediately the toggle is released it assists the instantaneous action, whereas in the case of a "wedge" type contact the pressure is in a direction diagonally to the toggle, and may, due to guide friction, give a total frictional resistance more than equal to the weight of the switch, thus holding it in after the toggle is released, with disastrous results. The porcelain sleeves shown are of the corrugated type, which are now superseded by the straight pattern, for the reason that they are much easier to clean, and less liable to collect dirt or semi-conducting matter. The reeded type was designed originally to increase the leakage distance with minimum space; practice, however, proves the reverse.

Vitrified porcelain, which is specially moulded and treated by several processes, such as glazing and extra firing, in order to withstand excessive electrical pressure, appears to be still to the front for this kind of apparatus as an insulator. It generally consists of

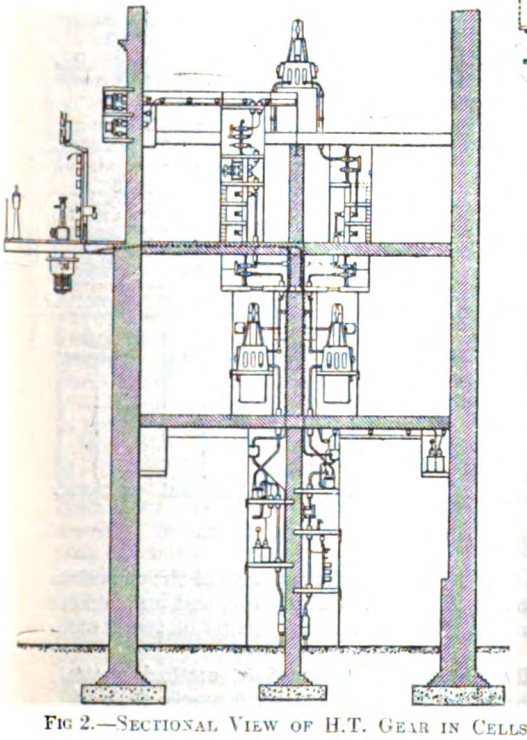

Fig 2.—Sectional View of H.T. Gear in Cells.

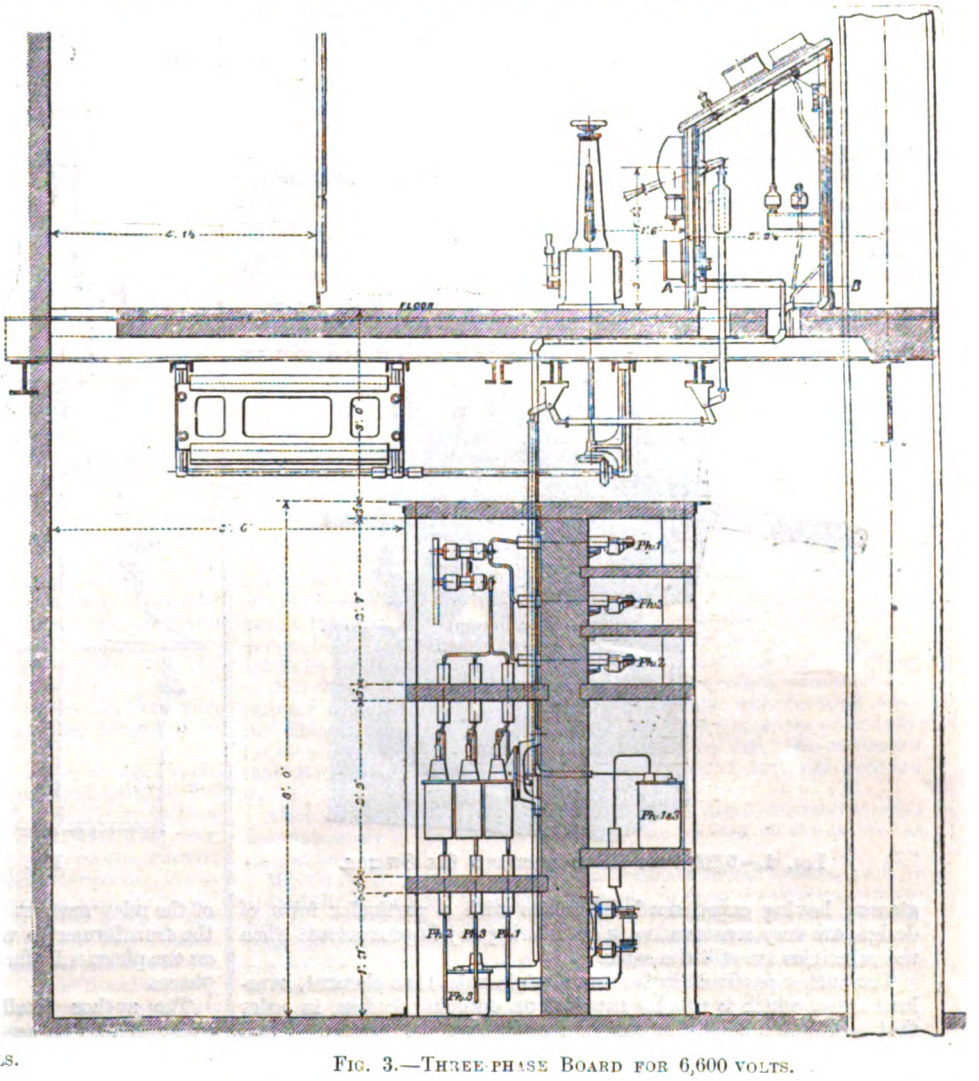

Fig. 3.—Three-phase Board for 6,600 volts.

desirable, for the reason that a brush or laminated contact, operated in the manner before described, has a self-seating position, rubbing away injurious surface films, and has the additional advantage of solid pressure without strains on auxiliary springs, and it also admits of a large contact area in proportion to its designed current-density. Tests show that a laminated contact will successfully rupture a much heavier current that a solid contact of the same sectional area at a lower temperature, and have also proved their superiority, as the contact area should not only be proportional to the sectional area, but also to the pressure. The contact area of a bar of copper (unlaminated) must be approximately five times the sectional area of the bar, with 25 lb. pressure per square inch, to have the same solid conductivity. The increase of the pressure to 35 lb. per square inch gives the same result with a contact area of only 4·2 times the sectional area. It will be noticed, however, that the contact area does not vary inversely as the pressure. The question of pressure must not be disregarded as affecting contact voltage drops. Contacts designed of the "wedge" or "cone" type are not usually the best practice, but are necessary in some cases for mechanical reasons and "kaolin," "felspar" and "quartz," the combination of which, after being properly fired, produces a crystalline silicate which only requires glazing to make it capable of withstanding the most severe potential strains. Apparently no other form of insulator has yet been designed to equal its effectiveness.

The above comments deal principally with the material of the switch. Lastly, but not the least important, is the mechanical construction. This construction must be of such movement that it will minimise shock, and also the manual effort in closing. It must be of parallel motion, and have a simple link construction. It will be noticed from the illustration that the handle operating the switch has a vertical movement, which places the operator in full command over it. When dealing with large capacities and heavy units, it should be noted that the mechanically operated remote control switch has many undesirable features, which have led to the electrical control type. On large power systems in America the motor operator switch is used. This is, however, not so efficient as the standard solenoid type, in which complicated mechanism and gearing, magnetic clutches, &c., are entirely eliminated, whilst it occupies

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less space and operates more nearly instantaneously. In order to render the electrical control switch (Fig. 5) more efficient, a controller is advocated to operate it. This not only serves the purpose of making it "fool proof," but also places the auxiliary contact-making and breaking devices, &c., in an accessible position, apart from the main switch. A switch of this type should be designed—apart from its rupturing capacity and the general principles involved in the mechanical type of switch—so that it will operate with certainty and decision, and without any tendency to overshoot in closing, or rebound in the open position. It must not be possible for the operator to hold the switch closed under overload or short-circuit conditions, or to check or reverse its motion in an intermediate position, as hesitancy might be serious. This switch fulfils all these conditions.

The author next considers some points in connection with instruments, describing the main features of a few types, and then passes on to discuss the protection of circuits. On the boards previously described the system of protection is "reverse relays" on generators and overload relays on feeders. This form of protection is very universal throughout the country, and, as far as can be ascertained, is giving satisfaction. At one time plunger relays and differentially wound coils were very much in use, but owing to their ineffectiveness, principally due to "mechanical" and "floating" troubles, regardless of their electrical efficiency, these designs are practically obsolete. The differentially wound coil proved defective on account of the fact that short-circuit conditions reduced the power factor and voltage to such a low value that the relay did not develop sufficient torque to operate, and, further, it was impossible to use it for synchronising, as it did not cut out on reverse power, but acted on the synchronising or wattless currents, thus cutting out the very set that was normally correct for closing. Without altogether condemning this form of protection, I would like to add that, although experts have made considerable improvements in the detail of design, I find that en-

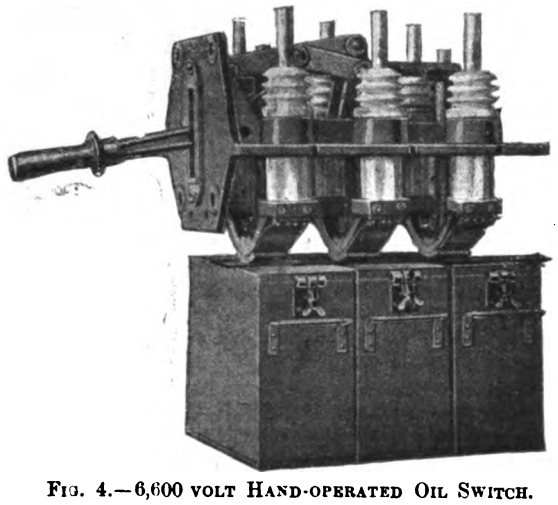

Fig. 4.—6,600 volt Hand-operated Oil Switch.

gineers, having experienced difficulties with a particular form of design, are very conservative in considering any improvements when the principles are still the same.

The author particularly favours a triple-pole, time element, overload relay, which is usually supplied on outgoing feeders, in order that a selective condition can be installed on the system. These relays consist of a rotary disc which revolves in a shaded pole-piece—that is to say, copper rings are placed on the poles, and the current induced reacts on the magnetic circuit, with the result that torque is exerted on the copper disc. The magnet is energised from the low-tension side of a current transformer, and when the current has reached its predetermined value the disc rotates, thereby winding up a hanging weight, closing the trip coil circuit by carbon contacts, and operating the switch. In addition, there is a damping magnet provided, by which the time element can be varied, the motion of the disc thereby being retarded to its predetermined time setting. The advantages of this type of relay are many, not only on account of its electrical effectiveness, but to the form of construction, which admits of the time element being varied within its range independently of its current value, and vice versa, a point which must not be overlooked in order to meet selective demands. The time element has an approximately inverse action, and will open the switch more quickly under normal conditions, which is very necessary. In order to meet competition and the demand for cheap gear, the time element on a feeder is provided in the form of a fuse, which is connected in shunt to the trip coil circuit. Owing to the high reactance of the trip coil the current normally passes through the fuse, but when it reaches the value the switch is set to open at the fuse blows, and the current then passes through the trip coil circuit, operating the switch. A fuse, however, has many disagreeable points, inasmuch as the time element cannot be changed without altering the current element, and although it has an approximate inverse action, there are no selective attributes.

There are several methods of "connecting up" relays and trip coils for protection against overloads, and the tendency should be to provide reliability with a minimum amount of gear, as additional links are a source of danger. Two overload trips with two current transformers will protect a three-phase system with neutral not earthed, or, further, two current transformers with one trip coil will be effective, the current in one phase being equal to the vectorial sum of the currents in the other two. Of course, protection in each leg further advances the degree of safety, but is not absolutely essential. With regard to protection on a three-phase circuit with earthed neutral, this can be met by having three current transformers and three trip coils. Preferably, it is a much better practice to instal three current transformers and two trips. With three transformer used in connection with two trip coils, the transformers would be connected in Z (*i.e.*, similar to a delta connection with the common transformer reversed), there being an advantage in using this connection over that of the straight delta, as in the latter each element

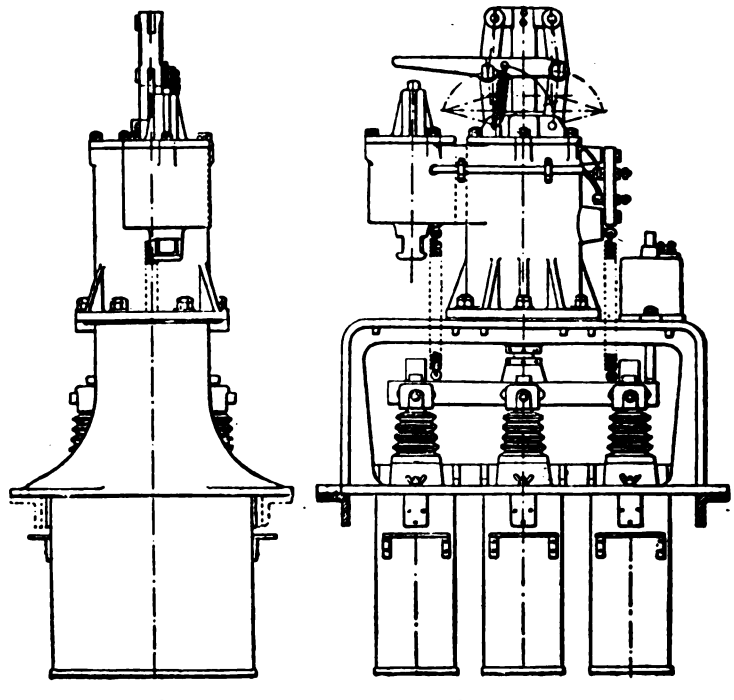

Fig. 5.—Electrical Control Switch.

of the relay receives current, which is the resultant of the current in the transformer to which it is directly connected, and an overload on one phase will affect the relay less than an overload on two or more phases

The author finally discusses the case of an earthed neutral, and describes an appliance which apparently effectively deals with the safety of an earthed neutral by means of a ring transformer, the principle being as follows: Consider a generating station, from which a number of high-tension three-core cables diverge, feeding separate areas. If there be no earthing on any particular feeder, or on the network connected thereto, the sum total of the currents in the three cores must be zero at every instrument, and this is true independently of whether the load is balanced or not. If, then, the feeder cable be surrounded by the magnetic circuit of a ring type transformer, there will be no total magnetisation in it. Now, although no point of the system is connected to earth, there will be a certain capacity current flowing to earth at any instant from any two poles, say A and B, which must equal the capacity current flowing from earth to the third pole C, at that instant via the dielectric. Suppose, now, there be an earth anywhere on pole C, reducing this part of the system to earth potential, the capacity current to earth from A and B must find its return path through C; but since C is at zero potential, the current cannot be passing via the dielectric, and consequently the whole capacity current must pass from earth to pole C via the fault; in other words, if we had 20 healthy feeders and one faulty one, with an earth on one core, the capacity current flowing to earth from the 20 healthy feeders would be restricted in its return path to the faulty

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one. Let us take it that the strength of this capacity current is 30 amperes. Then the induction of the magnetic circuit round the faulty cable will be due to 30 ampere-turns, and will be quite independent of the load on the feeder, while the induction in the transformer cores of the healthy feeders will be on the average due to 1·5 ampere-turns, the total capacity current being supposed to be equally divided among the 20 feeders. A ring type transformer of the type referred to can readily be designed to operate a relay with 30 ampere-turns primary current or even less, and this relay may in turn operate an indicator, or alarm, or close the trip coil circuit of the circuit-breaker. We should thus have a protective arrangement applicable to any extensive distribution with unearthed neutral, whereby any cable would be automatically disconnected should a core go to earth, and this without any rush of current and consequent disarrangement of the system.

We should arrive at the same result in a system of much smaller capacity by connecting the neutral point to earth through a relatively high resistance—viz., one capable of passing, say, only 30 amperes if a pole became earthed. There are many advantages in a high resistance of this order, besides that of cutting off the faulty feeder without excessive current rush. For example, the avoidance of interchange of current between generators working in parallel due to triple frequency terms in the E.M.F. wave; the relatively small size of the resistance required, &c. Complete protection would be afforded by current transformers inserted in any two of the phases with a ring type transformer surrounding the whole.

DISCUSSION.

Mr. CALDWELL said, in view of the very general trend of opinion to the contrary, it was interesting to note that Mr. Collis inclined to favour the use of reverse current protection for alternating generators, but the speaker was of opinion, owing to the unreliable action of this particular type of apparatus, that it was better to rely upon human protection. A large, healthy unit coming out on action of the reverse current relay, due to a wattless current, might mean the shut down of a station having only two or three sets. In a static transformer sub-station the case was different, as there was no attendant, and a faulty transformer must be cut out automatically and instantaneously, and reliable automatic apparatus to ensure this was very desirable. More attention should be given by designers of alternating switchgear to the reliability of instrument transformers. The frequent breakdown of these was a great nuisance, and potential transformers should be made larger in order to obtain a greater degree of reliability. With regard to oil switches for extra high-tension work, it was time designers entirely eliminated wood from this class of apparatus. In regard to facilities for making cable connections (particularly as to the conditions existing in coal mines, but applicable generally), in the best work armoured cables were employed, and there was no reason why the design of clamped rings to effect electrical continuity of the armouring should not be standardised. His remarks applied, of course, to isolated switchgear, such as oil switches, gate end panels and smaller motor panels. At present, even for the smallest item of such apparatus, cumbersome and expensive trifurcating boxes had to be employed.

After other speakers had expressed their appreciation of the Paper, Mr. COLLIS, in reply, said, in regard to reverse current oil switches for generators, he was aware that they had not fulfilled all the conditions attributed to them, and he thought the specified conditions were very extreme. He did not think it was possible to design a reverse current relay that would meet all the conditions Mr. Caldwell referred to. As to instrument transformers, most of the troubles referred to were due to the fact that, in order to get constant ratio at all loads, the primary and secondary windings were very close together, with a result that a short-circuit occurred between primary and secondary, and, as one side of the secondary was earthed, the primary went to earth. Additional security against this was an insulator, further surrounded by a core of stampings, on which was wound the secondary coil. Regarding cable runs for mines and for collieries, he differed from Mr. Caldwell owing to the difficulty of keeping the armouring of the cable from going to earth, due to the water and falling masses, together with the failing roofs, a direct connection might be formed between the cable and earth. In this connection he advocated that the armouring be supplied only for mechanical protection, and between it and the cores there should be a tubular core which was earthed at the pit bank. By interposing a coil in this circuit, should an earth occur the coil would be operated by the leakage currents and the section isolated before any external damage was caused, thus preventing the serious explosions referred to so frequently of late.

Tungsten Mining in Colorado.—According to the "Electrical World," the tungsten mining and milling industry has received a great impetus in Boulder County, Colorado, as a result of the improved methods of manufacture and the better prices obtainable. The Eureka Tungsten Mill has just begun operations, using a belt table arrangement of new design, and recovering a large proportion of the tungsten. The mill is a brick structure, and is entirely electrically operated.

LEGAL INTELLIGENCE.

City of Birmingham Tramways Co. v. Geo. Law.

Mr. Justice Lawrence gave judgment in this case on Saturday. Plaintiffs claimed for damages to a tramcar in Bristol-rd., Birmingham, in October, 1908, and alleged that one of their cars was derailed and damaged owing to the negligence of defendant, the contractor for the reconstruction of the line.

HIS LORDSHIP, in delivering judgment, said he understood the damages had been agreed at £421. 15s. 4d. in the event of plaintiffs establishing the liability of defendant. Only one line was in use at the time, the other being under reconstruction, and his Lordship said he had come to the conclusion that the derailment of the car was caused by the gearbox of the car coming in contact with one of the contractor's blocks, which had risen, that being due to the fault of defendants' servants. It was contended that defendant was under no liability to plaintiffs, because there was no contractual relationship between them, the Corporation owning the lines and the company being merely assignee of the lease of the tramway. Under that lease repairs were to be executed by the Corporation, but at the expense of plaintiffs. It was provided that the company should be able to continue the service during reconstruction, and the agreement imposed upon the contractor liability for any damages or injuries sustained while the work of reconstruction was in progress. Defendant, by that agreement, indemnified the Corporation, and plaintiffs were, therefore, entitled to judgment.

Wheeler v. Marylebone (London) Council.

The hearing of this case was continued on Friday last before Mr. Justice Grantham and a special jury.

Mr. JOHN LYNTON, assistant engineer to the Charing Cross, West End & City Electricity Supply Co., said he thought that a person holding the ends of the cable in question would receive a shock, but not sufficient to kill.

In answer to his Lordship, Mr. HOLDEN (with Mr. Shearman, K.C., for defendants) said the cables were on the three-wire concentric system, and the pressure between the outers was 480 volts. The pressure of supply was not more than 240 volts in any house. He had never known a case where a cable had been pot-ended and the dead cable left in the house. They always took away dead cable. He would not always remove a cable if the rebuilding operations were confined to the top of the house. He would not remove the cable if the housebreakers were not going to interfere with the cellars.

Mr. H. T. GORDON, architect and surveyor, said he always specified that all pipes should be removed from cellars or anywhere else when housebreakers were at work.

Mr. SHEARMAN, K.C., for the defence, explained that when the Council were notified that the housebreakers were going to commence work one of the Council's employés was instructed to "draw the service," which meant that the whole of the wires and cables in the house were withdrawn, but when he got to the house he was told that the cellars were not to be removed, so he simply shut off the current from the cut-off box in the cellar. That was perfectly safe, even if the cellars were used, and plaintiff did the only possible thing to cause trouble when he tried to cut it. They were sorry for him, but he suffered from a supreme act of folly, for he must have known that the cable was a live one. He contended that the Council had not been guilty of a breach of duty and were not liable.

After medical evidence, Mr. SIDNEY J. JONES, assistant meter reading superintendent in the Council's employ, said he shut off the service at the cut-out box.

Mr. CHAS. H. SMITH, constructional engineer to the Council, said he visited the house after receiving the request to draw the service, and was told by the foreman housebreaker that as the cellars, which were away from the house, were not to be interfered with, there was no need to remove the cable. He altered his instructions to the joiner, telling him to draw the service as far as the cut-out box and make that secure. The foreman told him that all he wanted removed was the meter and the appliances within the house. Referring to custom, Mr. Smith said, bearing in mind that it was a very expensive matter to meddle with or alter the service beyond the cut-out, the cables were left in their positions as far as it was consistent with safety, but in that particular case, had he known that the structure of the cellars was going to be interfered with, he should not have let the cable remain.

Mr. JOHN F. C. SNELL, consulting engineer, said the system of leaving a cable in a cellar such as the one in question, as long as the cellar was not to be interfered with, was universal. It was perfectly safe, unless cut or tampered with.

Mr. A. HUGH SEABROOK, the general manager of the Council's electrical undertaking, also gave evidence.

Mr. DUKE, K.C., for plaintiffs, said if the Council had done what was requested of them the accident would not have happened. Instead, in the hope of saving expense, only half of the work was done, and a live cable was left in a place where it was a danger to everybody on the place. Had they placed a switch in the service box under the pavement and right away from the house, and cut off the power at the switch, the cable would have been rendered harmless, and they would have saved the expense which they said would have been incurred by drawing the cable.

HIS LORDSHIP, summing up, said he thought that the Council had been guilty of a wrong in leaving the cable in the cellar without giving plaintiff notice.

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The jury awarded plaintiff £56, special damages claimed by him, in addition to £75 for pain and suffering, and £450 for loss of business during his incapacitation.

His Lordship entered judgment for plaintiff, and refused an application by defendants for stay of execution.

Hire of Electric Motors.

In the Shoreditch (London) County Court last week, Judge Smyly, K.C., heard an action by Herr Julius Grevener (Attorney of the Sachsenwerk Licht u Kraft A.-G., lately trading in London as the Electromotor & Dynamo Co.) against Mr. Geo. Chamberlain to recover £49, value of an electric motor, and £1 damages for its detention. For plaintiff, it was stated that defendant was the owner of premises which he let to a tenant named Gover, who hired a motor from plaintiff Company, and defendant entered into an agreement that, in the event of an execution for arrears of rent, he would not seize the motor. The motor was, however, seized and subsequently sold.

KARL KOPECH, for plaintiffs, gave evidence as to the hiring of the motor by Gover, £59. 8s. 7d. being the amount mentioned in the agreement.

In reply to defendants counsel, witness said the Sachsenwerk, &c., Co. was a German firm carrying on business in England in July, 1909.

Defendant's counsel: By sec. 274 of the Companies Consolidation Act, 1908, every company incorporated outside the United Kingdom and trading therein must be registered, under a penalty of £50 and £5 for every continuing day of default. Has this company been registered in the United Kingdom?

Plaintiff's Counsel: I object to that question.

Judge SMYLY: I do not see how you can object, except on the ground that the company is not bound to incriminate itself.

It was admitted that the motor had been sold, so plaintiffs counsel said all he had to put his mind to was the price, and he then detailed the hiring prices, cash prices, the time the machine had been had, amount allowed for depreciation, &c.

The defence was that the value of the motor had been greatly exaggerated—the claim being for £49 and £1 as damages for detention.

Judge SMYLY, asked if the machine could be returned, and having been informed it could not, as it had been sold, said he could find nothing wrong with the claim, and there would be judgment for plaintiff for £50 and costs.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A science master will be required in September at Huish Grammar School, Taunton, who is also qualified to teach electrical engineering and kindred subjects at the Municipal Technical Institute in the evenings. Salary £200 per annum, non-resident. Particulars from the head master, Mr. Arnold Goodliffe. See an advertisement.

An unmarried commercial assistant is wanted for a British electrical firm in India. Commencing salary £15 per month. See advertisement.

Applications are invited for the position of borough electrical engineer at Salford. Salary £500 per annum, rising to £700. Applications to the town clerk, Mr. L. C. Evans, by June 13.

Erith Council require a canvasser for their electricity department. Wages £2. 10s. per week. Applications by noon June 8.

The Council of the University of Manitoba, Winnipeg, Canada, require a lecturer in electrical engineering. Salary $1,500 a year. Applications to the Registrar by June 25.

Kent Education committee require an assistant master in the electrical engineering department of the Technical Institute, Gillingham. Forms of application from Mr. J. Thompson, Town Hall, Chatham, and applications to the Director of Further Education, Mr. R. L. Wills, M.A., Technical Institute, Gillingham, by June 20.

The Council of the University of Manchester require an assistant lecturer and demonstrator in the department of physics. Applications to the Registrar by June 13.

The professorship of physics at University College, Reading, will shortly become vacant. Particulars from the Registrar.

Sunderland Corporation have promoted Mr. J. A. Crowther (shift engineer) to the position of assistant electrical engineer, in succession to Mr. L. B. Humphreys, who has resigned.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, and the City and Guilds Technical College, Finsbury, are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years. The Finsbury College is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover a period of two years and those in chemistry three years.

University of Bristol.—The following have been appointed external examiners in the faculty of engineering:—

Civil Engineering.—Prof. S. M. Dixon, M.Sc., M.A., M.Inst.C.E. *Mechanical Engineering.*—Prof. W. Ripper, D.Eng., M.Inst.C.E. *Electrical Engineering.*—Prof. S. P. Thompson, D.Sc., F.R.S. *Mathematics.*—Mr. P. T. Wrigley, M.A. *Chemistry.*—Prof. S. Young, D.Sc., F.R.S.

Australasia.—The "Australian Mining Standard" states that a resolution was passed at the recent meeting of the Associated Chambers of Manufacture's, expressing disapproval of "the continued and growing interference by Government workshops with private manufacturers." There was only one dissentient vote.

Melbourne Electric Supply Co. has commenced the work of erecting cables for supplying current in Brighton (Victoria). High-tension underground feeders are to be laid to transformer pits, where the pressure will be reduced from 4,000 to 400 volts, the latter being transmitted by overhead distributors. The charges for current will be 5½d. for lighting, and 2d. for power, with a reduction to ¾d. for power after the first 1,000 units per month.

Leichardt and Petersham Councils have agreed to the erection of overhead transmission lines through their districts from the Sydney electricity works at Balmain to Newtown.

The net profit on the past year's working of the Wellington (N.Z.) tramways was £6,123.

Yarrawonga (Victoria) Shire Council are in favour of the provision of electricity supply for their district, if it can be done without putting an additional financial burden upon the public funds. Delegates have been appointed to visit towns possessing electricity works.

Austria-Hungary.—A 60-years' concession has been granted to Dr. H. Ofner for the construction and working of a light electric railway from St. Polten to Harland.

Birmingham.—The draft provisional order for the extension of the city has been issued and provides for the inclusion of Aston, Erdington, Handsworth, Yardley, and part of King's Norton and Northfield.

The tramway undertakings of Aston Corporation and of three Urban Councils are to be transferred and are to be worked and maintained by the Corporation. The electricity undertakings of Aston Corporation and of Handsworth Council, and the electricity undertaking of the Corporation of the existing city, are to be maintained and managed by the Corporation of the city as one undertaking, and the provisions of the Birmingham Corporation Act, 1899, which relate to the electricity undertaking of the Corporation of the existing city, and the provisions of part 130 of the Birmingham Corporation Act, 1903, will apply to the amalgamated undertaking. The prices to be charged by the Corporation for energy supplied by them to any consumer within Aston and Erdington must not exceed the prices charged by Aston Corporation on March 31, 1910, for energy supplied by them in the like circumstances. Within two years from the commencement of the order the Corporation must lay down distributing mains for general supply of electricity throughout every street within King's Norton and Northfield and Yardley.

Blair Atholl (N.B.)—About two years ago Blair castle was provided with an electric lighting installation, water power being employed in the generation of electricity.

His Grace the Duke of Atholl subsequently decided to supply electric current for lighting the village, the cost to be simply enough to cover the interest on the initial expenditure. On Saturday evening the first section of the public lighting was inaugurated, when current was switched on to the Atholl Arms Hotel by Mr. Macdonald. There are about 200 lights. The consulting engineer is Mr. W. H. Massey, whose assistant (Mr. Seth) superintended the general work.

Brighton.—At their meeting yesterday (Thursday) the Corporation were recommended to adopt a revised scale of charges for electricity for power, so that customers should pay 2d. per unit for electricity for power during the hours of peak load, subject to a two-rate meter being fixed.

The salary of Mr. G. Cloughton, power-house superintendent at Southwick works, has been increased to £300 per annum.

Cambridge.—The Council propose to have the Guildhall wired for electric lighting.

Church Lighting.—St. Matthew's Church, Bolton, is to be lighted electrically.

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Committee for the Protection of Electrical Interests.—At a meeting of this committee on 25th inst., Mr. Robert Hammond presiding, Mr. Arthur Preece was elected hon. treasurer, and Mr. R. Borlase Matthews, who has acted as hon. secretary pro tem., was elected hon. secretary.

Coventry.—The Corporation have approved a recommendation of the Electric Light committee to increase the salary of the electrical engineer and manager of the electricity department, Mr. G. Tough, from £350 to £450 per annum.

The Electric Light committee recommend the following charges for electricity for power and domestic purposes other than lighting: For first 2,500 units per quarter charge to be reduced from 1¾d. to 1½d. per unit. Where consumption exceeds 50,000 units per quarter, a flat rate of 1d. per unit will be charged, and for energy for domestic purposes other than lighting 1d. per unit.

Derby.—The Tramways committee claim that the charge for electricity for traction should be reduced from 1½d. to 1¼d. per unit.

Eccles.—The Borough Treasurer has been instructed to transfer the profit on the electricity undertaking for the year ended March 31 (£1,206) to credit of capital account of the undertaking towards the excess expenditure for which the L.G. Board refused to grant borrowing powers. An offer is to be made to supply energy for power to the works of Messrs. H. Cardwell & Sons, Winton.

An unopposed inquiry was held last week into the Council's application for sanction to borrow £3,234 for extensions of the electricity undertaking.

Electric Railways in America.—An electric railway 49 miles in length between the island of Galveston, by way of a causeway, to Houston, on the mainland of Texas, is expected to be completed next year. The cost (apart from that of the causeway) will be about $1,500,000 (£312,500).

The New York-Boston Railway Co. is building a rapid transit electric railway from the Harlem River, through Westchester County, into Connecticut.

Electricity in Mining.—The new mill and cyanide plant of the Roodepoort United Co. (Transvaal), which consists of 100 stamps in sets of 10, are to be driven electrically.

Each set is driven by a separate motor, and the stopping of one set will not involve the stoppage of the whole mill. The first installation of tube mills will consist of five. There are seven shaking tables to each tube mill, each driven by an independent motor. Each motor can be transferred by gantry or crawl to the electricians' repair shop, so that repairs can be speedily and economically effected.

An electrically-driven Belliss compressor had been erected near the central shaft. The company derived part of its power from the Umtali Waterfall, in which it owned a half share, but that power not being sufficient, they had to lease power from the Odzani hydro-electric station of the Penhalona Proprietary Mines, about 7 miles from the mine.

At the meeting of Rezende Mines (Ltd.) on Tuesday the chairman (Mr. S. H. Farrar) said that the west shaft had been thoroughly equipped with an electrically-driven hoisting engine and electrically-driven turbine pumps.

Exhibition.—A colliery and mining exhibition is to be held at the City Exhibition Hall, Manchester, from June 16 to July 1, inclusive.

Fatality.—At the Glamorgan colliery yard, Rhondda Valley, on Wednesday a surface foreman named Edward Abbott came into contact with a live electric wire and received a fatal shock.

A hauler named Doel was driving a horse attached to two trams to a brickyard, when the animal came in contact with a live wire and fell dead. Doel, who held the leading chain, also received a shock, and fell on the horse. Running to Doel's assistance, Abbott leaned over one of the trams and also received a shock which proved fatal. Doel recovered.

Folkestone.—The Council have deferred for seven years the question of purchasing the undertaking of the Folkestone Electricity Supply Co.

Fulham (London).—The outstanding capital expenditure on the electricity undertaking at March 31 was £229,960. 4s. 1d.

The Borough Treasurer reports that the revenue from the sale of current was satisfactory, and showed an increase compared with 1908-9 The total revenue was £29,917. 14s. 7d., against £29,535. 15s. 3d.; total expenses were £25,351. 10s. 7d., against £25,962. 1s. 2d. The net surplus is £4,551. 6s. 5d., against £1,914. 10s. 11d. The number of units sold for private lighting was 2,202,287 (at an average rate of 2·5d. per unit), and showed an increase of 4·85 per cent., while the receipts showed a net increase of £717. 9s. 5d. Public lighting revenue showed a decrease of £325. 3s. 1d.

Glasgow.—At the meeting of the Corporation last week it was decided to increase the salaries of three members of the staff by £25 per annum. The salary of the inspector of lighting (Mr. S. B. Langlands) was also increased from £350 to £450.

Grimsby.—The Council have abandoned the proposal to hire out arc lamps, &c.

Haslingden.—At the last meeting of the Council Mr. Barnes complained that little progress had been made with the electricity supply question. There was a certain demand for current in the district, and the Electricity committee should take steps to satisfy that demand.

In reply, the chairman of the committee (Ald. Barlow) stated that negotiations were proceeding with a company for a supply of electricity in bulk and he hoped to be soon in a position to call his committee together to consider the question.

Holland.—Middelburg communal authorities have voted 1,250 gulden (£104) for obtaining information as to the practicability of establishing electricity works.

Hull.—The Electric Lighting committee have acquired a site in New George-street for a sub-station.

Hydro-Electric Works in Japan.—It is reported that the Imperial Government has decided to establish an office under the control of the Department of Communications to make inquiries as to the water power available for the generation of electrical energy in Japan. Seven branch offices will be established. The work will probably be started in September next.

Inquest.—An inquest was held on Wednesday into the death of Henry Colburn, who was killed at Newland Collieries, Normanton, Yorkshire, on Monday.

Colburn and three others were working an electrically-driven coal-getter. When the current was switched on Colburn, inadvertently put his foot on the steel hauling rope and received a fatal electric shock. It was stated that water had affected the insulation of an electric cable, and caused a leakage, the current passing through the rope. Wordsworth, who attempted to drag deceased away, also trod upon the rope and felt only a slight shock. He was wearing clogs, and the wood acted as an insulator. Deceased wore leather boots.

The collieries manager (Mr. J. Gill) stated that such machines had been daily used for 23 years, and no accident had happened before.

A verdict of death from paralysis of the heart, due to electric shock, was returned.

Kingsbury (Middlesex).—The chairman of the Council (Mr. Jose Daiz) stated at the last meeting that numerous letters had been received from people who were anxious to know when electricity supply would be available. Although they had received the help of Hendon Council, it was not possible yet to formulate a scheme.

Leeds.—On the presentation of the report of the Tramways committee of the Council on Wednesday a question was asked as to the purchase of 350 additional renewable joint plates, and the acceptance of tenders for fishplates. It was also asked whether it was intended to replace the Thermit welded joint.

The chairman of the committee (Mr. R. A. Smithson) replied that the renewable joint plates were in no sense a substitution for thermit welding, which was being applied to all new rails. They found, however, that fishplates were more suitable, from an economical point of view, for the old rails.

L.C.C. Tramways.—Southfields residents have requested London County Council to extend the tramway from Wandsworth to the county boundary at Southfields.

Marylebone (London).—On the recommendation of the general manager (Mr. A. H. Seabrook) the insurance of the plant at the generating station against breakdown is to be discontinued. The original risks insured against have now been largely removed, and Mr. Seabrook is not aware of any similar undertaking having this description of risk covered by insurance.

Metropolitan Asylums Board.—The actual cost of substituting metal filament for carbon lamps at the Board's institutions amounted to £1,880. 5s., against an estimated cost of £1,921.

Naval Electrical Engineers.—The Admiralty have issued new regulations for the appointment of electrical engineers and of first and second assistant electrical engineers at the Admiralty and in the Royal Dockyards.

Vacancies for electrical engineers will be filled by selection from first assistant electrical engineers, and vacancies for first assistant electrical engineers will be filled by selection from one or other of the following classes:—Assistant electrical engineers; dockyard employés who have held the Admiralty scholarship; outside candidates, who will be required to produce evidence of having passed through a course of engineering study in a University technical college, or other educational establishment, to the satisfaction of the Admiralty, and of having been engaged in practical engineering work for at least five years, part of which time must have been spent in a responsible position as electrical engineer. As a rule every second vacancy will be filled by the appointment of an outside candidate. Second assistant electrical engineers will be made by means of a competitive examination at which inspectors or electrical fitters and first-class draughtsmen of three years' seniority and persons qualified by Admiralty scholarship will be eligible to compete, provided they are under the age prescribed by the Home Dockyard Regulations.

An Admiralty scholarship in electrical engineering (£40 per annum) has been established for a period not exceeding six years, and will be awarded

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to a specially able and deserving electrical fitter apprentice who has completed his four years' course of study in a dockyard school. The holder of the scholarship will be placed on the establishment as electrical fitter, and will proceed to the Royal Naval College, Greenwich, for a year's study in electrical engineering, at the end of which he shall, at the discretion of the Admiralty, continue to hold the scholarship for a second year. On passing satisfactorily at the conclusion of a two years' course at Greenwich he will return to service in a yard or at the Admiralty as supernumerary electrical draughtsman, and after one year's service will be eligible to compete for appointment as first-class draughtsman or inspector or second assistant electrical engineer in the event of a vacancy. He will further be eligible for selection as first assistant electrical engineer after not less then three years' service, subsequent to his Greenwich training. The first award of the scholarship will be made after the Dockyard Schools' examination this month, to the electrical fitter apprentice who has distinguished himself most highly in that examination or in the examination of the previous year.

Nottingham.—At the City Council meeting on Wednesday the Tramways committee were instructed to execute the works required for the Carlton road tramways, as soon as possible after the Corporation Bill had received the Royal assent. It is hoped to have the line completed by October.

Pakefield (Lowestoft).—The Mutford and Lothingland Council have been asked to consent to an application by a company for a provisional electric lighting order for this district.

Personal.—Mr. F. W. Hartmann, A.M.I.E.E., asks us to state that he is no longer actively connected with the Langdon-Davies Motor Co. (Ltd.), having resigned his position as assistant managing director.

Mr. Charles Bright, F.R.S.E., asks us to state that his appointment recently announced by the Australian Commonwealth is a home (London) appointment for partial services, and will not, therefore, as appears to have been supposed, take him to Australia.

We regret to learn that Mr. S. E. Fedden, manager of the Sheffield electric lighting department, is still confined to his house in consequence of an operation which he underwent two or three weeks ago.

Plymouth.—The borough electrical engineer (Mr. E. G. Okell) has been asked to report upon the question of letting motors on hire.

Printing, Stationery and Allied Trades' Exhibition.—An electrical engineer, visiting this exhibition, which remains open at the Agricultural Hall (Islington, N.) until June 11, cannot help being struck by the extended use that is being made of the electric motor for driving printing, composing and other similar machinery.

While the Agricultural Hall possesses its own steam plant and is willing to supply power to any of the stands, a large majority of the exhibitors do not appear to have taken advantage of these facilities, but have, instead, installed their own motors and have adopted the electric instead of the steam drive. Seeing what a large part printing and the allied trades play in our daily lives, it is not surprising that the engineering visitor will find much to interest him outside his own sphere.

The specimens of printed art, which are on view, may be justly called marvellous, and even the most casual observer cannot help being struck with the varieties of processes through which even the simplest piece of news has to go through before it can appear in the daily journals. The principal exhibit, from the electrical point of view, is to be found on Messrs. Harrild & Sons' stand, where Messrs. Electromotors (Ltd.) have a very complete installation of their motors and switchgear applied to the various printing and composing machinery to be found there. Other electrical firms represented are Messrs. Newtons (Ltd.), J. & H. Grevener and F. A. Glover & Co. The latter firm are also superintending the lighting of the exhibition.

Railway Signal and Telegraph Engineering Institute.—The last meeting of the session was held at Marylebone Church Institute on Monday. Mr. W. J. Thorrogood was in the chair.

Mr. F. W. R. May delivered a lecture on "Automatic Relays and Switches as applied to Telephone Installations." The lecturer also touched upon automatic relays for signal work.

A lengthy discussion followed, in which many of the members took part, after which the chairman gave an address, and hoped the movement for which the institute was established would continue to make progress equal to that which had attended its first season.

A vote of thanks to Mr. May for his lecture was carried unanimously, and a similar vote to the chairman for his services and the support he had given the movement from the start.

Richmond.—The Council have agreed to an extension of 12 months for constructing the tramway in the Kew-road as a single line, as proposed by the London United Tramways (Ltd.), provided the company widen the road so as to leave a space of not less than 9 ft. 6 in. between the outer rail and the kerb on both sides.

St. Pancras (London).—The chief electrical engineer (Mr. S. W. Baynes) has reported on the additional boiler plant required at King's road station.

Mr. Baynes states that the average yearly increased load during the past 10 years was 350 kw., and he estimates that the demand 15 years hence will have reached 9,871 kw. At present there are two generating stations, but for some years he has foreseen the desirability of collecting the generating plant under one roof, hence the introduction of three-phase plant and the opening up of sub-stations. He proposes that the generating plant at Regent's Park works should deal with the peak load only, and during the remaining nine months of the year it should be operated as a sub-station. It would be necessary to instal the following machinery: At Regent's Park works, two motor converters of 1,000 kw. each, with switchboards, &c., costing £5,900; three-phase trunk mains connecting King's-road with Regent's Park, £9,000. At King's-road, one spare turbo set, £9,400. Total, £24,300. The economies would be considerable, but they could only be brought about by extending the boiler plant at King's-road, and he submitted two schemes. He estimated the capital outlay on the first scheme as buildings, £18,200; boilers and superheater, coal conveyer and ash-handling plant, pipework, pumps, &c., £29,370; extra lengths of pipework, £932; extra length of coal transporter, £2,500; total, £51,002. The total annual expenditure under this scheme would be £4,744. The second scheme would involve a capital outlay of £84,549. The annual expenditure under this scheme would be £6,223. He estimated that the costs would be reduced from 1·02d. per unit sold to 0·69d. for 9,000,000 units, or a saving of £12,375 in one year. Altogether Mr. Baynes anticipates an immediate return of 11 per cent. on the capital invested after paying sinking fund charges at the higher rates now imposed by London County Council. But much as the boiler plant was needed, Mr. Baynes would not recommend a brick to be laid until a working arrangement is made with the Midland Railway Co., so that there would be direct means of running coal into the Council's works.

A special committee is to consider Mr. Baynes' report.

Salford.—Portions of the tramway track are to be relaid during the ensuing 12 months, at a cost of £13,000.

Sevenoaks.—The Council have called in Mr. W. M. Mordey to report upon the question of electricity supply in the district.

Sheffield.—Owing to the greatly increased demand for electrical energy, especially for power and heating, it has been found necessary to put in additional plant at Neepsend generating station, and an inquiry will be held next week into the Council's application for permission to borrow £78,000 for the purchase of the plant.

It appears that quite a new source of demand has developed in the form of energy for electric smelting furnaces in the East End works, and there are indications pointing to very considerable extensions in this direction. Already two furnaces have been connected to the supply mains, and others are awaiting connection.

Smethwick.—The Council have decided to oppose the Bill for the confirmation of the Smethwick Electric Lighting Provisional Order, which proposes to transfer the 1898 order from the Birmingham & Midland Tramways (Ltd.) to the Shropshire, Worcestershire & Staffordshire Electric Power Co.

Spain.—The Public Works Department have granted to the Compania General de Tranvias de Barcelona a concession for constructing and working an electric tramway from Sans to Coll. Blanch, Barcelona.

The Ministry of Public Instruction have decided to distribute 200,000 pesetas (about £7,400) for the purchase of experimental scientific appliances for the colleges in Barcelona, Granada, Oviedo, Salamanca, Santiago de Campostella, Seville, Valencia, Valladolid and Saragossa.

Stretford.—Some time ago a dispute arose between the Council and Manchester Corporation which has running powers over the local tramway lines, as to whether, under the existing agreement, Manchester could call upon Stretford to supply an abnormal demand for current caused by football traffic. Stretford contended that they could not be called upon to do so, but the Board of Trade arbitrator (Mr. S. Buckmaster, K.C.) has now decided against them.

Sweden.—The Swedish Budget for 1911 provides that additional expenditure on canals, electric works and railways is to be met by loans amounting to £729,000.

The Army Pageant.—We are pleased to learn that the technical side of the Territorial Force is occupying a prominent position in the Army Pageant which will take place at Fulham Palace from June 20 to July 2. The Electrical Engineers (London Division) have, in fact, been entrusted with the important task of carrying out the whole of the lighting for the pageant. The men of this corps have offered their services gratuitously not only during performances, but for the preparation as well, and have undertaken to carry out the wiring work for lighting the grand stand and dressing rooms, as well as the pageant itself.

The grand stand will be lighted by means of high candle-power metal filament lamps, hanging from the roof, and in addition a row of flame arc lamps will be used for the double purpose of lighting the stand and the camp behind it. Arc lamps will also be used for lighting the entrances, both for the public and the performers. The dressing-rooms, pay boxes, ambulance stations, &c., will be illuminated by means of incandescent lamps, and last but not least, the pageant itself will be made visible to the audience at night by means of arc lamps placed on the roof of the grand stand. In all some 30 arc lamps and 250 incandescent lamps will be installed, and owing to the situation of the supply will necessitate using many miles of wire. In addition to the above duties, the Electrical Engineers have also undertaken the work of installing and maintaining the telephone service between the directing station used by the pageant

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master and the various entrances to the arena and dressing rooms. This necessitates the use of a 12 way exchange board. The whole of the wiring work will be carried on insulators overhead. As the whole of the profits of the pageant are to be devoted to Army Charities, we wish it every success, and take this opportunity of expressing our appreciation of those members of the Corps of the Electrical Engineers, who have so generously offered their time in such a good interest.

The Rand.—We have received from the "Investor's Guardian," 21, Lime-street, London, E.C., a copy of a work entitled "Reduction of Working Costs on the Rand," being a reprint of series of articles contributed to our contemporary by their special commissioner (Mr. Howard) appointed to investigate the position of the mining industry on the Rand. Among the factors in the great reduction of working costs which has taken place are (1) the employment of heavier stamps, (2) the increased use of machine drills, and (3) the introduction of electric power. The work, which is published at 1s., consists of 38 pages of statistical and other information which should prove interesting reading to investors in the Rand mining securities. In regard to electric power Mr. Howard states that:—

The increased use of electricity in substitution of, or as an auxiliary to, the usual steam power has had a beneficial influence on working costs, but it is anticipated that the greatly extended use of electricity will still further lower working costs in the immediate future. To any one acquainted with the steadiness of machinery worked by electric power, and the ease with which any one of the component parts is thrown in and out of gear without interference with the rest of the machinery, it is apparent that the important steps which have been recently taken to secure an ample supply of electric power to the Rand cannot fail to exercise a far-reaching influence on the future of the industry. The superintending engineer of the Consolidated Goldfields has stated that in future it will probably be found economical to operate electrically all underground winders at the two Jupiter inclines, which will be of large capacity and designed to reach the limits of the property, a distance of 4,500 ft. on the incline. The charge for electricity will be reduced in October when an appreciable saving in running costs at the Simmer Deep and Jupiter plant is anticipated, and the electrification of the plants of the subsidiaries of the Rand mines and the Eckstein group will be completed towards the end of this year.

United States Telegraphs and Telephones.—On the 27th ult. the Senate adopted an amendment to the Railroad Bill introduced by Mr. Lafollette, placing the telegraph, telephone and cable companies, with the exception of the wireless telegraph companies, under the Inter-State Commerce Law.

Ventnor (I.W.).—At the last meeting of the Urban Council, on the motion of Mr. Smith, a resolution was unanimously adopted that it was expedient to consider the means of reaching the different levels of the town, with special reference to the construction of an electric tramway, and that any necessary action should be taken without delay.

Walthamstow.—An inquiry was held last week into the application of the Council for sanction to borrow £950 for additional plant at the electricity works, consisting of an additional booster set with the necessary connecting cables, switchboard and instruments, and an extension to the switchboard gallery.

The electrical engineer and accountant are in future to arrange the prices to be charged for the purchase of any installation which has been fitted up under the "free" wiring scheme, the price to be arranged by estimating the present value of the installation, or by adding 5 per cent. interest to original cost, and making an allowance for the amounts paid as rental since the installation was connected. Payment is to be spread over two years if desired, with interest at 5 per cent.

Watford.—An inquiry was held last week into the Council's application for sanction to borrow £7,500 for extensions of the electricity undertaking.

The clerk (Mr. H. Morten Turner) and the electrical engineer (Mr. F. W. Purse) gave evidence of the financial position of the undertaking and of the necessity for extensions of mains, &c. There was some opposition on behalf of the gas company and the ratepayers' association.

Wigan.—The Council has engaged Mr. C. W. Mallins, general manager of the Liverpool tramways, to report on the question of the working of the tramways.

Willesden.—Consent has been given to the Metropolitan Electric Tramways to lay additional cables through Church-road, Stonebridge.

A sub-committee has been appointed to make arrangements as to renting premises to hold electrical exhibitions from time to time. The Electricity committee recommend the Council to undertake the sale of domestic apparatus such as electric irons, kettles, &c.

Wireless Telegraphy.—Owing to satisfactory reports received from the owners of small craft as to the result of working wireless apparatus on these small vessels the Admiralty have decided to equip the torpedo gunboat "Sharpshooter," at Devonport, with wireless apparatus housed on the upper deck, the power generating machinery being placed below the water line.

Workhouse Lighting.—Congleton Guardians are considering the question of wiring their workhouse.

Barnet Guardians have engaged an electrical engineer to report upon the proposal to light the workhouse electrically.

Chorlton Guardians have decided to wire a portion of the workhouse premises.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Barrow-in-Furness.—The accounts of the electricity undertaking for the year ended March 31 show a total capital expenditure of £114,570, an increase of £1,323.

The total revenue was £13,266 (against £12,902), including £12,995 from the supply of electricity. Total costs were £5,882 (£6,286), gross profit £7,384 (£6,615). Interest on loans absorbed £3,197 (£3,242) and sinking fund £3,973 (£3,757), leaving a net profit of £249, against a deficit of £384 in 1908-9. The maximum load was 662 kw. (624 kw.), the load factor 13·95 per cent. (13·65). The equivalent of 83,419 30-watt lamps is connected, against 78,119; 1,130,092 units of current were sold (1,057,330). The average price per unit for private lighting was 4·224d. (4·217d.), for power 1·375d. (1·398d.) and traction 1·923d. (1·936d.). The works costs were 0·912d. per unit (1·045d.), and total costs 1·249d. per unit (1·426d.).

Belfast.—The report of the city electrical engineer (Mr. I. W. Bloxam) states that the net profit of the electricity undertaking for the year ended March 31 was £11,040, an increase of about 33 per cent. over 1909, due to the material increase in the total quantity of electricity sold and the substantial reduction in cost of generation.

The revenue from the sale of electricity for lighting and power was £42,722, increase of 15·4 per cent. The number of units sold for lighting alone was 2,238,019, increase 8·9 per cent., and for power 2,004,045, increase 26 per cent. The cost of production per unit has been reduced 8·5 per cent. The total number of units supplied for traction increased by 2½ per cent., but the revenue diminished by £1,522. The total equivalent of 30 watt lamps connected is 376,722 (increase 15·8 per cent.) including the equivalent of 5,835 H.P. in motors. The number of consumers is 2,305, increase 17 per cent. The maximum combined load last winter was 6,915 kw., viz., 4,000 kw. lighting and 2,915 kw. tramways.

Bexhill.—The total income of the electricity department for the year ended March 31 was £10,244, and after paying expenses the gross profit was £5,086.

After paying interest, sinking fund, &c., the net profit was £624, making with £726 brought forward a total of £1,350. As the L.G. Board inspector has suggested that capital expenditure in respect of meters and public lighting should be defrayed out of revenue, the Electric Light committee propose to transfer £654 to capital account, leaving £696 unappropriated.

Bolton.—The receipts of the electricity department from the sale of current for the year ended March 31 amounted to £62,730, and included £20,609 for private lighting, £22,173 for power and heating, and £19,948 for traction. The total income was £73,579.

Working expenses were £38,637, and included £20,792 for generation, £1,045 for distribution, £3,140 for rents, rates and taxes, and £1,773 for management and general expenses. The gross profit was £31,941 making, with £2,680 brought forward, £37,622. Interest absorbed £8,563, and depreciation £19,248 (6 per cent. on mains and transformers, 7 per cent. on machinery, 10 per cent. on meters, motors and instruments); £356 was written off mains account, £454 was spent on new meters, and £881 on new motors, £1,000 was written off Duncan-street sub-station, and £6,500 was devoted to relief of rates, leaving £619 to be carried forward. The total capital expended is £359,690. The works costs were 0·436d. per unit against 0·472d., and the total inclusive costs 1·125d. against 0·1199d. 14,257,257 units were generated; 1,627,135 were sold for private lighting, 6,013,928 for power, and 4,352,208 were supplied to the tramways department. The average price per unit was 1·18d., against 1·23d. There are 2,628 consumers, representing an equivalent of 434,561 8 c.p. lamps; the power consumers number 400 (increase of 25), and there are 915 (816) motors of an aggregate of 10,017¼ H.P. (9,219¼ H.P.) on circuit.

Brighton.—The accounts of the electricity supply department for the year ended March 31 were submitted to the Council yesterday (Thursday).

Capital expenditure is £800,753, an increase of £20,108 over the previous year. The total net revenue was £88,856, an increase of £5,575, and the total costs were £37,439, a decrease of £619, leaving a gross profit of £51,417, an increase of £6,175 over 1908-9. Interest required £19,243 and sinking fund contributions £25,922, so that the net profit is £6,252, against £565. Income from the sale of current for private lighting showed an increase of £1,489 and for power of £1,243. Total works costs were 0·70d. against 0·78d., and the total costs (including loan charges) 2·19d. against 2·47d. per unit, and 9,041,844 units of electrical energy were sold, against 8,037,711; 4,092,821 units were supplied for private lighting (against 4,241,747), 1,141,400 for power (842,198), 1,015,106 for public lighting (1,036,107), 1,938,305 for tramways (1,889,410), 41,407 to Aldrington (28,249) and 812,805 units were supplied on private contract. The equivalent of 363,124 8 c.p. lamps is connected, against

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333,143; there are 5,020 consumers, against 4,773. The maximum load on the feeders was 4,727 kw., against 4,437 kw., and the load factor was 21·8, against 20·1 per cent.

In the report of the engineer and manager (Mr. John Christie) it is stated that there had been a slight falling off in the sales for private lighting, due to the extended use of metal filament lamps, but it is stated that the department has now almost reached the point when additional business would enable them to show steady annual progressive increases. In regard to the use of power, the chief point was the substantial increase due, chiefly to the fresh business obtained in operating the railway shops, charging electric 'buses and the more general use of motors for driving industrial machinery. 34 motors were let on hire during the year (equivalent to 175 H.P.), bringing the total number on hire to 189 (947 H.P.) These motors had displaced a large number of small isolated steam plants, and the consequent reduction of the smoke nuisance must have a beneficial effect on the town. The sales to public lamps showed a decrease of 21,001 units, due to the extended use of metal filament lamps. The tramway output had increased by 48,895 units, and the reduction in price from 1·5d. to 1·25d. had benefited that department to the extent of £1,210.

At Aldrington (to which bulk supply was given) there were 117 consumers (with the equivalent of 5,562 8 c.p. lamps) connected to the mains. The great increase in output, obtained without a corresponding proportionate advance in maximum load, had raised the load factor from 20·1 to 21·8 per cent., thus effecting a substantial reduction in works cost. On coal the saving was 0·05d. per unit. They had sold over 1,000,000 units more than in the previous year, while the total cost for fuel had been £637 less. The surplus (£6,251) has been transferred to reserve.

Coventry.—At Tuesday's Council meeting the chairman of the Electricity committee (Mr. M. K. Pridmore) moved the adoption of the accounts of the electricity undertaking for the year ended March 31.

The year's revenue was £36,920 (against £30,607), and the receipts from the sale of current for lighting and power were £34,968 (against £28,500). The total expenditure was £11,380, but included in this amount are two items of £264 for repairs to motors on hire, &c., and £237 for attendance to public lamps. The gross profit was £25,540, and after paying all capital charges, £1,000 was voted to relief of rates, £2,598 was placed to reserve, leaving a net balance of £10,238, of which the committee recommended that £2,500 be applied in aid of rates, that £7,188. 11s. 4d. be placed to reserve to meet the cost of obsolete and superseded plant, &c., that £280. 9s. 6d. be placed to reserve, that £204. 18s. 8d. be applied in paying a bonus to the employees of the department, the balance (ff64. 3s. 6d.) being carried forward. The total capital expended is £241,098, an increase of £3,226. The units sold amounted to 6,093,825, including 5,859,792 for private lighting and power, and 234,033 to the public lamps, of which there are 117 on 59 brackets and posts. The total maximum supply demanded was 3,754 kw.

Mr. PRIDMORE said that, after paying expense (with interest and sinking fund) there was a net profit of £10,238, the highest amount in the history of the undertaking, and it was proposed to hand over £2,500 to the general district fund, £7,188 to a fund for obsolete plant and purchase of meters, £280 to reserve fund, and £204 as a bonus to employés of the department, the balance being carried forward. He urged that the Corporation should be satisfied with a fair return on the capital employed in the undertaking, and submitted that 1 per cent. was a fair return. Anything over that should go in the reduction of the price of current. As a matter of fact that would before long be established by Parliament, which would prevent other towns from devoting large profits to relief of rates.

Mr. HEWITT said the undertaking had borrowed £10,000 from the rates when it was a losing concern, and he thought that the undertaking should at least pay off that loan.

Mr. BETTMANN held that it was the first duty of the committee to put the undertaking on a sound basis. If manufacturers got a benefit from cheap current it enabled them to compete better with the manufacturers of other towns, and thus benefited the city.

Ald. WEST, a past chairman of the committee, spoke optimistically of the prospects of the undertaking, and called attention to the fact that about 1,500,000 units had been sold for power during the past year, which proved that the trade of the city had been flourishing. That increase had been produced at a cost of £1,412 less than the cost of the output of the previous year, and with the increase of only 179 tons of coal. The engine room stores was a remarkable item, as the cost worked out at only 6½d. per horse-power per annum. There was only one other Corporation in the country that was producing electricity at a lower cost than Coventry, and in that case they had a wonderfully good power load and a good tramway load. He would not be surprised if next year there was a neck-and-neck race between Coventry and Stalybridge for the blue riband of the lowest electricity works cost.

The report and accounts were approved.

Devonport.—For the year ended March 31 the total revenue of the electricity department was £17,819, including £16, 270 from the sale of current.

The cost of generation was £6,624, of distribution £839, public lighting £148, rates and taxes £446, private works £1,016, management expenses were £1,199, and after paying insurances, &c., the surplus was £7,468, out of which capital charges were met, leaving a net profit of £1,011. The outstanding capital expenditure is £112,451. The units sold amounted to 1,651,614, against 1,722,482, the decrease being accounted for by a drop of 124,907 in the units sold for traction. There are 439 consumers, against 397; the equivalent number of 8 c.p. lamps connected is 35,357, against 32,482. Total works costs were 1·337d. per unit, against 1·327d.

Dundee.—The receipts of the electricity department for the year ended April 30 were £39,908, compared with £36,975 in 1909, while the expenditure was £21,479 (against £24,928), which included £11,510. 8s. 7d. for generation of energy, £2,975. 10s. 6d. for distribution, £5,128. 9s. 11d. for rents, rates and taxes, and £1,864.2s.5d. for administration expenses. Gross profit was £18,429. 8s. 11d., against £12,046. 19s. 7d. Interest required £7,577, against £5,951, sinking fund £6,676 (£5,786), while there was set aside as depreciation £2,750, and to claim account £1,250. The balance carried forward was £1,259. 17s. 9d., against £1,256. 6s. 10d. The units sold were 6,144,956.

Lancaster.—The accounts of the electricity and tramways departments for year ended March 31 have been issued.

The total income of the electricity department was £9,625, including £5,438 from sale of current for lighting, £1,029 from power, £786 from public lighting and £1,845 for current for traction. Expenses came to £6,297 and after paying interest (£1,719) and providing for repayment of debt (£1,626) there was a balance of £84 which has been placed to reserve. The total capital expenditure is £63,252. 873,325 units were generated, 383,026 units supplied to private consumers by meter and 36,083 by contract, 260,519 units supplied to the tramways department and 74,826 to the public lamps (41 arcs and 84 incandescents). The equivalent of 75,842 8.c.p. (against 64,029) is connected and the motors aggregate 440 H.P. The total cost per unit sold was 1·48d. and the average revenue was 2·79d.

The income of the tramways department was £5,231 (including £4,993 traffic revenue) and the expenses came to the same figure, but after providing for interest and sinking fund there was a deficit of £2,897, against £3,235 in 1909. The total capital expended is £43,330. 1,335,534 passengers were carried and 166,394 car-miles run, the average receipts per car-mile being 7·2d.

Sunderland.—For the year ended March 31 the total revenue of the tramways department was £58,546.

The total expenditure was £37,216, including £17,298 for traffic expenses, £5,648 general expenses, £3,706 repairs and maintenance, and £10,565 power expenses. Gross profit was £21,330, increased by bank interest to £21,576. Interest on loans absorbed £7,848, and income tax £568, leaving a balance of £13,160. 0s. 4d. The repayment of loans required £10,092, reserve and renewals £2,444. 13s. 3d., Wheat Sheaf offices instalment £400, and Sea-lane shelter £225. The net balance, after taking into account £517. 18s. 4d. dividends from investments was £3,588, of which £2,963 was placed to reserve and renewals fund and £625 to Wheat Sheaf offices account, &c. During the year 14,380,214 passengers were carried (a decrease of about 500,000) and 1,461,592 car miles run (against 1,474,990), but owing to a reduction in price the amount paid for current was £1,867 less.

The average working cost per car-mile (including power) was 6·11d., and excluding power 4·37d. The general manager (Mr. A. R. Dayson) reports that all the cars have now been fitted with meters, and, as a result, there has been a saving in current, the units per car-mile having dropped from 1·19 to 1·15. The decrease in traffic receipts (£1,869) is stated to be due to the continuation of bad trade in the town, to the troubles in the adjacent colliery districts, and to unfavourable weather for seaside traffic to Roker.

The revenue of the electricity supply department was £49,361, and after paying expenses the gross profit was £28,351. Interest absorbed £12,524 and sinking fund £15,518 and £421 was required for renewals and special expenditure, leaving a net deficit of £112. The number of units sold was 7,848,815 (against 6,584,825 in 1909); for power 3,961,302 units were sold, an increase of 1,501,314; to ordinary consumers 1,761,576, a decrease of 127,332; for street lighting 426,179, an increase of 16,189, and for traction 1,690,918, a decrease of 79,483.

The electrical engineer (Mr. A. S. Blackman) states in his report that the outstanding features of the year were a partial recovery from the depression in the shipbuilding and engineering trades, the commencement of supply to consumers at e.h.t., the reduction of the price charged for traction (1¾d. to 1½d. per unit), representing a drop in revenue of £1,321, the introduction of the new Home Office Regulations relating to the generation, transformation, distribution and use of electrical energy, which necessitate alterations to portions of the works and sub-stations; the rapid introduction of the metal filament lamp, the reduction in the sale of electricity for lighting purposes consequent thereon, and the continued drop in the costs of production.

West Bromwich.—The capital expended on the electricity undertaking at March 31 was £75,118, an increase of £1,509 during the past year.

The income from the sale of current was £12,663, a decrease of £409, owing to the reduced demand for traction, which amounted to £1,282. There was an increase of £791 in revenue from private consumers, and of £82 from public lighting. Gross profit amounted to £6,349 against £6,856. After paying interest (£1,730) and redemption of debt charges (£2,862) there was a net profit of £1,756. 3s. 6d., a decrease of £686. 3s. 5d., compared with the previous year.

The net capital expended on the tramways department is £134,786. The full amount of rent chargeable to the Tramways (Lessee) Co., viz., £8,606, has been received less £502 income tax. The net profit on the rental of the tramways for the year is £246.

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TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

The Electric Lighting committee of HULL Corporation invite tenders for supply and laying of electric mains, &c., required in connection with the extension of the electric lighting mains during the period ending March 31, 1911. Forms of tender and specification from the City treasurer, Mr. T. G. Milner, and tenders, addressed to the chairman of the committee, must be delivered at the Town Hall, Hull, by noon June 20. See also an advertisement.

WEST BROMWICH Electricity committee invite tenders for the supply, delivery and laying of paper-insulated lead-covered feeder and pilot cables. Specifications, forms of tender, &c., from the borough electrical engineer and manager, Mr. W. A. Jackson, Electricity Works, West Bromwich. Tenders to the chairman of the Electricity committee, Town Hall, West Bromwich, by noon June 20. See also an advertisement.

Tenders are invited by July 6 for the supply of cordless switchboards to the Postmaster-General's Department in SOUTH AUSTRALIA. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to July 19 for supply and delivery of 4,200 telephone sets (as per schedule No. 231) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

BARNES Urban District Council invite tenders for supply of 4,000 yds. of 0·25, 0·25, 1·25 sq. in. triple concentric cable, paper insulated, lead sheathed and jute served, suitable for a working pressure of 660 volts, manufactured in strict accordance with the British Engineering Standards committee's specifications. Tenders to the Clerk to the Council, High-street, Mortlake, by noon June 14.

ERITH Council want tenders by noon June 20 for supply of a Lancashire boiler, mechanical stokers, superheater and pipework; a 750 kw. three-phase turbo-alternator, with surface condenser, air and circulating pumps and pipework. Specification from the Electrical Engineer.

DEVONPORT Corporation want tenders by noon June 15 for 12 months' supply of d.c. meters, paper-insulated cables, rubber-covered wires and cut-outs, lubricating oils, &c. Forms of tender, &c., from Borough Electrical Engineer.

The LIVERPOOL Overhead Railway Co. require tenders by 10 a.m. June 7 for 12 months' supply of electrical fittings, insulating tapes, iron and steel, ironmongery, oil and grease, packings, &c. Forms of tender, &c., from 31, James-street, Liverpool.

EALING Corporation require tenders by noon July 4 for supply and erection of surface condensing plant, &c., at the electricity works. Specification, &c., from Town Hall, Ealing.

MANCHESTER Electricity committee want tenders by 10 a.m. June 7 for 12 months' supply of stores, including carbons, dynamos, brushes, iron and steel, asbestos and rubber goods, oils, &c. Forms of tender from the Town Hall.

MANCHESTER Tramways committee want tenders by 10 a.m. June 7 for special (permanent way) track work. Specification from 55, Piccadilly, Manchester.

WEST HAM Education committee require tenders by 6 p.m. June 20 for the electric lighting of three schools. Specifications, &c., from Mr. Wm. Jacques, 2, Fen-court, Fenchurch-street, London, E.C.

BRISTOL Sanitary and Improvement committee want tenders by 10 a.m. June 13 for supply and erection of electrical plant and fittings at the proposed refuse destructor, Eastville, Bristol. Specification, &c., from City Engineer.

Tenders are wanted by noon June 13 for the electric lighting of the new asylum buildings on the Purdysburn estate, BELFAST. Specifications from Messrs. Watt, Tulloch & Fitzimons, 77A, Victoria-street, Belfast.

SOUTH SHIELDS Corporation want tenders by 10 a.m. June 13 for 12 months' supply of stores to the tramway department. Specification, &c., from the Tramways Manager.

WALLASEY Council require tenders by noon June 14 for the supply and erection of a water cooling tower. Specifications from engineer and manager of electricity department, Liscard.

SWANSEA Corporation want tenders by noon June 23 for 12 months' supply of motors and starting switches. Specifications, &c., from the Borough Electrical Engineer.

BIRMINGHAM Tramways committee require tenders by first post June 20 for supply of 2,100 tons of grooved steel girder tram rails with fishplates, &c. Specification, &c., from General Manager.

Tenders are wanted by noon June 6 for the electric lighting of the Stewart Institution, Chapelizod, DUBLIN. Specification, &c., from Mr. T. Tomlinson, 16, Beresford-place, Dublin.

CHORLTON Guardians want tenders by June 7 for the electric lighting of two blocks at West Didsbury Workhouse. Specifications from Messrs. C. Clegg & Sons, 21, Spring-gardens, Manchester.

The Penrikyber Navigation Colliery Co., PENRHIWCEIBER, Glam., require tenders by June 8 for 12 months' stores, including electrical fittings, ironmongery, oils, &c. Forms of tender from Secretary.

PORTSMOUTH Corporation want tenders by 10 a.m. June 22 for one or two years' supply of coal to the electricity department.

WALSALL Corporation want tenders by noon June 7 for erection of a sub-station. Forms from Borough Electrical Engineer.

The Deputy Postmaster-General, BRISBANE (Queensland), will receive tenders until noon June 22 for supply of 130 miles copper tinned wire and 25,000 insulators. Local representation is necessary. Specifications, &c., from 72, Victoria-street, London, S.W.

Tenders are invited for supply of 1,470 opalescent arc lamp globes to the city of MELBOURNE. Specification, form of tender, &c., from the agents of the City Council (Messrs. McIlwraith, McEacharn & Co. Propty., Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon June 8.

Tenders are also invited for supply of 941,000 arc lamp carbons to the city of MELBOURNE. Tender form, specification, &c., from the agents (Messrs. McIlwraith, McEacharn & Co. Propty., Ltd.), Billiter Square-buildings, London, E.C., to whom tenders by Friday, June 17.

Tenders are invited up to June 14 for supply of 100 party line common battery telephone wall sets, 10 party line common battery table sets, 100 switches, common battery, single extension and intercommunication, and 3,000 telephone protectors to the Postmaster-General's department in VICTORIA. Tender forms and specification at the Commonwealth office, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, BRISBANE (Queensland), will receive tenders until noon June 22 for supply of copper wire and accessories, covered wire, iron wire, insulators, ironwork and sal ammoniac and zinc for batteries. Local representation is necessary.

Tenders are invited up to June 7 for supply of one frame, main distributing, to the Postmaster-General's department in WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth office, 72, Victoria-street, London, S.W.

The Netherlands Colonial Office, THE HAGUE, Holland, will receive tenders on June 7 for supply of 3,000 iron telegraph poles and 500 top tubes (contract La C. 15). Specifications from M. Nyhoff, 18, Nobelstraat, The Hague (price 1s. 8d.).

The ITALIAN State Railways Department want tenders for supply of 19,600 glass shades for electric lamps in railway carriages. Tenders to 16, Via Ludovisi, Rome, by June 14. Only firms on the list kept by the department are usually allowed to tender.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit

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of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Marylebone (London) Council have accepted the following tenders for annual supplies :—

Rands & Co., ceiling roses, ordinary, 1s. 11d. per dozen; tumbler switches, linked and mounted, 10 and 20 amperes, 32s. per dozen and 5s. 4d. per pair. T. L. Scott & Co., tumbler switches, 5 and 10 amperes, 6s. and 11s. 6d. per dozen; d.p. distribution boards, 5 amperes, 1s. 9d. to 10s. 6d. each; china bridge fuses, 1s. 9d. per dozen; s.p. cutouts, 100 amperes, 22s. 6d. per dozen. Edison & Swan Co., wall plugs and sockets, 10 amperes, 14s. 6d. per dozen; switch plugs, 10 and 5 amperes, 34s. and 22s. per dozen; d.p. distribution boards, 10 amperes, 2s. 6d. to 15s. 6d. each; lamp holders, 2s. 9d. and 3s. per dozen; shades, 10 in. opal, 2s. 9d. per dozen; 10 in. green opal, 7s. 4d. per dozen; enamelled iron, 10 in., 2s. 9d. per dozen. Union Electric Co., 23 in. 10 mm. (metal core) arc lamp carbons (flame) per 250 ft., 28s.; 23 in. 9 mm. do., 19s. 3d.

West Bromwich Corporation received the following tenders for 1,000 kw. direct-current turbo-generator :—

C. A. Parsons & Co. (*accepted*); Richardsons, Westgarth & Co., three tenders (Brown-Boveri, Siemens and Westinghouse generators); James Howden & Co., two (Brown-Boveri and Siemens generators); Willans & Robinson, four (Brown, Boveri, G.E.C., E.C.C. and Siemens generators); Brush Electrical Engineering Co. and British Westinghouse Co.

For a surface condenser the Corporation received tenders from the following :—

C. A. Parsons & Co. (*accepted*), Richardsons, Westgarth & Co., Willans & Robinson, Mirrlees-Watson Co., Brush Co., W. H. Allen, Son & Co., British Westinghouse Co., Midland Engineering Co., Worthington Pump Co., John Thompson and Isaac Storey & Son.

Salford Education committee have accepted the tender of the British Westinghouse Co. for wiring the Wellington-street schools at £146.

Salford Council have accepted the following tenders :—

W. Lucy & Co., house service cut-outs; Liverpool Electric Cable Co., rubber covered cable; W. T. Glover & Co., paper insulated cable; C. Macintosh & Co., twin workshop flexible; British Westinghouse Co., wiring Wellington-street school (£146. 8s. 6d.); Thames Ironworks, &c., Co., combined evaporator and distiller for new battery "make up" water (£59).

The following tenders have been accepted by the Australian Postmaster-General's Department :—

British Insulated & Helsby Cables, multiple magneto switchboard for Canterbury telephone exchange, £2,239. 13s. 11d.; Sydney Electrical Engineering Co., electric lighting of Newcastle (N.S.W.) Post Office.

Kingston Council has accepted the following tenders :—

W. T. Henley's Telegraph Works Co., for ½ mile of 5 ampere cable at £44. 10s., and ½ mile of 35 ampere cable at £87. 10s.; and Siemens Bros. & Co., for ½ mile of 12 ampere cable at £58, and ½ mile of 22 ampere cable at £71.

Grimsby Council have accepted the following tenders :—

J. H. Tucker & Co., fuse boxes, £37. 10s.; Phœnix Dynamo Mfg. Co., three-wire balancer, £38; Chamberlain & Hookham and Ferranti Limited, meters; W. Lucy & Co., 300 c.i. lamp-posts, £326. 5s., and incandescent lamp fittings, £248. 3s. 9d.

Walthamstow Council have provisionally accepted the following tenders :—

General Electric Co. feeder booster set, £468; B. Thomas, switchboard, £242. 10s.; General Iron Foundry Co., constructional ironwork for switchboard gallery extension, £87.

Eccles Council have accepted the following tenders :—

British Insulated & Helsby Cables, h.t. concentric paper-insulated cable (£459. 11s. 3d.), and N. Brookes & Sons, construction of foundations for new steam dynamo, &c.

The order for replating the lighting battery at Derby, consisting of 240 cells, has been placed with the Chloride Electrical Storage Co. at £100, and six annual payments of £93, and maintenance for 12 years at £70 per annum.

The tender of G. F. Endersby has been accepted for supply of a reversible booster, storage battery and switchboard panels to Rochdale Corporation.

Dartford Council have placed orders with Chamberlain & Hookham and Ferranti Limited for 12 months' supply of meters, and with E. E. Beaven for general stores, &c.

The Metropolitan Asylums Board have accepted the tender of W. J. Fryer & Co. (at £51. 17s. 6d.) for wiring the assistant medical officer's quarters, North-Eastern Hospital.

Bishop Auckland Guardians have accepted the tender of E. Thompson & Co. for wiring their new infirmary at £78.

Stretford Council have accepted the tender of the General Electric Co. for a 500 kw. steam dynamo at £2,764 and spare armature at £325.

Derby Council have also accepted the following tenders :—

Electric Construction Co., switchboard extension, £303, and motor generator, £683; W. Rickard (Ltd.), bitumen cable, £1,721. 10s.

Middlesex County Council has accepted the tender of Dick, Kerr & Co. (at £429) for laying a double instead of an interlacing line in High-road, Willesden, widening the road, &c.

Sunderland Corporation have accepted the tender of the United States Metallic Packing Co. for a rail grinding machine.

Morecambe Council have accepted the tender of Edmondson Bros. for erecting a cooling tower at the electricity works.

Water Purifying Plant.—Among orders recently received for Paterson water purifiers are the following :—

H.M. Dockyard, Pembroke, repeat order for generating station; Hull Corporation, repeat order for tramway power station; G.P.O. generating station, Blackfriars (through Messrs. Aiton & Co.); Messrs. J. G. White & Co., repeat orders for Lacroze electric tramways (Buenos Aires) and Para Electric Light & Tramways Co.; and Midland Electric Corporation for Power Distribution, for Ocker Hill generating station.

Plant for Sale.—An 80 kw. Willans steam dynamo is advertised for sale.

Some second-hand electric motors are advertised for sale in another column.

Premises to Let.—Premises suitable for manufacturers are advertised to be let in the east of London.

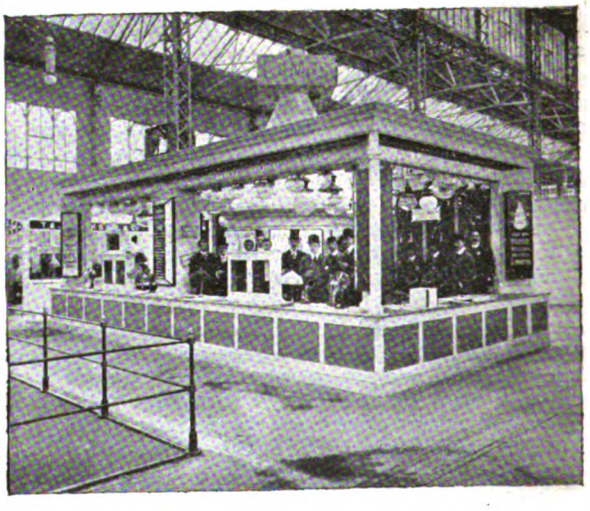
Patents Development.—The proprietors of the following patent desire to enter into arrangements by way of licence and otherwise for exploiting and developing the same in this country :—

No. 12,210/1901, relating to "Electrostatic Separators." Applications to Messrs. Cruikshank & Fairweather, 65 and 66, Chancery-lane, London, W.C.

"The Journal."—Part 201 of the "Journal" of the Institution of Electrical Engineers is now ready, price 5s. Particulars of contents are given in an advertisement.

"Indespenso Connectors."—A correspondent wishes to know the address of the manufacturers of "Indespenso porcelain connectors for electrical work." Will any reader please supply the information?

Japan-British Exhibition.—The accompanying photograph shows the General Electric Co.'s stand at the Japan-British Exhibition, the various features of which were described in last week's issue. It will be remembered that a great feature made is the utility of Osram



lamps for all purposes, while fans and other small electrical apparatus are shown on the market. The photograph clearly shows the various features of the stand, from the illuminated sign on the top to the artistic counter at the foot. The only thing left out are the interested onlookers, who seem to foregather round the General Electric Co.'s stand from every quarter of the Machinery Hall at all times of the day.

"Rugby" Metal Filament Lamps.—The Rugby Lamp Co., which has a modern factory at Rugby for the production of incandescent lamps, makes a speciality of metal filament and carbon filament lamps for all purposes.

Although the "Rugby" lamps have only been on the market for about two years, important contracts have been obtained from leading railways, tramways and steamship lines at home and abroad. Owing to the success of these lamps an extension of the factory has already become necessary. The selling agents for the "Rugby" lamps are Messrs. J. L. Cateaux & Co., 10, Bush-lane, London, E.C.; Taylor & Hutchinson, 23, Drury Buildings, Liverpool; and J. W. Maw, 40, Angel-street, Sheffield.

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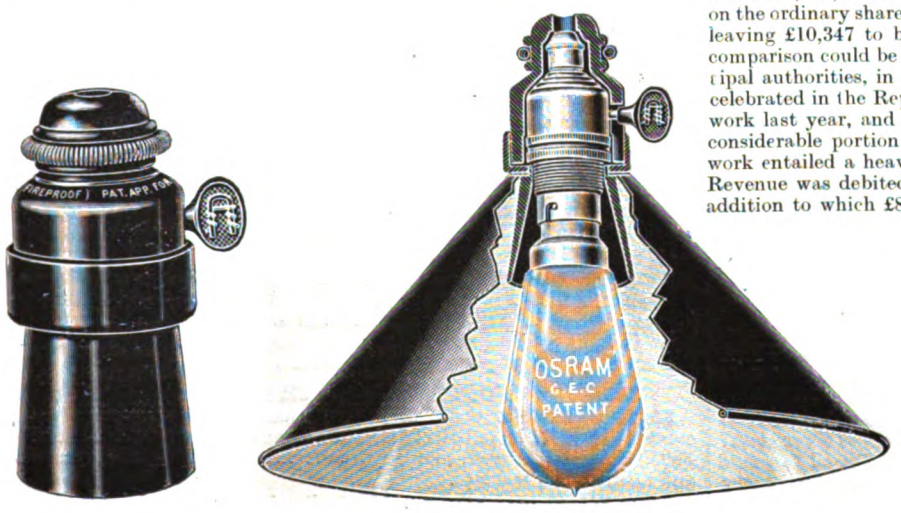
Tantalum Lamps.—Messrs. Siemens Bros. Dynamo Works, Tyssen-street, Dalston, N. E., have decided to reduce the price of tantalum lamps as from June 1, and copies of the revised list of prices are now available. The discounts, terms for contracts, &c., will remain exactly as hitherto, whilst the quality of the lamps will be, if anything, improved. The list will be supplied promptly in quantities to any contractor or electrical dealer for distribution amongst their clients.

A revised prices of tantalum lamps, showing full trade discounts, terms, &c., is issued by Messrs. Drake & Gorham, 66, Victoria-street, Westminster, London, S.W., and can be obtained on receipt of trade card.

Coates Patent Insulating Shield.—In connection with the Home Office regulations issued February, 1910 (Regs. 13 and 21), the General Electric Co. are placing on the market a new pattern of insulating shield, which is shown in the accompanying illustrations. When in position this shield entirely encloses all metal parts of the lamp-holder, and, at the same time, insulates the shade from the holder. The material employed is of a special nature, and after making tests, Mr. S. G. Castle Russell, M.I.E.E., states that these show that the material covering the holder is entirely satisfactory from a fire risk point of view. A novel and important feature is that the shield can be fitted without unwiring the holder, this operation being



simple and taking only a few seconds of time. The General Electric Co. will have ready in a few days a new price list illustrating and describing these shades.

CATALOGUES, &c.

"Freezor" Fans.—The General Electric Co. are sending out a small folder giving particulars of the special line of "Freezor" fans which they have just placed on the market. The company are willing to supply these folders in quantities to contractors and central station engineers and to print the name free of charge.

Oerlikon Fans and Ventilators.—We have received from the Maschinenfabrik Oerlikon (whose London office is Norfolk-street, Strand, W.C.) a publication dealing with this subject. Special points of the Oerlikon fans are that all parts are interchangeable, running is noiseless and current consumption is exceptionally low.

Ediswan Pendants and Electroliers.—The Edison & Swan United Electric Light Co. send us three fully illustrated leaflets dealing with this subject, and giving sufficient details as to price and design.

Electrical Fixtures.—Messrs. Falk, Stadelmann & Co.'s new catalogues deal fully with electrical fixtures supplied by them.

BANKRUPTCIES, LIQUIDATIONS, &c.

A dividend is to be paid to creditors of Robt. H. Walker, electrical engineer, &c., Elgin-road, and 16, Widemarsh-street, Hereford, and claims are to be sent by June 11 to Mr. M. J. G. Scobie, O.R.'s office, Hereford.

Wm. Hy. Trentham, consulting engineer, 39, Victoria-street, London, S.W., has been adjudicated bankrupt.

Meetings will be held at the office of Mr. A. R. Lancaster, Queen's College, Birmingham, on June 28, to receive accounts of the winding up of the Automobile Electric Lighting Synd. (Ltd.) and the Polkey Automobile Electric Lighting Synd. (Ltd.).

Mr. C. S. Beale, 72, Bishopsgate-street Within, London, E.C., has been appointed liquidator of the Typewriting Telegraph Corpn. (Ltd.)

The liquidator (Mr. H. de V. Brougham, 39, Carey-street, London, W.C.) of the British Power, Traction & Lighting Co. (Ltd.) has been released.

A first and final dividend of 10d. is payable at the O.R.'s, Station-road, Gloucester, to creditors of Walter S. Jenkinson, electrical engineer, Rodborough, near Stroud.

A dividend is to be declared under a deed of assignment executed by Wm. Hy. Alvey (trading as Alvey & Bower), electrical engineer, &c., Chesterfield. Claims by June 24 to Mr. S. E. Short, 17, Glumangate, Chesterfield.

COMPANIES' MEETINGS AND REPORTS.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—At the meeting on Wednesday the chairman (Mr. J. B. Concanon) said that during 1909 they had carried 223,823,792 passengers. The total receipts were £1,938,887 and the expenditure (including £50,000 carried to depreciation renewals fund) totalled £1,207,222, leaving a net profit of £731,665. After providing for fixed charges, dividends on both classes of preference shares, nine months' rent of the Metropolitan tramways, &c., the surplus was £140,972, from which had to be deducted the interim dividend paid on the ordinary shares and the further dividend which they recommended, leaving £10,347 to be carried forward. Owing to the fusion no useful comparison could be made with the previous year's working. The municipal authorities, in anticipation of the centenary which was now being celebrated in the Republic, undertook a large amount of street re-paving work last year, and they took advantage of the opportunity to relay a considerable portion of their lines on a deeper concrete base, and that work entailed a heavy expenditure under the head of permanent work. Revenue was debited under the head of maintenance with £207,486, in addition to which £83,648 was expended upon renewals. The profit in Buenos Ayres from Jan. 1 to April 30 last was £316,433, and they anticipated that the profits for the remainder of the year would be at least in the same proportion, or, say, £950,000 for the whole year. Deducting London expenses, and taking credit for sundry receipts, there would remain a surplus of £940,000. The City company annuity, interest and sinking fund on debentures, dividends and sinking fund on first and second preferences, &c., require £665,000, leaving £275,000 available for renewal funds, appropriation and dividends on ordinary shares. Some of them might feel surprised that, in view of the great success of their present system of surface lines, they should embark upon an enterprise which was somewhat novel and involved such a large expenditure of new capital. The whole of the £8,000,000 new debenture and share capital would not be required for the construction and equipment of the subways. The total cost of the subways and their equipment would not exceed £5,000,000, and the execution of the work would be spread over a considerable number of years. The last section could not be constructed before eight years. The directors came to the conclusion that it was absolutely necessary to provide for further development of the traffic in the suburbs by enabling the public to get quick and efficient access to the business centres, otherwise than by their surface lines, which indeed was becoming a physical impossibility. The municipal authorities met the company in a most enlightened spirit, the result being that the company had obtained the subway concession. From his personal knowledge of the city of Buenos Ayres he had no hesitation in saying that he considered the conditions for working combination services of surface and subway lines in Buenos Ayres were ideal. They anticipated that the working expenses of the subways would be only about 45 per cent. against about 60 per cent. as at present on the surface lines.

The report and accounts were adopted, and resolutions increasing the capital by £8,000,000 were agreed to.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—The accounts for 1909 show a gross profit of £22,528. 16s. 9d. After debiting general charges and maintenance, the net profit is £1,811. 12s. 11d. Debenture and other interest charges and bad and doubtful debts written off have absorbed £23,042. 6s. 4d., leaving a loss of £21,230. 13s. 5d. The conditions at the beginning of 1909 were unfavourable, and although the orders secured during the year showed a considerable improvement over the previous 12 months, it was not possible to make up for the shortage of invoicing during the earlier months. The directors' report states that the current year will benefit by the larger volume of unfinished work in hand at Dec. 31 last. Compared with 1908 a reduction of over £16,000 was effected in the general charges for the past year. The directors regret that the depression which has so long affected the engineering industries of the country still continues, and although there has been some improvement of late, the demand for steam and electrical machinery, as well as for rolling stock, is still far below the normal, and the great competition renders the prices obtainable for the most part unsatisfactory. There has, however, been an increased output from the works

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during the first five months of 1910, and it is hoped that this increase, coupled with the reduced working expenses, will lead to improved results. The directors report with satisfaction that the turbo generators manufactured by the company have gained a high reputation, and good orders are being received for plant of this description to work with live, mixed pressure, and exhaust steam. The company is interested in a variety of promising electrical and engineering developments.

DELAGOA BAY DEVELOPMENT CORPN. (LTD.)—At the meeting last week Mr. H. K. Heyland said the directors had been considering the question of acquiring the property of the Lourenco Marques Electric Light Co., which had declared a dividend of 2½ per cent. for 2 years. Their consulting engineers (Messrs. Mordey & Dawbarn) had reported that a considerable saving would result from the joint working of the two companies. For some time past the Board has felt that two electric power stations in Lourenco Marques was somewhat anomalous, and to bring both under one management must obviously result in a considerable saving in working costs. This economy would amount to £1,560 or £2,000 per annum. There was also a third power station in Lourenco Marques, owned by the Portuguese Government for working their railway shops and some cranes in the wharf. At present the Delagoa Bay Corpn. supplied a certain amount of power to the wharf, and they hoped eventually to be able to come to some agreement with the Government for the supply of all the power they required for their wharf and railway.

IMPERIAL TRAMWAYS CO. (LTD.)—At the meeting on Tuesday Sir. Geo. White said that the Middlesbrough, Stockton and Thornaby electric undertaking had suffered from want of full employment in the engineering and shipbuilding trades, and also from weather conditions. No dividend had been received on their principal investment (44,446 5 per cent. cumulative preference shares of £10 each) in the London United Tramways, and the arrears of dividend amounted to £27,778. For the 16 years during which the directors had had the management of the Imperial Tramways not only had the preference dividend been punctually paid, but the ordinary share dividends had averaged 10 per cent. in cash. From what the chairman of the London United Co. said in his recent speech, it was evident that whatever profit over and above their debenture interest was earned during the present year would be kept for renewals and reserve, and the Imperial Co. was therefore unlikely to be in receipt of sufficient income to pay the preference and ordinary dividend during 1910. The London United undertaking was undoubtedly a valuable property, and even in its present unfavourable position, with competition raging all round, it carried between 50,000,000 and 60,000,000 passengers a year, had a gross income of well above £300,000 and a net revenue of between £90,000 and £100,000 a year.

MIRRLEES, BICKERTON & DAY (LTD.)—We learn that at the recent meeting (at the works, Hazel-grove) the chairman (Mr. A. F. Baird) moved the adoption of the report, which showed profits available for disposal amounting to £5,577. 11s. 1d. The directors recommended that £4,000 be applied in paying a dividend at the rate of 5 per cent., £1,000 be placed to reserve, and the balance (£577. 11s. 1d.) carried forward. Mr. Baird pointed out that the works and equipment were now completed and in good working order, and that experience had proved they could produce, at a profit, Diesel engines which are exceedingly satisfactory. During the year important agencies have been established in foreign countries, and the company had supplied engines to China, Japan, India, Java, Bulgaria, the West Indies and other parts of the world. The discoveries of oil and starting up of new oil companies in many parts of the world would doubtless have a beneficial effect on their business. Under the auspices of the Argentine Government the company had on exhibit one of their engines at the exhibition in Buenos Ayres.

MONTEREY RAILWAY, LIGHT & POWER CO.—At the recent meeting it was reported that the Company now operates about 25½ miles of line, which is fully equipped with modern electrical plant and rolling stock. The company purchased all the capital stock of the Monterey Light and Power Co. in 1908, prior to which the directors had been negotiating with the Government for a concession to enable the company to do an electricity supply and gas business in and about the City of Monterey. During 1909 the negotiations resulted in the company getting a new concession for 99 years, from March 10, 1905, for an electric lighting, power and gas service in the city on satisfactory terms. The intention is to amalgamate the power plants of the Railway Co. and the Light and Power Co.

POTTERIES ELECTRIC TRACTION CO. (LTD.)—Mr. G. F. M. Cornwallis-West stated at the meeting last week that the company's increased balance (£4,830) was entirely due to lessened working expenses. Power, running and parcels expenses had been reduced by £1,023, repairs and maintenance by £2,876 and administration and general expenses by £1,236. The traffic receipts showed a decrease of £400. The parcels business formed quite a useful profit-earning adjunct, and year by year showed healthy growth. They had tried the "fair fare" system, but it had not yet been in operation for a sufficient length of time to test its increased earning capabilities.

SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)—The chairman (Sir Alfred Dent, K.C.M.G.) stated at the meeting last week that there had been an increase both in gross and net receipts, but those had been more than absorbed in expenses, and the result was a loss of £949. The loss in exchanges alone accounted for £13,341, besides which they had paid to the council £2,774 as royalty and a substantial sum for the maintenance of the public roads.

TYPEWRITING TELEGRAPH CORPN. (LTD.).—At the meeting on Friday last the chairman (Mr. A. J. Parker) moved an extraordinary resolution that, by reason of its liabilities, the company should be wound up. He said they had a machine which was an exceedingly good one, but the Government had unfortunately refused to take it up. They had now no customers to go to, either in England or abroad, and the bulk of their foreign patents had run out. Although they had tried every source, they were unable to sell their machines. The resolution was carried.

WINNIPEG ELECTRIC RAILWAY CO. (LTD.)—The net earnings for 1909, after providing for operating expenses, Municipal Council's proportion of earnings, &c., amounted to $863,405, out of which the directors declared four quarterly dividends ($600,000), leaving $263,405, which, with amount brought forward, made $861,430. The company's hydraulic works at Pinawa Channel were very satisfactory up to Nov. 23, when one of the penstocks burst, causing the closing down of the whole plant for six days. While the hydraulic plant was closed down a partial service was maintained by the steam plant. During the year nearly 5 miles of track was laid and 30 double-truck closed cars were constructed and put into service. In connection with the electric lighting and power-distribution system 749 new poles were erected and 120,141 lb. of wire, with 129 transformers, put up, in extension of the company's lighting and power-distribution system.

NEW COMPANIES, STATUTORY RETURNS MORTGAGES AND CHARGES.

NEW COMPANY.

TRANSIT CO. (LTD.) (109,799.)—Reg. May 24, capital £2,000 in £1 shares, to construct or acquire any tramways or light railways in United Kingdom, to carry passengers and goods, &c. Private company. Reg. office, Atherton, Lancs.

STATUTORY RETURNS.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—Return to March 1 capital is £300,000 in 40,000 ordinary and 20,000 preference shares of £5 each. All shares taken up. £298,250 paid on 39,650 ordinary and 20,000 preference. £1,750 considered as paid on 350 ordinary. Mortgages and charges, £150,000 3½ per cent. debenture stock and £205,472 4 per cent. guaranteed stock of Central Electric Supply Co.

SIMPLEX CONDUITS (LTD.)—Return to March 24 gives capital as £100,000 in 10,000 preference shares of £5 each and 50,000 ordinary shares of £1 each. 10,000 preference and 40,000 ordinary shares taken up. £50,000 paid on the preference. £40,000 considered as paid on the ordinary. Mortgages and charges, nil.

MORTGAGES AND CHARGES.

BALCHIN, SCHULZ & CO. (LTD.)—Particulars of £1,000 debentures, created May 13, have been filed, the amount of present issue being £500. Property charged, company's undertaking and property, present and future. No trustees.

HOWE ELECTRICAL ENG. CO. (LTD.)—Particulars of £500 debentures, created by resolutions of May 13 and 19, have been filed, whole amount being now issued. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

RECEIVERSHIP.

B. JOHNSON & SON (LTD.)—Notice of the appointment of T. Coombs, King-street, Leeds, as receiver and manager, on May 21, has been filed.

CITY NOTES.

MEMORANDA (June 2).—**Bank rate 3½ per cent.** (since June 2, 1910). **Price of silver,** 24⅝d. per oz. Consols 82⅝—82⅞ for money; 82⅝—82⅞ for account. Consols Pay Day, July 1; Stock and Shares Continuation Days, June 8 and 27; Ticket Days, June 9 and 28; Pay Days, June 10 and 29; Mining Shares Carry Over Day, June 7.

PRICES OF METALS (London).—*Copper*, cash, 56⅞; three months, 57⅜. *Lead*, English, 12¾—13¼; foreign, 12⅜—12⅝. *Spelter*, 22⅜—22½. *Tin*, English, 148—150; foreign cash, 149; three months, 150¾. *Iron*, Cleveland, cash, 49/6½, three months, 50/6.

MACKAY COMPANIES.—The regular quarterly dividend of 1 per cent. on the preferred shares and the regular quarterly dividend of 1¼ per cent. on the common shares in the Mackay Companies will be paid on July 1. The transfer books will not be closed.

ROBERTSON ELECTRIC LAMPS (LIMITED & REDUCED).—A petition has been presented to the High Court for the confirmation of a resolution reducing the capital of this company from £100,000 to £35,000.

SIEMENS BROS. & CO. (LTD.)—The directors announce a dividend of 4 per cent. (4s. per share) for the past year, allocating £23,600 for repairs to c.s. "Faraday," and carrying forward £3,689 to the pension fund.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted a quotation to a further issue of £23,500 5 per cent. mortgages of the *North Metropolitan Electric Power Supply Co.* The committee have been asked to grant quotations to £1,000,000 4½ per cent. first and general mortgage 30-year bonds (issued in Amsterdam) of the *New York Telephone Co.* and a further issue of £28,213 4½ per cent. first mortgage debenture stock of the *Rangoon Electric Tramways & Supply Co. (Ltd.)*

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	May 20	239	+ 14	20	4,340	+ 98
Anglo-Argentine	" 27	51,381	+ 11,847	21	927,883	+ 99,916
Ayr Corporation	" 28	279	+ 40	2	520	+ 6
Baker St. & Waterloo Ry.	" 28	3,230	— 90	21	72,125	+ 2,015
Barnsley	" 20	204	+ 39	20	3,444	+ 168
Barrow	" 20	367	+ 155	20	4,721	+ 603
Bath Electric Trams, Ltd.	" 25	1,071	+ 226	21	15,642	+ 1,532
Birmingham Corporation	" 28	6,546	— 205	8	56,179	+ 416
Birmingham & Midland	" 13	801	— 22	19	15,382	+ 257
Blackburn Corporation	" 25	1,239	+ 108	‡9	9,637	— 509
Blackpool and Fleetwood	" 28	750	+ 290	..	..	..
Bolton Corporation	" 29	2,303	+ 8	9	19,681	— 1,156
Bombay	April 28	2,787	+ 318	17	46,873	+ 3,268
Bournemouth Corporation	May 25	1,706	+ 185	8	12,991	— 419
Bradford Corporation	" 28	5,111	+ 277	9	41,963	+ 722
Brighton Corporation	" 29	915	— 59	§8	7,545	— 341
Bristol Trams & Carriage	" 27	6,129	+ 635	21	118,241	+ 13,287
Burnley Corporation	" 28	1,208	— 46	21	26,725	+ 842
Burton Corporation	" 29	248	— 32	8	2,203	— 10
Bury Corporation	" 29	1,233	+ 76	§8	9,875	— 462
Calcutta Tramways Co.	" 28	R49,056	+ R942	21	R1,089,306	+ R37,298
Camborne-Redruth	" 28	142	+ 10	21	2,541	+ 3
Cardiff Corporation	" 21	3,636	+ 519	8	15,873	— 115
Cavehill	" 20	159	+ 70	20	1,539	+ 166
Central London Railway	" 28	6,058	+ 275	21	117,913	+ 2,220
Charing C., Euston & H'stead	" 28	3,820	— 190	21	81,155	+ 130
Chatham & Dist. Lt. Rys.	" 26	980	+ 121	21	16,488	+ 936
City & South London Rly.	" 29	2,959	— 203	21	68,331	— 157
City of Birmingham	" 20	3,563	+ 791	20	56,990	+ 3,478
Colchester Corporation	" 25	190	+ 14	21	3,512	+ 564
Cork Electric Trams Co.	" 26	612	+ 114	21	9,542	+ 1,603
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	" 20	512	+ 160	20	8,153	+ 921
Dover Corporation	" 28	192	— 15	8	1,619	— 28
Dublin & Lucan Railway	" 27	153	+ 16	21	2,592	+ 92
Dublin United	" 27	6,243	+ 533	21	109,325	+ 4,556
Dudley-Stourbridge	" 20	1,353	+ 567	20	14,701	+ 2
Dundee Corporation *	" 25	1,264	+ 41	§1	1,753	+ 63
East Ham Council	" 28	1,025	+ 9	¶18	8,557	+ 170
Exeter Corporation	" 27	323	— 242	8	2,534	— 344
Gateshead & Dist. Trams	" 20	1,048	+ 81	20	19,114	— 222
Glasgow Corporation	" 28	18,803	+ 1,003	‡52	886,940	+ 6,010
Glossop Trams	" 28	125	+ 10	21	2,341	— 109
Gloucester Corpn.	" 25	330	+ 43	8	2,222	+ 110
Gravesend-Northfleet	" 20	297	+ 100	20	3,857	+ 189
Great Northern & City Rly.	" 28	1,357	— 29	21	31,263	— 442
Gt. Northern, Piccadilly, &c.	" 28	5,665	— 125	21	127,455	+ 5,905
Greenock & Port Glasgow	" 20	754	+ 155	20	11,136	+ 1,507
Hartlepool Tramways	" 20	303	+ 75	20	4,295	+ 254
Hastings Elec. Trams Co.	" 26	1,047	+ 93	21	17,775	+ 747
Hong Kong	" 28	$9,043	+ $1,380	21	$181,499	+ $17,489
Huddersfield Corpn.	" 28	1,660	+ 31	8	14,508	+ 846
Hull Corporation	" 28	2,587	+ 14	8	22,052	+ 1,034
Ilford District Council	" 28	537	+ 23	8	4,374	+ 186
Ilkeston District Council	" 25	138	+ 3	8	997	— 39
Ipswich Corporation	" 28	381	— 10	8	3,173	+ 122
Isle of Thanet Co.	" 28	487	— 54	¶33	11,202	+ 429
Jarrow	" 20	166	+ 54	20	2,288	+ 160
Keighley Corporation	" 26	189	+ 12	8	1,401	+ 49
Kidderminster & District	" 20	244	+ 152	20	1,881	+ 175
Kilmarnock Corporation	" 28	141	— 6	2	292	— 12
Lanarkshire Trams Co.	" 26	1,549	+ 311	21	28,370	+ 3,114
Lancashire United	" 25	1,773	+ 466	21	26,458	+ 463
**Leamington*	" 20	250	+ 96	20	2,962	..
Leeds Corporation	" 28	6,968	+ 183	8	58,144	+ 3,194
Leicester Corporation	" 28	2,238	— 162	..	..	..
Leith Corporation	" 28	649	+ 74	2	1,187	— 13
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	..	..	..	..	..	..
Liverpool Overhead Rly.	" 29	1,390	+ 54	22	29,355	+ 789
Llandudno&ColwynBayRy.	" 27	307	+ 112	§25	4,125	+ 476
**London County* Council	..	..	..	..	..	..
London United	" 28	7,334	+ 439	21	125,617	+ 10,216
Lowestoft	" 28	168	— 45	35	5,237	+ 341
Maidstone Corporation	" 28	163	— 19	18	1,371	— 142
Manchester Corporation	" 28	16,204	+ 1,093	8	126,670	+ 2,276
Mersey Railway	" 28	2,003	+ 3	21	42,474	+ 1,099
Merthyr	" 20	316	+ 104	20	3,926	— 127
Metropolitan Dist. Railway	" 28	10,767	+ 457	21	229,021	+ 22,977
Metropolitan Elec. Trams	" 20	11,369	+ 5,182	20	140,791	+ 28,444
Middleton	" 20	426	+ 89	20	5,721	— 464
Nelson Corporation	" 28	139	+ 4	§8	1,182	— 16
Newcastle-on-Tyne Corp.	" 28	3,749	— 177	¶8	31,359	— 1,628
Newport (Mon.)	" 28	657	+ 1	9	6,103	+ 274
Northampton Corporation	" 26	485	— 13	7	3,975	+ 8
Oldham, Ashton & Hyde	" 20	676	+ 139	20	10,699	— 55
Oldham Corporation	" 29	1,848	— 93	9	17,366	— 1,102
Perth (N.B.) Corporation	" 25	181	+ 22	§1	246	+ 21
Perth (W.A.) Elec. Trams	" 27	1,496	+ 142	21	32,939	+ 2,492
Peterborough	" 20	190	+ 81	20	2,093	+ 49
Portsmouth Corporation	" 28	2,073	+ 79	8	15,760	— 821
Potteries	" 20	2,031	+ 200	20	34,688	— 21
Preston Corporation	" 25	737	— 20	..	..	..
Rotherham Corporation	" 26	600	+ 5	8	4,959	+ 99
Rothesay	" 20	165	— 34	20	1,585	— 70
Salford Corporation	" 30	4,431	— 158	†9	39,405	— 351
Sheerness	" 20	57	+ 11	20	864	— 5
Sheffield Corporation	" 29	5,711	— 49	¶9	55,614	+ 3,461
Singapore Trams	" 28	$9,270	+ $237	21	$209,332	+ $5,203
South Metropolitan	" 20	1,349	+ 571	20	15,293	+ 1,219
South Staffs	" 20	1,216	+ 416	20	16,414	+ 275
Southend Corporation	" 25	578	+ 135	8	3,831	+ 373
Southport Tramways	" 20	522	+ 236	20	5,132	+ 310
Stalyb'dge, Hyde, &c., Jt. Bd.	" 28	792	+ 75	¶8	5,802	— 783
Sunderland Corporation	" 29	1,089	— 113	9	9,160	— 379
Sunderland District	" 25	426	— 23	30	12,396	— 836
Swansea Trams	" 20	1,446	+ 560	20	20,165	+ 2,567
Swindon Corporation	" 25	152	+ 15	..	..	..
Taunton	" 20	53	+ 19	20	803	+ 111
Tynemouth and District	" 20	446	+ 247	20	3,412	+ 477
Tyneside Trams Co.	" 25	466	+ 33	21	8,224	— 180
Wallasey District Council	" 28	905	— 20	§8	7,459	— 349
Walsall Corporation	" 28	494	— 15	21	11,231	+ 733
Warrington Corporation	..	..	..	..	..	..
West Ham Corporation	" 19	3,085	+ 837	7	16,905	— 436
Weston-super-Mare	" 20	347	+ 243	20	1,200	+ 158
Wolverhampton Co.	" 20	689	+ 300	20	8,286	+ 433
Wolverhampton Corpn.	" 25	901	+ 108	8	7,256	+ 925
Worcester	" 20	433	+ 172	20	5,061	+ 191
Wrexham	" 20	141	+ 49	20	1,897	+ 50
Yorkshire W.R. Trams	" 29	1,141	— 134	22	27,049	..
Yorkshire Woollen District	" 20	1,326	+ 397	20	19,156	+ 2,113

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	NAME.	Price Wed., June 1	Rate per cent. Yielded.	Dividend Due.	Business Week to June 1 Highest	Business Week to June 1 Lowest
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9½	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9¾	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 15 0	Feb, Aug	10⅜	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼—7¾	6 9 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.	7¼—7¾	4 13 0	Mar, Sept	..	..
St.	4%	†Central Elec. Sup. Co. 4% Guar. Deb. Stock	98 —101	3 19 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾—4¼	5 18 6	Feb, Aug	3 11/32	..
5	2/3	Do. 4½ per Cent. Pref.	4⅜—4⅝	4 17 6	Feb., Aug	4 7/16	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —100	4 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101½—103½	4 7 0	..	102½	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅞—4⅜	5 3 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅞—4¼	5 9 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11¼—11¾	5 19 0	Feb, Aug	11⅝	11½
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	12½	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 —103	4 7 6	Jan, July	102	..
5	..	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7½—8	6 0 0	Feb, Aug	7 7/32	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞—11⅜	5 5 0	Mar, Sept	11⅛	11 1/16
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	105 —108	4 3 6	Jan, July	106¼	106
St.	4½%	Do. Second Deb. Stock	98 —101	4 9 0	May, Nov	100¼	98½
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4¾	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord	6¾—7¼	5 10 6	Feb, Aug	6 31/32	6¾
5	6%	Do. 6 per Cent. 1st Pref	5⅞—6⅜	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94½—96½	4 3 6	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —99	4 1 0	April, Oct	98½	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2⅜	London Electric Supply Ord.	1⅝—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4¾—5¼	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	92 —94	4 4 0	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	3½—4	5 9 0	April, Oct	3 11/16	3⅝
5	2/3	Do. 4½ per Cent. Cum. Pref.	4½—4⅞	4 12 6	Jan, July	4 11/16	4 9/16
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	—
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	97 —99	4 11 0	June, Dec	..	..
5	4/0	Newcastle Elec. Supply Ord.	4⅛—4⅝	4 7 6	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4⅞	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	100½	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	99 —101	4 19 0	..	..	..
10	9/0	Notting Hill Electric Ord.	11¾—12¾	5 17 6	March	..	..
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8¼—8¾	5 14 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6⅞—7⅜	4 15 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	86 —88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¾—3¼	6 11 0	April	3 1/16	..
St.	5%	Do. 5 % 1st Mort. Stock (red.)	101 —104	4 16 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	¼—½	..	..	..	..
1	0/8⅝	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	½—1	..	April, Oct	..½	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..½	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8⅛—8⅝	5 14 6	Mar, Sept	8 7/16	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	5 11/32	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	96½	..
1	..	Bath Elec. Trams Pref. Ord.	¼—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	6 13 6	Jan, July	¾	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	83 —86	5 5 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6½—7	8 11 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7½—8	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¾ —1¼	..	June, Dec	⅞	..
10	3%	Do. 6 per Cent. Cum. Pref.	3⅛—3⅝	8 5 6	Feb, Aug	3 5/16	3½
St.	5%	Do. 5 Cent. Perpetual Debs.	90 —93	5 7 6	April, Oct	92	91
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	66 —71	6 7 0	May, Nov	69¾	..
St.	3%	Central London Ordinary Stock	71 —73	5 3 6	Feb, Aug	71½	71⅛
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	86½	..
St.	2%	Do. Deferred Stock	53 —55	3 12 0	Feb.	—	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb. Stk.	96 —98	4 2 0	Jan, July	97	96¼
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4½—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	33 —34	3 12 0	Feb, Aug	33½	33
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	103½	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	102½	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	98 —100	4 0 0	May, Nov	99½	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 —98	4 2 0	Jan, July	96½	96
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1½	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	70 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	15/16—1 1/16	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9¾—10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan, July	..	..
10	..	London United Trams, 5% Cum. Pref.	2¼—2¾	..	Jan, July	2¼	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	68 —72	5 11 0	Jan, July	69	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	21/32—25/32	..	..	..	..
1	..	Do. Deferred	1/16—⅛	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	23/32—27/32	5 11 6	Feb, Aug	25/32	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 —100	5 0 0	Jan, July	..	..
St.	1%	Metropolitan Railway Consolidated	42¾—43¼	2 5 6	Feb, Aug	44⅛	42¾
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	89½	..
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	93½	93

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Wed., June 1	Rate per cent. Yielded.	Dividend Due.	Business Week to June 1. High-est.	Business Week to June 1. Low-est.
		Electric Railways and Tramways—*Continued.*	£ s. d.				
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	91 —93	3 15 0	Jan, July	93½	..
St.	..	Metropolitan District Railway Ord.....	23¼—24	.. ..	Feb, Aug	24½	23½
St.	..	Do. Extension Pref. (5 per Cent.).....	70 —72	.. ..	Feb, Aug	71½	70½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	..	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	76½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —102	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.....	102 —104	3 17 0	Mar, Sept	103½	102
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	142 —144	4 3 3	Jan, July	143½	143
St.	4%	Do. 4 per Cent. Ditto.....	96 —98	4 1 0	Jan, July	97½	96½
1	4½	†Potteries Electric Traction Ord.	½—¾	.. ..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	½—¾	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	..	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	½—¾	.. ..		..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	67 —71	5 12 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	58 —63	7 18 0	Jan, July	58½	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoupo	38 —40	.. ..	June, Dec	39½	38
..	5%	Do. 5% Prior Lien Bonds.....	100½—101½	4 18 6	..	101½	..
..	4½%	Do. 4½% Bonds with coup. 5	89 —91	4 19 0	..	90½	90
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	97 —99	4 1 0	..	99	97½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	½—¾	.. ..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2½	.. ..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	79 —82	5 10 0	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101½—103½	4 7 6	..	..	..
1	..	Aron Electricity Meter Ord.....	¼—½	.. ..	..	½	..
1	7½d.	Do. 6% Cum. Pf.	½—¾	6 8 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.....	5¼—5¾	5 15 9	April, Oct	5½	5½
1	0/7½	Do Pref.....	1¼—1¾	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7	7 3 0	July, Feb	6½	..
5	3/0	Do. 6 per Cent. Pref.....	5½—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	¾—⅞	.. ..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	98 —100	6 0 0	..	99½	99½
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	59 —62	3 4 6	Jan, July	..	..
St.	4½%	BrushE. Eng. Co. 4½% Perp. 1st Deb. Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	25 —29	15 10 0	Jan, July	..	..
5	10/0	†Callender's Cable Con. Ord.....	9½—10½	6 8 0	Jan, July	9½	9½
5	2/6	Do. 5 per Cent. Cum. Pref.....	5 —5½	4 13 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	102½—104½	4 6 0	Nov, May	..	..
1	1/3	†Castner-Kellner Alkali Co.....	2⅛—2½	5 7 6	May, Nov	2⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	106 —109	4 3 6	Feb. Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	½—¾	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	½—1	7 0 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	½—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	½—¾	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	½—1½	.. ..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	⅛—1⅛	5 0 0	Sept	⅛	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	⅛—1½	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—¼	.. ..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1½	9 3 0	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	68½	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅛—¼	.. ..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1½	.. ..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)..	71 —77	5 16 6	June, Dec	..	..
2	..	Electric Construction Co.....	½—¾	.. ..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1⅛—1⅜	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	61 —66	6 1 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref..	7½—8½	6 1 6	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11½—12½	6 6 6	Feb, Aug	12½	11½
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 3 9	Feb, Aug	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. Stock	103 —105	4 6 0	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Works....	14½—15½	6 9 0	Feb, Aug	..	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10½—10¾	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	..	..
1	..	National Elec. Construction Co.	½—¾	.. ..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	.. ..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—½	.. ..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	.. ..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	.. ..	..	..	..
12	30/0	Telegraph Construction & Maintenance..	32½—34½	5 17 0	Mar, July	34½	33
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100½—102½	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 11 0	..	2⅛	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1⅜	4 4 3	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	103 —111	4 10 0	..	110½	108
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	101 —103	3 7 6	June, Dec	106	101½
100	4½%	†Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	103 —105	4 16 0	..	..	..
10	8%	J. G. White & Co. 6% Cum. Pref	9½—10½	7 12 0	..	..	..
1	..	Willans & Robinson Ord.....	½—¾	.. ..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1½—2	11 5 0	Apr, Oct	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3½—3¾	.. ..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100 —102	4 18 0	June, Dec	..	..
St.	15/0	Anglo-American	64 —66	5 11 0	F,My,Ag,N	65	..
St.	30/0	Do. Preferred	104 —106	5 14 6	F,My,Ag,N	106½	105
St.	25/0	Do. Deferred	26½—26¾	4 15 0	F,My,Ag,N	26¼	26
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	85½—87½	4 11 6	Jn,Ap,Jy,O	86	..
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 12 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3½—3¾	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable.....	14 —14½	5 17 0	Ja,Ap,Jy,O	14¼	13½
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.).	100 —102	4 18 0	June, Dec	..	..
St.	65/0	Eastern Ordinary	133 —136	5 3 6	Ja,My,Jy,O	135	133½
St.	17/6	†Do. 3½ per Cent. Pref. Stock.....	85 —87	4 0 6	Ja,My,Jy,O	85½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	101 —103	3 17 6	May, Nov	..	..
St.	6/6	Eastern Extension	12½—13½	5 7 6	Ja, Ap, Jy, O	13	12½
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	9½—10½	3 18 6	May, Nov	..	..
10	26/0	G.N (of Copenhagen), with Coupon 79 ..	30½—31½	6 0 0	Jan, July	30½	..
100	4½%	Halifax & Bermuda 4½% 1st Mt.Db.(red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	54½	..
100	5%	Mackay Companies Common	90 —93	4 16 6	Ja,Ap,Jy,O	..	..
100	4%	Do. Preference	77 —80	5 0 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	½—¾	.. ..	April	¾	½
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	98½—100½	3 19 6	June, Dec	..	..
2½	1/3	West Coast of America	1⅜—1½	4 1 6	May	1⅜	..
100	4%	Do. 4 per Cent. Debs.	98½—100½	3 19 6	Jan, July	..	..
10	..	West India & Panama	½—¾	.. ..	May, Nov	¾	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9½	6 11 3	May, Nov	..	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	100½—102½	4 17 6	Jan, July	..	..
10	3/0	Western Telegraph Co. Ltd.	13½—14½	4 18 0	Mr,Jn,O,D	14¼	13½
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	101 —103	3 17 6	June, Dec	..	..
—	4%	Western Union Telegraph Co. Bds.	101 —101½	3 16 6	—	—	—
		Telephones.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	140 —142	5 12 6	..	..	..
St.	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	103 —105	3 15 6	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
5	3/0	Chili Telephone	7½—8¼	4 15 9	August ..	7¾	..
1	0/7½	Monte Video Telephone Ord.....	½—1	7 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	½—¾	5 14 6	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	104½—105	5 14 6	Feb, Aug	105½	104½
St.	6%	Do. Def. Stock	124 —126	4 15 0	Feb, Aug	124½	124
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 10 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 10 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref....	5½—5¾	4 11 0	Feb, Aug	5½	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.).....	97 —99	3 11 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 —102	3 18 0	Jan, July	100½	..
	4½%	New York Telephone Co. 30 yr. Bnds.....	97½—98½	4 11 6	..	99½	97½
1	1/0	Oriental	1⅛—1⅜	4 15 0	April, Oct	1½	1½
1	0/7½	Do 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock.....	88 —90	4 9 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	100½—102½	4 8 6	Jan, July	..	..
5	3/0	United River Plate.....	7½—7¾	5 9 0	July	7¾	7½
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 12 3	June, Dec	5⅜	..
St.	4½%	Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan. July	104½	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2½—3½	8 18 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10½—10¾	5 11 6	Sp,DcMrJu	10½	10½
10	3/0	Do. 6 per Cent. Pref.	13 —13½	4 8 9	Sp,DcMrJu	13½	13½
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4½—4¾	5 5 0	April, Oct	4¾	4½
5	2/6	Do. 5% Cum. 2nd Pref.....	4½—4⅝	5 11 0	Jan, July	4½	4½
5	4/0	Do. 4% Deb. Stock	90½—92	4 7 0	June, Dec	91½	90½
St.	4%	Do. 4½% Deb. Stock	96 —98	4 12 0	..	97½	95½
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)....	105 —107	4 13 6	Jan, July	..	..
St.	4/6	Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 13 9	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.....	101 —103	4 6 6	Jan, July	102	..
St.	8%	British Columbia El.. Rly. Df. Ord.	142 —147	5 9 0	Mar, Sept	..	..
St.	6%	Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	124½	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock.....	109 —112	4 9 6	Jan, July	111	110
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
100	4½%	Do. 4½% Perp. Con. Deb. St.	104 —105	3 19 0	..	105½	104½
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	99½	99
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	..	..
5	2/6	Calcutta Tramways (1 to 137,610).....	4½—4¾	4 4 3	Mar, Sept	4½	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	..	..
5	4%	Do. 4½% 1st Deb. Stock (red).....	98 —101	4 9 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	½—¾	.. ..	..	..	..
1	3/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 9 6	F,My,A,N	5⅜	5⅛
St.	4%	Do. 4 per Cent. Deb. Stock.....	94 —101	3 19 0	June, Dec	..	..
5	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	94 —97	5 2 6	May, Nov	95½	..
100	5%	†Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	78 —81	6 3 6	June, Dec	..	..
5	1%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	96 —99	5 1 0	Feb, Aug	97½	..
..	..	Kalgoorlie Elec. Trams Sh.	⅛—⅜	.. ..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock.....	96 —98	5 2 0	Jan, July	..	..
100	5%	Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	76	75
5	3/7½	Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
100	5%	Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
100	5%	Manaos Trams and Lt. Co. 5% Debs.	88½—90	.. ..	..	89½	88½
5	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	95 —97	5 2 6	Feb, Aug	..	..
100	5%	Mexico Trams Co. Com. St.	128½—130½	4 17 6	..	129	..
100	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	97 —98	5 1 6	..	97½	96½
100	6%	Do. 6% 50 yr. Mort. Bds.....	100 —101	5 19 0	..	100½	100
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	..
100	5%	Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	101½	..
1	0/6	Perth Elec. Trams Ord.	½—¾	5 14 0	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5½—5¾	5 2 6	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	98	96½
100	$1	Rio Janeiro Tram, Lt. & P. Co.....	96½—98½	4 1 0	..	99½	98½
100	5%	Do. 30 yr. Gold Bnds.	98½—99½	5 0 9	..	98½	97½
100	5%	Do. 50 yr. Mt. Bnds	87½—88½	5 13 0	..	88½	87½
100	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	149 —151	6 13 6	..	150½	149½
100	5%	†Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 6	June, Dec	104½	104
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5½—5¾	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.....	10½—11	5 9 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red).....	95 —97	4 12 6	Jan, July	96½	..
5	4/9	Do. 5 per Cent. 2nd Mort. Deb. Stock..	96 —98	4 18 0	..	..	..
100	5%	†Calcutta Elec. Supply Ord.	6 —7	5 14 0	April, Oct	6½	6½
100	$3½	Canadian Gen. Elec. Co. Com. St.....	107 —111	6 6 0	..	111	108½
100	5%	Do. 7% Cm. Pf. Stock	118 —121	5 15 6	..	120½	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
500	5%	Elect. Development Co. of Ontario.....	82½—85½	5 15 6	..	84½	83½
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—1¾	.. ..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	.. ..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅛—¼	8 0 0	April, Oct	⅜	⅛
135	5%	Kaministiquia Power Co.5% Gold Bnds..	102 —104	4 16 6	..	..	..
100	$1	Madras E. S. Corp. Ord.....	2½—3½	.. ..	..	..	..
St.	5%	Melbourne E. S. Co. 6%Cum. Pref.....	33 —38	.. ..	..	..	..
500	5%	Do. 5% 1st Mortg. Deb. Stock.....	92 —94	5 6 9	..	93½	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84½—85½	5 17 3	..	85½	34½
30½	$1	Mexican Lt. & Power Co. Com. St.	78 —80	5 0 0	..	80	79½
St.	$3½	Do. 7% Cum. Pref. St.	103 —105	6 13 6	..	104½	103½
500	5%	Do. 5% 1st Mort. Gold Bnds.	89½—90½	5 12 0	..	89½	89½
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	135 —139	4 16 6	F,My,A,N	136½	..
1	1/2½	River Plate Electricity Co. Ord.	2⅛—2⅜	5 12 9	April	2⅜	2⅛
1	1/2½	Do. 6 per Cent. non-Cum. Pref.	1⅝—1¾	4 17 0	May	..	..
5	3/0	Do. 5 per Cent. Deb. Stock	103 —105	4 15 6	Jan, July	..	..
5	3/0	Rosario Ele . Co. Ord.	8½—9	.. ..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
5	3/0	Do 2nd Pref.	8½—8¾	6 14 6	..	..	..
100	$1	Shawinigan, Water& Power Co.Ca.	101 —103	4 8 6	..	..	..
100	5%	Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	108½	108
100	5%	†Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	103½	103
100	4½%	Toronto Power Co. 4½% Db. St.	100 —102	4 6 6	..	..	..
100	5%	Victoria Falls Power Co. Pref.(1 to 808,000)	½—¾	5 6 6	Jan, July	..	..
		Do. (803,081 to 1,700,000)	½—¾	.. ..	..	..	..

* In calculating the yield allowance is made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,673. [No. 9. Vol. LXV.] FRIDAY, JUNE 10, 1910. PRICE ONE SHILLING (by post, 1s. 0½d.), Abroad extra.

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NOTES.

Free Trade or Protection for the Electrical Industry.

THE conclusion of the debate inaugurated by the National Electrical Manufacturers' Association was distinctly more interesting than the opening thereof, and more than ever demonstrated the fact that there is much to be said on both sides. Unfortunately, it demonstrated also the impossibility of proving either case satisfactorily. There is too much that is uncertain and too much about which an argument can be woven in either direction. It is this that has given rise to much of the complexity, and probably holds people back on both sides. Considering that the effect of Protection cannot be absolutely proved, there is a very natural tendency on the part of many people to feel that its introduction might not produce the results hoped for by its advocates; a feeling that at least we know where we are with Free Trade, and that "bad one knows is better than bad one doesn't know."

IN regard to the question of efficiency, so strongly urged by Mr. KINGSBURY, the position of the boot industry is strong evidence of the undesirability of protecting an industry that is in a bad state. We believe that the milling industry is another example of the same kind, in which the highest possible efficiency has been brought about by necessity, and the result in the end has been satisfactory. Another point is the general good of the country. In our recent comments on this subject we seem to have misunderstood Mr. KINGSBURY on this item. It is not a question of the electrical industry on the one side and the general good on the other, but whether, if the general good suffers, the electrical industry will not suffer still more. In discussions of this kind much depends upon definition. People speak in a general way about raw materials "which would not be increased in cost," but they do not define what they mean by raw material. Thus, wire is raw material unless the man who buys it is equally prepared to draw copper. Similarly, prosperity is a term which often requires definition. If the electrical industry could be protected by itself, then we do not suppose there is any question that it would reap a benefit, but the case is not so clear when every other industry is to be protected also, and when those that shout the loudest get the most. There is also little doubt that we cannot hope to retain the same position as we had in the old days before other countries had developed on the manufacturing side.

ON the other hand, it is very difficult for many people to understand why this should be the only country in the world for which Free Trade is good. It would be an ideal thing from the British point of view if there were Free Trade universally. But why have other countries not adopted it when presumably their political economists are as good as ours? Also, why should Germany under Protection export nine millions compared with this country's three and a half millions under Free Trade? Another ideal is to buy in the cheapest market and sell in the dearest, but it is difficult for us to sell in the dearest when we are kept out of it by tariffs. Everyone seems to be agreed that there is too much competition, and the only way of regulating this, as regards the foreigner, is by tariffs. Again, there is the large question of wages. If other countries give lower wages than here, they have a double advantage, and it would seem that wages in this country must fall if we are to compete successfully. Then, again, there is the question of unemployment, which one speaker stated to be much more serious here than in Germany. In conclusion, we congratulate the National Electrical Manufacturers' Association on this interesting discussion. It may not have convinced many people on either side, but it is an advantage for the arguments on both sides to be put forward; and if we might make a suggestion for a future occasion it would be that a similar discussion should be arranged on the question of internal competition, as distinct from competition by foreign trade. This may be described as the other side of the picture, and possibly it is not the least important.

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Tramway Comparisons.

AT first sight the car-mile seems to offer a desirable basis for comparing the results achieved on different tramway systems. Like the kilowatt-hour in electricity supply it certainly has the merit of simplicity; but whereas the B.O.T. unit of electrical energy is universally adopted for calculating and comparing the cost of electricity generation and supply, tramway managers are far from satisfied—and rightly so—with the car-mile basis for comparative statements of revenue and working expenses. The kilowatt-hour is the product of two well-defined quantities; on the other hand, the car-mile involves a very indefinite quantity—viz., the car, to say nothing of its occupants. The use of the ton-mile as a unit has been suggested as a way out of this difficulty, but this unit would mainly be useful in ascertaining the relative power consumption in different cases. Again, the seat-mile has been suggested, and a month or two ago, in one of our American contemporaries, a "traffic unit" equal to 1,000 seat-miles was put forward. This unit is for many purposes undoubtedly an improvement on the car-mile. In regard to other units, it will be remembered that Mr. J. H. RIDER last year, in considering the question of energy consumption on tramways, introduced a "figure of merit," obtained by multiplying the units per car-mile by 100, and dividing the product by the average weight of the car in tons and the average speed in miles per hour.

AT the Dublin Congress of the Tramways and Light Railways Association this week, Mr. J. R. SALTER proposed a figure of merit obtained by dividing the number of car-miles per route-mile per annum by 10,000, and multiplying the quotient by the receipts per car-mile. The resultant figure, he claims, enables tramway systems to be compared better from a commercial point of view. The above expression may be written :—

$$\frac{\text{Number of car-miles per annum}}{\text{Length of route in miles} \times 10{,}000} \times \frac{\text{total receipts per annum}}{\text{number of car-miles per annum}},$$

and simplifies to 1/10,000th of the annual revenue per mile of route. It will be seen, therefore, that the figure mainly indicates the density of the traffic served by the tramway in question. Mr. SALTER particularly emphasised the importance of the first part of the above expression, which he terms the "density factor," and which is equal to 1/10,000th of the number of car-miles per route-mile per annum. This might certainly, with advantage, be included in tramway accounts.

IT is customary to express the working expenses per car-mile as a percentage of the receipts. This percentage in municipal tramway undertakings last year varied from 48 per cent. at Portsmouth to 111 per cent. at Lancaster. As Mr. SALTER points out, however, this figure is of little importance as an indication of the financial success of a tramway undertaking, since it can be reduced by curtailing the service, to the detriment of the net profit. In fact, it is evident that the more frequent the service the greater will be the percentage of the working expenses to the receipts to obtain a given result. The author in this connection draws attention to the frequent mistake of endeavouring to obtain high receipts per car-mile. A glance through the tabulated receipts of tramway undertakings will show that in a number of cases average receipts of from 10d. to over 13d. per car-mile are recorded; and as several of these undertakings show only a small profit on the year's operation, it would be interesting to see if improved results could be obtained with a more frequent service.

I.E.E. Council Elections.

WE desire to call attention to a letter appearing in our Correspondence columns from Mr. E. W. COWAN in regard to the method of selecting candidates for the Council of the Institution of Electrical Engineers. Mr. COWAN urges that the present Articles of Association evidently do not meet the case, and that they should be modified on the lines adopted by the American Institute of Electrical Engineers. We think there is a great deal to be said in favour of such a course, although, possibly, the details might be somewhat modified to advantage. The nomination of members after the list has been published by the Council is obviously undesirable, as it gives rise to an idea of antagonism to the Council. A much better course would be that any nominations, properly supported, should be sent in to the Council by a certain date, and that any such nomination *must* be published in the balloting list. At present, suggestions may be made to the Council; but it does not follow at all that they are accepted. If formal nominations were made, the Council might then extend the list if desirable, and the complete list would be issued for ballot. In many ways it would be an advantage to have the names of the proposer and seconder given after the name of each candidate, but this is only a matter of detail. If outside nominations became general it would be almost essential to have more candidates than vacancies, otherwise a ballot would be meaningless. In any case the aim of any such movement should be, as Mr. COWAN points out, to ensure the harmony and vitality upon which the well-being of the Institution so largely depends.

The Electrobus.

IN view of the passing of the horse omnibus, it is to be greatly regretted that the electrically-successful line of omnibuses (the "Electrobus") has, from purely financial reasons it appears, been taken off the London streets. These omnibuses were really a boon to the public. Clean and sweet, free from oil and dust, and running without rattle or noise, they had already become popular, and they might possibly have taken a prominent place in our principal thoroughfares if they had had a fair chance. In the interest of electric traction it would be well if the Electrobus venture could be exploited actively by a body of commercial men who would conscientiously develop this side of the electric vehicle industry. Now that it has been shown that the electrobus is a possible competitor with other vehicles on the streets, it is most desirable that the potentialities of the service should be brought home with emphasis to the public mind. Owing to the peculiar tactics of those who have hitherto handled the problem, the public has come to regard the electric vehicle as out of the running where public service is concerned, and in this way a branch of the electrical industry has been not only nipped in the bud, but somewhat discredited.

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Direction of Motion of an Electron.—A Paper on the direction of motion of an electron ejected from an atom by ultra-violet light was read before a recent meeting of the Royal Society by Mr. R. D. Kleman. Experiments were carried out to see whether the cathode radiation from substances exposed to ultra-violet light moved initially in the direction of propagation of the light. The amount of cathode radiation from a platinum film, deposited on a quartz plate in a discharge tube, was measured with the film facing the source of ultra-violet light, and with it facing in the opposite direction. It was found that if the intensity of the pencil of light used was denoted by unity, the intensity of the light after passing through the quartz plate and film was 0·55; and if the intensity of the cathode radiation from the film when it faced the source of light was denoted by unity, the intensity of the radiation when the film faced in the opposite direction was 1·15. Since the intensity of the light decreased as it passed through the quartz plate and platinum film, it followed that the larger leak in the latter case than in the former would not be obtained if the cathode rays were ejected equally in all directions, but might occur if they had a component in the direction of propagation of the light.

Obituary.—L. V. Lewis.—We regret to announce the death, on June 4th, of Mr. L. V. Lewis, who was for many years closely identified with the management of the "Observer" newspaper (London) and for several years its actual manager. He was also on the clerical staff of The Electrician in its earlier years. Mr. Lewis resigned his position on the "Observer" in 1898 and retired, more or less, into private life, continuing only his correspondence with several of the principal Continental journals. He was born at Boulogne-sur-Mer in 1844, was educated chiefly in England, and early in life commenced his connection with the press. He was a skilled writer on many subjects, an extreme Radical in politics, and for many years a well-known member of the National Liberal Club. He leaves a wife and son to mourn his loss.

Catalogue of Scientific Apparatus at the Brussels Exhibition.—The international exhibition which is now being held at Brussels is the first which has been directed by the Exhibitions Branch of the Board of Trade. It is not, therefore, without interest to see how this new department is shaping and what steps it is taking to keep up British prestige. On one part of its work it may certainly be congratulated, even at this early stage. It nominated a Liberal Arts Committee, to a sub-committee of which fell the task of organising the exhibit of philosophical instruments. In connection with this exhibit a very detailed catalogue has been compiled, which it is hoped may be of permanent value from the reference point of view. This catalogue has been edited by the National Physical Laboratory, under the supervision of Mr. E. H. Rayner, and contains well illustrated descriptions. To describe the various exhibits, advantage has been taken of the articles which appear from time to time in the technical and scientific journals, abstracts being made from them for the purposes of this catalogue. We are pleased to see that electricity in its measurement and applications is the branch of science most largely represented, the exhibits of the Cambridge Scientific Instrument Co. and Mr. R. W. Paul being typical of the wide range covered. Prices have not been included, but it was felt that sufficient space could not be spared for complete prices, and that incomplete prices would only be misleading. Information of this kind will be given by Mr. Danmatt, who has the catalogues of the various firms for distribution. Special value attaches to the bibliography accompanying this section, and Mr. Rayner may be heartily congratulated on his share in the work.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Assab—Perim	July 8, 1909 ...	—
Balik Papan—Kwandang ...	Nov. 1, 1909 ...	—
Malta—Tripoli.....	Aprll 20, 1910 ...	—
Mosambique—Majunga	May 3, 1910 ...	June 5, 1910
Suakim—Jedda	May 6, 1910 ...	—
Madagascar—Reunion.....	May 12, 1910 ...	—
Reunion—Mauritius	May 20, 1910 ...	—
Lattaquie—Talura	May 26, 1910 ...	—

An American Telephone Company and the Death of King Edward.—According to the "Electrical World," every person who called up any exchange of the Chicago Telephone Co. on May 6th between 6 p.m. and 10 p.m. was given this message without solicitation by the operator: "King Edward died at 11:45 p.m." The difference in time between London and Chicago accounts, of course, for the difference in the hours named. So many inquiries were received earlier in the day in relation to the dying king that a general order to operators to make the announcement was issued as soon as the king's death became known. In this way the news was carried to thousands of persons.

Paralleling Large Alternating Current Systems.—In a recent issue of the "Electric Journal" Mr. P. M. Lincoln discusses the problem of transmitting energy from one alternating-current system to another. The chief results of the discussion are as follows: Two alternating-current systems should not be connected together by a transformer or synchronous-motor-generator set having a rating smaller than 50 per cent. of the smaller system. If a transformer or synchronous-motor-generator set be used between two alternating-current systems, the only method of regulating the amount of power taken through such a connecting link is to control the power output of the prime movers of one or both systems. With sudden fluctuations in load, accurate or rapid control of the energy interchanged when using such a connecting link is practically impossible. The proper method of exchanging energy between two alternating-current systems is by the use of motor-generator sets, one at least of whose elements is an induction machine. When using an induction motor as one of the links, the alternating-current system that receives power must operate normally at a frequency somewhat lower than the generator end of the connecting link would generate were the set synchronous at both ends. The number of possible pole combinations that may be used in connecting a 60-cycle and 25-cycle system is limited and the choice of combination should depend on the direction in which energy is to be transferred.

Double Catenary Construction in Tunnels.—The "Electrical World" gives an account of a method of supporting double-messenger catenary trolley systems for use in tunnels, under bridges and in other places where the overhead space is limited. This construction provides a means of insulating the trolley conductor from its supporting messenger cables, which are in turn insulated at their points of suspension. The practice has previously been to treat both the messengers and trolley as electrified conductors, but the necessarily close proximity of the charged messenger to the earthed roof of tunnels and covered structures makes this construction unsatisfactory in those places. For continuing double-catenary trolley through tunnels and under bridges the trolley conductor is carried in a clamp which is in turn seated in a roughly-triangular treated-wooden clamping block which grasps the catenary messengers. A short pipe section between the clamping block and trolley car provides an adjustable link which permits allowance to be made for the catenary curve of the messenger. The messenger cables are in turn supported and insulated by structures comprising suspension pipes and a cross-piece carrying a fluted insulating collar which seats the suspension cables firmly in position. The cross-piece is not threaded into, but passes through the T-fittings, being held in place by cotter pins. This construction enables the cross-pipe to be put up or taken down after the supports have been installed, in case repairs become necessary.

Thermit Welding and Motor Repairs.—According to the "Electric Railway Journal," the Virginia Railway & Power Co. has been very successful in repairing motor casings by thermit welding. For the repair of the broken half of a motor case, the Company uses a mixture of 25 lb. to 35 lb. of thermit and 10 lb. of steel shavings. The pre-heating is done with a compressed air-gasoline torch. The cost for repairing a "half" is about £3, whereas a new half costs £18. This repair-cost includes the expense of gasoline and labour, but not the depreciation on appliances, or the compressed air

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which is available throughout the shop. About three to four gallons of gasoline are used per weld. The labour charge is 12s., and is made up of the day's work of two men at 6s., who carry out the complete process from the making of the moulds to the chipping of the case. The low cost for labour shows conclusively, our contemporary thinks, how little skill is required in this method of welding after the men have had a little experience.

Method of Renewing Carbon Filament Lamps.—A recent issue of the "Engineer" describes a method for renewing carbon filament lamps which has come into being in Germany. The lamp to be treated must have its filaments unbroken. The top of the lamp bulb is opened, and a tube is fused to it at this point. The bulb is then sufficiently heated to burn off the carbon deposit. A small amount of some suitable hydrocarbon is then introduced into the bulb and a vacuum produced. Current is passed through the filament, and carbon is thus deposited in a manner similar to that adopted in the ordinary flashing process. The cost is said to be about 2½d. per lamp.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

In our Marine Issue, which is incorporated with the present number of THE ELECTRICIAN, will be found a large number of articles, including the following: "The Future of Electricity on Ships," by A. P. Chalkley; "Marine Propulsion by Electric Motors," by H. A. Mavor; "A System of Turbo-Electric Propulsion of Ships," by H. C. Leake; "Electrical Marine Propulsion on the Paragon System," by W. P. Durtnall; "Electro-Mechanical Propulsion with Diesel Engines," by Eng.-Lieut. W. P. Sillince; "Electrically-Driven Shipyard Cranes," by H. H. Broughton; "Switchboards on Warships," by A. G. Collis; "The Wiring of Ships," by G. Austin; "Electric Steering Gear," by A. P. Chalkley; "Ship Illumination and Fittings," by G. Austin; "Searchlight Projectors for Marine Purposes," by E. A. Holmes; "Ships' Telephones," by H. S. Thompson; "Wireless Telegraphy for Marine Intercommunication," by W. W. Bradfield; and "The Use of Electrical Power for Auxiliary Purposes on Board Ship," by J. A. Seager.

We give a translation of Count Arco's recent lecture on "Some Experiments with the New Telefunken System," delivered before the Verband Deutscher Elektrotechniker.

The adjourned discussion on the comparative effects of Free Trade and Protection upon the electrical industry was concluded on Monday last. We give an abstract of this.

We also give an account of the discussion on Mr. G. W. Worrall's Paper on "Commutation Phenomena and Magnetic Oscillations Occurring in Direct-Current Machines," read recently before the Birmingham local section of the Institution of Electrical Engineers.

Bethnal Green (London) Council have now decided to enter into an arrangement with Shoreditch Council for a supply of electricity in bulk.

A proposal is under consideration for constructing an electric tramway between Maidstone and Chatham, a distance of about 7 miles.

An inquiry was held on Tuesday into the application of Sheffield Corporation for permission to borrow £78,207 for additional generating plant, &c.

Extensions of the electricity undertaking at Rotherham are projected, at an estimated cost of £27,832.

Northampton Corporation propose to extend their tramways to Far Cotton, at an estimated cost of £14,560.

West Bromwich Corporation are applying for sanction to a loan of £11,386 for extensions of their electricity undertaking.

Frome Council have decided to transfer their electricity undertaking to Edmundson's Electricity Corpn.

An inquiry was held at Coventry on Wednesday into the application of the Corporation for permission to borrow £54,200 for electric lighting extensions.

INSTITUTIONS AND SOCIETIES.

INSTITUTION OF ELECTRICAL ENGINEERS.—The annual Conversazione is to take place on June 28th at the Natural History Museum, South Kensington.

INSTITUTION OF MINING ENGINEERS.—At a recent meeting the list of awards for Papers read before the Institution was announced. Mr. Robert Nelson, H.M. Electrical Inspector of Mines, receives a premium for his Paper on "Electricity in Coal Mines."

THE ROYAL SOCIETY.—In addition to the meetings announced for the current session, an ordinary meeting will be held on Thursday, June 16th. Among the Papers read at the meeting of this society yesterday afternoon were the following: "The Distribution of Velocity in the β-rays from a Radioactive Substance," by Mr. J. A. Gray; "The Decrease of Velocity of the β-particles on Passing through Matter," by Mr. W. Wilson; "Rate of Emission of α-particles from Uranium and its Products," by Mr. J. N. Brown; "The Accumulation of Helium in Geological Time.—IV.," by Prof. the Hon. R. J. Strutt, F.R.S.; "The Effect of Small Traces of Water Vapour on the Velocities of Ions produced by Röntgen Rays," by Mr. R. T. Lattey; "The Effect of Pressure upon Arc Spectra, Part II., No. 4.—Gold," by Dr. W. G. Duffield, and "On Radiation in a Gaseous Explosion," by Prof. B. Hopkinson, F.R.S.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, June 11th.

ROYAL INSTITUTION.

3 p.m. Lecture on "Electric Heating and Pyrometry," by Prof. J. A. Fleming, F.R.S. (The Tyndall Lectures.) (Lecture II.)

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

TUESDAY, June 14th.

10 a.m. Convention opened by the Lord Provost of Glasgow (the Hon. A. McInnes Shaw) in the Rankine Hall of the Institute of Engineers and Shipbuilders in Scotland. Presidential address by Mr. W. W. Lackie (Chief Electrical Engineer, Glasgow Corporation Electricity Department). Papers on "Commercial Progress," by Messrs. A. C. Cramb (Chief Electrical Engineer, Croydon) and H. Collings Bishop (Chief Electrical Engineer, Newport, Mon.).

3 p.m. Visit to the (*a*) Springburn Sub-station of the Electricity Department; (*b*) Pinkston Power House of the Tramways Department; (*c*) Port Dundas Electricity Works of the Electricity Department.

7:30 p.m. Reception and Conversazione at the City Chambers by the Lord Provost, Magistrates and Town Council of the City of Glasgow.

WEDNESDAY, June 15th.

10 a.m. Meeting in the Free Gardeners' Hall, Picardy Place, Edinburgh. Papers on "Exhaust Steam Turbines and Condensing Plant," by Mr. F. A. Newington (Chief Electrical Engineer, Edinburgh), and on "Mixed Pressure Turbines," by Mr. Ashton Bremner (Chief Electrical Engineer, Burslem).

1:15 p.m. Luncheon at the Music Hall, George-street.

2:30 p.m. Visit to the Works of the Electricity Department, Macdonald-road.

THURSDAY, June 16th.

10 a.m. Meeting in the Rankine Hall of the Institute of Engineers and Shipbuilders, Glasgow. Discussion on "Advantages of Continuous Records of Costs and of Steam Consumption," opened by Mr. G. Wilkinson (Chief Electrical Engineer, Harrogate) and Mr. C. E. C. Shawfield (Chief Electrical Engineer, Wolverhampton); and on "Cheapening of the Cost of Mains and Services," opened by Mr. S. E. Fedden (Chief Electrical Engineer, Sheffield) and Mr. S. J. Watson (Chief Electrical Engineer, Bury).

1 p.m. Luncheon at the Grosvenor Hotel.

2 p.m. Visit to (*a*) St. Andrew's Cross Electricity Works of the Electricity Department; (*b*) Coplawhill Works of the Tramways Department; (*c*) Electricity Works of the Govan Electricity Department.

Alternative series of visits.

(*a*) Electricity Works of the Partick Electricity Department;
(*b*) Power Station of the Clyde Valley Electric Power Co. at Yoker;
(*c*) The Shipbuilding Works of Messrs. Beardmore (Ltd.), Dalmuir.

7 p.m. Annual Dinner at the Windsor Hotel.

FRIDAY, June 17th.

10 a.m. Annual General Meeting in the Rankine Hall of the Institute of Engineers and Shipbuilders, Glasgow.

1 p.m. Luncheon, Grosvenor Restaurant.

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, June 13th, "A" Company.—Recruits Infantry Drill 6 to 6:45 p.m. Technical Drill 7 to 9:30 p.m.

Tuesday, June 14th, "B" Company.—Recruits Infantry Drill 6 to 6:45 p.m. Technical Drill 7 to 9:30 p.m.

Wednesday, June 15th.—Gymnasium 6 to 9:30 p.m.

Thursday, June 16th, "C" Company.—Recruits Infantry Drill 6 to 6:45 p.m. Technical Drill 7 to 9:30 p.m.

Friday, June 17th, "D" Company.—Technical Drill 6:30 to 9:30 p.m.

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ELECTRIFICATION OF FERNDALE COLLIERIES.

The Paper on this subject, read by Mr. W. H. Patchell before the South Wales Institute of Engineers, and of which an abstract appeared in our issues of October 29th and November 5th, 1909, aroused so much interest that the discussion was twice adjourned. We give below an abstract, from the "Proceedings" of the Institute, of the remarks of the various members who contributed to the discussion.

The PRESIDENT, in opening the discussion, asked the reason for taking the water from the lodge rooms right down the pit to the pumps at the bottom and pumping the water up again. In connection with the ventilation a number of years ago he had made experiments on fans and was inclined to think that Mr. Patchell had been misled in taking the velocity at the top of the chimney. It was no easy matter accurately to measure air, but the figures given in the Paper seemed to him to impugn the reliability, at any rate, of the figures taken at the top of the chimney. He also asked Mr. Patchell to explain why the pressure of the motor placed in the return was reduced from 2,200 volts to 440. He thought 440 volts would be just as dangerous if the return air was in an explosive state.

Mr. D. HANNAH, with regard to the latter point of the President, said the electrical rules would not permit of greater voltage in return airways than medium pressure. Then with respect to placing one pump at the pit bottom instead of in the lodge rooms, this method obviated the winding of water from sumps at two pits and also the sinking of men to lodge rooms. It saved boiler power, and the whole of the work was done with one man at the electrical pumps at the bottom with one plant.

The PRESIDENT asked why not put the electrical pump in the lodge room?

Mr. HANNAH, continuing, said with the electrical work they had done away with boilers and with one engineman, and the whole of the water was taken down to one common centre. If the electrical pumps were in the lodge room an everyday inspection would be necessary, and a winding man and stoker would be required.

Mr. A. DAVIES (communicated) thought Mr. Patchell could have bought turbo-generators and condensing plant in which he could have placed as much reliance as in the plant installed; and the complete turbo-generating plant could probably be erected on the same floor space as one of the existing sets. A further point in favour of the turbo-generator was that the turbine and alternator were mounted on a combination bedplate; this was of great importance where the possibility of subsidence was present. As to the switchboard, switchgear could have been obtained which would have occupied about half the space and could be operated with the same degree of safety and certainty of action. The "switch-wagon" type of board was as safe, more easily erected and more economical of space and building work, the inspection of its component parts could be carried out with absolute safety, and the operator had only low-tension gear to handle. The haulage gears appeared to be well designed. The motors were all of the "end shield" bearing type; he preferred motors, for the two larger sizes especially, with low pedestal bearings and feet on the stator frame: this arrangement with a good baseplate for motor and gear lent itself to great stability. The "end shield" type of motor did not allow of any adjustment of the air-gap, and, further, the shields must make it awkward to inspect and test the air-gap. As it was quite good practice to make air-gaps as fine as possible, they necessarily ought to be inspected at least once a week. The controllers appeared to have been designed with a view to durability alone. This desire had evolved an expensive and intricate arrangement. He agreed with the principle, but suggested that the controller and reversing switch should be on one spindle, the movement of the handle being simply backwards and forwards, with a catch for the "off" position. The tramway type and the liquid type regulator, when properly designed, had a field for haulage work; and where the latter could be used it would be found to give a smoother starting effort, and this effort could be made independent of the engineman. He asked for information as to the life of the belts of the pumping plant. Would it not have been possible to have had pumps running at about 1,480 revs. per min., with an extra couple of stages and to use direct-coupled motors, instead of driving by belt? As to the winder, the Ilgner dynamo and the winder motor fields were excited by a motor-generator. This meant that in the event of a failure of the supply the winder would stop almost at once. With the A.E.G. Ilgner winders this did not take place, as the exciter dynamo was mounted on the same shaft as the flywheel motor-generator; and in the event of the supply failing, the winder motor could be run until the flywheel was unloaded, allowing of several winds. He believed the A.E.G. were the only firm who built the exciter dynamo on the motor-generator shaft. Other makers had a separate motor-generator and employed a battery as a stand-by. A slip regulator of the liquid type would probably give better results on account of its smoother action. Altogether about 240 Ilgner winders had been installed all over the world. He thought that Messrs. Siemens, Schuckert and the A.E.G. had made about 100 each, and the Lahmeyer Co. about 40. The direct three-phase winder was, in his opinion, a simpler solution of the problem; and in South Wales, with a public supply company, there should be no question of their adoption. Even if the question of increase of generating plant should crop up, it might be solved by putting the winder on the supply company's mains.

Mr. F. G. MAGUIRE referring to the President's statement that the author's readings of the air flow were incorrect, because the velocities at the centre of the discharge area should have been the highest, as was always the case with water or air flowing through pipes, said that an evase discharge chimney could not be considered to be the same as an ordinary pipe through which air or water was flowing. In some cases, more particularly where the fan was not working on full load, the velocity of flow at the centre of the top of the discharge chimney was considerably lower than at the sides; and in all cases the air had a tendency to follow the inclined side of the chimney. In some extreme cases he had even recorded a return current or down draught in the centre of the chimney. He felt perfectly satisfied that the figures given were as nearly correct as it was possible to get.

Mr. B. J. DAY said he had visited colliery installations in the Belgian coalfield and in Westphalia, and so far as the power station was concerned, he had never seen a better carried out installation, so far as the general design was concerned, than that at Tylorstown. It had been carried out practically on the same lines as many of the largest municipal installations in this country. Whether this was the point of view from which to carry out a colliery installation was another matter. He doubted whether engineers were right in spending so much money as in the installation under notice. The whole idea seemed to have been to instal plant to produce a unit of electricity with the smallest possible coal consumption. Mr. Patchell remarked that a unit of electricity was obtained for 17 lb. of water pumped into the boilers. The fuel used was worth only 5s. 8d. per ton, and therefore he would have been justified in not going for such a high coal economy and in reducing the capital charges. 9,000,000 units per annum, using two sets running and one standing, was equivalent to a load factor of 34 per cent.; the capital charges, therefore, represented 0·272d. per unit. This was equivalent at 10 per cent. per annum to £102,000 and at 15 per cent. to £68,000—a very large expense for any colliery company to incur. Mr. Patchell could have obtained absolutely the same results, so far as efficiency and reliability were concerned, if he had put down a first-class turbo-generating plant, and the cost would have been approximately about one half. Turning to the boiler plant, Mr. Patchell had got an efficiency of 79 per cent.—an extremely high figure. His CO_2 percentage, 13, was very good, but the heat of his gases at the base of the chimney was 478° F., and that of the feed water only 118 deg. If he was going for economy, it would have paid Mr. Patchell to have put in an economiser and brought up the feed-water temperature to 200 deg. or 250 deg., especially with induced draught plant. The necessity of installing a battery of accumulators was not apparent. Mr. Patchell had assumed a power factor of 0·85. Where the bulk of the plant was large slow speed haulage motors a closer figure would be 0·75; this would have the effect of reducing the capacity of the generators from 1,600 kw. to 1,400 kw. Again, it was stated that the operator in the ordinary course of his work only had low-tension gear to handle. This must be an error, as all switchgear was high tension, and was operated from a platform above by means of a rod. There was another point about Mr. Patchell's switchgear which could be improved upon, namely, the disconnecting links operated by means of hooks attached to wooden handles. A better method was to have these disconnecting links operated by a switch-handle as in the case of the oil switch, and these handles should be interlocked with the oil switches, so that the operator could not open his isolating links until he had opened his oil switch. With regard to the transmission line, the most distant point from the power station was only 2½ miles and the bulk of the power was only transmitted 1¼ miles. It was not stated what power was transmitted, but allowing for some transformers as spares, it was about 1,000 kw. A 0·1 sq. in. three-phase line transmitting 100 amperes—*i.e.*, 250 kw. to 300 kw.—would cost about £600 per mile, and at a rough estimate the cost of transformers and sub-stations would be at least £3,000, or more than it would have cost to have put up 2,000-volt lines throughout and a spare line. This would have simplified the whole scheme by keeping to one not excessive pressure—2,000 volts—and the trouble arising from surging, &c., need not have been expected. A 2,000-volt installation was more easily handled than a 6,000-volt installation. As to the return airways, if it was considered quite safe to instal 440-volt motors, why not instal 2,000-volt motors?

Mr. TRUMP, H.M.I., here remarked that it was not permissible to use higher than medium pressure in return airways.

Mr. DAY, continuing, said his point was: Mr. Patchell was on the Commission appointed to draw up these regulations, and if he put a motor there at all, why limit himself to 440 volts? If there was danger in the return airways with electric motors, they should be prohibited altogether, there was as much risk with 400 volts as with 2,000 volts. Referring to the power of the new haulage gear, Mr. Patchell had stated that in the case of a journey having run wild on an incline, the resultant heap at the bottom was not laboriously cleared up by a breakdown gang, but the haulage rope was attached to the top tram and the heap drawn out by an application of two or two and a half times normal torque into something like order, which very considerably shortened the time during which the road was blocked. The speaker considered this was an extraordinary thing to do. He asked what happened to the circuit-breakers or his cut-outs. If these were set high enough to bring a full journey back on to the road as described, they were useless to protect the haulage under working conditions. Such a practice ought to be condemned in the strongest possible manner. It was only encouraging the overloading of ropes and haulage gears. Unsuitable wheels had been a great drawback to electrical haulage underground. Firms were making a speciality of electrical haulage wheels, so that they could run with a motor speed of 360 revs. per min. with only a single reduction. With such wheels, a higher efficiency was obtained not only in the wheels themselves, but also in the motor, as well as a higher power factor. The design of Mr. Patchell's haulage gears was absolutely wrong. The motor was put on

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a separate bed from the haulage gear, and a flexible coupling had been introduced between the haulage motors and gears. He was bound to do this because the design was wrong, and entailed an enormous width of haulage chamber underground. The cost also was excessive. But apart from these considerations, the haulage motor and the gear should be one combined machine. The width of the 100 H.P. gear was 21 ft., but if designed on the plan he (Mr. Day) suggested, the overall width would be about 11 ft. 6 in. to 12 ft. As to controllers, he did not see that the arrangement was novel or why it was called "Patchell's System." For many years Continental makers had used two-phase rotors for haulage work so as to simplify connections. English makers had been slow to follow suit, but they were at length taking a wrinkle from the Continental practice. Again, he thought the figures for power factor of the haulage motors were manufacturers' figures, and off-hand he should say they were impossible.

Mr. I. V. ROBINSON said that Mr. Patchell had worked out the load factor upon the maximum load, whereas it should be taken upon the total capacity of the plant, as it was upon this capacity the total charges were based. The speaker next worked out the cost per kilowatt of plant installed as £14. 3s. If the plant was installed primarily to secure high economy, he asked why did not Mr. Patchell pay a little more and put in a gas-engine installation, which could be put down at from £16 to £17 per kilowatt? He did not think Mr. Patchell had got a sufficiently great economy to make anyone anxious to put in a similar installation. The weight of the engines was 155 tons each, and generators 107 tons, or 262 tons per set. A turbo for this output would weigh, approximately, 35 tons, and generator about 25 tons; total, 60 tons per set, or a saving of 202 tons of material on each set. This should represent a considerable saving in cost. Then the space occupied was also about double, so that the cost for engine house and foundations would certainly be less than half in the case of the turbo.

Mr. D. HANNAH remarked that he was entirely responsible for turbo-generators not being used, as three or four years ago, when the scheme was under consideration, he thought turbo-generators too risky to put down for colliery work. His opinion now might possibly be modified. The placing of the motors outside the haulages, described by Mr. Day as a clumsy arrangement, was also due to the speaker, but if the work had to be done again he should adopt the same method. He visited several collieries in South Wales, the Midlands and the North of England, and came to the conclusion that single-reduction haulages were the best system to adopt. This necessitated very large motors, and as it was desirable that the engineman should have a clear view of his haulage gear, it was decided that the motors should be placed alongside the haulages instead of in front of the engine In later designs the motor was put on a bedplate attached to the haulage set. He must exonerate Mr. Patchell from any blame with respect to the arrangement, if blame were merited.

Mr. C. W. JORDAN asked if there was any explanation of the comparatively high steam consumption of these engines. He had occasion a few months ago to go into the question of installing engines of about 2,000 H.P. and he was offered plant guaranteed to work at 8½ lb. per indicated. horse-power hour. He had particulars of a test made on a 1,500 H.P. Carels Freres tandem compound engine at the paper mills of Messrs. Edward Lloyd, at Sittingbourne, Kent. The steam consumption on two-thirds load worked out at 9·6 lb. per indicated-horse-power hour, compared with 11·5 lb. at Ferndale—*i.e.*, a saving of about 16·7 per cent. He also asked why did not Mr. Patchell generate at 6,000 volts instead of 2,000. He might add that the Carels Freres engine cost somewhat less than the Sulzer engine.

Mr. H. RICHES JENKINS said in choosing a controller for use at his colliery installation he selected Mr. Patchell's mainly because of its accessibility.

Mr. T. SUGDEN said the 8½ lb. steam consumption mentioned by Mr. Jordan was a very extraordinary figure, and indicated a result not likely to be obtained under normal working conditions. Results of that kind should be verified by an independent expert before being fully accepted.

Mr. C. W. JORDAN replied that he had a quotation from Carels Freres guaranteeing him a steam consumption of 8½ lb. per indicated horse-power hour under a penalty.

Mr. C. B. CHARTRES asked for further particulars of the working conditions. With regard to the figures given concerning the testing of the fans, he considered it doubtful if the outputs calculated from the velocities measured in the Evasé chimney could be relied on. His experience was that much more reliable results were obtainable if measurements of the air were made on the suction side of the fair, as it was possible to work with smaller velocities, and the danger of eddies upsetting the readings was not so great.

Mr. W. O'CONNOR stated that he had taken part in many fan tests and had found in the case of the larger chimneys of the older types of fans, without exception, that the higher velocities were in the centre of the chimney and the lower velocities along the outer divisions. He also suggested, in connection with the example in the Paper, a method of reducing the loss to a much smaller figure. As far as he could ascertain from the Paper, the angle of increase, or "flare," if he might use the term, was about 1 in 6½ along the spiral of the fan, but in the cone—the straight part of the chimney—it was about 1 in 4½. The results seemed to point out that this increase was not sufficiently rapid, or, possibly, a uniform rate of increase was not the best method. He would say that if the area of exit was increased more rapidly, say, to 12 ft. by 10 ft., and the velocity of efflux made fairly uniform, the loss, with 116,087 cubic ft. per minute would be exactly 1 H.P., showing a saving of about 3 per cent., if eddies could be removed from the present chimney, and more as compared with present conditions. Again, the tractive co-efficient was high, and he could only suggest that the weight, nearly two tons, was, perhaps, a little more than was usually carried on a pair of 2 in. axles.

Mr. W. H. PATCHELL, replying to the discussion, said he had made a number of tests on Evasé chimneys, and found, as Mr. MaGuire stated, that there was always a higher velocity on the inclined side of the chimney and a lower velocity in the centre. He quite agreed with Mr. Hannah that turbo-generators were too risky at the time the plant was projected. They had passed through many stages of development, and the machine now available was very different from that four or five years ago. Mr. Davies had leaned to the waggon type of switchboard. The author had not found that the floor space occupied gave any advantage over the type which he had adopted, and, further, he did not consider that the type was safer than the existing type. Some makers, in his opinion, unduly cramped the switchboard arrangements, and it had been his lot to redesign more than one board which was built on lines proved to be perfectly safe in connection with some supplies, but proved to be quite unsafe in connection with other supplies with high power behind them. Both the tramway and liquid type of controller were in his (Mr. Patchell's) opinion, unfitted, as offered, for work on underground conditions. The tramway type had proved most expensive in repairs, and both it and the liquid type required constant attention. It was because he was not satisfied with the available controllers that his controller was developed. He informed the meeting that the owners were thoroughly satisfied with the arrangement, that the repairs and attention required were practically nothing, and that not a single journey had been lost by faults on either the haulage gears or controllers during over four years' work. The advantage of mounting the exciter dynamo on the Ilgner flywheel shaft had had his consideration for some time. It promised to be quite satisfactory for a wind or two, but as the speed of the flywheel fell the speed of the direct-coupled generator was not sufficient to give the proper voltage required for the field circuits, so that although the supply was certainly not cut off suddenly, as in the case of a separate motor generator, it was not possible with the arrangements to get the full value out of the flywheel. The adoption of a three-phase motor for the winder had his very serious consideration. The operation of examples of this system that he had seen were certainly not such as would be permissible on the public supply company's mains in South Wales. The suggestion that the breakdown of the fan might have been avoided if pedestal bearings instead of end shields had been used was unfortunate, as the motor in question was fitted with pedestal bearings, and not with end shields. With regard to working costs, Mr. Davies compared costs given by Mr. Sparks of the Aberaman plant with the costs given of Ferndale. The great difference appeared to be in interest and depreciation on capital. Mr. Sparks stated in the Paper referred to that the plant was started in 1905. He (Mr. Patchell) was informed some time ago that the plant had been shut down and superseded; so that possibly it was put in with a view to a particularly short life; but in any case the figures quoted by Mr. Sparks hardly covered obsolescence in five years. The glazed bricks at Ferndale and some other details which were thought too lavish were adopted after full consideration by the board of directors, who were now good enough to say that they were quite satisfied that the expenditure had been economical and had repaid for itself. In a colliery district subsidence was much more likely to occur than elsewhere, hence good sound work was more than ever necessary. He would again repeat that plenty of light and elbow room round machines made for easier and better maintenance. The reason that he did not put in an economiser was because he considered it would not pay. On the other hand, the small battery of accumulators was extremely useful in the early stages of the development of the station, and was still useful as an insurance against interruption of the field circuits. As regards handling high-tension gear, it was a little difficult to follow Mr. Day's comment. There was all the difference between handling parts which, when metal, were earthed and were far removed from high-tension parts, and the juxtaposition of the switch operator to a high-tension switch and the necessary connection. A scheme for a 2,200-volt transmission was turned down on account of various objections. A total of 3 sq. in. area of copper would have been necessary; the difficulty of supporting it, the space occupied if the circuits were sub-divided into sizes which could be reasonably handled, and the expense, in view of the then high price of copper. With reference to the relative safety of medium pressure and higher pressures, his experience during the last 10 years with pressures up to 10,000 volts led him unhesitatingly to say, as he had often said before, it was easier to control the volts than the amperes. He believed that in due time this would be more generally recognised. Mr. Day suggested that he was considerably overloading the haulages and teaching the attendants bad habits. The details given in the Paper showed that the maximum torque was twice the normal torque. The 2½ times normal torque referred to some special haulages which were built on those lines. There was no question of overloading. The basis of calculating load factor that he had used had long been recognised by engineers as the standard upon which annual tables of costs, &c., were made out. In reply to Mr. Jordan he would state that although he had heard of the test referred to he had not seen particulars. There was no such practical difference in the design of the Carels and the Sulzer engines as would account for the figures mentioned. The essence of the Sulzer efficiency was in the form of valve adopted and the small clearance thereby obtained; this was common to both makers. He felt sure that the difference could only be accounted for by the environment of the engine and the conditions of the test. As regards the generation of the current at Ferndale at 6,600 volts instead of 2,200, and Mr. Jordan's suggestion that it was more economical to step down than to step up, so far as his experience went there was nothing in it, but he quite agreed that it was as safe to generate at higher pressures as at lower.

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The Applications of Electrical Engineering to Marine Work.

It has been rightly said that this is an age of explanation. Every man, and woman too for that matter, whose actions obtain some public recognition feels called upon, in season and out of season, to offer excuses or confirmatory details for such and such a course of behaviour, and to point out that a particular muscular effort has been occasioned by a certain grouping of brain cells at a psychological moment. And, therefore, so as to be in the fashion, we feel that we must offer a few words of explanation for the distended appearance of this particular Friday's issue.

In the race which inevitably occurs between the technical journal and the text-book both suffer under disadvantages. The first because its information on a given subject is scattered, the second because its information is out of date. In the MARINE ISSUE of THE ELECTRICIAN we have tried, as we have tried before, to sweep away both these drawbacks; to lay before our readers an account of electrical engineering applied to marine work which shall be both concentrated and up to date and to erect a platform which shall serve as a foundation for building to greater heights.

The subject is of quite natural interest. So much of our country's welfare is bound up with the sea that even the non-technical reader will be able to appreciate the meaning of many of the articles in the following pages. For the technical reader the interest will be enhanced. He will find that while we have still worlds to conquer and progress to make, yet the electric drive has even now an assured position on shipboard, and is doing work which could not be performed so efficiently in any other way. The signed articles will indicate concisely the advances that have been made on the technical side, while in other columns individual manufacturers have an opportunity of showing what they have done in their particular specialities.

In this connection we may be forgiven for pointing out that the MARINE ISSUE of THE ELECTRICIAN appears at a very opportune time. The electric motor is, in practically every modern ship, receiving a wide application for the driving of the auxiliary machinery. For the operation of fans, hoists, capstans and all the other multifarious auxiliary equipment which finds a place on the present-day liner or battleship, the motor has ousted the less efficient steam plant. This is satisfactory, but we wish for more. Much trouble has been expended in the design and perfection of a system of electric drive for the operation of the main engines. The last few years have seen the old marine reciprocating engines replaced by the turbine, and we shall not be thought unduly optimistic, in some circles at least, if we prophesy that the next few years will see the steam turbine in its turn replaced by some system in which electrical machinery will play the chief part. The reasons for this expectation cannot be entered into here, but they are sufficiently discussed in other columns of this issue.

We expect then a great future for marine electrical engineering, but we must not forget that its present is not without merit. Each age has its chronicler, and we hope that in the days to come the MARINE ISSUE of THE ELECTRICIAN will be looked upon as no mean historian of the state of electrical affairs in marine work as they were in 1910.

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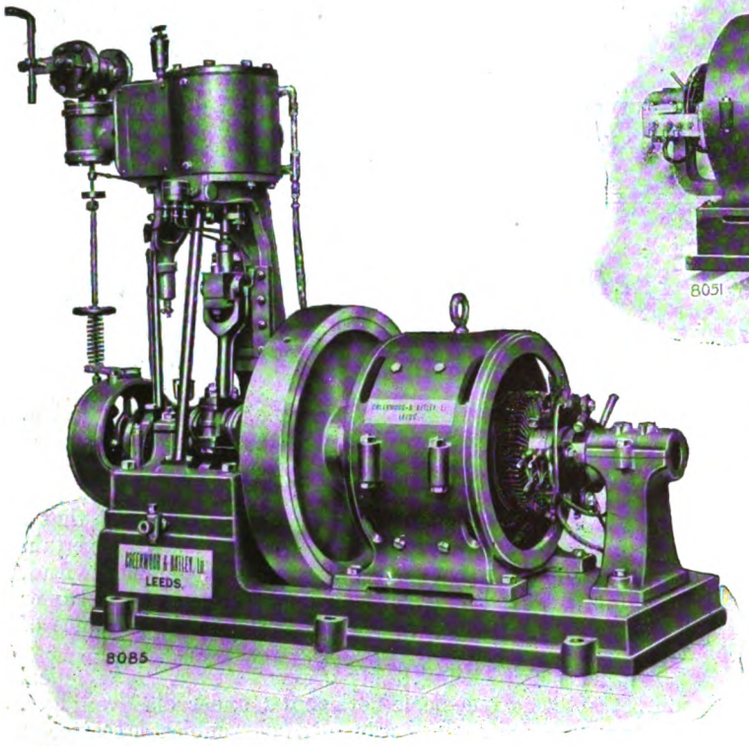

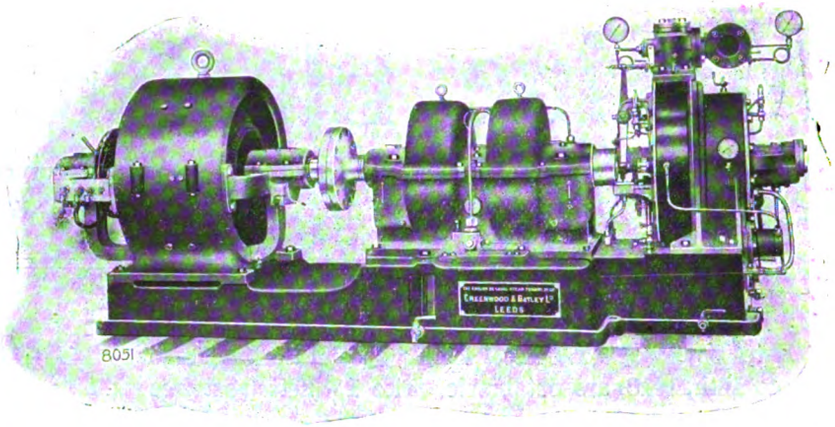

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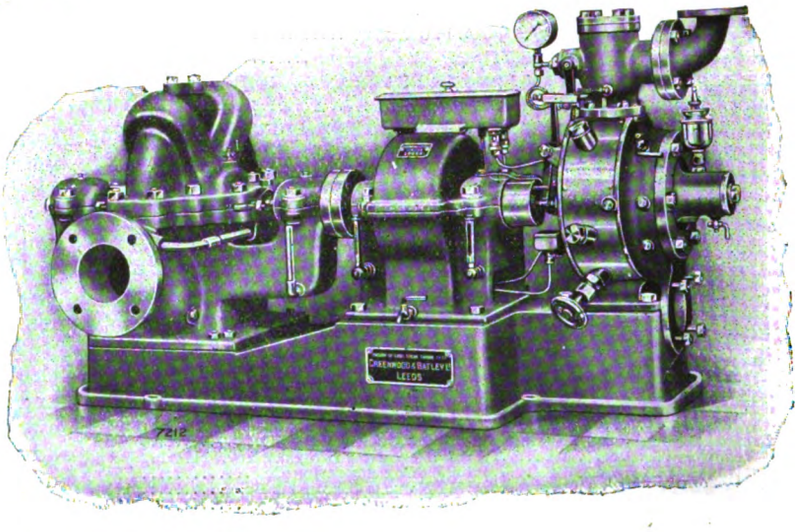

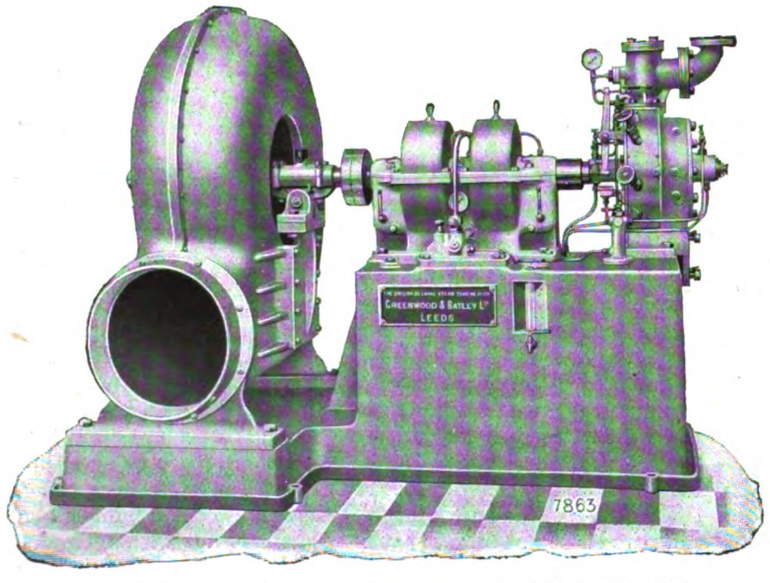

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The Future of Electricity on Ships.

BY A. P. CHALKLEY, B.Sc.

Summary.—It is pointed out that there are two tendencies at the present time in regard to the use of electricity on board ship; namely, either to use it for all purposes, or to apply it to every purpose except that of propulsion. The possibilities of the Diesel engine in this connection should be borne in mind. Producer plant has also been suggested, but the future in this line seems doubtful. On the other hand, the position of the turbine is assured. The standard voltage shows a tendency to rise, and there is much to be said in favour of alternating current in preference to continuous. A marked advance may be expected in electrical steering gear. Generally speaking, it may be said that the outlook for electricity on ships is very promising.

In attempting to foretell the future, one naturally looks to the past, and by deduction a fairly accurate idea of the minimum limit of possible developments is obtained—the minimum, because, particularly in the case of electricity, steady progress seldom diminishes, while, at the same time, important discoveries may at any moment give a hugh and unexpected impetus to its adoption.

The first ship to be equipped with electricity was the "Columbia" nearly 30 years ago, and the installation consisted of just over 100 10 c.p. lamps, and, in comparison with this, it may be stated that the electrical plant of the "Mauretania" comprises four generators with a total output of 1,600 kw. To maintain such a rate of advance in the future will tax the ingenuity of electrical engineers, and, if, as seems possible, the limit in size of ships is being reached, it can scarcely be anticipated that a corresponding increase in actual electric power installed will be more than realised. But it must be remembered that the "Mauretania" was to some extent a freak boat, as much in its way as the "Great Eastern," with the great difference that the one was successful and the other not, and the majority of the world's ships may be expected to adopt electricity on a very much larger scale in the next decade than they have in the last.

There are two tendencies with regard to the future of electricity at sea, one being towards its sole adoption as a motive power on ships, and the other its use for all purposes other than actual propulsion. The question of electromechanical propulsion is fully dealt with elsewhere in this issue, and need not be touched upon in this article except to mention that it is a development of the very near future, since no less than three separate systems will be put into practice within the next year, which serves amply as an illustration of the fact mentioned above that big strides may be made quite apart from the natural process of evolution. Were electric propulsion to become universal—which, however, its most ardent advocates do not anticipate—the progress of electricity on ships would be proportional to their increase in size and speed, but even without this there is a very wide field open for the economical employment of electric power at sea.

The adoption of electric propulsion would have little or no effect on the auxiliary electric machinery on ships. It might be thought at first sight that the main generating plant would be used for supplying electricity for all purposes, but it is probable for many reasons that such would not be the case. In the first place light is required at times when the ship is in port, and several motors are needed for ventilation, &c. Practically all ships at present use direct current, while the most promising aspect of electric propulsion is presented with the employment of alternating-current motors; but this will be discussed later. Moreover, were alternating current used for all purposes, the voltage would be different in the two cases which would necessitate inconvenient transformers or motor-generators.

It may safely be said that more than 90 per cent. of the existing electric generating plants on ships consist of reciprocating steam engines coupled to direct-current dynamos giving about 100 volts, which is equivalent to admitting that practically no advantage has been taken in the direction of cheap power production of which so much has been done on land in the last 10 or 15 years. There have, of course, been fairly substantial reasons for this attitude on the part of shipowners and shipbuilders, the chief being that economy of running has been scarcely considered, since the amount of steam used is small compared with that taken by the main propelling machinery. With the introduction of larger units, consequent upon the extended use of electricity, however, there is a tendency to pay greater attention to what has hitherto been considered a minor auxiliary, and there are signs that the reciprocating steam engine will, to some extent, be ousted from its monopoly. In some of the larger and more recently built battleships, Diesel engines, direct coupled to generators, have been installed, in conjunction, however, with the steam-driven plant of the old high-speed type. These engines have a very great advantage over steam engines on a small scale, as has been conclusively proved on land, though it must be admitted that the economy in working is more apparent than real when it is considered that exhaust steam is always useful for feed heating, and the capital cost of the boilers debitable to the electric generating plant is very small. There is another point of importance, however, namely, the fact that Diesel engines can be started up at very short notice, and may be run during the whole time a vessel is in port, thus obviating the necessity of having to fire boilers, specially for a small amount of electrical power. This is particularly noteworthy in the case of ships which lie up for a considerable portion of the year, or spend, say, a week in port and a week at sea, as many Atlantic liners, and there seems every prospect of a successful future for the mixed installation.

There are at present a good many advocates of producer gas engines for auxiliary drive, and though they would undoubtedly be a means of economy, it is somewhat doubtful if it is sufficient to warrant their adoption, since they cannot be started up so readily as the Diesel engines. They do, however, render the electrical generating plant independent of the boiler, which is a good principle, and it is possible that, under certain conditions of service, they might come into use.

Steam turbines of small size, both of the De Laval and Parsons types, have long been employed on ships—battleships, cross-channel steamers and liners—but they have, in most instances, only been used as auxiliaries to the main generating engines, in the case of battleships or, because of the very small space they occupy, for small boats, where the amount of electricity used is so small that lack of economy is of no importance. Should the size of ships increase largely in the future, and the electrical power needed likewise augment, there is every probability that turbines of moderate size (say up to 500 H.P.) will be used for generating. This has, of course, been done already on one or two ships, notably the "Mauretania" and "Lusitania," where four turbo-generators of 500 H.P. each were installed; and in very high-speed boats, where there is an enormous mass of machinery and so little available space, the turbine is likely to be preferred to the Diesel or other engine. The fact that practically no substantial foundations are required is a strong point in its favour, as is also its ready adaptability in running condensing, non-condensing and against a back pressure, when it is considered that these varying conditions are common at sea.

The question of voltage at sea and the future tendency in this direction is very debatable. Up to the present, or at any rate up to a couple of years ago, voltages of 100 were well nigh universal, and there has perhaps somewhat naturally been a timidity which caused shipowners to refrain from adopting a higher and more economical figure. The chief reason for this is the greater fire and personal risks involved, since it must be remembered that it is more difficult to maintain good insula-

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tion at sea than on land, owing to the presence of moisture throughout the vessel. While the electrical installation on ships remained small, the saving to be effected in cables by the use of a higher voltage was scarcely sufficient for the question to be raised, but with the advent of very large equipments the matter is somewhat different. At 100 volts the cables become abnormally heavy, and, apart from the cost involved, they are very difficult to fix, and the system now adopted on most of the new British battleships is a three-wire arrangement with about 220 volts across the outers from which the power circuits are taken, and 110 across the inners for the lighting and some special circuits. It is very probable that as confidence is gained, and immunity from breakdown is seen, this will become much more common and even higher voltages will be employed, always provided that the wiring is carried out under most careful supervision—a point which it is impossible to emphasise too strongly.

It is curious that when electricity was introduced on ships nearly 30 years ago alternating current was employed, dropping into disuse almost immediately—particularly when electric power became a feature of the installation—while at the present time there is a very strong feeling in many quarters towards its rehabilitation. There is no use denying the fact, only too well known to marine engineers, that commutators are a nuisance—not to put too fine a point on it. Motors and generators receive practically no attention, and the former are extremely badly used. Starters are at the mercy of all and sundry, owing to the shortsighted policy of shipowners in limiting the electrical staff to the irreducible minimum, with the result that burnt-out armatures are almost the rule and not the exception. All this points to the advisability of the adoption of alternating current, with the consequent absence of commutators, and the employment of fool-proof motors capable of standing almost any treatment at the hands of incapable men. The objection, as regards the low starting torque of induction and synchronous motors, is not of great importance since most of the motors used at sea are employed for purposes where high starting torque is not essential, and in cases where considerable variation of speed is required special controllers can be used. As is the case with practically all questions of this sort, however, there is much to be said on both sides, and if we may predict that in the future alternating current will be extensively employed on ships, it need not imply that direct current will drop into oblivion; each system will have its use, and all will depend on the class of ship and the purposes for which electric power is required.

Mr. Durtnall has evolved a system of auxiliary drive with alternating current which may be mentioned in this connection as a possibility of the future which shows much likelihood of economical running and suitability for all conditions of service. The generator consists of an alternator and four or more rotating transformer generators mounted on the same shaft, driven by the prime mover, all of them being small, so that the length and weight are but little greater than with an ordinary machine of the same power. The number of ship's main circuits corresponds to the number of machines, and the regulators of all the motors on the boat are connected to each of them, so that power may be taken from any at will. If the current be taken direct from the alternator (that is, from its lead and the common return) the periodicity is a certain comparatively low figure; if the supply be taken from the first transformer generator, the periodicity is rather higher, since the current from the alternator has passed through the primary of the transformer generator, so that the direction of the rotation of the flux due to it is the same as the direction of mechanical rotation in the primary. The periodicity of the current taken from the secondary is, therefore, the sum of the two periodicities—that due to the alternator and that due to the transformer generator. This process is repeated through the remainder of the transformer generators, and a great range of periodicity obtained. All the motors can therefore be operated economically, speed and torque being varied by changing the frequency of supply without the introduction of wasteful and bulky resistances.

Most of the auxiliaries on ships have now been electrically driven though there are many in which this is most uncommon. Perhaps almost the only exceptions are the air pumps for the condensers and the boiler feed pumps. There is no reason why the former should not be adapted to electricity, as is common on land, and it is rather remarkable that this has not been carried out. It is notorious that all steam-driven auxiliaries are uneconomical in steam, and it is chiefly lack of confidence which has partially prevented their being operated by electricity. Circulating pumps for the condensing water are eminently adapted for electric drive, and the addition of these two most important auxiliaries to the electrical installation will have the effect of lowering the cost of production of electricity to a very considerable extent. Boiler feed pumps are not likely to be converted to electricity, and even in central stations on land they are almost invariably steam driven, the difficulty being the large range of speed required and the undesirability of the use of rheostats for obtaining the variation.

In England electrically operated steering gear is, except in the case of one or two small yachts, practically unknown, and it is in this field that great advances may be expected in the near future. The present method of steering by large and cumbersome steam steering engines operated by mechanical means is not fully satisfactory and the reverse of economical. An electrical system can so easily be safeguarded against breakdown without large additional primary cost that it would probably work out considerably more cheaply than the steam-driven gear which is frequently in duplicate on large ships. The ease with which ships could be steered from two or three points merely by taking wires to these places is an advantage upon which it would be difficult to lay too much stress.

There are many ways in which an electrical steering gear may be designed. Two methods are already in use on several Russian and American battleships, and there is little doubt that these, or modifications of them, will shortly become common throughout the world generally, both for battleships and for mercantile boats. One of these gears consists of two similar motors coupled together through differential gear between them, by means of which an increase of speed in either will cause the shaft operating the rudder through further gearing to rotate in a direction dependent on which motor is accelerated. Since the differential gear is between the two motors, the armature shaft of one of them is hollow, and the steering shaft working the rudder passes through it and revolves within it, being supported in bearings at each end. The variations of speed of the motors are obtained by simple switchgear, which can be installed at various points. In another system there are two similar rheostats, the contact arms being operated respectively by the steering wheel in the navigating house and the rudder, and are so connected that when the arms are in corresponding positions no current flows through the circuit. The navigating rheostat controls the current supplied from the ship's circuit to the exciter of a motor-driven dynamo, which delivers its power to a motor operating the rudder through gearing. On working the wheel in the navigating house the steering motor starts up and moves the rudder until the contact arm attached to it reaches a stop on its rheostat corresponding to that of the rheostat in the wheel house, when current ceases to flow and the motor stops.

In view of the revolution which the introduction of metal lamps has caused on land, and their great increase in economy, it might be supposed that these lamps would find ready adoption at sea, but this is not the case. In the ordinary way a very large number of lamps are broken on every voyage due to vibration, and it has been found inadvisable up to the present time to employ those of the metal filament type, since they are of course considerably more fragile than carbon lamps. But the construction of the filaments is every day being improved and their reliability becoming very much greater, and there is a distinct possibility that in the near future metal filament lamps may replace the older type, though it must be noted that on modern ships the power required for lighting is quite small compared with that needed for motors, and the consequent actual economy in steam is so small as only to warrant the change if the reliability is in no way impaired.

Electricity has a wide field before it on battleships, though it

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must be admitted that the British Admiralty has been by no means conservative in the matter. Electric mounting for guns is still far from universal, though there are many undeniable advantages, and it is more than possible that the slight dissatisfaction in some quarters is due to an incomplete acquaintance with the best methods of usage. There is really very little doubt as to the future final adoption of electricity for all guns, and the fact that so many operations are required for each shot fired is a point in which hydraulic power is at a great disadvantage.

There is one question which must not be lost sight of in estimating the future possibilities of electricity at sea, and that is the necessity of educating marine engineers and impressing the fact upon shipowners that a large electrical installation cannot be left to run itself. It has in the past been all too common to have a totally inadequate electrical staff, and when the inevitable failure occurs—due to neglect—the fault is apt to be put down as inherent in electricity, whereas in most cases it is simply the result of imperfect supervision. Nothing could be more economical and reliable than electricity for nearly all the appliances at sea, but it is totally unfair to give it only half as much attention (and that often unskilled) as would be considered necessary if steam or hydraulic power were employed, and if the extension of the use of electricity at sea is to be as rapid in the future as we hope, this fact must be kept prominently to the fore.

The Evolution of Electrical Engineering in the Navy.

Summary.—The progress made in the employment of electrical apparatus in the navy from the earliest days is discussed, stress being laid on the difference in the conditions which exist on board ship compared with those on shore. The general lay out of the electrical equipment and the way in which it is maintained is then described, while the methods employed in lighting the ship and the directions in which the electric motor is employed on board a modern battleship are also considered.

The extent to which electricity and the electric drive are at the present time employed in the Navy has been prominently brought before the public by the recent discussion on the relative merits of electrical and hydraulic machinery for operating the main armament. On shore the average man nowadays looks upon electricity as one of the obvious things of life. The electric tram has ceased to astonish, while wireless telegrams have long ago lost their freshness. It, therefore, seems only natural to him that the same condition of things should exist in the Navy, that electric lighting and motors should be numbered among those things that are taken for granted, and used without any inquiry as to their why and wherefore. This is, however, scarcely the case, and for reasons which rest at bottom on the fundamental differences between a landsman and a sailor. A landsman, unless he be of a more than ordinarily enterprising nature, is willing to use the "benefits of civilisation" without attempting to find out their inner meaning, while, on the other hand, a sailor is the human embodiment of that mind which wants to know how everything works. He will, therefore, examine carefully the details of every piece of machinery which it is intended to use, adapt existing plant to his own requirements and generally strike out a line for himself.

These are, indeed, the reasons why the advantages of the electric drive for barbettes have not yet been recognised by the Navy as a whole, but it must not, therefore, be supposed that electrical engineering in the Navy has made no headway. This is far from being the case; in fact, for the very same reasons as those given above, paradoxical though it may seem, the progress of electric lighting and power in the Navy, especially during the last few years, has been extraordinarily rapid. At first much time was spent in adapting landsmen's plant to sea-going conditions, and to the discovery by experience of what arrangement worked best under gun-fire or in a heavy sea. But when these necessary preliminaries had been accomplished development in every direction was the immediate result.

Electricity was first used in the Navy for searchlight working. Small steam engines driving low-pressure (65-volt) dynamos were employed, each set supplying one light. It was, however, not long before the advantages of this system of illumination for wider purposes were recognised and arrangements made for lighting the cabins and other parts of the ship when the searchlights were not in use. This first step was followed by the introduction of electric lighting in a more extended form, and by degrees every ship was illuminated throughout by this means. The use of electricity for power purposes was not recognised then, or, indeed, till long after, such auxiliary machinery as there was at that time being driven by small and inefficient steam engines supplied through long lengths of piping in which no inconsiderable amount of steam condensed. The end of the first chapter of electrical work in the Navy, therefore, shows us the ship mainly electrically lighted throughout off low-voltage circuits. This stage, in fact, very fairly represents the state of things at the end of last century.

It soon became recognised that owing to the increasing size of the ships, and the consequent longer lengths of cable, the voltage then in use was too low for economical working, and 80 volts was therefore selected as the standard pressure. This pressure question again came up for consideration when the electric motor was first introduced in a small way, for it was naturally found cheaper to raise the voltage than to increase the copper. The voltage was primarily raised to 100, then to 105, while in the latest ships the pressure employed is 220 volts.

We may seem to have rather unnecessarily insisted on the voltage question, but here, again, the difference between land and sea-going conditions must be noted; and as this difference will continually crop up in what we have to say hereafter and is really not a little responsible for the present design of electrical apparatus in the Navy, it may be worth while to digress and to give a short sketch of the way in which electrical plant is operated on board one of his Majesty's ships.

At the present time all the electrical apparatus is in charge of the torpedo lieutenant, who is a commissioned officer. But the line of demarcation is drawn very sharply, and his responsibility begins at the dynamo and ends at the motor, irrespective of what machine is being driven, while he has no jurisdiction over the steam plant. This officer has under him a number of torpedo ratings, including one or more petty officers, who are, in turn, assisted by ordinary seamen, the actual number depending on the size of the ship. The officer and petty officers have all been through a course of instruction in electrical work on H.M.S. Vernon, and are thoroughly well acquainted with the plant employed in the Navy. But their outlook is necessarily narrow, and they view with a natural distrust anything they do not quite understand. In making this remark it must be understood that no reflection on the intelligence of naval electricians as a class is intended. But electrical engineering is a special subject, and even in civil life a man cannot expect to obtain a working knowledge of

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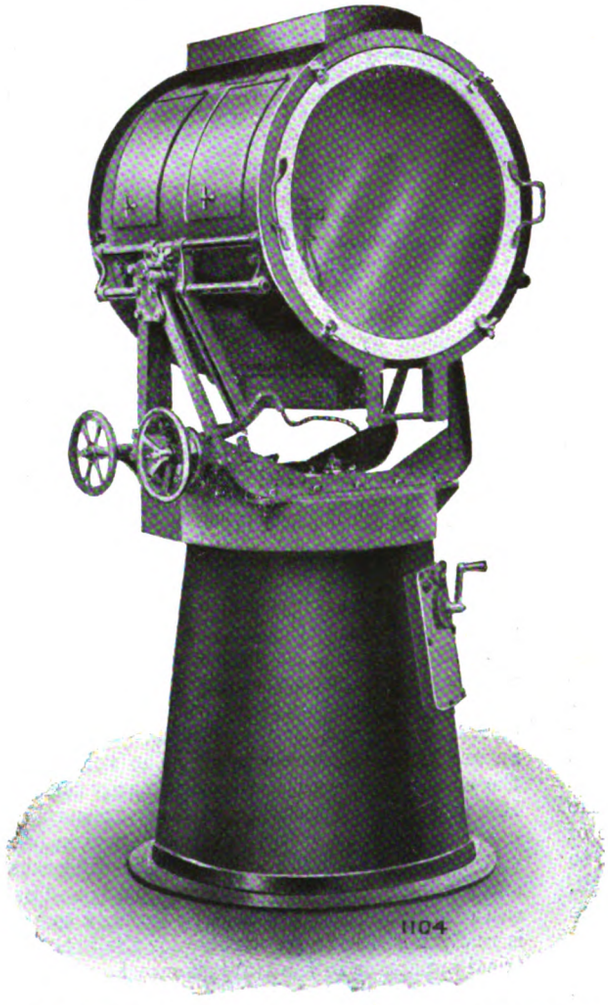

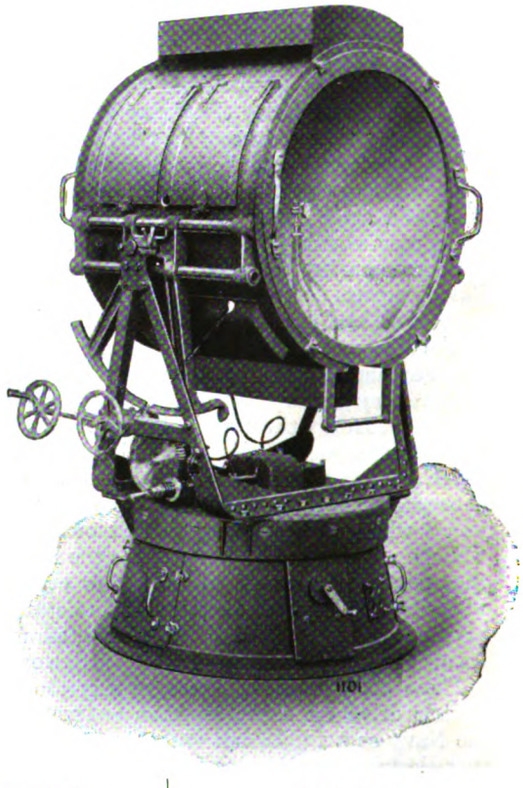

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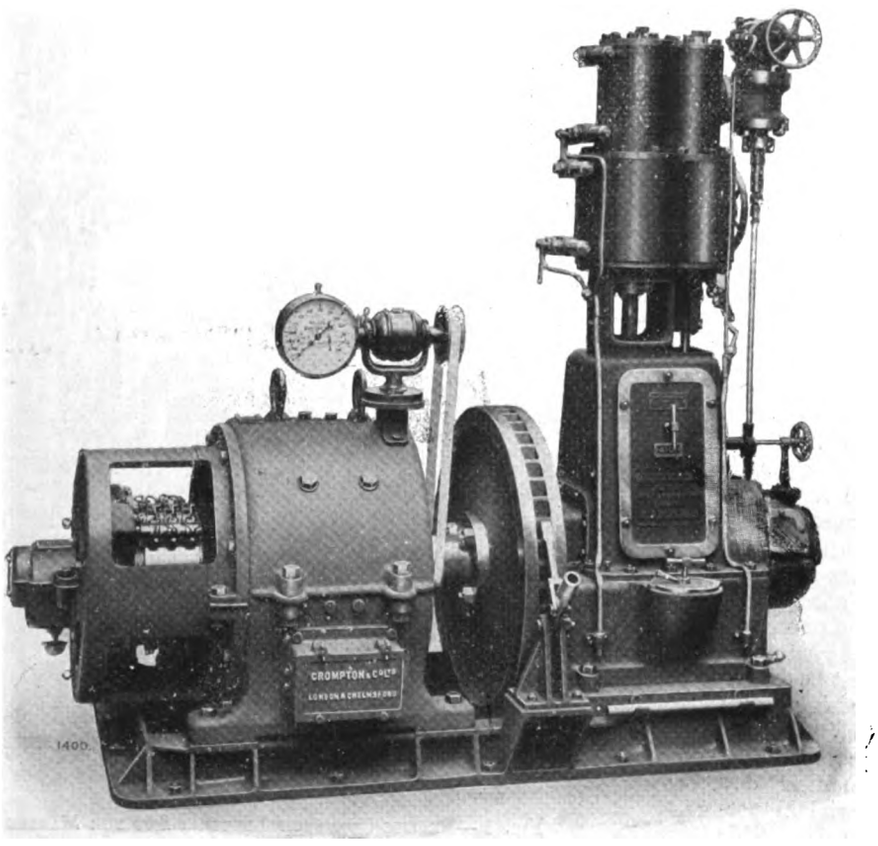

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every branch and phase of this very varied subject. Moreover, a civil electrical engineer has at least been trained in engineering from his youth up, while a torpedo lieutenant has only been able to take up electrical work as part of multifarious other duties. In the development that has been recently taking place, therefore, these officers and men have been hard put to it to keep up-to-date, and it is, therefore, scarcely surprising that there has been a certain amount of opposition to, or, perhaps it would be better to say "out-of-phaseness" with, the new *régime*. This has been especially so with regard to the question of voltage. In the early days, when electricity in the Navy was still in the experimental stage, and the best type of apparatus to use had not been determined, the equipment became easily damaged and shocks were sometimes obtained in unexpected places. Now, no one who has not experienced the effect can judge the magnitude of the shock that may be received even from an 80-volt circuit, when the recipient is standing on an iron deck that is in contact with the hull of a ship which is in turn immersed in sea water. The effect is literally electrifying. For this reason many naval electricians viewed with distrust the tendency to increase the voltage further. Simple arithmetical calculation will show that if the shock received from a 50-volt circuit be unpleasant, that from a 100-volt circuit is terrifying, while naval language on the subject of 220-volt circuits may be better imagined than expressed. In spite of this, however, it became an absolute necessity that the pressure should be raised, and, as this increase coincided with a better design of apparatus and a greater knowledge of electrical phenomena among the various ratings, the anticipated troubles have not been realised, and no more danger or unpleasantness is experienced with 220 than with 50 volts.

In this connection it may also be pointed out that the work of maintaining the electrical apparatus on board ship is hedged about with difficulties quite different from those met with on shore. In the first place there is the question of the *personnel*. We have said above that a certain number of men are told off to superintend the electric installations, but their number is by no means sufficient to do all the work, and they can at best only act somewhat in the position of charge hands. The labouring work, and even many of the more skilled operations, must be carried out by some of that large floating population which exists on board ship, by the sort of man who is one day painting, another day scouring, and another day replacing fuses—in fact, the original personification of the Jack of all Trades. This method of working obviously requires that all the apparatus should be sturdy and at the same time easy to understand, for to "take a brick and knock it" is the matlot's universal remedy for anything which will not work exactly and at once as it is wanted to. Further, when the motion of the ship is superimposed upon that of the plant, problems arise such as are never met with on shore. The design of a hoisting motor which will work at all angles to the horizontal requires some thinking out, while it must not be forgotten that such a motor may have to work and live in a cramped ammunition passage, where the ventilation is of the slightest. A ship, too, is not always in touch with the shore, so that large repairs cannot be made without difficulty, though each modern warship carries a fitters' shop. It is, moreover, highly essential that every part of the electrical apparatus should be capable of performing its work at a moment's notice, even after it has been standing idle for weeks in by no means ideal surroundings. It may be said that as a result of many years' experience these conditions are now fulfilled, and are reflected in the specifications on which the manufacturers have to tender. The Admiralty will take no electrical gear which, on the face of it, is not of the very best, and will not keep anything which has not shown itself capable of operating successfully both in the Indian Ocean and the Arctic Ocean, in the ammunition passages and on the boat deck. This is certainly as it should be, for the safety of the country depends on the good operation of this electrical apparatus at critical times.

We have seen that the electrical equipment of a modern battleship is made up of apparatus that can easily be looked after by an unskilled, though highly intelligent, *personnel*, that can be worked under a variety of very arduous conditions, and that is safe to handle in places where a low voltage shock is much more dangerous than on land. It may be as well now to come to particulars and to consider in some detail the various uses to which electricity is put in the Navy.

As regards the system of distribution, it was soon recognised that great precautions must be taken against damp, and in the older ships ordinary insulated cable was placed in impregnated wood casing, whose grooves were filled up with red lead. This method had certain obvious disadvantages—it was messy and the cables were not easy to get at. It has now been superseded by lead-covered wire, which is fastened direct to the bulkheads by brass clips. The wiring is not concealed, and, except at places where it is very liable to damage (for example, near bulkhead doors), it is not protected otherwise than by the lead covering. Where it passes through the deck special watertight stuffing boxes, rising some 8 in. from the deck, protect the cable, and in places where damage to the covering is likely to occur protection is afforded by covering the cable with sheet iron. No joints are made, but an ingenious system of sub-division in special distributing boxes is used. At the points where the wires enter the boxes an arrangement of soldered glands is employed to ensure watertightness, which is, of course, a very important point on board ship. The main circuits are metallic throughout, and leaving the main switchboard pass along one side of the ship returning along the other to the switchboard again, thus forming a complete ring. They are broken up on the way by a number of section boxes, from which sub-circuits are taken off to distributing boxes. In these latter boxes the circuit is further sub-divided and the lights supplied through suitable switches. This system, though it may appear unnecessarily complicated,

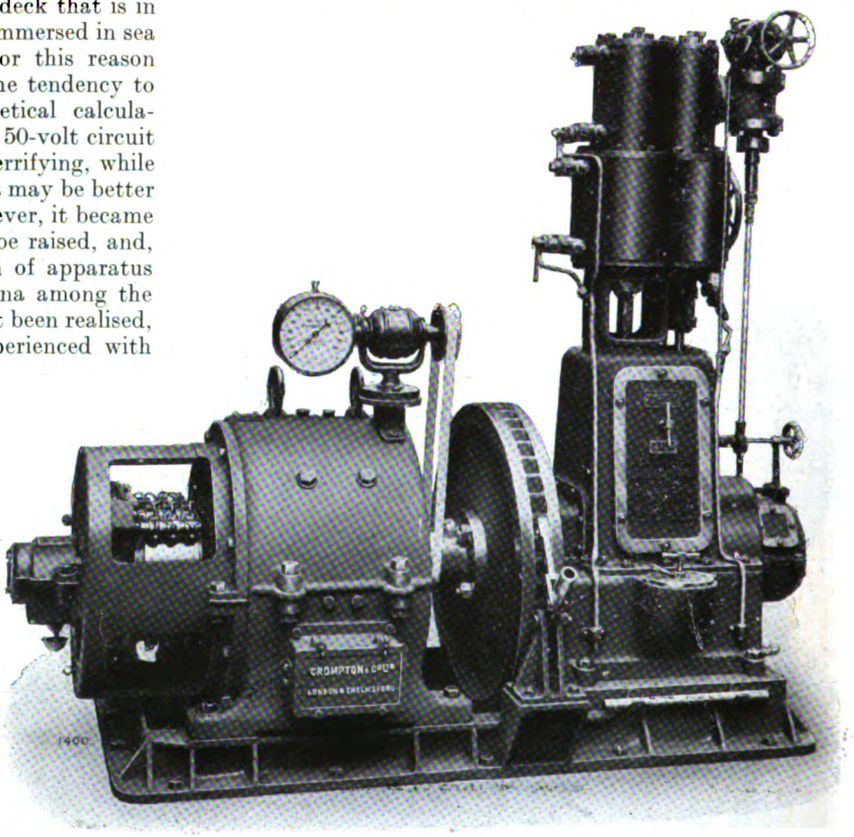

FIG. 1.—BELLISS-CROMPTON LIGHTING SET FOR MARINE WORK.

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is really best able to fulfil naval conditions. The ring main system allows every lamp to be fed in two ways, and a further advantage is that a faulty circuit can be cut out with a minimum of disturbance to the rest of the installation. Ample fuse protection is provided, while circuit-breakers on the main switchboard and copper links in the section boxes allow the whole of the circuits to be most easily controlled. The arrangement described above applies more particularly to the lighting of the ship, though smaller motors are also grouped on one switchboard circuit and sub-controlled from section boxes. In the case of the larger motors, however, the rule is, one circuit one motor. This arrangement has its advantages, as will be gathered when it is mentioned that the current required by the after-capstan motor is sufficient fully to load one generating set. As regards the switchboards very little can be said; land criteria are followed as far as possible, though questions of space limit the distance at the back of the board and between the switches. Special arrangements are made for taking the arc, and the current-carrying parts are suitably protected to prevent any accidental contact when the ship is rolling.

The lighting of an average battleship is usually carried out on distinctly generous lines. At one time lamps whose filaments terminated in two copper loops were used. The supply leads were brought into a special holder and bent round into hooks on which these loops were hung, the necessary good contact being obtained by a circular spring placed over the base of the lamp. This arrangement was supposed to combat the evils due to vibration, but after much experiment it was found that more casualties resulted from attempting to fit the loops over the hooks than from vibratory causes; and the use of these lamps has, therefore, been abandoned, those with ordinary bayonet caps being now employed. In most parts of the ship the fittings used are remarkable for their simplicity. Bulkhead lamps are protected by a glass watertight shade which is, in turn, covered by wire network, and a similar arrangement is followed with regard to bracket lights. Magazines and other dangerous places are usually lighted from the outside. It may in general be said that whenever any artificial light is required at the present time electricity is used. Incandescent lamps are mostly employed, though a certain number of arc lamps are carried which can be used on special occasions. In this connection it may be mentioned that a number of spare ways are provided in some of the section boxes to which temporary wires can be attached when extra lighting is required for coaling or other special purposes.

Perhaps one of the most important problems which is exercising the minds of naval men at the present time is that of the disposition of searchlights. The subject is a very wide one, and as it is still in the melting pot it is impossible, and would, moreover, be inexpedient, to give any very definite information about what is being done. The problems of searchlight design are intimately bound up with those of protection. The methods taken for preventing our own ships from being seen, while at the same time turning the enemies' ships into as good a target as possible have both to be considered, and on the solution of these depends the strength and disposition of the searchlights used. The latter of these is perhaps the more important, and exhaustive experiments are at present being conducted to discover an arrangement which shall enable the gun-fire to be most efficiently directed.

Electrically, as much progress has been made with searchlights as with other plant used in the Navy. In the early days hand lamps with practically vertical carbons were used, of comparatively low candle-power and requiring a man to be always in attendance. These lamps have now been replaced by others of higher candle-power of the horizontal type and entirely automatic in action. In designing such a horizontal arc lamp cognisance had to be taken of the fact that the horizontal gear would not always be horizontal, due to the rolling of the ship. Special care had, therefore, to be taken to prevent any accidental contact of the parts and to arrange that the jarring of the ship should not cause the lamp to feed prematurely. Like other electrical problems in the Navy, this has been successfully overcome, and a lamp is now in use which, while automatic, is also unaffected by external influences.

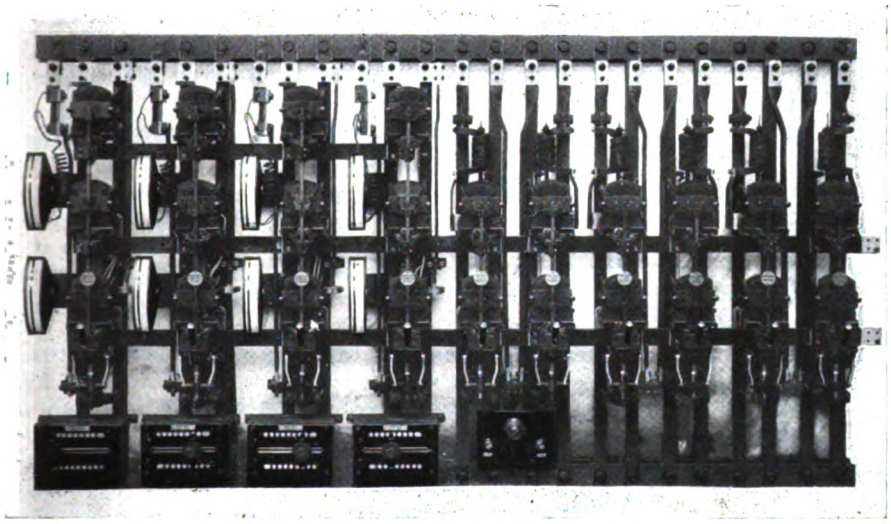

FIG. 2.—MARINE POWER AND LIGHTING SWITCHBOARD (CROMPTON & CO.)

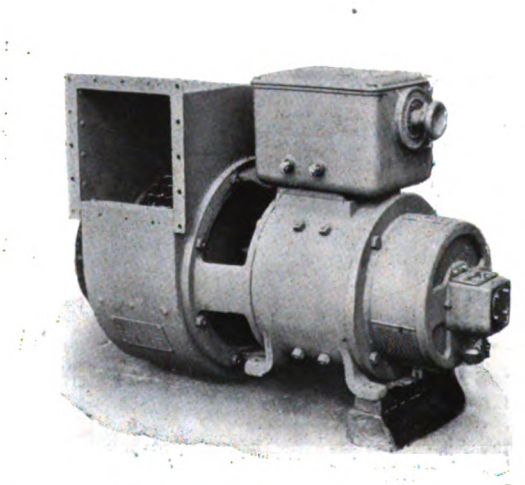

FIG. 3.—ORDNANCE FAN MOTOR (CROMPTON & CO.)

The adoption of the automatic lamp has also been the direct cause of the employment of another piece of electrical apparatus in connection with searchlight working. The movement of these lamps is now controlled from the bridge, small motors fixed in the base of the lamps being used to give the projectors the necessary elevating and traversing motions. Sufficient speed control is obtained by this means. In certain cases two projectors are fixed on a common base, so that the same motion can be imparted to both, while at the same time arrangements are made for moving each lamp independently.

Enough has been said to show that the use of electricity for lighting purposes on board ships of the Royal Navy is quite up-to-date, though the methods employed to attain the necessary end are rather different from those employed on land. The same remark applies equally well to power supply, in which connection the electric motor is finding an increasing application for the driving of the auxiliary machinery.

There can be no doubt that the low voltage employed militated for some time against the use of electric power to any great extent. And then, again, the authorities, following their practice of thoroughly examining a new thing before adopting it, were not at first quite sure of its advantages. The motor was first used in connection with the ventilation equipment, and even on the 80-volt ships, found an extended application

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for driving fans. The fans employed vary very greatly in size, those used for stokehold ventilation reaching as much as 36 in. in diameter, while those for ordinary ventilation do not much exceed 6 in. There is no doubt that the compactness and unity of the electric motor were always points in its favour. Steam-driven fans could not be placed anywhere, while even under the best conditions the necessary supply piping took up much more room than the cables. It is also hardly necessary to point out that the heating up of the connecting steam pipes and the condensation in them made steam working uneconomical, as the distance on board ship may be fairly great, while the prevalence of steam pipes made an atmosphere which is often none too good absolutely unbearable.

The design of the fan sets used is principally noteworthy for its compactness. The motor is direct coupled to the fan and the controller is usually placed on the top of the motor, two or more speeds being provided according to circumstances. The motors are totally enclosed, and the whole of the sets undergo a searching test before acceptance. The atmosphere of a stokehold is not of the best for an electric motor.

Special arrangements are made in the case of the ventilation of magazines, the air being drawn in over ice made by a refrigerating plant, which is also motor-driven.

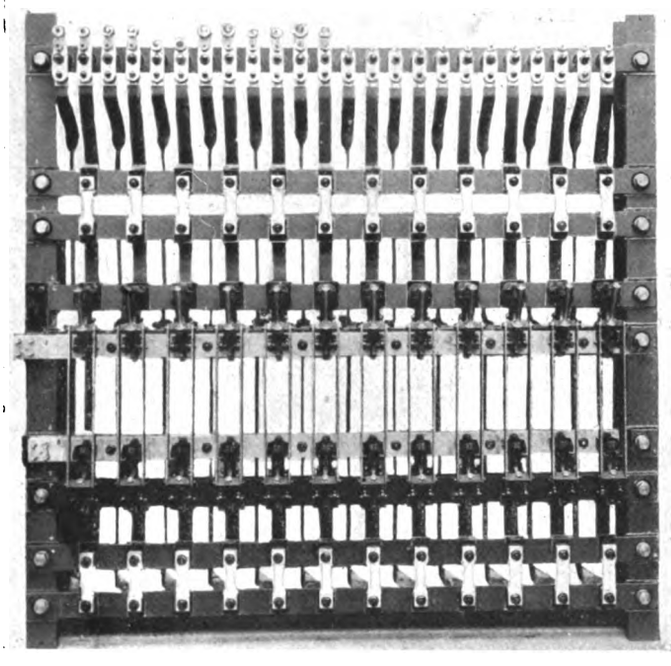

FIG. 4.—SWITCH PANEL (CROMPTON & CO.)

A large application of motors may be classed under the single word hoists. Electrically-driven hoists are, in fact, used in connection with the coaling, ash delivery, the supply of ammunition and the auxiliary boats, while the capstans mentioned above may also be placed under this heading. It would take too much space to go into the details of all this plant and would, moreover, serve no useful purpose, for as improvements are made the design alters and the description of one particular plant is not necessarily representative of a class. The necessity, however, for sturdiness in design mentioned above is exemplified in the following instance, which shows how the motor is applied to boat drill.

Each war vessel is provided with one or more steam-driven picket boats, which weigh five tons, and are used for conveying messages and passengers to the shore when the ship is lying in harbour. These boats are carried on special chocks on the boat deck and are hoisted and lowered by a motor. The movements are carried out in accordance with a drill, an officer on the bridge directing the man at the controller by means of flag signals. The motor's task would not be an easy one on land, for the load is both large and varying, but it is much more complicated at sea. If the sea is at all rough the directions of lift and the motor axis may be at constantly varying angles, while at the same time it is necessary that the motor should be brought to full speed practically at once, so that the boat may not be again touched by the waves after it has once left the surface of the sea. If this is not effected a chance wave may dash the boat against the side of the vessel, and at the same time, by taking the load off the motor, lead to double complications. It is, therefore, evident that the man at the controller must act instantly on the word of command and wholly forget that such operations as swinging the controller over to "full on" in one fell swoop are inherently bad for motors. Designers of boat-hoist motors are well advised when

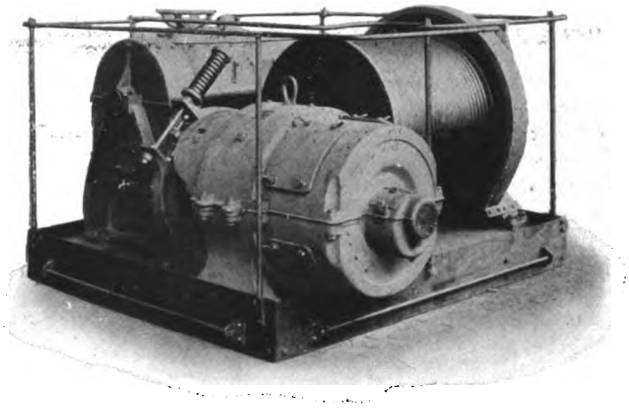

FIG. 5.—MARINE BOAT HOIST (CROMPTON & CO.).

they rate their motors and controllers generously and arrange for easily renewable contacts in the latter.

The motor is also finding an application for purely domestic purposes, for driving baking machinery, table fans and machine-tools. The problems to be met with in such cases are not different from those on shore, bearing in mind the variations mentioned above.

The one direction in which the electric motor has not yet fully established its claims is in the operation of the main armament. This is a matter which can scarcely be discussed here, but it may be said that success in this direction is merely a question of time and that the scare reports which have appeared recently on the unsuitability of the motor for this purpose emanate from circles who do *not* wish the motor to be a success—the wish being father to the thought. The problem is fairly clear; the motor has to move large masses very slowly and with great accuracy; given time and opportunity to experiment, the result can only be satisfactory.

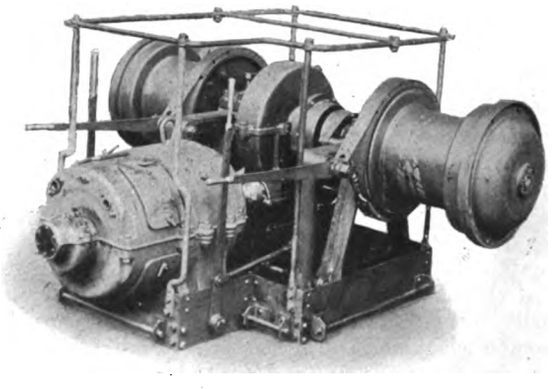

FIG. 6.—1-TON MARINE COAL HOIST (CROMPTON & CO.).

A part of the electrical equipment on board ship which is not the least interesting and certainly one of the most useful is that employed for signalling purposes. Both telephones and bells are largely used, code signals being employed in the former case. An ingenious combination of push and indicator

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in one fitting allows the return signal to be easily given and received. Loud-speaking telephones are generally used for communicating orders from the bridge to the engine rooms, from the conning tower to the barbettes and from the engine room to the stokeholds. This arrangement allows orders to be clearly heard above the din, while the recipient need not be close to the instrument.

Both the telephone and bell circuits are. in modern ships, worked off dynamos which deliver current at 15 volts, though in the old days batteries were used. These dynamos are driven by small motors supplied from the power circuits. In this way much more reliable working is obtained than with batteries, while, owing to the fact that the circuits are operated from a main switchboard, greater ease of control is possible. The method of wiring and distribution in general follows that described above, though multi-core cable is extensively used, and in this way each interdependent circuit is kept under one lead casing. Separate bell circuits in connection with the officers' cabins and the various ship's offices are also installed.

There are two other applications of electricity on war ships regarding which much has been done just recently, but about which, quite rightly, no information is made available. These are fire-control and wireless telegraphy. The first of these is a well-thought-out system of electrical signalling, whereby orders can be conveyed to the various gun commanders from the conning tower and other control positions. As regards the second the development of wireless telegraphy in the Navy has been exceedingly rapid. Its benefits were much more speedily recognised than those of other electrical apparatus, and a special system has been devised to meet special needs. Details about its operation are necessarily not made public.

In the foregoing paragraphs we have endeavoured to give some idea of the present position of electrical engineering as applied to the Navy, and to make it clear that, in spite of difficulties and differences, the progress has been just as great on sea as on land, and that steady headway is now being made. There still remain, however, one or two problems to be solved. The question of barbette operation is one, and has already been referred to; marine propulsion is another. Practically all the auxiliary machinery on board ship is worked electrically, and assaults are now being made on the main engines as well. The problem is being considered, and the claims of the electric drive in this connection are not thought chimerical by those "in the know." So much is this the case that on every occasion when the subject is discussed steam engineers travel long journeys to point out its disadvantages. A scheme with no backing of reality would not be worth all this trouble.

At the beginning of the article we gave some account of how electrical affairs on board ships of war were administered and endeavoured to show how the native talent of naval officers had been successfully applied to problems not of the everyday type. Under this *regime* on board ship progress was made, but there was little control on land, and it was not until fully qualified civil electrical engineers were appointed that things electrical really began visibly to advance. The Admiralty electrical staff is now controlled by Mr. C. H. Wordingham, who is, of course, well known to our readers, assisted in each dockyard by civil engineers of wider electrical experience than that obtainable in the Navy. This leavening of good with better has had excellent results, and it may be safely said that from a technical point of view the evolution of electrical engineering in the Navy at the present time is nearing the maximum.

Marine Propulsion by Electric Motors.

BY HENRY A. MAVOR
(Of Messrs. Mavor & Coulson).

Summary.—The author here investigates a special case of marine propulsion where the existing method of driving is admittedly efficient and cheap, and shows that while the possibilites of economy are restricted there is still a strong case for electrical methods. The logs of two voyages are used to illustrate the argument that the "load factor" is likely to be an important element in the consideration of economical working at sea as it is on land.

It has only very recently been generally recognised that the problem of propelling ships by electricity may be considered as taking a place in practical politics. The demand for some new method of dealing with the power on war vessels when long runs have to be made at speeds much lower than the maximum has led to special study of the possibilities of economy by electric transmission of power between the main generator and the propeller. On war vessels of the cruiser class it is certain that economy is attainable by the use of means now available for the purpose, and it is only a question of gaining the confidence of naval engineers and authorities by demonstration of these means to justify them in taking up a new line of development in naval work.

The war cruiser of 20,000 H.P. is a heroic stride from the largest existing examples of naval propulsion by electricity, and it is, therefore, well that the electrical engineer should endeavour to bridge the distance by making intermediate applications.

Few cases are available where the possibilities of economy are so conspicuous as in the war cruiser, and in all cases including the cruiser the outsider who attempts to deal with the problems of naval propulsion finds himself at a grave disadvantage. This is natural. The electrical engineer is much younger than the marine engineer. His experience is more diffuse. His ways of thinking are foreign to the ordinary practician in engineering science. His pretension to exactitude of forecasting results is derided. His previsions are unsympathetically assimilated. These prejudices have to be broken down by the Miltonian method: "Add deeds to thy knowledge answerable."

The prevalence in engineering workshops of the long-resisted electric power arrangements has already done much to win a respectful hearing for the electrical engineer who knows his business. He will get all possible help from the scientific marine engineers, but in attacking the problem there are several serious difficulties affronting. Every branch of marine engineering has for many years been the subject of repeated practical experiment and careful observation of results, so that there is a vast mass of empirical knowledge on each special point, and an essential adaptation of means to ends and of ends to means, which render it fundamentally difficult to make any change.

At the same time there is plenty of encouragement to the electrical engineer to proceed in his attack on this region. He soon finds evidence of the presence of conditions which make for the use of his special means of utilising and combating the forces of Nature. The case here to be specially examined is typical of many, where on the surface the appearances are discouraging because of the successful work already accomplished by the marine engineer, but where there is still a good field for

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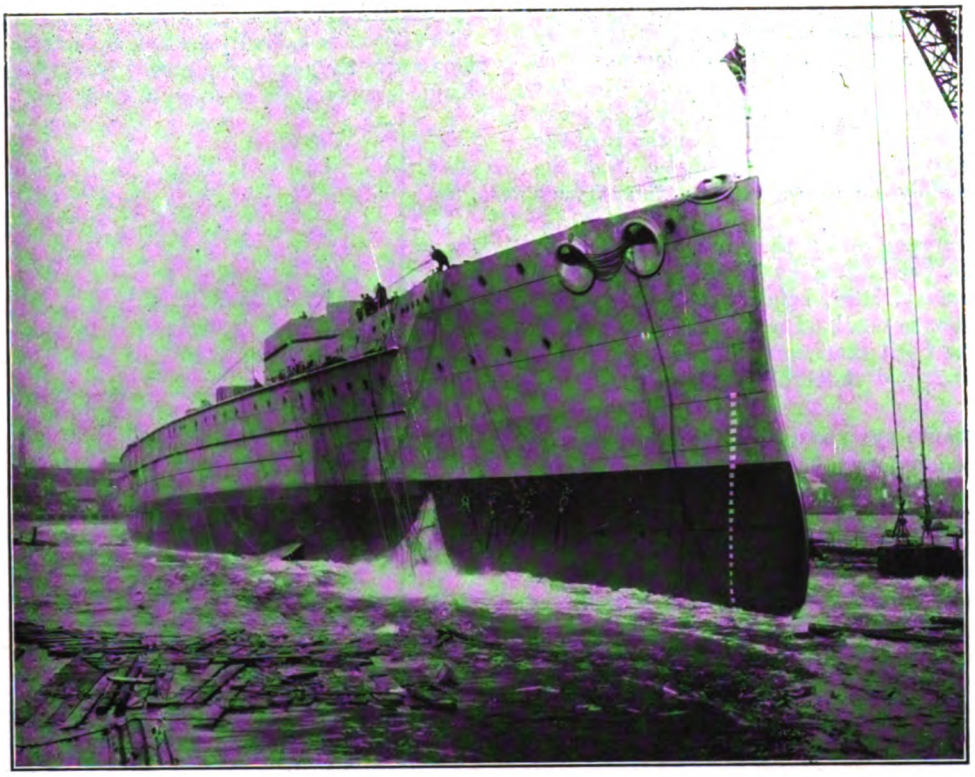

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the electrician. The character of the data of results of marine trials render them difficult of utilisation by the methods of the electrical engineer.

An example will make this clear. The records of trial trips are compared by the formula $\frac{\text{I.H.P.}}{D^{\frac{2}{3}}V^3}$, where I.H.P. is the horse-power developed in the engine cylinders, D is the displacement of the ship, and V the speed of the ship. The marine engineer says: "Here is a given ship; for what cost, weight of machinery and at what coal consumption will you give me the same I.H.P. to produce the same speed?" This seems to him a perfectly complete and fair way of stating the case; but to the electrical engineer such a question is absolutely meaningless, and it is not easy to put meaning into it. It is not safe to assume, although in most cases it is approximately true, that the propeller efficiency is the best attainable. It is rarely known what is the actual thrust imparted by the propeller to the ship.

If these two quantities were known, it still remains to be found what is the best attainable efficiency under the conditions of working to which the ship has to be subjected. This involves consideration of results of working the ship—in other words, the accumulation of a new group of data. All this looks very discouraging, but the application of the methods of the electrical engineer may be found to let daylight into the problem and may possibly be of service to the marine engineer.

The general principles upon which the proposal of electric Propulsion is based have been discussed by the present writer in Papers read in February, 1908, before the Institution of Engineers and Shipbuilders in Scotland, and in December, 1909, before the Institution of Civil Engineers. They need, therefore, be only summarily recapitulated here.

It is assumed—

That continuous currents are unsuitable for the purposes proposed because of the large size of the units, generators and motors, and because of the greater difficulty of dealing with large currents.

That, as it is now customary on land to generate all large currents as alternating currents, the same course should be followed at sea, and there does not seem to be any adequate reason for converting to continuous current.

That parallel working and synchronising are to be avoided, but that arrangements must be made for subdivision of the power equipment into convenient generating units, so that the load factor may be good.

Also that all switching arrangements for increasing, reducing or reversing power and speed must be of such a character as to be susceptible of instantaneous operation.

These requirements, it is claimed, have been met by the author's patented arrangements, which have reference to methods of combining the generator and motor elements.

The most important of the combinations are, first, that in which the secondary element of the generator or the primary element of the motor, which normally forms the stationary element, is rotated in a positive or negative direction by a concentrically arranged controlling motor, the connection being entirely magnetic and the currents used alternating. The use of this method gives a choice of periodicity or of speed of rotation, as the case may be, and, in the case of the motors, permits also of the independent application of two sources of power to one motor system, where they are added together without electrical connection.

In the second method, two or more generators are used at full power, each in connection with separate windings in the motor or motors, these windings being so proportioned that whatever may be their relative disposition they exercise no mutually inductive effect. These windings are arranged for successive connection to generators for change of speed.

It is to be noted that this is not simply a pole-changing arrangement. Although the motor is wound for two or more pole groups, these groups are at full power all in operation simultaneously.

For example, full power arrangement, three generators :—

—	Periods.	One motor having poles.	Synchronous speed per sec.
1. 4 pole, 6 revs. per sec....	12	24	1
2. 8 pole, 6 „ „ ...	24	48	1
3. 16 pole, 6 „ „ ...	48	96	1

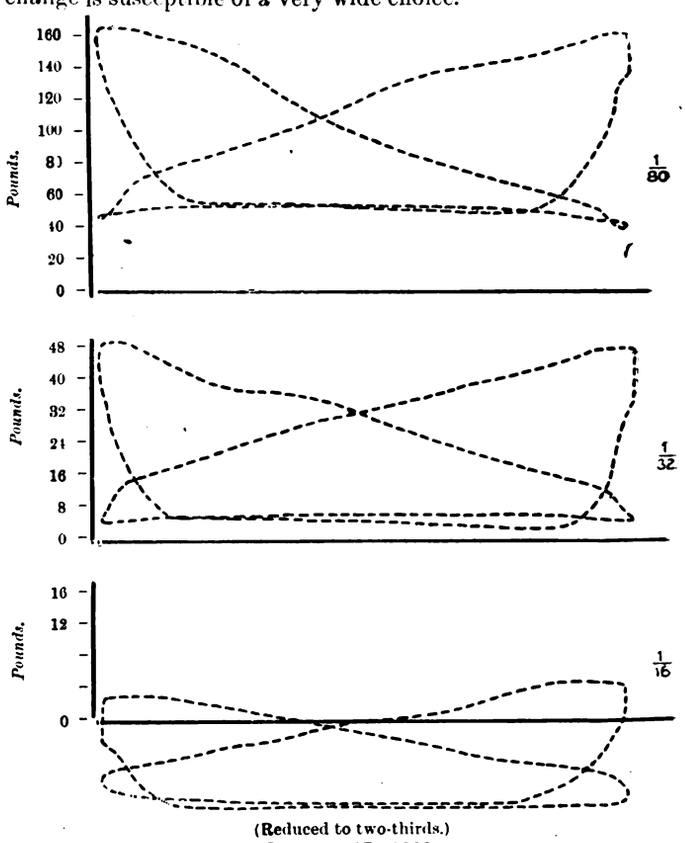
All three windings being laid in the same stator and at full power operating simultaneously on the same squirrel-cage rotor with the same resulting synchronous speed of 1 per second or 60 per minute.

The case supposed is one where the generators are driven by internal combustion engines.

Let now the arrangements be changed to two generators :—

—	Periods.	One motor having poles.	Synchronous speed per sec.
1. 4 pole 6 revs. per sec.....	12	48	0·5
2. 8 pole, 6 „ „	24	96	0·5

The speed is halved, the two generators being adjusted in size to give the required power. It will be seen that the speed change is susceptible of a very wide choice.



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OCTOBER 13, 1909.

The discussion on the recent Paper at the Institution of Civil Engineers turned principally on the proposed application to cargo vessels, and it may be of special interest to readers of THE ELECTRICIAN to study a type of this class of vessel from the electrical engineer's point of view to ascertain what may be the possibilities of economy.

This example is chosen, not because it is a favourable case for the application of electrical transmission—it is not a conspicuously favourable one; but because, being a well-developed example of the best result of long experience in dealing with the special problems involved, it may be taken as typical of the best accomplishment of the existing methods, and limits the discussion to regions which are beyond that attainment.

In this cargo vessel of the "tramp" type, designed for a given draught and speed in fine weather, the coal economy is as good as can be attained by a combination of turbo-electric generator and motor, but the changes in working condition produced by changes in trim and weather appear to justify the use of the new method so as to get a better *load factor*.

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The vessel is one of a fleet of many similar vessels carefully adapted to the work they have to do :—

Length between perpendiculars	370 ft.
Moulded breadth	52 ,,
,, depth	28 ,,
Draught loaded	23 ,,
Weight of hull	2,900 tons
,, ,, machinery	490 ,,
,, ,, cargo	7,194 ,,
Total displacement	10,584 ,,

Engine cylinders 25 in., 41 in. and 68 in. diameter × 48 in. stroke.
Boilers (three) 14 ft. × 11 in. natural draught, pressure 180 lb.
Total heating surfaces 5,868 sq. ft.
Total grate surfaces 165 sq. ft.
Bronze 4-blade propeller, 17 ft. 6 in. diameter, 17 ft. 9 in. pitch, surface 95 ft.

Comparison of three trials for which there are sets of indicator cards :—

	Nov. 1, 1907.	Oct. 13, 1909.	Dec. 10, 1909.
Displacement, in tons	5,041	10,000	4,500
Speed, in knots	12·4	9·8	9·8
Weight of coal per hour, estimated	3,450	...	...
,, ,, ,, measured	...	1,940	1,900
Indicated H.P.	2,038	1,265	1,096
Coal per I.H.P. hour	1·7	1·53	1·74
Estimated per shaft H.P. hour	1·9	1·7	1·93
Revolutions	72·5	56	62
Cut off on H.P. cylinder	0·608	0·45	0·47

Consumptions include steam steering, evaporator, and auxiliaries.

The first of the sets of indicator cards was taken on the "trial trip" of the vessel, the other two at sea on regular voyages.

The conditions of this trial are so abnormal that they are shown here simply for the purpose of general comparison. It would evidently be most uneconomical to drive this ship at 12·4 knots, and the engines are clearly not designed for this condition of working. They give a much better economy under the normal working conditions of a fully-loaded ship at a lower speed.

The other two records illustrate in a striking manner the incidence of "load factor" in ship propulsion.

Analysis of trial of October 13, 1909, for comparison with turbo-electric equipment :—

Assume value of coal at 13,000 B.Th.U. per lb.
Coal burned, 1,940 lb. per hour, as measured.
Total heat (assumed), $1,940 \times 13,000 = 25,250,000$ B.Th.U. per hour.

Boiler loss, assuming evaporation of 10 lb. water per lb. of coal from and at 212° — 25,250,000 — 1940 × 9,657	$6,650 \times 10^3$
∴ Boiler efficiency assumed = 0·73.	
Radiation and leakage	800×10^3
Cylinder condensation, &c.	$1,000 \times 10^3$
Driving auxiliaries and heating feed	$1,400 \times 10^3$
Steam in diagram— Cylinder volume $\frac{\pi(2\frac{1}{12})^2}{4} \times 4 = 13·6$ cubic ft. Cut off 0·45 = 6·1 cubic ft. Clearance 0·7 ∴ Total volume per stroke 6·8 cubic ft. at 0·304 lb. per cubic ft. mean weight at cut off × 1,100 B.Th.U. per lb. ; × 112 strokes per minute ; × 60 min.	$15,400 \times 10^3$
	$25,250 \times 10^3$

Heat efficiency of engine and auxiliaries in B.Th.U.
= 2,545 (being the heat equivalent of one horse-power-hour) × 1,265 H.P. ÷ $18,600 \times 10^3$ = 0·173.
Shaft H.P. (assumed) = 0·9 I.H.P.
∴ Heat efficiency of shaft H.P. = 0·155.

A single turbo-electric equipment for the same work would work out as follows :—

1,265 I.H.P. (assumed) = 1138·5 shaft H.P.

$$\frac{1138·5 \times 0·746}{0·93 \text{ motor efficiency}} = 910 \text{ kw.}$$

The guaranteed consumption of this plant would be 18·1 lb. steam per kilowatt-hour, including auxiliaries and all losses.

B.Th.U. per lb. steam = 1,100.

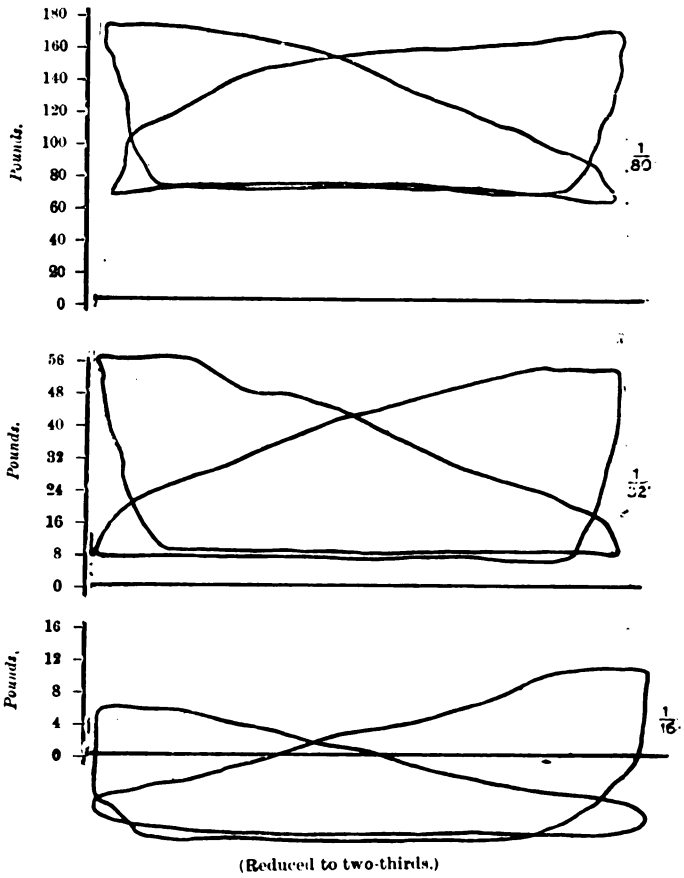
Kw.	Lb. per kw.	B.Th.U. per lb.	Total heat, units.
910	× 18·1	× 1,100	= 18,200,000

The economy of the turbo set would be slightly better than that of the normal equipment under the given conditions—

i.e., $\frac{1,138·5 \times 2,545 \text{ H.P.}}{18,200 \times 10^3} = 0·158$ of the total B.Th.U. delivered to the engine are accounted for by shaft H.P.

Evidently we have here in the existing reciprocating engine a highly efficient plant designed for its normal work, and not for the abnormal conditions of the trial trip in November, 1907, when the ship was run at a speed which would be very uneconomical in service. The cards taken on October 13, 1909, and on December 10, 1909, are typical, the first of the fully-loaded condition and the second of a half-loaded condition at normal speed.

The fully-loaded condition naturally gives the better result in respect of economy, and it has been seen that, making a reasonable assumption of mechanical efficiency, this result is so near to the economy of a turbo-generator motor combination at the same working pressures that no claim could probably be made on this score in favour of the substitution of the new method for the old. The daily log of the whole voyage



(Reduced to two-thirds.)
NOVEMBER 1, 1907.

of 22 days shows that the horse-power and revolutions were nearly constant over the whole period, and that the coal consumption varied little, although the speed of the ship varied from 7·55 to 9·9 knots average on the day's run by variation in resistance due to wind and sea causing a propeller slip varying from 0·007 negative to 0·215 positive.

The turbo-electric generator and motor equipment would be considerably lighter than the existing equipment, but it would cost more.

While accepting the position that on the voyage now in question the existing plant shows as good results in coal economy as a turbo-electric plant would show under the same conditions, we may digress for a moment to suggest that even here there is room for argument.

The great variation in resistance which is shown by the slip and speed variation is met by a change in speed of the ship till equilibrium is restored between pressure on propeller and piston. There is a great variation in propeller efficiency. The

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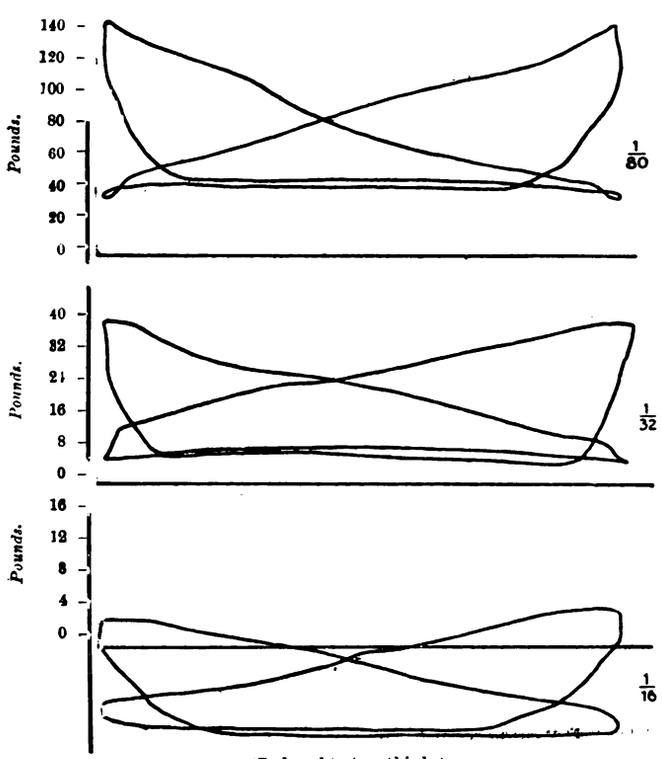
fine weather efficiency of the propeller is high, as high as could reasonably be expected. To increase the diameter to improve the efficiency in heavy weather is probably impracticable. To use twin or triple screws is possibly out of the question with reciprocating engines on account of space, weight, cost and loss of cargo space by tunnels; but an electric equipment might change all this and provide a more favourable arrangement also for the condition now about to be examined.

Racing and consequent loss of power take place in bad weather, even when the ship is fully loaded. It is argued that the moment to moment changes in load would be more economically dealt with by a turbine running at constant speed than by the reciprocating engine, which must work under disadvantageous conditions with a fluctuating load.

The above diagram, taken on December 10th, is typical of a voyage of 20 days in a half-loaded condition. Here also the vessel was subjected to varying weather conditions, so that



(Reduced to two-thirds.)

DECEMBER 10, 1909, 10-11 A.M.

the speed of the ship varied from 8·2 knots to 10·05 knots average on the day's run. The propeller slip varied from 0·04 to 0·391. The average revolutions per minute on the day's run is constant at 60, with the exception of three days at 50, 58, 59. The average horse-power is again nearly constant, and is 86 per cent. of the horse-power required to run the ship when fully loaded. But this horse-power is developed under much less advantageous circumstances. The cut-off is later, the steam is checked at the throttle, the mean pressure is much lower, the clearance losses are relatively greater, the propeller, being only partly immersed, races badly, wasting steam and losing way. All these losses would be obviated by the use of an electric arrangement in which the power on the ship would be divided into two units of the relative power shown on these two trips—*i.e.*, they should be in the ratio of the two values of the horse-power—viz., 1,096 and 1,265—1,096 = 169. Assumed brake horse-power = 980 and 152.

It is probable that the mechanical efficiency of the engine is much less at the lower power, and that 980 is too high an estimate of the shaft horse-power for 1,096 I.H.P., but this difference may be neglected in the line of argument here adopted; the principle is fully illustrated as it stands.

The motor would have two windings, and the general arrangement would be :—

—	Motor.					Generator.				
	B.H.P.	Poles.	Synchronous Revs. per sec.	Synchronous Revs. per min.	Actual revs. per min.	Kw.	Poles.	Revs. per sec.	Periods.	Revs. per min.
1st winding...	980	104	0·96	58	56	785	2	50	50	3,000
2nd winding.	152	94	0·96	58	56	123	2	45·83	45·83	2,750
1st winding...	152	104	1·06	64	62	123	2	53·6	53·6	3.220
2nd winding.	980	94	1·06	64	62	785	2	50	50	3,000

The two motor windings would be of equal area, and the larger unit would be run at or near its full speed and best economy, and on this voyage only one unit (the larger) would be required. It would run at full load all the time, and its coal consumption would be per hour :

$$\frac{\text{Kw.} \times \text{lb. B.Th.U. per lb.}}{\text{9,657 B.Th.U. per lb. coal}} = \frac{785 \times 18 \times 1{,}100}{9{,}657} = 1{,}620 \text{ lb. coal per hour}$$

as compared with 1,900 lb. used by the existing plant. A very handsome saving. When the whole plant is required at either speed of revolution the coal consumption would be increased by

$$\frac{\text{Kw.} \times 125 \times 22 \times 1{,}100}{9{,}657} = 310 \text{ lb. per hour,}$$

making the total coal, as has been said, about the same as at present.

The question for the owner is to evaluate the debits and credits on account of the electric proposition on the basis of the existing propeller arrangements in the first instance :—

Dr.	*Cr.*
Novelty and breach of conservative policy.	Saving in weight.
Extra cost.	,, space.
	,, coal on light voyages.
	Use of the small plant for cargo working.

In the case which we have discussed the owner has decided that in the meantime the balance is to the debit.

The matter does not rest here, but we may leave the argument for the moment at this stage, with the claim to have shown that the margin in favour of the existing arrangements has already been narrowed down close to the disappearing point, and that there is here a wide field for the electrician.

In the case chosen it is disputed that economy is possible and admitted that it is much to be desired. Probably the internal combustion engine may come to our aid in dealing with comparatively small powers such as here discussed, and enable us to proceed with confidence to the larger sizes, where it is much easier, owing to the higher efficiency of the larger sizes of steam turbo-generators, to show a decided advantage in coal economy.

One very great difficulty with which the electrical engineer has to deal may be emphasised in conclusion.

Marine engineers are accustomed to work on much wider guesses or estimates of the quantities with which they deal than are electrical engineers. They do not know that an electrical engineer's guarantee of efficiency can be checked to a degree of accuracy unapproached in any other branch of engineering, and they make claims of economy which the electrical engineer cannot dispute, but which it is impossible to verify. It is, therefore, necessary to show for the electric proposal a much larger margin of saving than is actually required to justify its adoption.

There are cases in which the margins are sufficient to satisfy the most exacting critic. These are the cases where large powers are used with wide and prolonged variations in the load factor.

In the smaller powers the method has to be demonstrated in more difficult and less remunerative cases, such as have been here discussed.

The discussion at the Institution of Naval Architects' spring meeting has added considerably to the knowledge of

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this subject by the experiments made by the Hon. C. A. Parsons in transmission by gearing. The present writer agrees with Mr. Parsons and the other speakers in the discussion referred to that the question of electrical propulsion must be compared with the older methods under conditions which are rigorously similar. There must be no mixing up of gains by the use of superheat, the assumption of propeller efficiencies obtainable only under conditions which are precluded by the working limitations of the ship, or other methods which are not at present available at sea. To do so is to obscure the issue and to alienate the sympathies of people who are expert in the business of marine propulsion.

A System of Turbo-Electric Propulsion of Ships

BY H. C. LEAKE.

Summary.—In the system here described ordinary three-phase generators and squirrel-cage motors are used, and speed variation of the propelling motors is obtained by varying the speed of the turbo-generators. To enable the motors to be reversed, braking drums are employed, mounted on the turbine shafts, and which may be described as a species of turbine designed to absorb power instead of to produce it.

General interest is being felt at the present time in the question of methods of improving the efficiency of turbine propulsion of ships. Among the methods that have been proposed the turbo-electric system ranks high on account of the advantages it seems to offer, and it may fairly be anticipated that sooner or later the enterprise of the shipping section of the community, both naval and mercantile, which collectively has so successfully led the way to advances in the past, will result in the carrying out of a trial on an adequate scale to verify the possibilities of utilising electricity for this purpose.

An account of a new system of turbo-electric propulsion covered by patents held by the British Westinghouse Electric & Mfg. Co. (Ltd.) may, therefore, be of interest at the present moment, as this system, the invention of Mr. J. N. Bailey, has not yet been described in any publication.

Before going into details, we may briefly refer to the leading points by which the relative merits or demerits of any electrical system for ship propulsion must be judged, without attempting to recapitulate those well-known advantages which can be claimed in common for all systems of electrical propulsion.

First and foremost is placed economy, and by this is meant economy in the most comprehensive sense, bringing in many points outside the province of the electrical power specialist. Steam per horse-power delivered to the propeller is only one element, as the question of the possible efficiency of propellers at various speeds of revolution also becomes of equal importance. The commercial or other value of any saving or excess of weight and space realised in engine room, boiler room, and coal capacity must necessarily enter into the complete problem. Lastly, the question of probable expenditure on running stores and attendance, maintenance and repair, is one that the marine engineer may be trusted not to lose sight of.

Together with economy, reliability and simplicity of the mechanical and electrical system necessarily take a high place. The chief engineer's share of the responsibility for the safety of a ship, whether naval or mercantile, is so onerous that he cannot be expected to welcome an aggregation of machinery in which, from want of familiarity, he does not feel confident of being able to locate any breakdown that may occur in working. It is, therefore, desirable that an electrical system should be as simple as possible in both mechanical and electrical respects, so that its action may be easily comprehended, which will tend not only to reduce the chances of a breakdown, but also will render it easier to deal with any trouble that does arise. As experience under seagoing conditions grows, the embodiment of complications might be found justifiable if superior advantages could be thereby obtained, as has been the case in the development of other applications of electricity that will occur to the reader; but, in the initial stages at any rate, a simple system is the one most likely to present a practical compromise between conflicting requirements.

Much has been written at various times about propelling ships by electrical transmission, but very little information has been vouchsafed by the advocates of various systems as to how they propose to stop the ship when in full motion. Yet in all matters of land transportation, such as railway trains, tramcars and motor cars, the attainment of high speeds under practical everyday running conditions has been due quite as much to the excellence of the braking devices as to the sufficiency of the propelling agent. Ships with propellers direct-driven by reciprocating engines, or by turbines with astern sections, possess a natural braking power, so that this point has not demanded special consideration; but with electrical transmission the situation is somewhat modified, and when engineers propound ingenious means of applying electricity to impart motion to a ship they should not omit to explain how they arrange to stop the ship quickly as well. In brief, rapidity of stopping and going astern are most important points to be provided for.

With any electrical system full power can be utilised when actually travelling astern.

There must be afforded a certain power of regulation of speed, but the particular requirements in this respect vary with different classes of ships, and each case requires detailed consideration on its merits. In the case of war ships, the exigencies of "station keeping" render it necessary to have a very fine adjustment of speed over a large range, whereas for mercantile ships the conditions in this respect are not so onerous, and it seems likely that with experience it would be found that regulation facilities essentially superior to such as are obtained in the case of electrically-driven trains were not as a rule indispensable. The question of speed regulation is, however, bound up with that of economy at reduced speeds, as to which the necessary requirements vary much in different cases.

An electrically-propelled ship of fair size must naturally in the first instance be considered somewhat an experiment, just as the early turbine-driven ships were experiments in their day. It is, therefore, very desirable that the essential elements of the propelling machinery of such a ship—viz., turbines, generators, cables, and motors—should be in as many respects as possible of standard and well-tried construction which has been well proved by everyday successful operation under the less onerous conditions of land service. In this respect we shall merely be following the precedent set by marine turbine development, as it was not until the genius of Mr. Parsons had perfected the steam turbine for land uses that serious attention was paid to its application to marine propulsion.

In the case of large ships with not less than two turbo-generators and two motors, it is worth considering to what extent any electrical system is well adapted to afford opportunities of minimising the effect of breakdown in any one part by means of temporary expedients, either designedly provided for as a precautionary measure or improvised when the occasion arises. In this way any increased liability to a breakdown due to the multiplication of parts in the chain of transmission of power, as compared with direct-driven propellers, may well be offset by the increased opportunities which electrical methods afford

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to make temporary arrangements to cope with such emergencies.

Coming now to describe the British Westinghouse Co.'s system, the motors direct coupled to the propellers would be of the alternating-current three-phase squirrel-cage type. Such motors are, as is well known, the most simple and robust type existing, and require neither commutator, slip-rings, brushes, regulating switches, nor resistances. In Fig. 1, which shows diagrammatically an arrangement for a ship with four propellers, the motors are indicated by A, A, A, A.

There would be two turbo-generators, B, B, each driving two motors, and consisting of a high-speed steam turbine fitted with a special device to be described later, and coupled to an alternating-current three-phase generator. The exciting current would be furnished by separate small generators, which would also supply current for other auxiliary purposes.

Each motor would be supplied with current by an independent line of three-phase cable, C, C, C, C. Each line of cable would pass through a simple reversing and isolating switch, D, D, D, D, which would be enclosed in iron cases located in accessible positions in or near the engine room. The voltage of transmission could be selected at any value desired within reasonable limits, and as the whole of the parts of the machinery which carry current at this voltage are stationary,

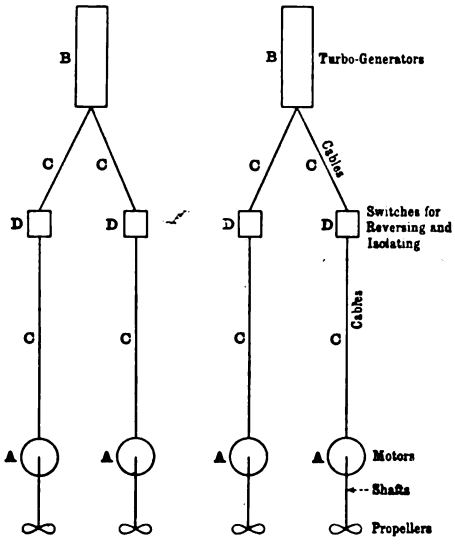

FIG. 1.—GENERAL SCHEME.

enclosed, and inaccessible to those running the machinery, there would be no difficulty in going to very considerably higher voltages than those at present used for power purposes on ships.

Each of the turbines would be fitted with a very powerful brake, one form of which would consist of some rows of stationary and moving blades so shaped and set that on turning steam into this part of the turbine sufficient resistance would be offered to the rotation of the drum to reduce its speed quickly. The amount of steam which could be utilised in the brake would be the same as would be available for driving the turbine in the ordinary way, and as questions of economy would not arise, it would be possible to obtain a very powerful braking effort with very little addition to the size and weight of the ordinary turbine.

With the exception of the exciting arrangements for the alternators, which being simple and of ordinary character have not been indicated, Fig. 1 comprehends the whole of the parts of this system which are vital to its effectiveness in respect to generation and application of the power; and, in view of the nature of the elements described, the claim for simplicity may thus far be well sustained. Any complication in construction or arrangement would be confined to the controlling apparatus, the functions of which will be explained later, but any derangement or breakdown in this controlling apparatus would not incapacitate the ship in any degree from propelling itself.

We may now consider the use of this system. The generators having been excited, in order to start the ship from rest all that is needed is to open the steam valves of the turbines, when the motors will start up with the generators, running almost in synchronism with them until full speed is reached. Any speed of ship may be obtained by suitably regulating the speed of the turbines in the same way as in present turbine ships. If when running at a considerable speed it is desired to stop the propellers and reverse their rotation, this, as is well known, cannot be done by simply throwing over the reversing switches D, D, D, D. To take this course without any supplementary measures would bring about, through electrical action, an excessive strain on both generators and motors.

It may be done if adjustable rotor resistances are provided for the motors, but the great advantages offered by the squirrel-cage motor must then be sacrificed, and, moreover, rotor resistances for such large powers as are likely to be required present considerable practical difficulties which are best avoided on ship-board.

A method that has been proposed in some electrical schemes with the object of enabling the squirrel-cage motor to be retained consists in breaking the generator field circuit in order to make it possible to throw over the reversing switch and then to build up the field again by gradual steps. This cannot be considered a satisfactory method, because, in order to develop any reasonable amount of torque, the current in the generator and motor would be excessive, so that, as the permissible current fixes a limit to the torque that can be exerted, this method is not adapted for stopping and starting a ship with the degree of promptness that is desirable.

By the British Westinghouse Company's system in the form described above the difficulty is overcome in the following way: Assuming that it is desired to change from "full speed ahead" to "full speed astern," steam is shut off from the working portion of the turbine and admitted into the steam brake. The motion of the ship in the ahead direction operating through the propellers drives the motors as generators, transmitting power back to the generator, and thereby driving the turbine. This power is absorbed in the steam brake, where any amount of surplus energy can be dissipated in a form which offers no difficulty in its disposal. The speed of the ship is thereby effectively and rapidly checked, until finally the speed of the generator and motors has fallen to a point at which the frequency is sufficiently low to enable the reversing switch to be operated without causing excessive current. Steam is then immediately shut off from the brake and simultaneously admitted into the working portion of the turbine. At the reducad frequency which the voltage applied to the reversed motors now has the motors are able to develop full load torque with normal current without the need of rotor resistances, and consequently a powerful effort can be exerted to check completely the motion of the ship and start it in the reverse direction. The turbine gradually runs up to full speed, when ultimately the ship travels astern with the same full power available as for propulsion ahead.

In order to illustrate the general nature of these operations, a diagram is given in Fig. 2, which shows graphically the general manner in which the various speeds, torques, &c., vary during the process of carrying out the order "full ahead" to "full astern." These curves are intended to be typical only, and are not to scale.

The various operations described—namely, shut off main steam, open brake steam, throw reversing switch, shut off brake steam, open main steam—are brought about automatically in the correct sequence and period by an electrically-operated controlling mechanism which is brought into action by any movement of the regulating hand wheel on the starting platform or elsewhere. It would unduly extend this article to describe the details of this controlling mechanism by which the steam valves and reversing switch are automatically operated, which mechanism may take various forms; but it is important to notice that the control of the ship, though impaired, would not be destroyed by breakdown in any part of this automatic controller, since the various operations which it brings about could

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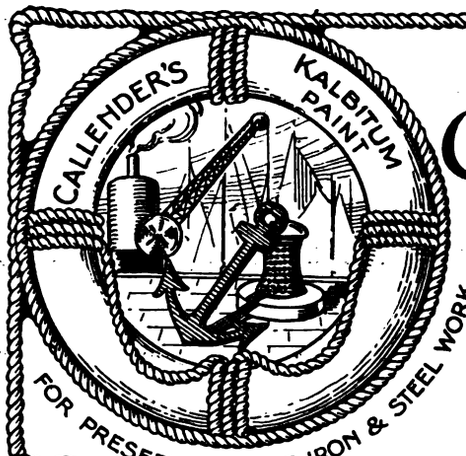

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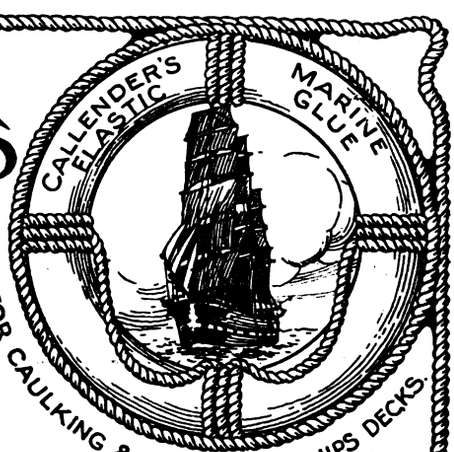

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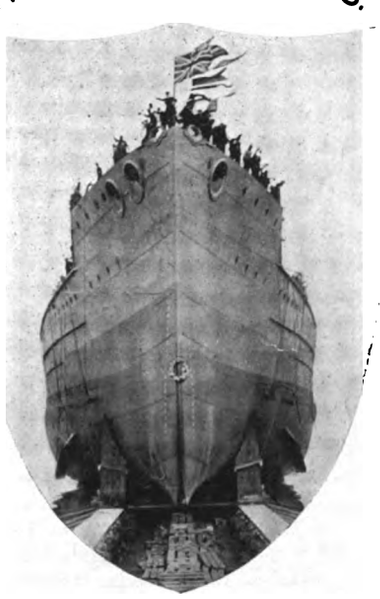

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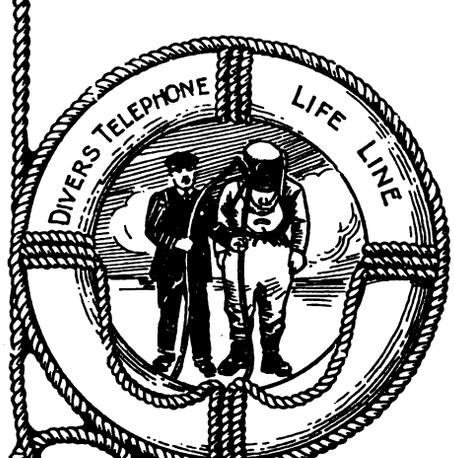

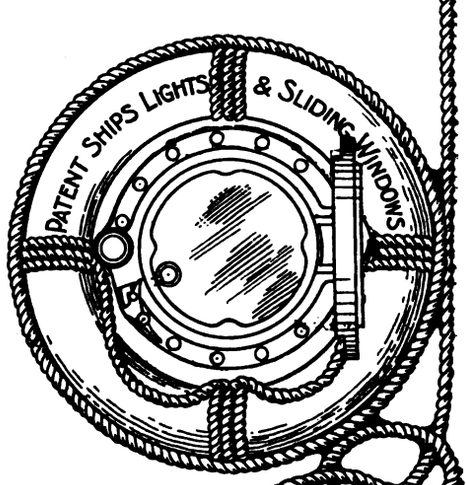

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in case of necessity be effected entirely by hand equally well, though not so expeditiously. The controlling mechanism is the only part of the equipment in which there is any degree of intricacy, but the ship would in no way be disabled even by some derangement of this part.

A similar cycle of operations, except for reversing, would be followed when reducing from any speed to a lower one, the object then being to cause the speed of the ship to respond to the control hand wheel in the shortest possible time; but, of course, this cycle would not be brought into action when increasing speed.

The system lends itself excellently to direct control from the bridge in the event of this being required.

From the particulars that have been given it will be seen that thus far the British Westinghouse Company's system embodies the desirable points, that great economy can be attained at full speed, that full power can be utilised for checking the speed of the ship and for travelling astern, and that any speed from zero to full speed can be obtained; but in respect to relative steam economy at reduced speeds, compared with that at full speed, there cannot be much advantage over direct-coupled turbine ships, as in each case reduced speed of ship entails a reduced speed of turbine, though the absolute economy in the former system may perhaps sometimes be superior.

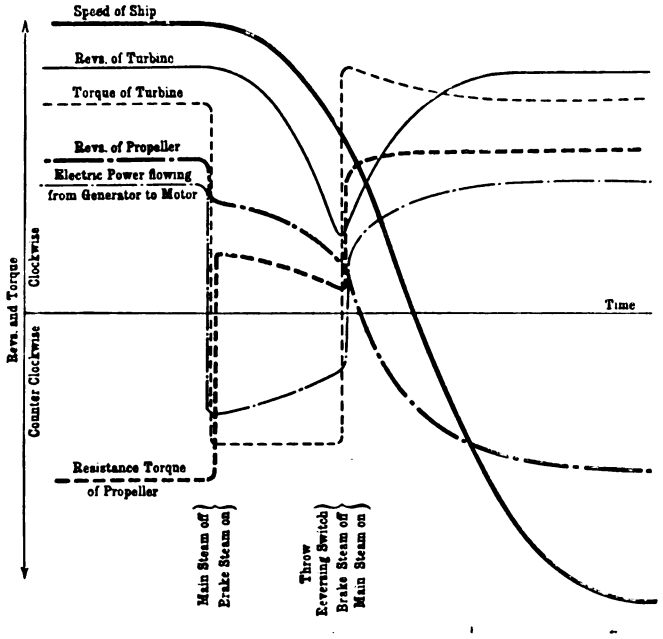

FIG. 2.—FULL AHEAD TO FULL ASTERN. (TYPICAL CURVES.)

Propeller assumed left-handed. Going ahead requires clockwise rotation of propeller (looking aft), and resistance torque is counter clockwise.

It depends very much on the special circumstances of the individual case whether the attainment at reduced speeds of better economy than this system gives is of importance; but, if necessary, such as is the case with warships, there are various ways of arranging for this. Any method which is now applied to improve the economy of direct-coupled turbines at reduced speeds is also applicable to the electrically-driven ship, and, in addition, there is a gain in that the whole of the propellers may be grouped on one turbine where more than one is fitted, and the other turbines be shut down entirely. Or by varying the number of poles of the motors by means of pole-changing switches, the speed of the turbine may be kept up to the full at a reduced speed of the ship.

In some cases it may be found justifiable to instal a single small turbo-generator to drive all the propellers when cruising at reduced speed for a considerable period, this machine being arranged so that its full speed frequency corresponds to the reduced speed of the motors. It is easy to embody change-over switches (which are only operated when there is no voltage) with the other switches in the switch boxes D, D, D, D. As the power required for propulsion varies roughly as the cube of the speed of a ship, the relative weight and space of such an auxiliary cruising turbo-generator in conjunction with its superior steam economy may not represent an excessive increase, and it affords substantial additional advantages in the way of stand-by resources, thus reducing still further the chance of complete disablement of the ship due to a breakdown.

As regards the question of the actual steam consumption for propulsion at full speed, it is not proposed to take up this point on the present occasion, as figures published from several sources have shown sufficiently encouraging possibilities for turbo-electric systems in general. In respect to the influence which the propeller has on the question, there seems to be at present no general consensus of opinion among naval architects and marine engineers. It is sufficient to note that, as the Westinghouse electrical transmission system utilises the most simple type of generator and the most simple type of motor, the losses are likely to be certainly no greater than those in any other electrical system.

Already electrical machines of the ordinary form have been built in sufficiently large powers to suit almost any ship yet constructed. The arrangements described render it possible to adopt an electrical system of propulsion in which machines of standard construction such as are in everyday successful operation for land service can be employed in the most simple manner possible. The predominating feature of this system from a practical point of view thus lies in its mechanical and electrical simplicity, which is in a high degree conducive to maximum reliability of operation, so important in the case of propulsion of ships.

In conclusion, the combination of advantages special to the British Westinghouse Company's system may be summarised as follows:—

(*a*) The electrical generators and motors are in every respect similar to machines of standard and well-tried construction, and the turbines are also standard, except for the addition of the steam brake, which offers no mechanical difficulties.

(*b*) Slip-rings, starting switches and resistances in connection with the motors are completely eliminated.

(*c*) Means are provided for rapidly checking the speed, which should materially assist the handling and manœuvring, of the ship.

(*b*) During starting, stopping, and reversing, practically full torque may be exerted on the propeller shaft without exceeding normal current in generator and motors.

Acknowledgments are due to Mr. J. S. Peck and Mr. J. N. Bailey for advice and assistance in the preparation of this account.

Motors for Marine Work.

On sea as on land the motors of the Lancashire Dynamo & Motor Co. are well known for their excellent qualities. They are now being daily employed on R.M.S. "Mauretania" in connection with the ventilation of the enigne rooms and cabins. Eight fans are in use, each being driven by a 25 H.P. motor. The same company have lately supplied a number of motors to various battleships, where they are engaged on the following duties: Workshop driving, turbine turning and lifting, refrigerating and pumping. On one of the recent ships, too, the necessary electrical energy is generated by dynamos of the Lancashire Dynamo & Motor Co.'s make. These machines are of the open type with a commutator end-bearing only. They are coupled direct on a combination bed to the flywheel of a vertical four-cylinder oil engine. The capacity of each set is 450 amperes, and they deliver current at 210 to 240 volts when running at 400 revs. per min.

The Lancashire Dynamo & Motor Co.'s machines are found to be quite reliable when stowed away in the ammunition passages or on one of those cramped landings which are come across on the descent to the stokehold. The stoker, in spite of the atmosphere in which he works, is able to come up now and then for a breath of fresh air; but even this boon is denied the motor, which must always welter in the heat.

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Electrical Marine Propulsion on the "Paragon" System.

BY WILLIAM P. DURTNALL.

Summary.—After a brief reference to the conditions to be observed in marine propulsion, the author considers two cases in detail in which the effect is estimated of replacing the usual steam drive by the "Paragon" electric system. The first is the ss. "Lusitania," in which, although the saving in weight of plant is not material, the saving in coal and wages is shown to be considerable. The second case is that of a "tramp" steamer of 500 H.P., in process of conversion.

The great commercial success of electrical power transmission on shore is now well established, and many thousands of electric motors are to-day employed in innumerable ways in many and various industries. While, however, these applications have made progress, electrical marine propulsion has also been receiving attention, and has more or less quietly asserted itself as an art and a very promising industry. Thanks to the great modern improvements in steam turbines and internal combustion engines, the time has now arrived when electrical propulsion for vessels of large power and size may be discussed as a commercial subject.

In the author's opinion, owing to the vast power to be handled, the electrical propulsion of large ships will only be possible by the adoption of a polyphase current system.

The great advance made quite recently in the design and construction of turbo-alternators and induction motors of large output has made the successful application of electricity in this large and important field appear commercially feasible, and several schemes are now in hand for the propulsion of large passenger and cargo steamers; in fact, the present year may witness some remarkable advances in marine electrical engineering.

All designers of steamships are at the present time striving to obtain the highest efficiency—that is to say, the greatest amount of thrust from the propeller—for every horse-power delivered to the propeller shaft, and at the same time to reduce the steam or fuel consumption per horse-power-hour so delivered. Every little increase in efficiency in this direction means that the steaming radius for a given amount of fuel is increased.

It has been proved beyond doubt that the propeller that gives the most efficient results is one which runs at a low speed and with blades of large area, and is the result of many years' practical experience on thousands of vessels both at home and abroad.

As regards prime movers, the advent of the steam turbine has overcome many of the disadvantages of the reciprocating engine. The best efficiency of a steam turbine is generally obtained when the linear velocity of the rotating blades is equal to one-half that of the steam velocity impinging on these blades, and as this figure is very high, in order to apply the steam turbine to marine propulsion, it has been necessary to raise the speed of the propeller at the expense of propulsive efficiency, so as to reduce the possible steam consumption per shaft horse-power developed; but the result is not comparable as regards steam and fuel economy per horse-power developed with that of the high-speed land turbine under equal steam and other conditions. In order still further to raise the turbine to more efficient operation it has been suggested by the author and others that mechanical gearing should be used.

If by some means the steam turbine can be run at a high speed, not only is the weight and cost of the turbine per horse-power reduced considerably, but the amount of steam used per horse-power-hour delivered is also considerably reduced. If the first cost and running costs are sufficiently reduced, although there may be some losses in transmitting the power produced by the high-speed turbine to a slow-speed propeller, on the whole there will be a net gain. Further, there may be a great reduction in weight and cost of decreased boiler, steam-pipe, condenser and coal bunker capacity required when using the higher speed turbine.

It will not be out of place here to refer as briefly as possible to some of the conditions that have to be met with when designing the propelling machinery for steam vessels of all kinds. It must be remembered that as far as we engineers are concerned we must "save coal." It is obvious then that the turbine must be run at its one and most efficient speed, and that a high speed, in which the use of superheated steam is possible. But it is important that provision should be made for running a ship economically at the lower speeds which are often required. This applies particularly to "tramp steamers." It is also very important to provide a quick and powerful reverse, so that the vessel is under complete control. Further, it should be borne in mind, that although the power falls rapidly with the vessel speed, the torque required on reversing is higher than that when running at top speed, so that suitable provision must be made. For this it is essential to reduce the weight of the working parts as much as possible. Means must also be provided that in the event of the propeller leaving the water, as is often the case in rough weather when the vessel is pitching or rolling, racing of the propellers cannot be excessive.

The importance of a suitably low propeller speed is shown by the opinion of Dr. Robert Caird, who is one of the most eminent authorities on naval architecture and marine engineering, that had the "Lusitania" been fitted with propellers suitably designed to give the same vessel speed, and if they were driven at 80 revs. per min. instead of 188 revs. per min., as at present, the propulsive efficiency would have been raised to 60 per cent., instead of the 48·4 per cent. as now at about 25 knots. Consequently, instead of the 65,500 shaft horse-power now required, only 52,830 shaft horse-power would have been necessary.

Electrical engineers labour under a very great difficulty in making extremely accurate estimates in connection with electrical propulsion, but certain published data are available on which estimates may be based. Certain engineers in this country have in the past stated that there is no room for electrical power in the propulsion of vessels of such large size as the "Lusitania." From this view the author would respectfully differ, and he will endeavour to make out a case for an electrically-driven boat of similar lines and speed, in which the "Paragon" system can be employed if necessary. We will first consider what the existing boat is doing, and to do so we cannot do better than take the points that are given by Mr. Thomas Bell, the engineer of the firm who built the vessel, in a most interesting Paper that he read before the Institution of Naval Architects a short time ago, and which dealt with the steam trials of that important and record breaking Atlantic liner. From these it appears that the total steam consumption for all purposes with a horse-power of 68,850 was 14·94 lb. per shaft horse-power-hour. The corresponding coal consumption was 1·46 lb., the speed being 25·4 knots, and the estimated total coal consumption for a voyage of 3,100 nautical miles at this speed is 5,490 tons. The actual coal consumption was very close to this figure.

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The steam consumption works out as follows :—

Main turbines	851,500 lb.	= 13·1 lb.	per S.H.P.-hour.
Auxiliary machinery	114,000 lb.	= 1·75 lb.	„ „
Evaporating plant and heating, &c.	32,500 lb.	= 0·5 lb.	„ „
Total	998,000 lb.	= 15·35 lb.	„ „

The average amount of coal burnt per hour for all purposes was 43½ tons, and the water evaporated per lb. of coal burnt was 10·2 lb., the feed temperature being 196°F. It will thus be seen that under service conditions the total average power of the four propeller shafts of the "Lusitania" was found to be approximately 65,000 H.P., and the propulsive efficiency being 48 per cent., shows that the effective horse-power was 31,200.

Turning now to the electrical scheme, we will first consider the power required on the propellers for the same vessel speed, using four propellers as at present. The author, after careful investigation, has come to the conclusion that if induction motors are to be of such a diameter that they shall go into the narrow after-lines of this boat, a speed of 140 revs. per min. for the top vessel speed would have to be adopted. Thus, the saving in power by reason of the extra propeller efficiency, due to the adoption of lower propeller speeds, would not apply to a very great extent, but would apply as between the efficiency at 188 revs. per min. and that which can be obtained at 140 revs. per min. The ascertained propulsive efficiency being increased from 48 to 52 per cent., we shall therefore require for a thrust equal to 31,200 H.P., 60,000 shaft horse-power at 140 revs. per min.

To provide the above power at 140 revs. per min., we can assume two 7,500 B.H.P. induction motors, mounted on each of the four shafts. Each motor will have, say, 42 poles, and an efficiency of about 97 per cent., so that, leaving out of account the small losses that would, of course, take place between the generators and the motors in conductors and control gear, we shall require a total of, say, 47,000 kw. of electrical power for propulsion purposes. Motors of this power and speed can be designed with the above efficiency and a weight not exceeding 50 lb. per B.H.P., so that each motor will weigh, say, 167·4 tons, and the eight motors would have a total weight of say, 1,340 tons.

To supply them with the necessary current at full speed and load, as given above, the installation of six 11,000 B.H.P. steam turbines will meet the case. Fig. 1 shows the layout proposed, with four of the above turbines (B, C, D, E) running at 600 revs. per min., and the other two (A, F) running at 1,050 revs. per min. G and J are six-pole non-synchronous three-phase generators, H and I are four-pole transformer-generators, K and L are four-pole synchronous generators, and mounted on the same shaft are M and N two-pole transformer-generators; and O and P are the small series wound exciters, which, owing to the arrangement, act for the whole combination, by exciting the revolving magnets of K and L, through slip-rings Q and R. The output from K can be put into the revolving primary member of M, by means of the slip-rings S, and the output from L can be put into the like member of N through the slip-rings V.

The estimated efficiencies of K and L can be put at 96 per cent., also 96 per cent. for H and I, and for the higher speed short-circuited generators G and J 97 per cent., and for M and N 94 per cent., which are reasonable figures for the estimated steam consumption required for the various powers. Working at 180 lb. pressure above atmosphere, and with the steam superheated to a total temperature of 600°F., and with a vacuum of 28·5 in. (easily obtained in the Atlantic), it can be safely stated that at full load the above turbines, if constructed on the mixed principle, will require a total not exceeding 9 lb. of steam per brake horse-power-hour; so when the above plant is working at full speed and load (as at top vessel speed) the boiler capacity need only be sufficient to supply 594,000 lb. of superheated steam per hour.

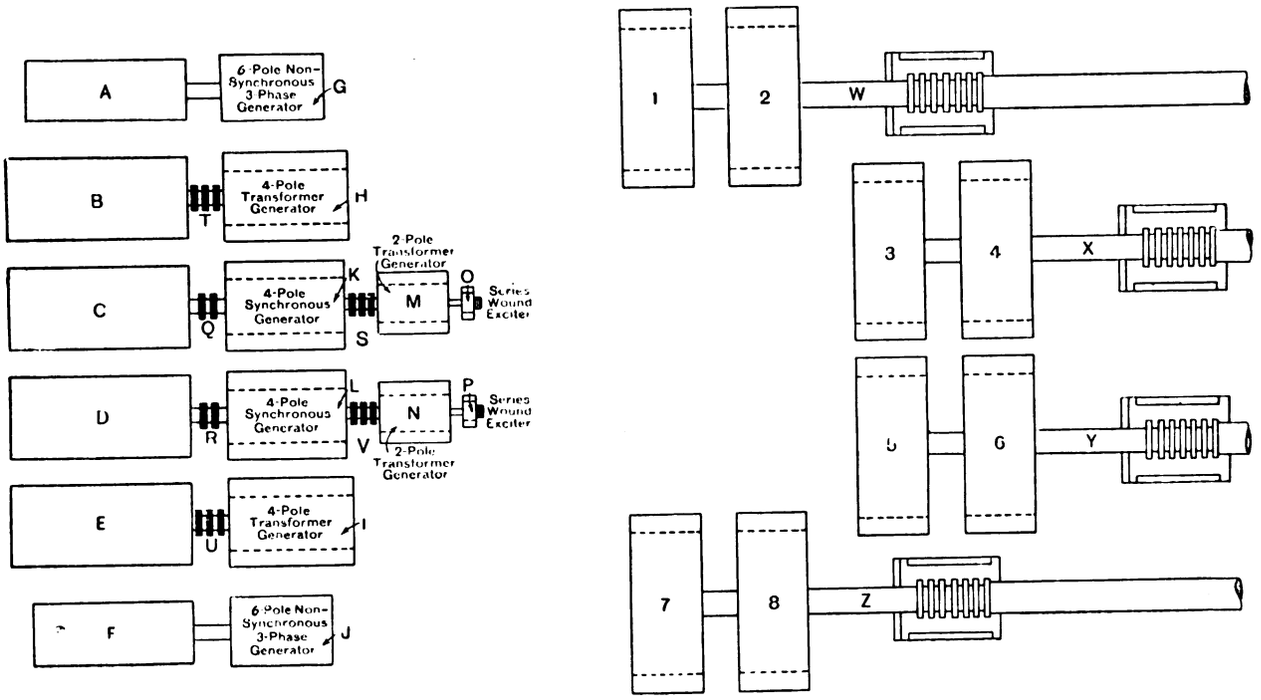

FIG. 1.—PROPOSED LAYOUT FOR VESSEL OF 60,000 SHAFT-HORSE-POWER AT 139 R.P.M.

The weight of the turbines, generators, transformer-generators, non-synchronous generators, exciters, steam and exhaust piping and condensers is estimated at 90 lb. per kilowatt of output, so that for the 47,000 kw. required for propulsion the total weight of the engine-room equipment will be 1,880 tons.

The remote control system would be adopted with motor operated switchgear, and all connections would be arranged to be made or broken under no-voltage conditions, and in such manner that either port or starboard motors may be changed in speed or direction of rotation. The weight of the whole of this control gear can be put at 25 tons.

So far we have dealt with the generation and transmission of the electrical power from the steam valves of the high-speed turbines to the half couplings of the motors driving the propellers. As regards the weight of the boiler installation, a very good estimate can be made from the report of the committee on naval boilers, in which the Cunard liner "Saxonia" was taken, and the details show that the weight of the boiler-room equipment was 1,000 tons, and that the total output from

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the cylindrical boilers installed was equal to 132,600 lb. of saturated steam per hour, or 132·6 lb. of steam per hour per total ton weight of the boiler-room installation. This weight included the following items: Water in boilers at working level, Howden forced draught fittings and funnelage, auxiliary machinery in boiler room, including evaporators, &c., and steam pipes, platforms, &c. A figure of 180 lb. per ton weight per hour may be safely taken for modern cylindrical boilers.

Thus the total weight of the boiler-room equipment for the electrically-driven boat for propulsion only will be, for the 594,000 lb. of steam required, 3,300 tons, to which must be added, say, 75 tons for superheaters, bringing the weight of the boiler-room plant up to 3,375 tons. We have then the total weight of the boilers, and the propelling machinery for the electrically-driven boat as follows :—

Boilers, &c.	3,375	tons.
Turbines, generators, &c.	1,880	,,
Controllers, &c	25	,,
Conductors, say	10	,,
Motors	1,340	,,
Total weight of propulsion machinery	6,630	,,

As laid out in Fig. 1 the working would be as follows for five speeds of the propellers in either the "ahead" or the "astern" direction.

First Speed.—Start up either turbine set C or D, say, C. This will run at 600 revs. per min. By means of the control gear send current from the small exciter O, through the slip-rings Q, to the windings of the revolving four-pole magnet of the synchronous generator K. The three-phase current from the stationary armature of this machine passes to the slip-rings S of the primary member of the transformer generator M, the direction of the current being such that the magnetic flux revolves in the opposite direction to that in which the generator is being driven by the turbine C. The three-phase current for the motors will then have a frequency of 600 cycles per minute, and the motors having 42 poles will run at a synchronous speed of 28·6 revs. per min.

Second Speed.—The second speed is obtained as follows :—First short-circuit the field of the small exciter by means of the control gear; then couple the motors direct to the armature of the generator K, the transformer generator meanwhile running idle. The current will then have a frequency of 1,200 cycles per minute, with the result that the motors will run at a synchronous speed of 57·2 revs. per min.

Third Speed.—It should be here noted that the power for the two lowest speeds of such a vessel would easily be provided by one turbine. To obtain the third speed, turbine D is now started up and runs at 600 revs. per min., together with the synchronous generator L, transformer generator N, and exciter P. Motors 1, 2, 3 and 4 are then supplied by turbo set C, and motors 5, 6, 7 and 8 by the set D. By opening the links across the fields of the exciters O and P, the exciting current flows through the slip-rings Q and R to the revolving magnet windings of K and L. The output of the armatures of the last-mentioned machines passes to the primary windings of M and N, the direction of the current being such that in both cases the magnetic flux revolves in the same direction as the turbines C and D. It will be seen that the frequency of the current supplied to the motors will then be 1,800 cycles per minute, and the motors will run at a synchronous speed of 84·8 revs. per min.

Fourth Speed.—Under no-voltage conditions, as mentioned above, the connections are changed as follows, and more power being required, turbines B and E are started up (running at 600 revs. per min.) The current from the armatures of K and L, instead of going to the slip-rings S and V, is in this case sent to the slip-rings T and U, which are connected to the windings of the primary members of H and I, the direction of the current being such that the flux revolves in the same direction as the turbines B and E. The frequency of the current obtained from the stator secondary members of H and I will be 2,400 cycles per minute, and the motors will run at a synchronous speed of 114·2 revs. per min. It may be mentioned that the power required for propulsion will at this speed be easily met by the four turbines B, C, D and E, and also that in each case the voltage goes up with the frequency so as to meet the extra demand for power.

Fifth Speed.—This (in the present layout of the "Paragon" system) the highest speed is obtained in the following manner. The current, instead of flowing from the armature of the generators K and L to the slip-rings T and U, as in the previous speed, passes again into the slip-rings S and V; and the current from the secondary members of M and N is then taken to the slip-rings T and U, so that the magnetic flux in the mechanically driven members of H and I revolves in the same direction as the turbines B and E. The frequency of the current thereby obtained is raised to 3,000 cycles per minute, so that the motors will run at a synchronous speed of 143 revs. per min. (with, say, 3 per cent. slip, giving actually 139 revs. per min.). At this speed more power will be required for propulsion, and this extra power can be obtained by starting up turbines A and F. These latter drive short-circuited squirrel-cage rotor generators, wound for six poles. By coupling the stator windings to the mains by means of a simple chopper type switch, the 3,000-cycle current revolves in the same direction as that in which the rotor is being driven, say, 1,050 revs. per min., by turbines A and F. The power is thus boosted up (as it may be termed) to meet the 60,000 B.H.P., say, that is required from the motors at top speed.

Under the above working conditions, and when the ship has a clear run for a long distance, the necessary adjustment can be made on either of the turbines C or D; and when a synchronous speed is obtained, the port and starboard sets of generator H and I can be paralleled.

With a vessel such as the "Lusitania" rolling 10 deg., say, the propellers are very unequally immersed. Ordinarily the speed varies between the port and the starboard side, with the result that with heavy rolling there is a great waste of fuel by reason of the unequal torque on the two sets of engines or turbines. It will be obvious, however, that in the electrically-driven boat, when running with the generators in parallel, the power will fluctuate between the port and starboard motors, and that the generating plant will run at a constant load whatever the difference in immersion of the two propellers. Also that when a propeller is lightly immersed its motor (owing to the frequency being fixed by the generators) will not race, and the motor driving the more deeply immersed propeller will, for like reasons, not slow down (at least not more than, say, 2 per cent.). Further, owing to the extra pressure per square inch of blade surface, better grip will be obtained on the water by the more deeply immersed propeller and more thrust will consequently be given, especially if calculated per ton of coal used per vessel mile under such conditions. This result could not be so effectually obtained in practice by any other means than electric propulsion and squirrel cage motors, the running characteristics of the latter being almost identical with those of the screw propeller.

I hope to be in a position in the near future to publish some interesting figures as to the actual performances of vessels so fitted.

It will also be interesting to make a comparison of the relative weights and steam consumptions. Here, again, we shall deal with the matter up to the half-coupling of the existing turbines, which run at 186 revs. per min. at top vessel speed. As regards the engine room weight of the "Lusitania," the weights of the six rotors are given as follow :—

	Weight in tons.	No.
High-pressure rotor, each	80	2
Low ,, ,, ,,	120	2
Reversing turbine rotor ,,	60	2

It is reasonable to suppose that the weight of the bed and case of the above turbines will be at least twice that of their rotors in each instance; that being so, we have the following weights :—

Low-speed marine turbines,	at least 1,570	tons.
Condensers (two)	,, 300	,,
Circulating water	,, 100	,,
Steam pipe connections, including exhaust, with the necessary change-over valves, &c.	200	,,
Total estimated weight of engine room equipment	2,170	,,

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Now, as regards the weight of the existing boiler room plant so far as that portion required for propulsion only is concerned, it is stated that under service conditions the total steam used by the main turbines is 851,500 lb. per hour. Assuming that 180 lb. of saturated steam can be produced per total ton of boiler room equipment weight, the weight of the existing boilers will be 4,730 tons, which includes the weight of all mountings and steam pipes to the stop valves of the turbines and the funnelage and necessary auxiliary machinery, feed pumps, &c. Thus we have the estimated weight of the propulsion machinery and apparatus for the existing boat as follows :—

Engine room machinery	2,360 tons
Boiler room plant	4,730 ,,
Total estimated weight of plant for propulsion	7,090 ,,

Compared with the electrically-driven boat the weights are as follows :—

Direct drive at propeller speed of 186 r.p.m.	7,090 tons
"Paragon" electric drive at propeller speed of 140 r.p.m.	6,630 ,,
Saving in total weight by electrical equipment	*460 ,,

Although this is the saving in dead weight of the plant, it is not to be assumed that it nearly represents the total saving in weight, since difference in fuel has still to be taken into account. The evaporation on the "Lusitania" being at the rate of approximately 10 lb. of water per pound of coal, it follows that the existing boat requires at top speed no less than 38 tons of coal per hour, or 882 tons per day. Assuming five days' steaming, this becomes 4,410 tons of coal for the run from, say, Liverpool to New York.

In the electrically-driven boat the steam consumption per hour is only 594,000 lb., so that, taking the same evaporative efficiency for the boilers, we have a coal consumption of only, say, 26·5 tons per hour, or 636 tons per day. For the five days' steaming, therefore, the boat will only require 3,180 tons for propulsion, which is a reduction in fuel for the same vessel speed of 28 per cent. This means a saving in weight to be carried of 1,230 tons. Quite apart from the weight so saved there is a liberation of space to the extent of 54,120 cubic. ft., which is no longer required in coal bunkers and is available for other purposes. Similarly, there is a saving of 50 furnaces on the 192 now used, and only three funnels instead of four would be necessary. Again, there would be a saving of, say, 50 stokers and 31 trimmers. It is obvious that for every man saved in the stokehold there is corresponding keep, and accommodation is set free for a larger number of steerage passengers.

As to first cost in types of vessels that the author has recently investigated, it has been found that with the "Paragon" system the cost is approximately the same as for reciprocating triple-expansion engines running at 80 revs. per min. of the equivalent power, and that the weight of the plant is about the same; but in larger powers the first cost of the propelling machinery and steam plant for a given effective horse-power is less than with either direct-coupled turbines or reciprocating engines.

Assuming five days' steaming and 30 trips per year, the cash saving is therefore as follows :—

Coal, 1,230 tons per trip, or 36,900 tons per year at 13s. per ton	£23,935	0	0
50 stokers at 28s. per week	3,640	0	0
31 trimmers at 22s. per week	1,773	4	0
Net saving per boat per annum	£29,398	4	0

Apart from the above commercial saving in cash in operation, it must not be forgotten that valuable time is saved in not having to bunker the coal saved.

So much for the largest type of vessel afloat. We will now investigate electrical driving for the smaller class of vessel, such as the usual "tramp," as these boats are in the great majority and a very large business will be done in the near future in their conversion, as well as the equipment of new vessels.

Fig. 2 shows a side view of a vessel of the above description that the author has now in hand for equipment on this system, and which he anticipates will be the forerunner of a large number of similar vessels, owing to the great reduction in fuel that will be demonstrated and to the extra steaming radius that will be shown.

Fig. 3 shows a side view and plan of the turbine and generating plant proposed for this vessel. This is as follows :— A is the steam inlet for the supply to the high-pressure turbine of De Laval type shown at B, C the connection between the high-pressure and the low-pressure De Laval type turbine D.

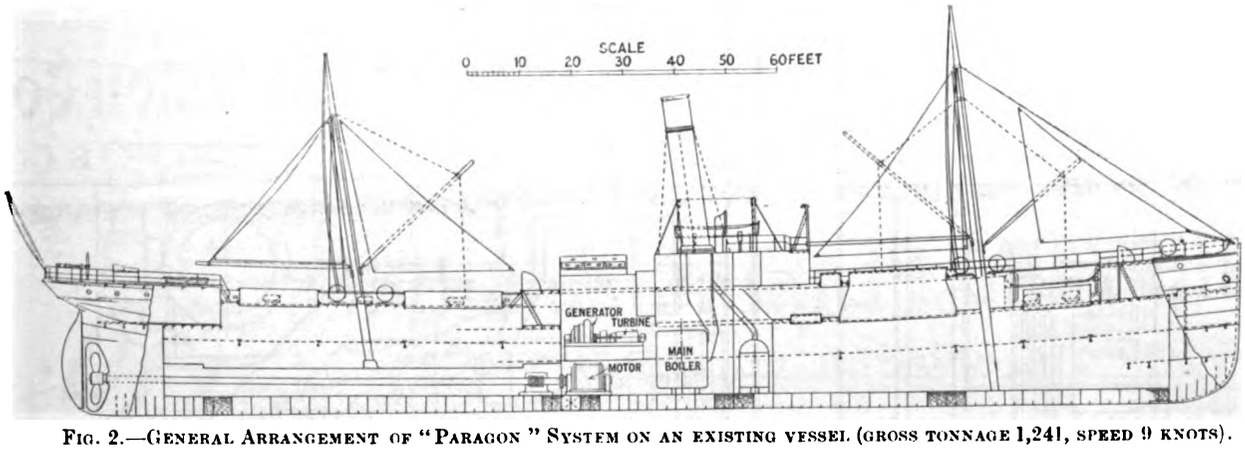

FIG. 2.—GENERAL ARRANGEMENT OF "PARAGON" SYSTEM ON AN EXISTING VESSEL (GROSS TONNAGE 1,241, SPEED 9 KNOTS).

The exhaust is shown at E; this is coupled to the condenser, which will be directly under the turbines; F is the speed regulator; G G are two pinions that reduce the turbine speed from 2,400 to 500 revs. per min., H the main driving gear wheel which, by means of the coupling O, drives the revolving magnet I of the four-pole three-phase alternator. On the same shaft, and also driven mechanically by the turbine H, is the primary member of the transformer-generator K. This is a two-pole machine, with its secondary member L stationary. The exciting current, which will be taken from the electric lighting installation on board at 80 volts pressure, will be led to the slip-rings M; and for the lowest and the highest of the three speeds provided in this instance for the motor and the propeller (a single-screw vessel is in question) the output from the alternator will pass into the slip-rings N, and the operation will be as follows :—

First Speed.—The turbine will be started up and run at 2,400 revs. per min. For both the high and low-pressure turbines the revolving magnet and the primary members therefore run at 500 revs. per min., say, in a clock-wise direction. The motor that is to be used will be wound for 34 poles, and will be of the simple squirrel-cage type. For the first speed the terminals of the alternator will be coupled to the slip-rings N, and the current sent in such a direction that the magnetic flux revolves in the opposite direction to that in which the revolving member is being driven. Three-phase

* 6·4 per cent.

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current at a frequency of 500 cycles per minute will therefore be drawn from the secondary member L, and being supplied to the 34-pole motor, the latter will have a synchronous speed of 29·4 revs. per min.

Second Speed.—This speed is obtained by taking the current from the armature of the alternator J direct to the motor. This will then run at a speed of 58·8 revs. per min., the transformer-generator running idle.

Third Speed.—This speed will be obtained by again sending the output from the alternator to the slip-rings N, but the current will flow in such a direction that the magnetic flux revolves in the same direction as the mechanical rotation. The transformer also acts as a generator, raising the frequency to 1,500 cycles per minute, and the motor will run at a synchronous speed of 88·2 revs. per min.

The actual speeds for the propeller will, of course, be slightly less by reason of the slip at the motor when under work, and they will probably be 29, 57·5 and 86 revs. per min. respectively.

The existing engines are triple expansion, running at 78 revs. per min. and indicating about 500 H.P. With the same amount of steam the turbine will give, with saturated steam at 150 lb. pressure and with 28 in. vacuum, 630 B.H.P. at the main wheel; the over-all electrical power transmission efficiency will be, at top speed and load, 82·5 per cent., so that the motor will give to the propeller shaft 520 brake or shaft H.P. at, say, 86 revs. per min., the increase in shaft speed giving a higher vessel speed. The present reciprocating engines have an efficiency of about 83 per cent., so that they give only about 415 shaft H.P. to the propeller; the extra power required for the higher propeller speed, when the vessel is on top speed, will be easily met by the extra 105 shaft H.P. given by the electric motor at 86 revs. per min. with the same boiler power.

The weight of the engines and the condensers that are to be replaced by the electrical installation is about 37 tons, and the weight of the turbines, generator-transformer, condenser and motor is about 36 tons; but with the extra girders that will be put in to carry the turbines it can be safely said that the weight of the machinery will be approximately the same as the reciprocating engines.

Before being dismantled the vessel will be docked and cleaned, the engines and boilers put in condition, and then the vessel will undergo a thorough trial under various draught conditions and speeds, in which the towing resistance, I.H.P., steam and coal consumption, and the actual cost of carrying a certain freight per vessel-mile will be observed. Exactly the same test will be made when the electrical plant is on board, and the results will be recorded in these columns at a later date.

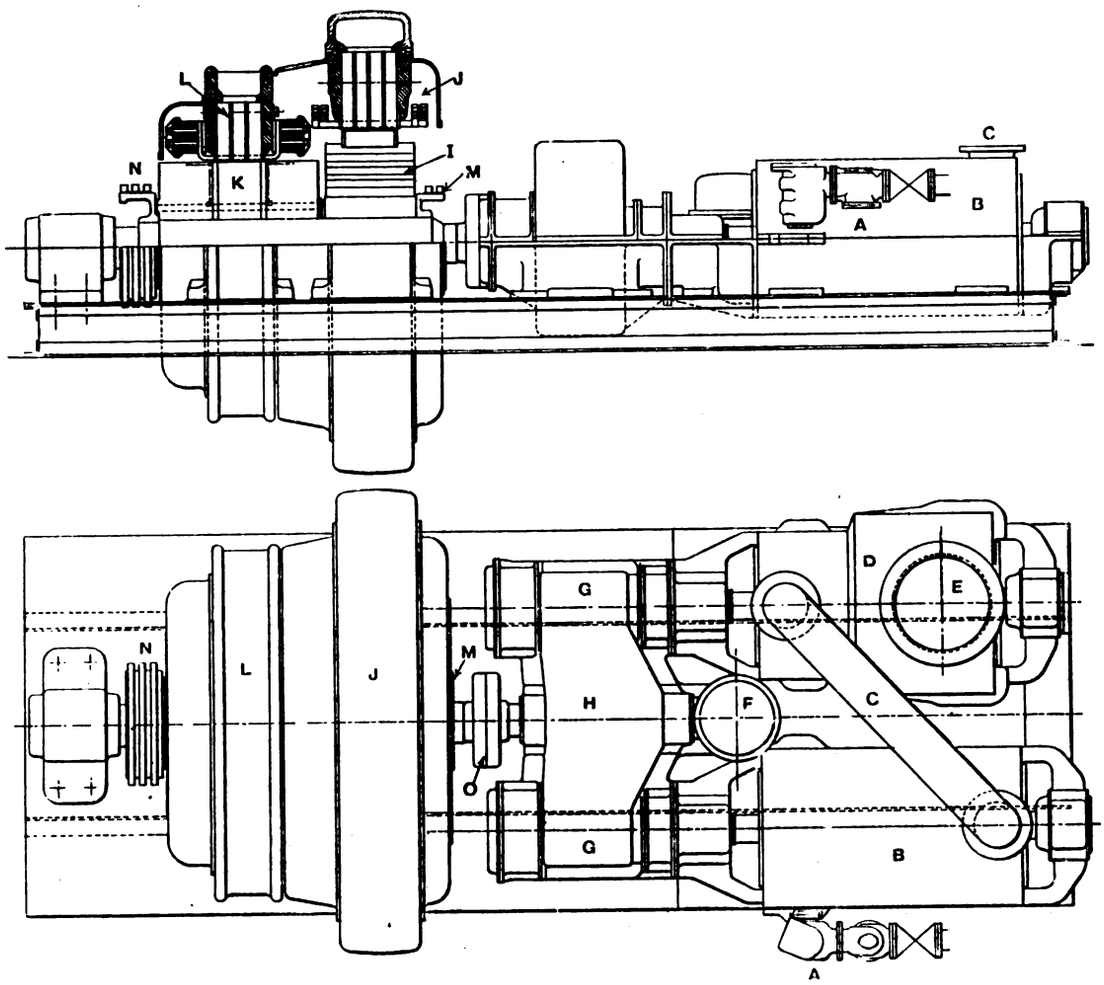

FIG. 3.—"PARAGON" GENERATING PLANT FOR VESSEL ILLUSTRATED IN FIG. 2. (Scale 1:40.)

The author hopes that the above remarks will awaken some further interest in what he believes to be the future field for the progressive electrical engineer with the co-operation of his marine colleague.

The author's thanks are due to those friends who have already considered the possibilities of this system of electrical power generation and transmission for marine propulsion, and also to Messrs. Willans & Robinson and other important turbine makers who have so kindly given the writer the particulars for the turbine section of this article and drawings. Signs are not wanting that the shipping industry is about to undergo a great change in view of the lively foreign competition that is now taking place; and based on the information that is available to the author in various directions, his views are that immediately the electrically-driven vessel is put to a real test the shipowner will be driven to adopt electric driving on the lines here laid down.

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Electro-Mechanical Propulsion with Diesel Engines.

BY ENGR.-LIEUT. W. P. SILLINCE, R.N.

Summary.—After giving figures as to the economy of the Diesel oil engine and features of construction, the author describes its use at the present time in boats, and finally outlines the Mirrlees system of electro-mechanical propulsion. In this system, generators direct coupled to Mirrlees-Diesel engines are used. For speeds between full speed and half speed a combined friction and positive clutch couples together the engine and propeller shafts. For speeds below half speed the shafts are disconnected and motors are used.

The Diesel oil engine is well known and is firmly established in land installations; it has also been frequently applied to marine purposes, both for generating electricity in ships and also for the propulsion of surface and submarine boats and of cargo-carrying vessels.

In the British Navy alone every battleship and armoured cruiser commissioned since the time of the "Dreadnought" has been fitted with at least one, and most of them with two, Diesel oil engines, whose duty has been to generate electricity for auxiliary purposes. These engines were manufactured by Mirrlees, Bickerton & Day (Ltd.), of Hazel Grove, near Stockport.

The installation of these engines has resulted in great economies in fuel and attendance. For example, one of these Diesel oil engines was found to use ½ ton of residual fuel oil (the same as used for boiler firing) per day of 24 hours, whilst to do the same work with a steam plant of exactly the same capacity 7 tons of Welsh coal were required—that is, 14 times the weight of fuel. Assuming coal to cost £1 per ton and fuel oil £2. 5s. per ton, the Diesel engine thus effected a saving of £5. 17s. 6d. per day, or about 84 per cent of the fuel bill. The guaranteed fuel consumption given by the makers of these engines is 0·55 lb. per brake horse-power per hour at full load, 0·57 lb. at three-quarter and 0·65 lb. at half load, and the actual results on service are usually 10 per cent. less than these figures.

Further, to attend to the steam plant, each watch consists of four men—two to trim coal, stoke and tend the boiler, one to tend the engine-room auxiliaries (such as condensing plant and feed pumps) and one for the steam dynamo—and, as there are four watches per day, 16 men are required. When the Diesel oil engine is in use 12 of these men are available for other duties, since the Diesel oil engine requires only one attendant. It might here be mentioned that when two Diesel oil engines are installed in the same dynamo room one attendant looks after both.

As touching on the question of continuous running and reliability, these engines have on several occasions run for 30 days and nights without a stop.

The engines are vertical and direct acting, each having four cylinders and capable of developing 160 B.H.P. (200 I.H.P.) continuously, when running at 400 revs. per min. They are direct coupled to 105 kw. generators, and run in parallel with either

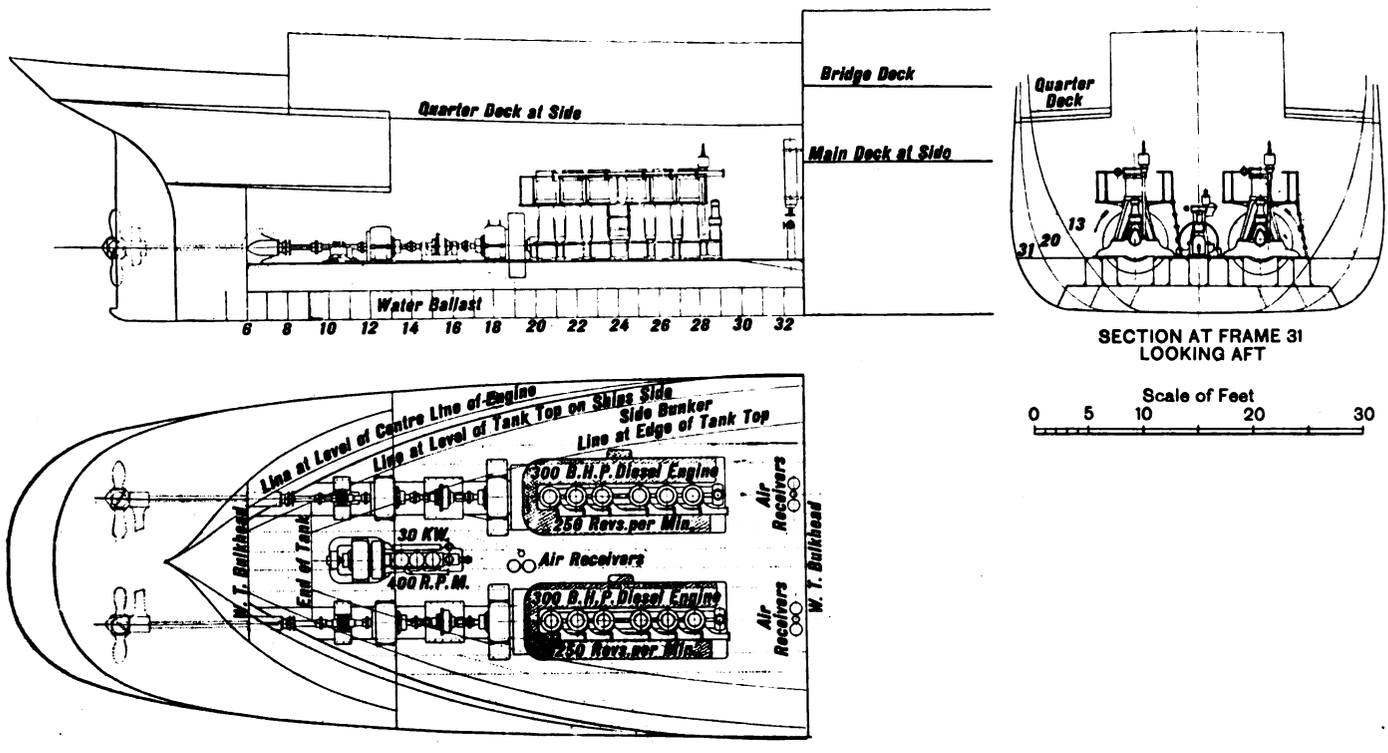

FIG. 1.—GENERAL ARRANGEMENT OF "MIRRLEES' DIESEL" OIL ENGINE FOR AUXILIARY PURPOSES AND PROPULSION OF AN OIL-CARRYING VESSEL OF 1,800 TONS.

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Diesel or steam engines in any combination. They are further capable of an overload of 10 per cent. for two hours.

The engines are totally enclosed and fitted with an efficient system of forced lubrication, which lessens the attendance necessary and reduces wear and tear to a minimum. Engines have run for periods of two years without any bearings having been adjusted, and on examination at the termination of this period the wear was found to be inappreciable and the bearings were put back to their original adjustments.

One special feature of this engine is its accessibility. All valves are provided with separate removable seats. This enables specially hard and durable metal to be used for the seats and reduces the stopping periods. Since there is a spare valve and seat provided for each working valve and seat, the periodical overhaul of valves can be carried out without a prolonged stoppage of the engine, as the working valve and its seat can be removed and replaced at once by the corresponding spare, the engine started, and the valve last removed attended

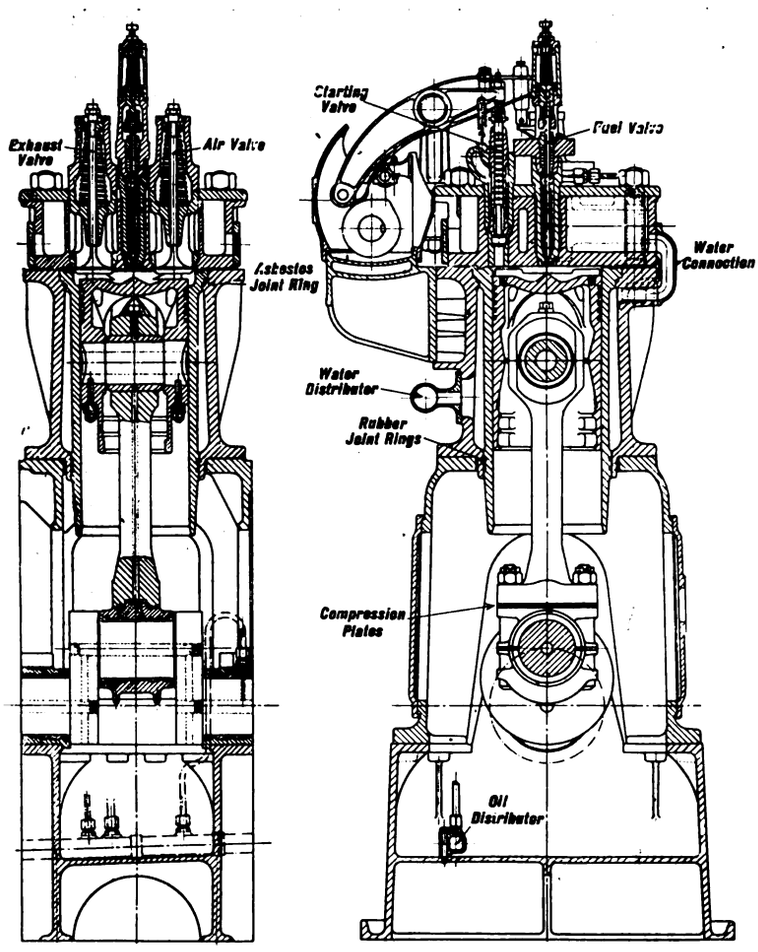

FIG. 2.—SECTIONAL VIEWS SHOWING ARRANGEMENT OF CYLINDER, COLUMN AND VALVES OF A 160 B.H.P. "MIRRLEES-DIESEL" OIL ENGINE Scale, 1:20.

to at leisure. To facilitate the removal of the exhaust and fuel valves (which require to be examined about once in two or three weeks), the levers operating these valves are divided so that, by removing a single bolt, that part of the lever which is above the valve can be swung back clear, enabling the valve to be removed without disturbing the remainder of the valve gear.

Another special feature is the air compressor. This is a two-stage compressor, delivering air at between 600 lb. and 950 lb. per square inch, the air being used for atomising and injecting the fuel into the cylinder. The compressor has a large margin in capacity, and is capable (in addition to supplying the air for fuel injection) of replenishing the starting reservoirs. The whole of the parts of this compressor are metallic, no fibre or vulcanite packings being used. The valves only need to be withdrawn for cleaning about once a month, an operation performed in a few minutes

The third special feature is the governing. When all the load is sudd nly removed the momentary variation in speed does not exceed about 7 per cent. and the permanent variation about 3 per cent.

There are many other special features in the constructional details of the engine which are of particular interest, but for which space is not at present available. The keynote of the whole design has been reliability and accessibility combined with extreme fuel economy.

Fig. 1 shows the general arrangement of one of these engines, and also a vertical section through one of the cylinders.

"Mirrlees-Diesel" engines have also been applied to the propulsion of boats, three of which have been supplied to the Navy, two being for Vedette boats (of 120 B.H.P. or 160 I.H.P. each) and one for a 60 ft. harbour service launch of 100 B.H.P. (130 I.H.P.). Fig. 2 is an illustration of the latter.

In engines of the above sizes, and even considerably beyond them, the necessary reversibility is easily and satisfactorily obtained by the use of either reversible-bladed propellers or of mechanical reversing gears. The boats above mentioned are fitted with the latter.

When the powers demanded exceed the limits imposed by such mechanical devices, the "Mirrlees" system of electrical propulsion is adopted, and this system is considered to offer special features of advantage.

The scheme is shown in the illustration attached and is described as follows: The propelling machinery, as shown on the drawing, consists of two six-cylinder "Mirrlees-Diesel" oil engines, capable of developing 300 B.H.P. each, when running at 250 revs. per min. When proceeding ahead at any speed between full speed and half speed, the engine and propeller shafts are coupled together by means of a combined friction and positive clutch, the speed being varied between these limits by a controlling apparatus fitted on the engines. On each shaft is secured a dynamo capable of developing about 60 B.H.P. at 125 revs. per min. (that is, about 20 per cent. of the full power of the engine at one-half of the engine revolutions). On each propeller shaft is secured a reversible variable speed motor, capable of absorbing the full power of the dynamo. When manœuvring ahead and astern with the propellers, or proceeding ahead at less than half speed, the engine and propeller shafts are disconnected. The dynamos on the engine shafts operate the motors on the propeller shafts, the engines and dynamos running at a constant speed of 125 revs. per min., the speed and direction of rotation of the motors and propellers being controlled electrically by varying the intensity and direction of the current in the fields. In emergency, such as to avoid collision, &c., when running electrically, it is possible to increase the speed of the engine up to its maximum, whereby the dynamos and motors are capable of an increased output for a reasonable period. The electrical arrangements can be so disposed that each dynamo operates either or both motors, thus providing for a breakdown of either the other dynamo or engine. This device has been protected by patents, and its special features of advantage are:—

1. Losses in transmission, as compared with a purely electrical transmission, are avoided at all speeds above half speed ahead.

2. The size, weight and price of the electrical equipment are much less than in a purely electrical transmission.

3. It is anticipated that the handling of the vessel will be quite as satisfactory as that of the latest turbine vessels, in which the maximum power when going astern rarely exceeds 40 per cent. of the maximum power when going ahead.

4. In connection with the electrical apparatus nothing that has not been thoroughly tried on shore is proposed for use afloat.

In conclusion, the scheme above outlined enables full advantage to be taken of the superior economy, as regards fuel, of the Diesel oil engine, whilst avoiding complications of mechanism necessitated by a reversible engine, and it also enables fine gradations to be obtained in the speed control of the vessel on moderate weights and at moderate cost.

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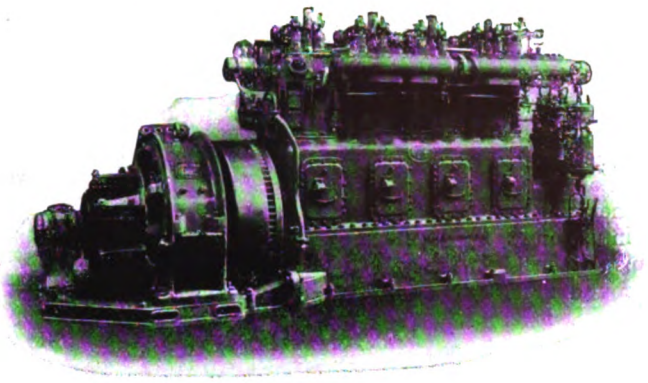
DIESEL OIL ENGINES.



"MIRRLEES-DIESEL" OIL ENGINES, AS ILLUSTRATED, HAVE BEEN FITTED ON BOARD:—

H.M.S. "DREADNOUGHT."
H.M.S. "BELLEROPHON."
H.M.S. "SUPERB."
H.M.S. "COLLINGWOOD."
H.M.S. "INFLEXIBLE."
H.M.S. "VANGUARD."
H.M.S. "MINOTAUR."
H.M.S. "SHANNON."
H.M.S. "INDOMITABLE."
H.M.S. "INVINCIBLE."
H.M.S. "TEMERAIRE."
H.M.S. "ST. VINCENT."
H.M.S. "VERNON."

ALSO APPLIED TO MARINE PROPULSION.

Admiralty Harbour Boat, with "Mirrlees-Diesel" Engine for Propulsion.

SEE ARTICLE ON THE DIESEL OIL ENGINE.

MIRRLEES, BICKERTON & DAY, Ltd.,

HAZEL GROVE, Near STOCKPORT.

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Electrical Plant for Marine Installations.

Especial interest attaches to Messrs. Allen's work in the production of electrical plant for marine installations, as those who can call to mind the early days of electricity on board ship will remember what an important part this firm took in pioneering in this field. As might be expected, the results of a long experience are to be found embodied in their newer designs, and the fact that their machinery still continues to command an ever-extending field of application in marine work is ample evidence of the thoroughness with which the various essentials of such a plant have been considered in the design.

Chief of Messrs. Allen's productions in this connection is still the generating plant, and that it is exclusively in use on by far the majority of the ships of the British Navy, and is also to be found in most of the navies of the world, is considered by Messrs. Allen, not without reason, to justify the statement that it has few equals. The steam engine is usually of the compound totally enclosed type, and is fitted throughout with forced lubrication, having generally two cylinders, though occasionally in the more powerful sets the second expansion stage is divided between a pair of low-pressure cylinders, the engine then having three cranks, an arrangement which gives a better balance and more uniform turning effort. The type of engine is well known and need not here be described in detail; suffice it to say that in the two-cylinder types the cylinders and valve chests are all arranged in one casting, the centres being placed as near together as possible, thus making a very compact and well-balanced arrangement. In the three-cylinder types, each cylinder with its valve chest is cast complete, the cylinders being mounted independently of each other on top of the trunk which encloses the working parts, thus avoiding distortional strains in the framing due to unequal expansion of the metal, which would produce faulty alignment of the working parts and consequent excessive wear. The governor is of the crank-shaft type, and provided with hand regulation, permitting of adjustment of the running speed through a considerable range on either side of the normal while the engine is working. When desired, Messrs. Allen also fit a special emergency stop-valve closing gear, which automatically shuts down the steam supply when the speed exceeds a predetermined limit. The materials employed throughout are of the very finest, and a rigid system of inspection and testing obviates entirely the possibility of any faulty material finding its way into any part of the machinery.

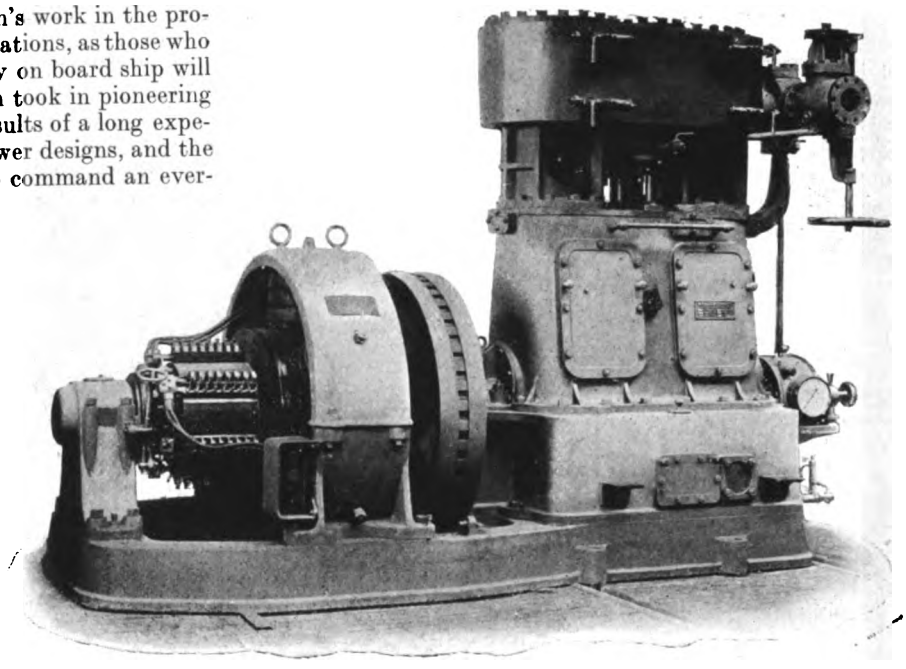

FIG. 2.—ALLEN'S 200 KW. MARINE SET.

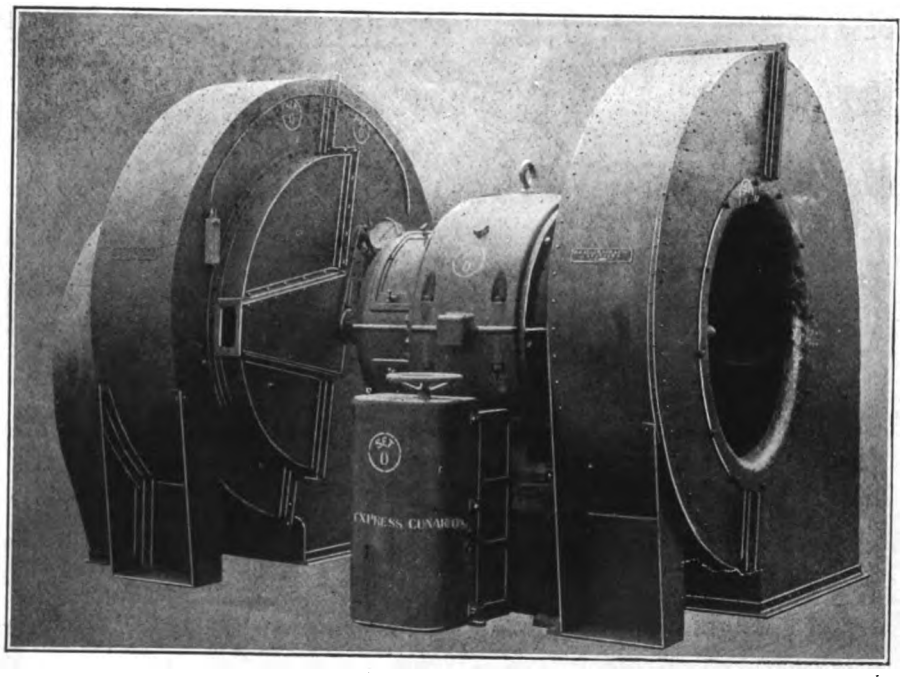

FIG. 1.—ALLEN MOTOR-DRIVEN FAN AS USED ON THE SS. "MAURETANIA."

The dynamo is usually of the continuous-current multi-polar type. The magnet yoke and pole pieces are of cast steel of high permeability, the latter being securely bolted to the inside of the yoke, and the field exciting coils are wound on formers. The armature is of the ordinary slotted type drum-wound, built up of soft annealed plates, and is provided with the usual ventilating ducts. The commutator is of hard drawn copper sections insulated with mica and micanite, and secured together on a cast-iron sleeve; it can be removed entire by simply unsoldering the connections to the armature winding. The commutator bars are of sufficient depth to permit of being turned down a considerable amount without requiring renewal of any parts. The brush gear consists of carbon brushes, carried in a substantial brass guide, and each brush is held against the commutator by a separate spring, so arranged as to admit of the pressure being adjusted and the brushes withdrawn separately for inspection. A neat hand worm-gear is also fitted for adjusting the "lead" of the brushes. The brush rocker and hand-adjusting gear are carried by the outer bearing. The dynamo shaft is flanged to form a coupling for bolting to the end of the engine shaft. A light and rigid under base plate extends completely under both engine and dynamo, and this, by preserving the alignment of the bearings, &c., adds greatly to the life and conduces not a little to the smooth running of the whole plant.

It is only within recent years that the electric motor has begun to supersede the steam engine on board ship for the

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purpose of driving fans for forcing the draught in the boilers and for ventilating purposes. This appears at first sight a little surprising, in view of the great facility with which such plant can be regulated. On closer investigation, however, it will be seen that there are several practical difficulties attending the adoption of electrical power for this purpose. It usually happens that the fans have to be placed in a part of the stoke-hold where the temperature is exceedingly high, and hence, if electric motors are employed, either special means must be provided for cooling the motors, or the motors themselves must be so constructed as to be able to withstand successfully very high temperatures. Messrs. Allen have carried out a large number of installations on both systems, the latter, however, being a somewhat costly arrangement as the insulating materials employed are naturally of a much more expensive nature, and are such as otherwise greatly to increase the cost of manufacture.

We shall here describe briefly a couple of large installations carried out on the former plan, being those of the ss. "Mauretania" and "Lusitania." Each installation consists of 32 fans arranged in pairs, one electric motor providing the necessary power for two fans. The fan impellers are of the single-inlet type, being 66 in. in diameter, and each capable of delivering a maximum of 33,000 cubic ft. of air per minute against a water pressure of $3\frac{1}{4}$ in. when running at 450 revs. per min. The motors are of the four-pole continuous-current type, completely enclosed, and each capable of developing 50 B.H.P. at a speed of 450 revs. per min. and at a pressure of 110 volts. Owing to the high temperature of the compartment in which these motors have to work, situated as it is above the boilers, a special arrangement for cooling has been adopted. This consists in passing through each motor casing a current of cool air which enters it below the commutator and leaves it at the upper side of the further end of the casing. The air for this purpose is supplied by an auxiliary fan arranged alongside one of the main fan casings, one such fan being provided for each pair of main fans and driven direct from the motor spindle. Each of the main fans is fitted with a water gauge to indicate the draught pressure, and also with a tachometer.

The controllers for these motors are also of Messrs. Allen's manufacture, and by them the speed can be regulated by equal steps from 225 to 450 revs. per min. No-voltage and overload automatic releases are also fitted, giving complete protection to the motors under all conditions. When running at the lowest speed the approximate output of air from each fan is 17,000 cubic ft. per minute at a gauge pressure of 1 in.

The ventilation of the fan room on the "Mauretania" is effected by eight of Messrs. Allen's single-inlet motor-driven fans. The motors are of the totally-enclosed type, and each set is capable of delivering 1,000 cubic ft. of air per minute at a pressure of 1 in. water gauge and at a speed of 900 revs. per min. They are of the four-pole series-wound type, and develop 5 B.H.P. at 900 revs. per min. and 110 volts. Each motor has a separate controlling panel, consisting of one double-pole quick-break switch, tubular fuses and starting and regulating resistances.

The accompanying illustrations show examples of the plant Messrs. Allen have designed for marine work.

De Laval Steam Turbines.

The value and importance of the steam turbine for ship propulsion have come to be recognised mainly as the outcome of experience with this class of prime mover in connection with ship-lighting plants. The De Laval turbine was instrumental in initiating the high-speed turbo-generator into ship work, demonstrating by its light weight and running economies the possibilities of a compact equipment from which electrical energy could be obtained for lighting, and

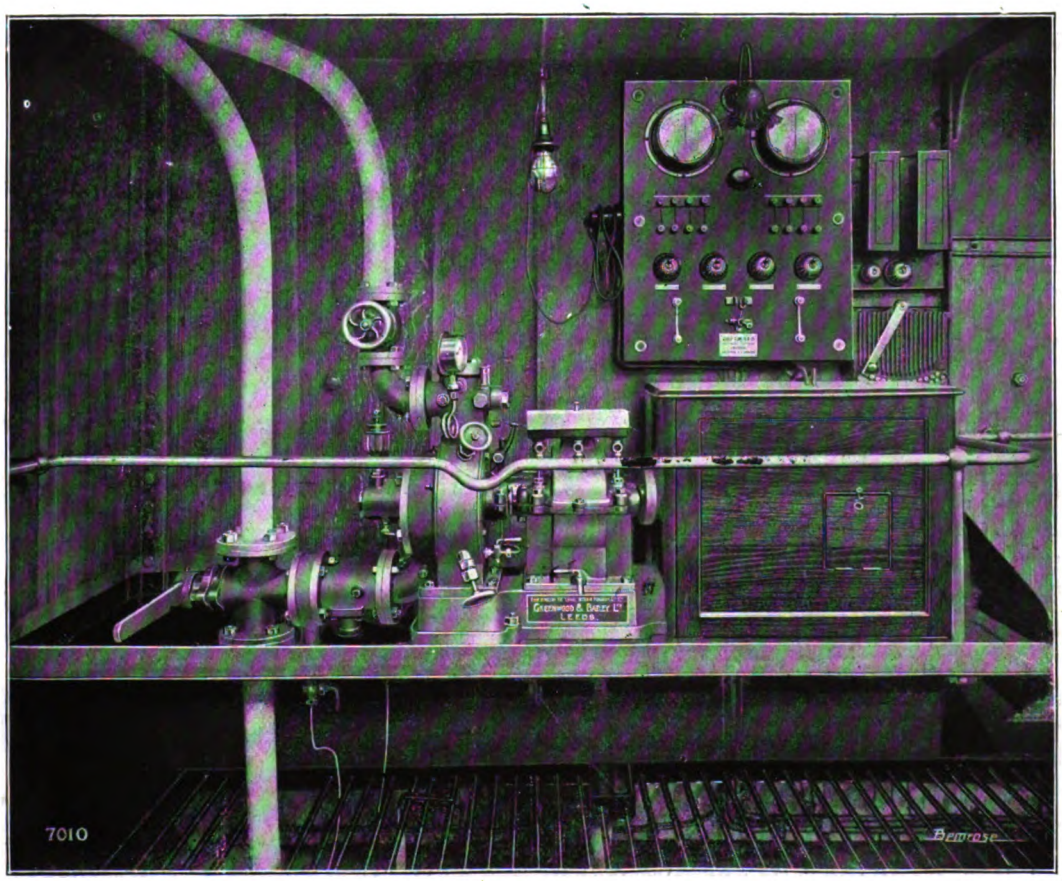

FIG. 1.—DE LAVAL STEAM TURBO UNIT FOR SHIP LIGHTING, INSTALLED IN A CORNER OF THE ENGINE ROOM.

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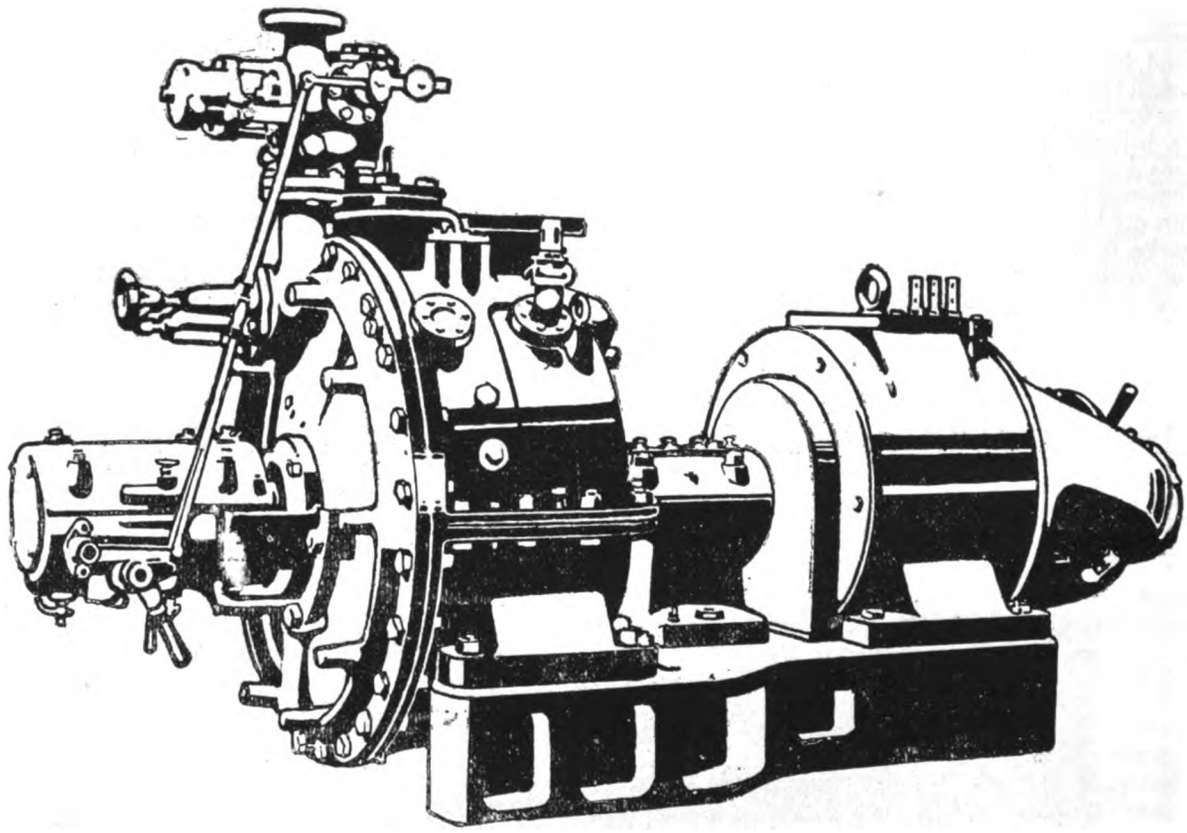
A.E.G.

TURBO SHIP-LIGHTING SETS



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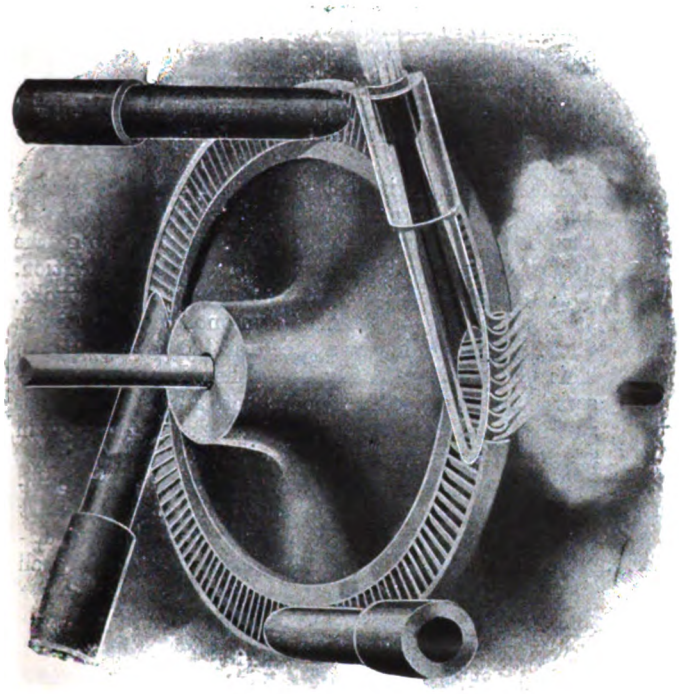

FIG. 2.—EXPANDING NOZZLES AND BUCKET WHEEL OF DE LAVAL STEAM TURBINE.

The De Laval turbines are of the single expansion type arranged with one turbine wheel only, the wheel running at a high speed, which is reduced by gearing so as to suit the dynamo. The steam is expanded in a row of nozzles, and the arrangement of these and the working of the steam is shown in Fig. 2. The general arrangement of the smaller sizes of the De Laval turbine-dynamo sets is shown in Fig. 5, which illustrates a machine seen from above with the cover of the gears removed. The turbine wheel, with its nozzles, is enclosed within the casing to the extreme right of the figure; the pinion and the shaft of the turbine wheel is supported by bearings *m* and *n* and the gear wheels by bearings *h* and *j*. The gear wheel is connected to the armature of the dynamo by a flexible coupling.

The larger sizes of turbines—above 30 B.H.P. or 20 kw.—are constructed similarly to the smaller units except for the arrangement of the gearing. Fig. 3 shows a large turbine-dynamo set seen from above with cover of gears removed. The pinion of the gearing is arranged in two parts and the turbine shaft supported by *three* bearings *m*, m_1 and *n*; the gear wheel is also constructed in two wheels (on the same shaft) separated by the bearing *i*. These larger machines are provided with forced lubrication for the high-speed bearings, an oil pump being

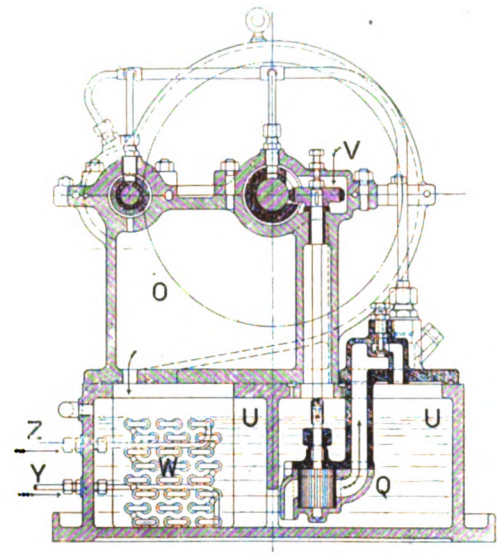

FIG. 4.—GEAR OIL PUMP AS USED ON DE LAVAL TURBINES.

arranged as shown in Fig. 4, this pump being driven by worm gearing from the gear-wheel shaft. The slow-speed bearings are provided with ring lubrication.

The speeds of the electric generators coupled to the turbines are not excessive, the number of revolutions of the smallest unit—3 B.H.P. or 1·625 kw.—being 3,000 revolutions, and that of the larger machines 750 revs. per min. The dynamos are of the ordinary construction, open self-ventilating with carbon brushes and commutating poles. The smaller sizes are two-pole, the larger four-pole.

The turbines are regulated by a centrifugal governor, com-

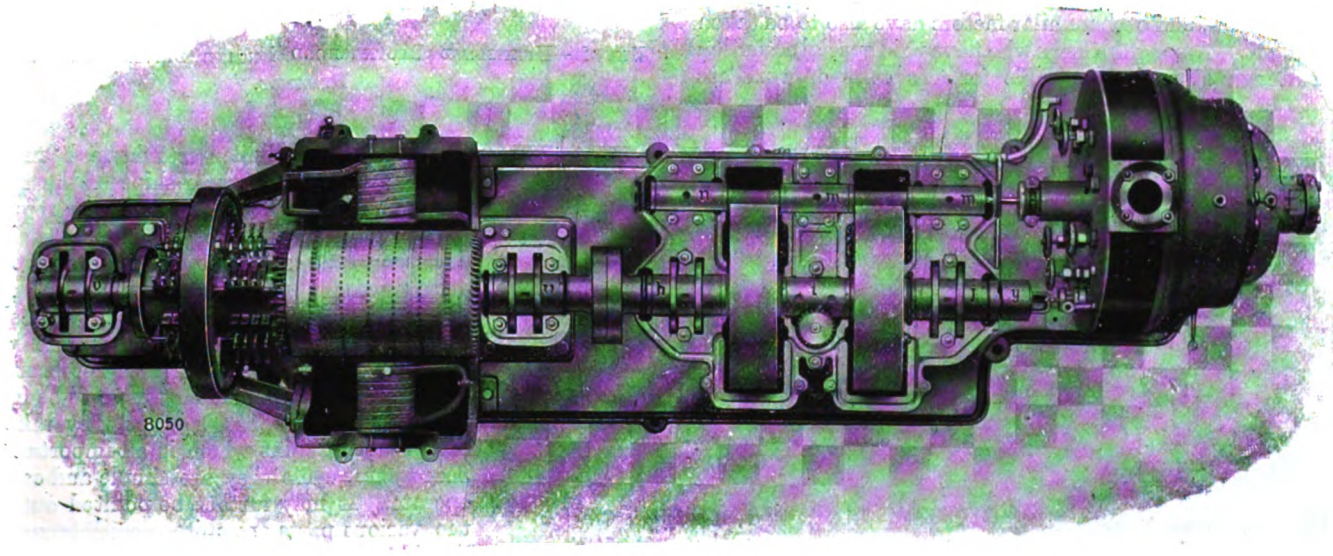

FIG. 3.—LARGE TYPE DE LAVAL TURBINE, SHOWING DOUBLE GEARS.

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bined with a double-beat governor valve and also with a throttle valve on the exhaust. The regulation is very accurate.

The turbines for ship work are arranged with steam nozzles both for exhausting to the main condenser of the vessel and

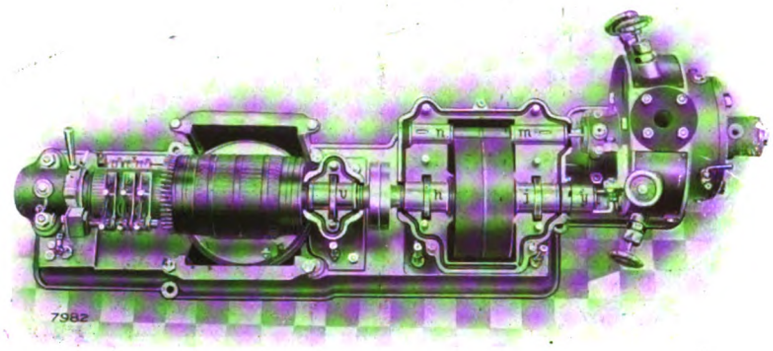

FIG. 5.—SMALLER PATTERN DE LAVAL STEAM TURBINE, SHOWING GEAR CASING REMOVED.

with nozzles for working exhausting either to the atmosphere or to the auxiliary condenser without or with slight vacuum. In addition to this, these turbines are sometimes provided with nozzles to work off the donkey-boiler. Fig. 1 illustrates a ship lighting turbounit with switchboard complete, erected in corner of the main engine-room.

Brotherhood Engines for Marine Work.

The design of engines suitable for driving electric generators on board ship requires that rather different problems should be solved from those met with on land. The atmosphere is none too good for the operation of such machines, the deck to which the set is fixed often moves about in an exceedingly complicated fashion, and other similar factors have also to be taken into account. Among the firms who have paid special attention to the design of engines suitable for this class of work are Messrs. Peter Brotherhood, some examples of whose plant we illustrate in this article.

Fig. 2 shows a standard high-speed enclosed engine fitted with forced lubrication and direct-coupled to two 20 kw. dynamos. The plant illustrated generates current at either 110 or 220 volts, but similar sets could also be used for supplying a small three-wire system, as each generator is so arranged that the pressure from it can be regulated in accordance with the requirements of the load. The engine shown develops 35 H.P. when running at 450 revs. per min., but it may be run at 600 revolutions, and then its output increases to 45 H.P.

Another interesting set consists of an engine direct-coupled to a dynamo which has been designed to be used on either ship or land. This engine is also of the enclosed type, and is fitted with forced lubrication. It has a cylinder 7½ in. in diameter and a 5 in. stroke. It is coupled to a Siemens dynamo, which delivers 7 kw. when running at a speed of 400 revs. per min. This plant, as can easily be gathered from the description, is exceedingly compact, and we are not surprised to learn that many of them are now in successful operation.

Fig. 1 represents a standard 200 kw. set made up of a Brotherhood engine and generator. The engine runs at 400 revs. per min., its cylinders being 14¼ in. and 24 in. in diameter, and 8 in. stroke. Forced lubrication is fitted to all

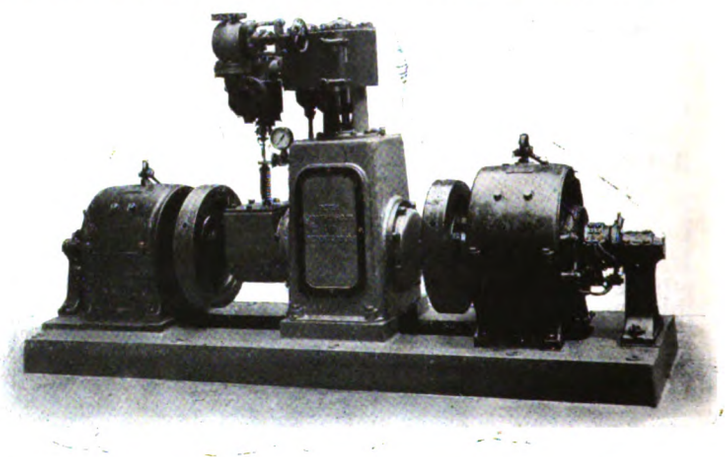

FIG. 2.—HIGH-SPEED BROTHERHOOD ENGINE DRIVING TWO 20 KW. DYNAMOS.

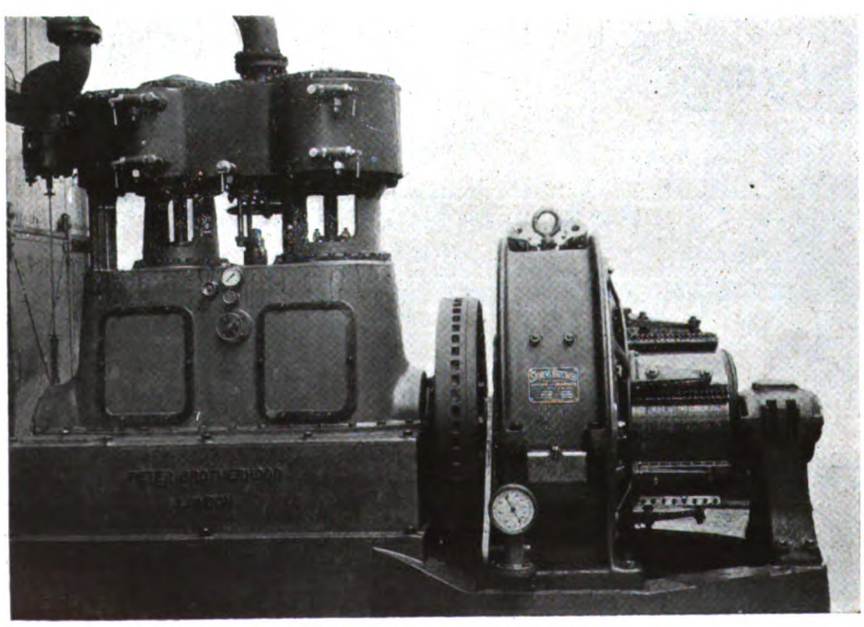

FIG. 1.—STANDARD 200 KW. BROTHERHOOD ENGINE AND GENERATOR.

the bearings. Similar sets have been supplied in large numbers to ships of the Royal Navy for lighting purposes, and are required to develop the full output against a back pressure of 25 lb. per square inch above the atmosphere.

A study of these photographs will show that in designing engines for marine work Messrs. Peter Brotherhood have not been unmindful of the problems that have to be faced. The sets are compact, so that they take up little space, a point which is all-important on board ship, while they are simple and easy to operate. It may further be pointed out that the various parts are quite accessible, so that should any repairs be necessary the damaged portion can be got at with a minimum of trouble. This advantage can only be appreciated in its proper fulness by those whose fortune (or misfortune) it has been to carry out repair work in the circumscribed space usually allotted to electrical plant on board ship. In short, Brotherhood engines are essentially suitable for marine work.

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Electrically-driven Shipyard Cranes.

BY H. H. BROUGHTON.

Summary.—Certain detail work which affects the performance of all types of electric cranes is briefly considered in the first part of the article. In the second part descriptions are given of several cranes and crane systems which are in use in a number of the principal shipyards. Yard cranes, building slip equipments and fitting-out basin cranes are dealt with.

Probably in no branch of engineering is it more necessary to expedite the handling of material than in the building of ships. At the present time the shipbuilding industry is characterised not only by work of enormous magnitude but also by rapidity and economy of construction, and the remarkable achievements of recent years are due in large measure to the development of appliances well suited to the duties which they have to perform. Foremost amongst these appliances are electric cranes.

In any industry, more particularly in the shipbuilding industry, in order to promote rapid and economical construction it is necessary to reduce to a minimum the cost of unskilled labour, or, in other words, the cost of unproductive labour. When it is remembered that it is economical to instal a machine costing £500 to take the place of a labourer at £1 per week it will be seen that huge outlays of capital can profitably be incurred in cases where much material has to be handled. As an example a type of fixed crane may be quoted much used in the fitting out of vessels. Such a crane may be, and often is required to lift loads up to 150 tons in weight anywhere in an area defined by two concentric circles having radii of 30 ft. and 100 ft., the maximum load being lifted at 5 ft. per minute. Moreover, loads up to 30 tons in weight may be dealt with at a radius of 140 ft. The average cost of such a crane is £35,000. Another example is the crane equipment installed over the building slips in a yard turning out the largest vessels. The cost of a slip equipment (including the gantry) runs well into five figures.

It is unnecessary in this article to set forth the many advantages of electrically-driven cranes over all other types. Notwithstanding the united efforts of pessimistic mechanical and hydraulic engineers to oppose the introduction of electric driving, the electric crane has during the last 10 or 15 years ousted practically every other type of crane, and new works, docks and harbours are, almost without exception, provided with electrically-driven cranes.

When an installation is being planned it is advisable carefully to consider the question of providing a battery-booster plant for equalising the load on the main generators. If the load fluctuations follow one another rapidly, and if the generating plant is of sufficient size to withstand the overloads, the conditions may be met by over-compounding the generators. If, however, the motors connected deal intermittently with comparatively heavy overloads, the installation of a battery and booster would result in a considerable saving in the first cost of the generating plant and feeders, and would admit of the constant operation of the plant at a steady load. The saving which is effected by the proper application of a battery may exceed 25 per cent. per annum on the capital expenditure.

In a series of articles contributed to THE ELECTRICIAN the writer described the electrical and mechanical arrangements common to all types of electric cranes, so that an extended treatment on these lines is unnecessary. There are, however, a number of important points which the crane user would do well to bear in mind in drawing up specifications for new cranes, and it is these which will be discussed before noteworthy examples of modern shipyard cranes are described.

STRUCTURAL DETAILS.

Every care must be taken to ensure that the brakes on the several motions are of suitable design. Generally speaking, at least two independent brakes are provided on the lifting mechanism to check the descent and to hold the load. In some cases as many as four independent sets of brake-gear are provided. On account of the high speeds at which modern cranes are worked efficient brakes are usually fitted on the slewing, traversing and travelling mechanisms.

The four types of brakes most used are : (*a*) Electric or rheostatic, (*b*) electro-mechanical, (*c*) mechanical and (*d*) hydraulic. Of these, perhaps, the best known are the electric and electro-mechanical types.

Electric brakes give complete control over the speed with light or heavy loads, and are cheaper than mechanical brakes. If properly operated excessive strains on the gearing are avoided. They depend for their action upon the fact that under certain conditions if a motor be driven mechanically, and at the same time short-circuited by a variable resistance, current will be generated ; the current generated, and hence the braking effort, depending upon the resistance and the speed. Since current is generated only as long as the armature is in motion it follows that an electric brake cannot be used for retaining the load. For this purpose a holding brake must be provided. An objection to the electric brake when applied to a busy crane is that little time is allowed for the motor to cool,

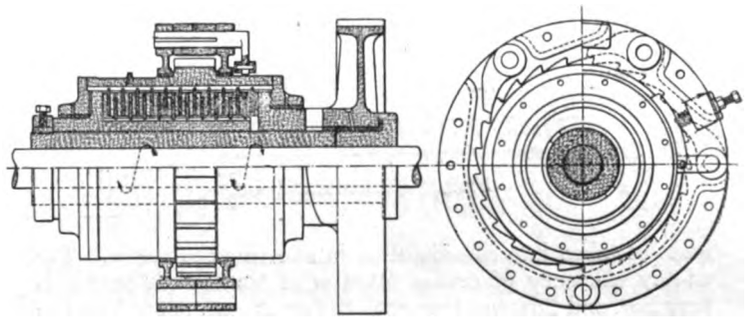

FIG. 1.—WESTON TYPE MECHANICAL LOAD RETAINING BRAKE.

as current is passing during hoisting and lowering, and to avoid overheating the question of rating must be carefully considered. A further objection is that since the braking torque acts direct on the motor armature any breakage of the gear wheels or intermediate mechanism would leave the load free to descend.

Electro-mechanical brakes (wrongly called electric brakes) are in reality mechanical brakes of the band, shoe or disc type provided with an electro-magnetic release. The arrangements are such that the brake comes into action if the current supply be interrupted, intentionally or otherwise. To minimise the cost it is usual to apply the electro-mechanical brake to either the motor spindle or to the second motion shaft, and as in the electric brake, fracture of the wheel teeth or of any of the shafts leaves the load free. It should here be stated that when polyphase alternating-current motors are used to operate cranes, brake motors should be used in preference to polyphase electro-magnets.

In nearly all heavy cranes mechanical load-retaining brakes of the "Weston" type are fitted on the winding-drum shaft, or on the shaft next to it, and when properly designed they will work for years without attention. For satisfactory performance the sliding velocity must not exceed 30 ft. per second, and the "brake work" (per square inch) must not be greater than 24 ft. lb. per second. A typical brake of this kind is shown in Fig. 1, and the structural details will readily be inferred from the drawing. When the load is being lifted the brake is locked

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and revolves with the spindle, but when lowering the casing is prevented from turning by means of a ratchet wheel and pawls, the friction between the revolving and fixed parts constituting the brake. Current is required to lower the load, and this fact

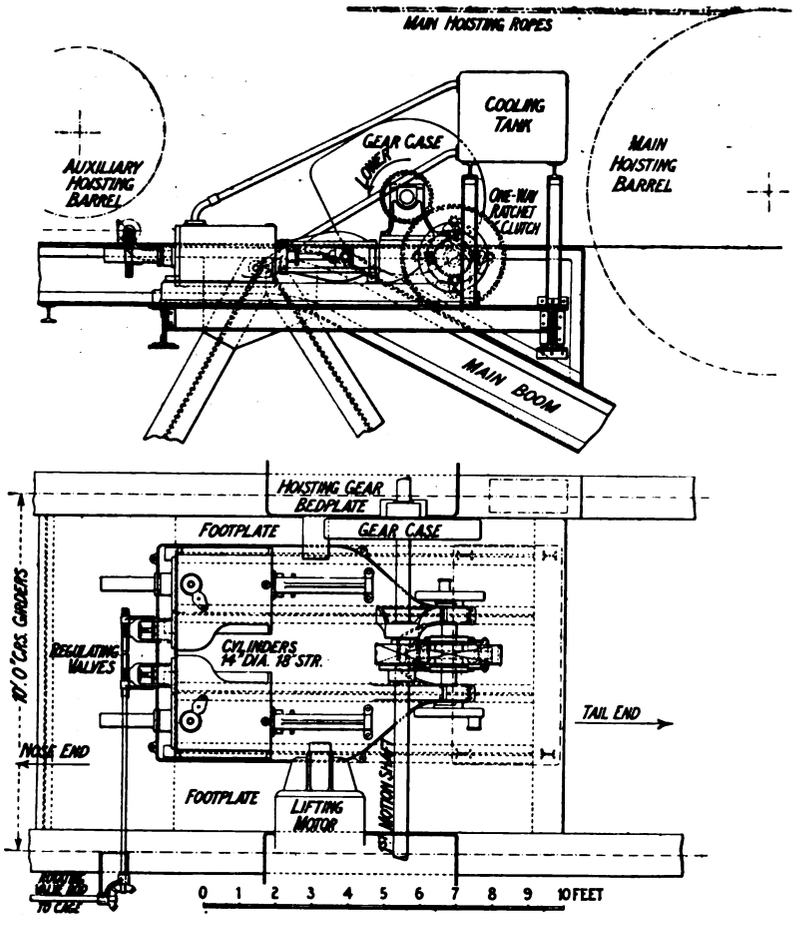

FIG. 2.—HYDRAULIC BRAKE.

must be taken into consideration in selecting the motor. The all-day efficiency of cranes fitted with mechanical brakes is very low, and this, together with the great cost, neutralises the advantages to some extent.

The hydraulic brake shown in Fig. 2 has been used on many of the heavy giant and titan cranes constructed by Messrs. Stothert & Pitt, and has proved entirely satisfactory under the most exacting conditions of service. The brake consists of two hydraulic cylinders fitted with pistons, guides and cross-heads. To prevent overheating, the cylinders are water-jacketed. By-passes connect the ends of the cylinders, and throttle valves are provided for opening or closing the ports. The pistons are actuated from crank-discs which are driven by the main lifting gear of the crane when the load is being lowered. A ratchet free-wheel clutch is fitted in order that the hydraulic pistons may remain at rest when the load is being lifted, so that no resistance is opposed to hoisting.

Where several brakes are provided, each should be thoroughly tested with the proof load before the crane is accepted. Electro-mechanical and mechanical brakes should, independently, be of sufficient size satisfactorily to sustain and to lower the load. During the test on the mechanical brake the electro-mechanical brake should be disconnected and vice versa. Moreover, tests should be made which approximate to normal operation, so as to determine the temperature rise of the brakes. Electrical engineers have long recognised that the output of a dynamo electric machine is limited by rise of temperature, and it is to be regretted that many mechanical engineers forget that some machine parts must have not only sufficient strength to resist the forces acting but also cooling surface of such an area and disposed in such a manner as to get rid of the heat which is generated in overcoming frictional resistances.

Another matter which receives insufficient attention is the provision of appliances which make it impossible either suddenly to start or to stop the several motions of a crane. It is desirable to accelerate and retard quickly, and the gears, shafts and structural work must be proportioned to withstand the forces due to the inertia of the moving parts. The travelling and slewing motors, and in some cases all the motors on high-speed cranes should be provided with some kind of elastic connection or slipping drive which can be set positively to slip when the torque exceeds a certain amount. Such devices are inexpensive; they ensure smooth running and enable unskilled operators confidently to work the cranes at their utmost speeds and capacities.

In the main all the gearing should be of steel, the pinions being made from well-hammered high carbon or nickel steel billets, and the wheels of superior quality mild steel practically free from blow holes and shrinkage cracks. With the exception of the slewing curb, and in some cases the barrel wheel and mating pinion of the lifting mechanism, the gears should be machine cut. Involute teeth are now generally used on account of their advantages over the cycloidal form. Overhung wheels and pinions should always be viewed with suspicion. There is a tendency on the part of crane builders to use overhung pinions on the motor spindles, and the practice is bad, for quite apart from mere noise such wheels give trouble in many ways. All high-speed gears should be enclosed in dust-proof cases.

Worm-reducing gears, although widely used on the Continent, are fitted on comparatively few cranes in this country. When properly designed and constructed they are as reliable and have as high an efficiency as cut spur gears giving the same speed reduction. Here again we desire to emphasise the fact that the output is generally limited by the rise of temperature and not by the mechanical strength of the teeth. As long as the question of temperature rise is neglected, worm gears will not give satisfaction. Worm gears are generally constructed by specialist firms, and we would suggest that such gears be subjected to a crane rating test of, say, one hour's duration, or to an intermittent run of six hours' duration under a specified load factor, the temperature rise not to exceed 150°F.

The lifting and traversing ropes should be of extra special flexible plough steel quality with a factor of safety of seven,

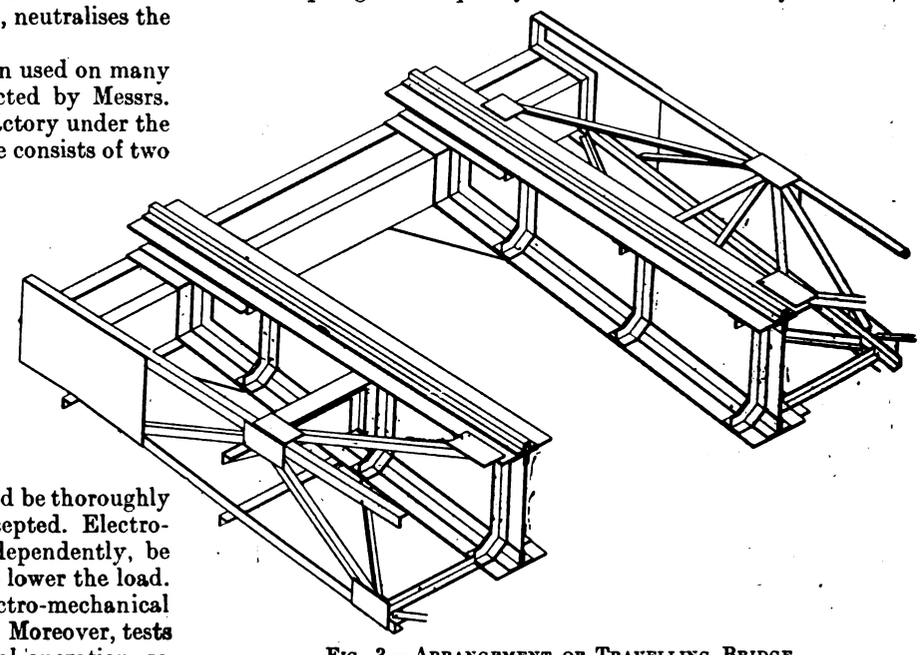

FIG. 3.—ARRANGEMENT OF TRAVELLING BRIDGE.

and the diameter of the winding drums should not be less than 24 times the diameter of the rope.

For ordinary overhead travelling cranes of medium span the best form of cross girder construction to use is shown in

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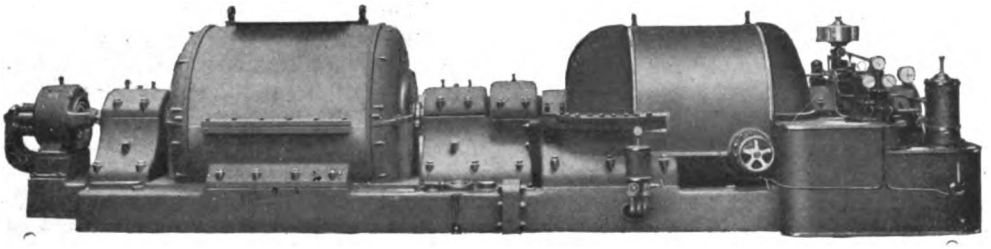

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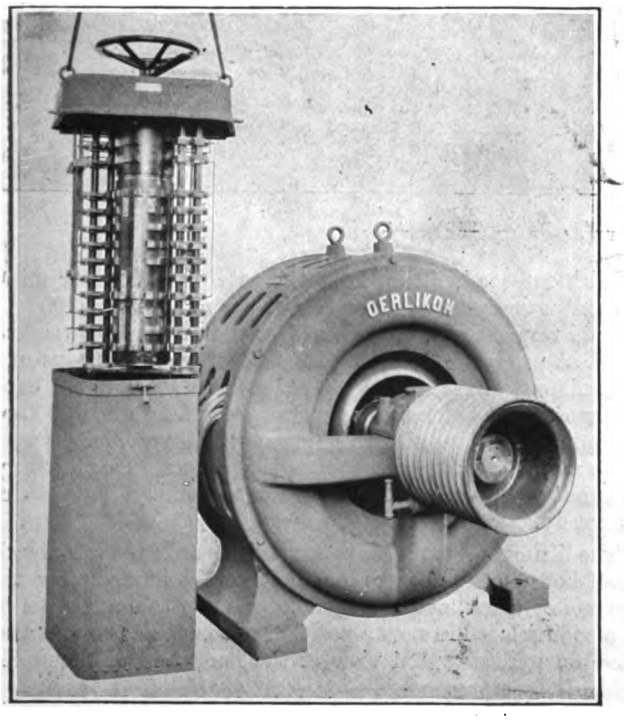

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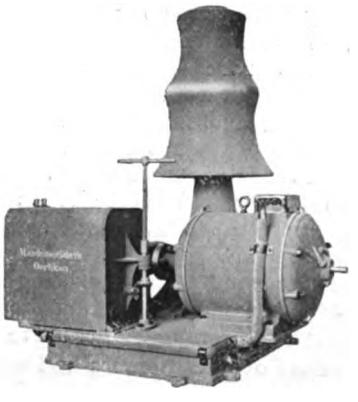

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diagrammatic form in Fig. 3. From the drawing it will be perceived that girders of the single web type are braced to light outrigger lattice girders, which give great stiffness without excess of material, and the open nature of the construction admits of thorough inspection at all times. The structural work of shipyard cranes is liable to corrode on account of the exposed positions in which the cranes have to work and of their proximity to the sea. It follows, therefore, that all parts must be accessible for inspection and painting, and so arranged as to allow a free circulation of air through them. No plates or sections less than $\frac{3}{8}$ in. in thickness should be used except for detail work, platforms and so forth.

In adopting electric driving engineers should endeavour to arrange the machines in such a way that a comparatively small number of different sizes of motors are required. By so doing few spares have to be stocked, and switchgear and accessories may be standardised. The writer has shown that the same principle can be applied to cranes of widely varying capacities and speeds.*

Generally speaking, all the motors and brake-releasing electromagnets should have a one hour rating with a rise of temperature not greater than 75°F., or, better still, the rating should be based on the load factor to which the motors are subjected. Controllers, switchgear, and resistances should be of robust mechanical construction, and all live parts protected in an efficient manner. Care must be taken to ensure that the whole of the wiring work is carried out in a thoroughly satisfactory manner. No cables other than "Association" quality, taped, braided and compounded, of not less than 600 megohms grade should be used, and the wiring should be run in galvanised steel barrel (free from burrs), with screwed joints, and inspection boxes at the bends, outlets being bushed to avoid abrasion. The entire electric equipment and each motor circuit on a crane should be protected against overloads and short-circuits by circuit-breakers or enclosed fuses. As a safeguard against mechanical injury, limit switches are generally provided which interrupt the supply in the event of the motion being carried too far. Hammer cranes and jib cranes are usually provided with an indicator which records the working radius and the safe load at that radius.

Apart from overhead cranes and ordinary jib cranes which resemble those used in all engineering works, shipyards are provided with special cranes in the plate and stock yards, over the building slips and at the fitting-out basin. The remainder of this article will be devoted to the description of a number of these special cranes, and for convenience they are taken in the order named above.

YARD CRANES.

Double cantilever and gantry cranes are generally used in the plate and stock yards. They are characterised by their great size, and by the high speeds of the several motions. Thus the capacity and dimensions of the yard cranes installed at the works of Messrs. Vickers, Sons & Maxim, Barrow, by the Brown Hoisting Company, are as follows* :—

Trolley travel 159 ft. 1½ in. each way from the centre of the crane, or a total of 318 ft. 3 in. centre to centre of the extreme positions of the hoist block. The maximum load is 5 tons, which can be lifted and travelled through the entire length of the travel of the trolley on the runway. An open trestle structure supports the cantilever, and pieces of 60 ft. in length can be carried through the pier without turning. The double tracks on which the cranes run are gauged 30 ft. 6 in. centre to centre. A motor of 85 B.H.P. output drives the several motions, and under full load the lifting speed is 200 ft. per minute, the travelling speed of the whole crane is about 300 ft. per minute, and the trolley may be traversed at any speed up to 750 ft. per minute.

A 5-ton double cantilever crane constructed by the Appleby Crane & Transporter Co. (Ltd.), and installed at Messrs. Beardmore's Shipyard, Dalmuir, is shown in Fig. 4. The total range of traverse is 240 ft., and the total height of lift above rail level is 22 ft. From the photograph it will be seen that the cantilever is of very light construction, so as to minimise the effect of wind pressure. An under-carriage of double portal form supports the cantilever. It is mounted upon eight pairs of wheels, arranged two pairs under each leg, and compensating trucks are used in order to ensure that all the wheels bear evenly on the rails. The double tracks are pitched at 25 ft. centres apart, and the wheel-base of the crane is 52 ft. 3 in.

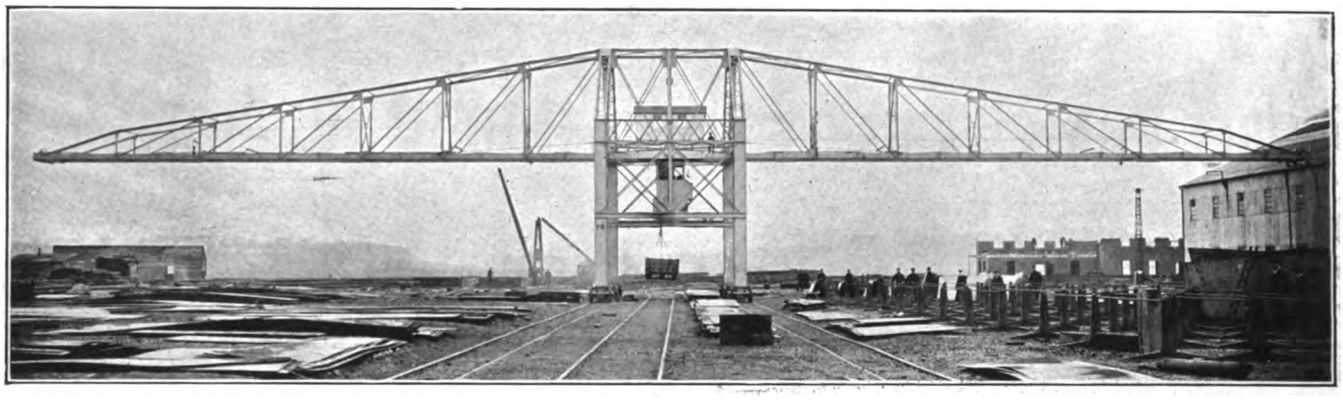

FIG. 4.—5-TON DOUBLE CANTILEVER CRANE, BY APPLEBY'S LTD.

With full load, lifting is at the rate of 100 ft. per minute, traversing and travelling at 400 ft. per minute and 300 ft. per minute respectively. Loads of less than 5 tons in weight are lifted at proportionately higher speeds, and by means of the controllers the speeds can be reduced to any desired extent. The motors, of which there are two, are of 50 B.H.P. at 500 revs. per min. Lifting and traversing motions are effected by the same motor, and the mechanism is arranged in such a way as to admit of each motion being performed singly, but not simultaneously.

The lifting and traversing mechanisms are fixed in a weather-proof house on the centre line of the crane immediately above the trolley track, and the whole of the controlling gear is fixed in a cabin placed in such a position as to enable the operator to have an uninterrupted view of the hook and of the working field of the crane.

Gantry, or bridge cranes, as they are called, of considerable size and capacity are used in a number of yards on the Continent and in America. If so desired they may be made with single or double cantilever extensions. When the span is large it is customary to fix the bridge at one end to a stiff portal frame having a large wheel-base, and hinge the other end to a △-shaped trestle. To give the necessary lateral stiffness to the structure, lattice frames are fitted which extend diagonally on both sides from the centre of the bridge to the portal.

In the gantry cranes made by the Brown Hoisting Company,

* THE ELECTRICIAN, October 25, 1907.

* *Proc.* Inst. Mech. Engineers, July, 1901.

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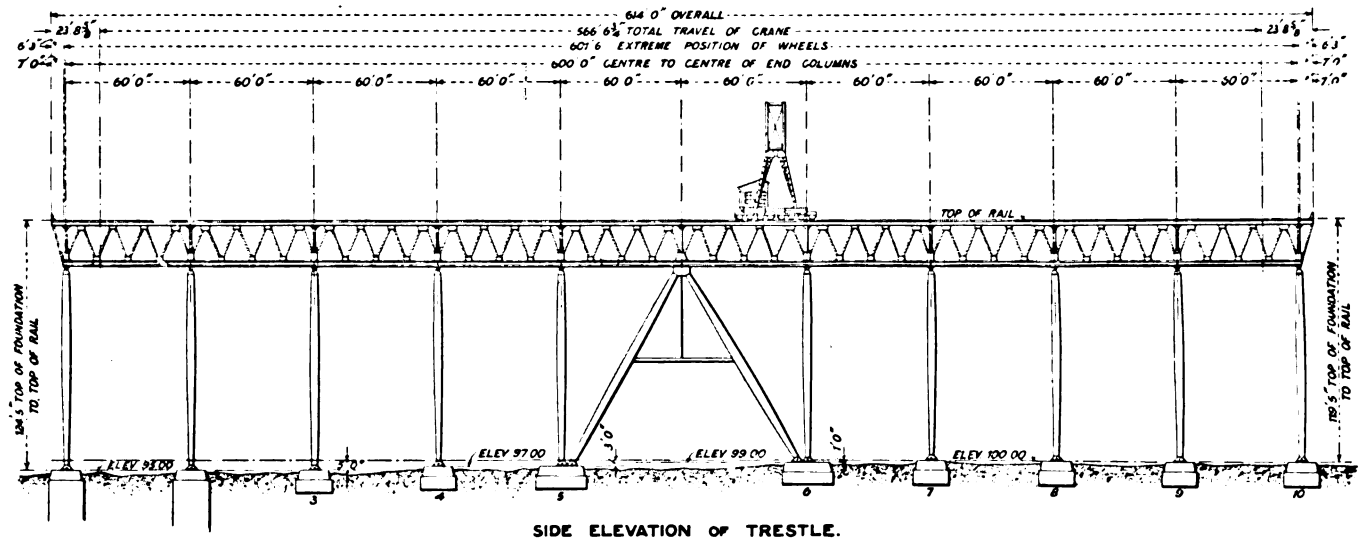
the girders are hung to the movable piers in such a way that if the tracks upon which they run get out of parallel or out of level, as frequently happens, or if by reason of slippery rails or other causes, one end of the crane gets behind or ahead of the other, the crane can yet be operated safely and satisfactorily within reasonable limits. No attempt is made to connect the bridge to the legs rigidly. At one end it is pivoted to a double truck pier, and at the other end it is suspended from a single shear or pier by means of a universal connection.

The girders or bridge trusses are designed to give maximum strength with the smallest dead-weight and area of material, with the members of such shapes and so arranged in the trusses as to expose the least possible surface to wind pressure.

BUILDING SLIP EQUIPMENTS.

There are half a dozen or more modern systems of building slip crane equipment, and it is impossible without careful consideration to say which of them is best suited to a certain class of work or arrangement of yard. An equipment involves a large outlay of capital, and in every case full care must be taken to select the best. The best system is the one which enables material to be placed in position at minimum cost. It is generally admitted that the crane system is superior to the side derrick system. The first cantilever crane installed at Cramp's Shipyard, Philadelphia, is said to have placed in position a sternpost weighing 18 tons in about 20 minutes, taking it from trucks at the front end of the yard with but a few men,



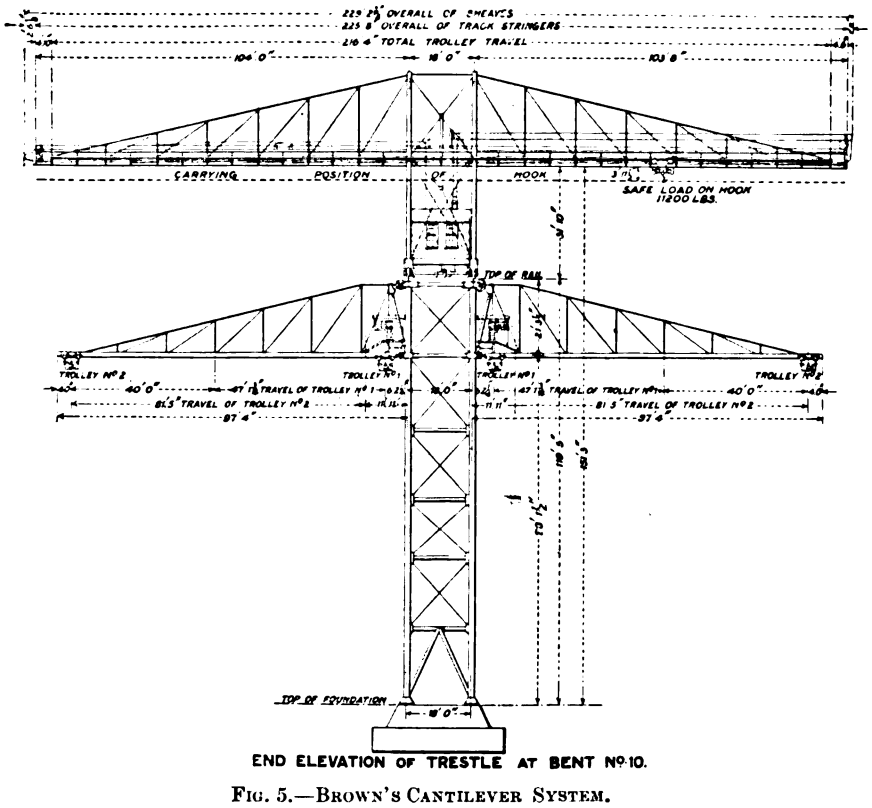


FIG. 5.—BROWN'S CANTILEVER SYSTEM.

A single motor, driving through friction clutches, is used to operate all the motions of the Brown gantry crane. The speeds of these cranes of 5 to 10 tons capacity and of 200 ft. to 250 ft. span are as follows: Lifting full load, 100 ft. to 300 ft. per minute; travelling with full load, 300 ft. to 900 ft. per minute; traversing with full load, 500 ft. to 1,200 ft. per minute. Such speeds can only be attained by cranes possessing a proper amount of flexibility and little inertia.

an operation never before accomplished in less than two or three days and with many men.* After the launch of the ship the same crane cleared the ways in four hours.

The essentials of a building-slip crane equipment are: (i.) Efficient service over the whole berth, (ii.) many cranes of reasonably large capacity and high speeds, (iii.) provision for working the cranes in concert, (iv.) minimum interference with operations along the sides of the ship, (v.) minimum obstruction of daylight, (vi.) adequate means of supporting and manipulating the riveting appliances (vii.) railway service to each crane.

We shall here describe several equipments that have been installed in various shipyards during the last six or eight years, and which conform more or less closely to the requirements stated above. For more detailed particulars of a number of important overhead crane equipments the reader is referred to an article in THE ELECTRICIAN (August 27, 1909).

A typical example of the "Cantilever" system, installed at Messrs. Harland & Wolff's Shipyard by the Brown Hoisting Company, is shown in Fig. 5. From the illustrations it will be perceived that the equipment consists of a gantry or trestle 614 ft. long and 18 ft. in width, placed between two berths, on the top of which a balanced double cantilever crane travels. There are also two side cantilever cranes for taking the hydraulic riveting machines. The gantry is of sufficient height to bring the underside of the crane girder 151 ft. above the ground.

The double cantilever crane extends 104 ft. on each side of

* Methods of Handling Material over Ship-building Berths in American Shipyards. *Trans.* Inst. N.A., 1902.

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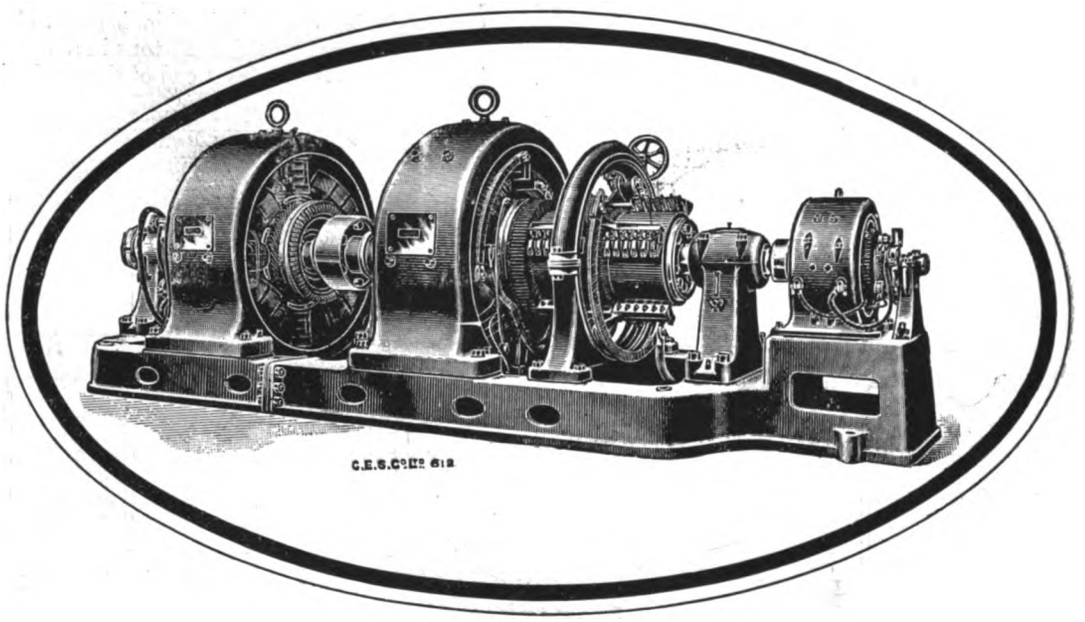

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the gantry, and can thus serve any part of either of the ships which are being built on the two slips. Loads up to 5 tons in weight can be handled by the crane, and the rate of travel is 400 ft. to 600 ft. per minute (depending on the load and wind pressure). Cross-travel is at the rate of 400 ft. to 800 ft. per minute. The speed of hoisting is 200 ft. to 250 ft. per minute with maximum load. A single motor of 80 B.H.P. output is used for driving the crane.

Cross-travel of the trolley is accomplished by two drums winding wire rope connected to the trolley. These drums are mounted on a shaft which is never reversed. When one drum is thrown into gear with the driving shaft the other is disconnected and remains idle, so that as one winds the other pays out. The drums are kept in the same relative position by means of a return loop, or small wire rope, which is wound in an opposite direction to the main ropes.

Lifting is accomplished by a single drum, and the load is lowered by gravity, a powerful brake being provided to check the descent. The resultant force of the crane under load is kept within the proper limits by a counterweight which can be moved along a track on the cantilever arms above the load trolley. Wire ropes connect the counterweight to the trolley in such a way that the former automatically takes up a position on one arm of the crane corresponding to the position assumed by the load on the opposite arm. When unusually heavy loads have to be dealt with an additional weight can be added to the counterweight, and if so desired the "arm" of the balance weight can readily be altered.

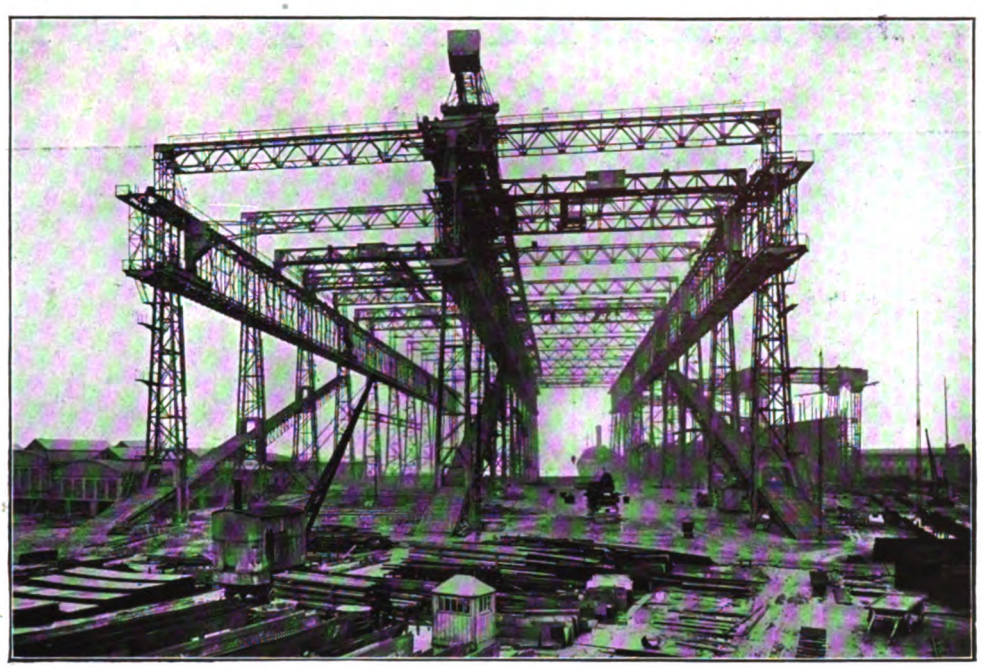

FIG. 6.—VIEW OF SLIPWAY AT MESSRS. HARLAND & WOLFF'S. (SIR WM. ARROL & CO. AND MESSRS. STOTHERT & PITT.)

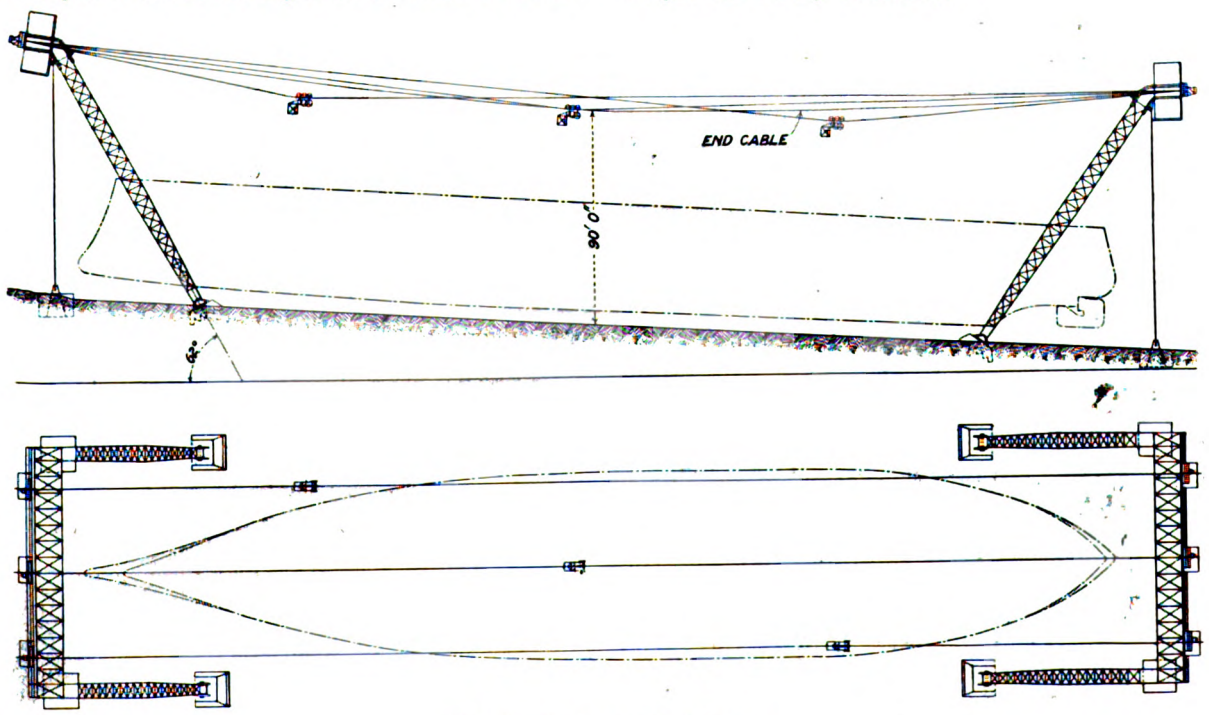

FIG. 7.—HENDERSON'S SYSTEM.

The side riveter cranes extend 106 ft. from the centre line of the gantry. Each is provided with two independent travelling bridges, capable of lifting loads up to 10 tons in weight at 10 ft. to 16 ft. per minute. Bridge travel is at the rate of 20 ft. per

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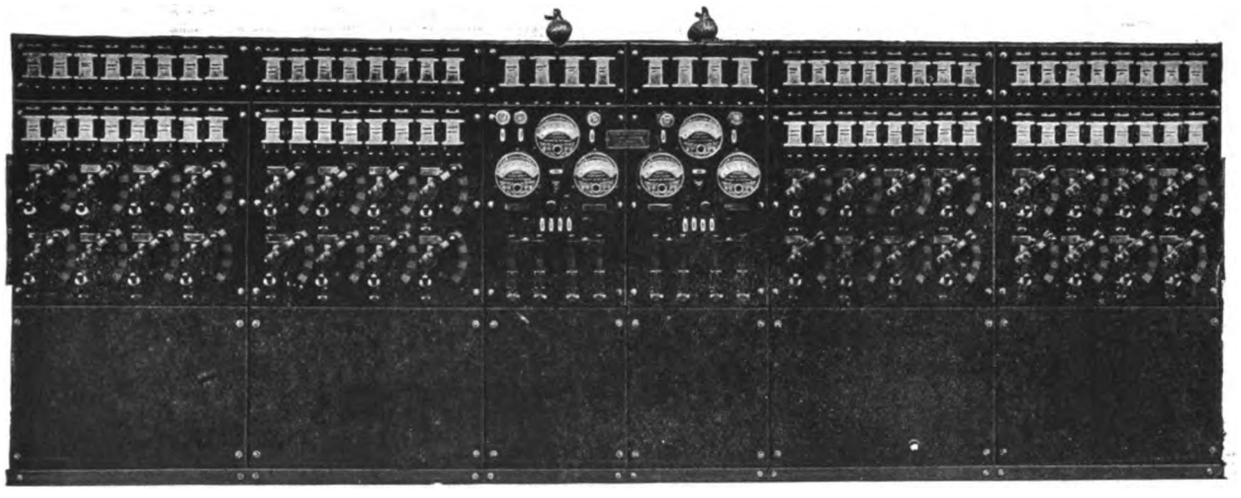

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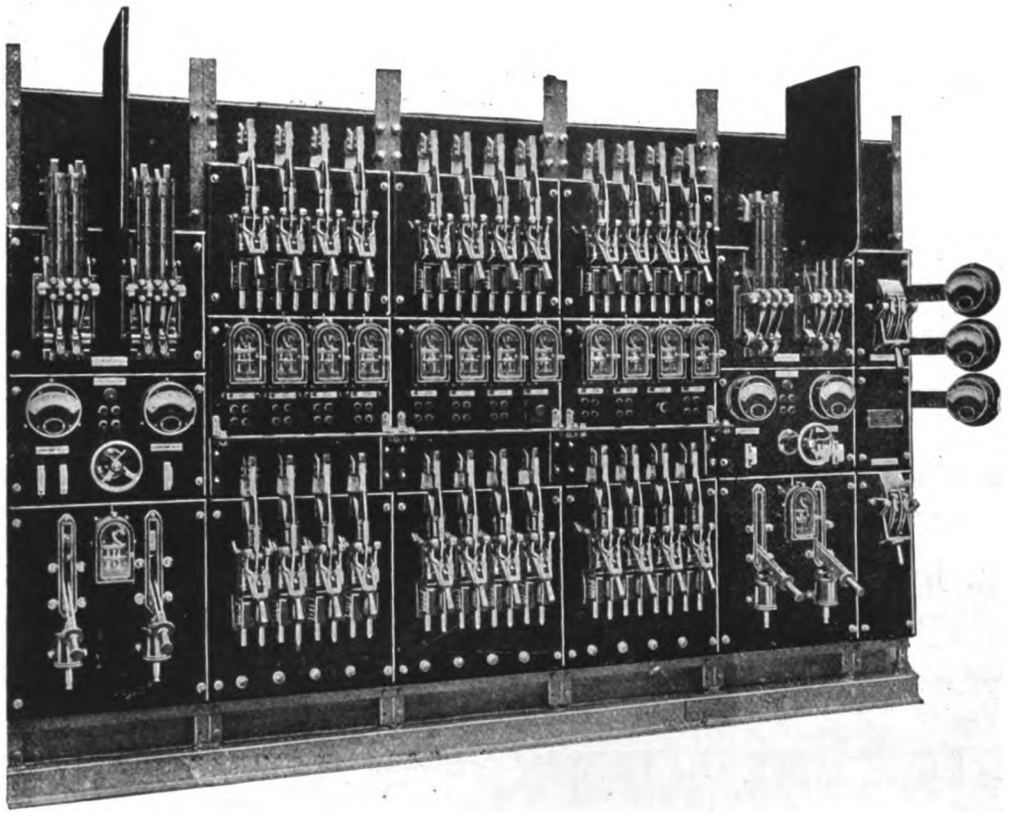

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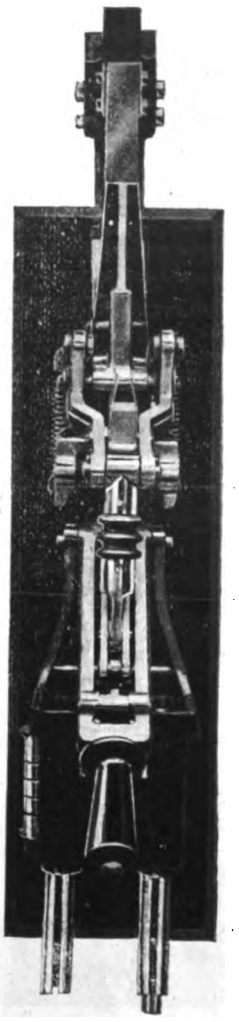

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minute, and the travelling speed along the gantry is 50 ft. per minute. The lengths of travel of the bridges on each crane are about 47 ft. and 81 ft. Motors of 6, 1¼, 1¼, and 50 B.H.P. are used for lifting, trolley cross-traverse, bridge travel and crane travel respectively. The controllers, the main travelling motor and the two bridge travelling motors are located in the operator's cabin. On each bridge are two motors, one for cross-traverse and one for hoisting, and these can be controlled from the riveting position in the ship.

The "Overhead Crane" system is used in a number of yards engaged on the largest vessels. In an equipment of this kind a gantry is erected over the berth which supports a number of travelling bridges, and walking jib cranes are provided on each side of the berth immediately underneath the bridges. Swing jibs are sometimes fitted to the trolleys of the overhead cranes. In the new Harland & Wolff equipment, however, each bridge supports two complete travelling cranes with lifting, traversing and travelling motions.

This equipment was described at some length in a recent issue of THE ELECTRICIAN,* but a further note must be given, as no article on shipyard cranes would be complete without a reference to the largest slip equipment in this or in any other country. The photograph (Fig. 6) gives but a poor idea of its magnitude. On the right will be noticed a gantry which in its day, and that not very long ago, was probably of record size, and this serves to give some idea of the progress made during the last 10 or 15 years.

The gantry, 840 ft. long by 270 ft. wide, covers two berths, and consists of three parallel rows of steel towers rigidly connected together at the top, both longitudinally and transversely, by means of lattice girders. The towers, approximately 170 ft. high, are pitched at 80 ft. centres apart, and the distance between the rows is 121 ft.

A revolving cantilever crane (seen end on in Fig. 6) of 135 ft. radius runs on a track placed directly above the centre row of towers. This crane is of the four motor type, with lifting, racking, slewing and travelling motions. The cantilever arm is 181 ft. above the ground, and loads up to 3 tons in weight, can be dealt with at the maximum radius, and 5 tons at a radius of 65 ft. The speeds are as follows: Lifting, 5 tons at 125 ft. per minute and 3 tons at 205 ft. per minute; racking, 5 tons at 150 ft. per minute; slewing, 5 tons at 400 ft. per minute at jib head; and travelling, 5 tons at 200 ft. per minute. The lifting and travelling motors are each of 70 B.H.P. output, and the slewing and racking motors are of 15 B.H.P. The crane is controlled from a cabin mounted in the jib.

Some distance below the track for the cantilever crane, runways for the travelling bridges and for the walking jib cranes are fixed on the inside of the outer towers and on both sides of the inner towers. There are six travelling bridges and ten jib cranes, three of the former and five of the latter per berth.

Each travelling bridge consists of two open type girders rigidly tied together by stiff lattice frames. Rails are fixed to the bottom flanges of these girders for the purpose of carrying two 10-ton travelling cranes. To place in position heavy stern frames and propeller brackets tackle for handling 40-ton loads can be suspended from eye bolts fitted to the two bridges nearest the water. The travelling cranes may be controlled from a cabin on the bridge or from below at the riveting position. The constants are set forth below:—

Bridge—Span 113 ft. 4½ in., travelling speed 100 ft. per min., motor 40 B.H.P.

Travelling cranes—Load 10 tons, span 43 ft. 3¼ in., height of lift 126 ft., travel of hook 33 ft. 10¼ in.

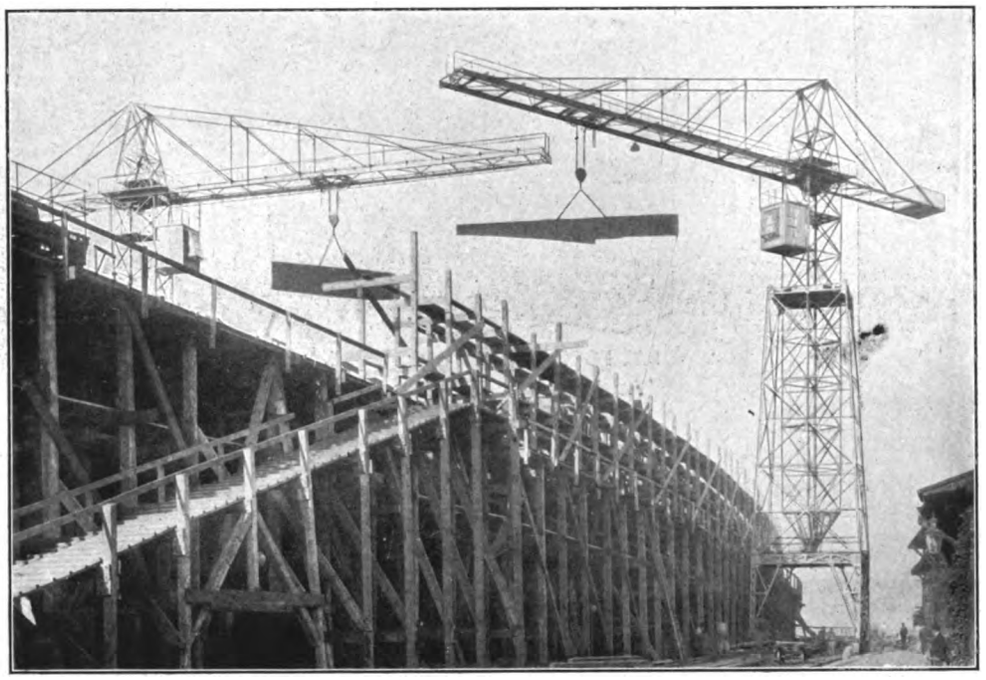

FIG. 8.—BUILDING SLIP EQUIPMENT, BY THE M.A.N. CO.

Speeds—Lifting 10 tons 15 ft. per min., traversing 15 ft. per min., travelling 30 ft. per min.

Motors—Lifting 25 B.H.P., traversing 5 B.H.P., travelling, 5 B.H.P.

The walking jib cranes have a height of lift of 123 ft., and are arranged two on each side of the centre row of towers and three on the inside of each of the outer rows. They run on single rails below the travelling bridges, and are designed to lift 5 tons at a radius of 54 ft. The lifting speed is 100 ft. per minute, the travelling speed 100 ft. per minute, and slewing is at the rate of 250 ft. per minute at the jib head. 50 B.H.P. motors are used for lifting, and for travelling and slewing motors, of 20 B.H.P. and 5 B.H.P. respectively are used. All the control gear for each crane is placed in a cabin fixed near to the junction of the jib and the vertical post.

Access to the cranes and to the working parts of the cranes is afforded by means of protected staircases, platforms and ladders.

"Henderson's" system, shown diagrammatically in Fig. 7, consists of a number of wire-rope cableways (suspended lengthwise over the building berth) carried at both ends on cross-

* August 27, 1909.

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girders, placed transversely, and supported by lattice-work columns. Each cross-girder is constructed in two parts with a clear space between to admit of the passage of the cables for transverse movement, and rails are provided on which travel the end carriages to which the cables are attached. On each end carriage is mounted a motor-driven traversing mechanism, and the two sets of gear are controlled simultaneously by the operator from the load trolley.

The load carriage or trolley is constructed of steel sections, and is provided with a suitable cage for accommodating the operator and the controlling gear. A single motor drives both the travelling and lifting mechanisms. The trolley is moved along the rope by connecting the motor through friction and spur gearing to a shaft on the ends of which two rope drums are keyed. Two wire ropes are stretched from end to end of the cableway, and each rope is coiled on its drum a sufficient number of times to prevent slip in the opposite direction to that in which the trolley is travelling. The load is lifted on four parts of rope, reeved double, the two parts coiling on the barrel, and the loop passing round a compensating pulley fixed to the trolley. Mechanical friction brakes are fitted to both travelling and lowering motions, with operating levers arranged within easy reach of the driver.

Two equipments have been installed over the building slips at Palmer's Shipyard, Jarrow. The first, with three load handling units, serves a berth 500 ft. long by 100 ft. wide, and the second, with four load handling units, serves two berths each measuring 700 ft. by 75 ft. The speeds are: Of longitudinal travel, about 500 ft. per minute; hoisting, 3 tons 100 ft. per minute; cross traverse, about 25 ft. per minute. Three-phase current at 440 volts 30 ~ is used. The arrangement of the current collectors is as ingenious as any part of the equipment. The five trolley wires are arranged in a horizontal plane, with steel supporting cables at each side held apart by distance pieces pitched at 85 ft. centres. Into the distance pieces are fixed the insulator bolts for carrying the ears which hold the trolley wires. The wheel type collectors are mounted upon a light four-wheeled bogie which rests on the upper surface of the supporting cables. Flexible conductors are brought down to the cab, and the pull on the bogie is taken up by steel cable connections between it and the trolley. The trolley wires are supplied with current by three-core flexible conductors from a distribution board fixed on one of the cross-girders. Each cableway is protected by an overload circuit-breaker mounted upon the distribution board, and the board is itself energised by a three-core cable which passes up one of the inclined columns at the end of the berth.

Revolving tower cranes, either fixed or movable, are used in a number of shipyards on the Continent for serving the building slips, and for yards turning out small vessels they appear to have advantages over other types of cranes. In a Paper on Cranes for Shipbuilding Berths,* Signor Piaggio suggested that an equipment for three berths for ships of, say, 460 ft. long might be installed as follows: The three berths should be placed at a distance of 100 ft. between centre lines, and the centre of each crane respectively 44 ft. from the lateral berth's centre lines. The fixed revolving tower cranes should be eight in number, each of 2½ tons lifting capacity, in two rows, four in each. The height of the horizontal jib from the ground should be about 100 ft. for the four forward, 82 ft. for the two aft and 90 ft. for the central ones. All the cranes should have a working radius of 82 ft., and three independent motors, one for lifting, one for traversing the trolley and one for slewing. The speeds should be as follows: Lifting speed 80 ft. per minute, traversing speed 95 ft. per minute, slewing speed at the extremity of the jib 400 ft. per minute.

Many portable cranes of this type have been installed at the Bremer Vulcan Shipyard, Vegesack, and at the Actien-Gesellschaft Weser in Bremer. For particulars of these the reader is referred to a Paper by Mr. Alexander Murray on the Introduction of Cranes in Shipyards.† Two such cranes, designed and constructed by the Maschinenfabrik Augsburg-Nürnberg, and installed at the Kaiserliche Werft in Kiel, are shown in Fig. 8. Loads of 6 tons can be dealt with at a radius of 39 ft., 4½ tons at 48 ft. 6 in. radius, and 3 tons at 78 ft. radius. The speeds under full load are: Lifting 52 ft. per minute, slewing 94 ft. per minute, traversing 65 ft. per minute and travelling 197 ft. per minute. Separate motors are used for each motion, 28 H.P. for lifting, 7 H.P. for slewing, 6 H.P. for traversing and 20 H.P. for travelling. A general idea of the arrangement of these interesting cranes will be obtained from the photograph.

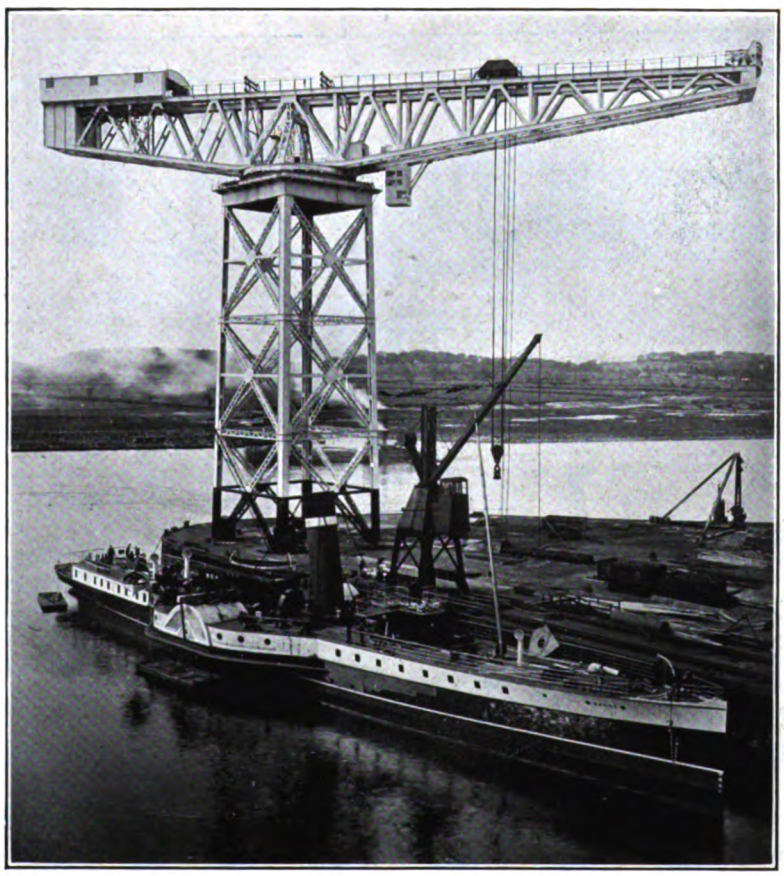

FIG. 9.—150-TON CRANE, BY SIR WM. ARROL & CO. AND MESSRS. STOTHERT & PITT.

In the building of the Cunard liner "Lusitania" two large electric derricks, made by Sir William Arrol & Co., were used. They were designed to lift loads up to 5 tons in weight to a height of 120 ft. from the ground level, with a working radius of 35 ft. from the centre of the mast, and with a jib slewing through 180 deg. The mast is made in the form of an open lattice-work column of square section, with four corner angles, well braced together. Four guys are attached to the top of the mast, and one underneath the jib. A platform for the electrical gear is arranged at a height of 95 ft. above the ground, and from this point is carried the jib which is rectangular in section. The jib is set at an angle of 45 deg., and at the outer end there is fixed the usual pulley for the lifting rope. This rope passes over a deflecting pulley at the base of the jib, and thence through the centre pin to the winch located on the ground level. The lifting motor, of 30 B.H.P., is arranged for two speeds of lifting—90 ft. per minute and 210 ft. per minute, the former being for the full load of 5 tons. The slewing motor is placed on the working platform.

* *Trans* Inst. N.A., March 21, 1907.
† *Ibid.*, April 6, 1906.

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A new type of travelling jib crane, intended to take the place of derricks, overhead cranes and ropeways, has been designed and constructed by the Babcock & Wilcox Co. for service in the Tees Dockyard, Middlesbrough. The crane is of the derricking type, with a jib 60 ft. long, balanced by means of a travelling weight and compensating gear in the column. It is mounted on a carriage 60 ft. high, so designed that it will work on a track of 22 ft. gauge, laid between the berths with sufficient clearance to permit travelling jib cranes or railway trucks to pass underneath. By means of the derricking gear the jib can be used on a long or short radius, either above or below the horizontal line, which admits of the jib being lowered to within a few feet of the position where the load is to be landed. Dangerous swinging of the load is thus avoided. Separate motors are provided for lifting, derricking, slewing and travelling, and these are controlled from a cabin on the platform.

FITTING-OUT BASIN CRANES.

From a careful study of the arrangement of existing shipyards it would appear that the form of crane best suited for placing in position the heavy machinery which enters into the construction of a ship is a fixed revolving tower crane of variable radius, which, for want of a better name, is known briefly as a hammer crane on account of the hammer-like appearance of the double-armed outrigger and crane post or tower.

The ideal position for a hammer crane is on a mole or tongue of land, because in this position two ships can be fitted out at once, thus obviating the necessity for moving the ships to and from the crane.

British and German built cranes of this type are shown in Figs. 9 and 10. It will be perceived that in the German design, Fig. 10, the double cantilever jib is connected to a structural steel post which forms the central axis of a pyramidal framework. The post rests on a roller footstep bearing, and near the upper extremity it bears against a pressure ring formed in the caps of the tower. In the British design, Fig. 9, the post is dispensed with, and the jib is carried on a live ring supported by box girders fitted between the legs of the tower.

The mechanisms for lifting the load and for traversing the trolley are usually arranged on the balancing arm of the outrigger, so as to minimise the weight of the trolley and of the jib, and the weight of the machinery assists the moment of the balance weight. In some cases, however, the mechanism is arranged entirely upon the trolley, or partly upon the trolley and partly on the balancing arm of the outrigger.

An objection to the ordinary type of hammer crane is that the cantilever arm in rotating may foul the masts of vessels which are being fitted out, or prevent masts higher than the crane itself being placed in position. Whether this objection will limit the use of these cranes in the future cannot be foretold, but it has been overcome in an ingenious manner in a 150-ton crane constructed by the Benrather Maschinenfabrik A.-G. for Messrs. J. C. Tecklenborg's Shipyard, Bremerhaven.

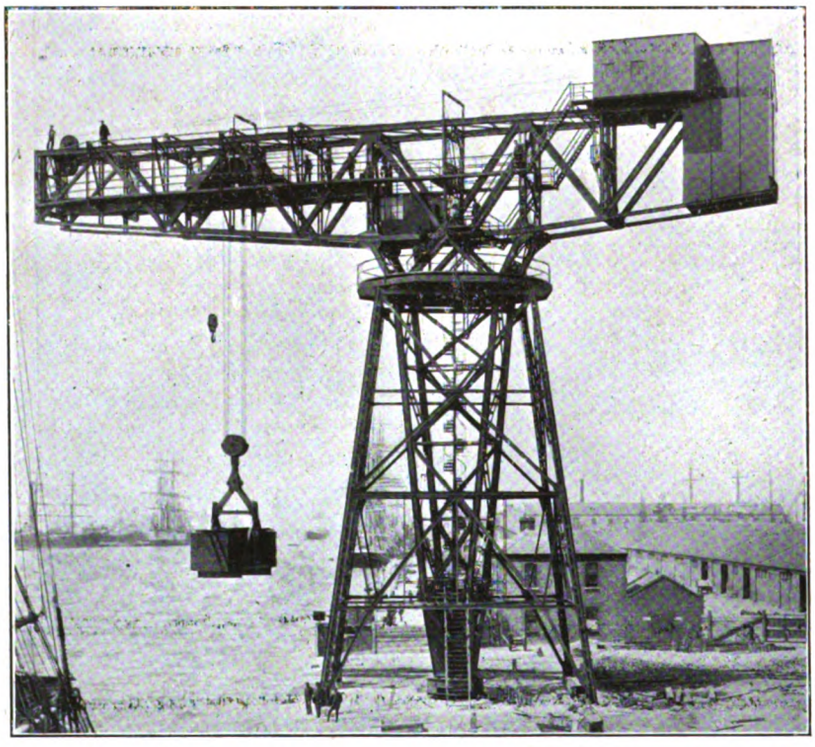

FIG. 10.—100-TON CRANE, BY THE M.A.N. CO.

In this crane the main crab runs between the main girders of the jib, and the machinery house is placed between the girders at the tail end. A slewing jib crane of 20 tons capacity travels on a track laid on the upper flanges along the entire length of the cantilever from back to front, namely, 220 ft. 6 in. The maximum radius of the main block is 125 ft. with a load of 65 tons, and the maximum radius of the travelling jib crane is 156 ft. with a load of 5 tons, and 144 ft. with a load of 20 tons.

General arrangement drawings are given in Fig. 11 of a giant crane of 160 tons capacity, designed by Messrs. Cowans, Sheldon & Co. (Ltd.), and installed at H.M. Dockyard, Devonport. The crane differs from other cranes of this type in several respects. To meet Admiralty requirements the lifting mechanism is composed of two complete sets of 80-ton gear, either of which may be operated separately, or the two may be used together. Moreover, the operator's cabin is not mounted directly in the jib, but is fixed 25 ft. above the quay level on a lattice frame which rotates with the jib.

From the drawings it will be seen that the crane consists of a strongly-braced tower 109 ft. high, composed of four columns 2 ft. 6 in. square set at 46 ft. centres apart, provided with a roller bearing 46 ft. diameter on the top for carrying the two cantilever jib girders. These girders have a total length of 220 ft., and the depth at the centre is 28 ft. They are fixed at 20 ft. centres apart, and upon the top flanges of each two sets of rails are laid. There are 72 wrought steel rollers 12 in. in diameter in the live ring, and the forged steel centre pin is 18 in. in diameter.

The lifting and traversing mechanism is enclosed in a steel-plated house fixed at the tail end of the jib, and assists in counterbalancing the crane. A ballast box is built in between the girders, and filled with 160 tons of stone ballast. A 12-ton travelling crane, with electrically-driven lifting gear, is mounted over the machinery, and in order to lower any of the machinery to the ground level the crane can be run out at the back end of the house. The slewing gear, in duplicate, is enclosed in a steel house in the jib at the centre of the crane, and lifting tackle is provided for dismantling and repairs.

Loads of 160 tons in weight can be lifted at 95 ft. radius, 80 tons at 105 ft. radius and 30 tons at 128 ft. radius. The several motions are worked at the following speeds :—

Main lift	160 tons,	two blocks,	at	6 ft.	per minute.
	80 tons,	one block	,,	6 ft.	,,
	15 tons	,,	,,	30 ft.	,,
Light lift	30 tons	,,	,,	20 ft.	,,
	7½ tons	,,	,,	75 ft.	,,
Traversing	160 tons	,,	,,	30 ft.	,,
	80 tons	,,	,,	60 ft.	,,
Slewing	160 tons,	one revolution	in	8 minutes.	
	80 tons	,,	,,	6	,,
	No load	,,	,,	6	,,

The total height of lift is 170 ft.—viz., 120 ft. above and 50 ft. below quay level. Each main block is carried on eight

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parts of extra special flexible plough steel wire rope 4¾ in. circumference, and the free ends coil on to grooved barrels 75 in. diameter and 10 ft. long, which are driven through treble reduction steel machine-cut gears. The light block depends from four falls of rope, 4¼ in. circumference, reeved double, the two parts coiling right and left-handedly on to a barrel 39 in. diameter. Electro-mechanical and Weston automatic mechanical brakes are fitted on each lifting gear. It is inter-

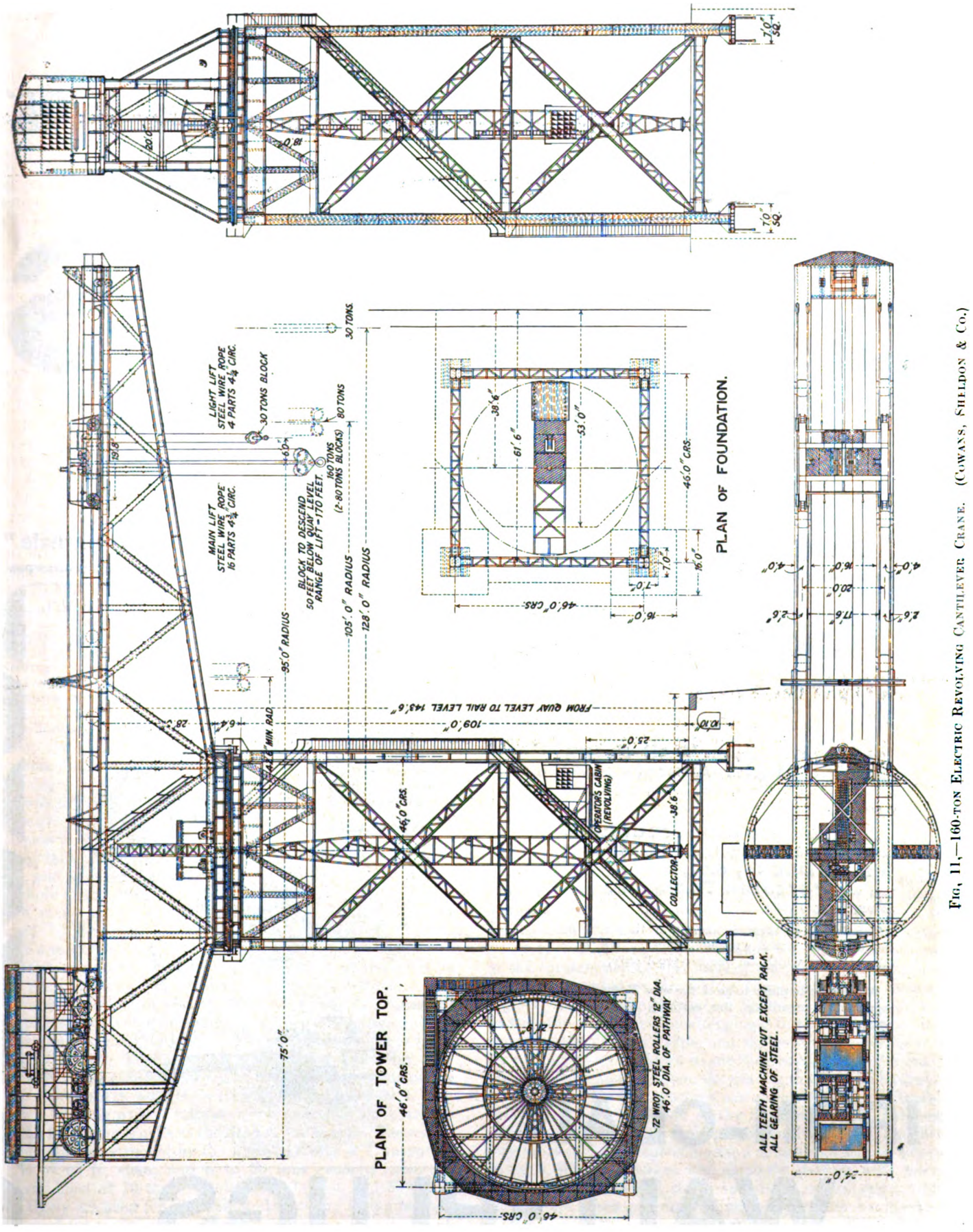

FIG. 11.—160-TON ELECTRIC REVOLVING CANTILEVER CRANE. (COWANS, SHELDON & CO.)

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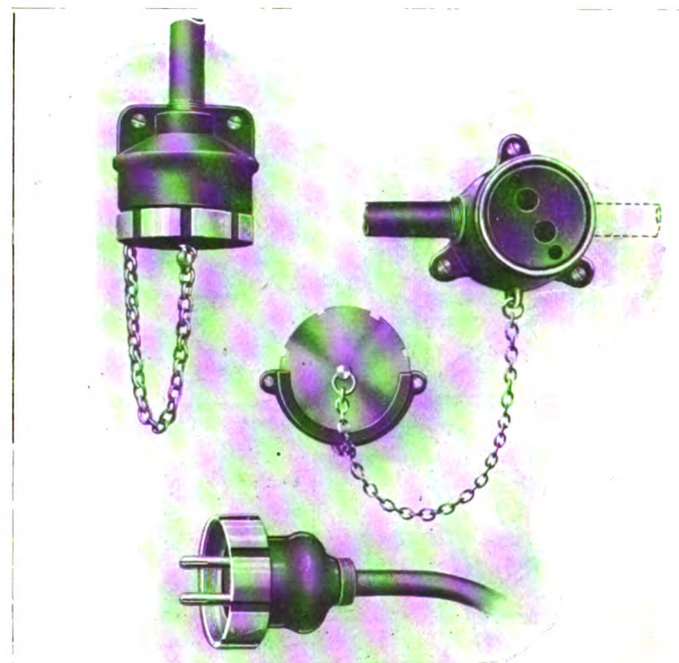

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IRON-CLAD WALL-PLUGS.

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esting to note that the brakes, change-speed gears and motors for the main and auxiliary lifting mechanisms are alike and interchangeable.

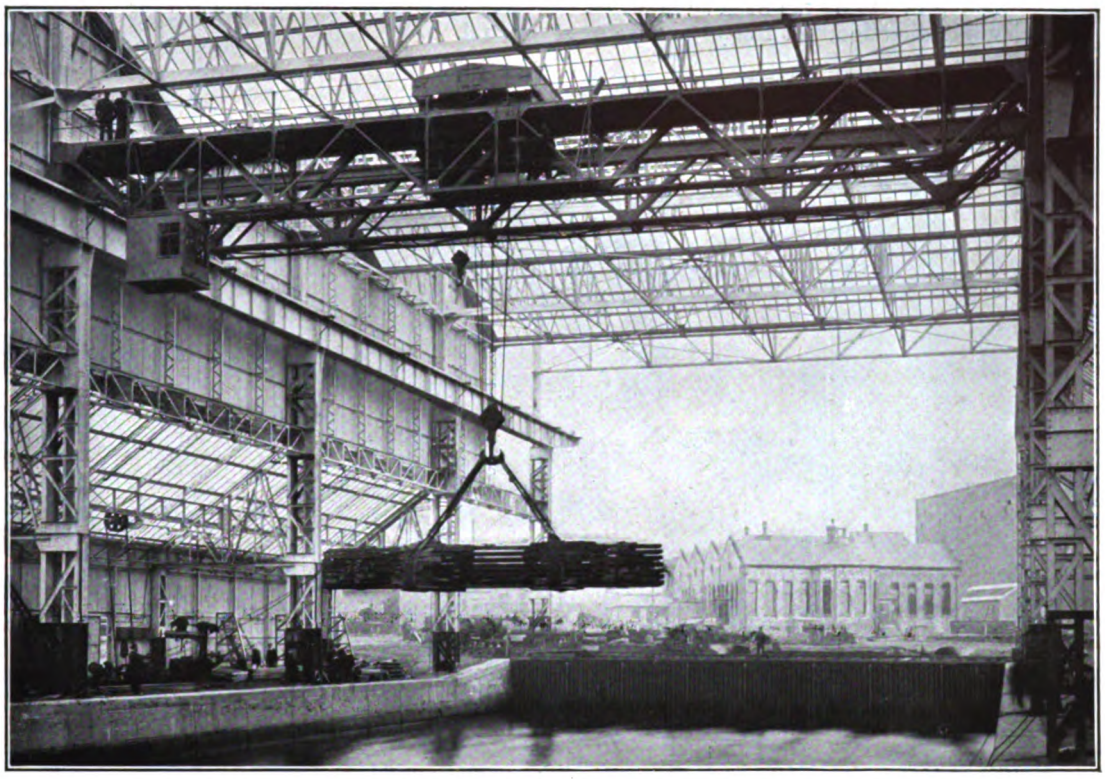

FIG. 12.—COVERED-IN FITTING-OUT BASIN AT YARROW'S SHIPYARD.

The various motions are worked by means of totally-enclosed 440-volt series-wound continuous-current motors (one hour rating with a 70°F. temperature rise) of the following sizes :—

Main lifting	2 motors, each	60	B.H.P.	at 550	revs.	per min.
Auxiliary lifting	1 motor	60	,,	550	,,	,,
Slewing	2 motors	60	,,	550	,,	,,
Traversing.....	1 motor	30	,,	580	,,	,,
Overhead crane	1 motor	10	,,	630	,,	,,

The main lifting motors are operated by a three-drum controller, the right and left-hand drums of which control the corresponding sets of lifting mechanism in the usual way. The third drum is used when it is required to work the two sets of gear together, and an adjustable field rheostat is provided to ensure the two motors running at the same speed irrespective of the loads upon them.

The crane was tested with a load of 240 tons at a radius of 95 ft., and no lateral deflection or vibration was noticed during the whole of the tests.

The many cranes of this kind designed, constructed and erected by Sir Wm. Arrol & Co., the Appleby Crane Co., and Cowans, Sheldon & Co. bear eloquent testimony to the skill of British engineers, and serve well to show that designers at home are in no way behind their Continental brethren.

Covered-in basins served by overhead travelling cranes are used to some extent in America, and to a less extent in this country and on the Continent. An excellent example is to be found at Messrs. Yarrow's new shipyard at Scotstoun, and Fig. 12 serves to give a general idea of the arrangements of the basin. The gantry—323 ft. in length—is continued 20 ft. outside the building over a railway track to enable the crane to take the load from trucks at the head of the basin. The crane, designed and constructed by the Appleby Crane & Transporter Co., is of 93 ft. span, and is of 50 tons capacity with an auxiliary hoist of 10 tons. Motors of 50 B.H.P. and 30 B.H.P. respectively are used for the main and auxiliary lifting mechanisms, and the travelling and traversing motors are capable of developing 10 B.H.P. and 15 B.H.P. for one hour with a temperature rise not exceeding 90°F. Under full load the speeds are: Main lifting 10 ft. per min., auxiliary lifting 30 ft. per min., travelling 250 ft. per min., and traversing 80 ft. per min.

From the foregoing it will be apparent that the electrically-driven crane lends itself in an admirable manner to the many and varied requirements of shipbuilders. The "new" motive power has enabled man to be of greater service to his fellow men, but assuredly one of the greatest engineering triumphs of modern times is the remarkable progress made in one of the oldest arts practised by man—the art of handling material.

The "Clyde" Electric Capstan

Electric capstans, although admittedly more economical than their hydraulic rivals, have always been regarded with some suspicion on account of their alleged unreliability and proneness to breakdown, and many engineers have frequently adopted the latter type, preferring to accept its many inferior qualities in order to secure the more robust construction. We are, therefore, pleased to have an opportunity of illustrating a new type of electric capstan which marks decided progress in the construction of this class of machinery. This capstan has been patented by Mr. Walter Dixon, consulting electrical engineer to the Clyde Navigation Trustees, and Mr. George H. Baxter, the chief mechanical engineer to that authority; it is known as the "Clyde" type, and the general arrangement of its working parts is shown in the illustration. In addition to the usual wear and tear upon the gearing the heads of hydraulic and ordinary electric capstans are subjected to considerable grooving, due to the action of the hemp ropes ordinarily employed upon them, and the ropes themselves, owing to their very short life, are responsible for a substantial annual expenditure. Where capstans are regularly dealing with traffic incidental to docks and similar places, it would appear that the cost for ropes per capstan per annum may be anything from £10 to £20, a fair average being £15. The "Clyde" capstan, while possessing in a marked degree the increased

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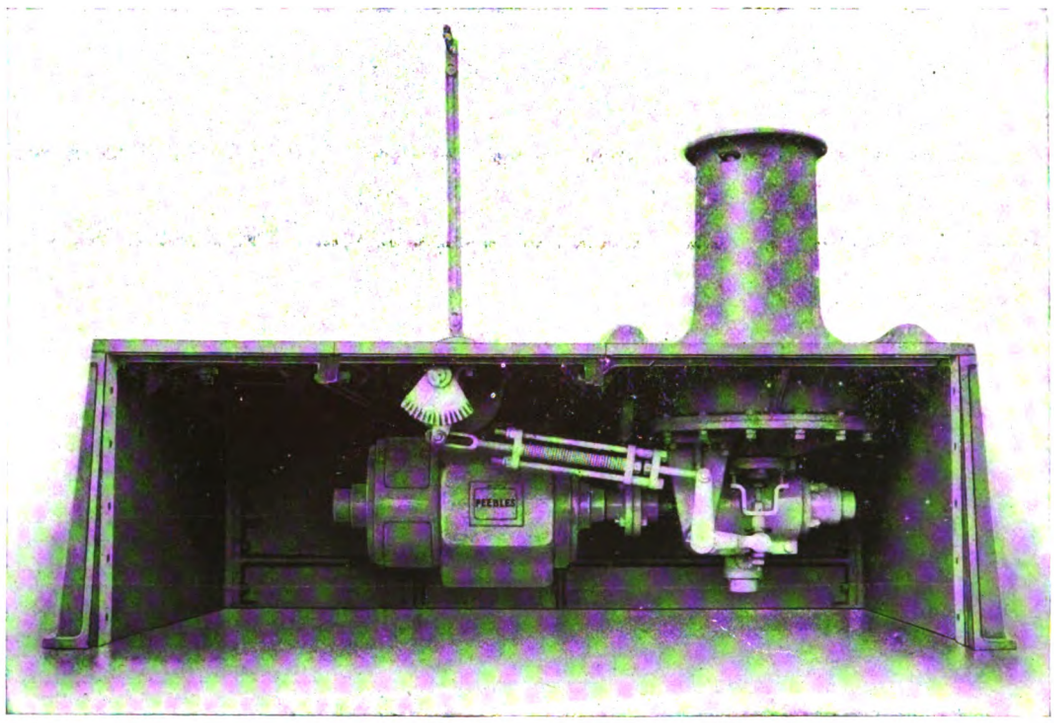
efficiency and other well-known advantages of the electric capstan, claims to have further increased its field of usefulness by eliminating the abnormal expenditure in ropes. This is attained by means of the special features embodied in its construction, primarily consisting in having the head so arranged that it is fixed in the hauling direction, but free to revolve in the opposite direction, thus rendering it possible to use a fixed wire rope in place of the loose hemp rope, and reducing the cost of ropes to something under £1 per capstan per annum.

With regard to power consumption, it has been found that the employment of the "Clyde" capstan reduces the amount of current consumed by not less than 25 per cent., and, what is an equally important matter, the maximum demand from the power station by, perhaps, 50 per cent. These important points are well worth the serious consideration of all interested in the installation of capstans.

The "Clyde" capstan can be controlled either by one handle, or by one handle and a foot pedal, and in either case no attention is required for the rope, which, as stated above, is fixed permanently to the capstan head. The capstan head and box containing the electrical equipment is of well-ribbed cast iron and the box is arranged for letting in flush with the ground.



THE "CLYDE" ELECTRIC CAPSTAN.

Although a number of these capstans have been in use for some years, they are only now, after their reliability has been amply proved, being actively put on the market. They are manufactured by Messrs. Bruce Peebles & Co., Edinburgh, who are one of the firms at present licensed. About 100 capstans have been installed, or are in course of construction, and in practically all instances, we believe, repeat orders have followed their installation, thus demonstrating that they appear to fill a long-felt want, and confirming the claim that the difficulties and troubles hitherto experienced in electric capstans have been overcome.

Oerlikon Gearing for Marine Work.

Worm gearing, as is well known, is one of the most efficient means of reducing the speed of a motor. It takes up less room than does other gearing, runs more silently and is more certain in operation. These advantages are of great importance when the ratio of reduction is above 1 to 10, that is, when an ordinary gear with a single pair of toothed wheels is not sufficient. In this case, also, the small expenditure of energy must be added to the advantages detailed above. Greater efficiency is obtained from worm gearing than with toothed gear wheels, and it can further be very efficiently applied in connection with electric motors which generally run at high speeds. Up to the present it has not found such an extended application as had been hoped, taking into account the rapid extension of the electric drive, a state of things which is due to an erroneous idea that such gearing has only a low efficiency and wears out very soon.

To the existence of such prejudices books on mechanics have contributed not a little, though the success obtained by this gearing in certain directions, especially on travelling cranes and machine tools, is so much in its favour that it is now finding an application in several new directions. The Maschinenfabrik Oerlikon, who have a London branch, were one of the first firms to undertake the manufacture of worm gearing, and they have, since 1890, contributed greatly to the advance of this class of machinery.

In constructing such gearing great care must be taken, and the Maschinenfabrik Oerlikon have laid down a special set of tools for this purpose. The gearings made by them are constructed in six different sizes, and each part of any one set of gearing is interchangeable. In the new type the pressure of the teeth along the shaft of the worm is no longer taken up as it used to be by two bearings, but by one alone, which takes up the axial pressure in two directions. Besides, the bearing is no longer placed in the same compartment as the worm and worm wheel, but is separated from it. This arrangement has the great advantage of preventing damage to any part of the gear should it carry away. The worm is now made of cast

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steel of the first quality, and is highly polished, the worm wheels being of cast iron with a capping of phosphor bronze. In the newest type of Oerlikon gearing, the worm is placed above the worm wheel, an arrangement which has many advantages, both from the designing and operating point of view. The whole of the gearing is contained in a cast-iron case in which is placed the lubricant for the gearing.

As regards the application of this type of gearing, it is now employed for a number of widely different purposes. One of the most extended directions for which it is used is in connection with the electric motor on such intermittent work as cranes, hoists, rolling mills and other similar applications. Another direction which is not less extended, but is rather more of a continuous character, is the driving of machine tools and machines for printing textiles. Lastly, the worm gearing can be successfully employed on quite continuous operations, such as driving pumps or air compressors and other similar work. The illustrations herewith show this gearing more specially adapted to marine work. Fig. 1 is a special set of worm gears fitted with brakes, which have been designed for use in the barbettes of certain battleships in the Italian Navy. Fig. 3 shows an electrically-driven horizontal double winch

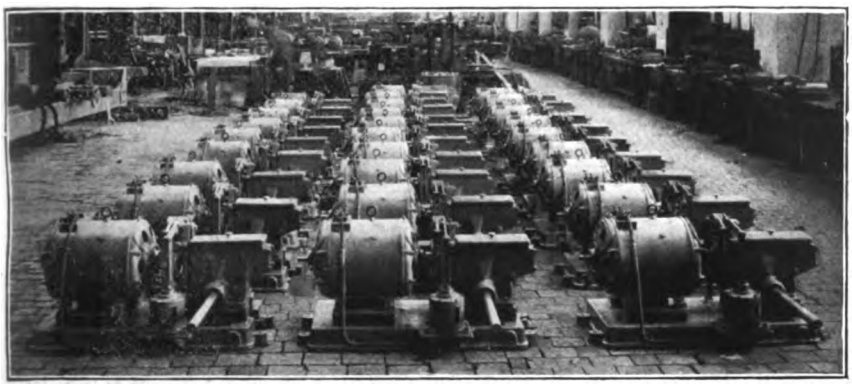

FIG. 1.—A SET OF WORM GEARS DESIGNED FOR THE ITALIAN NAVY.

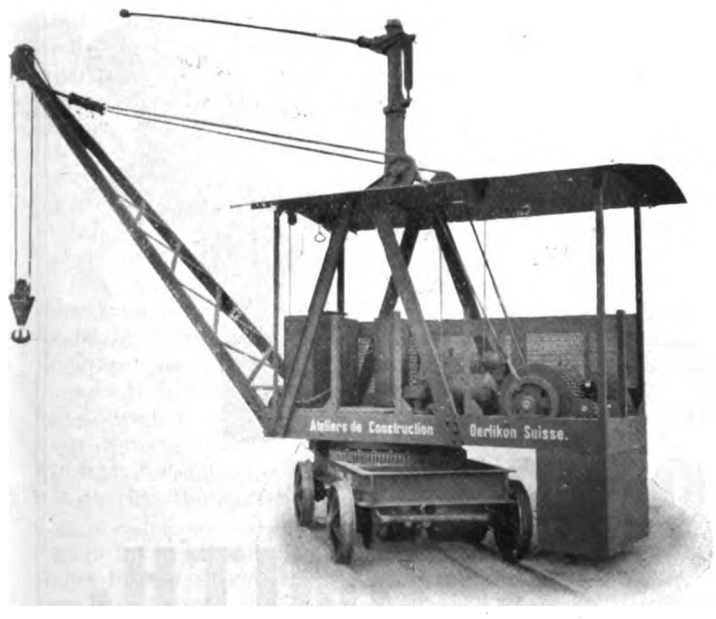

FIG. 2.—ELECTRICALLY-DRIVEN 5-TON WHARF CRANE.

fitted with worm gearing and electric brake, while Fig. 2 shows an electrically-driven 5-ton wharf crane.

The application of worm gearing is limited in one direction by the ratio of reduction which must not be less than 1 to 6 or 1 to 7, and in the other direction by the pressure between the teeth. The most favourable ratios of reduction are between 1 to 10 and 1 to 20 and for large gearings these figures cannot be very much extended without considerable inconvenience. Under favourable conditions worm gearing may be employed for powers up to 100 H.P. For large powers and small speeds it is recommended that the gearing should be used in connection with a toothed wheel in order to ensure high efficiency and prevent wearing out. In general, worm gearing is constructed for as high an efficiency as possible, especially when large

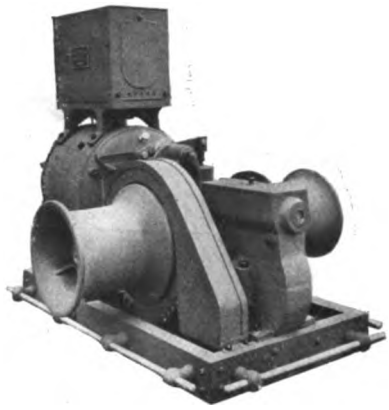

FIG. 3.—ELECTRICALLY-DRIVEN DOUBLE WINCH WITH AN ELECTRIC BRAKE AND WORM GEARING.

powers are being transmitted. By a judicious choice of the dimensions and careful manufacturing, the Oerlikon Company consider that worm gearing can be made to work under the most severe conditions. On the other hand, for small powers and low speeds, the efficiency plays a less important part than simplicity and cheapness of the apparatus. In such cases a lower efficiency may be allowed in order that the ratio of reduction may be increased.

The Coaling of Ships.

An arrangement of the greatest importance for sea-going folk in general has recently been placed on the market by the Felten & Guilleaume Lahmeyerwerke, of Frankfort. This enables coaling at sea to be easily effected.

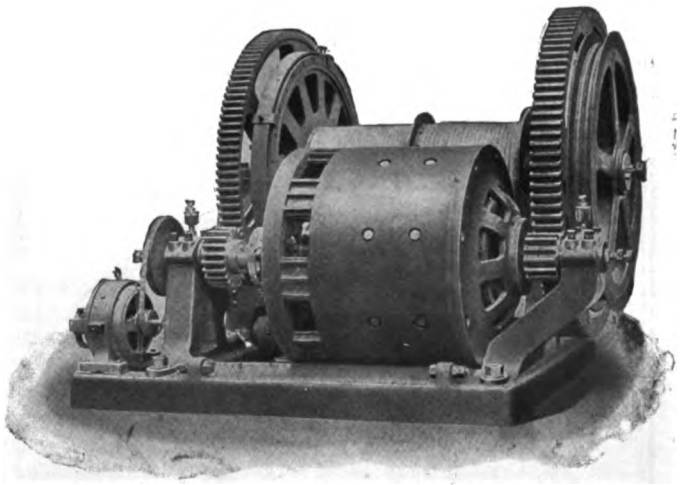

FIG. 1.—HOISTING GEAR FOR COALING SHIPS.

The system, which is shown diagrammatically in Fig. 2, is based on the principle of continually transporting small loads from ship to ship on an endless rope stretched between them. To this rope the loads are affixed by elastic slings, and are drawn direct from the collier to the deck of the battleship.

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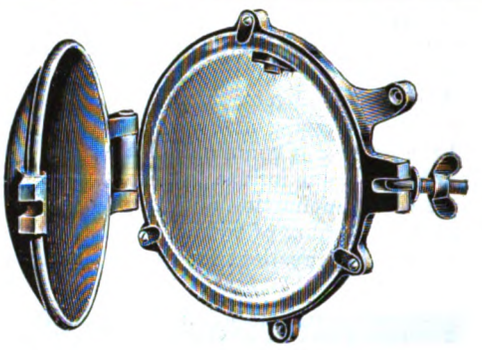
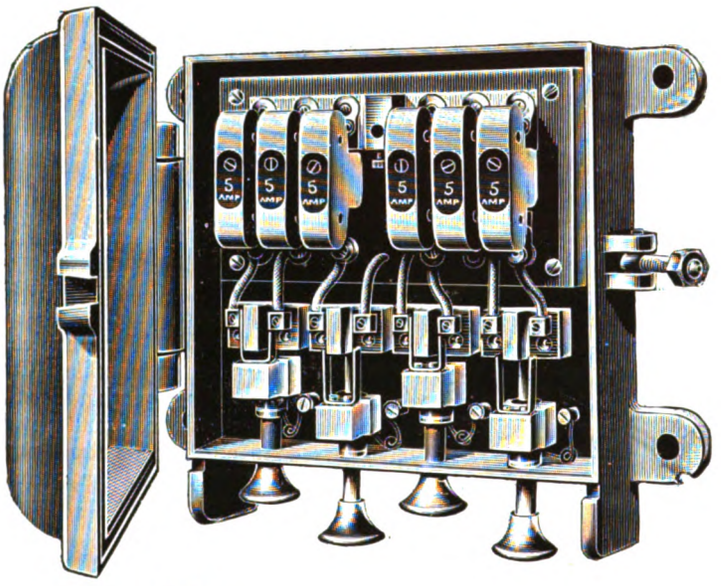
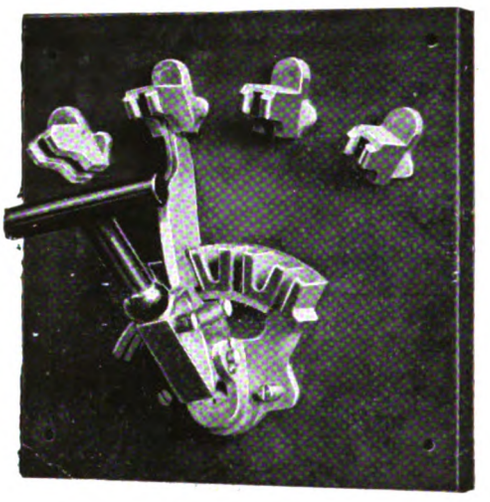
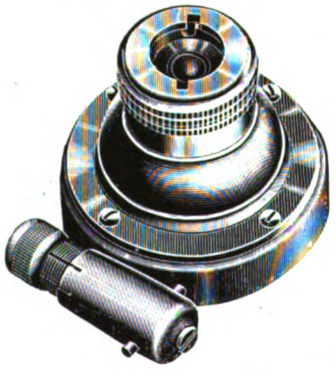

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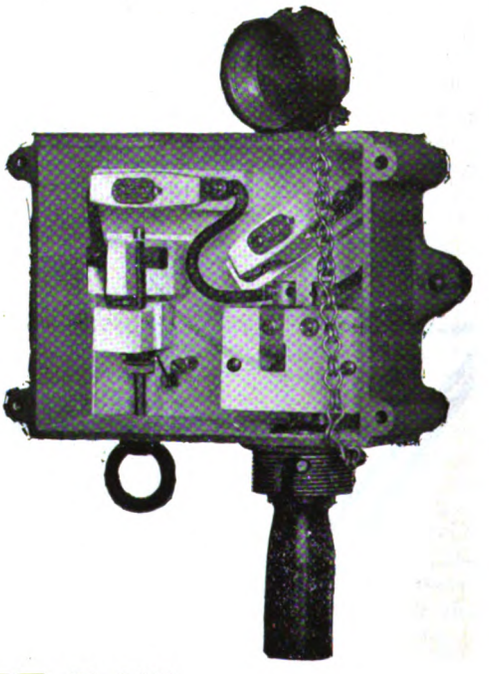
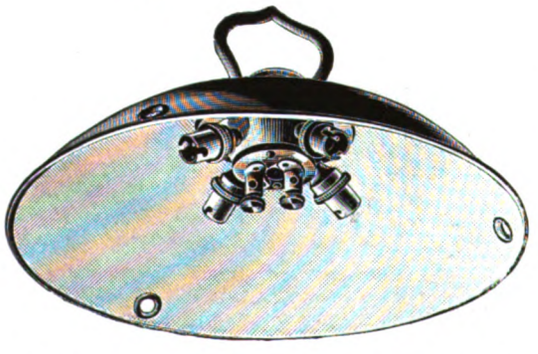

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The slings, contrary to the usual hook arrangement, are enabled by their flexibility to be brought very quickly to any desired level, and are carried to several discharging places which are placed, so to speak, in series. This arrangement is not, it is

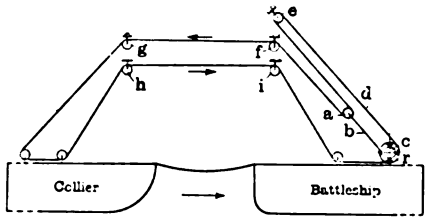

FIG. 2.

said, employed in any other system, and on it rests the great efficiency of the apparatus. The "uncoaling places," which can be placed in any desired position depending on the hatch, consist of a simple, rigid cone, through which the wire passes, but which is fitted with a slit so that the loads placed on at the other stations pass freely by it. The sling is placed on this cone, and, when the load is ready, is drawn on to the running cord. On the deck of the warship the load is cut away by a knife placed under the wire.

A characteristic of the system is the electrical driving and tension system used in connection with the endless rope. As shown in Fig. 2, the wire is driven by a motor, and is kept at a constant tension. In this way the energy consumed is reduced to a minimum. Fig. 1 shows the gear used with this arrangement. In the newest form gearing is entirely avoided, the wire pulley being directly driven from the magnet, and the tension drum directly from the armature. This combined tension and driving arrangement makes up a very simple equipment which, it is claimed, is entirely free from disadvantages. Many tests have been carried out with the apparatus on both sea and land with uniformly satisfactory results.

Switchboards on Warships.

BY A. G. COLLIS.

Summary.—The author summarises the former and present specifications of switchboards for warships, and criticises the lack of uniformity in design. It is essential that manufacturers entering this field of work should specialise. It is also highly desirable, he urges, that parts of gear should be interchangeable even if made by different makers.

Political feeling is centred on the question of the efficiency of our Fleet, comparison being made numerically relative to the "Two-Power" standard, from which calculation is deduced whether we are in a position to prevent an invasion or to lose our present supremacy at sea; and so it appears that the effectiveness of our Navy is fundamentally based on the number of "Dreadnoughts" we have at our disposal, there being a total disregard of other measures adopted to protect and maintain our commerce.

Such comparisons are not only erroneous, but misleading, inasmuch as the determining factors of our effectiveness are not only to be found in numbers but in the efficiency and application of the methods as well as the results obtained by the engineering architects in the production of a war vessel. When all details are considered, apart from the electrical or mechanical features, such as "value of fighting force," "speed and control of the boats," "the performance of exceptional tactics," "skill of superior officers," "position of naval bases," "precision of gun fire," "efficiency of the marine," &c., there is no doubt that this country will shortly be in need of more vessels in the fighting line if we wish to keep up the developments of these machines in distinct ratio to other naval forces.

It is known that the control departments of other naval powers are endeavouring to approach standardisation and simplicity without destroying efficiency, in order that replacement and assembly of gear can be made in the shortest possible time. It is therefore necessary that the engineering section of the public should direct their attention to this important portion of the vessel, so that we, too, shall be in the advance line of development in this direction. There is very little doubt that the modern electrical equipment of a battleship is complicated by the introduction of variable designs which could be simplified with equally efficient results, although it must be understood that in electrical control design we are in advance of other nations through the instrumentality of Mr. C. H. Woodington.

The standard battleship switchboard of former times consisted of an iron or steel channel frame of substantial construction, the metal testing to a tensile stress of 25·30 tons per square inch. 4 in., by 1½ in. in section, and was of such a form as to admit of all the power circuits on one side and the lighting circuits on the other, the generator control gear being in the centre. The number of circuits is varied to meet requirements, the average being eight power circuits, 13 lighting circuits, the board then having an overall length of 17 ft. 9 in. by 8 ft. 3 in. in height. There were four generator circuits, each being controlled by a maximum and reverse current circuit-breaker, interlocked with an equaliser switch, ammeter and voltmeter of the edgewise type and rheostats. The power circuits were fitted with D.P. circuit-breakers only, the lighting circuits with D. P. switches and fuses, the 'bus bars and all live gear being insulated from the frame by mica or micanite, ambroin shields being provided between crossings. Expansion joints were used as occasion demanded.

The circuit-breakers were of special design and for machines were of the maximum and reverse type, and, if possible, fitted with time limit attachment, but must be interlocked with equaliser switch. The overload has a range of adjustment for the excess current between 50 per cent. and 100 per cent., and for the reverse current 10 per cent. to 30 per cent. of the normal load current. With reference to time limit attachment, if it is possible to fit same on the circuit-breaker the rupture should be delayed from 5 to 10 seconds. The circuit-breaker must have a non-closing feature, which prevents the operator closing the circuit when an excess or a reverse current exists. The contacts are to be protected first by auxiliary metal contacts and secondly by carbon breaks upon which the arc is broken. These contacts must be easily replaceable. The breaker is operated by a single handle, and stress is brought to bear upon the point that the circuit-breaker must not open accidentally by vibration or shocks. The insulation is mica or micanite throughout, and the working parts are fitted on a strong channel frame or steel plate. The weight is as light as possible without reducing efficiency, strength and reliability.

The Admiralty favour a uralite partition fixed between the poles if circuit-breakers are arranged in parallel, so as to prevent arcing across. Also they like some guard whereby an operator cannot come into contact with the two poles when operating. The series coils are preferably made of solid drawn H.C. copper, connections being taken therefrom by cast gun-metal pillars. Shunt coils are wound with D.S.C. copper wire, and are protected by brass shields, the wire connections being carried in beaded tubing.

The equaliser switch is designed for the same current density as the circuit-breaker. The switch is coupled to the breaker in such a manner as to prevent the latter being closed

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while the former remains open, and also to cause the circuit-breaker to release before the equalizer switch can be opened. The tripping gear of the circuit-breaker is actuated entirely separately on either or both poles.

The total cost of this board, including breakers is in the neighbourhood of £1,000, and it is very efficient. The "Scout Class" board is of a similar nature with the exception that the conditions are not so severe, and it is of much smaller dimensions. D.P. maximum circuit-breakers, with ammeter and voltmeter are used for the generators, and D.P. switches and fuses for, say, 10 circuits, the switch contacts being directly on the 'bus bars with front connections.

At this time, considering that some of the Japanese boats were being built in this country, one would have thought that the Japanese would have followed English practice. This, however, was not so. The switchboard base in their case was slate, the circuit switches being of the multiway type. This, of course, is bad practice, as a concussion or severe shock in action would destroy the equipment; and, further, owing to the small space available, and the number of small sections which comprise the board, in order to get it down the hold, the strength of the base was materially reduced by the number of holes for the fixing of the gear, so much so that in erecting one board in particular the base cracked and had to be strengthened by stays in fitting up. Slate for mounting on marine work is bad practice. Its electrical features as well as its mechanical strength are inconsistent with the duties to be performed.

The Admiralty are exceptionally precise as to the constructive details of the board, and in the course of time many details are redesigned to meet conditions found by experience, and it is remarkable that shipbuilders do not follow even the principal features of their development, especially with large liners and subsidised boats. In some of these vessels one notices complicated details, such as relays and delicate mechanism. Yet it is obvious that, in case of war, these vessels would play a very important part, not only in protecting commerce, but in supplying the needs of the country. A sharp and decisive shot would settle for good the functions of this control, slate being the base of the mountings.

There is no necessity for a feeder to be protected by time element overload, and, in addition, from instantaneous short, as in the case referred to above. This may be correct for central stations and land distribution supply, as the conditions are difficult.

In another group of large liners there is another variety of design, in one case D.P. switches and enclosed type fuses protecting the machines. In yet another case the generators are protected by D.P. circuit-breakers of the maximum type. The fuses of the various boats are, "porcelain enclosed type," "open type with asbestos tubes," "patent semi-enclosed type," the circuit switches being of the change-over four-way type interlocked with a S.P. switch, so that each outgoing circuit could be placed on any set of bars. There appeared to be no provision for parallelling the generators. It is obvious that, consistent with the property of fuses, should a short-circuit occur on the outgoing feeder, and the circuit-breakers protecting the generators be instantaneous, the plant would be shut down while the fuse continued to hold; and on the other hand, in the case where the generators were protected by fuses, that the generator fuse may blow before the circuit is interrupted. A further peculiarity with these transmissions was the fact that circuit-breakers were supplied on the motor side. It is not a question of criticism as to what form of switchboard is the best, but these facts show a lack of uniformity. The present Admiralty board is totally different from the one described above, and is generally now of the electrical solenoid type, each circuit being controlled by an auxiliary circuit.

The solenoid switch as now designed is very difficult for manufacturers to make, and the specification is exceptionally stringent. It may be quite necessary, but here again is an entirely different departure from the board first described, and if it is admitted that the new design is essential so much more so are the remarks above emphasised. It is agreed that the conditions at sea are unique, and therefore the usual practice in land transmissions is not applicable in this direction. Therefore is it necessary that such manufacturers as are desirous of entering this special field should specialise and apply individual departments to this manufacture. Many firms have suffered severe losses by not realising this fact. The Admiralty are very desirous to meet any manufacturer's standard. The standards submitted, however, in most cases show that the principles of construction adopted are a negative quantity to a ship's equipment; hence definite laws and rigid specifications are submitted to tenderers, which, from a manufacturer's point of view, are extreme, and the manufacturer either submits a tender without any endeavour to secure the work, or, if he does not specialise in this class of material, he submits a price that will result, almost in every case, in a loss. Although Admiralty gear is special, provided proper organisation is made for its manufacture, the establishment charges necessary are considerably lower than the general establishment charges of a large number of firms.

High-tension switchgear entails considerably more dead charges, and if it is decided to develop all the designs of electrical control used in a ship, such repetition designs as the watertight switch, plug and bulkhead fittings, &c. (when once the jigs are made) will considerably reduce the estimated dead charges on such designs as are not produced in machine manner. The experience of Admiralty gear is the most abstruse on the foundry side, as most of the designs do not lend themselves to machine moulding, and are even difficult to cast on brass founders' sand moulds as artificial leavings and cores are necessary. Small details, such as turn buttons, &c., come out cheaper in casting in sprays on sand beds than on machine moulds.

In German designs, although they have the advantage in sand and casting, using practically no facing whatever, machine moulds are employed on day work in preference to the practice of piece work in some of the foundries I have visited. The design of their gear, however, is such that evidently it is the cheapest method, and it is admitted that their standardisation is more in advance, not possibly in design, but in uniformity of design, the component parts of the gear being as far as possible interchangeable with all apparatus. For instance, the terminal on the distribution box being, according to its size, the same throughout as the other distributional apparatus in the ship. Their switchboard design is practically identical on all classes of boats in outsea manœuvres.

It must be expected that the gear controlling, say, a gun boat and battleship cannot be identical, but its component parts could be interchangeable, so as to be easy of production, and so that gear put out of action could be easily replaced.

We, on the other hand, taking as an example, the circuit-breakers described above, make a contract over a period with, say, two companies who have successfully passed the tests, and these circuit-breakers may be totally different in design, and not interchangeable with the other company's manufactures. This does not only apply to circuit-breakers, but also to starting gear, instruments, &c., so it will be seen that a heavy variable stock has to be kept for replacements, it being understood that some portions of the design are made to gauge. On the other hand, other naval powers approach this matter as far as possible differently, the design being settled by those in command, and must be rigidly adhered to. This is the case with the British Admiralty concerning the manufacture of distribution boxes, connecting boxes, plugs, switches, &c., but the regulations do not apply over the whole material. The system of balancing is not used by large foreign admiralties, and their transmissions are very similar to the principle used on the King Edward VII. class. Ambroin, together with mica or micanite of a definite quality, appears to be used almost exclusively by most naval powers; asbestos or asbestos slate are considered unsatisfactory for sea conditions, and it is peculiar that these dielectrics have not been replaced by other material, thus leaving the field entirely open to patentees. On systems used on land this material is not so essential as others, such as uacolite or pegamoid, the latter being noted for resistivity to breakdown under high voltage tests.

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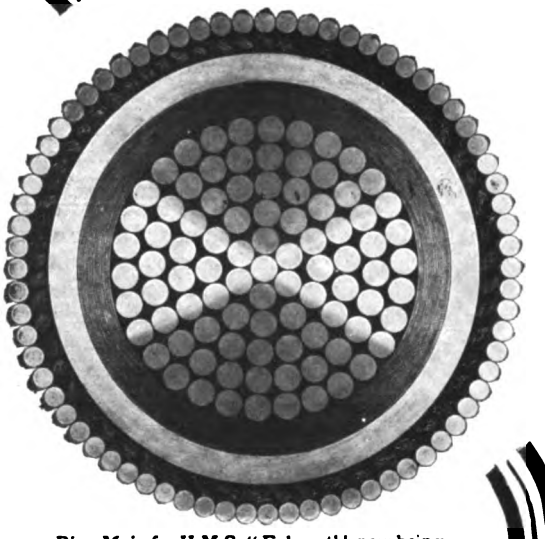

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The connections on a boat of a foreign power are amalgamated. This is not a new idea, as it has been used in bonding tram rails, but it is evident that it is possible to amalgamate without deterioration. Amalgam would be vastly superior to our present methods for heavy currents, heat losses being of primary importance. Tests prove the advantage of amalgamated joints, except in regard to corrosion. In one test of copper contact surfaces, 36 sq. in., fixed with four heavy bolts, a contact loss of 0·00199 volt was encountered in carrying 1,800 amperes. When the amalgam was used the loss fell to 0·00058 volt. It is possible that at some future time amalgamated joints will be the standard order of specifications.

Regarding the voltage used on most battleships, a saving in expense without any degree of risk could be made by using higher voltages of, say, 500 volts, thus saving approximately £6,600 in cable costs, the insulation used being of such a character that no deterioration would result from sea air.

Too little attention is directed by electrical engineers to the mechanical construction of the gear on general lines, but it is particularly noticeable that the mechanical construction of switchgear used by the Admiralty is superior to that of gear used on land, and it is refreshing to note that the electrical staff of the Admiralty is considered the most efficient staff of all the naval powers.

Large Capacity Switchboards for Ship Work.

From an extremely modest piece of apparatus the ship switchboard has evolved until at the present time it ranks in capacity with the gears which are to be met with in a large land central station. Electricity supply on board ship is no longer confined to the lighting of the vessel. The bulk of the subsidiary power operations is now entrusted to electric motors, and consequently the service conditions are very similar to those which obtain on an ordinary distributing network. The switchgear must be arranged to give independent control to a number of generators and a large number of feeders. Where the electrical installation is carried out on such a scale as that introduced into vessels of the "Mauretania" type the switch-gear scheme must provide for duplicate 'bus bars and interconnecting gear so as to ensure absolute continuity of supply.

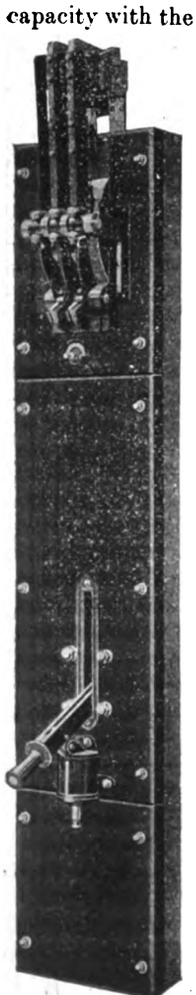

FIG. 1.—4,000-5,000 AMPERE CIRCUIT-BREAKER AS INSTALLED ON THE "MAURETANIA."

A typical example of switchgear of large capacity for ship work is that installed by Messrs. Ferranti Limited on the Cunard Company's ss. "Mauretania." This gear is divided into two portions, which are separated by a watertight bulkhead, and each section controls the energy supplied by two generators. An illustration of the complete gear showing the division between each portion is given in Fig. 2. Each half of the gear is placed in a separate engine room and one portion is practically a duplicate of the other. The equipment provides for two generator panels, three feeder panels, each fitted with four feeder circuits, making 12 feeders in all, and one coupler panel. These will be readily distinguished in the illustration. Each generator circuit is provided with a 4,000-ampere carbon breaker, which has an overload rating of 5,000 amperes for one hour. These breakers are separately operated by a lever handle which projects from the lower section of the panel in a position most convenient for closing. A time limit overload and reverse relay of Ferranti standard construction is fitted to each panel. The breakers themselves are placed on the top section of the panel, and each is provided with a substantial carbon break of the sliding type. The

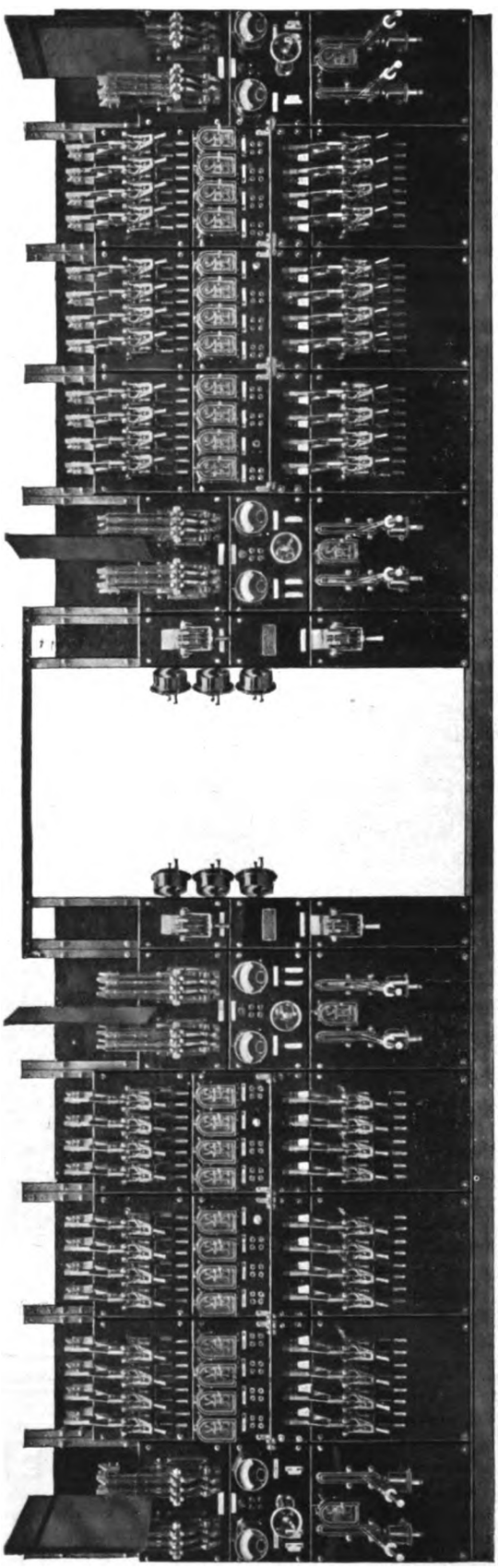

FIG. 2.—MAIN SWITCHBOARD ON THE SS. "MAURETANIA."

breaker is fitted with a free handle mechanism. Each of the feeder circuits is provided with a double-pole free handle carbon breaker, the positive and negative poles being arranged in a straight line down the board. The circuit protecting

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devices include a shunt solenoid in conjunction with an overload time limit relay and a series solenoid. The latter is adjusted to a high-current value, so that it will not trip the breaker with less than 500 per cent. of its normal load. This method has been adopted to ensure that the distributor fuses in another part of the ship will come into operation before the breaker itself for all normal overloads. Anything in the nature of a short-circuit, however, will cause the series solenoid to trip the breaker immediately, whether the 'bus-bar voltage falls or remains near normal. The 'bus-bar voltage is only depended upon for tripping the breaker for ordinary overloads up to, say, 500 per cent. of normal, as under these circumstances the pressure is not materially reduced.

The 4,000-ampere circuit-breaker installed on the "Mauretania" is separately illustrated in Fig. 1. This illustration gives an admirable idea of the load which is now placed upon the generators installed in large modern vessels.

Ironclad Fused Switches.

The importance of ironclad switchgear for naval and marine electrical work is now recognised, and standard types have been developed for this class of work. A typical example of the modern ironclad fused switch is that made by Messrs. Berry,

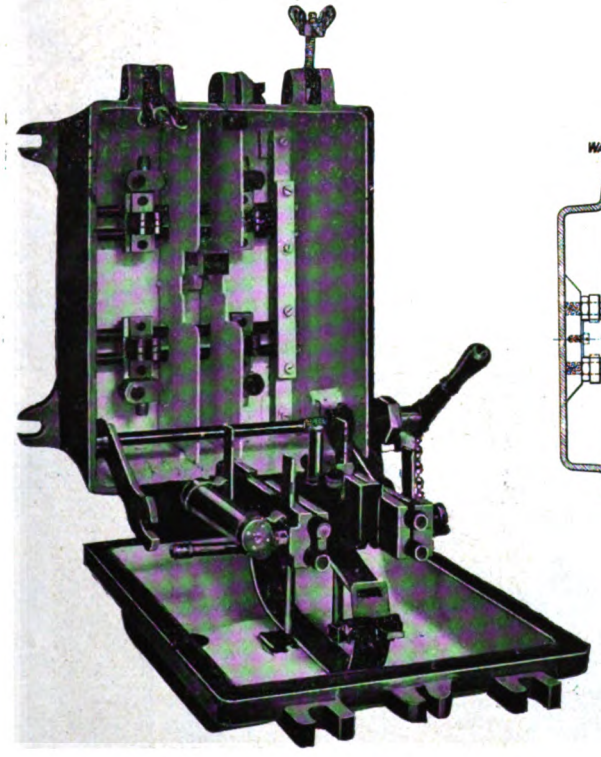

FIG. 1.—THE "DREADNOUGHT" FUSED SWITCH.

Skinner & Co., and appropriately termed the "Dreadnought." This switch which is shown in Fig. 1, is a development of the well-known push-and-pull pattern introduced by this firm some years ago, and installed in very large quantities for the control of electrical circuits in exposed situations, and more particularly in industrial services. The principal features of the switch are the method of insulation, quick make and break, breaking all four contacts simultaneously, and the interlocking of the cover with the switch mechanism, so that the circuit cannot be made with the switch cover open. In Figs. 2 and 3 we give line drawings of this switch, which indicate the substantial construction of the various parts and the attention which has been paid to the method of insulation. The fixed contacts are clamped to two parallel steel rods, each of which is heavily covered with mica. The same fitting which supports the contact clip is also used to hold the incoming sweating lug. The insulating bars are firmly secured to the bottom of the box by two saddles, one at each side, the saddles being held down by four screws.

The moving contacts are supported in a similar manner on insulated steel rods, and the mechanism is arranged to slide on two parallel guides which are firmly fixed in the lid of the box. A substantial bowspring fitted to this mechanism ensures quick make and break at all times. The spring is built up of three parts, and the longest of the three is attached to the lid of the box. This section is slotted at each end, and into the slots a shorter length of stiff flat spring is placed. The other ends of these two flat springs slip into slots in the body of the switch movement. These additional spring pieces have been introduced to admit of easy replacement in case of breakage. In the older pattern type of switch the bow spring was made in one piece only, and in case of failure it was troublesome to fix a new spring.

Projecting from each side of the switch carrier is a pin which engages with the forked ends of two levers, one at each side of

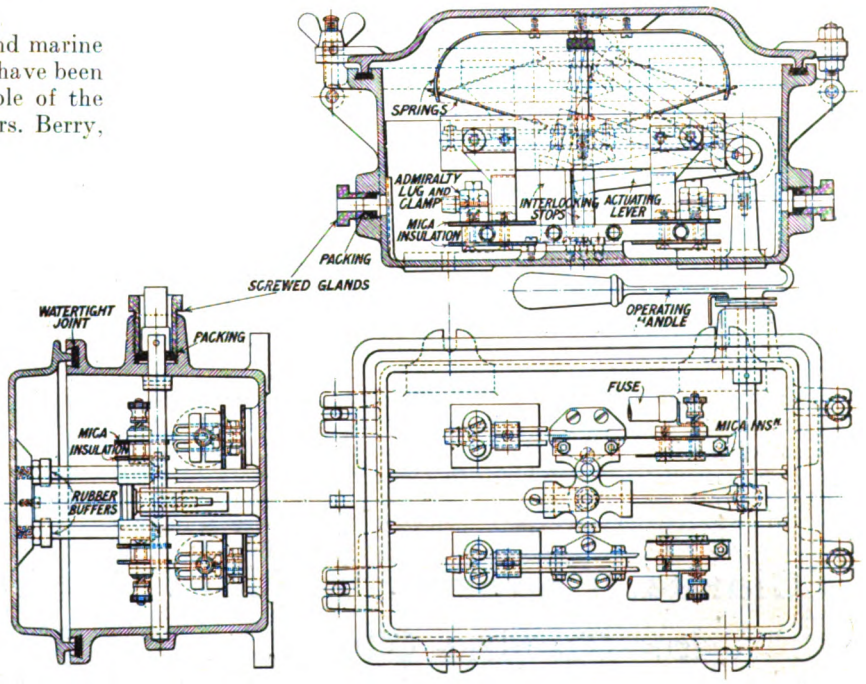

FIG. 2.—THE "INVINCIBLE" FUSED SWITCH, GAS AND WATERTIGHT 50 AMPERES, 600 VOLTS D.P.

the box. The other ends of these levers are secured to a shaft which projects at one side of the case through a stuffing box, and which terminates in a triangular-shaped boss, taking the standard Admiralty key. This construction will be clear on reference to the drawings. The switch movement is fitted with knife contacts, and each of these is bridged by an enclosed type cartridge fuse.

In the bottom of the box is a lug which acts as an internal lock, and prevents the cover being opened when the switch is on. This locking motion operates in the following manner. When closing the switch after shutting the cover the projecting pin on the switch carrier runs clear of the lug in the bottom of the case, and while the switch is in this position any attempt to open the lid is prevented by the fact that the pin will require a radial motion, which cannot possibly be given to it owing to the position of the switch.

The apparatus has been designed for and approved by the Admiralty. It is completely watertight, and is fitted with stuffing boxes for the incoming and outgoing cables. We understand that an insulation test showed practically infinity, and this speaks well for the type of insulation adopted.

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The switch is made for pressures up to 600 volts and capacities up to 250 amperes.

We understand that during gun-fire tests the switch withstood the excessive vibration set up on these occasions, and it has been proved to be both dust and flame proof. It has also withstood a dead short-circuit test simultaneously across both poles at 600 volts without arcing to the cover. The replacement of the fuse is a simple matter, and we understand that only 30 seconds are required for this operation.

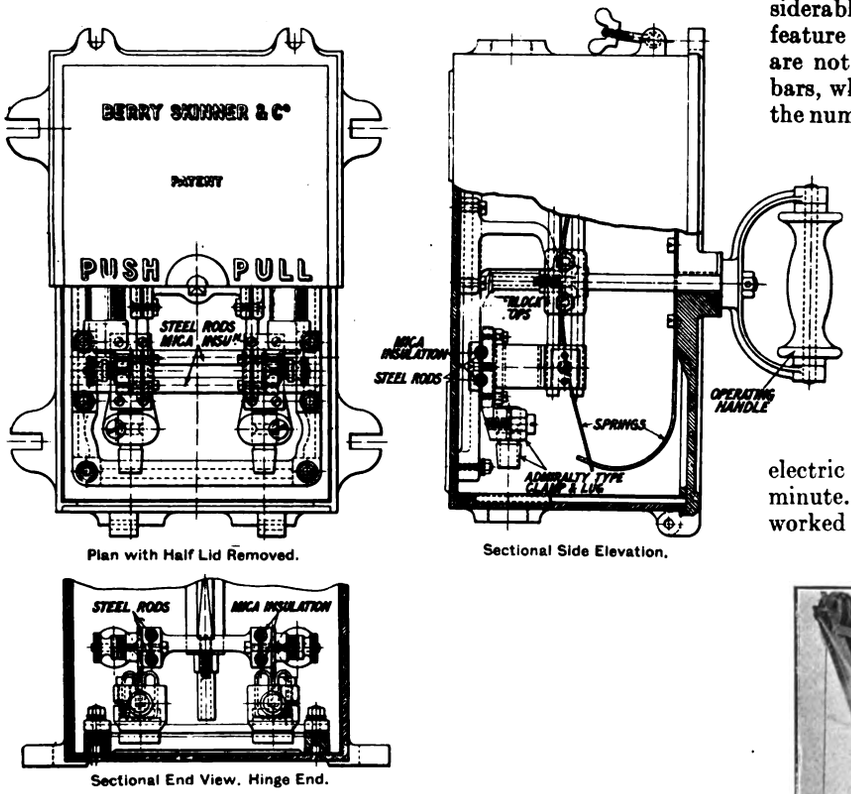

FIG. 3.—THE "DREADNOUGHT" FUSED SWITCH, 60-150 AMPS., 500 VOLTS.

Clarke, Chapman's Plant for Marine Work.

A firm who have for some years paid special attention to the design of electrical plant for marine work are Messrs. Clarke, Chapman & Co., of Gateshead. The accompanying illustrations and description give some idea of their activities in this direction.

To commence with the ship equipment, the two photographs of switchboards (Figs. 1 and 3) are representative of the class of board used on merchant vessels up to quite a considerable size. It will be noticed that the characteristic feature is that the dynamos, even where there are three sets, are not run in parallel, but are provided with separate 'bus bars, while each feeder circuit has a separate multi-way switch, the number of ways corresponding with the number of dynamos. Single-pole switches are used on the feeder circuits, though double-pole fuses are employed.

An interesting piece of apparatus is the steering gear made by Messrs. Clarke, Chapman. It consists of the ordinary screw type of gear modified for electric driving by fitting between it and the motor. This will be found described in a special article on Electric Steering Gear elsewhere in the present issue.

In connection with ship equipment mention may also be made of a small electric whip, which is found very useful for general purposes, such as lifting mails, stores or light baggage up to about 10 cwt., and of an electric jib crane, designed for lifting 30 cwt. at 120 ft. per minute. Four of these cranes were supplied all alike and worked very satisfactorily.

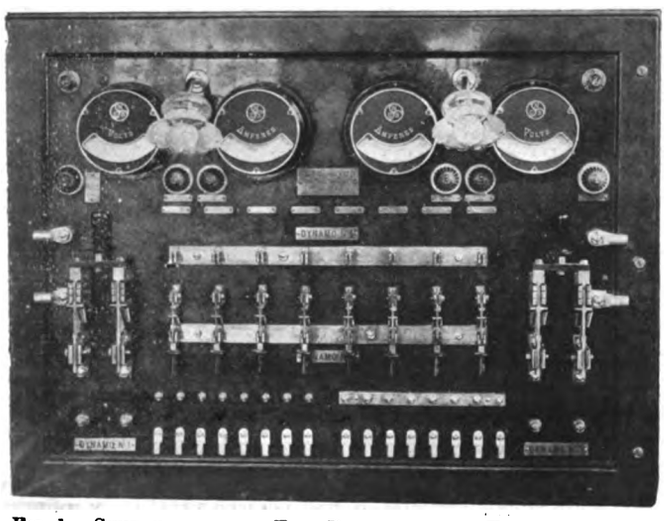

FIG. 1.—SWITCHBOARD FOR TWO DYNAMOS, WITH EIGHT CHANGE-OVER SWITCHES AND TWO DOUBLE-POLE DYNAMO MAIN SWITCHES.

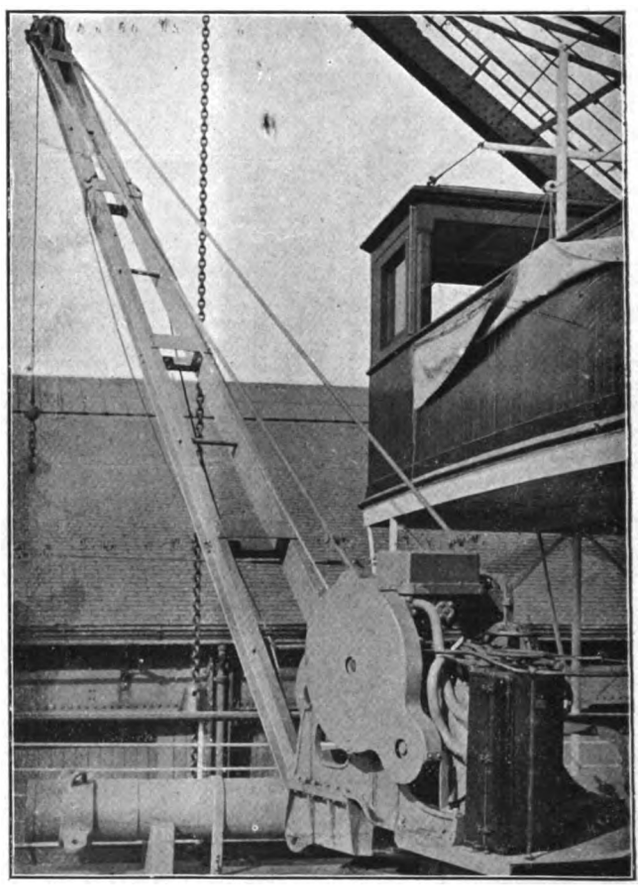

FIG. 2.—JIB CRANE FOR MARINE WORK.

Turning, now, to the question of shore equipment, three of the most useful pieces of apparatus are slipway haulage gear, dock capstans and a travelling jib crane. The first of these, shown in Fig. 2, needs but little explanation. It was designed to exert a pull of 30 tons by means of two chain cables, which are hauled in by means of cable lifters of the type used in ships' windlasses. The photograph makes the arrangement perfectly clear. The crane shown is fitted on a warehouse by the side of a dock and runs out over the vessel, the rails on which it runs being extended beyond the end of the shed.

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The capstan, Fig. 4, is designed for a load of 8 tons and is provided with two speeds so that a higher speed can be obtained by changing the gear inside the box by means of one of the T handles shown projecting; the other T handle operates the controller, which is of the tramway type. The head is loose on its shaft, and driven by the two pins shown at the top, so that when these are withdrawn, the head can be operated by hand-bars inserted in the holes provided for them. When being worked by hand, the pawls at the base of the capstan are thrown in so as to engage with the rack at the top of the case.

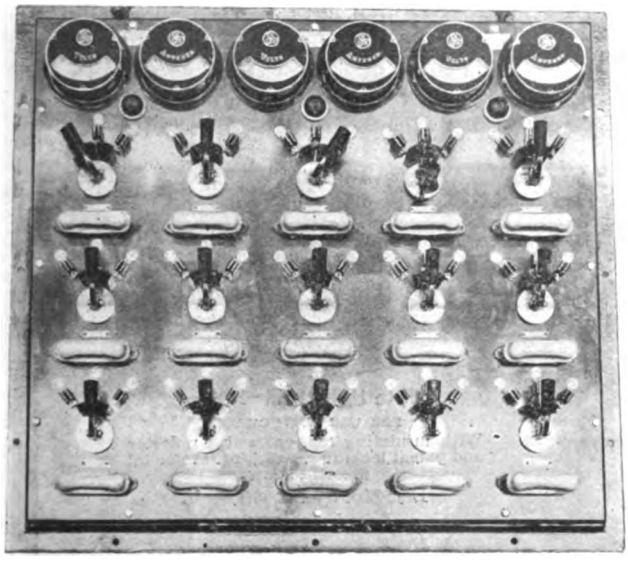

FIG. 3.—THREE-WAY SINGLE-POLE SWITCHBOARD FOR LIGHTING, VENTILATING FANS, &C.

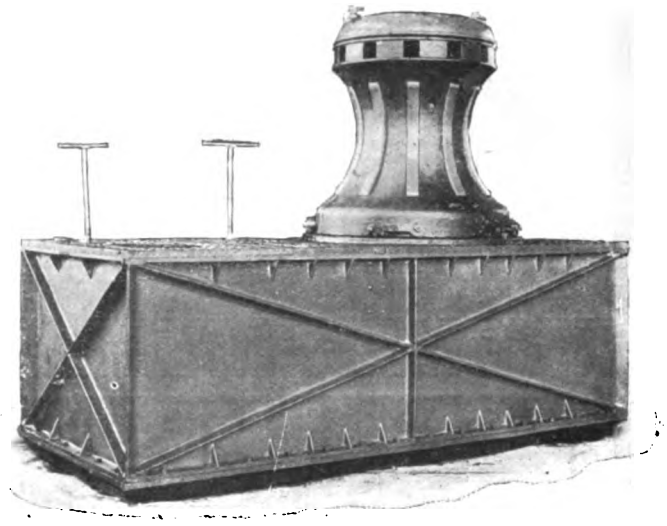

FIG. 4.—ELECTRICALLY-DRIVEN CAPSTAN.

EXPERT Control Manufacturers.

A correspondent to "ENGINEERING," on April 27th, called for increased co-operation between Shipbuilders and Expert Control Manufacturers; only by this means will the former secure the most reliable and wholly satisfactory operation of their electrically driven plant.

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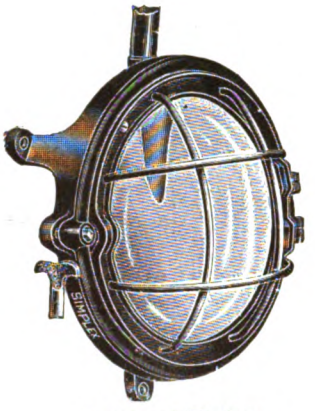

Bulkhead Fittings, from 4/3.

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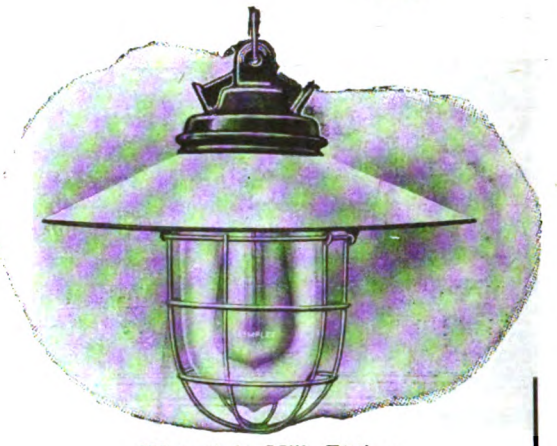

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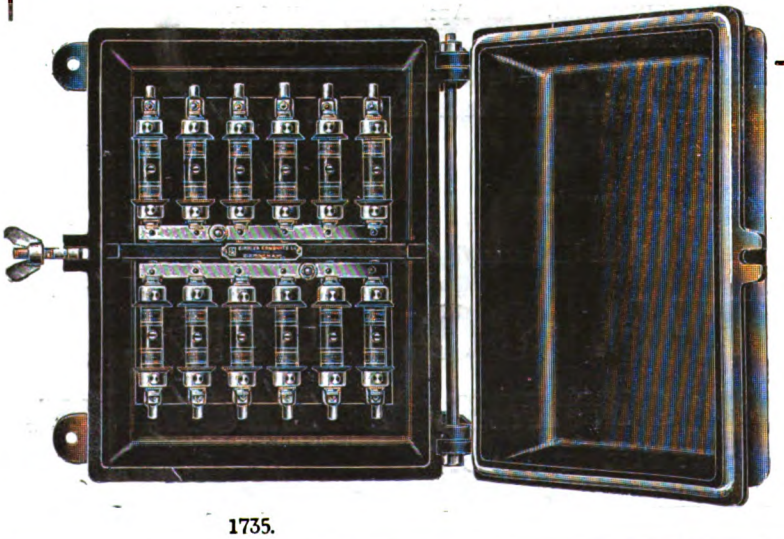

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The Wiring of Ships.

BY G. AUSTIN.

(Of Messrs. W. C. Martin & Co.)

Summary.—After enumerating the uses to which electricity is put on board ship and the various circuits that are desirable, the author discusses the question of the most suitable voltage, and the various systems of wiring that may be used—namely, single wiring, concentric and double wiring. The wires may be protected by wood casing, tubes, lead sheathing or armouring. Twin cable has much to recommend it. The insulation of wiring is rendered difficult by condensation and by the inevitable presence of salt. Careful erection is most important. Distribution may be on the system in which each light has its own fuse, or on that in which each group has a fuse; the latter appears to be sufficient. Owing to the special conditions, bell wires, as well as those for supply, should have good insulation. The article concludes with a reference to sundry applications.

There is perhaps no place where the use of electricity is so essential, and yet so easily applied, as on board ship. Essential, because cabins and other spaces are necessarily restricted in size, and, so far at least as lighting is concerned, there is no other illuminant available which does not vitiate the air. It is easily applied because in all steamships the steam-raising plant is already installed, and the addition of an electric generator or two, makes little or no difference to the engineering staff.

Before considering the subject of electric wiring in passenger and trading vessels, it may be well to enumerate some of the uses to which electricity is applied, and for which a system of cables or wires is required.

A passenger ship may be compared to a hotel fitted for the comfort and entertainment of a large number of guests, and the following are some of the services required:—

1. Lighting.
2. Wing fans or punkahs for wafting the air in saloons or lounges.
3. Cabin fans for circulating air in state-rooms.
4. Supply and exhaust fans for ventilating the accommodation generally, in conjunction with which may be installed apparatus for heating or cooling the air, or adding a small percentage of ozone to it.
5. Heaters for passenger cabins and lounges.
6. Cranes or winches for handling cargo, stores, mails and baggage.
7. Appliances in the kitchens, bakery, &c., such as for dough mixing, iceing, dish washing, knife cleaning, silver polishing, potato peeling, mincing, ham slicing, bread cutting, and revolving roasting spits. In addition to these there are hot-plates and other cooking appliances for use in pantries and bars, and food warmers for use in saloons or when serving refreshment on deck.
8. Laundry machinery and apparatus.
9. Curling iron heaters in cabins, and hairdresser's machinery and water heaters.
10. Wireless telegraphy.
11. Rudder indicators.
12. Watertight door indicators.

In addition to these, which require supply from the generating station, the following form a not unimportant addition to the wiring in a ship:—

13. Bells and telephones for passengers' use.
14. Bells and telephones for use of ship's staff.
15. Loud-speaking telephones for use on navigating bridges, machinery spaces, and lookouts.
16. Fire alarms, and fire signal bells.
17. Revolution indicators for showing on bridge, or other desirable place, the speed and direction of rotation of main engines.

There are many other uses to which electricity can and will be put on board ship, but enough has been said to show how varied and important are its applications.

The arrangement of supply cables to these consuming devices is a subject which requires some thought, and, in order to be successful and economical in use, the route on which the vessel is to trade must first be considered. Our floating hotel is sometimes in a cold climate, at other times in a hot climate, and frequently it lies in harbour with only a few officers and men in charge.

Under these circumstances supply should always be available when required, yet in such a way that power cannot be wasted by unauthorised or thoughtless persons. For example, a steamer trading between London and Australia would, while in port, require supply available in the daytime for lights in the engine rooms, officers', engineers' and crew's accommodation, and in parts of the ship where there is not sufficient daylight.

In addition, the cranes, winches and other electrically-driven machinery, also the Marconi apparatus, might require a supply. At night it would be necessary to add the cargo lights for illuminating the deck hatches and cargo holds. After leaving London the same lighting would be required in the daytime, with the addition of heaters and cooking apparatus, &c., also the supply and exhaust ventilating fans.

In the evening all lights would be available. At night (say after 11 o'clock) all unnecessary lighting would be cut off, but light and heat would be available in the passenger cabins for use if required. On reaching the Suez Canal the same routine would still be observed, but the supply to heaters would be cut off, and the circulating fans and punkahs added instead, and so on till the end of the voyage.

For the Atlantic trade the arrangement required is not so elaborate, because of the more even temperature during the voyage.

A suitable combination of main circuits for any ship can usually be selected from the following groups. Each group, of course, may be divided into a number of main circuits as found convenient:—

A. *Service Circuit.*—This includes all lights and appliances for the use of officers, crew, stewards and in galleys, pantries and elevators, also for the navigation of the ship. This circuit is usually required day and night.

B. *Evening Circuit.*—This group consists of lights which are only required in the evening, and are not required during the day or night time.

C. *Passenger Circuit.*—This group includes all lights and appliances required by passengers during the evening and night, but not during the daytime.

D. *Heating Circuit.*—Required only in cold climates.

E. *Fan Circuit.*—Required only in hot climates.

F. *Ventilation Circuit.*—Required when passengers and cargo are on board.

G. *Cargo Circuit.*—Required only when loading or discharging cargo.

H. *Machinery Circuit.*—Always required.

Fig. 1 is a diagram of a typical passenger steamer and Fig. 2 that of a trading steamer, showing the arrangement of feeder cables, section boxes, branch feeders and distributing boxes that would be necessary, assuming that these ships were intended for trading in both hot and cold climates.

By arranging the circuits in the manner shown, the electrician or engineer in charge may limit the load on the generating station without inconvenience to passengers or others,

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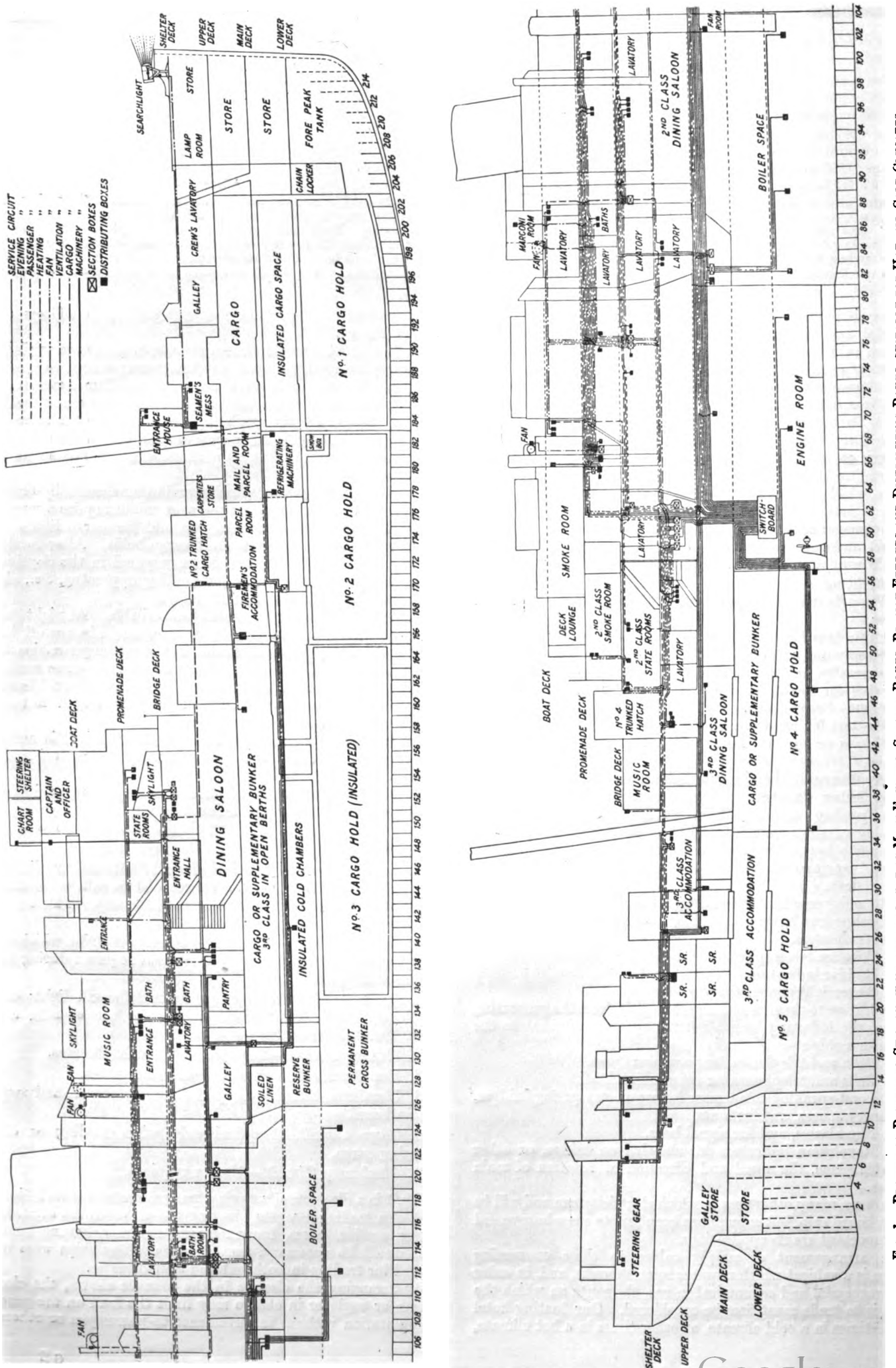

FIG. 1.—PROFILE OF PASSENGER SHIP, SHOWING ARRANGEMENT OF MAIN FEEDERS, SECTION BOXES, BRANCH FEEDERS AND DISTRIBUTING BOXES, SUITABLE FOR HOT AND COLD CLIMATES.

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while permitting a free and reasonable use of lights and appliances.

Nature and Voltage of Supply.—On account of the large number of variable-speed motors in use on board ship, and the increased tendency to use them, the best supply for all auxiliary purposes is the continuous-current system. The best voltage to adopt, however, is a question about which there are many opinions. The general practice is to instal at a pressure of 100 volts, while there are quite a number of ships where 65 volts is the rule, and a few at 110 volts. In the British Navy the voltage has recently been increased to 220. The use of metallic filament lamps will tend to keep the voltage low, while the extended use of motors and heaters will make a rise in pressure imperative.

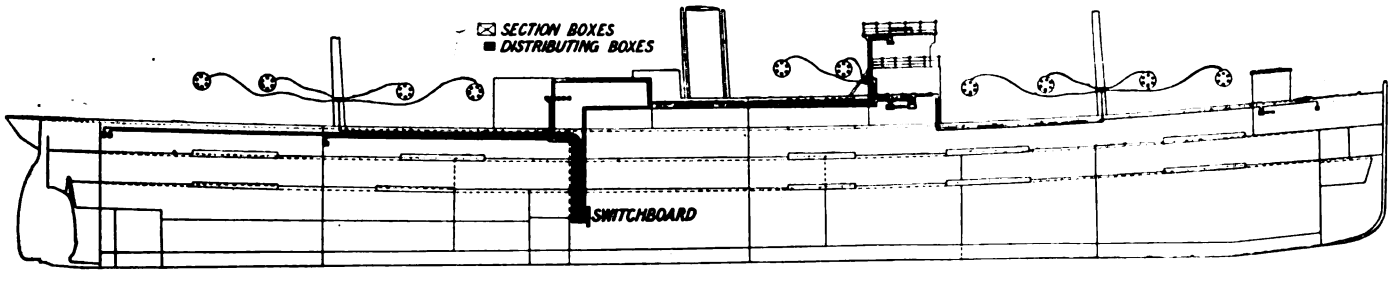

FIG. 2.—PROFILE OF TRADING STEAMER, SHOWING ARRANGEMENT OF FEEDERS, SECTION BOXES, AND DISTRIBUTING BOXES.

To those unacquainted with conditions on board ship it may seem strange that a low voltage like 100 volts is preferred, but a few moments' reflection will show that there is much to be said in its favour, at any rate for lighting and small appliances. Firstly, lamp filaments must be able to withstand vibration. It may be said that there is very little vibration in modern vessels, but in rough weather the stoutest ship afloat will vibrate a great deal when buffeted by heavy seas. Secondly, with increased voltage there is some risk of fire. Imagine a large steamer having five or six decks each crammed with cabins built of wood, and fitted with all manner of combustible furnishings. Think of the miles of wiring that must be installed in these rooms, and of the frequent and hurried alterations that are often made to suit passengers, involving risk of damage to wires. Think of the sea water which at some time or other finds its way, say, to a fitting block through leaky

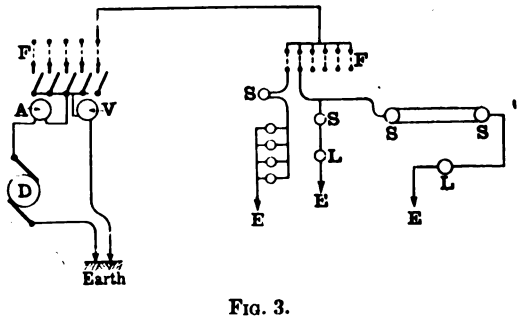

FIG. 3.

D=Dynamo. A=Ammeter, V=Voltmeter. F=Fuse. S=Switch. L=Light. E=Earth.

decks or otherwise; and who shall say that there is not some danger at 220 volts which is entirely absent at 110 volts?

The system which is likely to suit the case of large steamers, at any rate, is the three-wire one, using 220 volts across the outers and distributing on the two-wire system to lights at 110 volts. The middle wire would be earthed through an ammeter, resistance and alarm apparatus at the generator end in the usual way.

Wiring.—At present there are three wiring systems available for use on board ship—viz., the single-wire system, the concentric system and the double-wire system.

Single Wiring.—This system is still a favourite with some shipowners. It is slightly cheaper to instal, but here its advantages end. One insulated conductor only is used, and the return circuit is by the hull or framework of the ship. The arrangement of cables on the insulated pole is similar to that used with a two-wire system, switches being inserted on the live side of the lights (*see* Fig. 3). At each light the return wire is soldered to a brass screw, which is tapped into the nearest beam or plate. Larger cables are soldered into sockets, which in turn are fastened by strong brass bolts to the hull beams. It is essential, of course, in all cases that the contact surfaces be thoroughly cleaned.

The objection to the single-wire system is that, being magnetically unbalanced, it affects the deviation of the compass as the load changes, and renders the compass readings unreliable. In order to reduce this to a minimum, all small conductors within 15 ft. of a compass must be, by Lloyd's rule, arranged on the double-wire plan, and larger conductors must be double wired for a greater distance. Fear of compass troubles, however, makes many shipowners fit double wiring to all lights forward of a line drawn across the ship 30 ft. behind the compass (*see* Fig. 4). This, as a rule, means that the entire forward half of the ship is double wired, leaving only the afterpart to be single wired. The advantage in cost is, therefore, not so great as would at first sight appear, while there remains a grave risk should an earth develop in any wiring near the compass.

Fig. 5 illustrates this point. The section feeder is single until it reaches the point E_2, say 30 ft. aft of the compass, where the return feeder is earthed. Normally there is no unbalanced magnetic field forward of this point, but should an earth occur at E_3, for example, on the telegraph return wire, a portion of the current will return direct through the hull to the dynamo, leaving unbalanced the supply wire to the telegraphs which passes close to the compass. Nor is this all. Should the fault at E_3 be of very low resistance, part of the return current from other lights in the vicinity may find earth at this point also. We will, under these conditions, have unbalanced magnetic fields in, first, the telegraph circuit supply wire; second, the

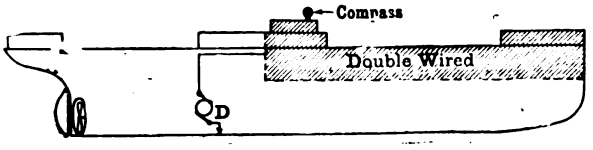

FIG. 4.—SHOWING THE PORTION OF A SINGLE WIRED SHIP WHICH IS USUALLY DOUBLE WIRED.

telegraph circuit return wire (because of the current from other lights finding earth at E_3); and, third, the main feeder (because of the reduced current now finding earth at E_2).

The danger lies in the possibility of the fault occurring at any time without the knowledge of the officer or engineer. The lights burn as usual, no fuse opens circuit to give warning, the switches control the lights as usual; but the compass error comes on in the night time, a time when the utmost accuracy and skill are required in navigating the ship.

It is an advantage to use double-contact lamp-holders throughout a single-wired ship installation. Where single-contact holders only are used, there is danger that a workman may, carelessly or by mistake, connect the live wire to the fitting instead of to the centre contact of the holder, especially

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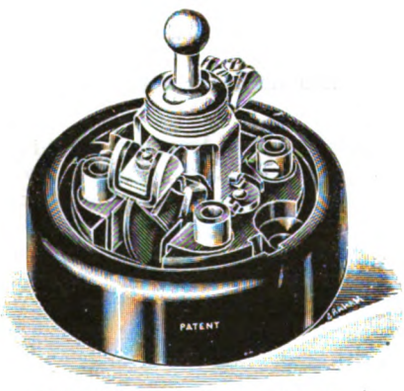

SERIES-PARALLEL and OFF.
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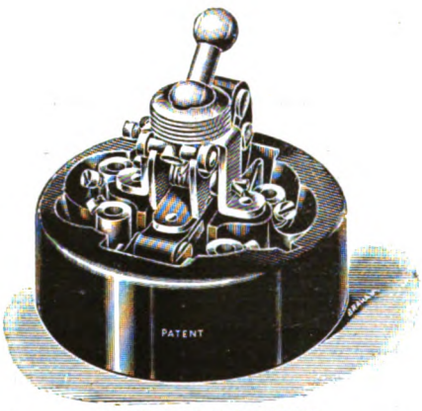

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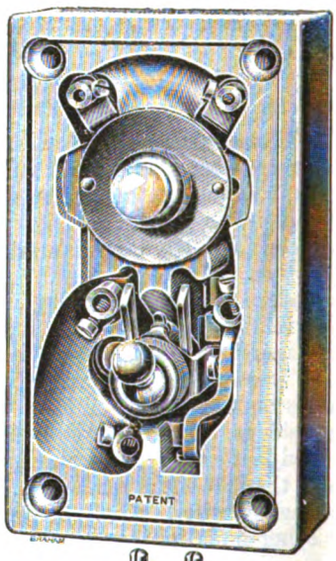

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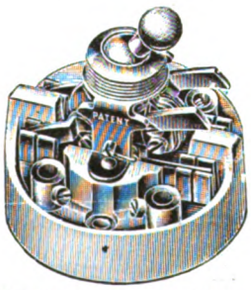

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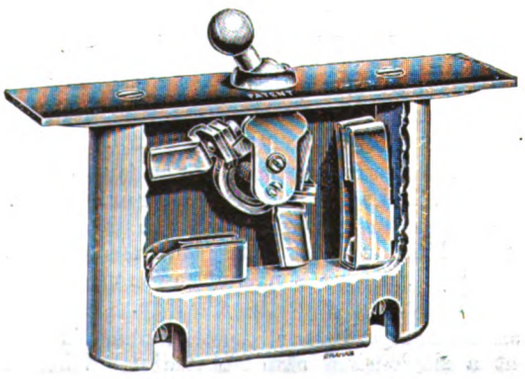

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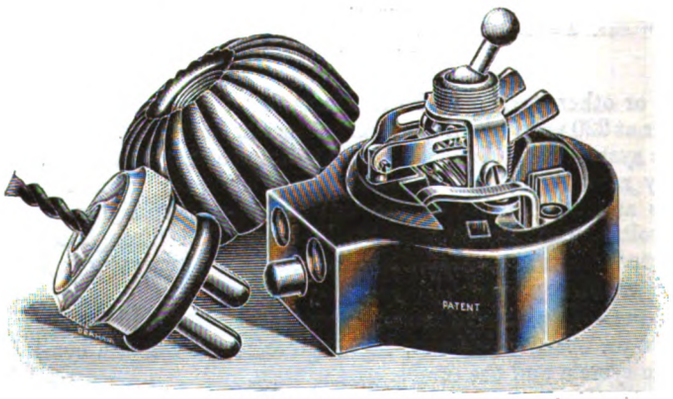

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when wiring portable lamps. If, while current is switched on, the fittings be earthed for a moment, the fuse will open circuit on any that have been wrongly connected.

Concentric Wire System.—This system is installed in some vessels, and as a rule the outer conductor is uninsulated. It is obvious that the same objections apply here as in the case of single wiring, but if the outer conductor be even lightly insulated and braided for protection it becomes quite a good and safe method. In most cases it suffers, however, from the use of special joint boxes and connections, which must be soldered and made watertight, and too much depends upon the workman who erects it.

It is not a system which can be readily extended or repaired by engineers or by contractors at a foreign port, and is consequently not favoured by many shipowners.

The Double-wire System is installed in the great majority of ships. By its use the compasses are quite unaffected, and any faults on either pole are readily detected and repaired. Under this title it is proposed to consider the following methods of installing :—

A. Vulcanised rubber insulated wires in wood casing.
B. " " " tubes.
C. " " " lead sheathed.
D. " " " steel sheathed.
E. Twin *versus* single-armoured cables.
F. Special systems.

Before considering methods of installing, a few words in regard to the insulation of the copper conductor may not be unjustifiable. It is the universal practice to insulate small wires with pure rubber and vulcanised rubber compounds; and, perhaps, no better wire is available at present than that insulated to the standard specification of the British cable makers, but there is still room for improvement. Rubber-insulated cable, when exposed to the action of sea air and sea water, deteriorates in time, and it is due to this that special precautions must be taken in installing on board ship.

Paper insulation depends too much on its lead sheathing to be thought of for branch wiring work, but there is great need for an insulating substance which will remain unaltered under the influence of electric strain, sea water, sea air and variations of temperature.

Such substances as bitumen, or enamel combined with a fibrous base, might be expected to give better results.

Wood Casing.—For passenger accommodation, rubber-insulated and braided wire enclosed in wood casing makes a good job, and quite a safe job at low voltages, if the casing be kept dry. It is impossible as a rule to find space for casings having a groove for each wire, as is the custom in work on shore at higher voltages. The practice on board ship is to bunch the positive wires in one or more sets of grooves, and the negative wires in corresponding separate sets, according to the space available. Until the day of more perfect and lasting insulating material appears it would be unsafe to bunch positive and negative wires in one groove, but even the bunching of wires of opposite polarity in separate grooves is an argument in favour of a moderate voltage, say not exceeding 110 volts.

Wood casing should be so arranged that the covers may be readily removed without interfering with constructional or decorative woodwork other than the cover itself. Fig. 6, A, B and C, shows some methods of constructing casings with this end in view.

It is in the saloons and lounges, where special decoration is fitted, that one finds most difficulty in arranging proper grooves for wires. The growing custom among shipbuilders is to employ architects to design the woodwork for these places, and these gentlemen are so accustomed to have gas pipes and electric wires fitted under the floor above that they get quite a shock when they find their cherished design must be modified in some way to accommodate electric wires.

Wires should be placed in wood casing with as much slack as possible. It has been observed by many that, after a year or two in use on board ship, wires not only become brittle, but they appear to contract in length. If a wire be erected with a slight wave in a wood casing it will be found in a year or two after to be straight and in tension (*see* Fig. 7). Wires should be plugged into grooves by wood wedges, as shown in Fig. 8.

Although wood casing makes a good job in cabins, it is not at all suitable for machinery or cargo spaces.

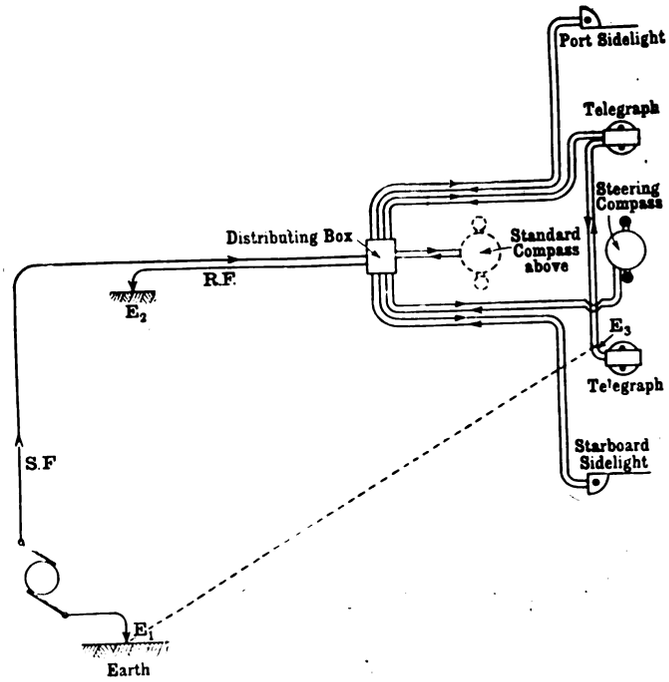

FIG. 5.—SHOWING ARRANGEMENT OF DOUBLE WIRING ON BRIDGE WITH "SHIP" RETURN.
S.F.=Section Feeder. R.F.=Return Feeder.

Tubes.—It might be considered that steel or other metal tubing would form an ideal covering for electric wires on board ship, yet such is not the case, except for vertical runs, where the tubes are open at the bottom. No matter how carefully jointed a system of tubes may be, water will soon collect inside.

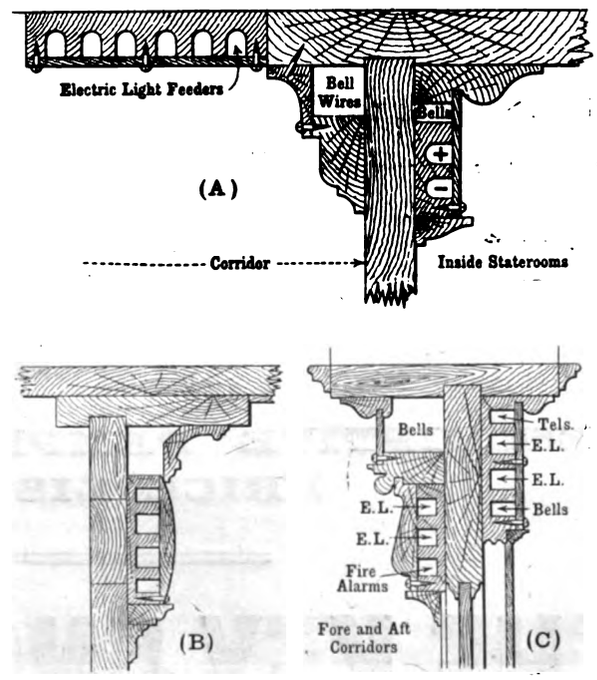

FIG. 6.—CASINGS.

The air is always so moist and temperatures vary so much that there is a continual condensation of moisture inside the tubes, varied by re-evaporation when the tubes become warm. Outlets for condensed water would, in many cases, provide inlets for sea water. Even although outlets be provided at the

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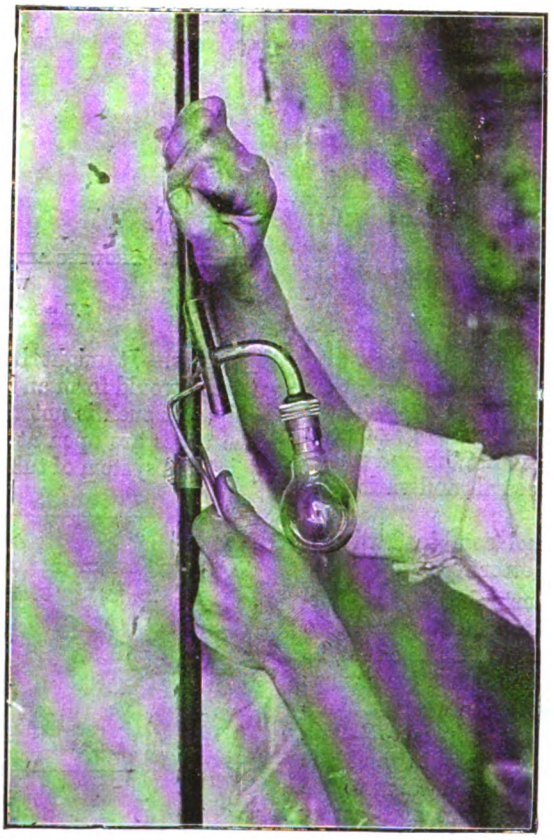

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lowest points, it does not follow that these points will always be the lowest, for the ship is continually tossing about, and may even have a list to one side during a whole voyage. Tubes, however, are necessary on such exposed vertical runs as on masts, where there is danger of mechanical damage, and also at all points where wires pass from one deck to another.

Tubes with insulating lining have been used in some vessels, but their success has not been great, probably on account of the flimsy nature of the draw-in boxes, and the ease with which water can enter at the inspection covers and joints. Even if a tube system had not the faults described, it is probable that the wires would be damaged in course of erection, for, under the conditions of modern shipbuilding, where hundreds of workmen are employed in a limited space, wires are certain to be trampled and damaged while they are being drawn into the tubes.

Lead Sheathing forms an excellent covering for wires on board ship, but its use is limited to spaces where it is not exposed to mechanical injury. It can be erected very neatly by skilled men, and when painted resembles the beading of a wood moulding. It is usually fastened by brass clips screwed to the wood or iron work of the rooms, and, on account of the plastic nature of the lead covering, these clips must be closely spaced, say 6 in. to 8 in. apart. When two or more wires enter a fitting block they should enter at the same side, and the sheathing be connected together as shown by the bonding saddle at B, Fig. 9.

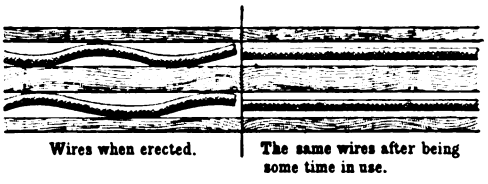

FIG. 7.—ILLUSTRATING CONTRACTION OF WIRES.

So long as lead-sheathed wire is erected on the surface and painted it lasts well, but when enclosed in wood casing, or placed behind wood mouldings, or in any space where fresh air does not freely enter, the lead is sooner or later reduced to a white powder. It is probable that lead acetate and lead carbonate are formed by the reducing action of vapours arising from the wood, particularly in hot climates.

Armoured Wire.—For use in engine rooms, boiler rooms, cargo holds and similar spaces, where wires would be exposed to damage, the best form of protection is a sheathing of galvanised steel wires, with a substantial packing of hemp, treated with waterproof compound, underneath the armour.

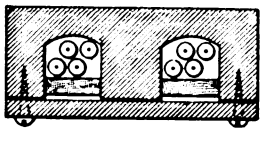

FIG. 8.—METHOD OF FIXING WIRES IN CASING.

It has been observed that when a lead sheathing is also used under the armour, and the cable exposed to sea water, the cables do not last for many years, and that when deterioration once starts the end comes rapidly. The following is a probable explanation of this destruction :—

In order to prevent the steel wire sheathing from cutting into and damaging the lead sheathing, the latter is served with tape or braiding and soaked in compound before the armouring is put on. In course of time this taping becomes saturated with sea water, and virtually becomes the exciting liquid in a voltaic cell, of which the lead sheathing and the zinc galvanising form the couples. A small difference of potential is set up between the lead and zinc, and it only remains for accident or other cause to connect the lead and zinc in order to complete the circuit. The difference of potential, of course, is small, but the area of metal exposed to the action is large, and the destruction correspondingly great.

At first, while the armour is all coated with zinc, the direction of this current is from the zinc through the separator to the lead, and the zinc is consumed, but eventually the zinc coating is removed and the couples become iron and lead. When this occurs the direction of the current is reversed, and the lead becomes the consumed metal, till in a short time the insulation is exposed to the action of the sea water.

It has also to be noted that, as the lead sheathing, separator and armour are all in the leakage path of the cable, the action described may be retarded or augmented by leakage, according to the polarity of the core. Thus, in the case of a +core, the zinc-lead couple would be opposed and the iron-lead couple assisted by the leakage current.

Armoured cables without any lead covering last exceedingly well if special attention be paid to the braiding and waterproof compound provided between the cable and armouring.

Twin Cables.—For the smaller cables and wires such as would be used for sub-mains and distributing feeders, there are some

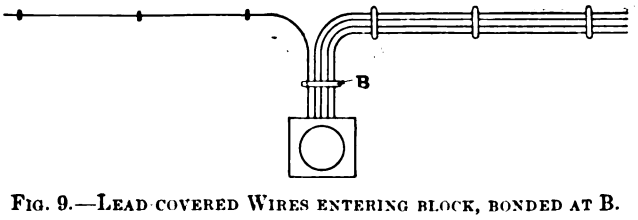

FIG. 9.—LEAD-COVERED WIRES ENTERING BLOCK, BONDED AT B.

advantages in using twin cables. First, a twin cable is larger and stronger than two single cables, and, on account of the extra packing required to make the cable circular, the insulation is better protected. Second, the rules of Lloyd's Register require an armoured cable in cargo spaces to be sheathed with wire of not less than No. 15 S.W.G. The small sizes of single wire are not easily sheathed with wire of this size, the sheathing is not proportional to the conductor and insulation, and an unsatisfactory cable is the result. Twin wires, on the other hand, can be most suitably armoured with the required gauge of wire. Third, a twin cable will stand a severe blow or heavy pressure without showing external signs of damage to the insulation.

The conductors may even fuse together within the sheathing without danger of causing a fire outside. Two cases from actual experience illustrate this point very clearly. A twin cable was carried along an engine-room bulkhead and crossed behind a vertical water pipe, there being about ¼ in. clearance between the pipe and cable. During the trial of the electrical installation a short-circuit developed in this cable and opened the fuse protecting it. An examination of the exterior of the cable revealed nothing, but a loop test quickly located the fault in the vicinity of the pipe referred to. On opening the cable at the fault the insulation was found partly burned away and the conductors fused together. The damage was due to the bulging of the steel bulkhead while the bunker was being filled with coal, and the cable was crushed between the pipe and bulkhead.

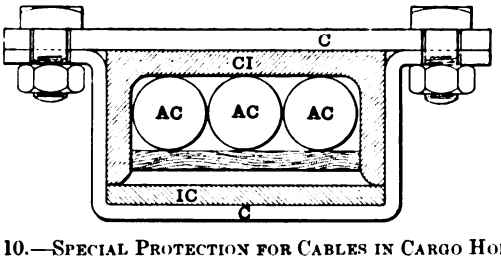

FIG. 10.—SPECIAL PROTECTION FOR CABLES IN CARGO HOLDS.
AC = Armoured Cables. IC = Iron Cover. CI = Channel Iron. C = Clamps (spaced every 3 ft.).

A similar fault, on the other hand, occurred where two separate armoured cables were used. In this case an expansion pipe was bolted hard against two cables while current was passing in the latter. As the bolts were being tightened a partial "short" developed across the two cables, through the

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armouring, which quickly burned away, and before the circuit could be switched off a hole had been fused in the pipe also. This happened at the time of light load, and the current did not reach 120 amperes, for which the fuse was adjusted.

Fourth, a twin cable is more convenient to work with than two single cables, is more suitable also for fitting into watertight packing glands at fittings, switches or distributing boxes, and its use makes connections at fuse boxes more simple, although this is not an important point.

Special Systems.—"Stannos" wire, invented by Messrs. Handcock and Dykes, has only recently been put on the market, and there has not been time as yet to give it a fair trial for ship work. In the "Stannos" wire the conductor, which is insulated and taped in the usual way, but not braided, is wrapped round twice with a closely compressed sheet of tinned copper, forming a watertight sheathing.

Another wire, known by the name of "Kuhlos," is similar, but only a single layer of brass is used, the two edges of the sheet being folded together to form the joint. This sheathing is not watertight. It seems to the writer that there is in some of these wires an insufficient padding between the insulation and the sheathing. If at least three layers of tape treated with waterproof compound were laid over the rubber the wire would be much more suitable for ship work. Packing between the rubber and sheathing is as important as the insulation itself, not only as protection against blows or similar rough usage, but to protect the rubber at ends, where the sheathing is cut off. If a sheathed wire is to be satisfactory in practice, some safeguard must be used to prevent injury while the sheathing ends are being trimmed, and also to prevent the sharp edge of the sheathing from cutting into the insulation where wires enter junction boxes or fittings in which space is limited.

It is attention to such details as these that makes the difference between a good or bad job where sheathed wire is used.

Another reason why sufficient packing should be inserted is that in small stranded cables, say of 3/20 size, a strand often breaks, and, owing to the twist, and possibly also to the contraction in the length of the conductor previously referred to, the two ends of the broken wire spring out and pierce the insulation. If there is only one layer of tape over the rubber the distance between the sheath and these broken ends is so small that the dielectric soon breaks down. This defect could be remedied by first binding the copper core with a thin layer of strong waterproof tape before putting on the rubber, but probably the best method is to use solid conductors for all single wires smaller than No. 16 S.W.G.

Erection.—No matter how good the cable be, if it is not carefully erected by experienced workmen, it will not last long.

The success of a ship wiring installation depends greatly on a suitable choice of material and carefully considered runs for the wiring. It is not only the quality of material that matters, but the suitability of the material to the position in which it is to be erected, and experience can best enable one to decide this.

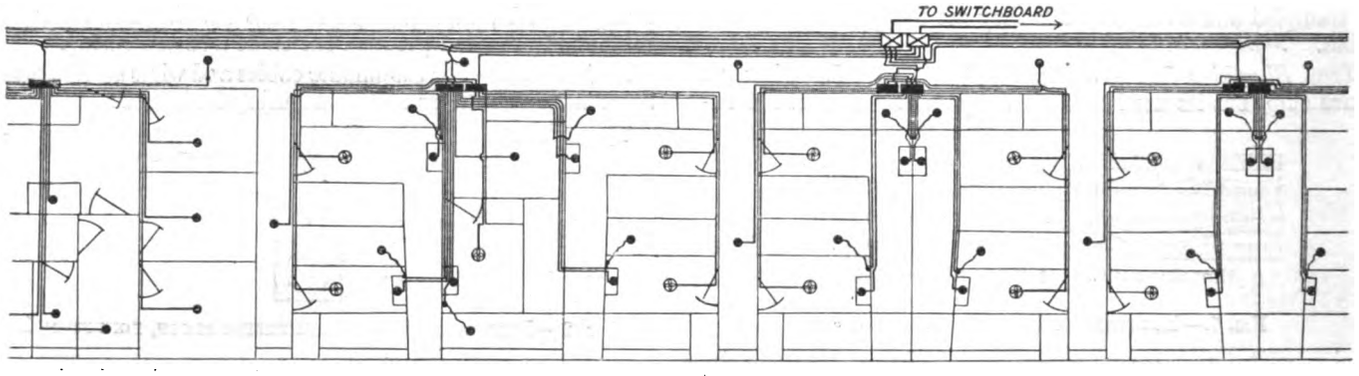

FIG. 11.—DISTRIBUTION WITH FUSE TO EACH LIGHT.

Sharp bends should always be avoided. Holes through beams and plating should be bushed with a material softer than the wire. Where wires pass through a watertight bulkhead, stuffing boxes should be fitted for each wire to prevent the passage of water should one compartment be flooded at any time.

Where wires enter fittings exposed to water, or where moisture may condense and collect, the wires should be led upward into the fitting.

In general it is better to dodge water, to lead it away to another resting place, than to oppose its entrance into fittings, for water has the unhappy knack of finding a way where it is least desired.

Special Protection is sometimes required in cargo holds and spaces where wires would be exposed to excessive damage. Advantage should always be taken of such protection as the beams and girders in the ship afford, but for maximum safety shipowners sometimes prefer to have special protection.

One of the best methods in these circumstances is to fit armoured cables inside strong channel iron bars not less than $\frac{3}{8}$ in. thick having a heavy iron cover, as shown in Fig. 10.

Distribution.—In the majority of ship installations, joints in cables and wires are not now used, and all connections are, as a rule, made on terminals. There are two methods of distribution in general use: first, that in which each light or other apparatus has its own fuse; second, that in which the lights are arranged in groups (usually 3 amperes), each group being pro-

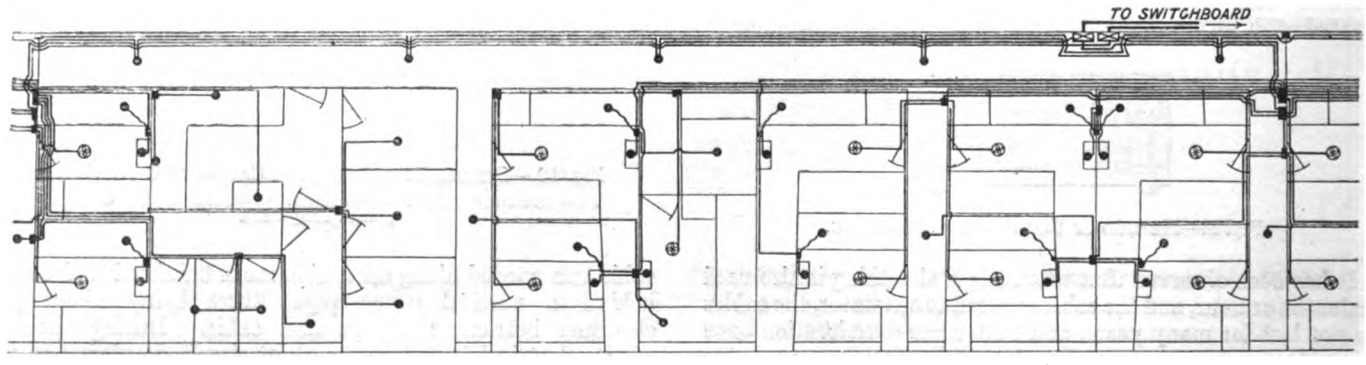

FIG. 12.—DISTRIBUTION WITH FUSE TO EACH GROUP OF LIGHTS.

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tected by a fuse. In either case it is bad practice to have single fuses scattered throughout the installation, and all fuses should be arranged in proper distributing boxes. In the first system—viz., that of having a fuse for each light—it seems to the writer

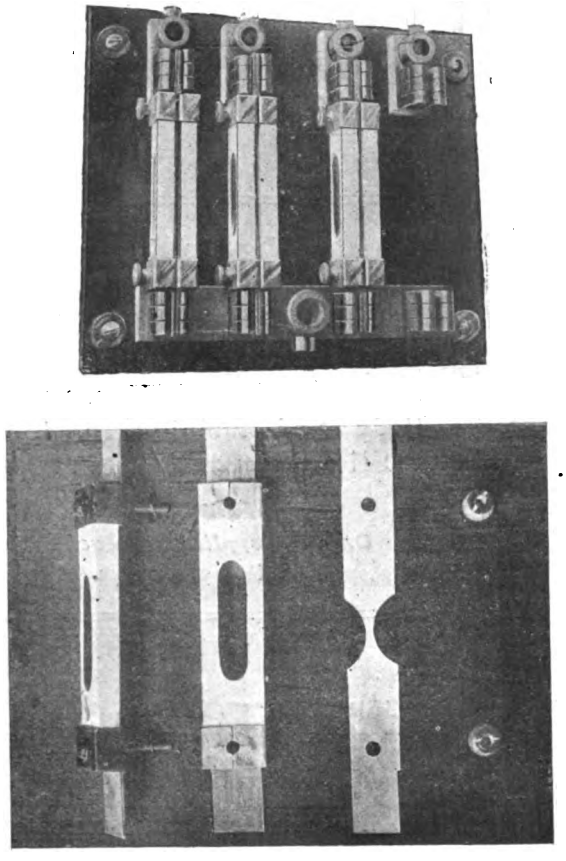

FIG. 13.—"MAURETANIA" FUSEBOARD SHOWING FUSE HOLDER SEPARATELY.

that sub-division is carried to quite an unnecessary extent. The object, of course, is to prevent inconvenience to passengers in any other room but the one in which a fault may be, but faults do not occur so frequently, and are generally of a trivial nature. The objection to this plan is that it requires so many

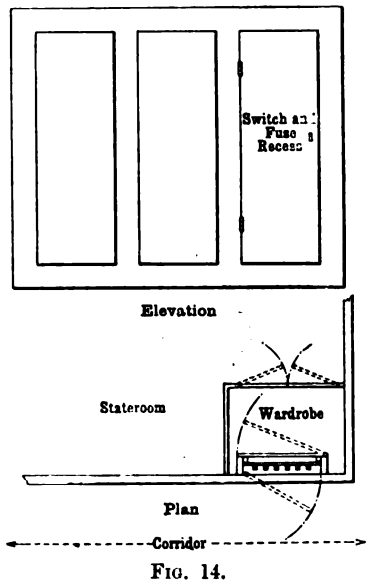

FIG. 14.

small distributing boxes that they give the passages an unsightly appearance.

In the second system the wires are either looped at lights and switches, or extension boxes are fitted for each group. Figs. 11 and 12 illustrate both methods. In either case the sub-mains are carried to section fuse boxes, and main feeders carried from the latter to the switchboard, a fuse being always introduced where the conductor is reduced in size.

Fuse-holders should be of the removable type. They should be so arranged that the contact nuts cannot slacken back by vibration, nor the fuse-holder fall out of the clips, and they should not project much in front of the base of fuseboard. A fuse-holder which fulfils these requirements, known as the "Mauretania," is shown in Fig. 13. It consists of two strips of fireproof insulating material (not porcelain) fitted with sheet copper end pieces and clamping bolts, as shown. The fuse (a strip of zinc or zinc-tin alloy) is clamped between the two halves thus formed, and, owing to the notch on the clamping nut

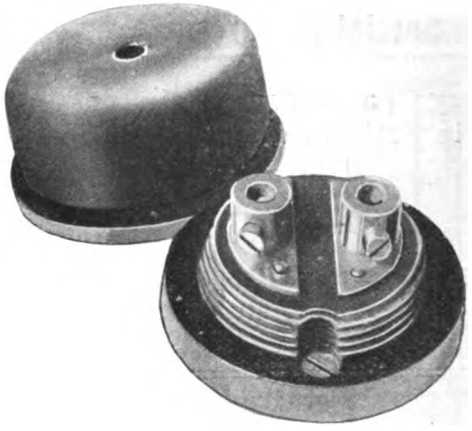

FIG. 15.—ORIGINAL EXTENSION BOX.

which engages at each half turn with the raised line on the sheet copper, the nut cannot turn back except by force. In addition to this, the fuse is also held in contact by the clips into which the holder is inserted. The fuse cannot fall out of the clips, and does not project in front of the terminal clips, which in the 50-ampere size is about 1in. from the base.

It is desirable, wherever possible, to fit fuse boards into recessed spaces, forming the panel in the framework into a door for access to the fuses, and also to have a door behind for access to the wiring, as illustrated in Fig. 14. Suitable places for these recessed fuse spaces are found at wardrobes, linen lockers and pantries.

Extension Boxes were first introduced by Messrs. W. C. Martin & Co., and Fig. 15 shows the original pattern, which is now extensively used. The supply wires and branch wires to lights and switches are connected together by the stout pinching screws shown, in the same manner as connections on ceiling roses. A later pattern, shown in Fig. 16, has many advantages, especially when it is probable that portable lights, fans

FIG. 16.—"TRITON" EXTENSION BOX.

or curling-tong heaters may be added after the installation is completed. Fig. 17 is a diagram of connections, showing some of the most useful applications of this extension box. There are four terminal blocks, two of which are fitted to receive the pins of a two-pin plug, in addition to the ample terminal sockets

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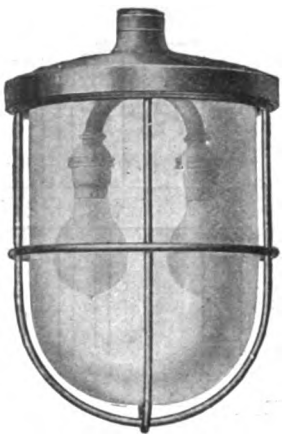
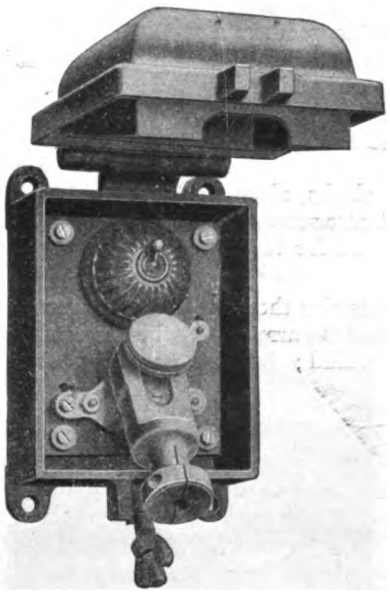
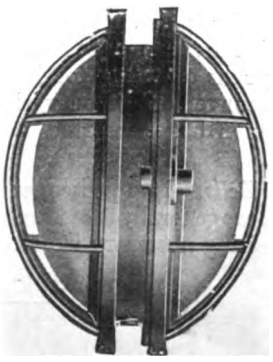


Watertight Cast-iron Fitting, No. 753.

Guarded Single Bulkhead Fitting, No. 9051.



Cast-iron Cargo Connection Box.



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Hand Lamp, No. 372a.

Pendant, No. 1260.

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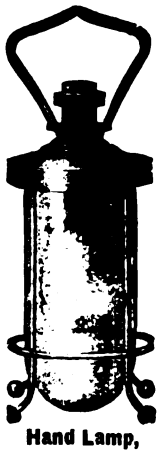

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for connecting the permanent wiring. For exposed work extensions are fixed inside watertight metal boxes fitted with watertight glands suitable to the kind of wire employed.

As this article does not deal with "illumination and fittings," it is now proposed to describe shortly some of the other apparatus installed on board ship, especially with reference to the necessary wiring.

It is commonly supposed, for example, that electric bell wire need only be insulated with cotton and paraffin wax, but wire of this description would not last for six months on a ship without breaking down. For any purpose on board vessels, whether for bells, telephones, fire alarms or special apparatus

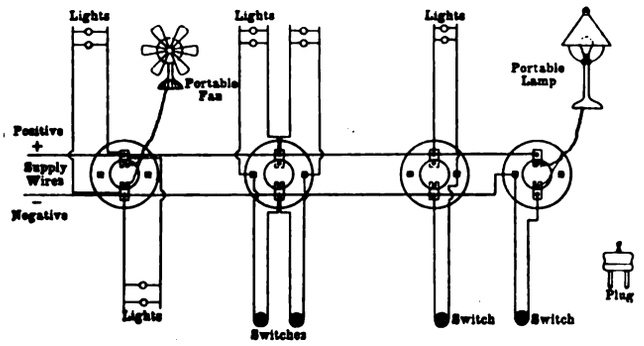

FIG. 17.—DIAGRAM OF CONNECTIONS FOR "TRITON" EXTENSION BOX.

with battery supply, the insulation cannot be too good, and should be similar to that used for electric lighting. Bell and telephone circuits especially are subjected to fairly high inductive potentials; indeed, under conditions which frequently occur on ships, a sharp shock may be obtained from a metal bell push if the metal plate be in circuit.

In long runs of wiring for bells, telephones, clocks, alarms, &c., it is convenient when wiring, and useful afterwards, to have junction boxes inserted at suitable intervals for testing purposes.

Electric Bells.—In a passenger ship of moderate size the bell indicators are generally fitted near the pantries, and the arrangement of wiring necessary is of the usual simple kind; but in larger vessels the bedroom stewards are not required at the pantry, and are stationed near the rooms they have to attend. In this case it is necessary to have local indicators, and also a master indicator at the pantry, for use at night or when the local steward is off duty. A change-over switch is fitted at each local indicator, arranged to cut out the local bell, but not the indicator movement, and to put the master indicator and bell in circuit. In this case one drop is provided on the master indicator for each local indicator.

It is alleged that with this system passengers may not get prompt attention from local stewards, and to meet this objection a very ingenious indicator movement was introduced some time ago. The passenger is informed, by notice or otherwise, that one press of the push calls the local steward, but if the push be pressed a second time the steward at the master indicator gets notice of the inattention.

This is effected by the movement in the local indicator, which at the first call is arrested by a small catch and prevented from dropping the full distance. At the second call the catch is released, and the shutter drops the full distance, closing the master indicator circuit at the same time.

This would be an ideal arrangement, but, unfortunately, passengers, especially when impatient, are in the habit of giving a number of short pushes, and the stewards would really be hindered in the performance of their duties.

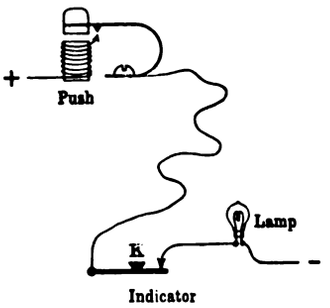

FIG 18.

Bells should not be fitted in indicator cases, but should be placed in positions where the rattle of the hammer will not annoy passengers. In order to avoid this nuisance, luminous indicators are sometimes used. In one system a small electromagnet is fitted in the base of each push, and is in series with the push contacts and a small lamp and closed key at the indicator (*see* Fig. 18).

When the push is pressed the magnet holds the push in contact so long as the circuit remains completed, but on noting the call the steward presses the key K and opens the circuit. The magnet cannot now hold the push in contact, and the press button springs back with a click, which announces to the passenger that his call is having attention.

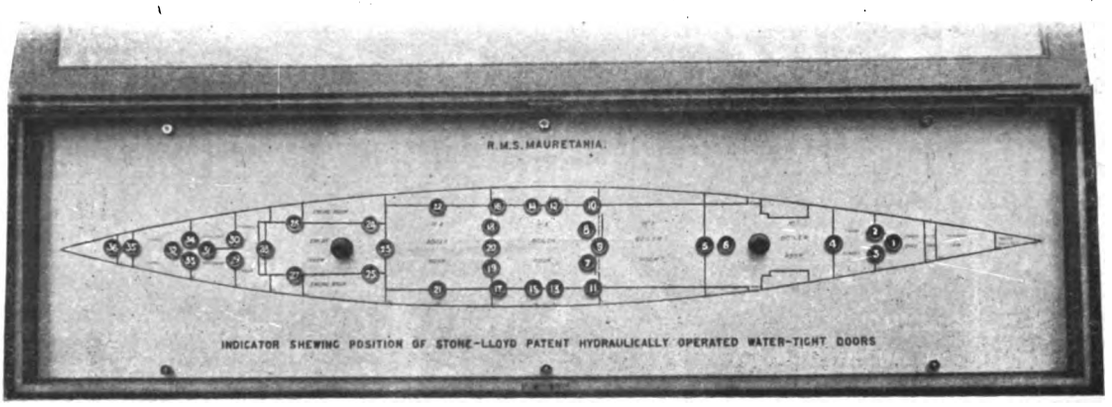

FIG. 19.—INDICATOR SHOWING POSITION OF WATER-TIGHT DOORS.

Another system is that in which the interior of the indicator is illuminated, but the light is blocked by indicator discs. When a push is pressed the corresponding shutter falls and allows the light to illuminate the number exposed. The shutters are replaced by rods in the usual way.

It frequently happens that a number of cabins are arranged so as to be available for either first or second-class passengers. It is then necessary to fit a two-way switch for each room, in a place near the room, but only under the control of the steward. The bell push in the cabin is connected to the central terminal of the two-way switch, while from each of the other switch

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terminals a wire is carried to the first-class and second-class indicators respectively.

Watertight Door Indicators are frequently fitted in passenger steamers. The indicator screen forms a plan of the ship, with a small electric lamp fitted to indicate the position of each watertight door (*see* Fig. 19). At each door a special push is fitted, which completes the indicator lamp circuit when the door is closed.

Should the officer on duty wish to know if the doors are open or closed, he closes the main switch at the indicator, and immediately the closed doors are indicated by a light in the screen. These indicators ought also to have a test key for each lamp in order to prove whether a door is really open or the lamp filament faulty.

Watertight doors are often operated by hydraulic power, and all the doors in the ship may be opened or closed simultaneously by means of a single two-way valve under the control of the officer, while at the same time each door may be operated locally independently of the master control.

There is scope here for electrical apparatus to perform the same duty, for, considering the cost of installing a special hydraulic pump, with high-pressure water pipes and special fittings, it surely is possible to make use of the electric supply, which is always available, for this purpose at less cost than the hydraulic system.

Conclusion.—There are many other special purposes for which electricity is used on ships, but space does not permit of further reference, and, while much has already been accomplished, there remains a wide field for further thought and activity.

Marine Cables on Ship Board

While the success of a marine electrical installation depends largely on the reliability and efficiency of the generating plant, even more is the system dependent on the feeders and distributing cables. The generating plant is subject to constant supervision, but the distribution system cannot be kept under the eye of the staff and must therefore be capable of carrying its load and maintaining its insulation at all times. In the present issue special attention is directed in one of the contributed articles to ships' wiring and the methods usually adopted in the distribution of electrical energy about a vessel. From this it will be gathered that cables and wires are now run to the most distant parts of a ship, where they are subject to the attacks of moisture, sea water and various other influences.

In a modern liner the capacity of the generating plant and the load on the distributing system will exceed those usually met with in a good-sized town. There is, however, this difference. In a land installation the distributing network is under the constant supervision of the mains staff. On board ship the same amount of attention is not paid to the cables after they are once installed, the quality of the conductor and its insulation being relied upon to maintain absolute continuity in the supply.

On the ss. "Mauretania" over 200 miles of wires and cables are installed. These consist of cables of many sizes and types and they supply energy for all the many purposes to which electricity is put on shipboard. There are the large main cables, feeder cables, power mains, telephone cables, switchboard cables, bell wires, lighting wires, flexible leads, &c. They are all insulated with best quality vulcanised indiarubber and are protected in various ways. The main feeders are braided with two coats of asbestos yarn impregnated with

FIG. 1.

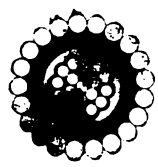

FIG. 2.

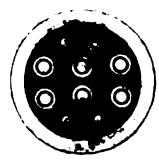

FIG. 3.

special fire-proof compound, and other cables have an armouring of lead or galvanised steel wire, or both. Messrs. W. T. Henley's Telegraph Works Co. supplied the cables for the "Mauretania" and "Lusitania," and we produce some sectional illustrations of a few of those in use on these splendid ships.

Fig. 1 shows a 19/17 tinned copper conductor insulated with pure and vulcanised indiarubber (two coats), waterproof taped and sheathed with a solid drawn lead tube. This is afterwards served with jute and subsequently wire armoured. This cable is installed on the "Mauretania." Fig. 2 is a 19/16 tinned copper conductor pure and V.I.R. insulated (two coats) waterproof taped, braided with jute and wire armoured. Fig. 4 illustrates a 1·5 sq. in. cable, 127/112 tinned copper, pure and V.I.R. insulated. These two were also installed on board the "Mauretania." This cable is finished off with waterproof tape, braided overall with two coats of asbestos and finally treated with Henley's fire-resisting compound, and generally constructed in order to withstand the great heat of the engine room.

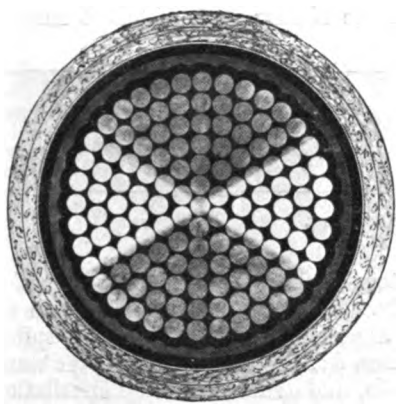

FIG. 4.

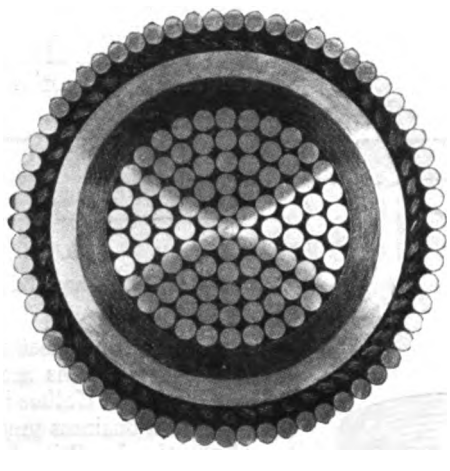

FIG. 5.

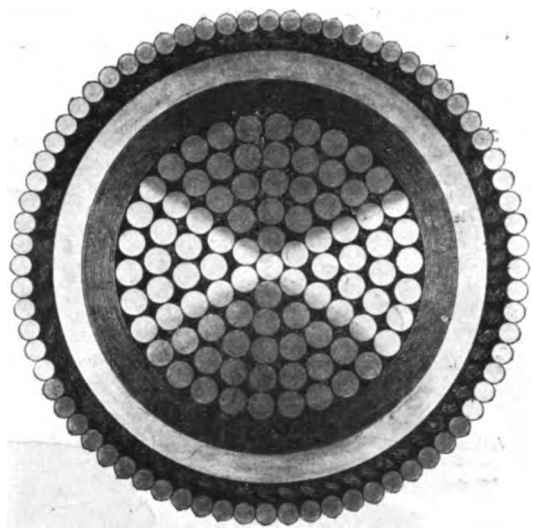

FIG. 6.

Modern battleships perform many operations by electric power which a few years ago were entrusted to steam, while at the same time a large number of mechanical devices are electrically driven which were never previously driven by any other agent. We illustrate samples of Henley's cables now

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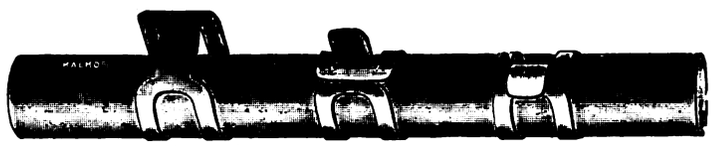
being fitted in H.M.S. "Bristol," being built by Messrs. John Brown & Co., at Clydebank, and H.M.S. "Falmouth," being built by Messrs. William Beardmore & Co., at Dalmuir. These cables have also been supplied by Messrs. W. T. Henley's Telegraph Works Co. (Ltd.), who have supplied cables for many battleships, cruisers, &c., practically ever since electric cables were first used.

We illustrate in Fig. 3 a 10-core V.I.R. cable (16s tinned copper conductors) which is laid up with wormings and sheathed with a solid-drawn lead tube. This has been installed on H.M.S. "Bristol." In the same vessel a 1 sq. in. ring main, similar to that shown in Fig. 5 has been installed, this being paper insulated, lead covered, and afterwards jute served and wire armoured. On board H.M.S. "Falmouth" a 1·5 sq. in. conductor, also paper insulated and lead covered, protected with jute and wire armouring has been installed and is shown in Fig. 6.

These are typical of the heavy character of the cables now installed on board ship, and they serve to indicate the high standard of Henley's cables for this class of work.

Tinned Tube Wiring for Ships

The Kalkos system of wiring, with tinned brass tubes for the reception of the insulated conductors was introduced some three years ago, and many important installations have been



KALKOS TUBE SHOWING BUCKLE FIXING CLIPS.

carried out. In all steel conduit work the problem of condensation is a troublesome one to solve, the trouble being accentuated particularly in ship installations on account of the wide differences of temperature which a vessel experiences in travelling to different quarters of the globe. It is these temperature changes, many of which occur rapidly, that produce condensation in steel conduit, but which, the makers of Kalkos claim, have no effect upon their system of tinned brass tubes. In order to engender confidence in the system, the Sun Electrical Co., who are the pioneers and present suppliers of Kalkos, are prepared to renew any length of C.M.A. cable which fails, on account of condensation, within three years of its being drawn into Kalkos tubing. Quite naturally the guarantee is conditional upon the work of installation being in accordance with the company's standard specification. It may be noted here that the Kalkos conduit system complies with the L.C.C. regulations, and is passed by that body for installation on licensed premises.

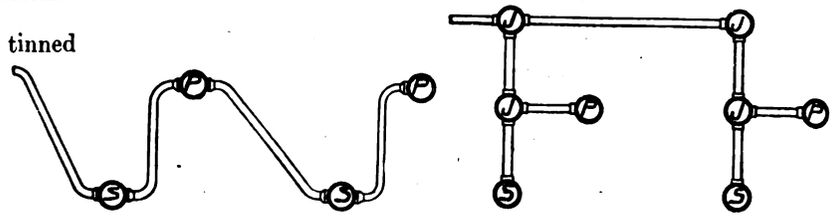
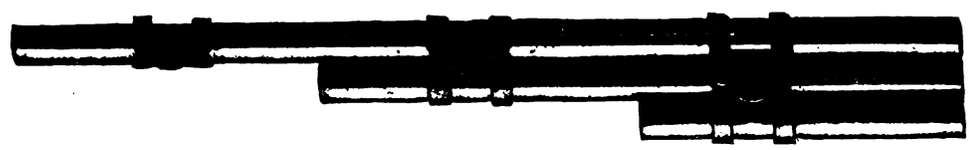


DIAGRAM SHOWING DIFFERENCE IN LAYING OF KALKOS (ON LEFT) AND STEEL CONDUIT.
S=Switch P=Light. J=Junction Box.

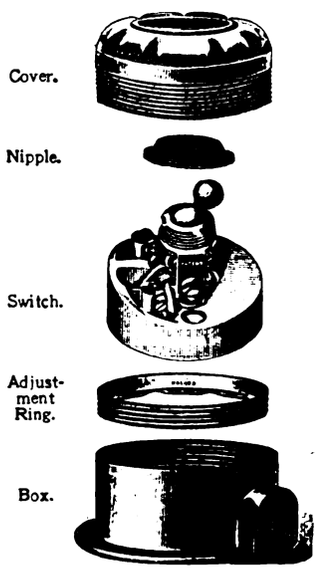
In the Kalkos wiring system, tinned brass tubes are first installed, and the insulated wires are subsequently drawn into them. A complete scheme of boxes and accessories has been provided in connection with the system, and the accompanying illustrations depict the patterns commonly employed. A standard pattern of box has been devised, and with this a variety of fitments with switch, wall socket, pendant and bracket outlets can be effected. The boxes are on this account interchangeable throughout. An important feature of these Kalkos boxes is the amount of flexibility in the matter of entry and exit which they afford. Wires may be brought in at the bottom and out at any point of the side.

ONE, TWO, OR THREE-WAY OUTLETS FROM KALKOS POXES FOR STANNOS WIRES.

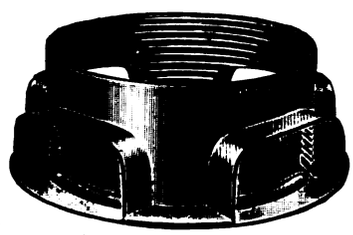
In the space of the present article it is not possible to detail the many accessories of the Kalkos system, but it may be remarked that a most extensive range is presented for selection. All of these items are based on practical experience in the installation of Kalkos in many large public buildings, hospitals trade and business premises, &c. The system bears the stamp of practice in all its details, and as far as marine installations are concerned a number of vessels of the private yacht pattern have been carried out.



STANNOS WIRES AND BUCKLE CLIPS.



TYPICAL KALKOS BOX, AS USED WITH SWITCHES, CEILING ROSES, WALL SOCKETS, &c.



KALKOS FOUR-WAY BOX.

The brass tubing employed in Kalkos wiring is heavily tinned inside and out, and all accessories, such as boxes, &c., directly connected to the tubing are treated in a similar manner. The system is accordingly particularly suitable for marine work in that the tinning effectually protects the brass from the action of the sea air, salt spray, &c. The whole of the work of connecting up the tubing and boxes is done by sweating, consequently, a watertight joint is made at all coupling points. The tubing becomes, by this process of soldering, both electrically and mechanically continuous.

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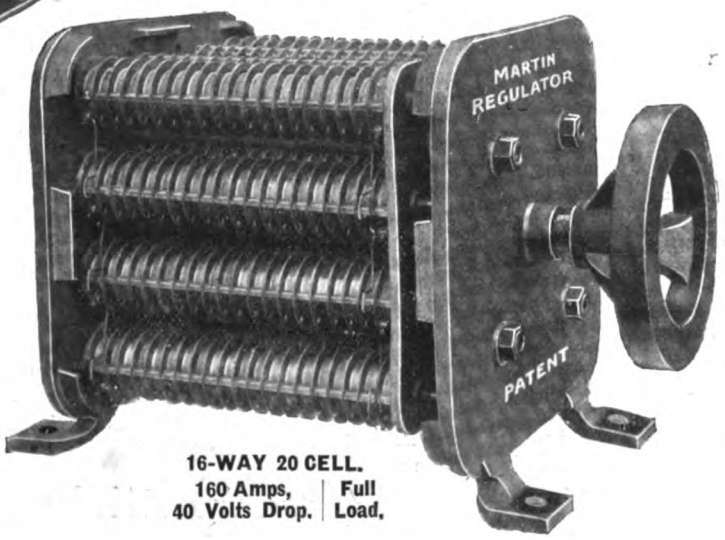
SOMETHING QUITE NEW.
SUPPLIED TO GOVERNMENT DEPARTMENTS.
GRADUAL RESISTANCE CONTROL WITH NO CURRENT PEAKS.
NO TEMPERATURE CO-EFFICIENT.

4-WAY
12 CELL.
40 Amps. | Full
24 Volts Drop. | Load.

2-WAY
12 CELL.
20 Amps. | Full
24 Volts Drop. | Load.



16-WAY 20 CELL.
160 Amps, | Full
40 Volts Drop. | Load.

No Liquids.

No Wires.

No Steps.

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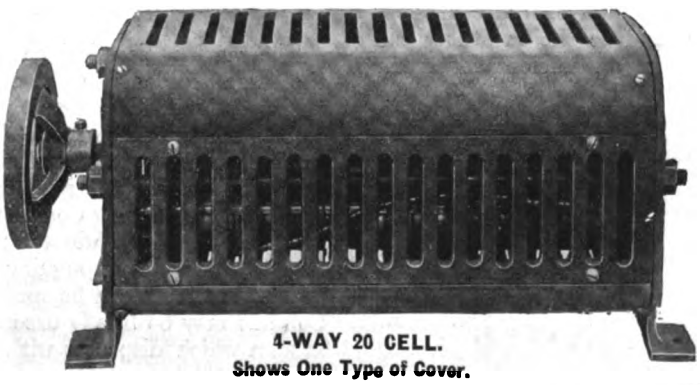

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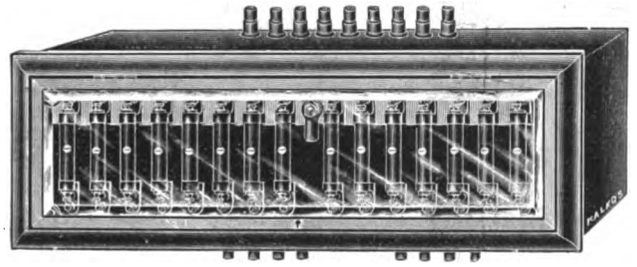
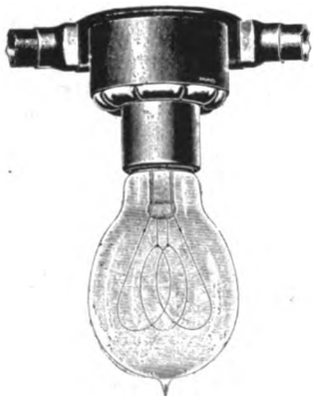
The makers of Kalkos claim that the system is ideal for ship-work, on account of the continuity of the tubing, and the facilities thus afforded for the use of the tube as the return conductor for concentric system. Kalkos can be satisfactorily employed for the main and branch runs about the ship, and with equal facility on the surface or behind panelling. It is exceptionally neat as a surface system. In connection with the Kalkos system Stannos wires are employed to a large extent, the two together forming what is known as the O.S. wiring system. For the interconnection of these two systems special outlets at boxes and other accessories are available, and these maintain the electrical and mechanical continuity of the outer conductor in a simple yet effective



KALKOS DISTRIBUTION BOX FOR CONCENTRIC WIRING, USING TUBE AS RETURN.

manner. It is difficult to conceive of any more flexible, and we might even say any more ideal, system than that in which Kalkos and Stannos are combined in the way above suggested. It is thus claimed that Kalkos tubing overcomes the difficulties of condensation in the feeder and distributor runs about the vessel, and Stannos affords a handy yet neat method of reaching switch and light outlets, and more particularly in surface work.

We may mention that Stannos wires are made by Messrs. Siemens Brothers & Co., and are manufactured with a 10 mil tinned copper taping. These wires, in combination with Kalkos boxes, as noted above, make a very satisfactory and watertight job; and as the sheathing can be employed as the earthed return, an efficient concentric



KALKOS WATERTIGHT LAMP-HOLDER.

ORDINARY WATERTIGHT FITTING WITH ADAPTOR USED ON KALKOS.

system is afforded; the sheathing being also tapped on to the hull at various points. Until recently Stannos wires were only made in sizes up to 7/20, but 7/18 and 7/16 Stannos wires have now been placed on the market. As the voltage adopted for electric lighting on vessels is usually low, the currents flowing are larger than in installations on land, so that the larger sizes of wires mentioned above should prove useful.

Although Stannos wires have only been on the market for little more than a year they are now well known to all electrical engineers, but as marine engineers are usually not so conversant with electrical progress, it may be as well to give the following brief explanation of this system of wiring.

Stannos wires are made by encasing ordinary rubber-covered conductors in tinned copper. A sheet of this latter is wrapped twice round the cable, the second lapping being thoroughly soldered to the first. It will be seen, therefore, that the cable is absolutely impervious to moisture; other features of the system being its great flexibility and the ease with which it can be installed. The metal sheathing can readily be removed, and special continuity fixtures are provided for rendering the outer casing continuous where ceiling roses, switches or other fittings are installed.

As to the labour cost of the Kalkos system, it is claimed by the makers from their extensive experience, that this item is very low because of the ease with which jointing and bending of the tubes can be effected. Again, in drawing in, it is not necessary to make provision for special draw-in boxes, and further the wires can be pulled round four to six bends, owing to the smooth interior surface of the tubes. The work of sweating up the tubes to the boxes at different points of an installation can be easily and quickly carried out, and is, we understand, completed more readily than screwing.

Kalkos wiring makes complete provision for the use of every pattern of switch and pendant accessory, and any desired form of fitting, ornamental or otherwise. In the matter of watertight fittings the Kalkos system provides an outlet for a light in which the lamp holder does not require to be enclosed in a special fitting. The adjoining illustration explains the details of this fitting. The lamp holder is enclosed by a coned socket, and a rubber ring is then slipped over the lamp holder cap. By the provision of a shade ring on the holder ordinary glass shades can be used. On the other hand the more usual bell glass can be fitted to the same pattern of Kalkos outlet box, with no other alteration than the screwing in of a suitable adaptor. Bulkhead fittings can be adapted to Kalkos in a somewhat similar manner.

Ship Wiring with Key Spring Conduit.

The marine electrical contractor is faced with practically the same problems in the selection of a suitable method of wiring as his land confrere, while he has a greater number of special conditions to meet. Finality has by no means been reached in ship-wiring systems, and it will be of interest to describe the features of the latest comer in the field. This is known as Key Spring Conduit, a name which aptly conveys the idea of the principle adopted; the conduit employed is divided into two parts, (1) troughing, and (2) cover, and the latter is so shaped that it can be sprung over the former. Key Spring Conduit may be briefly described as a steel casing and cover system which dispenses with the drawing in of insulated conductors. The work of erection is similar to that of wood casing, that is, the protecting conduit is first fixed in position, the wires are laid in place and the cover is put on; there is, however, a marked saving in time in favour of Key Spring Conduit. The actual cutting, bonding (and bending where required), fixing, wiring and springing on of the cover are speedily performed and with a degree of permanence in the completed work which wood casing never could and never will possess. At the same time it is important to note that with Key Spring Conduit the wires can be examined at anytime even while current is passing.

To the marine electrical contractor a conduit system which removes the risks of abrasion of the insulated conductors and which appears to strike at the root of a trouble that often occurs with steel conduit work—viz., condensation followed by rusting of the interior surface of the conduit—should strongly appeal. Key spring conduit is not a sealed system, the construction, in fact, provides for free ventilation and consequent evaporation of any moisture that may find its way into the conduit. It is claimed that this feature tends to prevent accumulation of moisture just as a house with open windows keeps much dryer than a closed-up house. At the same time, the overlap of the conduit cover and fittings effectually prevents direct access of water.

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A further great advantage is secured by the fact that the above construction permits of the interior surface of the conduit being more thoroughly coated with enamel than is possible with any closed conduit, thereby effectually preventing the formation of rust. Key Spring Conduit and its accessories

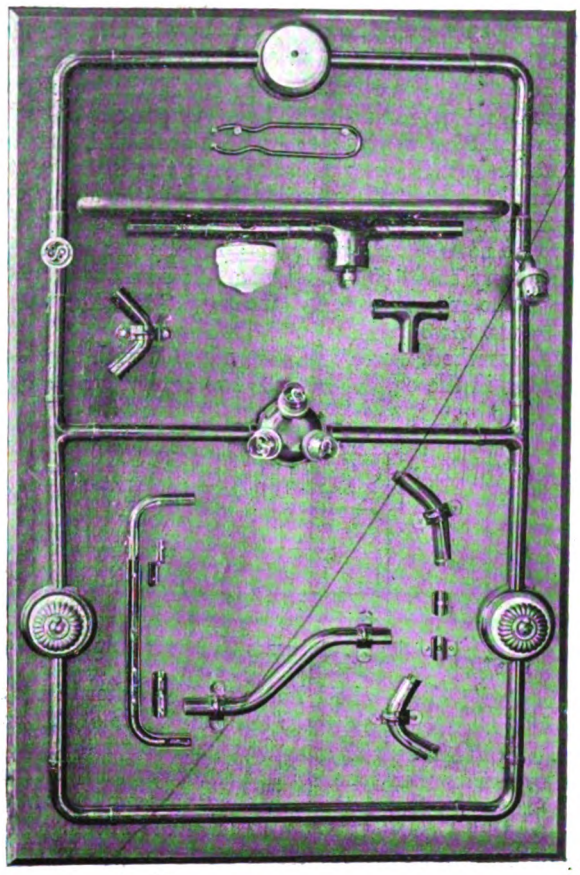

FIG. 1.—SHOWBOARD OF KEY SPRING CONDUIT, DEPICTING PRINCIPAL PARTS.

are only just being placed on the market by the Key Engineering Co. Consequently, no opportunity has been given to marine electrical contractors to test its merits. They will, however, gather from the following description that many advantages are offered by Key Spring Conduit and that it will be worth a trial on a practical scale.

The elements of Key Spring Conduit are neatly displayed on the showboard illustrated in Fig. 1. The conduit is comprised of a semicircular troughing and a semicircular cover which springs over it. Than these two items nothing could be more simple. The general scheme of the system is completed by fixing saddles, tees, elbows, bonds, and bracket and pendant fittings; the special tools required are a hand punch and a hand riveter. The accompanying illustrations (Figs. 2 to 5) depict the more important of these in greater detail than they appear on the showboard.

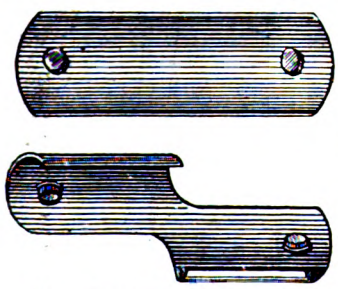

FIG. 2.—BONDING PIECES.

The troughing can be fixed either directly to the wall or ship's side by countersunk screws passing through the bottom of the troughing, or it may be secured to a saddle by a semi-circular clip about 1 in. wide, which passes over both troughing and cover. Where the saddles are used the conduit is held slightly away from the fixing surface so that moisture can run down between the two.

With all conduit systems the question of efficient bonding is recognised to be of the utmost importance. The system adopted for bonding Key Spring Conduits appears to be a particularly efficient one. The lengths of conduit are electrically and mechanically connected by a small steel bond (Fig. 2) and the joints between this and the troughing are made by riveting. Each bond has at each end two copper rivets, and these pass through holes punched in the ends of the troughing. For the punching of these holes and the clinching of the rivets special tools are provided (Figs. 3 and 4). The tools are light to handle and can be used with the conduit in any position. The bond is permanent and of negligible resistance. The cover is easily lifted off by a forked tool which engages with the undersides so that depression of the handle levers the cover away from the troughing.

The Key Spring fittings are all designed to spring on to the troughing. After wiring up the lampholders and bracket, ceiling fitting or three-light cluster, it is only necessary, in order to fix the particular outlet firmly in place, to press the fitting over the troughing and cover. No screws, wood blocks, unions, adaptors or reducing nipples, are facts which cannot fail to impress the contractor.

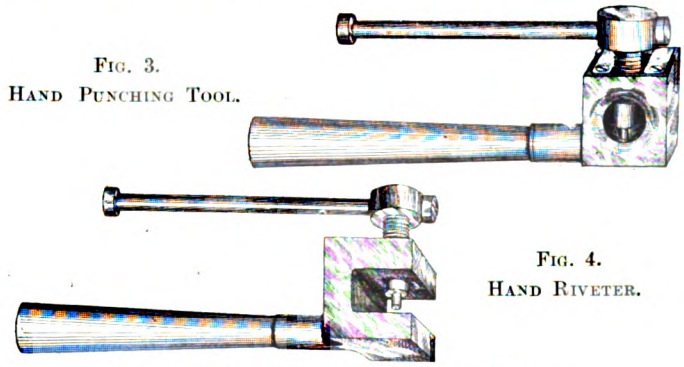

FIG. 3.
HAND PUNCHING TOOL.

FIG. 4.
HAND RIVETER.

KEY SPRING TOOLS FOR BONDING CONDUIT.

The illustration given of the three-light cluster (Fig. 5) shows that this is made up of two parts, one screwed directly to the spring clip for attachment to the troughing and the other, carrying the three holders, held in position by three turned-down lugs, which grip the flanged edge of the fitting. A slot in this flange admits of the passage of one of the lugs, so that a quarter-turn only is required to secure the lower half of the fitting in place. Bracket outlets are, of course, in one piece only, and sprung directly on to the troughing. The actual wiring of fittings can be done on the bench, and their position can be altered as required.

Any number of wires up to the limits of the troughing can be enclosed by the conduit. When laying in, as distinguished from drawing in, the wires, the work is facilitated by the use of small clips, which prevent the conductors from falling out of the troughing prior to the springing on of the cover. The latter

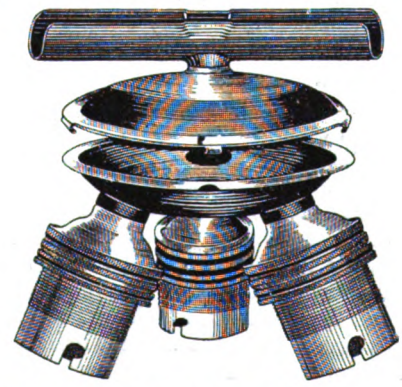

FIG. 5.—THREE-LIGHT FITTING FOR KEY SPRING CONDUIT.

operation is performed when the last of the wires is laid in the troughing.

In conclusion, it may be remarked that the system appears to meet many of the principal objections to ordinary conduit wiring, and it will be interesting to follow its future development. The Key Engineering Co. have prepared a quantity of useful data on the subject of the conduit, and they will furnish any information required.

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Electric Steering Gear.

BY A. P. CHALKLEY, B.Sc.

Summary.—A number of systems of electrical steering are described, and in particular those of the Union Electricitäts Gesellschaft; Pfatischer; Siemens Brothers; Clarke, Chapman & Co.; and Brown Brothers (the Brown-Haigh system).

Though in other matters concerning the use of electricity at sea it cannot be denied that England is well to the fore, very little has been heard regarding the adoption of steering gear operated wholly or partially by electric power, though in several other countries considerable progress has been made in the matter, and electric steering gears are doing successful work on many important ships. Before it was proposed to operate actually the rudder by means of electric motors the question of controlling the usual steam steering engine by electricity instead of by hand, or hydraulic power, was very carefully investigated by many engineers, and several methods are now in use for this purpose. The navigating house of a ship is usually well forward, and the steering engine is naturally placed as far aft as is conveniently possible and almost always very low in the boat. The distance between the steering wheel and the engine is therefore considerable, necessitating either an auxiliary steam engine near, or in, the wheel house for operating the engine slide valve by rods and links, or else hydraulic power for the same purpose—both systems being to some extent uneconomical and cumbersome. The former is particularly inconvenient owing to the great length of steam piping required and the friction of the mechanism, while the latter is not entirely safe and is usually duplicated.

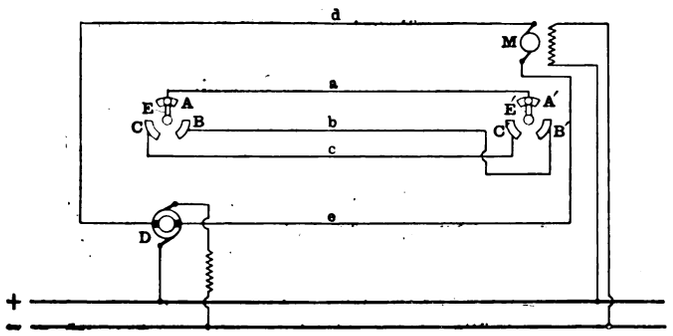

FIG. 1.—ARRANGEMENT OF ELECTRICAL CONTROL OF STEAM STEERING ENGINE.

In all stearing gear the two absolute essentials are entire reliability of the apparatus and synchronous motion of the steering wheel and the rudder; that is to say, any movement of the wheel must cause an exactly corresponding and immediate motion of the rudder. A properly designed electrical system can accomplish this with great satisfaction, but there are one or two points in connection with it which must be borne in mind, and this applies not only to any electrical arrangement for controlling a steam steering engine, but more particularly to motor-driven steering gear, as described later. One of the earliest methods for electrical regulation of steam steering engines was that employed on the Russian cruiser "Bogatyr," nearly 10 years ago, and this is shown in Fig. 1. By means of spur gearing, the steering wheel operates a circular commutator switch D, which cuts off the current from the main ship's circuit when the wheel is in its normal position, a slight movement in either direction causing current to flow through a controlling circular switch with three contacts, A, B, C, mounted on the same casing and also operated through gearing at the same time. This switch is connected by wires to a similar switch with an equal number of stops, A′, B′, C,′ which is operated through gearing by the electric motor M; this works the slide valve of the steering engine, the motor being separately excited from the ship's main circuit. On turning the steering wheel and moving the contact arm E on to the stop B, current flows along the wire *d* through the motor armature, which thus begins to rotate, causing the contact arm E′ to move in the direction of the arrow, and when contact is made with the stop B′, the wire *b* short circuits the armature, which then ceases to rotate. Similarly, if the contact arm E be moved on to the stop C, current flows in the opposite direction through the motor armature, due to the commutator switch being reversed, and the motor continues to run until the arm E′ makes contact with the stop C′. The arrangement has operated very satisfactorily and the chief point to be noted in the design is to make the resistances of the wires very small compared with the armature resistance, otherwise the motor will continue to rotate when short-circuited by the wires *b* or *c*.

Another method, which has been adopted with considerable success, lies in the employment of two similar motors, one of

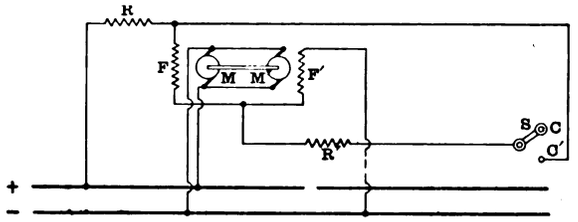

FIG. 2.—U.E.G. ELECTRIC STEERING GEAR.

which is placed in the wheel house and the other in the steering engine room and this works the slide valve of the steering engine. The terminals of the motors are coupled together so that they must run in synchronism, and to ensure further that this shall be so, each armature shaft has three slip-rings mounted on it, which are electrically connected to the windings in order to provide a three-phase current, the two sets of slip-rings being joined by wires. As the slip-rings are connected at similar points, if one motor is slightly out of synchronism with the other, current flows between the armatures, one of which accelerates until synchronism is reached again. Each motor is separately excited from the ship's circuit and the speed and direction of rotation are controlled by a rheostat operated through the steering wheel. In another similar system the motor working the steering engine slide valve, is controlled by a switch operated through an auxiliary synchronous

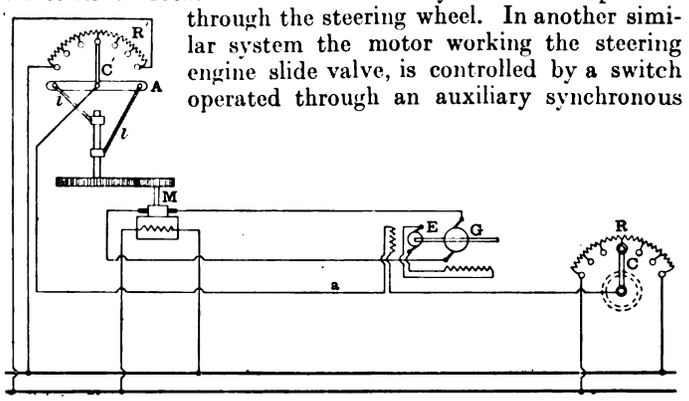

FIG. 3.—PFATISCHER ELECTRIC STEERING GEAR.

three-phase motor in the wheel house. The field of this motor is excited by current developed from a small three-phase machine coupled through gearing to the slide-valve motor, this machine being supplied by direct current from the ship's main circuit and delivering three-phase current to the auxiliary motor by means of three slip-rings. The auxiliary motor and the slide valve motor must therefore always work in synchronism.

Coming to the more interesting problem of the direct control of the rudder by means of electric motors, we find there are several questions which raise substantial difficulties in the case of electrically-operated gears. Taking, as before, synchronous movement of the steering wheel and rudder and reliability as the criterion of success, electricity has no easy

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task to improve upon steam steering gears, though, as previously mentioned, there are other advantages. Further important points to be kept in view in designing electrical arrangements for operating the rudder are the desirable minimum of complication, ease and rapidity of control, besides, of course, cheapness, lightness and excellence of construction of the motors and gear. It might be thought that for this type of work series motors, with their high starting torque, would be applicable, but, as a matter of fact, they are practically never used, since the pressure of water on the surface of a rudder varies approximately as the square of the sine of the angle of the rudder with the length of the ship; hence the speed of the motor for equal torque, good efficiency and effective operation should vary inversely as the square of the sine of the angle—that is to say, the nearer the rudder is to the centre line the higher should be the speed of the motor, and it is usually attempted to fulfil this condition.

One of the earliest systems is that shown diagrammatically in Fig. 2, this being a construction adopted by the Union Electricitäts Gesellschaft before its amalgamation with the A.E.G. for a Russian cruiser and a German warship. There are two exactly similar motors mounted on the same bed-plate

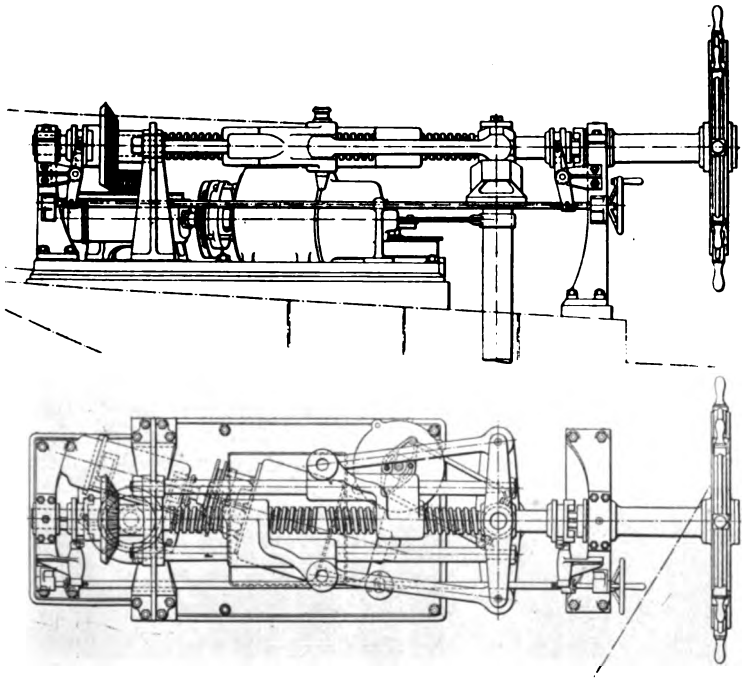

FIG. 4.—GENERAL ARRANGEMENT OF COMBINED ELECTRIC AND HAND STEERING GEAR. (CLARKE, CHAPMAN & CO.)
(Scale 1 : 40.)

with a gear-box between, containing a differential gear by means of which a shaft revolving inside the shafts of the armatures of the two machines is caused to rotate. This inner shaft has a spur wheel keyed on at one outer end, and by means of bevel and worm gearing operates the rudder. When the two motors are running at exactly the same speed there is no tendency for the interior shaft to revolve, but any slight alteration in the speed of one of them causes it to rotate in one direction or the other. As is seen from Fig. 2, the control is obtained by the switch S operated in the navigating house, and the resistance R′ can either be put in parallel with F, the field of the motor M, or with F′, thus causing an increase of speed in the motor with whose field it is in parrallel, being M, as shown in the diagram. The arrangement can be very substantially constructed, but it possesses the inherent defect that it is impossible to rely absolutely on the motors running at exactly the same speed, so that slight movement of the rudder often occurs when it is not desired, and on the whole it is probable that the system will not receive wide application.

An arrangement which has had much success is an American one designed by Pfatischer, and this is in use on several American and Russian ships. It is shown in diagram in Fig. 3. G is a generator driven by a steam engine or other means, an exciter, E, being mounted on the same shaft, delivering its current direct to the field of the generator, whose output therefore depends directly on the power developed by the exciter, which in turn depends on the strength of its own field. This is excited by the current flowing in the wire *a* and only exists when the contact arm C, operated by the steering wheel is in a different position relative to the stops of its rheostat R, from the arm C′, connected to the rudder arm as shown, relative to its rheostat R′, since the rheostats form a Wheatstone bridge arrangement, with *a* as the connection between the arms. The generator G delivers its power direct to the motor M, which operates the rudder through spur gearing, driving a screwed shaft which turns the arm by means of right and left-handed nuts with links, *e*. Though the connections seem complicated, the operation is very simple and exact, a movement of the arm C causing E to be excited and the generator to deliver power to the motor, which continues to revolve until the contact arm C′ reaches a corresponding position to that of C.

An electrically operated steering gear was installed by Messrs. Siemens Bros. on the "Manxman," the ordinary steam steering engine being also employed so that either means could be used. A series-wound motor was employed for operating the rudder, and the control was obtained by a set of relays operated from the bridge, by means of which resistance was put in or out, the arrangement being similar to that which has been adopted in some instances for traction purposes. The relays were not operated direct from the bridge, but two synchronous motors were used, as explained previously, the one in the steering room serving the double purpose of controlling the slide valve of the steering engine when in use, and working the relays of the rudder motor controller. Magnetic blow-outs were employed to prevent dangerous sparking in the controller. The arrangement is unique, and in many ways most interesting, but its complication and the employment of series motors, with the attendant disadvantages, do not warrant any expectation of its extended use.

In an Italian system which has been brought forward within the last few years the principle of the Wheatstone bridge is again employed for producing the synchronous operation of the rudder and steering wheel, as in the Pfatischer arrangement; the rudder motor, however, is not controlled by a separate generator, but takes its power direct from the ship's mains, being controlled by resistances operated by relays in a very ingenious manner. There are several relays, the windings of which are in series with the armature of the rudder motor, and as the speed of this rises, the back E.M.F. increases and operates the relays one after another, thus short-circuiting the resistances until all are cut out. The arrangement is very original, but the necessity of relays is disadvantageous at sea and the system will probably only be adopted in small boats.

The Russian cruiser "Rurik," built by Vickers, Sons & Maxim, in 1907, was fitted with both electric and steam steering gear, either of which could be used as desired. The electric motor operating the rudder was series wound, and current was supplied to it from a motor generator situated in the steering room, this current being controlled by varying the excitation of the generator by means of a rotary rheostat operated from the steering motor itself. Two small synchronous motors, as previously described, were employed to produce synchronous motion of the rudder and steering wheel, the same arrangement being also used to work the slide valve of the steam steering engine. The direction of rotation of the steering motor was reversed by means of a rotary switch on the same shaft as the controlling rheostat, but the adoption of a series motor, and the necessity of switches breaking heavy currents are disadvantages which weigh heavily against the system.

Messrs. Clarke, Chapman & Co., of Gateshead, are the constructors of an electric steering gear which has now been in use for several years with considerable satisfaction, and their arrangement is illustrated in Fig. 4 and a general view is shown

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in Fig. 5. With this type of gear a head is fitted to the top of the rudder post with two arms, each of which is connected by a connecting rod to a nut on the right and left-handed screw shown in the figure, so that when this screw is rotated the rudder is turned.

This is a usual type of gear and has simply been adapted in this particular case to electric driving by fitting at one end a

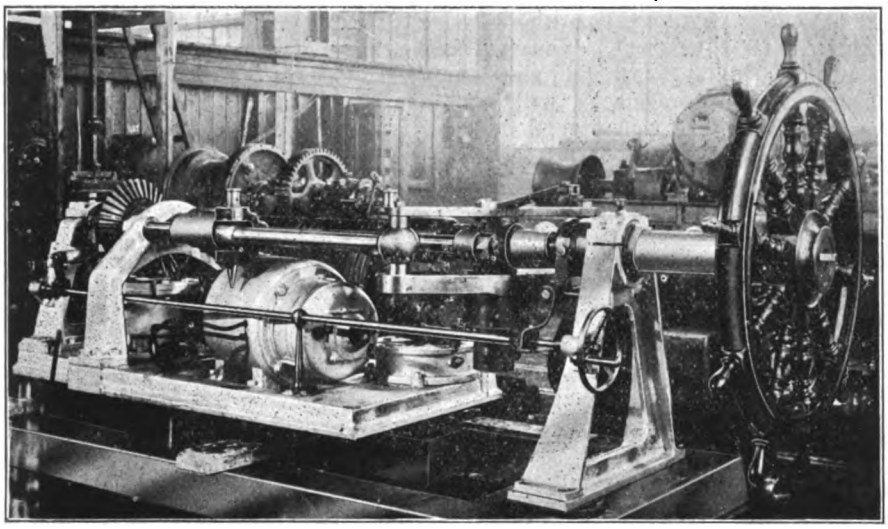

FIG. 5.—CLARKE, CHAPMAN & CO.'S ELECTRIC STEERING GEAR.

pair of bevel wheels, one of which is keyed to the shaft of a worm wheel enclosed in a case shown below the main screw and driven through the worm gear by the motor. Messrs. Clarke, Chapman are also prepared to fit steering gears with "following up" gear, so that when the steering wheel is turned the steering gear will be started, and will automatically stop when the rudder reaches the desired angle.

It will be seen that there are two claw clutches operated by a hand-wheel, the purpose of this being to connect the main screw either to the bevel wheel at the one end for driving by the motor, or to the hand-wheel at the other end, for driving by hand in case of emergency.

The small round box fitted on the bedplate of the gear under

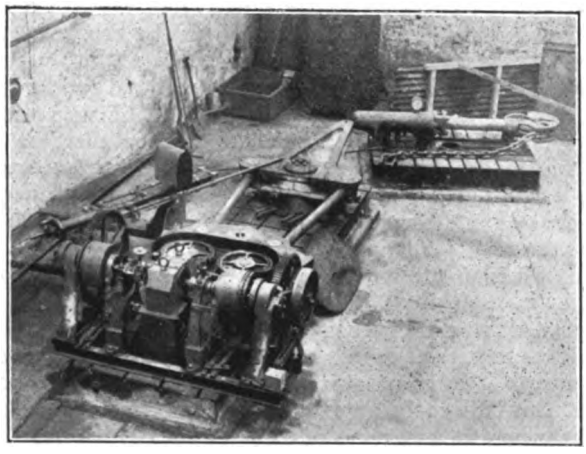

FIG. 6.—BROWN-HAIGH STEERING GEAR AND TESTING ARRANGEMENT.

the hand-wheel end and connected to the rudder post by two small connecting rods, is the transmitting apparatus of a helm indicator to indicate the position of the rudder, on the bridge.

An interesting steering gear has recently been designed and built by Messrs. Brown Bros. & Co. (Ltd.) in conjunction with Mr. B. P. Haigh, of Glasgow University, whose patents are embodied. The gear is illustrated in Figs. 6 and 7, and has been running very successfully at the Rosebank Ironworks, Edinburgh, for several months past. The general view also shows the hydraulic cylinder by which the steering gear can be tested at normal loads and also at heavy and jerky overloads. The design has several novel mechanical features which render it specially suitable for a mechanical drive, and notably a variable leverage link gear, which enables an increased effort to be applied to the tiller crosshead when hard over and at the same time increase the normal speed of working within the range near the midships position. The toothed sector is driven by right and left-hand worm gear, a speciality of this firm, which allows the usual thrust block to be dispensed with, and considerably increases the efficiency of the gear. The current demand from the ship's generating plant is therefore very moderate, even on the rare occasions when the rudder must be put hard over at full speed. The motor is kept running continuously and the gear is started and stopped by magnetic friction clutches on the motor shaft. In this way the sudden peaks of current which are so undesirable in a lighting installation, are entirely eliminated, and the minimum of working switchgear is required. The clutches are controlled by one of Messrs. Brown's new hydraulic standard telemotors, and the whole of the switchgear is, in fact, contained in the small controller mounted above the telemotor receiving gear. It will also be noted that the clutches are built with considerable weight, and are mounted directly at each end of the motor shaft, so that no gearing is in motion except when the rudder is actually being moved. A very desirable result of the use of these clutches is that when the wave-pressure on the rudder exceeds a certain overload, the clutches slip momentarily and thus protect the electrical system.

Very satisfactory results have also been obtained from preliminary tests on a Haigh patent electrical telemotor, by which the motions of the hand-wheel on the bridge are exactly copied by the receiving apparatus in the steering house aft. This result is obtained in a very simple manner by the use of two induction motors, without any working switchgear, and full reliability is claimed. Alternating-current to supply this telemotor is obtained from slip-rings fitted to the main steering motor in the case of the Brown-Haigh steering gear described

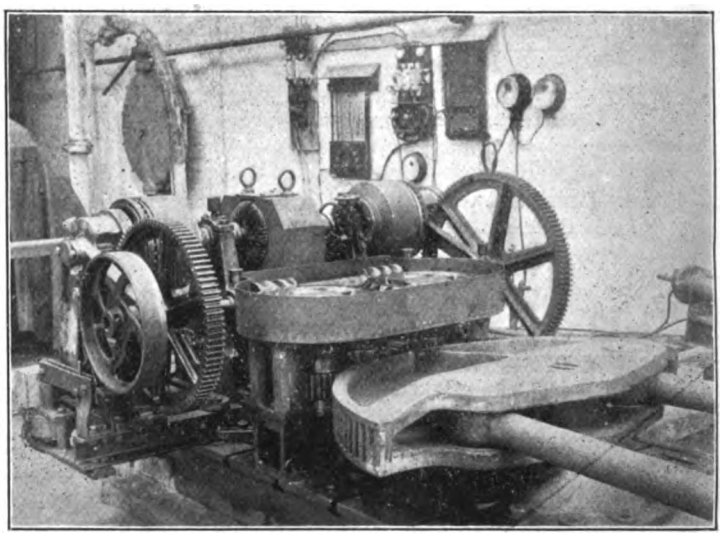

FIG. 7.—GENERAL VIEW OF BROWN-HAIGH STEERING GEAR.

above; but a three-phase system is preferred as the main steering motor can then be of the simpler squirrel cage type.

There are a number of other methods now in use or about to be tried, but they all bear some resemblance to one or other of those already described. There are such obvious advantages in the employment of electricity for steering that very marked progress may be expected in this direction in the near future, and this is all the more probable in view of the present tendency to replace all steam auxiliaries on ships by electrical machinery, which is advisable both from the standpoint of efficiency and simplicity of operation.

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Electric Helm Indicators.

The object of the helm indicator is to show on dials on the bridge or other positions in a vessel the angle of the rudder.

The Richards-Evershed system of helm indicators, which has been in use for many years in the British and other Navies, depends for its action upon the movement of a soft iron needle freely pivoted at the centre of two coils whose axes lie at right angles to one another. The position of the needle, of course, depends upon the ratio of the currents flowing in the two coils.

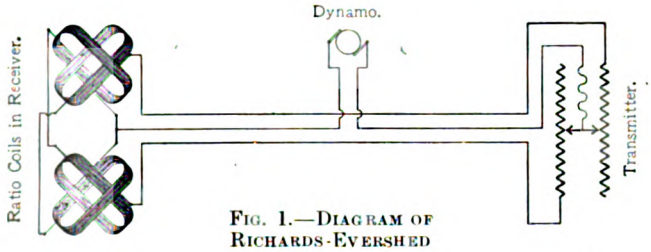

FIG. 1.—DIAGRAM OF RICHARDS-EVERSHED SYSTEM.

In the earlier form of this apparatus the ratio of the currents was altered by sliding a contact on a resistance. In 1906, however, an improved design was adopted. This is illustrated diagrammatically in Fig. 1, from which it will be seen that resistance is added to one circuit and removed from the other. The general arrangement of the Indicator is shown in Fig. 2. Two soft iron needles are used, each in a separate pair of coils; they are linked together by a light coupling rod, which transmits their motion to the indicating pointer. The coil system is duplicated, and the current is passed through corresponding coils in opposite directions, in order that the system shall have as little external field as possible; and what little effect remains is neutralised by an automatic compensator fixed in the upper part of the instrument. This is merely an electro-magnet energised by the current, so that its field varies with that of the coils; and its size and position have been determined by experiment, so as accurately to compensate for the external field of the coils.

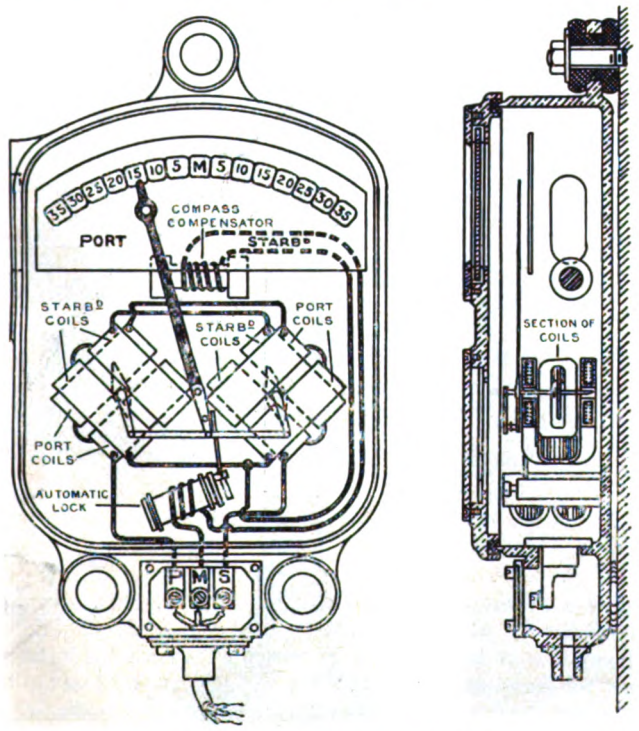

FIG. 2.—GENERAL ARRANGEMENT OF HELM INDICATOR (1906 PATTERN).

The dial of the indicator has a scale divided at every 5 deg. of helm, corresponding to the motion of the contact arm in the transmitter over the contacts in the transmitter switches, which are spaced 5 deg. apart. The bridging of two adjacent contacts by the contact arm causes an intermediate signal, roughly corresponding to 2½ deg. of helm; but no attempt is made to make this indication accurate, except immediately on either side of the 'midships' point. Under the nameplate on the front of the indicator is fitted a device, which enables an accurate adjustment of the pointer to 'midships to be made, by simply turning a screw, which, by means of an eccentric, gives a limited sideways motion to the axis of the pointer.

It should be noted that these indicators are now made universally interchangeable, provided, of course, that they are wound for the same voltage. The utmost possible care is also taken to render the instrument absolutely watertight, a point of extreme importance; and the terminals are therefore placed in an external terminal box so that the instrument may be coupled up without opening the inner case. Provision is also made for a lamp which can be fixed outside the case when it is necessary to provide an illuminated dial.

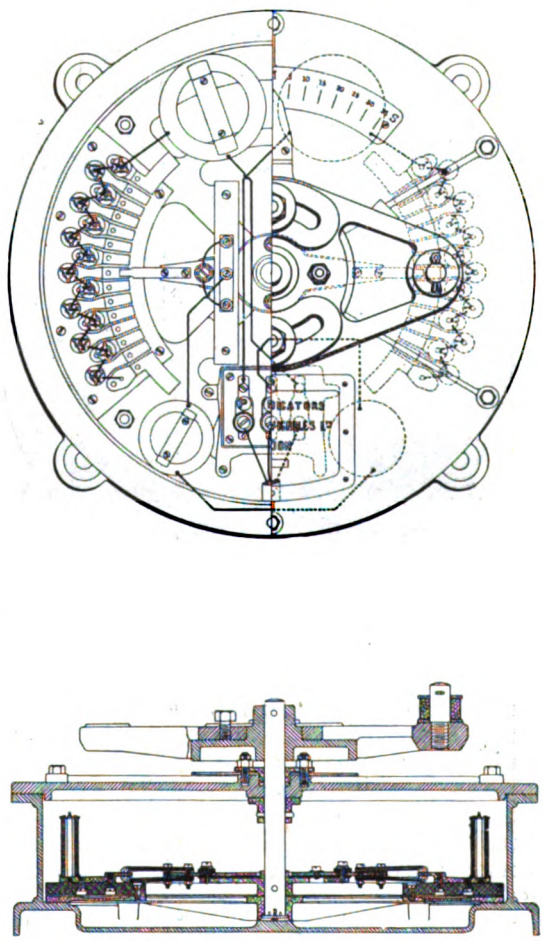

FIG. 3.—GENERAL ARRANGEMENT OF AUTOMATIC TRANSMITTER.

The general arrangement of the transmitter is shown in Fig. 3. The resistance is distributed on china bobbins mounted on the switch contacts, and the connecting switch arm is attached to the central spindle, whose motion is determined by the rods which connect it through a cross-head to the rudder-stock. The arrangement of the cross-head and rods is clearly shown in the view of the transmitter given in Fig. 4, which also illustrates the arrangements adopted for the relative adjustment of the coupling rods and transmitter spindle to secure an accurate adjustment at 'midships when the transmitter is being fitted in the ship. The connections for the transmitter are made under the name plate shown in Fig. 4, a rubber joint being provided to

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secure that the instrument shall be watertight after the plate is screwed down.

In nearly all ships two or more indicators are provided, provision being made for coupling any one of the indicators to the transmitter. The whole of the transmission is effected by one three-core cable.

Fig. 5 shows the simple manner in which the system can be applied to provide a complete system for transmitting orders and receiving a reply, by the addition of one wire only. In such an arrangement as this the indicator and the transmitter are combined in the same case.

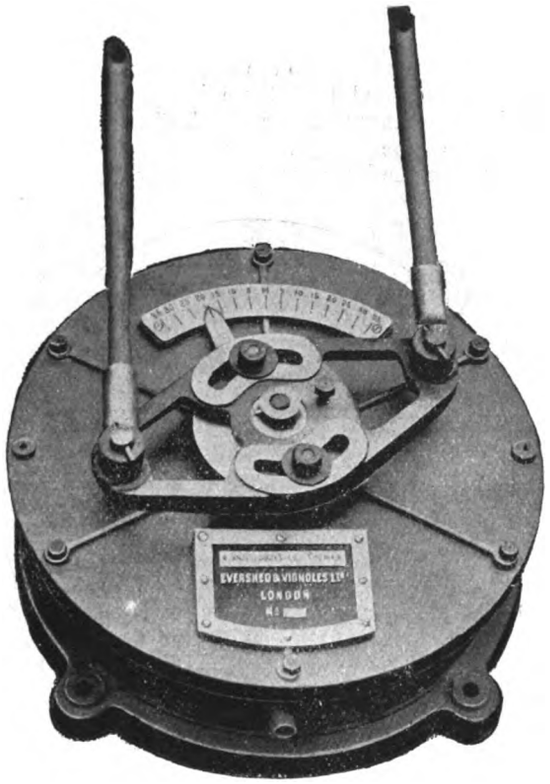

FIG. 4.—VIEW OF RICHARDS-EVERSHED TRANSMITTER.

The electric helm indicator, made by Messrs. Siemens Bros & Co., consists of a transmitter situated near the rudder stock, and connected to it by means of a pulley and special driving gear, and in electric connection, by means of a four-core cable, with any number of indicators or receivers placed where required. The transmitter is a form of switch or contact maker, which sends current to a group of magnets in the receivers and causes their armatures to revolve and move the pointers in such a manner that these take up positions corresponding with that of the rudder.

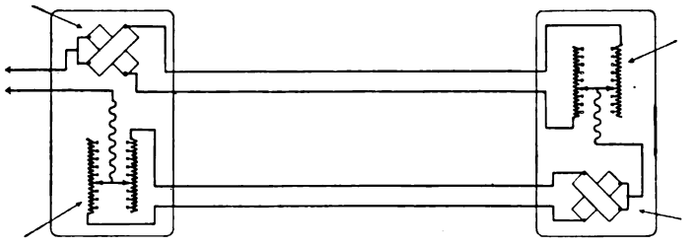

FIG. 5.—DIAGRAM SHOWING ARRANGEMENT WITH REPLY TRANSMITTER AND INDICATOR AT EACH STATION COMBINED IN ONE CASE, FOUR WIRES ONLY BETWEEN STATIONS.

The driving gear, by means of which the transmitter is connected to the rudder, consists of a grooved pulley clamped on to the rudder stock. To the latter are fastened flexible steel wire ropes connected by special spiral spring couplings to lengths of roller chains driving toothed wheels on the spindle of the transmitting switch. These spring couplings are provided to allow a certain movement of the rudder before the switch is actuated. This, together with a form of escapement gear, ensures that the movement of the switch is definite from one set of contacts to another, thus avoiding sparking and other contact troubles. Two sets of ropes, springs and chains are provided, either set being sufficient to do the driving of the switch.

The switch is contained in a gunmetal case provided with a watertight cover and separate terminal box, and mounted on a brass column, the height of which is arranged to suit the particular type of steering gear. All parts are very accessible and of substantial construction.

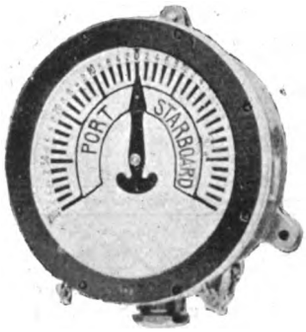

FIG. 6.—SIEMENS HELM INDICATOR "RECEIVER."

The indicator or receiver (*see* Fig. 6) is a dial instrument, and consists of a gunmetal case with a watertight front fitted with plate glass. It contains the magnetic motor for actuating the pointer. The dial over which the pointer moves is of opal

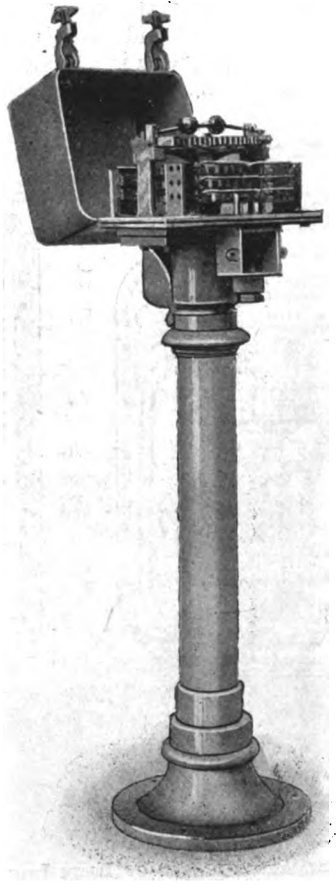

FIG. 7.—SIEMENS HELM INDICATOR "TRANSMITTER."

glass for purposes of internal illumination, and has on its surface the scale for indicating the movement of the rudder in degrees. The scale is of a very open and bold character, and embraces an angle of 120 deg. from "amidship" to "hard over."

The transmitter switch (*see* Fig. 7) consists of four rings, one of which is continuous and forms the feeder to the other three,

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which alternately make contact as the switch is revolved to the three pairs of magnet coils of the magnetic motor. The motor consists of three pairs of magnets, between the poles of which are mounted two armatures, one at each end, both carried on one spindle, on the end of which is fixed a small worm for actuating the spindle, which carries the pointer of the receiver.

The internal illumination is provided by a lamp, provided with a special watertight fitting which enables it to be readily removed and which makes contact to the terminals of the lamp when placed in position. The indicator case is provided with lugs for fixing to a bulkhead or other support, and has a polished front, and is fitted with watertight cable glands. It can also be provided mounted on a column. It should be noted that any number of receivers can be actuated at the same time from the one transmitter.

Revolution Indicators.

In marine work it is highly necessary that the number of revolutions of the main engines should be indicated continuously on the bridge. Several arrangements have been proposed for doing this, and we may be forgiven for recommending an electrical one, such as that made by Messrs. Siemens Bros. & Co.

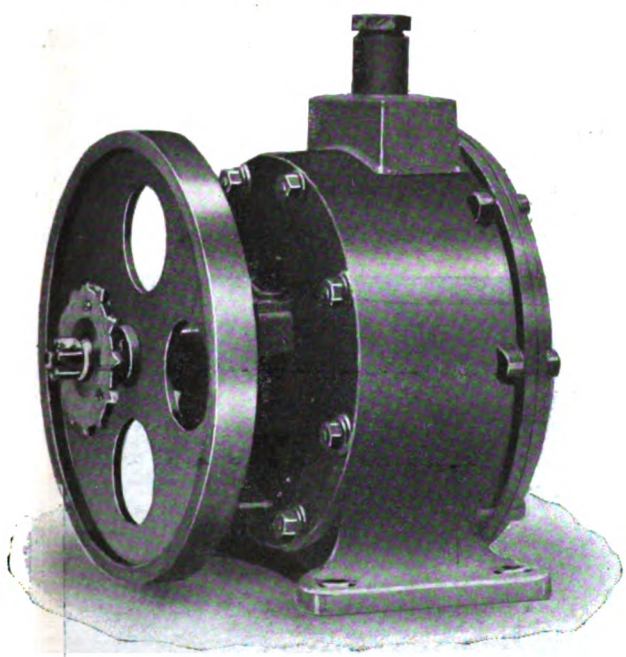

FIG. 1.—TRANSMITTER.

This apparatus is used for indicating the speed in revolutions per minute of an engine or other shaft, at positions situated at a distance from the shaft. It offers, it is claimed, many other advantages over all other types designed for the same purpose, and embodies several features which make it eminently suitable for indicating on the bridge of a vessel the speed at which the engines are running.

The method of transmission is by alternating current, supplied by a special form of generator driven by chain gearing from the engine shaft, the indicators or receivers being voltmeters constructed on the well-known "Ferraris" principle. The transmitter is constructed so that the voltage generated is proportional to the speed, a result obtained by employing a fixed armature and revolving a magnetic field composed of permanent steel magnets. This method does away with the necessity of slip rings and contact brushes, which are liable to introduce errors due to wear taking place with a consequent alteration of the points of contact, and also to variation of the resistance of the contact surfaces, causing a difference voltage.

The Ferraris voltmeter, which forms the receiver or indicator, is the most accurate form of alternating-current voltmeter, and has the additional advantage of having a scale which subtends about 280 deg. permitting of large and open divisions. The zero is in the middle position, and the pointer moves to the right or the left, according to the direction of rotation of the shaft. The turning force of this type of instrument is very great, by reason of which the pivots and other moving parts can be of substantial construction.

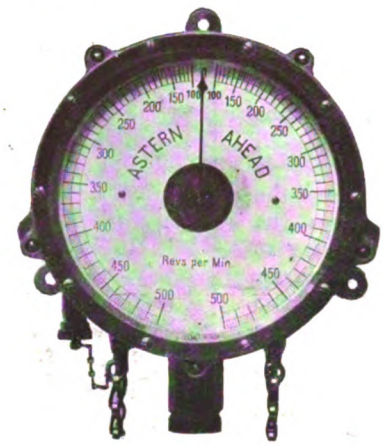

FIG. 2.—INDICATOR.

The transmitter, Fig. 1, is of water-tight construction, with very efficient lubrication to the revolving spindle. For turbine-driven shafts, where the turning movement is uniform during a revolution, the chain drive is direct from the engine shaft but for reciprocating engines the drive takes place through a regulator, to ensure the speed of the transmitter keeping regular during a revolution. A flywheel is added to assist this. The regulator is a form of spring coupling, arranged as a countershaft, which is driven by a chain from the engine shaft, and to which the transmitter is connected by a chain drive. The receiver or indicator (Fig. 2) is contained in a water-tight case, provided with lugs for fixing to a bulkhead or other support. Arrangements for illumination are provided when required.

Battery-Booster Plants on Rapidly Fluctuating Loads.

Some remarkable economies have been effected by the installation of a battery and reversible booster in cases where heavy fluctuations occur on the generating plant, as, for instance, a crane load or the electrical equipment of a steel works or shipbuilding yard. It is, of course, necessary that the booster used in connection with this class of work should be instantly reversible and capable of coping with the heavy fluctuations that occur without any adjustments being necessary as the load varies and the state of charge of the battery alters.

The "Entz" booster, supplied by the Chloride Electrical Storage Co., is controlled by the operation of a carbon regulator consisting of two sets of piles of carbon discs, a lever being pivoted between the two sets, from one end of which is freely suspended a soft iron core surrounded by a solenoid carrying the entire generator load. To the other end of the lever is attached a spiral spring, the tension of which is regulated to counterbalance the pull of the solenoid. This enables any predetermined load to be allotted to the generator. Variations in the total load above or below this fixed generator load will cause changes in the pressure on the carbon piles, resulting in

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a wide variation of their contact resistance, which will affect the field excitation of the booster through the intermediary of a small exciter, the field of which is controlled by the current passing through the carbon regulator. When the desired average load is on the generator the pull of the solenoid and the spring counterbalance each other, and as then the resistance of the carbon piles is equal, the booster field coil is not excited. Should however, the line load rise above the average, so that the load on the generator tends to increase, the pull due to the increase in current flowing round the solenoid overcomes the tension of the spring at the other end of the lever. This action compresses the carbon piles on one side and allows the current to flow in the field of the exciter in a direction which will energise the booster field coil in such a manner as to add to the voltage of the battery and cause it to discharge. If the load should fall below the average the generator output will tend to drop, and the spring at one end of the lever of the carbon regulator will overcome the pull of the solenoid. The carbon piles of the regulator (on the other side to those which were compressed when the battery was discharged) will then be compressed, and the battery will receive a charge equal to the difference between the average generator load and the line load.

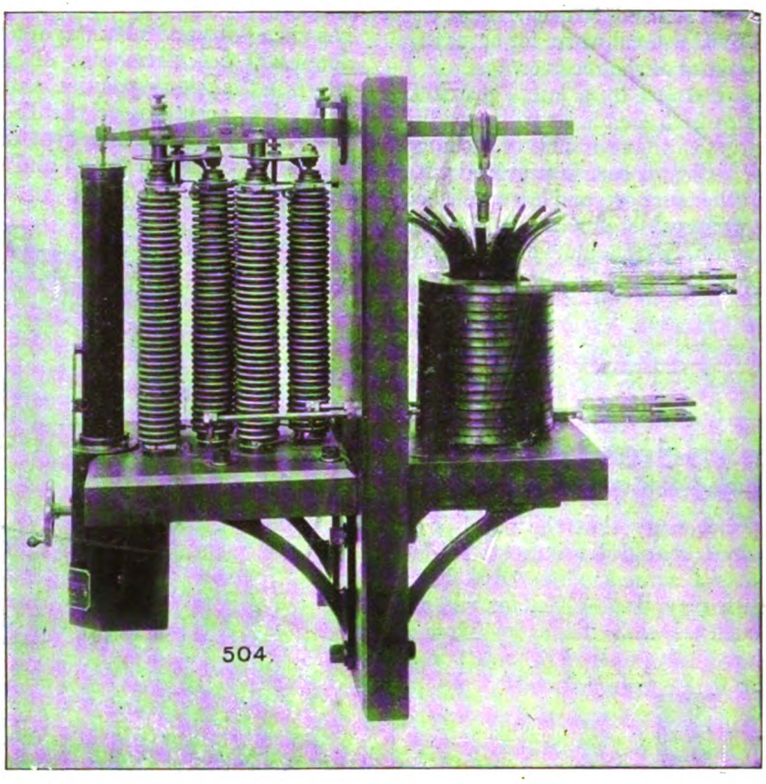

FIG. 1.—VIEW OF ENTZ REGULATOR.

The load to be taken by the generator may be adjusted to any desired amount by varying the tension of the spring at the end of the lever which regulates the pressure on the carbon piles. This adjustment is instantly made by a small hand-wheel, and may be altered from time to time to meet any considerable changes in the nature of the load, so that the battery can be either floating, giving a continuous peak discharge, or being charged according to the adjustment, while at the same time it will always automatically take the momentary fluctuations of the load.

An interesting application of the "Entz" booster is afforded by a plant installed at a steel works in Scotland. At the time when this plant was laid down the generating plant consisted of two 375 kw., 20 to 230 volt high-speed direct-coupled steam sets. As about 70 per cent. of the motors installed are series-wound, the starting currents are very heavy, with the result that it was

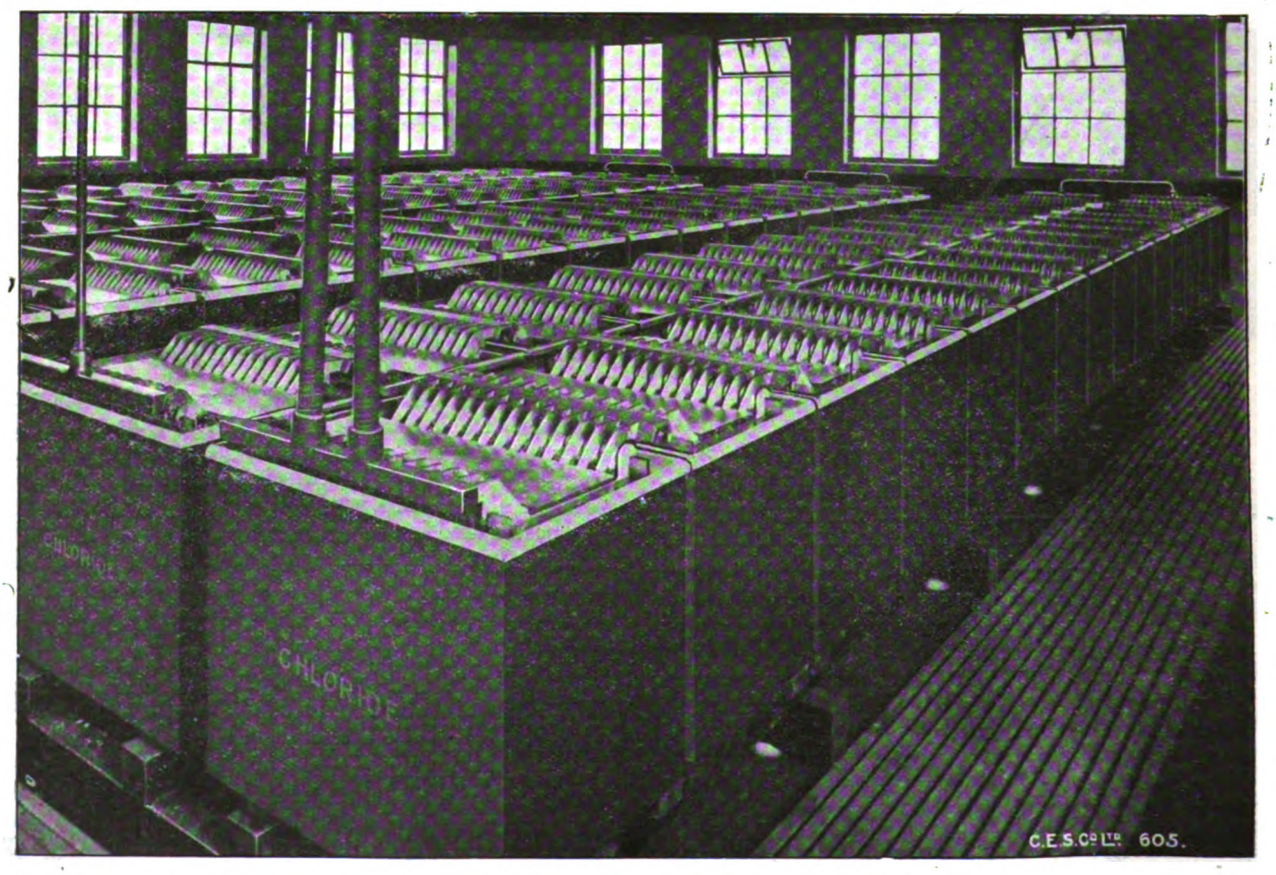

FIG. 2.—BATTERY OF CHLORIDE ACCUMULATORS.

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occasionally necessary to run both sets, and as new plant is in contemplation it would have necessitated both sets running continuously.

It was decided to employ a battery-booster plant to relieve the generating plant of the peaks of the load, and a battery of 114 cells was installed, capable of discharging at the rate of 1,190 amperes for 1 hour, together with a booster to control the charge and discharge of the battery. Any increase in the load, above the mean load, is now automatically thrown on the battery by the action of the carbon regulator which controls the booster, and in the same way any decrease in the load, below the mean load, is automatically compensated for by the carbon regulator causing the booster to charge the battery and so maintain the load on the generating plant practically constant. The net result is that, whereas formerly it was at times necessary to run both steam sets, it was then found that one could deal with the load, resulting in a considerable economy in steam consumption, a reduction at top load of 50 per cent. in the amount of running plant required (one set being thus set free to act as a stand-by), while the battery acts as a further stand-by, and is also available for a source of supply for week-end repairs and lighting. The battery-booster plant is arranged to run in parallel with any set that may be required to meet the average demand.

Since the battery was installed a considerable amount of additional plant has been laid down, involving a large number of motors, of which there are now about 200 installed in the works, with an aggregate of about 4,000 B.H.P. There are eight charging machines, which take from 300 to 400 amperes starting current. The rest of the motors work roller racks, screw-down gear, cranes, pumps, &c. To deal with this increased load, a steam turbine set was installed of 500 kw. capacity, and it is found that this set, together with the battery, is able to deal with the whole electrical requirements of the works.

The various economies brought about by this combination of turbo-generator and battery-booster plant are worth consideration in all cases where a fluctuating load has to be dealt with.

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Ship Illumination and Fittings.

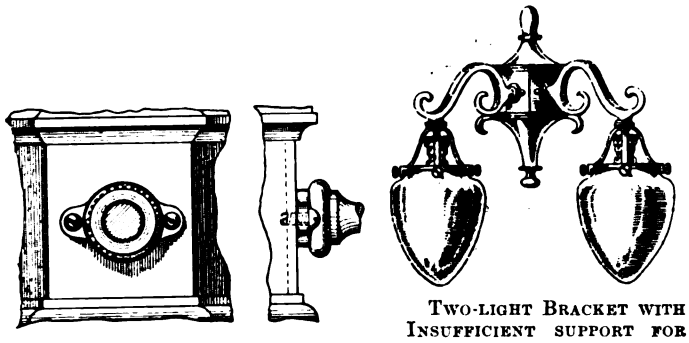
BY G. AUSTIN.

(Of Messrs. W. C. Martin & Co.)

Summary.—The author discusses the character of lighting and fittings suitable for decks, cargo holds, cattle spaces, emigrant accommodation seamen's and officers' quarters, passengers' cabins, dining saloons, lounges, drawing rooms and smoking rooms, signal lamps and navigation lamp indicator. It is necessary that particular attention should be paid to insulation and the prevention of trouble by vibration.

Among the endless variety of electric lamp fittings on the market only a small proportion is suitable for use on board ship. The demand for flexible pendants and flexible drops on brackets and electroliers, which has been the fashion for some years, makes the proportion available still smaller.

But even the majority of brackets and electroliers made with rigid arms for use on land would be quite unsuitable if fitted on board-ship. Ship fittings must be strong and well put together in order to withstand the vibration and rough handling to which they are exposed. A frequent source of weakness is to be found, for example, in bracket fittings where the arms are fastened to the backplate. One often finds long slender bracket arms screwed into a very thin plate, with nothing to prevent the arms from turning round, or the arms are frequently fastened to the base plate by a tiny flange and two small screws. The small flange referred to is often fixed as shown in Fig. 1, and there is no adequate means for supporting the weight of the bracket arms, so that the small screws soon lose what hold



DETAIL OF FAULTY CONSTRUCTION AT BASE OF BRACKET ARMS.

TWO-LIGHT BRACKET WITH INSUFFICIENT SUPPORT FOR BRACKET ARMS AND FAULTY GLOBE HOLDER.

FIG. 1.

they have of the base plate, and the inevitable result follows. Fittings of this kind, if chosen for ship use, must be altered and strengthened, or failure is certain.

In view of these defects and the exceptional conditions prevailing on board ship, the writer proposes to deal with the illumination of each part of a passenger and cargo steamer separately, and at the same time to describe the most suitable fittings for each section.

Cargo Fittings.—While loading or discharging cargo from a vessel at night it is advisable to have the decks and cargo spaces properly lighted. For deck lighting, arc lamps were tried many years ago, the lamps being suspended from the rigging, but they did not prove so successful as was expected and were soon discarded. There were many reasons for their want of success. The lamp mechanism was affected by vibration, and the light often flickered when the winches were used, just when light was most required. In those days arc lamps were invariably made having the return circuit through the lamp case, and trouble resulted when the lamp case came in contact with a wire stay or wire rope, to say nothing of the shocks experienced by seamen and others. Perhaps the greatest drawback was that the carbons only lasted eight hours, and the engineer had often to be roused in the early hours of the morning to trim the lamps.

But now these drawbacks have all been overcome. There are many excellent makes of arc lamps on the market which maintain a steady illumination under very severe vibration, and in which the lamp case is entirely insulated from the circuit. Arc lamps are now extensively used for lighting cargo decks in port, and the 1,000 watt enclosed arc is a great favourite. Instead of outer globes, octagonal lanterns with panes of flat obscured glass are preferred, because a broken pane can be easily replaced in any port. For most cargo ships two arc lamps are sufficient, one at the foremast and one at the aftmast.

In addition to the arc lamps, clusters of incandescent lamps are always provided at each cargo hatch, also at coaling ports and at the stern of vessel for use when repairing propellers.

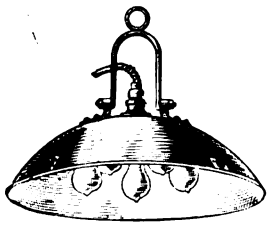


FIG. 2.—CLUSTER WITH FAULTY CABLE ENTRANCE.

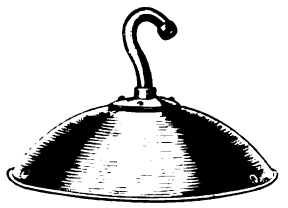


FIG. 3.—CLUSTER WITH APPROVED CABLE ENTRANCE.

Figs. 2 and 3 show two forms of cluster commonly used, each similar in general appearance, yet differing in one important detail. In Fig. 2 it will be noticed that the flexible cable enters by a grip gland on top. Water is not only likely to get into the connections at this gland, unless it is very carefully packed, but the flexible cable will always be bent sharply at this point and pulled in so many ways that it is apt to be injured. In Fig. 3, on the other hand, the flexible cable is led in a downward direction by the leading-in tube, and water falling on the shade cannot enter the fitting.

These cargo shades are hung in the corners of hatches or on railings, or in some cases over the side of the ship to give light

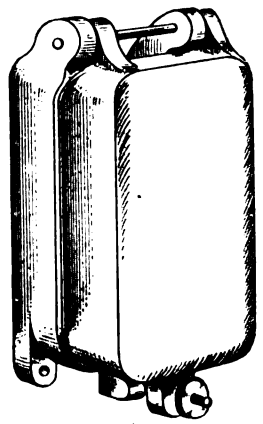


FIG. 4.—CAST-IRON WATERTIGHT CONNECTION BOX.

FIG. 5.—HOLD FITTING.

to barges. Clusters are sometimes used in cargo spaces, and in such cases it is usual to fit permanent sockets in strong iron boxes near the hatches. Fig. 4 shows a serviceable box of this kind, which is suitable and very strong.

Portable plug connections should be constructed to receive a flexible sleeve, one end of which is bound to the plug and the other end to the flexible cable. These sleeves may be made of leather or rubber, or built of whalebone bound with tape and cord. Connection boxes for use on deck must be thoroughly

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watertight, but in any case it is preferable to fit these in sheltered positions.

Hold Lights.—It is not usual to fit many lights in cargo holds, six or eight lights being generally considered sufficient. They must be placed in positions where they are naturally protected by beams or other structures, because any guard that may be on the fitting itself cannot possibly be made strong enough to withstand heavy knocks from cases and bales of cargo, and at the same time allow sufficient light to pass. There are, therefore, two kinds of fittings used for cargo spaces, those in which the lamp is protected by a strong metal guard of rectangular cross-section, as shown in Fig. 5, and those in which the light is covered, when not in use, by a solid metal cover, as shown in Figs. 6 and 7. The covers in the latter patterns are held up by strong T shaped catches when the lights are in use. In

FIG. 6.—CATTLE OR HOLD FITTING.

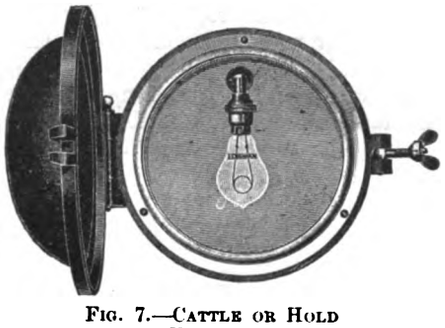

FIG. 7.—CATTLE OR HOLD FITTING.

fittings of this type, also, the lamp glasses are exposed while the lights are in use, and the shutters are apt to be broken at the hinge. In spaces where cotton and bales of soft goods are stowed, the pattern shown in Fig. 5 is most suitable. The bales are pressed into position by screw jacks, and any obstruction is easily carried away. The guard on Fig. 5, however, diverts the bale sufficiently to prevent damage to the lamp. Indeed, for general cargo purposes, this style of fitting is very successful. Lights in cargo spaces should not be placed in positions where they are likely to be blocked up by cargo built in front of them.

Cattle Spaces are lighted by lamps placed in the passages from 24 ft. to 30 ft. apart, and here the patterns shown in Figs. 6 and 7 are best suited to the conditions. Nothing short of a

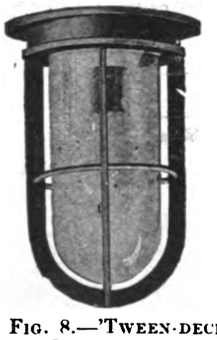

FIG. 8.—'TWEEN-DECK PENDANT.

FIG. 9.—CARGO CAP FOR 'TWEEN-DECK PENDANT.

solid cover will withstand the butt of a bullock's horn, and yet the position of the cover may be so adjusted as to give all the light necessary.

Emigrant Accommodation is often improvised in the upper portion of a cargo hold, called a "'tween-deck," and for this reason the electric lighting must always be fitted in such a manner that the space may be available for either emigrants or cargo, according to the demand. When there is a definite plan arranged for portable rooms, the best method is to fit in each room space, and also in passage spaces, an electric light fitting as shown in Fig. 8. When cargo is to be carried, the lamps and guards are removed and a metal cap, as shown in Fig. 9, takes the place of the guard and protects the lamp-holder from damage. Sockets may also be fitted at each lamp fitting in series with the lamp for inserting portable switches if required.

When a definite plan has not been arranged for any emigrant space, it is perhaps best to fit a number of sockets throughout the space for connections to temporary wiring or portable lights.

Deck Lights are usually fitted from 20 ft. to 30 ft. apart, according to the class of passengers and the nature of the deck space. Deck spaces forward of the navigating bridge are usually left unlighted, because of the glare which would prevent the officers from seeing distant lights effectively.

FIG. 10.—DECK FITTING.

Lights on other decks must also be so arranged that they do not interfere with the navigation of the ship. Probably the best method is to place bulkhead fittings, similar to that shown in Fig. 10, on the deck houses. When lights in this position are objected to, on the plea of interference with navigation, the only alternative is to fit an additional number of lights overhead, so that the direct glare of the light is screened by the deck beams.

FIG. 11.—GUARDED PENDANT.

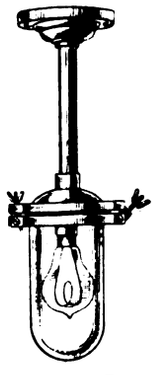

FIG. 12.—DECK PENDANT.

Fittings for use on deck must be watertight, and arranged so that water cannot find its way into the fitting from behind. The best method is to mount the fitting on a metal box with stuffing glands for the entrance of the wires.

The fitting shown in Fig. 11 is not successful as a deck fitting on account of the screw of large diameter necessary for fixing

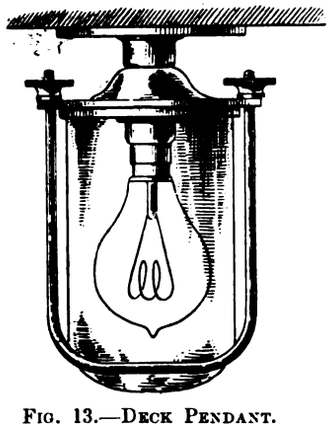

FIG. 13.—DECK PENDANT.

FIG. 14.—OFFICERS' BRACKET.

the guard. This screw, unless kept well lubricated, becomes so stiff in a short time that it is often impossible to remove the guard without twisting the stem of the fitting. The fittings shown in Figs. 12 and 13 are more suitable, because the glasses may be removed at any time by unscrewing two small thumb nuts, the threads of which are more easily kept in good order.

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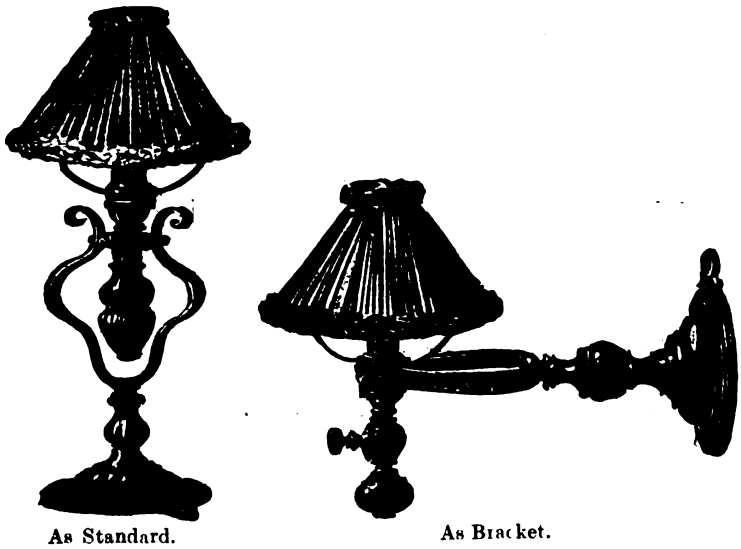
Seamen's and Firemen's Quarters.—Any of the fittings shown in Figs. 8, 11, 12 and 13 are suitable, the main requirement being that the lamps are protected from breakage by accidental knocks.

Officers' and Engineers' Rooms have usually one fixed and one portable light in each room, and, as a great deal of writing is done here, a bracket lamp fixed over the writing table is most appreciated. Fittings of the same style as fitted in passengers' state rooms are, as a rule, suitable; but the bracket shown in Fig. 14 is a good example of the type preferred. It is strong and serviceable, and gives a well-diffused light. Portable lamps should have a broad and heavy base, and should be fitted with means for placing them on the bulkhead, as a bracket lamp, when not required on the table. Fig. 15 shows a balanced standard in which the lamp is always kept in an upright position by the balance weight shown. The objection to this particular pattern is that, on account of the weight being so high, the fitting is somewhat top heavy, and the base is not broad enough to prevent it falling over in rough weather.

Passengers' Cabins.—A number of fittings, all suitable for use in passengers' cabins, are shown in Fig. 16. There is, of course, no end to the diversity of patterns used, all varying with the class and style of the rooms, or with the taste of those responsible for the choice of fitting; but in the majority of ships a simple and strong fitting of neat appearance is usually preferred. Makers of fittings are slowly coming to realise that a



As Standard. As Bracket.

FIG. 15.—GIMBAL PORTABLE LAMP.

⅜ in. lamp-holder is preferred by ship contractors, but some have not yet learned to make the tubes leading to these lamp-holders large enough to pass two 3/20 insulated wires. One sometimes finds a fitting contracted at some part of the tube to almost ¼ in., usually at a nipple or joint in the tube, when there is really no need for such a reduction.

Another common fault in fittings is that the nipple to which the lamp-holder is screwed is often made so long that, when the holder is screwed home, the end of the nipple presses against the porcelain interior of the lamp-holder.

Perhaps the worst defect in some fittings is the flimsy globe carrier and globe screws fitted. A heavy globe acts, as the ship rolls about, with considerable force, and tends to loosen the connection between globe-holder and stem, and therefore a thin stamping clamped between two nuts is hardly good enough for ship use. The practice also of fitting three small pinching screws, tapped into a thin stamping, cannot be too strongly condemned as an effective globe-holder (*see* Fig. 1). The screw threads strip, as a rule, but even if they did not the screws soon slacken back and the globe falls.

There are two methods of fixing globes in common use, one in which a split ring is slipped between the screw ring and the lip of the globe, and the other in which the globe rests on a tripod suspender, and is held in position by a gallery on top, pressed into position by a small nut on the central stem. Either of these methods makes a very satisfactory job.

Dining Saloons are most effectively lighted by fittings placed on the ceiling over the tables, if regard is to be had to economy. When the design of the ceiling does not lend itself to a proper distribution of lights over the tables, a good plan is to fit a light in each panel or division in such a way that the ceiling is evenly illuminated. Clusters of lights in dining saloons are not so successful as single lights evenly distributed. Another very successful method of lighting a dining saloon is to fit wall brackets round the room, and provide each table with one or

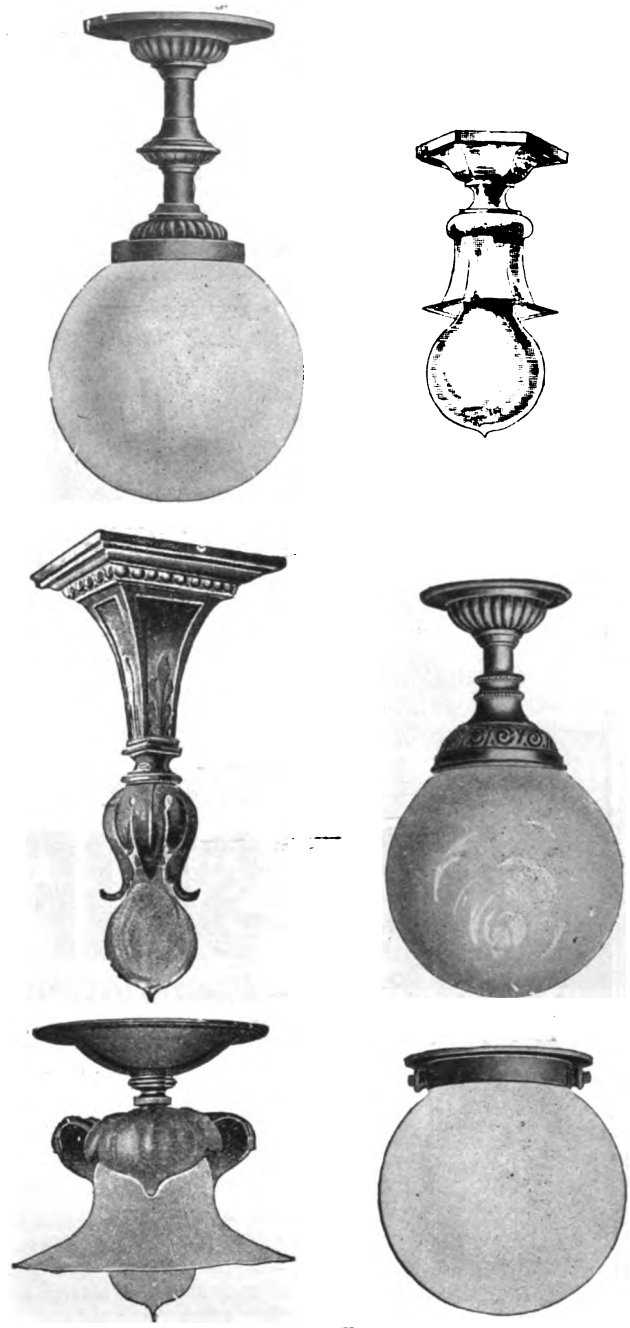


FIG. 16.—CABIN FITTINGS.

more standards with suitable silk shades. In this case no ceiling lights need be fitted, and the effect of the brightly lighted tables in the dimly lighted room is very pleasing.

The number of lamps required to light a dining saloon, besides depending on its size and class, also depends on the height and colour of ceiling and walls, and the density of shades or globes employed for diffusing the light. As a general rule, however, good lighting is obtained by installing one 16 c.p. lamp for each 30 sq. ft. of floor area in the case of first-class saloons, and one 16 c.p. lamp for each 45 sq. ft. in the case of second-class saloons.

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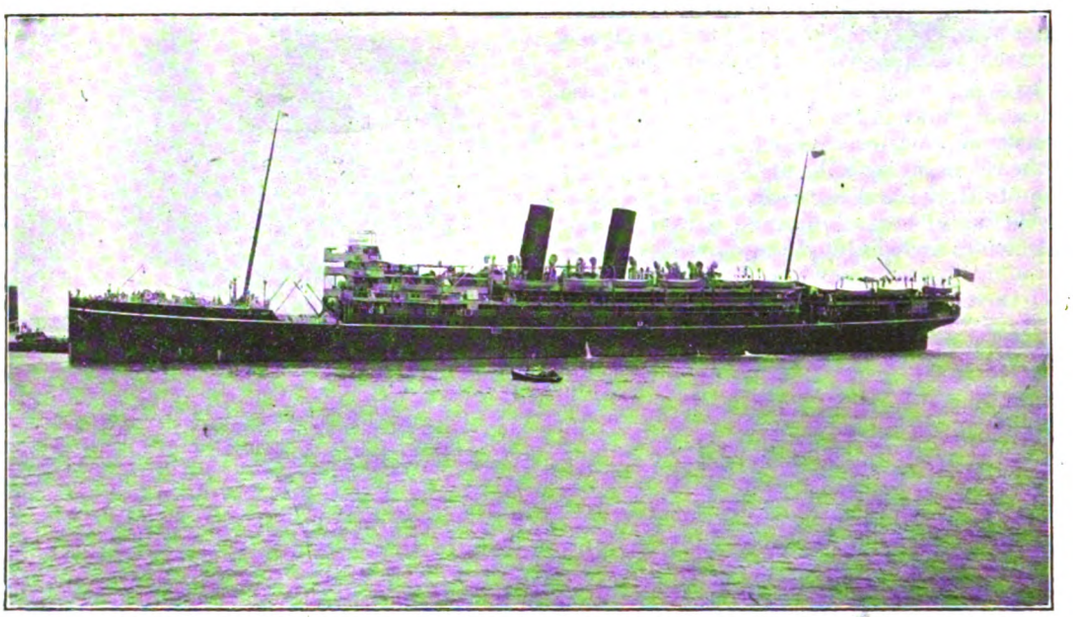
OSRAM

LAMPS



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FOR SHIP LIGHTING.

Reduce Illumination Expenses to a Minimum.

BURN IN ANY POSITION. ARE NOT FRAGILE.

TESTIMONY.

Extract from "Electrical Review," April 15th, 1910.

"One of the White Star Liners upon which "Osram" Lamps are fitted "throughout has recently returned to port after five months' cruise, and "the Engineers' report states that only one lamp has failed throughout "the whole period of absence, although the average life of the lamps in "question is already over 700 hours. This liner is now leaving for "another cruise with identically the same lamps and only half the usual "number of spares are being taken on account of the present perfect "condition of lamps now installed and the very satisfactory results on "the last voyage."

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Nearly every dining saloon has a well in the centre to give light in the daytime and also to ventilate the saloon, and this well provides a special opportunity for artistic lighting.

FIG. 17.—DINING SALOON FITTINGS.

Fittings suitable for dining saloons are shown in Fig. 17.

Lounges and Drawing Rooms are now frequently built with high ceilings, which enhances their appearance and gives greater scope for displaying fittings. Electroliers of special construction, capable of withstanding vibration, fixed to the ceiling, together with brackets fixed to the wall panels, and a few figure fittings, form the most effective method of lighting these rooms. Indirect lighting by means of concealed lamps reflecting on a white ceiling is not a conspicuous success. The ceiling has to be much over-illuminated in order to provide normal illumination near the floor, while the power required is about four times that necessary with direct lighting.

Owing to the light absorbed in shades, &c., in these rooms it is necessary to allow one 16 c.p. lamp for every 16 sq. ft. to 24 sq. ft. of floor area in the case of first-class rooms, and one 16 c.p. lamp for every 32 sq. ft. to 40 sq. ft. in the case of second-class rooms. Fig. 18 shows fittings suitable for lounges and drawing rooms.

Domes with plaster ornamentation and coloured glass windows, or coloured glass domes supported on wrought-iron grilles, are frequently fitted in lounges, and require special

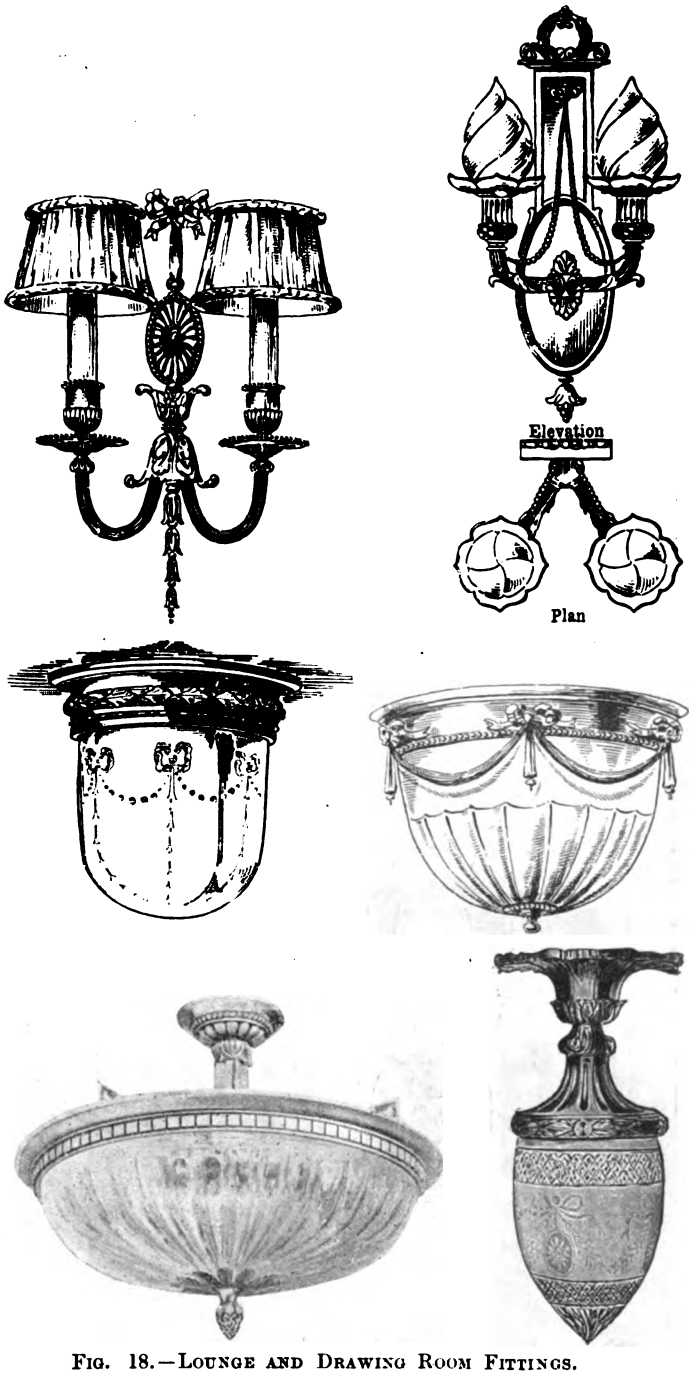

FIG. 18.—LOUNGE AND DRAWING ROOM FITTINGS.

consideration. When plaster work is fitted, perhaps the most successful method of illumination is to fit frosted bulb lamps in small ornamental recesses in the plaster. Certainly the best

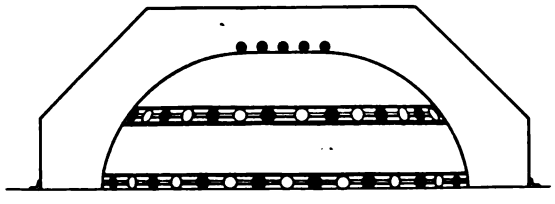

FIG. 19.—ARRANGEMENT OF LIGHTS BEHIND STAINED GLASS DOME. LIGHTS SHOWN THUS: ●

effect from a small number of lamps is obtained in this way. Another method is to fix Linolite lamps in a concealed position at the base of the dome. In this case the light is thrown

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directly on the objects to be illuminated, and should not be depended on for lighting the area below.

In the case of stained glass domes, a number of small brackets arranged round the base of the dome gives all the light required

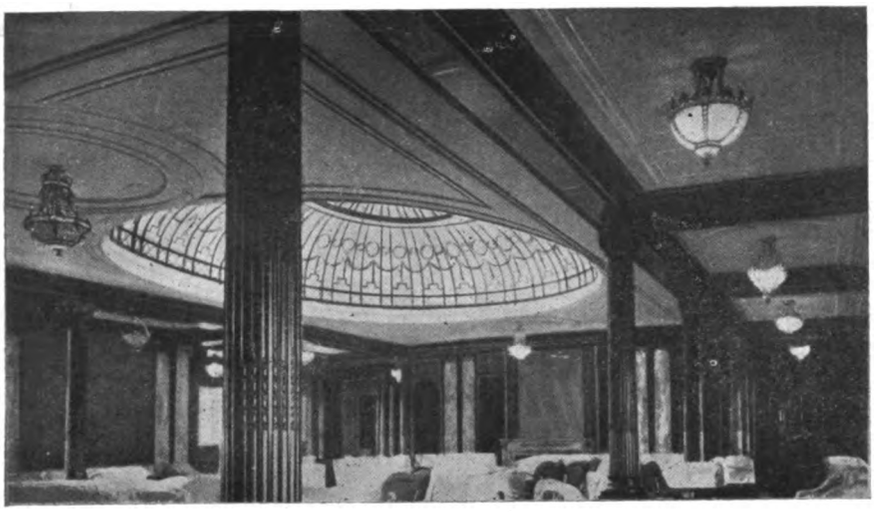

FIG. 20.—DOME OF THE SS. "MAURETANIA" LOUNGE.

at night. The stained glass may be seen and admired in the daytime with advantage, but it is unnecessary and extravagant to illuminate the space behind the glass. Lights placed directly behind stained glass appear at night like so many unsightly spots, so that in order to show the glass to advantage the light itself must be kept out of the line of vision. Fig. 20 illustrates a stained glass dome lighted in this way, and Fig. 19 shows the arrangement of lights above the dome.

It has been found that whereas 12 lights make a successful effect under a dome, it requires 48 lights above the glass before the design can be seen, and even then the effect is disappointing, except when the lighting in the lounge itself is reduced. The light from a flame arc lamp would in some cases form an ideal method of illuminating behind stained glass, and if a lamp were available capable of burning, say, 100 hours with one pair of carbons, one would be tempted to give it a trial. The work of trimming the lamp, and the cost of upkeep, however, might not be quite so ideal.

Smoking Rooms may be lighted in the same manner as lounges, except that they need not be so brilliantly illuminated. The wall framing and other woodwork is usually dark in smoking rooms, and this reduces the lighting effect to a considerable extent as a rule. It is better in these cases to instal the same number of lamps as in a lounge of equal size. Some fittings suitable for use in smoking rooms are shown in Fig. 21.

Direction Sign Lanterns are often used in passenger steamers, and are made in various forms to suit the surroundings. They are used to indicate the locality of bath rooms, lavatories, steward's and stewardesses' rooms, saloons, lounges, entrances, &c., and may be made as pendants, brackets or bulkhead fittings. The illustration Fig. 22 is a bracket with glass on both sides, suitable for fitting above a doorway. There are two supporting arms which, in addition to the lower flange, give ample support to the lantern. For exposed situations the glasses are double, a plate of opal glass with the lettering being inside and a clear sheet outside. Access to the interior of the lantern is obtained by a door at the bottom.

FIG. 21.—SMOKE ROOM FITTINGS.

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Signal Lamps.—We now come to what is, perhaps, the most important lamp fitting on board a steamship—namely, lamps for navigating the ship. These are placed in strong copper or brass lanterns (Fig. 23) having dioptric lenses of a special form and size, which are fitted as follows :—

One lantern on the foremast showing a clear light.
,, ,, mainmast ,, a clear light.
,, ,, port lighting screen showing a red light.
,, ,, starboard lighting screen ,, a green light.
,, ,, stern of the vessel ,, a clear light.

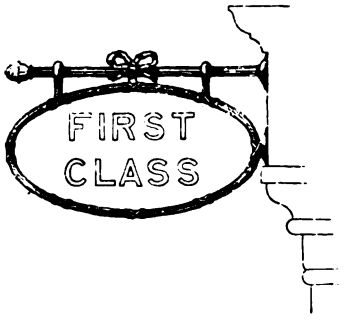
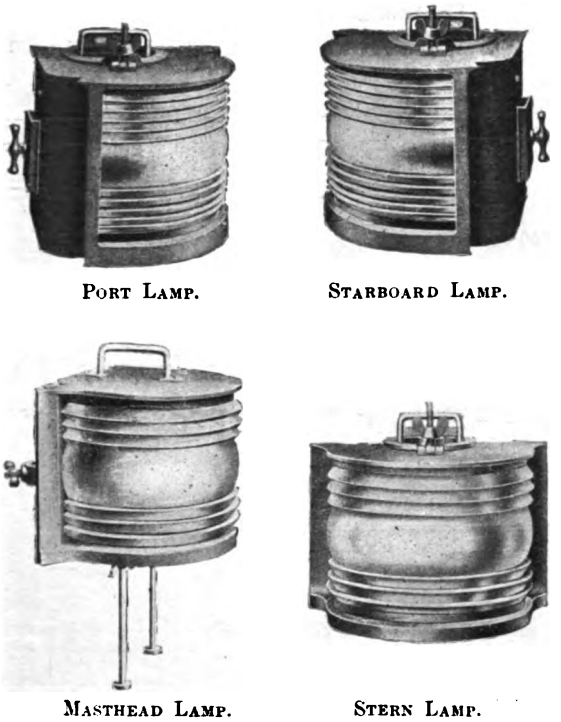


FIG. 22.—SIGN LANTERN.

Dividing a circle into 32 sections or points, the position of the electric lamp filaments must be such that the following conditions are complied with :—

1. In the case of mast lamps, a uniform unbroken light must be visible in a forward direction from any position within 20 points of the circle—that is, 10 points on each side of the centre line.
2. In the case of side lights, the full light must be visible only on port or starboard sides within an arc of 10 points of the circle.
3. The stern light must give light only behind the vessel within an arc of 12 points.



PORT LAMP. STARBOARD LAMP.

MASTHEAD LAMP. STERN LAMP.

FIG. 23.

Fig. 24 is a diagram showing the arrangement of these lights. The full lines show the angles at which the full light begins to vanish, and the dotted lines the angle at which the light vanishes. Double filament lamps are used with filaments 1 in. wide. These are shown in plan by two parallel lines in the diagram, and are seen more clearly in detail in Fig. 26.

Navigation Lamps Indicator.—As safety in navigating a ship at night depends largely on the navigating lamps remaining always alight, it is an advantage to have some means of switching in a stand-by filament when a failure occurs, and at the same time give warning of the fault. An indicator which does more than this, made by Messrs. W. C. Martin & Co., is shown in Fig. 25. Each navigating lamp has two filaments, only one of which is in use at one time. The upper part of the indicator contains three fuses for each lamp (two line wires and one return wire). The lower part of the indicator contains a control panel for each navigating lamp. Each panel is provided with a signal lamp, magnet and barrel switch, and a main switch and test key is fitted below as shown. The handle of the barrel switch acts as a weight, and keeps the control rod down, except when prevented by the magnet armature.

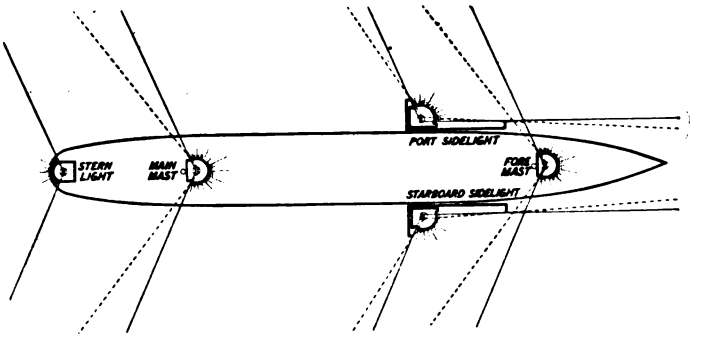


FIG. 24.—ARRANGEMENT OF NAVIGATION LAMPS.

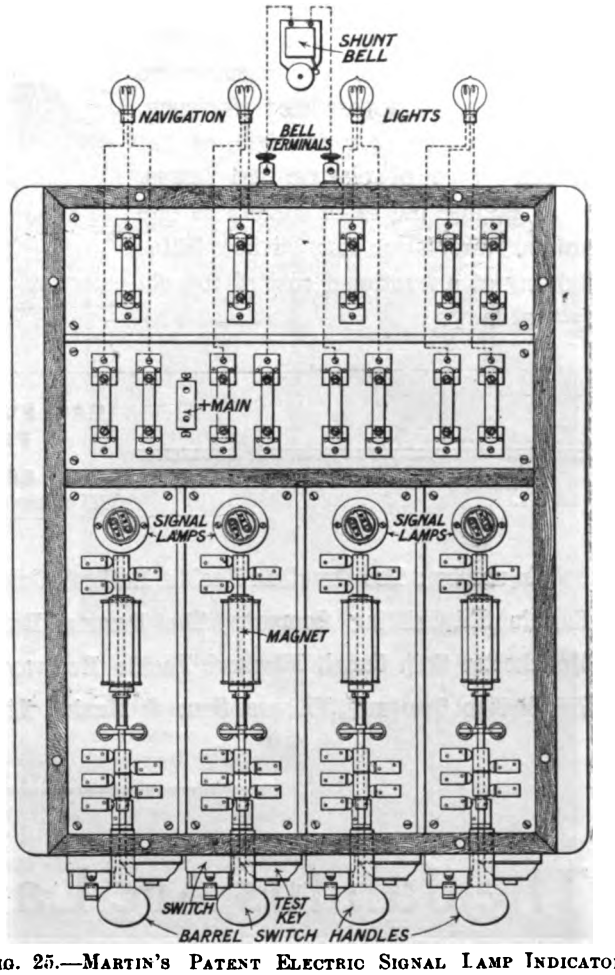


FIG. 25.—MARTIN'S PATENT ELECTRIC SIGNAL LAMP INDICATOR, RELAY AND ALARM.
Scale: One-sixth Full Size.

Normally the barrel switch is down, and in this position the magnet is in series with one of the filaments. Should this circuit fail, the magnet armature drops and puts in circuit the stand-by filament and also the signal lamp and alarm bell. The officer

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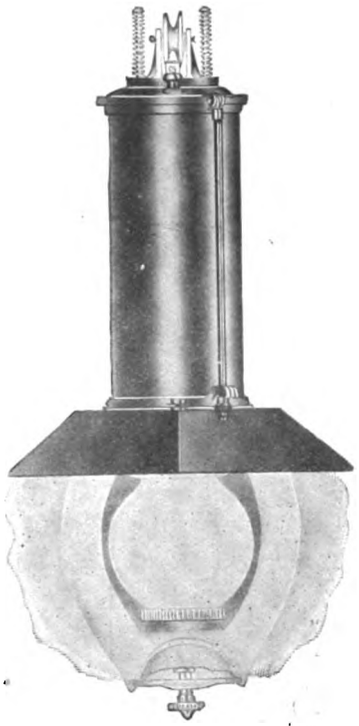
ELECTRIC FLAME ARC LAMP.

The Jandus Regenerative Lamp is an English invention enabling flame carbons to be burned in an air-tight enclosure, the regenerative action enabling the chemicals to continually pass through the arc. This regenerative action gives an unparalleled efficiency. It will replace four to eight of the ordinary type of electric arc lamps, while taking the same current as one ordinary arc lamp, thus giving better lighting at a fractional cost of the old type of lamps



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4,000 Candle power.
Will efficiently light 50,000 to 100,000 super feet.

The Arc flame being contained within an air-tight enclosure, is totally unaffected by high winds or gales.

The lamp will burn 70 hours on one pair of carbons. It is the only flame lamp that can run continuously through long night shifts and foggy days without interruption to work for the purpose of trimming. There is an entire absence of shadows, and the light is thrown in a horizontal direction, rendering it an ideal lamp for the lighting of large spaces. It is the cheapest form of lighting extant.

In use by: The Canadian Pacific Railway Company, The Carnegie Steel Company, Dover Harbour Contract, Earle's Shipbuilding Company, The Furness Railway Company, Grimsby Corporation, John Brown & Co., Manchester Ship Canal, Missouri Pacific Railway Company, Swan, Hunter, Wigham & Richardson, Ltd., Tee Side Bridge Company, Vickers, Sons & Maxim, Ltd., &c., &c.

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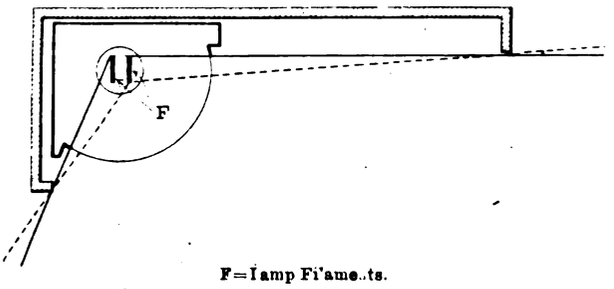
on duty now raises the barrel switch in order to stop the bell, but this action also inserts the magnet in series with the stand-by filament, and the armature, engaging with a collar on the switch rod, retains it in its upper position.



F=Lamp Filaments.

FIG. 26.—DETAIL OF NAVIGATING LAMP.

Should the stand-by filament circuit fail, the armature releases the rod, which falls, and the alarm is again sounded. The bell cannot now be stopped ringing till the fault is removed or the circuit switched off. The test key is used daily to ascertain if the apparatus is in good working order.

The Author desires to thank Messrs. Wm. McGeoch & Co., Ltd., for placing many illustrations at his disposal for use in this article.

Arc Lighting in Marine Work

For many years the lighting of dock and harbour sides was only carried out with a view to ensuring a reasonable amount of safety to passengers or workmen. Loading and unloading operations were rarely carried out at night time; the handling

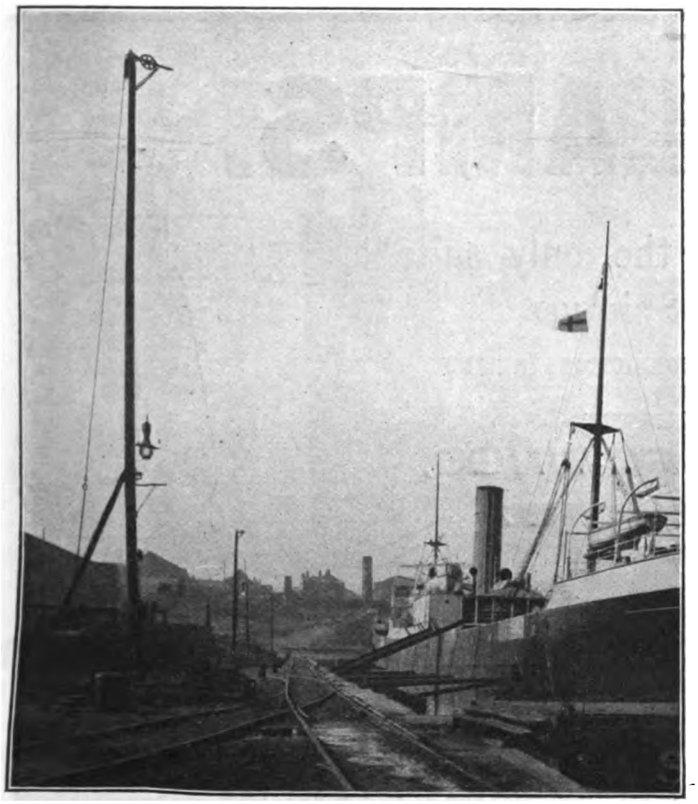


FIG. 1.—JANDUS REGENERATIVE FLAME LAMP AT WALLSEND-ON-TYNE.

of cargo which had to be effected after daylight was accomplished by temporary lights which were usually fixed over the spot where work was carried on.

The increased size and cost of present day ships have necessitated the brilliant lighting of docks and harbours. The interest and standing charges on a first-class ship now amount to hundreds of pounds every 24 hours, and it is therefore essential that all dockside operations should be carried on at the ship night and day, in order to save as much time as possible. The extra cost of brilliant lighting is so small an amount in comparison with the saving effected, that the great shipping centres have, almost without exception, considerably increased the illumination of their dock and harbour property.

Mists and sea fogs are always prevalent in seaport towns, and they materially affect the class of illuminant to be used on dock sides. It is necessary, in order to obtain the most satisfactory results, to use a light of an orange or yellow colour, as experience shows that this light penetrates any mist far more easily than white or violet coloured light. Incandescent gas is rarely used for this class of work, on account of the effect of severe wind and gales upon the mantles. The general unsuitability of high-pressure gas for dock work is also admitted, and, further, high-pressure pipes cannot be placed underground and subjected to the passage of heavy loads and railway trucks.

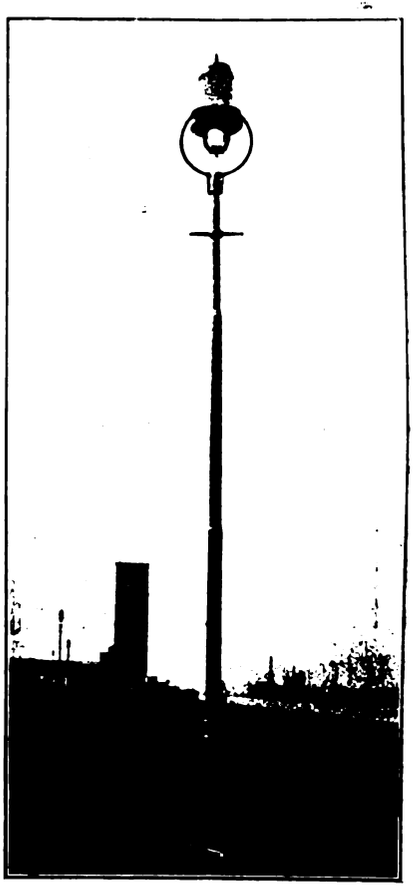


FIG. 2.—JANDUS REGENERATIVE LAMP AT TRAFFORD WHARF.

A lamp to give satisfaction in dock work should be of special design. The mechanism must be adequately protected from the severest gales and driving rain, and it must also be able to resist the action of salt water spray. It is essential that the arc should be totally enclosed or a gale may cause the complete extinction of the light. The Jandus Regenerative lamp has met with considerable success in marine work, a fact which may be attributed to its being the only enclosed flame lamp. It combines the advantages of the intense yellow light with a complete enclosure of the arc and mechanism. The lamp is in use in a large number of dock and harbour installations.

The Middle Docks & Engineering Co., South Shields, own three dry docks, which have the reputation of being amongst the busiest on the Tyne. In September last year their largest dock, 463 ft. by 63 ft., was opened, and at the same time the lighting of all three docks was considered. A number of exhaustive tests were carried out, and the Jandus Regenerative flame lamp was subsequently chosen. These lamps are burned

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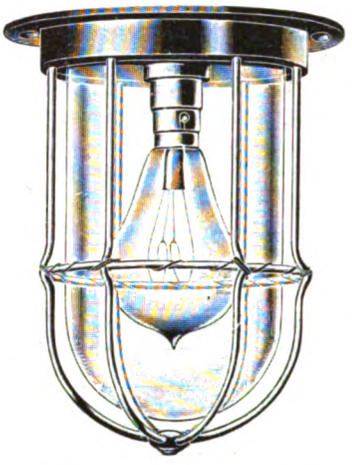

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on a 550-volt direct-current circuit, and each lamp is hung at a height of 25ft. The very wide distribution of light from the vertical carbons is fully made use of, and some of the lamps are in a shed where they also serve the double purpose of throwing a good proportion of light on the adjacent dock.

It was recently reported by an official of the General Steam Navigation Co., in charge of one of their steamers using the above docks, that these were the best lighted docks he had visited in any country.

Swan, Hunter, Wigham & Richardson, Ltd., Wallsend-on-Tyne, have a dry dock of 550 ft. by 76 ft. where the regenerative lamps were installed 12 months ago. These lamps are placed 150 ft. apart, and hung from wooden poles 25 ft. high (Fig. 1). Work can be carried on in any part of the dock throughout the night. The lamps burn two in series on a direct current of 240 volts, one switch controlling each pair of lamps, thus allowing a small amount of light to be used when work is being carried on in one part of the grounds only.

Another excellent example of the efficient lighting of a large area is that of the Trafford wharf of the Manchester Ship Canal Co. (Fig. 2). With the complication of railway track and sidings, with standing trucks and timber stacks, &c., efficient and economical lighting would appear impossible. Lighting a total area of 1¼ million square feet there are 15 Regenerative lamps in three circuits of five lamps on 500 volts. The lamps are spaced at 200 ft. apart, and are 26 ft. to the centre of the lamps from the ground. At this altitude the clear way between adjacent tracks is well lighted.

On this ground shunting, &c., takes place all night, and from the Trafford wharf jetty boats are being unloaded continuously.

Brockie-Pell Arc Lamps for Marine Work.

In the accompanying illustration (Fig. 1) we show a lamp which has been designed by the Brockie-Pell Arc Lamp Co. for coaling work and ship lighting generally.

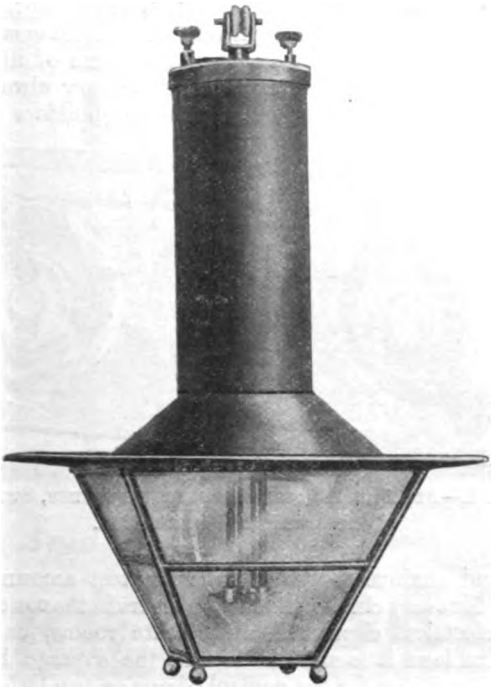

FIG. 1.—MARINE ARC LAMP.

One form of lamp of this description largely manufactured by this firm is their open type "Admiralty" pattern lamp fitted with square lantern with two doors adjacent to each other. This lamp burns about 10 hours, and runs on 50-volt circuit or in series on higher voltage. The lamp, a general illustration of which is shown (Fig. 2), is insulated on both poles throughout, and is fitted with special terminals. For Government work it is fitted with malleable castings.

The lamp is the firm's well-known differential type, controlled by a chain brake, but is fitted with special terminals, the sockets in which are of different sizes to take corresponding connections on the positive and negative leads from the ship's mains; this provision being made to prevent the reversing of the lamp by inserting the leads in the holders incorrectly. The case is supported from a ring at the bottom by means of a thumb clip and wing nut so as to be readily lowered for special attention. Special holders are provided, the lower being capable of alignment in a horizontal and vertical direction. The lantern is fitted with substantial balls at the bottom of the frame for the purpose of standing the lamp on the deck without breaking the lower pane of glass. From the illustration and the above description it will be seen that the whole terminal arrangement at the top of the lamp is entirely waterproof, and that all provisions have been made for contingencies in handling

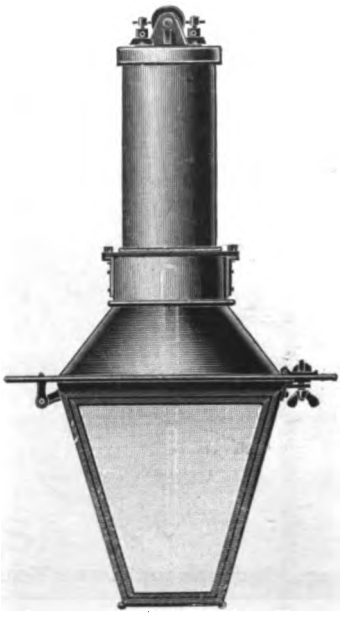

FIG. 2.—OPEN TYPE ARC LAMP FOR MARINE WORK.

the lamps. The controlling gear is fitted with the well-known Brockie-Pell subsidiary brake giving a steady feed to the carbons. The lamp is generally supplied with a separate resistance, but overhead resistances, rigidly attached to the lamps, can be had when required.

A special enclosed type arc lamp made also for ship installations by the Brockie-Pell Arc Lamp Co., is shown in Fig. 1. This lamp is insulated on both poles, and has special terminals at the top of the lamp. The case and lantern dome, with the reflector, are all made in one piece, the lantern bucket being fitted with small panes ribbed horizontally and vertically.

The bucket is arranged to swing downwards, on a hinge in one side of the lantern, and, when in this position, hangs quite clear of the globe. It is provided with large balls at each corner of the bottom lantern pane, to prevent the latter being broken when stood on the deck.

The inner portion of the lantern case forms a complete enclosing case for the lamp itself, excluding all wind and protecting the globe and other portions of the lamp from atmospheric conditions. The globe itself is suspended by a gun-metal ring sprung tightly to the globe cap. The illustration (Fig. 2) shows a twin carbon lamp arranged in this manner. The lamps are supplied with resistance, separate or overhead as desired, to run singly on 100 or 200 volts, and are specially designed so as to be transported in one unit to any position. In order to prevent the reversal of the lamp through changing

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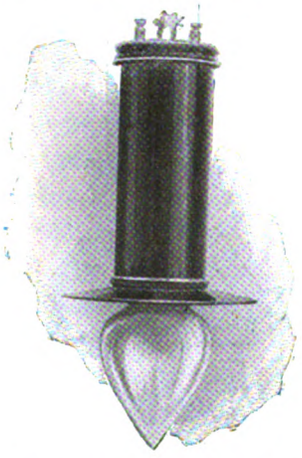
over, the positive and negative terminals are of different sizes, similar thimbles being fitted to the arc lighting circuit leads.

This firm also make ship and bulkhead lighting fittings which are largely sold by them in connection with their "B.P." metal filament incandescent lamps. The metal filament lamps are made throughout at Wimbledon and, we understand, are very satisfactory. The firm are also specialising in power transformers which are an outcome of their auto-transformer business in connection with house supplies.

Foster Lamps for Marine Work.

A type of arc lamp which has been specially designed for marine work is that shown in the accompanying illustration. It is made by the Foster Arc Lamp & Engineering Co., of Wimbledon. The construction is very solid, and special attention has been given to the water-proofing of all parts.



FOSTER ARC LAMP FOR MARINE WORK.

The lamp is of the coil type, is of the simplest form, and is so arranged that satisfactory operation under the somewhat severe conditions of marine service is well assured. The globe is supported by a wire strap which passes under the globe, the two ends projecting through the top plate being tightened by screws—a simple device, but one well calculated to withstand the jolting and swaying met with on board a boat. This is not shown in the illustration. The lamp gives about 1,000 c.p., burning 60 hours per trim, and taking 400 watts per hour. Although direct-current lamps are usually required for marine work, the firm upply an excellent model for alternating-current service. A goodly number of Foster enclosed marine lamps are doing yeoman service both on board ship and in various docks and harbours.

Kaye's Copper Oil Cans for Marine Work.—A not unimportant part of any engineering equipment is the oil can. And to preserve the amenities, to permit the plant to run smoothly, and to keep the engine room clean it is necessary that this should be of sturdy construction and capable of delivering a supply of oil wherever it is needed. These criteria are fulfilled, it is claimed, by the copper and brass oil cans made by Messrs. Joseph Kaye & Sons, of Leeds. These cans are practically seamless, and may be fitted with a double wrapped spout, which may be bent into any position without break or leakage. The cans are made in eight sizes, varying in capacity from $\frac{1}{6}$ to 2 pints.

Accessories for Cabin Lighting, Heating and Bells.

The extension of electric lighting on board the modern passenger vessel has naturally brought with it improvements in methods of controlling cabin lights and in the provision of special facilities for the use of extension lamps, radiators, telephones and bells. Many of these improvements, which were looked upon as refinements a few years ago, have now come to be regarded as absolute necessities, particularly on board an Atlantic liner. The introduction of accessories for work of this class has entailed considerable labour on the part of manufacturers, and every credit is due to them

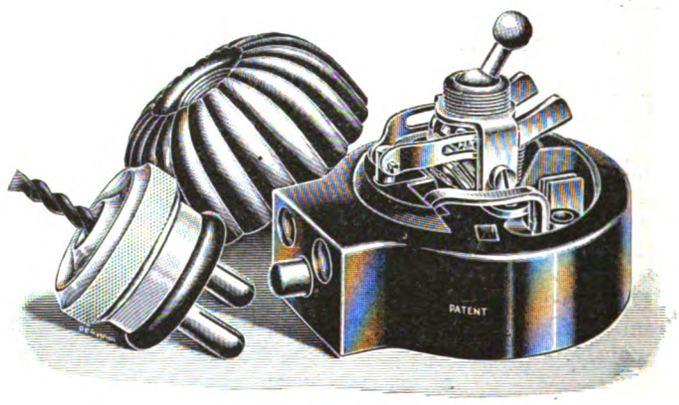


FIG. 1.—AUTO-COMBINATION SWITCH AND WALL PLUG.

for the standardisation of many of the articles now in common use. Messrs. A. P. Lundberg & Sons have been prominently identified with this class of work, and, in fact, they might almost be termed the pioneers of the electrical accessory business. The range of their products includes almost every type of combination for the control of lighting, heating and bell circuits for ship work.

Users of electricity on land are always being impressed with the convenience of electric light and the advantages which it possesses in this respect over any other form of illuminant. On board ship, where electrical energy is now always available, it is not surprising to find that shipbuilders are both

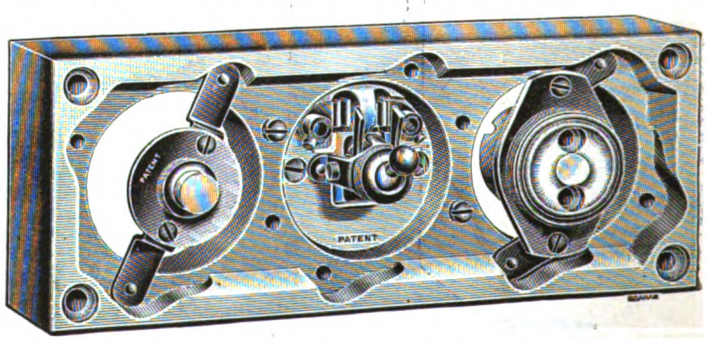


FIG. 2.—ADAPTABLE COMBINATION, SHOWING PUSH, SWITCH AND SOCKET IN RECEPTACLES.

willing and anxious to provide the greatest amount of convenience for every class of their passengers in the control of the various electrical circuits in their state rooms, cabins, &c. Whereas on land it is unusual to find the average household fitted with switches for the control of one or two lights from a number of positions, it is practically a necessity that a ship's passenger should be able to light up his cabin or ring for an attendant from, at any rate, two positions.

The specialities of Messrs. Lundberg have been developed with a view to provide the maximum of convenience in control with a minimum of wiring trouble. The space at our disposal

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is too limited in which to introduce the large number of combinations which can be obtained, but it will be interesting to comment on a few principal lines.

Fig. 1 illustrates what is known as the Auto-combination switch and wall plug, which is becoming the standard device for the control of radiator circuits. It will be noticed from the illustration that an ordinary two-pin plug is used, but when this is inserted in the socket the plunger is depressed, which admits of the tumbler switch being used in the ordinary manner, but removal of the plug causes the circuit to be broken at the switch itself and not at the contact prongs.

In Fig. 2 is illustrated an adaptable combination which comprises a standard porcelain base. Into this base can be fitted any desired type of accessory, such as bell push, tumbler switch and wall socket, as shown in the illustration. Two switches and one socket can be used, two sockets and one switch, or one switch and two bell pushes, just as may be necessary without alteration to the base. This base is suitable for both surface and flush fixing in either a vertical or horizontal position. The same base may be used for three-pin connections, and bell pushes and additional contacts can be provided for bell and telephone extensions without necessarily using any of the three recesses. The switches which may be fitted can be of any standard "Lektrik" type, not necessarily the ordinary single or two-way type.

A word may be said at this point regarding the details of construction of Lundberg switches. Needless to say accessories for the control of lighting and heating circuits on board ship require to be substantially made and efficiently insulated. Up to the present time mica has proved to be the best insulating material for switch work, and in all Lundberg switches this form of insulation is employed in connection with the current-carrying parts. It is preferable in ship work that the interior metal parts should be tinned as a preventative against the action of sea air. A feature of the Lundberg construction in switches is the provision made in the action of the switch for effectively locking the arm in the "on" position. There is usually a considerable amount of vibration on board ship, and with poorly designed accessories, a switch may be jarred from the "on" position and the circuit broken in consequence. Another feature is the provision made in Lundberg accessories for a locked cover, either to switches or wall sockets as the case may be.

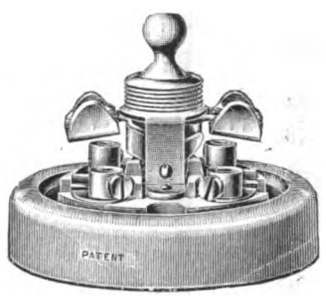

FIG. 3.—TWO-WAY AND OFF SWITCH.

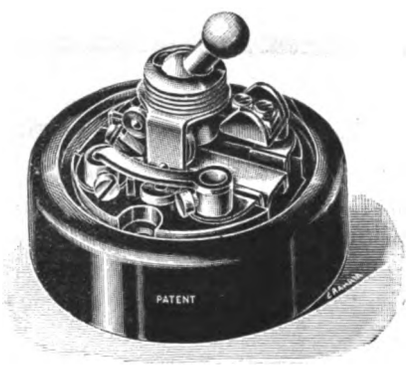

FIG. 5.—ALL OR PART AND OFF SWITCH.

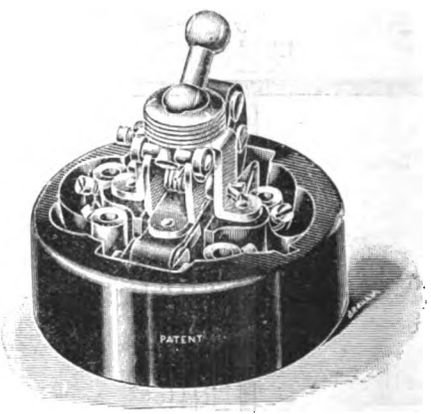

FIG. 6.—GENERAL VIEW OF "MARVEL" SWITCH.

As to methods of light control in cabins, the simple two-way switch with intermediate switch which gives control of one or more lights from any number of positions is too well known to need special reference. The value of the intermediate two-way switch is frequently overlooked, as in cabin lighting it is exceptionally useful. A cabin having a number of berths will be lighted by only one lamp, but each sleeper should have control of the lamp. This facility is readily afforded by the use of the intermediate two-way switch. By the use of a two-way and "off" switch, such as is shown in Fig. 3, two different lights can be controlled from one point. A modification of this switch is suitable for series-parallel lighting with two lamps, the effect produced being a dim light with the lamps in series and the full light with the lamps in parallel. This full and glow effect can also be obtained with a two filament incandescent lamp controlled by a two-way and off switch. Previously this pattern of lamp has been fitted with filaments of different candle-power—one, say, 16 c.p. and the other 2½ c.p. The filament of the latter is, however, most fragile, and will not withstand for long the shocks due to heavy seas and vibration on shipboard. This can be readily understood, seeing that it is the custom to place the lamp in a rigid fitting fixed either to the cabin roof or ship's side. To obviate this difficulty two filaments of equal size are used in the lamp, and are placed in series for dull light or glow, and for full one filament is cut out altogether. Fig. 4 is a diagram showing how a lamp of this pattern can be controlled from two positions, being turned to glow, full or off. This combination utilizes the "Marvel" switch, which is referred to below.

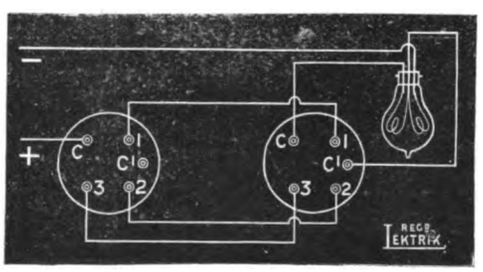

FIG. 4.—DIAGRAM SHOWING TWO FILAMENT LAMPS CONTROLLED FROM TWO POSITIONS WITH "MARVEL" SWITCH.

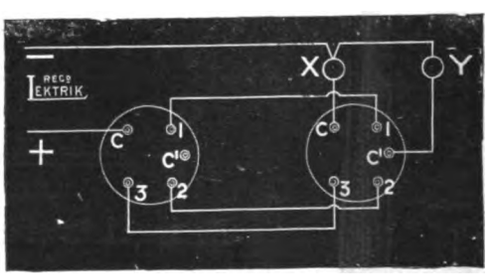

FIG. 7.—CONNECTION DIAGRAM SHOWING CONTROL OF TWO LAMPS, X ALONE, Y ALONE, AND OFF, FROM TWO POSITIONS WITH "MARVEL" SWITCH.

Fig. 5 illustrates another pattern of cabin switch by the use of which all or part of the lights can be turned on or off. The Lundberg "Twinob" switch is now well known and needs no description. It is practically a combination of two tumbler switches under one cover, the two operating knobs being slightly smaller than that usually provided. The switches are quite independent of each other, and either one, or both together, may be used. For instance, in a cabin, one knob might control the light and the other a small ventilating fan. This pattern of switch can be used for both flush and surface work.

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Possibly the greatest variety of combinations in circuit control is afforded by the use of the Lundberg "Marvel" switch, which gives facilities for switching on or off a number of lights from two positions. This switch has the advantage of allowing control of the circuit at all times irrespective of the position of the switch knob. Fig. 6 gives a general view of this switch which has three positions, each of them well defined. The point to emphasise is that it greatly simplifies the wiring connections, and only requires the use of one pole in the switch itself. Fig. 7 is a typical diagram showing the use of the Marvel switch for the control of two lamps from two positions.

Ships' Illumination and Osram Lamps.

The carbon lamp is gradually giving place to the metal lamp for illumination purposes in connection with every class of marine work. Experience with the metal lamp on land has been productive of very valuable results as to its ability to withstand excessive vibration, wide variations of voltage and

FIG. 1.—CEILING FITTING FOR MARINE WORK.

FIG. 2.

application to practically every known pattern of fitting. The modern warship and passenger boat are such stable vessels that it is not uncommon for ornamental pendant fittings to be used in saloons and cabins, special provision being made for securing the fittings in very rough weather. At the same time the majority of ships' fittings are of the rigid type and with this pattern the lamp is subjected to the harshest possible treatment so far as vibration is concerned.

The Osram lamp has met with great success in illumination on terra firma, and it is perhaps difficult to conceive of any general or specific purpose to which it has not been applied. Similarly on shipboard and for cargo lights it is being installed

FIG. 3.

on an extensive scale. The mechanical strength of the filament and its high economy of energy combined with intensity of illumination make it especially suitable for shipwork, and it is not surprising to find that Osram lamps are becoming more and more employed in this sphere.

The fittings used on board ship are, in the case of saloons and first and second class cabins, of a necessarily ornamental nature, and the Osram lamp lends itself peculiarly adaptable to bracket, ceiling fitting, pendant or table light.

That these remarks are true will be gathered by an examination of the accompanying illustrations, which show fittings designed by the General Electric Co. for use on board ship in connection with Osram lamps. Fig. 1 shows a ceiling fitting appropriately known as the "Lusitania." The fitting itself can be supplied in polished brass, oxidised copper and oxidised silver, while the bowl can be either of clear, frosted or cut glass. This fitting is designed to take one Osram lamp, and should find a wide application in saloons and other parts of the living room accommodation on board the modern ship.

Fig. 2 shows another type of ceiling fitting supplied for marine work, though of a cheaper type, and, therefore, more suitable for the less ornate parts of the ship. It is simply made in polished brass, and since simplicity is true beauty, its good points speak for themselves in the illustration.

Fig. 3 shows a two-light bracket which has been designed for marine work. In manufacturing these fittings it must be remembered that space is a, if not the, deciding factor on board ship. Brackets with long projecting arms are quite out of place. In fact, they would very soon be knocked out of place in a literal sense if provided with any part which sticks out much from the bulkhead. The bracket shown is, however,

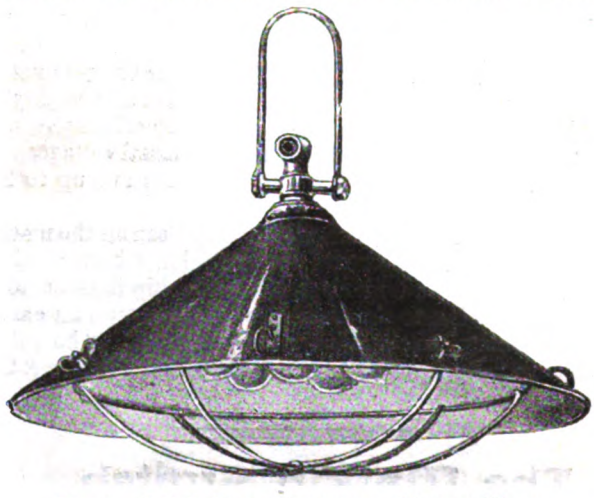

FIG. 4.—G.E.C. CARGO FITTING FOR MARINE WORK.

neat and compact, and should not run into danger from this cause, being only 4¼ in. in projection.

Turning to a part of the ship which the ordinary passenger is not generally allowed to visit, it must be mentioned that good light is just as much, perhaps even more, required in the stokeholds and engine rooms than in the cabins. The fittings must be well and strongly built, must be out of the way as much as possible, and yet must be capable of throwing the light down where it is required. Such lights are required constantly in the working parts of ships. On the other hand, there are other parts, in the holds, for instance, which it would not be necessary to light continuously, and where it might not be expedient

FIG. 5.

FIG. 6.

or possible to use permanent lighting. A hold filled with cargo has no room for ordinary fittings, and it is further necessary when loading that a good light should be thrown down the hatchway. Fig. 4 shows a fitting which has been designed by the General Electric Co. for this purpose. It consists of a holder, bearing from three to eight lights, which is contained in an enamelled iron reflector. This reflector is fitted with a wire guard to prevent damage to the lamps. Arrangements are made so that the fitting can be suspended wherever required over the hatchway. Figs. 5 and 6 show other fittings

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which have been designed by the General Electric Co. for marine work.

As regards the actual application of Osram lamps to ship work it will not be without interest to mention that these lamps are to be found on a number of British warships, as well as on the ships of the Brazilian and Argentine navy. The metal filament lamp was once supposed to be a fragile article, but there is no doubt if it can stand gun fire it can stand anything.

The suitability of these lamps for marine work is, in fact, shown by the statement that one of the White Star Line ships which was recently fitted throughout with Osram lamps has recently returned from a five months' cruise, and only one lamp failed during the whole of this time. The boat is leaving for another cruise with the same lamps, but is taking only half the usual number of spare lamps with it.

"Rugby" Metal Filament Lamps.

Among the firms who are doing their share in furthering the use of electricity on board ship are the Rugby Lamp Co., a firm which has a modern factory at Rugby for the production of incandescent lamps. They, in fact, make a speciality of metal filament and carbon filament lamps for all purposes.

The "Rugby" lamps are made in all the usual voltages, and in candle-powers up to 80 in the low-pressure and up to 200 in the high-pressure types.

Although the "Rugby" lamps have only been on the market for about two years, important contracts have been obtained from leading railways, tramways and steamship lines at home and abroad. Owing to the success of these lamps an extension of the factory has already become necessary. The selling agents for the "Rugby" lamps are Messrs. J. L. Cateaux & Co., of London.

The Watkin Switch.

Numerous attempts are made to provide the ship's passengers, particularly the first-class, with some means of dimming the electric lamps in their cabins. The full light is always too bright to sleep under, and yet it may be necessary in the case of invalids or "poor sailors" to keep a glow on the whole time. The two-filament lamp and series-parallel control of two separate lamps only give two definite illuminations. A perfectly regulated light can only be obtained by means of a reducing resistance, by the use of which considerable economy is effected in the current consumed.

The Watkin switch was introduced a few years ago to provide a means of "turning down," to borrow a gas phrase, electric light. Judging by the large number sold, and the appreciative comments of users, the claims of the makers appear to be fully justified. The device is compact in size, and easy to operate. It comprises a number of neat carbon resistance frames, and a special pattern of tumbler switch. Movement of the latter causes the switch arm, which is, of course, longer than the ordinary switch, to travel over a radial group of contacts. These contacts are connected to the various resistance frames, more or less of which are brought into circuit by the movement of the switch. It is claimed that the saving effected is from 12½ to 80 per cent. by the use of the switch. The same device is employed for the reduction of the speed of small electric fans.

The Watkin switch is made by the Adams-Watkin Co. in five sizes to absorb energy as follows:—70, 130, 70 to 200, 200 to 440, 450 to 600 watts.

The switch is specially suitable for use on board ship, for it can be made with any number of variations of resistance, although the standard pattern has seven—and the passenger can regulate the light or fan as desired. On board the ss. "Minnewaska," which is fitted throughout with the Watkin switch, it is made without an "off" position, and consequently has an independent switch to cut off current when necessary.

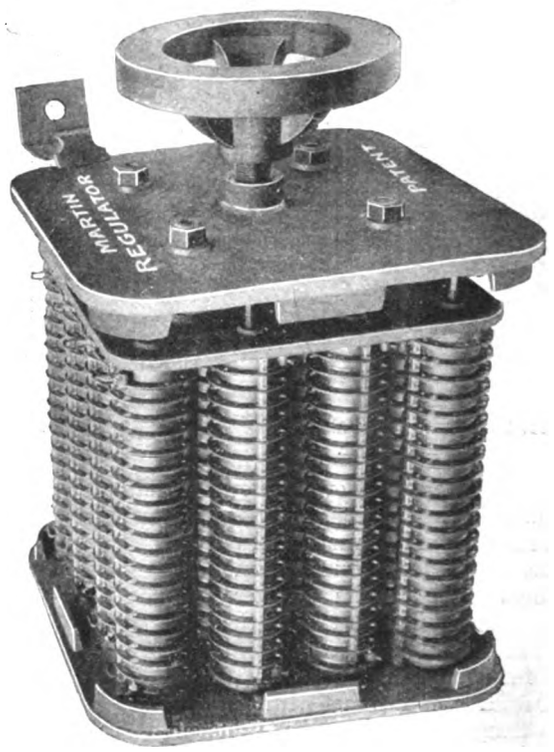
Martin's Regulator Switch.

A useful regulator switch, which should find a ready application on shipboard for the control of fans and other similar apparatus, is manufactured by the Electrical Regulators & Economisers, of Liverpool. The general arrangement of the regulator, which consists of a number of cells containing an elastic mixture and built up into a unit, is shown in the accompanying illustration of 16 piles or ways of 20 cells.

The mixture, which is indestructible in the ordinary sense of the word, is contained in small round brass cells lined with special bisque porcelain that is not affected by heat. Each cell is provided with a convector flange and piston, so that a number may be built up either in series or parallel-series to the capacity desired, whilst the cellular form allows an exceedingly good heat conduction from the centre of the mixture. This gives, it is claimed, reliable and steady working for lengthy periods as a resistance or convector.

Upon varying the pressure on the pile of cells by means of a hand-wheel, a quite unusual and gradual range of resistance is possible. No liquids or moving contacts are used, while the mixture is not affected by heat below very high temperatures.

Some idea of the flexibility of resistance range and carrying



MARTIN REGULATOR (CAST-IRON COVER REMOVED).

capacity may be gathered from the following figures: Each unit cell has a minimum resistance of 0·2 ohm, whilst the maximum may be over 200 ohms, and an even longer range is attained by varying the mixture from the standard which has been adopted for general purposes. The carrying capacity is 10 amperes per cell, but this may be increased if heavy terminals are substituted for those of the standard type. Continuous dissipation of heat may be at the rate of 20 watts per cell at ordinary atmospheric temperatures.

These appliances, which are primarily intended for commercial uses, may at nominal extra expense be fitted with separate and collective adjustments and connections, and so arranged they would form a most useful addition to the laboratory for very many and varied purposes, so great being the range that the same appliance may be used as a resistance on all voltages from 2 or 4 volts up to the higher pressures. These regulators have already been supplied to Government departments, many leading laboratories and scientists, and to over 60 Corporation supply departments, amongst other purposes being the testing of meters to comply with the new Board of Trade meter regulations and shunt field regulation.

The regulator has been patented in all foreign countries.

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"Tantalum" Lamps and Fittings for Ship Lighting.

It is scarcely surprising to find that metal filament lamps are now receiving a wide application for ship illumination, as high efficiency leads to great economy in energy consumption. The outstanding objection, in fact, to the introduction of this particular class of lamp was the high initial cost, but with increased facilities of manufacture, important developments have taken place, and the prices of these lamps are being considerably reduced. In this respect the makers claim there has been no lamp in which the development has been so marked as in the case of the "Tantalum." Placed on the market some years ago, they proved themselves to be the only really commercial lamp at that time, whilst the extraordinary tests to which they have been put have only demonstrated their superior strength. They are, Messrs. Siemens inform us, specially suitable for ship and train lighting where considerable vibration is experienced, and very effective lighting installations can be made when "Tantalum" lamps are employed in suitable types of fitting. Many installations of this class have been carried out by Messrs. Siemens Bros., the manufacturers of the "Tantalum" lamp, and we are illustrating here a few of the types of fittings which have been most widely adopted by them for this class of work. The majolica fittings are of a very cheap and efficient design, whilst they are also easy to instal and very artistic in appearance. We illustrate herewith (Figs. 4 and 5) two designs of this type of fitting which can be obtained in 16 or 18 different styles. They are not affected,

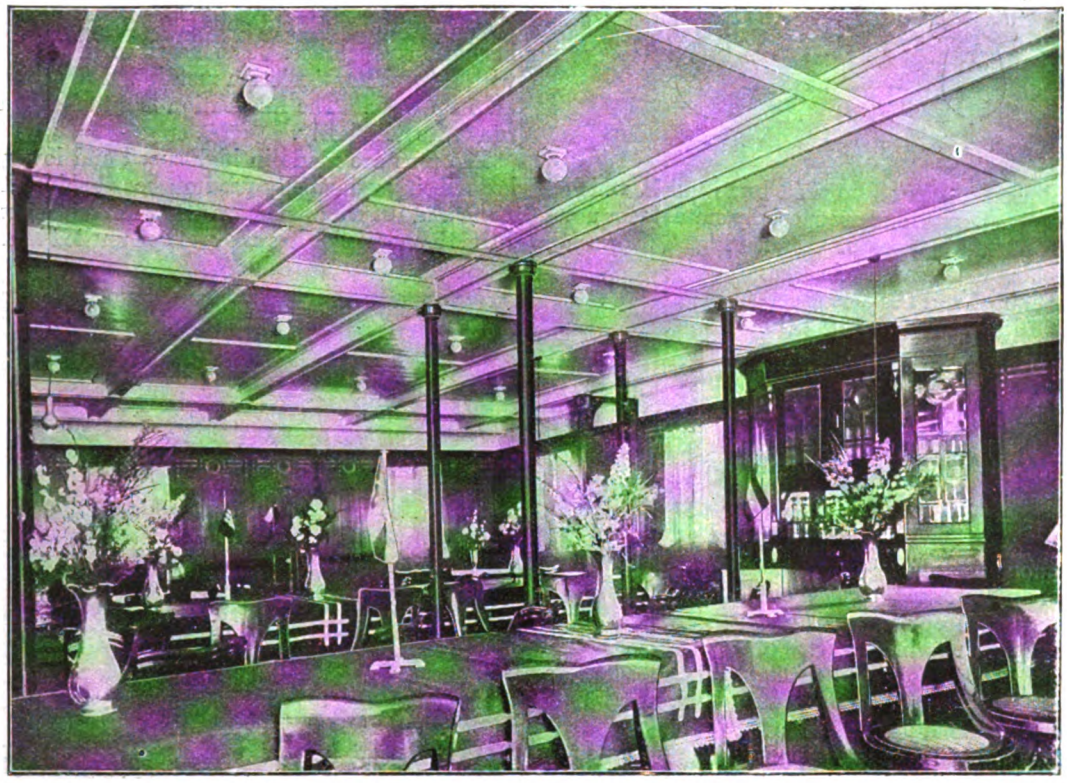

FIG. 1.—SHIP'S CABIN EQUIPPED WITH MAJOLICA FITTINGS.

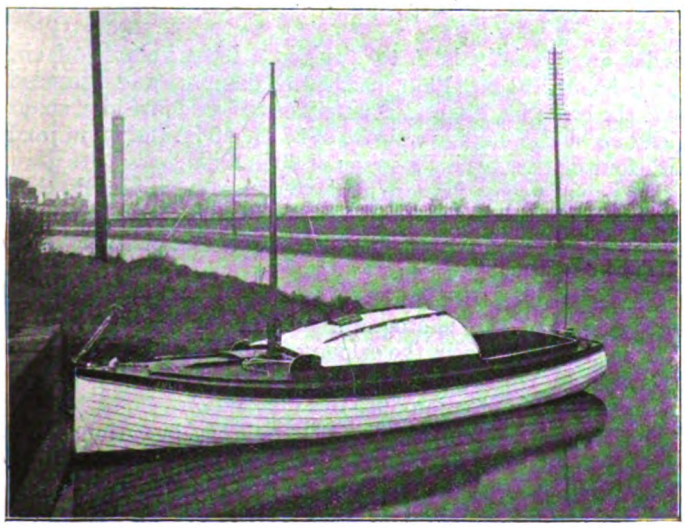

FIG. 2.—PLEASURE BOAT LIGHTED BY "TANTALUM" LAMPS.

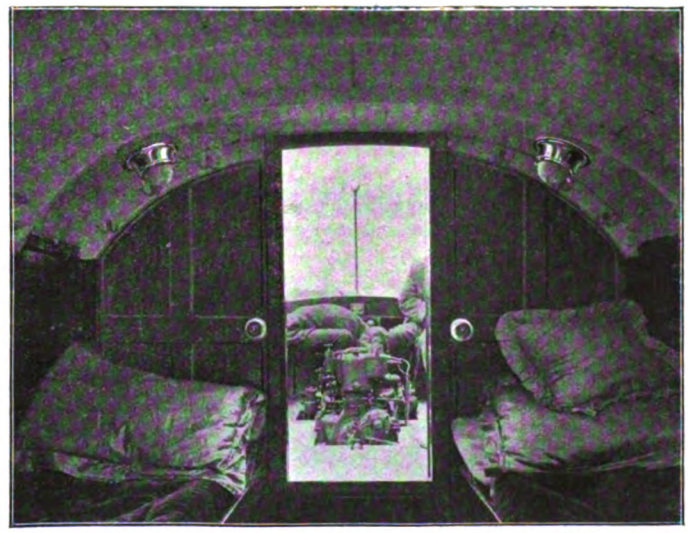

FIG 3.—INTERIOR OF THE SAME PLEASURE BOAT SHOWING ILLUMINATION.

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it is said, by atmospheric conditions, and, with the exception of the lamp holder, are composed entirely of insulating material. Fig. 1 shows a ship's installation in which majolica fittings are installed. We also illustrate herewith (Fig. 6) an example of the artistic brackets of fixed design, which can be supplied in

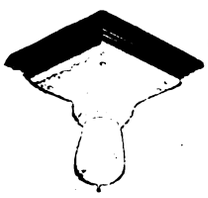


FIG. 4.

FIG. 5.

FIG. 6.

polished brass, oxidised copper or bronzed brass finish, which are of rigid and massive design, and are specially suitable for use in the saloons of the larger types of vessel. Fig. 7 shows a special design of ceiling fitting for use in cases where the space is limited and the roof necessarily rather low. In this type of fitting the Holophane type of glassware is used to concentrate the light in a downward direction, thereby obtaining the most efficient illumination possible. Messrs. Siemens Bros. also stock a comprehensive number of designs of watertight and weatherproof fittings specially suitable for use in exposed positions on board ship. One of these is illustrated in Fig. 8, but should any special design of fitting be required they will be prepared to get out designs to suit any special requirements, and to submit the same, with estimates, free of charge. A special type of cargo fitting (Fig. 9) is illustrated here. This fitting can be supplied for any number of lamps between two and ten for 25 c.p. or 50 c.p. lamps; it is arranged with a jockey pulley directly over the centre, with two rope grips at the base, which enables it to be fixed at any required angle.

It is also specially protected so that the lamps cannot possibly be broken with any ordinary usage. These fittings seem worth the consideration of all who are concerned in ship's installations, and Messrs. Siemens Bros. inform us that they will be pleased to supply any further particulars regarding them which may be required. We publish two illustrations Figs. 2 and 3, of a small pleasure yacht, the one showing the exterior, from which the size of the boat can be seen, and the other the interior of the cabin, in which the special types of ceiling fittings may be noticed. Messrs. Siemens Bros. have carried out installations on vessels from the smallest to the largest, some of these only requiring a few lamps and others in which over 1,000 lamps are installed.

FIG. 7.

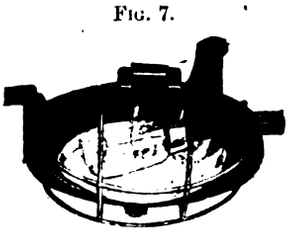


FIG. 8.

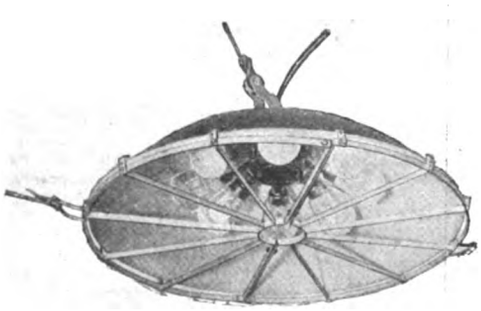
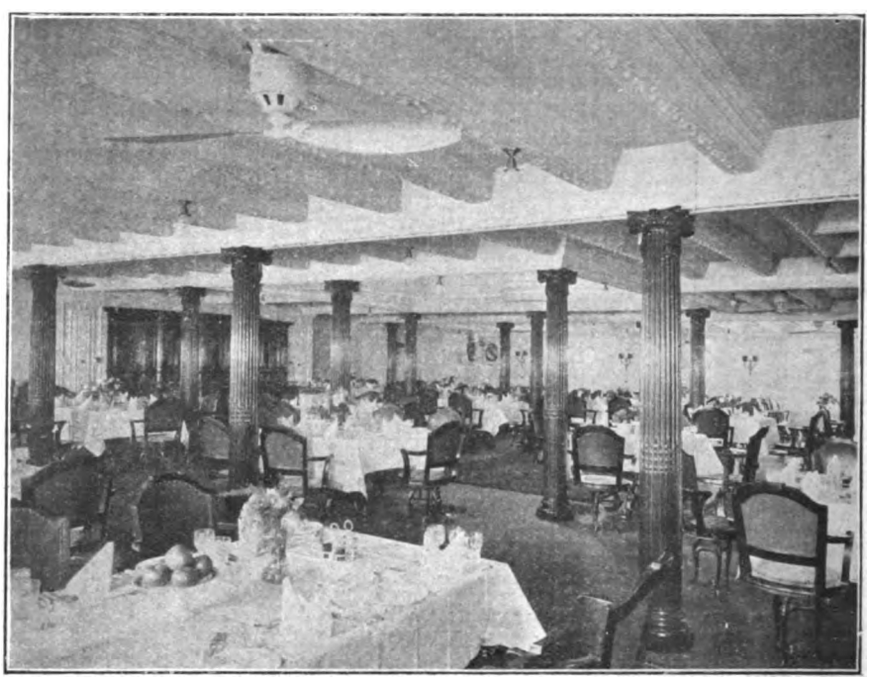


FIG. 9.

E.M.I. Ship Fans.

Messrs. Hogan & Wardrop's E.M.I. fans have created a sterling reputation among all classes of fan users, and the wide variety of fans and small motors they supply, covering in all 109 types, are suitable for every purpose for which fans are utilised in tropical countries, home, marine and for workshop use. All these fans are well made and of the best materials. Only double cotton and double silk covered wires are used for the armature and field coils. These conductors have a high insulation resistance. The bearings of these fans are fitted with a special anti-friction metal, and they can be adjusted to take up wear. The lubrication is automatic, and the motors run quite noiselessly.

The fans are made in high-speed and low-speed types, the latter being principally used on board ship. Porthole fans of 12 in. and 16 in. diameter are fitted with six brass blades, and the 20 in. diameter size has six black enamelled iron blades. These



VIEW IN SALOON OF SS. "ORVIETO," SHOWING INSTALLATION OF E.M.I. CEILING FANS.
By permission of the Orient Steamship Co.

blades are specially bent to displace a large volume of air. Cabin fans of 9½ in., 12 in. and 16 in. diameter and provided with six brass blades, and ceiling fans are made in four sizes: with two blades, having a sweep of 28 in., 40 in. and 60 in., and with four blades, having a sweep of 60 in.

The parts of these fans are made to gauge, consequently they are interchangeable, and spare parts can be easily supplied. The standard finish is black enamel with gold lines and polished and lacquered bright parts.

During the last 12 months this firm has equipped 26 liners with fans, and the photograph reproduced herewith shows their fans in position in the saloon of the Orient Co.'s steamer "Orvieto." We are indebted to the managers of the Orient line for permission to reproduce this illustration.

Messrs. Hogan & Wardrop's fans are in use in various parts of India and Canada, Zanzibar, Sierra Leone, Suez, Hong Kong, Singapore, Shanghai, &c. In some of these places the climatic conditions are in themselves a severe test of the successful running of any fan. It might also be pointed out that without these fans the climatic conditions in the places mentioned above would severely test both the temper and constitution of the European inhabitants. The electrically-worked fan prevents the too great ascendancy of this deplorable state of things.

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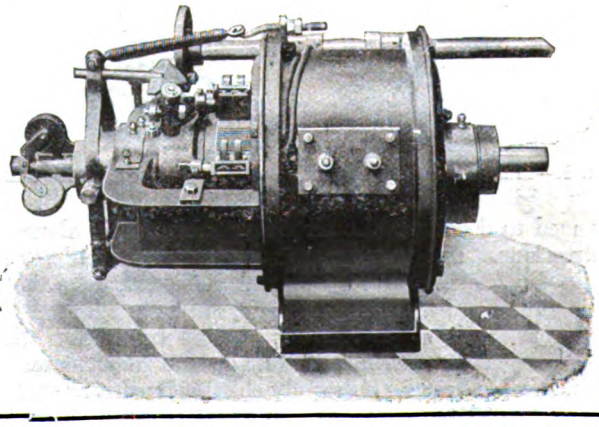

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"Arctic" Propeller Fans.

Every modern vessel is fitted with electric fans of one type or another in order to ensure proper ventilation of the different parts of the ship. A fan which has met with every success of recent years is that known as the propeller fan, this being distinguished from the box blade fan by the broad open ends of the blades. The Wilson-Wolf Engineering Co. specialise in electric fans and have a large number of their "Arctic" fans in operation.

The "Arctic" propeller fans are fitted with combined thrust and journal ball bearings, so that they are suitable for working either vertically or horizontally. The makers claim that large volumes of air can be moved with these fans for a low energy consumption and that they are extremely quiet in working. The fans are made in standard types and the construction includes an iron ring with four wide seatings for fixing to the wall, and to this ring the motor is bolted by separate arms, thereby giving rigidity and strength. The fan blades are securely bolted to the motor spindle and two bearings only are employed.

The motors are series wound, totally enclosed in the 12 in. and 15 in. sizes and enclosed ventilated in the 18 in. size and upwards. The commutator and brushes are accessible through removable covers. Where the fans are required to work in exposed situations in which they are subject to the action of steam or acid fumes, the motors are totally enclosed.

Marelli Fans for Marine Work.

The accompanying illustrations show the contributions which Messrs. Ercole Marelli & Co. have made towards the proper ventilation of ships' cabins and other passengers' quarters. This firm have had a wide experience of this class of work and, in fact, supply fans of all descriptions, including special cabin fans, low ceiling fans for use in ships' saloons, as well as desk, exhaust and wall fans.

The fan illustrated has been designed in response to a wide demand for a new type of oscillating fan. This fan can

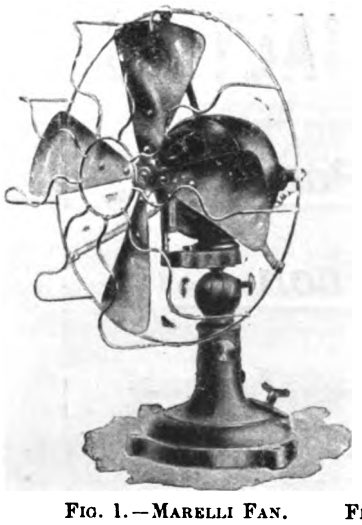


FIG. 1.—MARELLI FAN.

FIG. 2.—MARELLI OSCILLATING FAN.

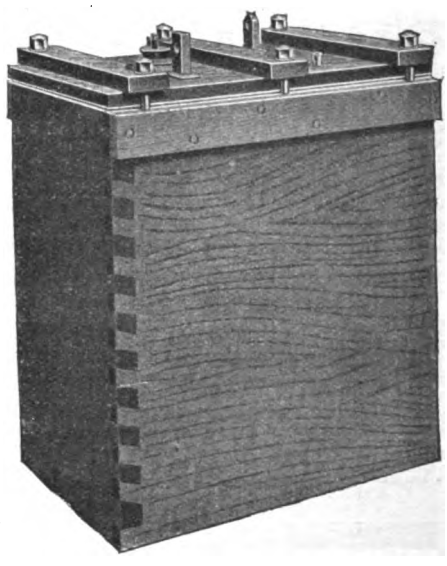
be arranged to distribute the air either horizontally alone or in all directions. In the latter case the fan body oscillates as shown in Fig. 2. This set, we are informed, runs both smoothly and silently and is, therefore, specially adapted for "living room" work. The motor used in connection with these fans can be supplied for all voltages and frequencies.

Messrs. Ercole Marelli also supply electrically-driven centrifugal blowers and pumps as well as small electric motors of both the continuous and alternating-current type.

Yacht Lighting.

The practice of installing a battery of accumulators in connection with the electric lighting of a yacht is so universal that there is no need to emphasise the advantages which such a practice offers. The Chloride Electrical Storage Co., of Pendlebury, Manchester, have for many years past made a speciality of this work, and have supplied the "Chloride" accumulator to many of the principal yachts both at home and abroad. The company's well-known special Planté type of positive is employed, the construction allowing the electrolyte to circulate right through the plate from one side to the other, thus ensuring even working and taking the fullest advantage of the entire surface of the active material.

Special "box" type negative plates are used in conjunction with the company's wood separators, these latter being the exact size of the plate, grooved on both sides, and specially prepared and treated by a patent process. The separators are highly porous, thus permitting a free circulation of the acid, while all possibility of internal short circuits is absolutely precluded, a point which, as engineers will at once appreciate, makes the separator of special value for yacht cells. The boxes are constructed of well-seasoned teak, dovetailed together,



"CHLORIDE" ACCUMULATOR FOR MARINE WORK.

and are impregnated with wax, or thoroughly well coated with acid proof paint as desired.

Ample freeboard is allowed between the top of the plates and the lid, and any possibility of the acid slopping over is prevented by rubber joint rings. The holding-down bolts for the lids are T-shaped, let into teak battens screwed to the side of the box. A broken bolt can thus be readily exchanged without having to mutilate the box. The metal used for the bolts is brass washed with lead, and the nuts are lead covered, so that the whole is protected from the effects of acid fumes.

Adjoining cells are connected by cables fitted with lead sockets, which are attached to pillars projecting through the lids from the section bars. Where the pillars pass through the lids they are sheathed in indiarubber gaskets. The pillars are of a patent type, consisting of antimonial lead below the acid level, finishing in pure lead above the acid level. The positive lug is pointed to be readily distinguished from the negative lug, which is flat.

Since the advent of the metal filament lamp, it is practicable to employ batteries on sailing yachts and motor launches to run a few lights for periods up to a month without recharging. A special light type of battery known as the "Exide" has been developed by the Chloride Company for this purpose, and is arranged in a conveniently portable form in a crate so that the battery can be easily taken ashore for recharging when necessary.

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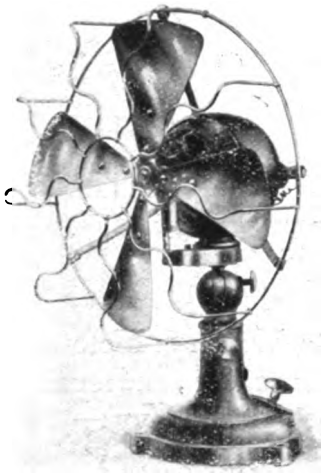

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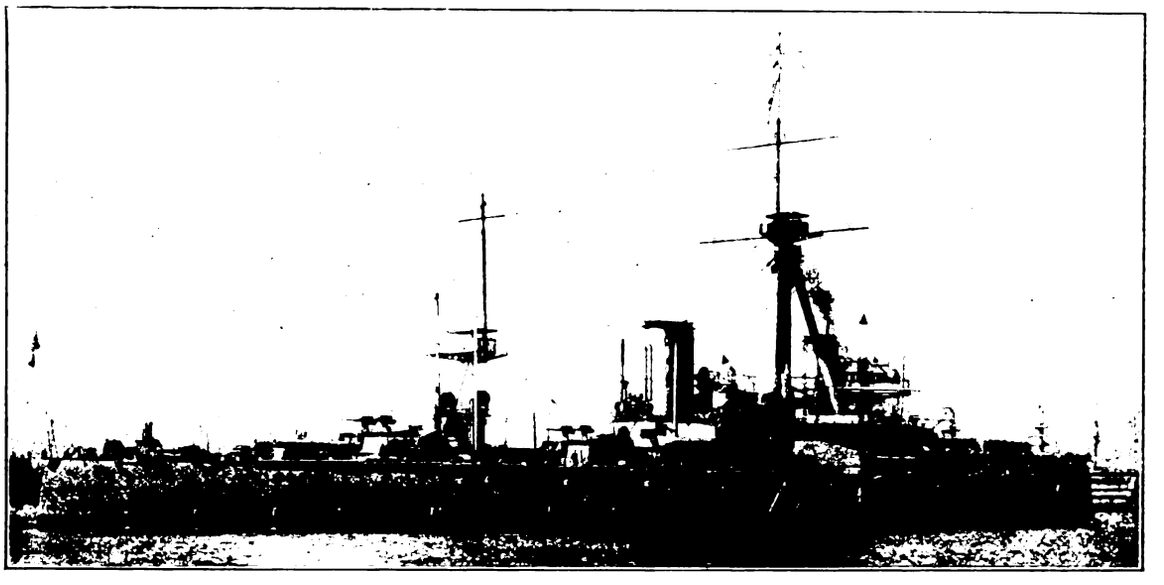

H.M.S. "Dreadnought," fitted with Crompton Projectors.

Messrs. Crompton & Co. have supplied Projectors, Dynamos, Electric Hoists, Winches, Motors, Motor-Generators, Switchboards, Instruments, Automatic Devices, Arc Lamps, &c., and such apparatus has been installed in the following ships, built or building, of the British Navy :—

Aboukir.	Bristol.	Drake.	Hibernia.	Mars.	Saracen.
Achilles.	Britannia.	Dragon Fly.	Hindustan.	Maori.	Sand Fly.
Actaeon.	Bull Dog.	Dreadnought.	Hogue.	Mayfly.	Savage.
Africa.	Bulwark.	Duke of Edinburgh.	Illustrious.	Marten.	Scorpion.
Afridi.	Blonde.	Europa.	Indefatigable.	Minstrel.	Spider.
Argonaut.	Cæsar.	Euralis.	Indomitable.	Mosquito.	Suffolk.
Agamemnon.	Cochrane.	Exmouth.	Inflexible.	Mohawk.	Superb.
Albemarle.	Collingwood.	Fire Fly.	Invincible.	Moth.	Swift.
Amazon.	Commonwealth.	Formidable.	Isla.	Natal.	St. George.
Amphrite.	Cossack.	Fox Hound.	Kent.	Nautilus.	Scourge.
Argyll.	Cressy.	Glasgow.	King Alfred.	Neptune.	Tartar.
Beagle.	Cricket.	Gloucester.	King Edward VII.	Newcastle.	Thunderer.
Basilisk.	Cyclops.	Ghurka.	Lancaster.	New Zealand.	Temeraire.
Bedford.	Colossus.	Goliath.	Liverpool.	Onyx.	Triumph.
Bellerophon.	Defiance.	Good Hope.	Lord Nelson.	Pincher.	Vanguard.
Bellona.	Diadem.	Grasshopper.	Leviathan.	Prince of Wales.	Venerable.
Black Prince.	Donegal.	Hannibal.	Larne.	Queen.	Vernon.
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MANCHESTER : 42, Deansgate.
BRISTOL : 28, Baldwin St.
BIRMINGHAM : 27, Paradise St.

ARC WORKS, CHELMSFORD.

BELFAST : Grosvenor House, Wellington Place.

CALCUTTA : 99, Clive St.
BOMBAY : Marshall's Bldgs., Ballard Road.
MADRAS : Armenian St.
SYDNEY : 56, Margaret St.
SHANGHAI : 10, Nanking Road.

(N.S. 138.)

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Searchlight Projectors for Marine Purposes.

BY E. A. HOLMES.

(Of Messrs. Siemens Bros. Dynamo Works, Ltd.)

Summary.—The searchlight projector has now become a necessity alike in the Royal Navy and in the mercantile marine. Parabolic mirrors for projectors are usually of glass, silvered at the back, the precision of manufacture depending upon the quality of the result desired. This accuracy can be determined by two simple tests. The carbons are usually horizontal and may be adjusted by hand, or will burn automatically. In conclusion, some special accessories are described.

The electric searchlight or projector may be said to have been brought into existence to meet naval requirements when the spar torpedo, rigged on the bows of a fast steam launch was brought out. Some means of defending a warship from this form of attack was necessary, and an electric arc lamp, enclosed in a casing fitted with a Fresnel lens and mounted on a suitable support for directing the beam of light in any direction, was the answer to this new development.

The invention of the Whitehead torpedo discharged from a torpedo boat at a distance necessitated a more powerful apparatus, and the Fresnel lens gave place to the glass mirror backed with a coating of silver. This was a great improvement and remains the type of projector in use at the present moment. Improvements in detail, especially the perfecting of the mirror and lamp, have brought the searchlight to its present high efficiency.

The searchlight is extensively used in the mercantile marine. It is now usual for all first-class passenger ships to carry one as part of its permanent equipment, especially those ships that make use of the Suez Canal, the searchlight making it possible for them to continue their journey after dark, and thereby reducing the length of the voyage, and at the same time increasing the tonnage capacity of the canal. There are many other purposes for which they can be used with advantage. River steamers find them very useful, especially those navigating the large inland waterways of North and South America and the Continent of Africa. Steam yachts in which current is available are hardly considered complete without at least one searchlight.

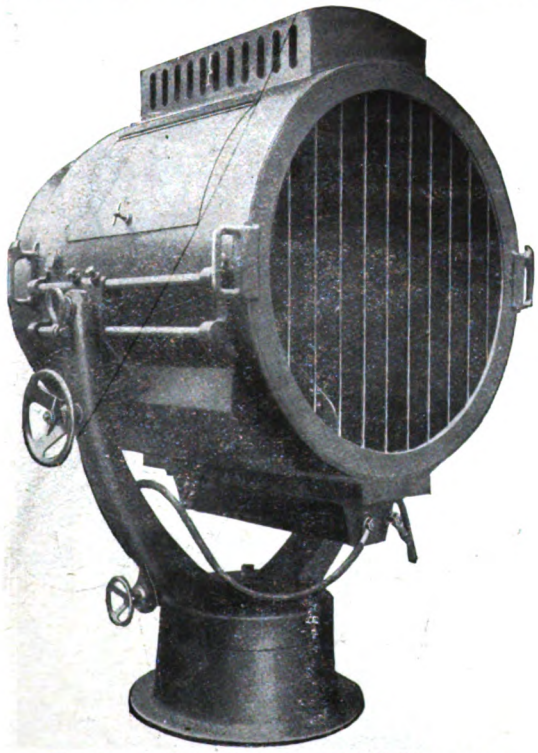

FIG. 1.—A 24 IN. SIEMENS "M.P." PROJECTOR.

The searchlight fitted with a signalling shutter forms a valuable means of transmitting messages to distances within range of the beam of light; by using the Morse code this can be rapidly dealt with both by day and night.

As the efficiency of the projector depends so much on the mirror, great attention has to be paid to this part of the apparatus so as to obtain the best results. At the present moment, for general purposes, the reflector of glass, parabolic in form and backed with a deposit of silver, holds the premier position. The glass mirrors have been found to withstand the deteriorating effects of the gases given off by the arc whilst burning better than any metallic mirrors tested up to the present, and at the same time they are not injured by the frequent cleaning found necessary to keep them free from dust, &c.

Modern high-grade parabolic mirrors are optically perfect; their manufacture requires great skill and care in carrying out the several operations of grinding, annealing, polishing, &c. Both surfaces of the mirror are worked to a high degree of accuracy. A coating of silver is deposited on the convex side, which is, in turn, protected by means of a composition capable of withstanding the high temperature it is subjected to.

The Mangin mirror is a concavo-convex lens; the back convex surface (on which silver is deposited, forming the reflector) is ground to a larger radius than the front one, giving a much greater thickness to the edge than the centre of the mirror. The radii of the two surfaces are selected of such a length as to correct the mirror for spherical aberration. Mirrors of the Mangin type are still made, but, owing to the varying thickness of the glass, they are more liable to fracture when subjected to great difference of temperature, and in cases where minimum weight is desired they are not suitable, the weight being about three times greater than a parabolic glass one of the same diameter.

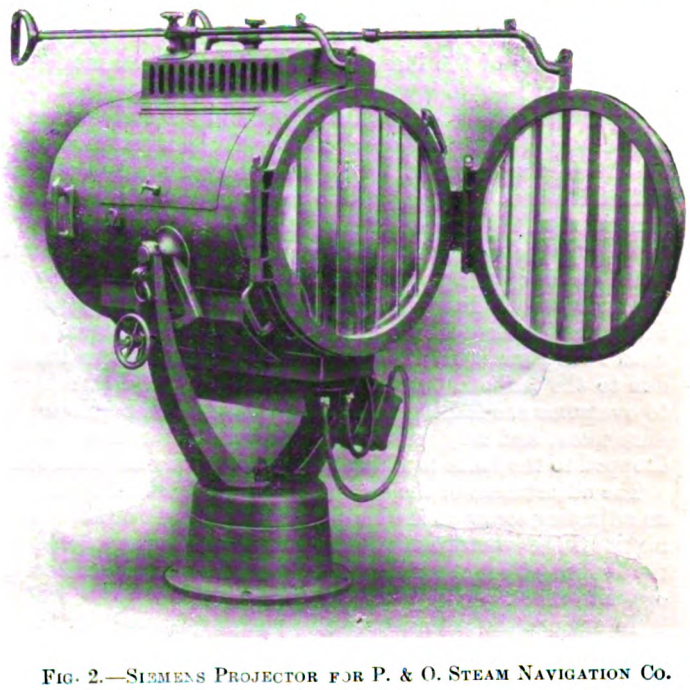

FIG. 2.—SIEMENS PROJECTOR FOR P. & O. STEAM NAVIGATION CO.

A perfect mirror should theoretically throw a parallel beam if the source of light is a point; this is never the case, the crater of the positive carbon having a diameter the ratio of which to the focal length of the mirror gives an angle of dispersion to the beam of light between $2\frac{1}{4}$ deg. and 3 deg. In practice this angle of dispersion is necessary for giving an illuminated field large enough to distinguish objects at a distance. It will be readily understood that, were it possible to throw a parallel beam of light to a great distance, it would

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have a diameter no larger than the reflecting mirror, and would appear as a small bright spot, which would be useless.

The accuracy of the form of a mirror can be determined by two simple tests. The first is to discover whether the curvature is regular from the centre to the edge. This can readily be examined by placing the mirror in front of a screen with a white ground on which are ruled black lines across one another, dividing the whole surface into squares, measuring about 2 in. each way. In the centre of the screen a hole is cut, through which the lines can be viewed reflected on the surface of the mirror. These lines may appear straight or curved, depending on the distance of the mirror from the screen, but any waviness or blurring of the lines denotes irregularities of the surface. The second test is to prove the accuracy of the parabolic form. The rays from a distant source should meet at a point if it has been corrected for the slight deviation to the rays caused by the thickness of the glass. Screens with annular openings of varying diameters are placed separately in front of the mirror and the focal length of the point of light measured carefully in each case; any variation given by the screens denotes inequality of the curvature.

The horizontal lamp has almost driven the inclined type out of use in recent years, it being acknowledged to have several advantages over the latter. The lamp takes its name from the position of the carbons, whose axes coincide with the beam of light which is horizontal in its normal position.

The horizontal lamp is usually designed to burn automatically or by hand at will, and every part should be made with a view to simplicity and durability, mica insulation being made use of wherever possible. The whole of the mechanism should be readily accessible by means of dust-proof covers. All small screws should be secured so that there is no possibility of losing them.

The feeding of the lamp with automatic shunt mechanism is as follows:—

When the current is switched on and the carbons are not touching, the only path open is through the shunt-wound coil of the feeding magnet. This coil, therefore, has the full potential across it, causing it to feed the carbons together at a rapid rate. The moment they touch current flows through them, and the arc striking coil in series with the carbons energises an electromagnet and strikes the arc by drawing the negative carbon from the positive, this immediately causing the current to drop in the shunt coil, which then ceases feeding until such time when the volts have increased across the arc, due to the carbons burning away, causing the electromagnet to overcome the feeding spring. The lamp then begins to feed once more, and only stops when the volts across the arc have dropped to the value to which the feeding spring has been set.

The adjustment of the spring is usually obtained by turning an adjusting screw on the lamp body to the right or left. Turning it in the one direction strengthens the spring, increasing the length of arc; turning it in the other direction has the opposite effect.

To cut out the automatic feeding mechanism a lever, placed in an accessible position, is provided, which, when thrown over to the position marked "Hand," breaks the circuit of the shunt coil and at the same time throws the feeding pawl out of gear, allowing the hand wheel to be rotated in either direction and moving the carbons to or from one another.

Dispersing lenses are employed for dispersing the rays in a horizontal direction. Two types are manufactured, one having a fixed angle of dispersion, which must be determined when ordering the lens, and can be ground for any angle up to 35 deg., the other fitted with a pair of lenses so designed that the beam of light can be dispersed at any angle at will, from a concentrated beam to an angle of 45 deg. maximum dispersion, by simply turning a handle which varies the distance between the two lenses.

Under certain circumstances in warfare, it is necessary to throw a beam of light suddenly in any given direction without allowing the enemy to detect the presence of the projector before its use. As it is impossible to make the signalling shutter absolutely light-tight, the Iris shutter has been designed for this purpose. This is composed of a number of thin sheets of metal of crescent form mounted on the front of the projector in a frame in such a manner that by actuating a lever the beam of light can be absolutely shut off or exposed at will.

To obtain the best results with a projector the volts across the arc should be steady, and for this purpose high-grade carbons must be used. It is now usual to fit a voltmeter and ammeter on the projector, so that the attendant can note any falling off of regularity in the current supply and make the necessary adjustments from time to time. The shape and regularity in the burning of the arc should also be under constant supervision. High-class projectors are sometimes fitted with reflectors for throwing two views (at right angles to one another) of the carbon points on a ground glass screen, hand wheels for adjusting the carbons from outside the projector body being within easy reach.

In conclusion, attention is drawn to the great falling off in efficieny of the projector with the accumulation of dust. Both the mirror and front glass door must be kept scrupulously clean. The cloths and cleaning pads should be kept in a dust-proof box, and used for no other purpose.

Siemens Projectors.

The firm of Siemens was one of the first to take up the manufacture of searchlights. Large numbers have been supplied to the British Navy, and they have found a place in almost every foreign one also. They are manufacturers of a line of

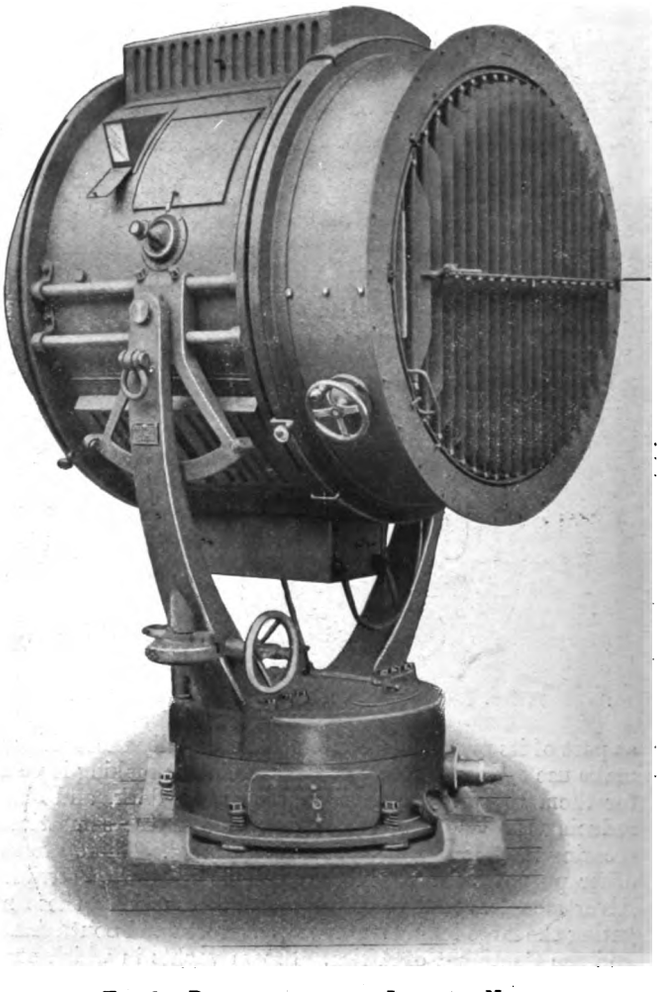

FIG. 1.—PROJECTOR FOR THE JAPANESE NAVY.

projectors fitted with mirrors ranging in size from 10 in. to 80 in. in diameter, and supplied with hand and automatic horizontal lamps suitable for burning with a current of 15 amperes in the smaller sizes up to 250 amperes in the largest.

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The Siemens 24 in. "M.P." projector on a short pedestal is illustrated in the preceding article. The pedestal is fitted with adjustable trunnion, worm turning and geared tipping

FIG. 2.—TWIN PROJECTOR.

motions and automatic lamp. The pedestal can be increased in height to suit any special requirements.

The same article includes an illustration of one of a large number of projectors supplied to the P. & O. Steam Navigation

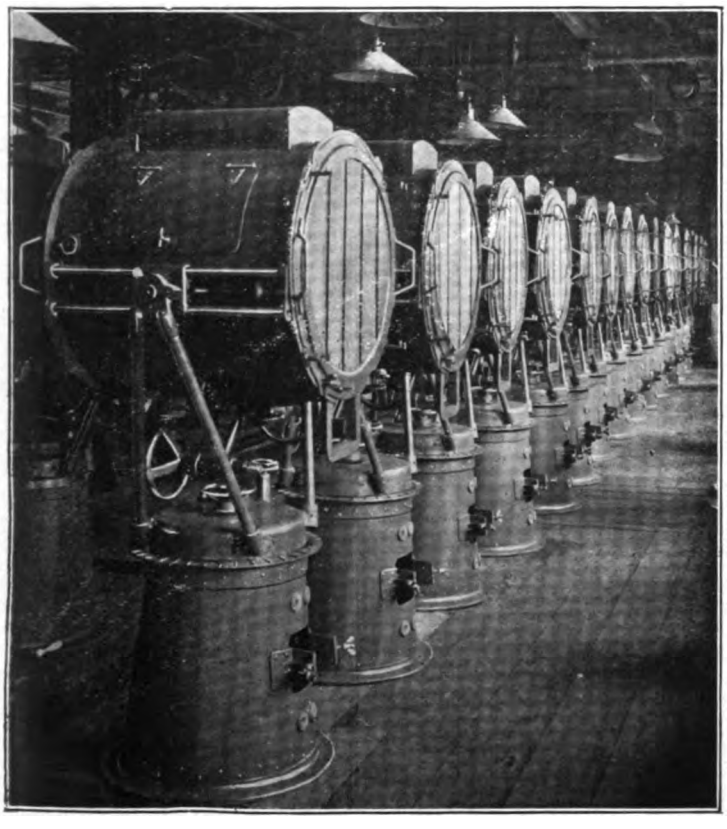

FIG. 3.—ROW OF 24 IN. PROJECTORS FOR BRITISH ADMIRALTY.

Co. These are of the ordinary "M.P." pattern, but fitted with two dispersers, one of which is ground to suit the special requirements necessary for navigating the Suez Canal—which is, that the beam of light shall be split into two rays to illuminate the buoys on either side of the canal and leave a zone of darkness directly ahead so as not to interfere with the navigation of ships coming in the opposite direction.

Fig. 1 is taken from a large order received from the Japanese Government for their Navy. The one illustrated is fitted with a 36 in. mirror, double disperser, Iris shutter and signalling shutter, arc viewer and carbon adjusters. A large number have also been delivered, similar in pattern, but arranged with electric motors for controlling the tipping and turning motions from a distance.

Fig. 2 represents a twin projector for use on warships; it consists of two projectors mounted on a common pedestal.

Fig. 3 shows a row of 24 in. projectors forming part of an order received from the British Admiralty.

We might add that Messrs. Siemens have not only made projectors for marine purposes, but large numbers have been supplied to the British War Office and Colonial Government for use in protecting the sea coast; and also a light design, varying in size from 15 in. to 36 in. diameter of mirror, for mounting on carriages for field use.

Crompton Projectors.

The subject of projectors is one hedged about with a definite amount of intelligible mystery. For it is not to our advantage, as a nation, to give away the details of the design of this

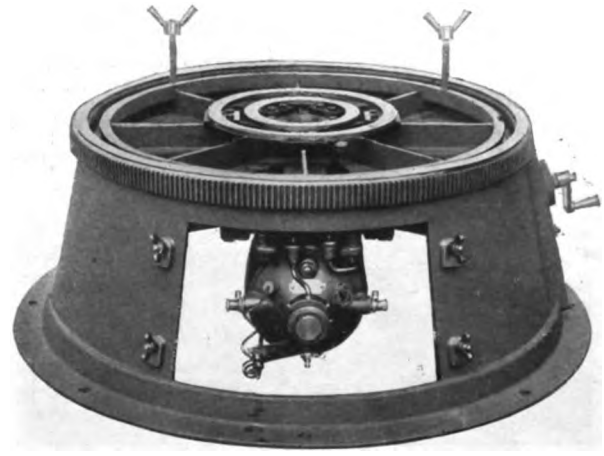

FIG. 1.—BASE OF ELECTRICALLY-CONTROLLED 36 IN. PROJECTOR.

plant, as on its secrecy depends much of the safety of both our coasts and ships.

Certain firms have paid special attention to the design of this class of plant, and among them are Messrs. Crompton & Co., of Chelmsford. It will, therefore, not be without interest to give some information about their projectors, though, for the reasons mentioned above, this cannot be done in any great detail.

The requirements for projectors are so varied that it is a matter of difficulty to standardise any particular forms, but in general the four sizes, 16 in., 20 in., 24 in. and 36 in. may be taken as typical.

Fig. 5 shows a 16 in. projector on a high base with slow motion in the vertical and horizontal plane with diverging lens and switch on the base of the piston. The latest pattern of these is fitted with a hand-wheel for training in a vertical plane, this handle being fitted with a throw-out clutch in order that the operator may work the projector quickly by hand in the vertical direction. There is also an observation glass fitted to the right of the barrel, by which the operator is enabled to see the condition of the arc burning when he is standing at the rear of the projector. Anyone who has worked a searchlight will readily appreciate this as an advantage. This

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particular type of projector has, further, been fitted with two diverging lenses hinged to the front of the projector and used

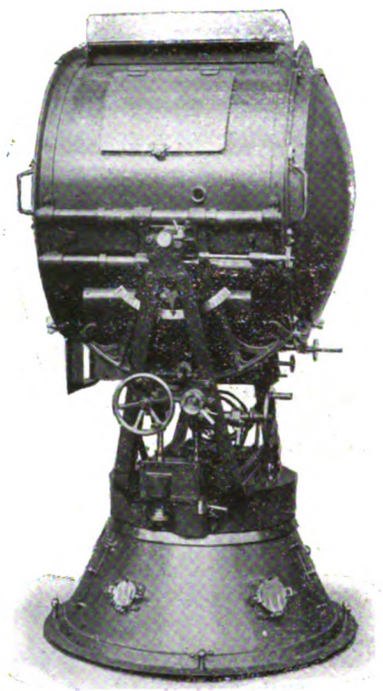

FIG. 2.—36 IN. CROMPTON PROJECTOR.

in conjunction with ships going through the Suez Canal. One diverging lens is an ordinary diverger which gives a diverging beam of 15 deg., the other is arranged so as to give a

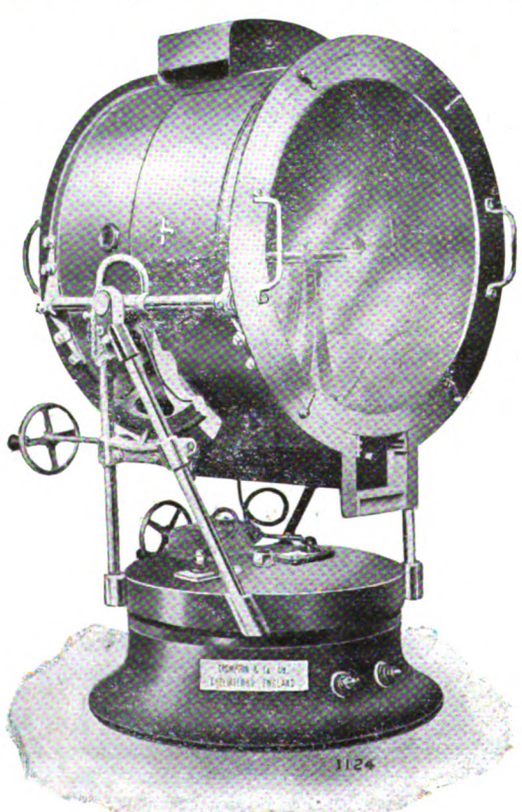

FIG. 3.—24 IN. CROMPTON PROJECTOR.

divergence of 15 deg. from the outside of the beam with a 5 deg. dark centre, thereby giving 5 deg. of light in the beam on either side of the dark centre.

The latest type of 20 in. projector, shown in Fig. 4, is fitted to such ships as torpedo boat destroyers and small ships in the

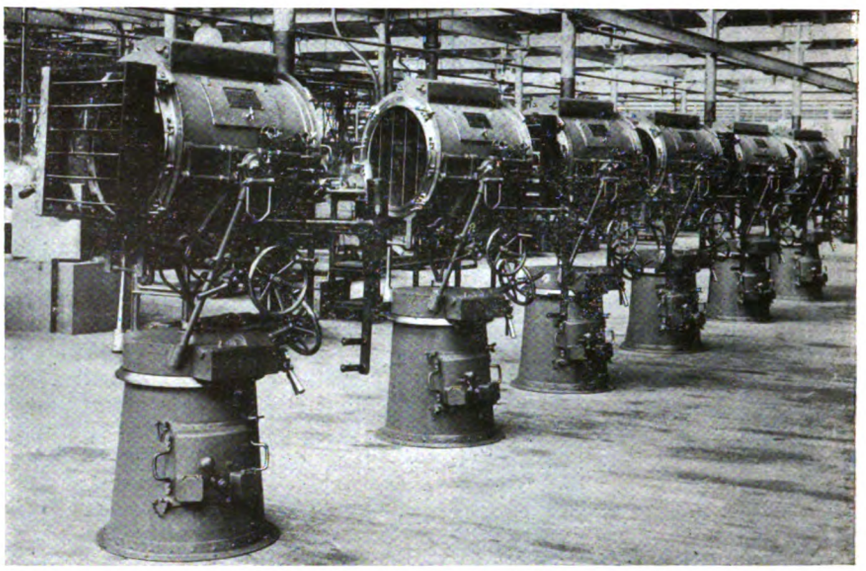

FIG. 4.—A SET OF 20 IN. PROJECTORS.

Navy. This projector has many special fittings, among which may be mentioned a shoulder-piece to enable the attendant to

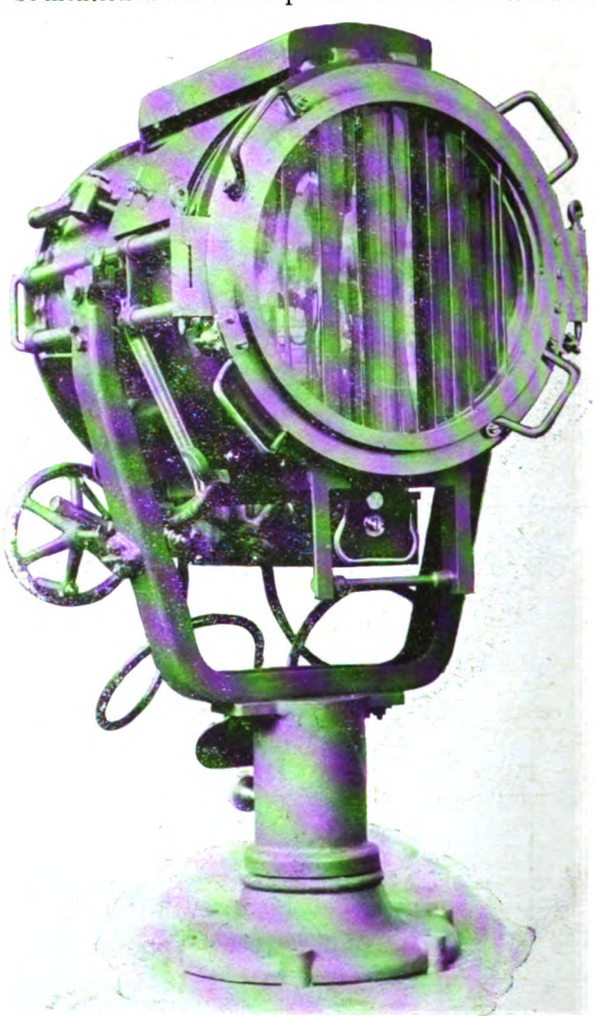

FIG. 5.—16 IN. CROMPTON PROJECTOR.

train the projector similar to the manner in which small light quick-firing guns are trained, the operator keeping his eye to a telescope which is fitted in the brackets shown at the side

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of the barrel. The barrel is also fitted with running-out gear for balancing, which, as will be seen, is operated by the small milled head screws at the rear end of the barrel. This balancing indicating pointer being fitted on the turntable. A watertight double-pole switch and, in the latest pattern, an ammeter and voltmeter are provided fixed. Fig. 3 shows a 24 in. projector.

FIG. 6.—CROMPTON SEARCHLIGHTS IN USE DURING THE FLEET ILLUMINATION AT SOUTHEND-ON-SEA, 1909.

becomes necessary when the Scott's flashing shutter is either put on or taken off from the front. The projector is fitted with what is termed slow gear for both vertical and horizontal

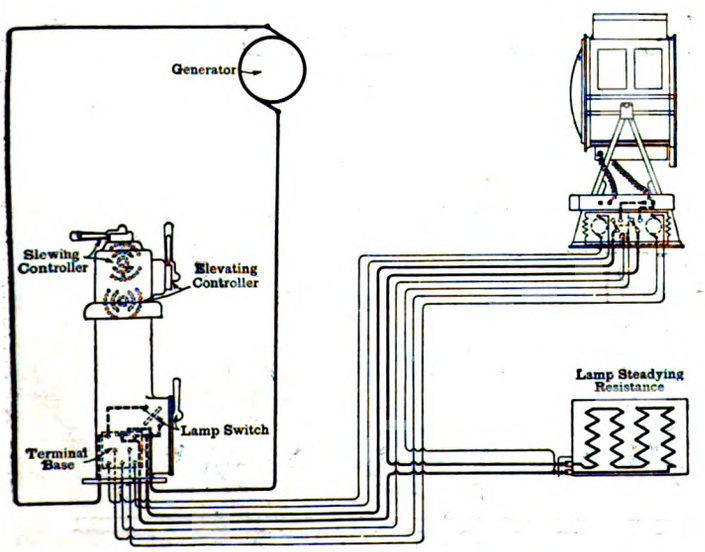

FIG. 7.—DIAGRAM OF CONNECTIONS FOR ELECTRICALLY-CONTROLLED PROJECTOR.

training, each being fitted with throw-out handles so that the movements can be thrown out quickly by hand. A training arc with degree strip is placed round the top of the base, the

Fig. 2 shows a 36 in. projector of the electrically controlled type. A base of a 36 in. projector is shown in Fig. 1. If electrically controlled, there are two motors placed within the base of the watertight type and operated by means of the controller which is shown diagrammatically in Fig. 7. This controller can be placed at any convenient distance away from the projector, and is fitted with a single-pole switch on the base, and has two operating handles at the top, one for elevating and one for training. In this way a large range and variation of speed in the vertical and horizontal planes can be obtained, and both operations can be carried out at one time. The speeds can be varied, say, from one revolution in about 20 minutes up to one revolution in, say, 25 seconds. The 36 in. hand or automatic projector lamp is also fitted with an arc deflector fitted in the centre, which keeps the arc steady during the time the lamp is burning.

Fig. 6 shows Crompton searchlights in action. Our London readers will not have forgotten the display of Britain's naval power at Southend last year, and the illustration indicates that Crompton searchlights were well to the fore on that occasion.

The whole question of searchlight design is a subject on which much unobtrusive and necessarily secret work is being done. Experiments are being made on the carrying power of various types of mirrors and the suitability of new details which it is proposed shall be used in the lamps. A sort of searchlight drill is being got out which enables the fire commander to employ his light to the best possible advantage, a great advance which has been much helped by electrical systems of operation. The searchlights on board ship are now practically one sub-divided unit. They can be either worked as a whole or separately as desired.

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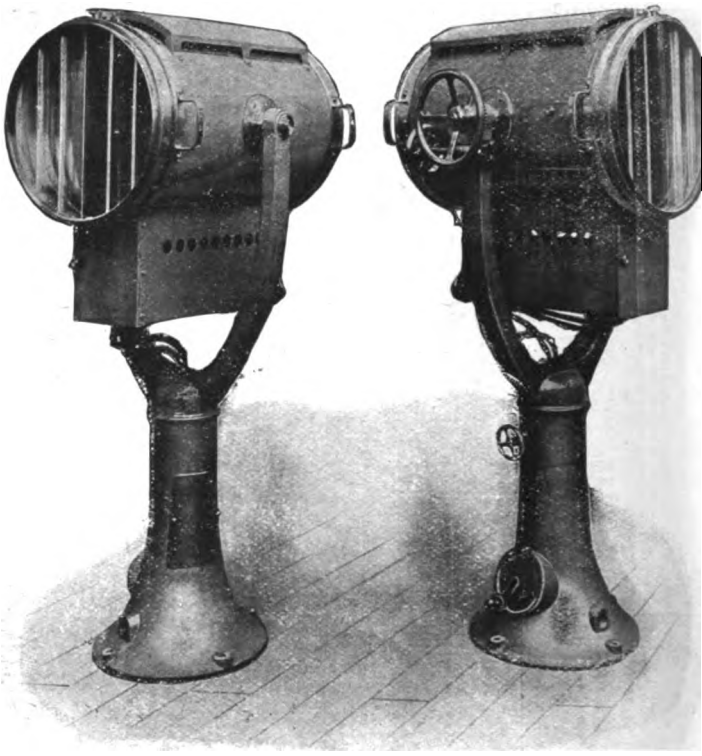
J. & P. Searchlight Projectors

As considerable experience is required for the production of an efficient searchlight, and as until the last few years the demand for this apparatus has been very limited, it is not surprising that the manufacture of searchlights has been confined to only a few firms. Among these must be included Messrs. Johnson & Phillips.

The illustration herewith shows the yacht pattern of searchlight manufactured at the Victoria Works, Charlton, of this firm. It will be noticed that the projector consists mainly of the usual two parts—the projector body and the supporting pedestal, the latter, which is either a casting or a wrought-iron sheet of conical shape, being suitably arranged to hold the projector in any direction in which the beam of light is required to be thrown. For this purpose the supporting side arms carrying the body trunnions are fixed to a revolving turntable which is mounted on ball bearings. As to the projector body itself, this is of stout sheet steel, suitably strengthened at the ends by wrought-iron rings. A lamp "well" is riveted underneath and fitted with a focussing screw, whilst ample ventilation is also provided. The mirror is of silvered glass and is parabolic, being mounted in a suitable frame.

Next to the mirror, the lamp is probably of most importance. The J. & P. lamp is of the horizontal type and is arranged for combined automatic and hand feed, being also provided with a magnetic arc centerer. Flexible cables run from the lamp through a bushed hole in the top of the pedestal, on which the terminals for connecting up the supply cables are fitted. For viewing the arc, observation windows are inserted in the sides of the projector body, whilst the front of the projector body is closed by means of a glass door, built up of a plate-glass circle, or set of strips, mounted in a metal ring attached to the body. It will be evident from the illustration herewith



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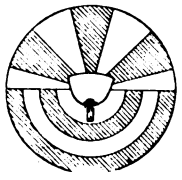
TRADE  MARK.

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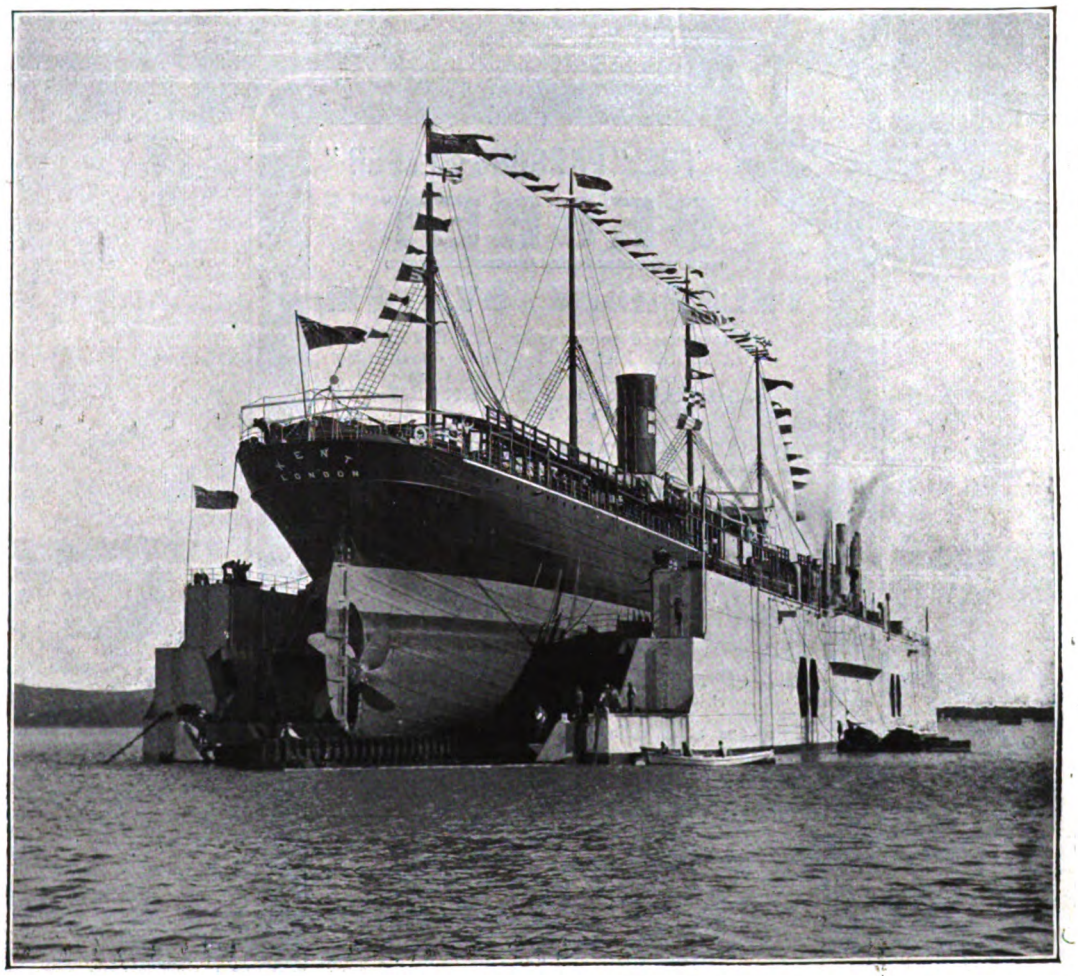

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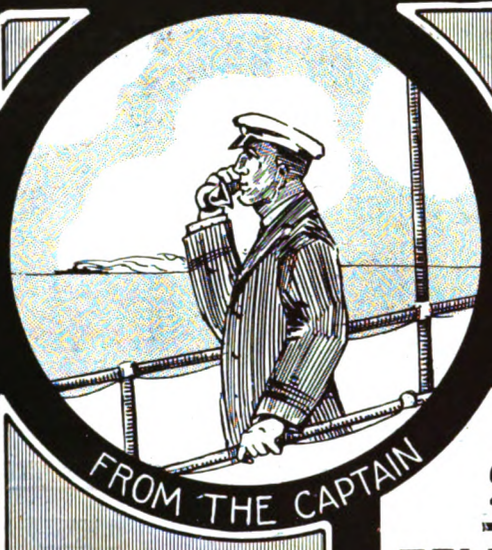

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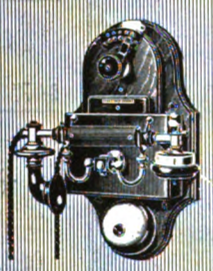

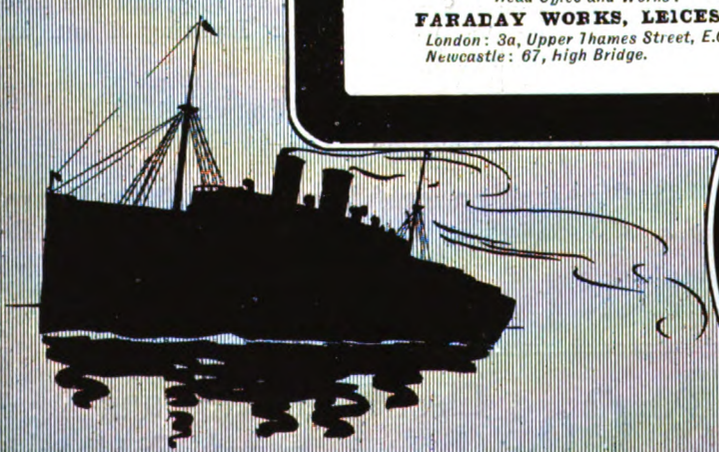

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Ships' Telephones.

BY H. S. THOMPSON.

(Of the National Telephone Co.)

Summary.—After describing the general scheme adopted on board a ship, which, from the telephone point of view, may be looked upon as a large hotel, the instruments and other details, such as wiring and protection from stray currents, are considered. Owing to the special conditions at sea, such installations differ materially from those on land. For connecting a ship to a shore exchange a special flexible cable, with connecting boxes, is used.

Within the last few years a new branch of telephony has been opened up by the adoption of the private branch exchange service on some of the larger ocean-going liners.

When it is remembered that such vessels are in reality huge floating hotels, the number of whose guests often reach well into four figures, it will readily be seen that a very wide field here exists for an efficient and time-saving telephone service, affording instant communication between the various officials, between the passengers and the small army of stewards and others who attend to their wants, between the passengers themselves, and with the local and trunk telephone service when the ship is in port. Installations affording in some measure all these facilities are already in use on certain of our larger liners, and the purpose of this article is to give some idea of the methods which have been adopted and the apparatus used. These installations are worked on the central battery system, and the equipment provided is similar in many respects to that used in connection with the ordinary private branch exchange installations which are now such an essential feature of all large business establishments.

In considering such a scheme the first essential is to determine the position of the room in which the switchboard and its associated apparatus is to be located. In order to economise in wiring it is important that this room be as nearly central in regard to the telephones to be served, as is practicable. It should be in a sheltered portion of the ship, so as not to be exposed to the weather, and should preferably be one in which artificial lighting is unnecessary during daylight hours. Its size will, of course, depend upon the number of telephones to be served, but it is very desirable that reasonable space be left for the operator and that the apparatus be not unnecessarily cramped.

Having decided upon the switchroom, plans of the various decks are prepared and the positions of the different telephones marked thereon. Working on these plans the number, size, and positions of the distributing boxes are fixed and the wiring scheme is planned out. Between the switchroom and the distributing boxes the wires are run in cables. These are made up in various sizes. The conductors used are of tinned copper, No. 20 S.W.G., insulated with vulcanised indiarubber, which brings the external diameter up to No. 12 S.W.G. These are laid up in twisted pairs and the whole cable is encased in lead sheathing. The cables are generally run along the main corridors and are fixed in position before the wood panelling is fitted. Where this is not possible it is usual to employ wooden casing, or to cleat the cable to the bulkheads without any covering. One or more main cables are run from the switchroom according to the size of the system and the location of the telephones. At convenient points en route branches are taken out from the main cable and run to the various distributing points, a corresponding reduction being made in the number of wires in the main cable after each branch. When deciding upon the number of wires in these cables it is necessary to keep in view what the ultimate requirements will be and to make provision for any additional telephones which may subsequently be required, otherwise their installation at a later date becomes a matter of considerable expense and often of great difficulty.

In installing and jointing these cables all the usual precautions in regard to preserving the proper twists in each pair of wires must be taken. Plumbers' joints are made in the lead sheathing over all joints, and the ends of the cables are sealed with compound to prevent the entrance of moisture.

Between the distributing boxes and the instruments, V.I.R. wires, similar to those in the cables, are run in wooden casing or steel conduit according to the surroundings. In the cabins and staterooms it is usual to employ wooden casing, which is either an actual part of, or is made to harmonise with, the panellings and decorations. The wires are led from the casings to the instruments behind the bulkhead panelling and are brought out immediately behind the instrument or terminal block so as to be completely concealed.

FIG. 1.—TYPICAL INSTRUMENT.

When the installation of the wiring is completed very careful tests are made for insulation and for cross talk to ensure that there are no crosses between pairs and that the proper twists have been maintained throughout.

The instruments used are of the central battery type, similar in all essentials to those used on shore in connection with central battery exchanges, but somewhat different in appearance and details. The wall set illustrated in Fig. 1 is the instrument most generally used. This instrument is of the Western Electric Co.'s manufacture and has a special gimbal device fitted on the switch hook to prevent its action being interfered with by the rolling of the ship. This device is clearly shown in Fig. 1, and consists of a spring clip pivoted horizontally so that the receiver may swing and retain a vertical position when the ship rolls. Without this arrangement there

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would be a danger of the switch hook lifting when the ship rolled, owing to the shortening of the horizontal distance between the centre of gravity of the receiver and the fulcrum of the lever. Allowance is made for a movement through 30 deg. in either direction. The spring clip is a safeguard against the receiver being dislodged altogether, and also prevents the rattling which might otherwise be set up by the vibration from the engines.

All the external metal work of this set is gilded or silvered to match the fittings in the cabins, and the plating is specially heavy as a precaution against corrosion. The internal parts are specially lacquered for the same reason, and all contacts are of platinum. The rosette below the instrument is provided for making connection with the line wires and the wires to the bell, induction coil and condenser. These latter are fitted together in a metal box, which is enamelled to match

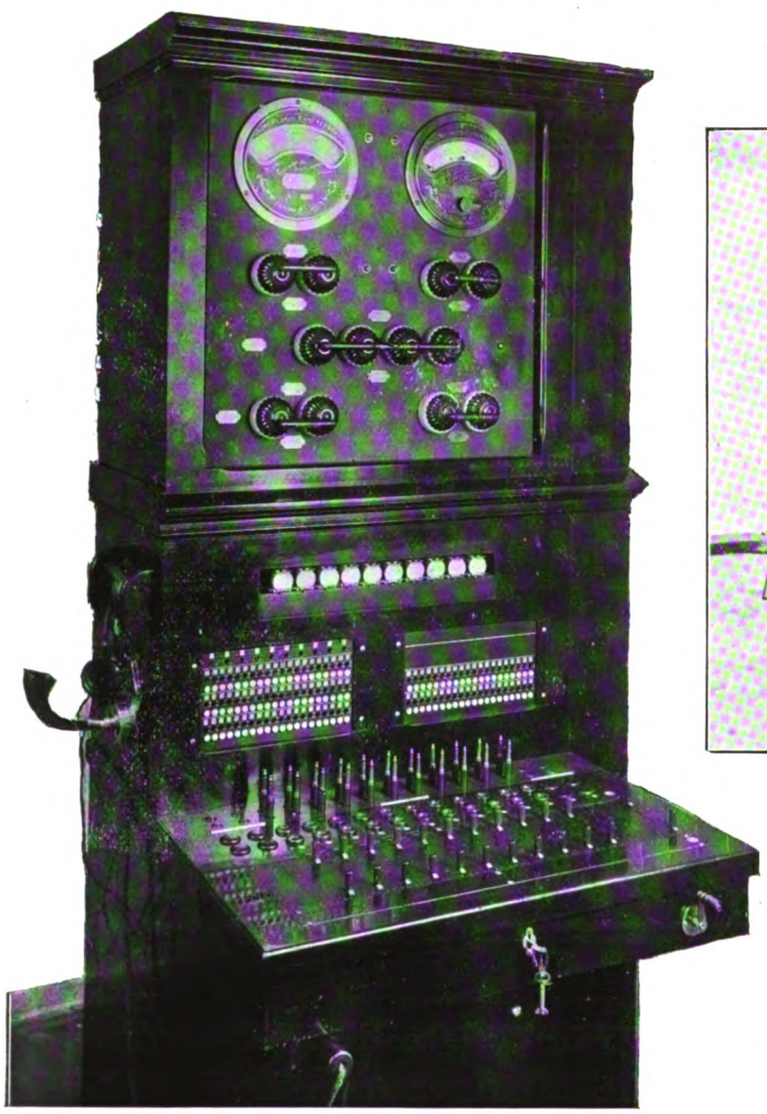

FIG. 2.—TELEPHONE SWITCHBOARD.

its surroundings, and can be fitted in any convenient position, the wiring being carried to it behind the bulkhead panelling. The connections of this instrument are shown in Fig. 4.

From the end of the main cables in the switchroom the V.I.R. wires are taken in wooden casing to a distributing frame. This is a simple construction of bar iron consisting of vertical supports fixed to the wall and standing out therefrom some 6½ in. and horizontal bars fixed across the vertical supports. The V.I.R. wires are terminated on strips of fuses mounted vertically in pairs between the horizontal bars in the upper portion of the frame. These strips usually contain 60 single fuses each, so that two adjacent strips serve 60 lines. The fuses are similar to those fitted on the main distributing frames in central battery exchanges; they carry 2½ amperes, but will operate if the current be increased beyond 3·75 amperes. Between the lower horizontal bars, heat coils and carbon arresters are fitted. These are in strips of 60 pairs each, and are of the standard central battery type; the heat coils will carry a current of 0·35 ampere but are actuated by a current of 0·5 ampere. The cables from the switchboard are terminated on these arresters. The connections between the fuses in the upper portion of the frame and the arresters in the lower portion—*i.e.*, between the line wires and the switchboard cables, are made by means of twin flame-proof cross-connecting wires run in the space between the apparatus and the wall and held in position by means of bridle rings fixed to the iron framework.

It is usual to arrange these cross-connections so that the switchboard numbers will correspond with the numbers of the cabins in which the telephones are located. The whole frame is enclosed in a glazed mahogany cabinet.

It will be seen from the foregoing that each line circuit is protected by a double pole fuse, a carbon arrester and a pair

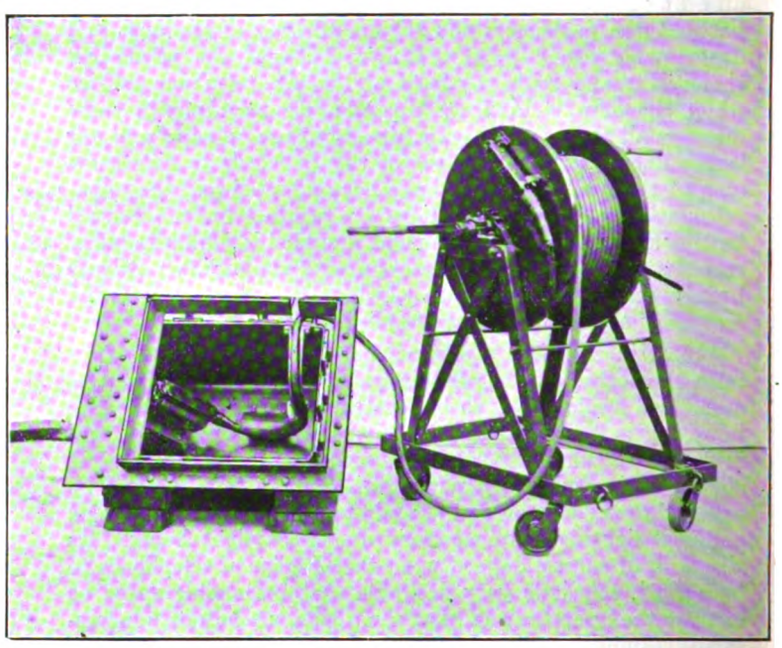

FIG. 3.—CABLE DRUM AND SUNK TERMINAL BOX.

of heat coils. The object of this protective apparatus is to prevent injury to the switchboard apparatus and wiring in the event of any of the line circuits getting in contact with the lighting or power circuits on the ship, or of any stray currents coming in over the shore lines when the ship's installation is connected up to the land system.

The heat coils afford protection against smaller currents which, while insufficient to blow the fuses are of sufficient magnitude to damage the apparatus if allowed to continue for any length of time. The heat coils do not act immediately, so that they are not affected by such currents when only of short duration.

Between the distributing frame and the switchboard, cables insulated with silk and wool and enclosed in lead sheathing are used.

A typical switchboard used on one of these installations is illustrated in Fig. 2. It is very similar in external appearance to an ordinary private branch exchange switchboard, excepting that for the sake of economy in space the switchboard controlling the battery circuits and ringing machines is fitted on the top. Lamp signalling is employed, and the lamps and line jacks are fitted in the two panels immediately in front of the operator. The 10-drop indicators above the jack panels are wired to the top strip of jacks in the left-hand panel and are used in connection with the lines to the shore system when the ship is in port. The keyshelf is equipped with connecting cords in pairs, each having two supervisory signals and the

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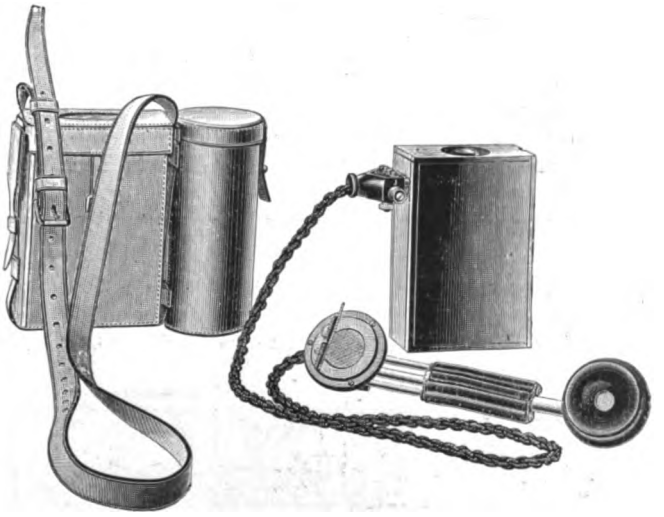

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usual listening and ringing keys. The switchboard illustrated has a capacity for 200 lines. The cables from the distributing frame enter the switchboard in a casing at the side and are connected to terminals on a connecting rack at the rear.

Current for operating the system is supplied from a battery of 13 secondary cells. In order to prevent loss of electrolyte from splashing caused by the motion of the ship, cells of the portable type are employed. It is usual to charge these direct from the ship's lighting mains, series resistance lamps being inserted to bring the voltage down to the proper figure. Duplicate batteries are provided, and one is charged while the other is discharging. This arrangement avoids any disturbance from the lighting mains being introduced on the telephone circuits.

Alternating current for ringing at 75 volts 16 ~ is supplied from dynamotors running direct off the lighting mains. These also are provided in duplicate and used alternately, change-over switches being fitted on the power board for effecting the necessary alterations in connections. It is usual to instal the ringing machines in the switchroom in a specially designed sound-proof case.

The batteries are installed as near to the switchroom as possible, in a position easy of access and permitting of efficient ventilation. The main discharge leads from the batteries are taken to the switchboard at the rear of which a slate panel carrying the distribution fuses, is fixed. Alarm type fuses, rated to carry 1½ amperes, are used.

In designing circuits for a ship's installation it is necessary in view of the unstable conditions which prevail when the ship is at sea, to give careful consideration to the type of signal employed. For example, it is obvious that an indicator of the falling shutter type would be quite unsuitable. (The self-restoring indicators on the switchboard illustrated in Fig. 2 are only used in connection with the shore lines when the ship is in port. A switch is provided to cut these off the alarm bell, when the ship is at sea.) Lamp signals are, of course, ideal, in that they are unaffected by the motion of the ship, but the knife edge type of relay by which these are usually controlled cannot be relied upon to operate satisfactorily in rough weather. The line circuits on a ship, however, are always short and the variations in their resistances are small. It is, therefore, possible, by using a 26-volt battery in place of the usual 22 volts, to work the lamps in series with the lines and dispense with line relays altogether.

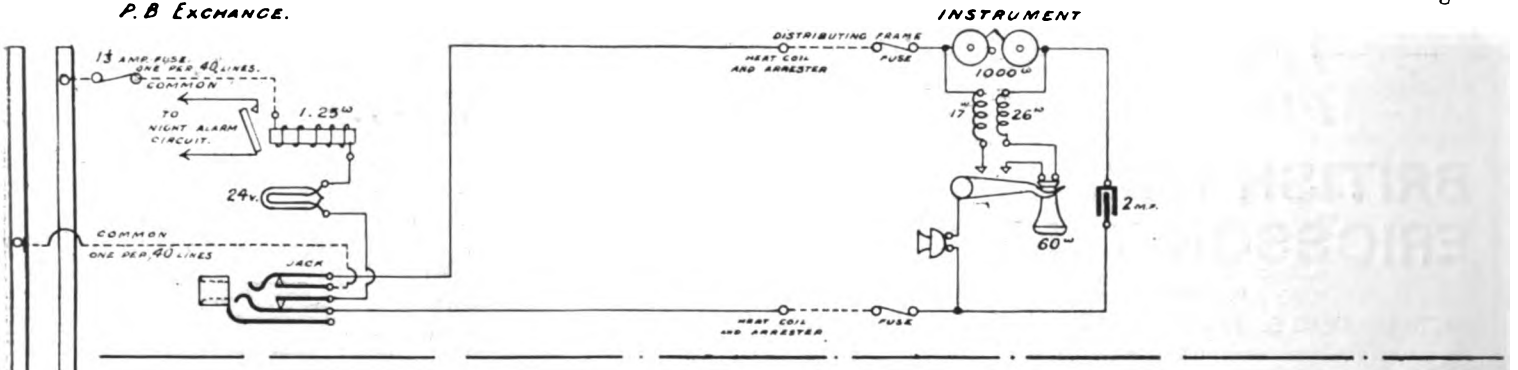

FIG. 4.—EXTENSION LINE.

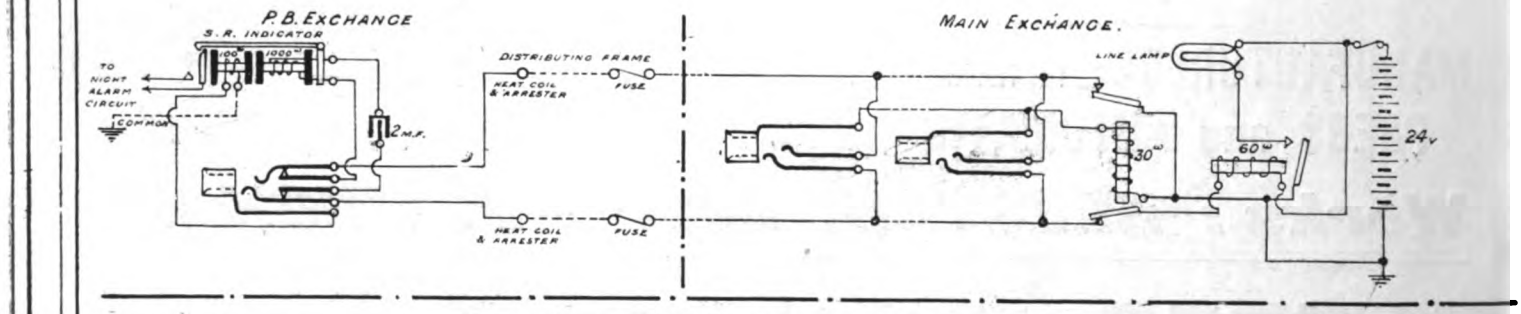

FIG. 5.—EXCHANGE LINE TO CENTRAL BATTERY EXCHANGE.

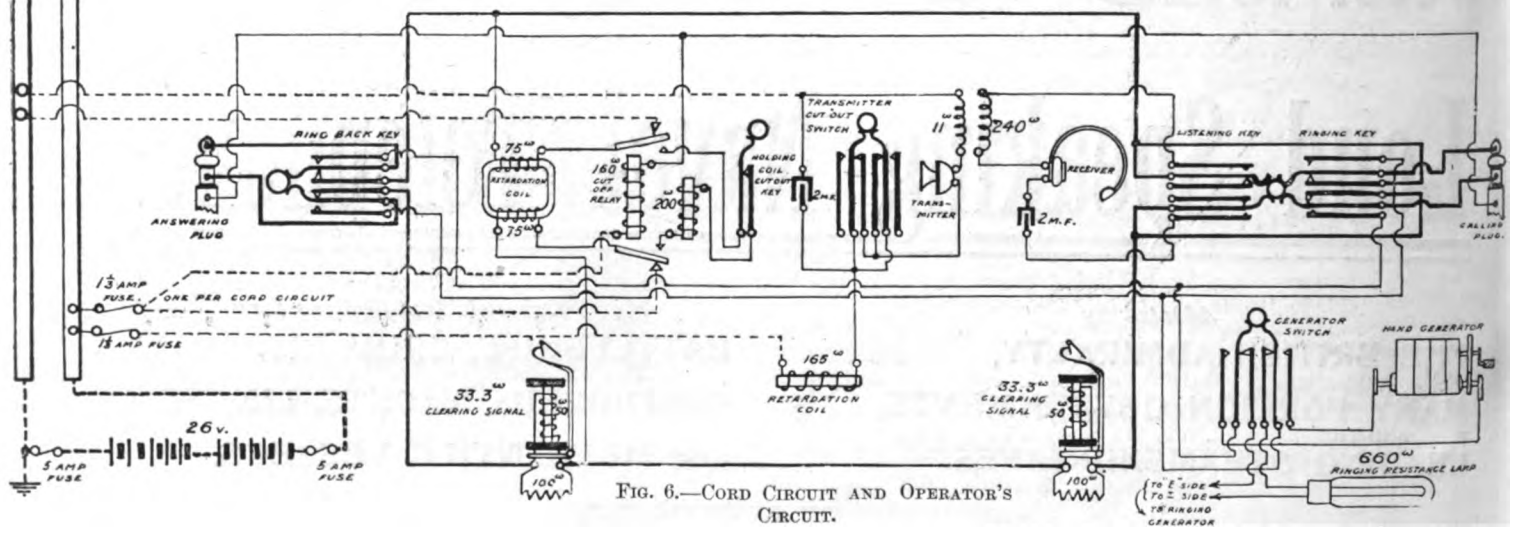

FIG. 6.—CORD CIRCUIT AND OPERATOR'S CIRCUIT.

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On referring to Fig. 4, which illustrates the line circuit used, it will be seen that when the receiver is removed from the switch hook, current flows from the battery through the common night alarm relay, through the individual calling lamp and out to the A line, passing back to the B line and earth, via the 17 ohm winding of the induction coil and the transmitter. An ordinary 24-volt lamp is used, and this current is of sufficient magnitude to light it. The common night alarm relay, which is the only knife edge relay used, has a spring controlled armature and is unaffected by the motion of the ship.

The cord circuit, illustrated in Fig. 6, is identical with the circuit ordinarily used on private branch exchange switch-

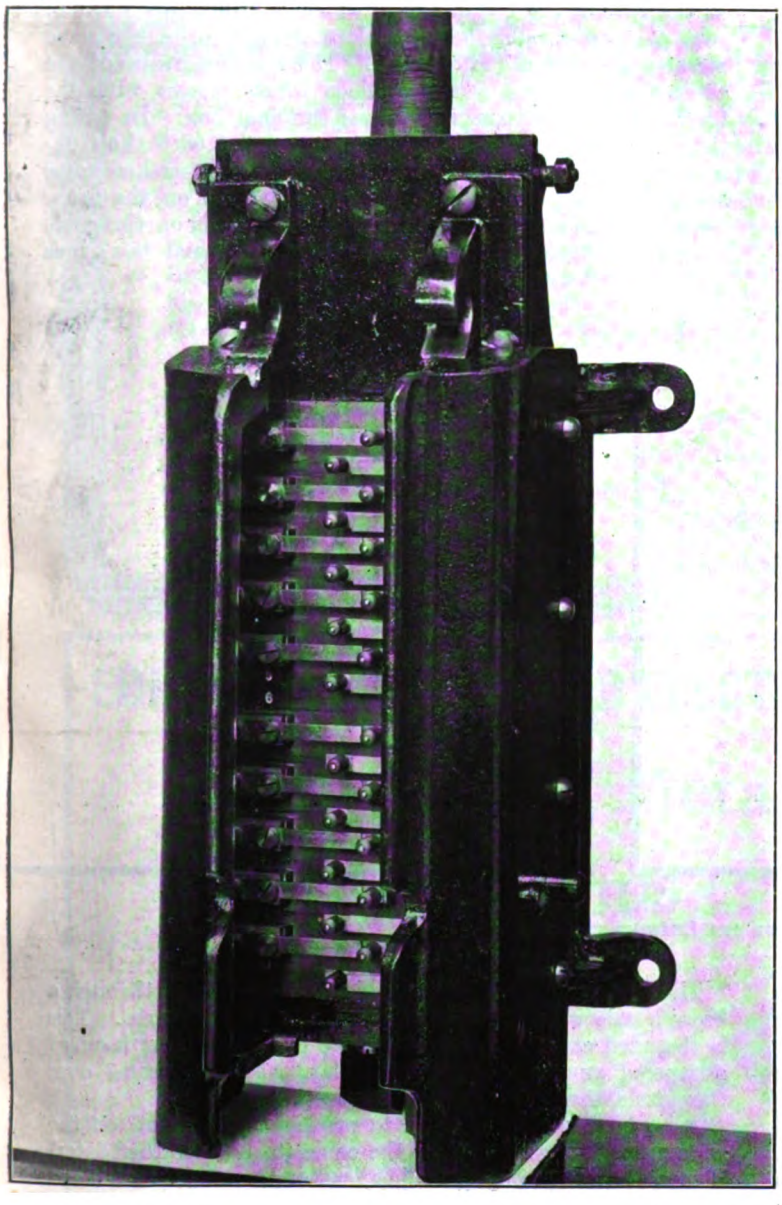

FIG. 7.—CABLE BOX WITH COVER REMOVED, SHOWING THE PLATINUM-TIPPED SPRINGS.

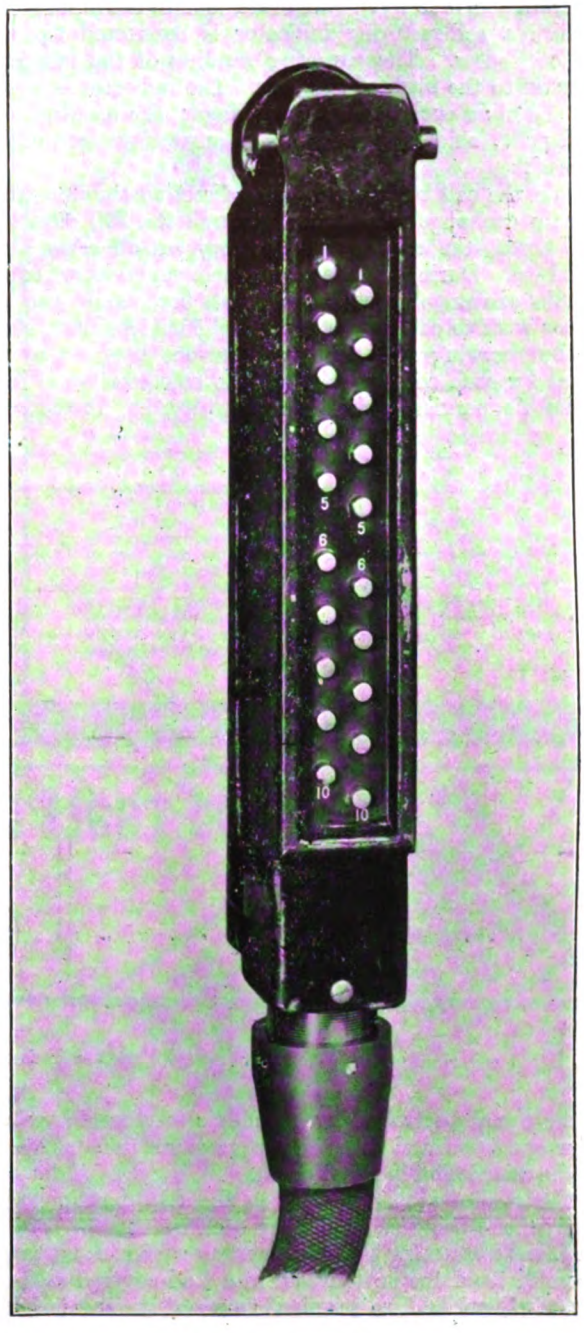

FIG. 8.—CABLE HEAD.

boards. There are two supervisory signals fitted in connection with each pair of cords. These signals are of the disc type, and are mounted vertically in the keyboard. When actuated, a white disc about the size of a sixpence is displayed; when not actuated, this disc hangs down out of sight and the aperture in the keyshelf is dark. The operating coil of the signal is wound to a resistance of 50 ohms; superimposed on this winding, and joined in parallel with it, is a non-inductive winding of 100 ohms. This provides an alternative path for the speech currents which would otherwise be considerably reduced by the impedance of the inductive winding, as the signal is connected in series with the talking circuit. Battery current for operating the transmitters and signals is fed on to each cord circuit through an individual retardation coil having two windings each of 75 ohms. The object of this coil is to prevent any overhearing which might otherwise be introduced from the common wiring between the fuses and the battery.

In order to obtain the best results in transmission when speaking over the shore lines it is necessary that the current for the transmitters be drawn from the battery at the main exchange. To effect this a cut-off relay is connected to the sleeve connections of each cord circuit. This relay is only operated when a plug is inserted into an exchange line jack, and, as will be seen from the diagram, it is arranged to disconnect the double 75 ohm retardation coil from the ship's battery and join the two windings together through a 200 ohm retardation coil. This leaves a 350 ohm bridge across the line which serves to hold the line at the main exchange.

The exchange lines are connected, as shown in Fig. 5. This diagram shows the circuits used in connection with a central

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battery exchange. Should the exchange on shore be worked on the magneto system, special arrangements are made at the exchange end of the line to enable the ship's central battery circuits to work in connection with the magneto shore system. This obviates the necessity of having special circuits on the ship should the exchanges at the ports between which she plies be worked on different systems. The circuit shown at the main exchange in the diagram is the standard central battery subscribers' line circuit. On the ship the exchange line terminates on a five-point break jack to the inner contacts of which a self-restoring indicator is connected through a series condenser. The restoring winding of the indicator is connected to the bush of the jack. The indicator is operated when the main exchange operator rings; the insertion of the plug by the ship's operator when answering automatically restores it.

Should the call be in the reverse direction the line relay at the main exchange is actuated through the 350 ohm bridge joined across the cord by the battery cut-off relay already referred to. During conversation the supervisory relay at the main exchange remains operated, but should the ship's operator wish to call in the main exchange operator, she can do so by throwing the holding coil cut-out key, one of which is fitted for each cord circuit. While conversation is in progress both supervisory signals are displayed. At the conclusion the signal controlled by the ship's telephone is released, but the one associated with the exchange line remains operated until the connection is taken down.

In the case of a call confined to the ship, both signals are operative, one being controlled by each instrument.

The lines connecting the ship's system with the shore system are carried from the switchroom in a lead-covered cable such as already described, to terminal boxes of special design, one of which is fitted in a convenient position on either side of the ship. These boxes are provided in duplicate in order that the shore connections may be made with equal facility whichever way the ship is berthed.

One of these terminal boxes is illustrated in Fig. 7. This particular one has capacity for 10 circuits. The lines are connected to flat bronze springs seen in the front of the box. These springs carry at their extremities small studs tipped with platinum. They are mounted on an ebonite slab and the whole is enclosed in a gun-metal casting. Behind the slab is a space in which the connections with the line wires are made. The cable is brought into this space through a brass nozzle, which can be fitted at the top or bottom as desired. A plumber's joint is made between the lead sheathing of the cable and the brass nozzle. When the line wires are all connected up the whole of the rear space is filled solid with compound and the back screwed tightly on, red lead being used to ensure a watertight joint.

The terminal boxes are fitted in positions adjacent to port holes through which the shore cable can be brought. Each end of this cable is terminated in a cable head designed to fit in the terminal box and effect connection with the contact springs therein. The cable head illustrated in Fig. 8 is the companion one to the terminal box just described. It consists of a gun-metal casting fitted with an ebonite slab in a similar manner to the terminal box. Fixed on this slab at centres to correspond with the contact springs in the terminal box are solid gun-metal studs tipped with platinum.

The connections to the contact studs are made in a space at the rear of the ebonite slab, which is afterwards filled in with compound, and the back plate screwed on in the same manner as with the ship's box. The upper portion of the cable head is fitted with trunnions which engage with the trunnion plates on the top of the terminal box. In fitting the cable head into the box, the upper portion with the trunnions is placed in position first: the head is then pushed home and is held in position by a spring catch fixed on the lower portion of the box. When in position, the studs on the cable head press on the contact springs in the terminal box, thus completing the connections.

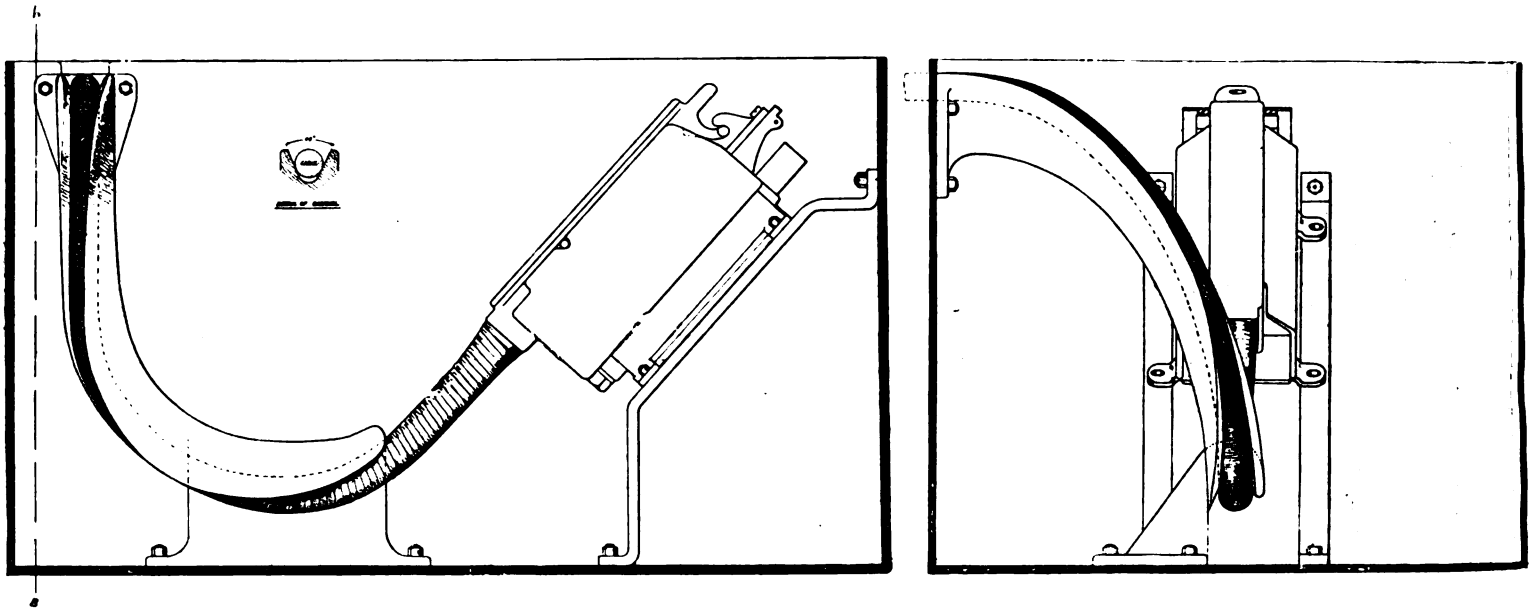

FIG. 9.—ARRANGEMENT FOR LEADING IN CABLES.

The cable enters the cable head at the lower end through a brass nozzle which is made in the form of a split grip. This is threaded externally, and after the cable has been inserted a tapered gun-metal clamping collar is screwed home over the nozzle, thus ensuring a tight grip on the cable.

As a further security, and to prevent any tension on the conductors, the steel core of the cable (to be described later) is carried through into the cable head and made off on a stout screw fixed in the casting. Before being inserted in the nozzle the end of the cable is saturated with a mixture of compound and beeswax in order to render it moisture proof, and is then served with a wrapping of waterproof tape. After the cable is inserted a helix of steel wire is fixed over the nozzle and cable for a distance of about 12 in. in order to prevent any sharp bending of the cable at the point where it enters the nozzle. The steel helix is protected by a final wrapping of waterproof tape.

Very great care has to be taken in all these operations, as it is of vital importance that the cable head and the joint should be absolutely waterproof.

The flexible cable used for completing the connection between the ship and the shore has to withstand very severe conditions, such as are seldom met with in telephone work.

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When not in use it is kept coiled up on a portable drum, and in order that the process of coiling and uncoiling may be rapidly and easily carried out extreme flexibility is required. During the time the cable is in use a long bight swings unsupported from the ship, and it is therefore necessary that the cable should have sufficient strength to support its own weight. The insulation must be such as to suffer no deterioration from immersion in sea water.

The cable used has conductors each consisting of 23 strands of No. 36 S.W.G. tinned copper. The dielectric consists of three concentric layers of indiarubber, the first pure rubber and the second and third vulcanised rubber. Over this is a wrapping of waterproof tape. The conductors so insulated are laid up evenly in pairs with 7 in. right-hand lay. These pairs are then laid up around a stranded galvanised-steel suspender covered with ozokerite braiding. For a 10-pair cable this suspender is made up of five strands of galvanised steel, each strand consisting of seven No. 35 S.W.G. wires. It will carry, without breaking, a load of 400 lb. The whole cable so made up is wrapped with a serving of waterproof tape and finally with two flaxen braidings saturated with ozokerite. The 10 pair cable mentioned above is approximately 1 in. in diameter and weighs 6 oz. per foot.

On the landing stage or dock side, as the case may be, terminal boxes of similar design to those used on the ship, are fitted. These are installed in sunken chambers with flush covers. A sufficient number are provided to ensure one always being in reach wherever the ship is berthed. The boxes are connected in parallel and joined to the lines running away to the main exchange. In order to prevent any strains being transmitted to the cable head, a heavy casting with a curved V-shaped groove is fixed in each chamber, and the flexible cable is laid round this groove before it is taken to the terminal box.

A sketch of this arrangement is given in Fig. 9. It will be noticed that the curved groove is approximately in the form of two quadrants at right angles. The sides of the groove are inclined at an angle of 45 deg., this being the angle which provides the most effective grip. A similar device is fitted where the cable enters the ship. Fig. 3 is a photograph of one of these chambers ready for installation in the deck of a landing stage, with the cable head and flexible cable in position. It also shows the portable drum carriage on which the cable is stored when not in use, and from which the cable is paid out to the ship.

When the shipping company has a private branch exchange working in its offices at the docks the terminal boxes on the dock side can be connected to this private branch exchange instead of to the main exchange. As during the time the ship is in dock most of the calls will be between the various officials of the shipping company and the ship this is a more convenient arrangement. It does not preclude exchange calls from the ship as these can still be put through when required via the shipping company's exchange lines.

In the case of those passenger vessels on which the owners are unwilling to instal the private branch exchange system in its entirety, a system has been devised which gives all the advantages of the shore connections when the ship is in port, but is not in operation when she is at sea.

In such cases one or more telephones, preferably of the type already described, but in some instances of the magneto local battery type, are installed in certain cabins on the ship.

When the number of circuits warrants it terminal boxes of the type just described, but of smaller capacity, are fitted, and the shore connections are effected in the same way as with the larger equipments. Where only one line is required a watertight plug and socket similar to those used in electric light work is fitted on the ship, and the connection is completed by means of an armoured flexible cable. The exchange lines in these cases can either be run overhead and terminated on a pole at the dock side, or, where this method is not practicable, run underground and terminated in a watertight socket fitted in a suitable position. When the shipping company has offices close at hand it is generally found most convenient to connect the line on the switchboard at these offices and work the ship's telephone as an ordinary extension station. Where this condition does not obtain, the line is run direct to the public exchange.

When the shore exchange is worked on the central battery system no special arrangements are necessary, but where the magneto system is in use special circuits are arranged to feed battery current out to the ship's telephone so that its signalling is entirely automatic and no local batteries for speaking are required.

The writer is indebted to the Editing Committee of the "National Telephone Journal" for the use of the blocks illustrating this article.

The Telephone on Board Ship.

The conditions of working of a telephone service on board ship are so materially different from those met with in land installations that a brief description of the systems generally used will be of interest.

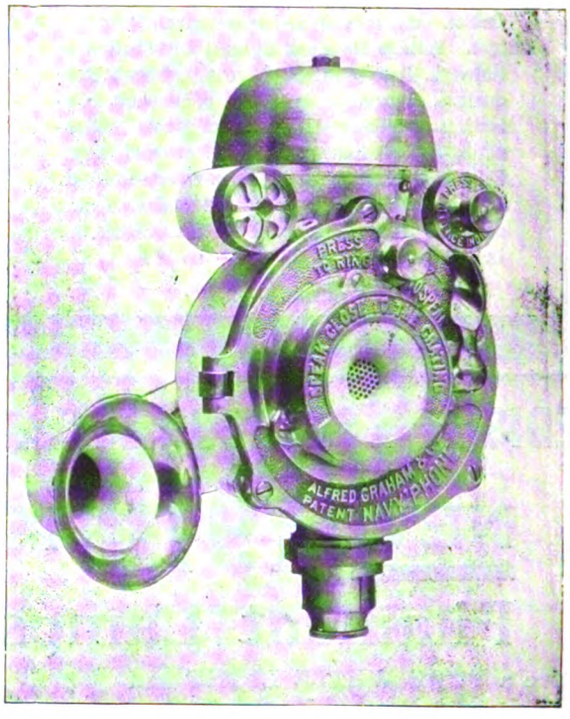

FIG. 1.—GRAHAM & CO.'S LOUD-SPEAKING TELEPHONE, AS FITTED ON THE BRIDGES.

Previous to the introduction of special types of loud-speaking apparatus the communications provided on war vessels were by the medium of voice pipes with electric bells and indicators for signalling purposes. By the employment of voice pipes of large diameter, and by carefully insulating the tubes from the hull of the ship, a certain degree of efficiency was attained; but with the increase in dimensions of ships, necessitating the use of longer lengths of piping, this method of communication was gradually superseded by the telephone. At first the application was restricted to circuits between positions some distance apart, but as the reliability and increased efficiency of the telephone apparatus have been established, the voice pipe has gradually disappeared and the use of the telephone has become general.

The requirements of the naval service are such as to call for apparatus of a totally different character from those familiar in the ordinary exchange or in domestic telephony; indeed, only the fundamental telephonic principles are in common. The characteristics of the naval telephone are particularly loud and distinct reproduction of speech, mechanical strength and

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watertight construction, and with these leading features many electrical and mechanical details have been embodied, resulting in the production of apparatus of the most reliable and efficient character.

The loud-speaking naval telephones, generally referred to as "Navy 'phones," manufactured by Messrs. Alfred Graham & Co., of Crofton Park, London, are well known, being not only adopted by the British Admiralty, but by many foreign Governments and the leading steamship lines throughout the world. The types of telephones generally used are illustrated. Fig. 1 shows a loud-speaking instrument as fitted on bridges, in conning towers and many other positions; Fig. 2, shows a loud-speaking telephone with side hearing tubes and pneumatic ear-pads for use in engine rooms, boiler rooms and at stations where there is a great deal of noise. In officers' cabins a special form of hand telephone set is provided and arranged for use in combination with the various types of apparatus. An installation of telephones for a war ship is usually arranged in three groups. Firstly, a system of communication between the bridges, conning towers, engine rooms, boiler rooms and the more important positions, with instruments connected independently; and switches with indicating devices are frequently used enabling one station to communicate with several others simultaneously. The second group comprises a number of circuits similarly arranged, but in connection with the gun and fire control positions, magazines, &c.; and the third section, which links up the officers' cabins, auxiliary machinery rooms and stations of secondary importance, is connected on a central exchange system. The current for operating the telephone system is, as a rule, on the central energy plan, employing specially constructed motor-generators for the purpose of supplying current at a voltage suitable for telephonic working. The arrangement of wiring adopted on war vessels provides for the utmost protection of the cables, which are carried, as far as possible, below armour, and the feeders for each group of telephones are in many cases duplicated, and every precaution is taken to ensure the communications remaining intact during a naval action.

On board vessels of the mercantile marine, loud-speaking telephones are generally employed for communication between the navigating bridge, forecastle, docking bridge, crow's nest and engine room; also between the engine room and stokeholds. On bridges the watertight pillar instrument, shown in Fig. 3, is commonly installed. This convenient form of apparatus is also provided with a switch for communicating with several distant stations. The modern ocean liner is also provided with a cabin telephone system on intercommunication lines for the officers' quarters, and circuits from the state rooms to the respective stewards are installed for the convenience of the passengers. A form of cabin telephone, manufactured by Messrs. Graham and used extensively, is shown in Fig. 4.

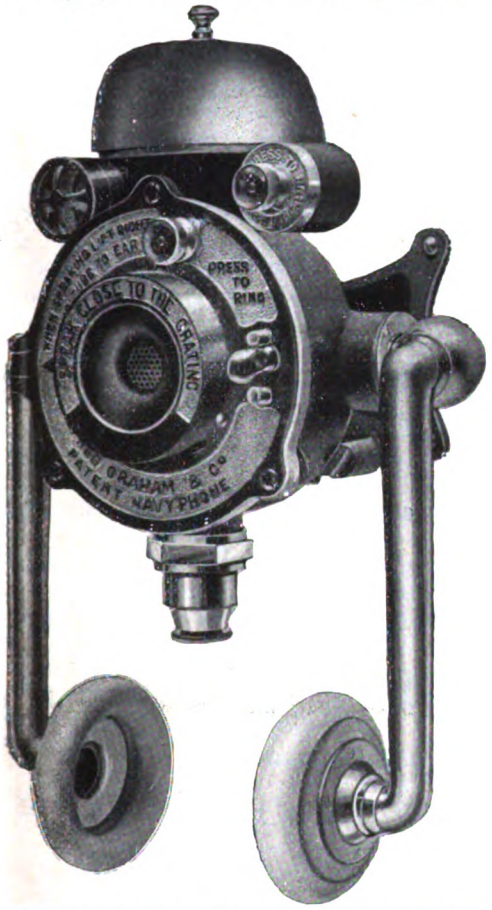

FIG. 2.—LOUD-SPEAKING TELEPHONE FOR USE IN ENGINE ROOMS, &C.

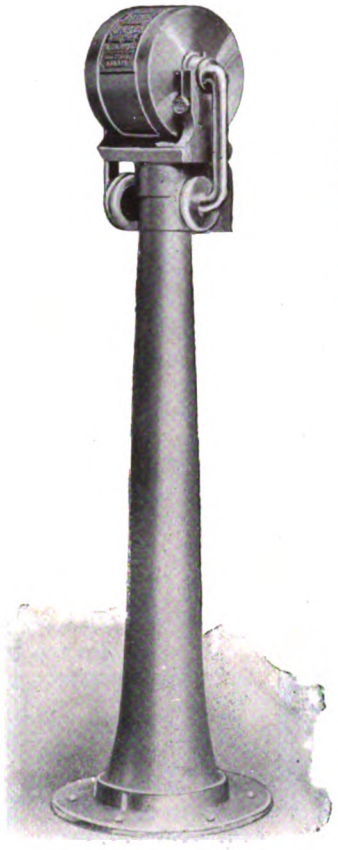

FIG. 3.—WATERTIGHT PILLAR TYPE OF TELEPHONE FOR THE BRIDGE.

FIG. 4.—CABIN TELEPHONE

Battleship Telephones.

The loud-speaking telephone has been specially developed for battleship service during the past few years, and a type of instrument is now in use which embodies the results of a large number of exhaustive experiments. For service of this kind it is essential that the instrument should be protected as much as possible, and that the system of signalling should be both simple and effective. The Ericsson Co. have completed a number of important installations of their loud-speaking telephone on several Swedish battleships, and a brief description of the system adopted will be of interest. The equipment generally consists of a nine-line switchboard on the fire-control platform, an 11-line switchboard in the conning tower and 11 telephone instruments in different parts of the ship—namely, eight for the guns and one each for the fore bridge, aft bridge and fore-and aft-bridge. An accumulator of 180 ampere-hour capacity at 4 volts completes the equipment. Fig. 1 illustrates the switchboard in use on the fire-control platform.

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The whole board is enclosed in a special containing box made of zinc and brass with a watertight lid, having special tightening screws and a padlock. The switchboard is also enclosed in a metal frame which is arranged for ready removal so as to expose the connections. Within the box are a hand

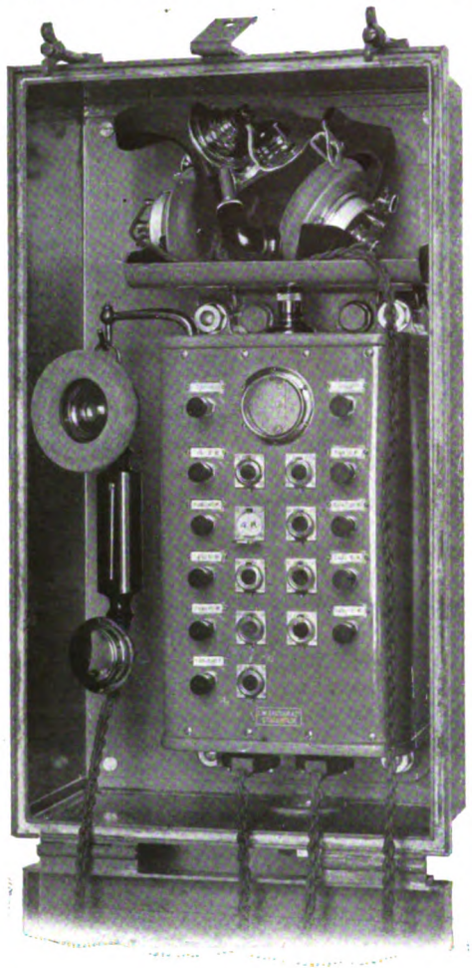

FIG. 1.—TELEPHONE SWITCHBOARD ON FIRE-CONTROL PLATFORM.

set with cord and plug, a breast transmitter with cord and plug and a headgear receiver with cap. In the illustration the latter may be seen on the shelf at the top of the box immediately above the switchboard. On the switchboard itself

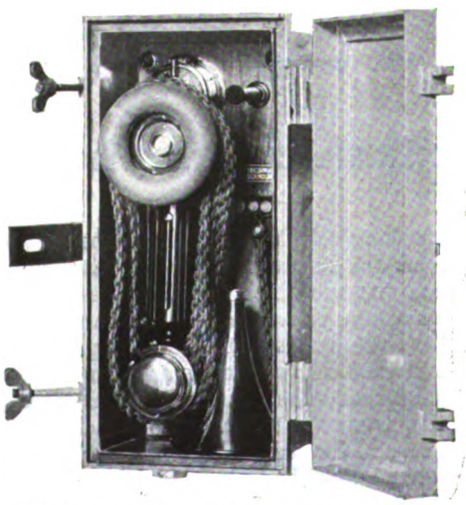

FIG. 2.—GUN TOWER TELEPHONE OUT OF USE.

are drop indicators with buzzer contacts, speaking switches, buzzer, buzzer switch, signal switch and switch-hook for hand set. At the back of the board are 32 line terminals with contact springs in groups of four terminals each. These are carefully marked to indicate the nature of each particular circuit.

The switchboard in the conning tower is similar to that illustrated for the fire-control platform, the principal point of difference being an additional number of keys and drops. There is also only a hand set for listening and speaking.

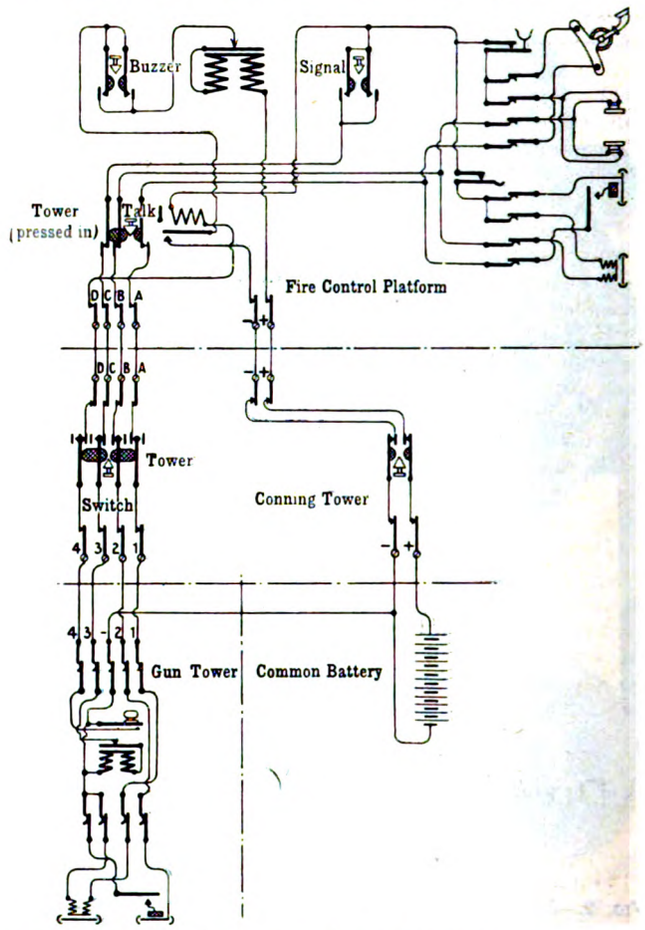

FIG. 3.—CONNECTION DIAGRAM FOR SPEAKING BETWEEN FIRE CONTROL PLATFORM AND GUN TOWERS.

The type of telephone instrument used in the gun towers is shown in Figs. 2 and 4. This comprises a hand set with cord and plug, a buzzer, a push for signalling to the conning tower

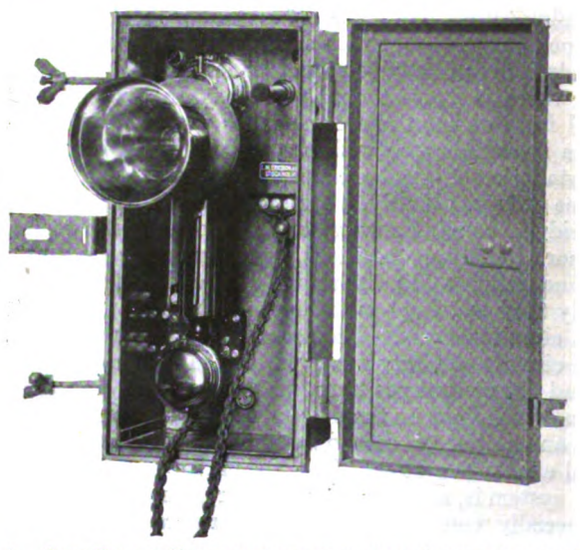

FIG. 4.—GUN TOWER TELEPHONE IN USE, WITH LOUD-SPEAKING HORN IN POSITION.

switchboard or the fire-control platform, and four-point jack and a loud speaking horn, which can be fitted into the centre of the receiver. The whole fitment is enclosed in a zinc and

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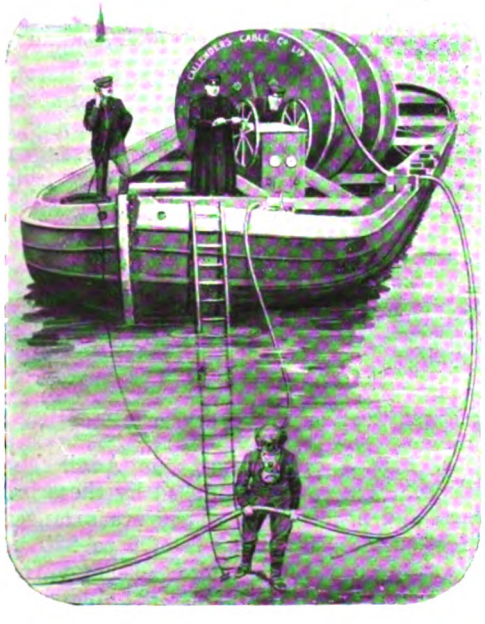
iron box, which can be made watertight by thumb screws. Fig. 2 shows the hand set and horn placed in the box when not in use, and Fig. 4 illustrates the apparatus as hung up for use.

In Fig. 3 a diagram is given of the speaking connections between the fire-control platform and the gun towers, and indicates how the various circuits are arranged for this particular communication. When calling up the gun tower from the switchboard on the control platform the speaking switch and the key of the number wanted are pressed down and a signal is given by pushing the switch marked "Signal." The answer from the gun tower is taken through the headgear receiver. When finished, the speaking key is placed in the normal position. In the gun tower itself the signal above mentioned starts a buzzer, the hand set is taken off the hook and placed in the usual position, and the listening key is pressed down. When it is only required to listen to the fire-control platform the horn is placed in the receiver and the hand set is left on the hook (*see* Fig. 4). The operations in the reverse direction—that is, the speaking between the gun tower and the fire-control platform—are equally simple. A signal is given from the gun tower and the answer is taken on the fire-control platform through the hand set. This signal is noticed on the fire-con trol platform by the fall of an indicator shutter. The buzzer circuit is closed and remains so until the shutter is raised. The speaking switch corresponding to the indicator is then pressed down and conversation commences. When finished, the speaking switch is returned to the normal position. It is also possible to communicate in both directions between the fire-control platform and the conning tower, and the conning tower can communicate with the other 11 telephone instruments when the switchboard on the fire-control platform is cut out. We are indebted to the British L. M. Ericsson Co. for the above details and illustrations.

A Diver's Electrical Life-Line.

An important part of every diver's equipment is the system of life-lines whereby communication can be effected from the bottom of the sea to the attendant boat. It is not surprising to find that the telephone has been largely used for this purpose. In the past this telephone communication with the diver has been established by means of wires laid up in the rubber air tube or by means of wires laid up in the hauling rope or life-line attached to the diver. In the former case, any fracture of the wires in the air tubes necessitated the purchase of new tubes, which was an expensive matter; in the case of the old life-lines, an extension of these, due to expansion or strain, resulted in the fracture of the telephone wires.

To combat these difficulties Callender's Cable & Construction Co. have designed a special diver's life-line, in which the telephone conductors consist of a number of small wires, giving great flexibility, and these are laid up on a central rubber core and insulated with high-class rubber. These insulated telephone conductors then form the centres of the strands of the manila life-line, with the result that such life-line can be stretched to breaking point before there is any fracture of the telephone wires. The ordinary standard rope supplied is tested to carry 1 ton.



MESSRS. CALLENDER'S CABLE & CONSTRUCTION CO.'S DIVER'S LIFE-LINE.

Marine Type Telephones.

It is not surprising to find that the telephone is just as useful on board ship as it is on land, though, owing to the much smaller space covered and the essentially different conditions in which the instruments work, it must, of course, vary in constructive details. Messrs. Gent & Co., of Leicester, have long paid a great deal of attention to this class of work, and in Fig. 1 we illustrate an instrument which is designed by them specially for ship use. It works on the central battery system with a lamp signal annunciator. By these instruments state rooms and saloons can be put into communication with the service departments of the vessel. The instruments consist of a combined transmitter and receiver of the Post Office type, contained in a polished teak case, along with the relay, press button and fixed cradle support. To call up, the button is pressed and lights a lamp signal on the exchange board. Direct the button is released the bell ceases to ring, but, on the other hand, the lamp remains alight until the plug is inserted into the jack by the exchange operator. Special features of this system as regards the exchange working are that there are no moving parts, while it is claimed that the

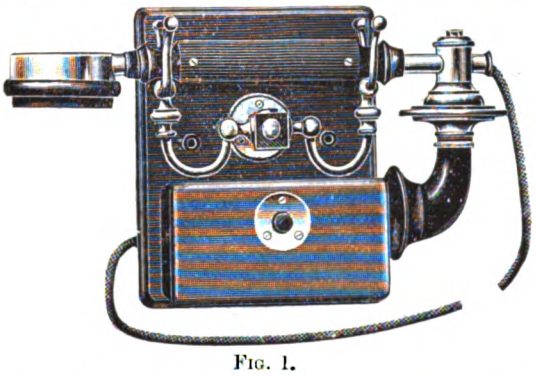


FIG. 1.

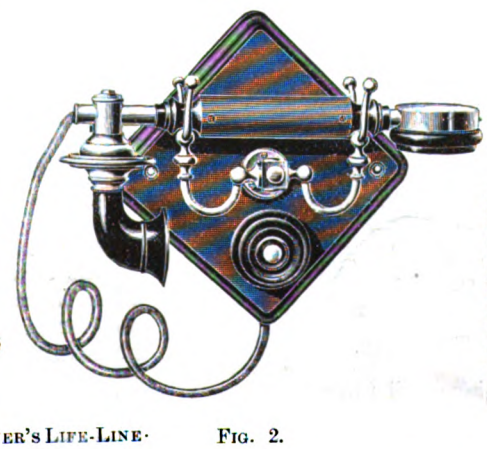


FIG. 2.

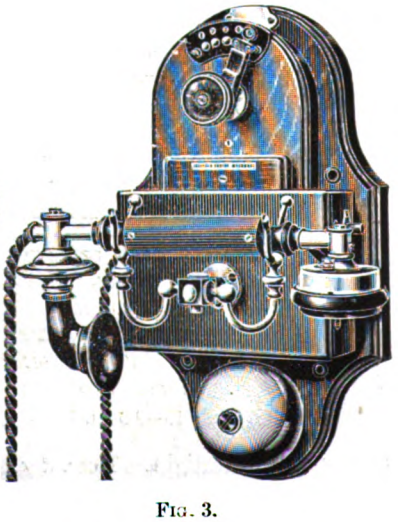


FIG. 3.

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apparatus is simple and reliable. The annunciator consists of a polished solid teak case, fitted with lamp signals for working on a 4-volt circuit, together with jacks, plug and board, as well as a call bell and the operators' combined instrument.

Another system, which has been designed by Messrs. Gent & Co., is one by which the ordinary bell indicator is used as an annunciator. Separate telephones, like the one shown in Fig. 2, are placed in the various state rooms and communicate direct with the indicator. This system has been recently installed on the ss. "Eskimo," recently built by Messrs. Thos. Wilson, Sons & Co. The advantage of the instrument is that the cradle carrying the combined instrument is fixed and is not of the rocking type, while the lines can be used for bell ringing without interfering with the telephone apparatus.

Another interesting telephone apparatus made by this firm is the Parsons-Sloper *secret* intercommunication telephone, Fig. 3. With these instruments conversation can be effected by direct calling without the delay of passing through an exchange. At the same time, it is claimed, there is no cross-talk when several couples are speaking, conversation being secret. A feature of this system, which should be found as useful on board ship as on land, is that immediately on ringing up and before speaking takes place the calling operator knows if the instrument is already engaged, if the attendant at the instrument is absent, and the moment the latter comes to speak.

Telephones in watertight metal cases are made for use on bridge or other exposed positions,

Adnil Ships' Telephones and Hooters.

In designing a telephone for use on board ship care must be taken so to arrange the apparatus that it suffers the minimum of damage from the constant vibration. It must also be

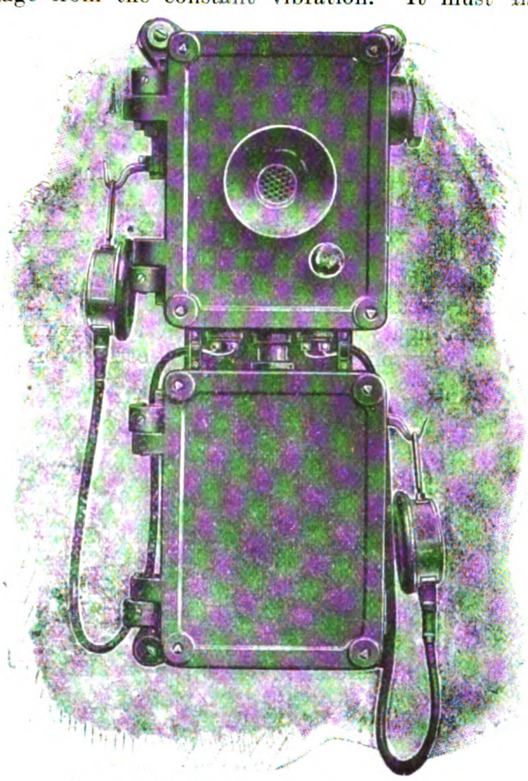

FIG. 1.—ADNIL CALLING TELEPHONE.

strong and watertight. Recently the Adnil Electric Co. have been considering these problems, with the result that they have produced an interesting instrument for telephonic purposes on board ship.

A high-frequency converter is used, consisting of a combined pole charger and transformer. This arrangement, which takes up very little room, is enclosed in the case of the calling telephone (Fig. 1) and serves the double purpose of calling generator and induction coil. A battery of two ordinary dry cells is contained in the lower part of the telephone. Pressing the calling push connects the primary side of the vibratory converter to the two-cell battery. The converter transforms this direct-current supply of about 3 volts into an alternating current of 35-40 volts which is sent out to line. The alternating current being of a very high frequency causes the receiver of the "called" instrument to emit a loud hoot or blast. This is sufficient to attract the attention of the wanted party, who then merely waits for the

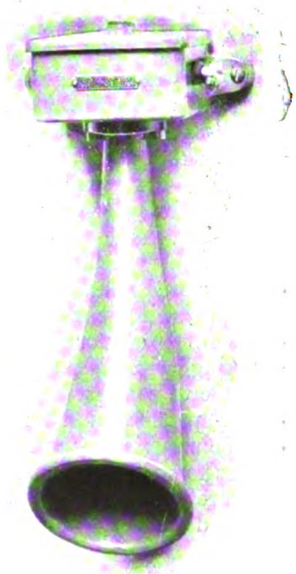

FIG. 2.—ADNIL RECEIVING TELEPHONE. FIG. 3.—ADNIL ELECTRIC HOOTER.

message. It is not necessary for him to go nearer than two or three yards from his telephone, as the words spoken into the transmitter of the "calling" telephone are loudly reproduced by the receiver of the "called" telephone, whilst any words spoken by the "called" party within a distance of a few yards of his transmitter are clearly audible in the receiver of the "calling" instrument. The "called" or "receiving" telephone shown in Fig. 2 is mounted on a cast-iron pedestal, the top aperture being the combined hooter and loud-speaking receiver, and the lower one the transmitter. In this way, loud speaking is obtained with a small current, an arrangement which possesses the advantage that "caking" or "frying" in the transmitter is avoided.

FIG. 4.—ANOTHER TYPE OF ADNIL ELECTRIC HOOTER.

The illustrations, Figs. 3 and 4 show the Adnil electric hooters for ships' use. The sound produced by these instruments is very loud and penetrating. They are arranged to work from a direct-current supply of from 3 to 220 volts. These instruments are actuated by a high-frequency vibratory generator somewhat similar to that used in the loud-speaking telephones. From a supply of anything between 24 and 220 volts, one vibratory generator is capable of actuating simultaneously as many as eight large cast-iron hooters installed in different parts of the ship. The hooters are all connected up in series with the secondary terminals of the generator, and are actuated by one press button or switch fitted in any convenient place in the ship or on the navigating bridge, and subject to the control of the officer in charge.

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Ships' Telegraphs.

To take the place of the mechanically connected instruments at present in use, an electric engine-room telegraph has been placed on the market by Messrs. Siemens Bros. & Co., who claim that this apparatus embodies several advantages over the mechanical type of apparatus.

Any number of order-giving instruments can be employed, which only require the movement of a switch to change the control from one to any of the others. This can be done instantly, without regard to the relative orders appearing on the different transmitters, the engine-room instrument immediately registering the order appearing on the transmitter to which it is connected. This, of course, is not possible with the mechanically connected apparatus, and can only be effected by positive action instruments such as the one in question. The system of transmission is the same as that used in the Siemens gun fire control apparatus, which has been largely used in the service and gives every satisfaction; by this system there is only one position possible for the pointer on the engine-room instruments for each position of the handle on the bridge instrument.

The transmission is independent of the speed of movement of the transmitting handle, and can be accomplished instantly by moving the handle from one order to another. This is an advantage over the mechanical type. Moreover, the receiver pointer stops absolutely definitely on the centre of the order space on the dial, irrespective of the distance between sender and receiver, with no possibility of interference due to backlash.

The instruments on the bridge and in the conning towers have reply pointers actuated from the engine-room instruments. The position of this pointer will immediately register the last order given to the engine room, on changing the control from one instrument to another. Fig. 1 shows the instrument which is intended to be installed in the engine room.

In H.M.S. "Triumph" and "Swiftsure," as well as in many ships of the Japanese Navy, a complete system of steering telegraphs has been provided by Messrs. Evershed & Vignoles, in addition to the standard helm indicator gear described elsewhere in this issue. The system of circuits fitted in the "Swiftsure" is shown in the accompanying diagram, Fig. 2. It will be noticed that there are three hand transmitters, any one of which can work either of the receivers fitted at the hand or steam-steering stations while the receiver in the forward steering position can only be actuated by one of the two forward transmitters. The hand transmitters are usually mounted on deck pedestals, as shown in Fig. 3, illustrating an actual instrument fitted in the "Swiftsure" (then the Chilian ship "Constitucion"). They work on precisely the same principle as the automatic transmitters, differing merely in details of construction, and in the fact that the switch is moved by hand instead of automatically through the coupling rods. The transmitters can be fitted with illuminated dials, if required, and the switch for the illuminating lamp (fitted inside the instrument shown on the dial of the hand transmitter immediately below the central spindle.

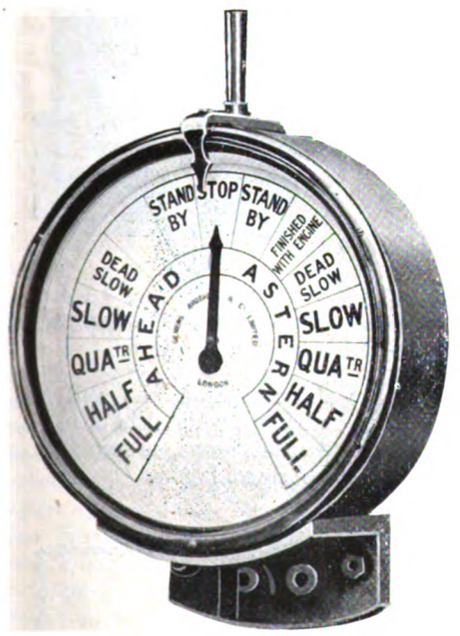

FIG. 1.—SIEMENS ENGINE ROOM TELEGRAPH (ENGINE ROOM INSTRUMENT).

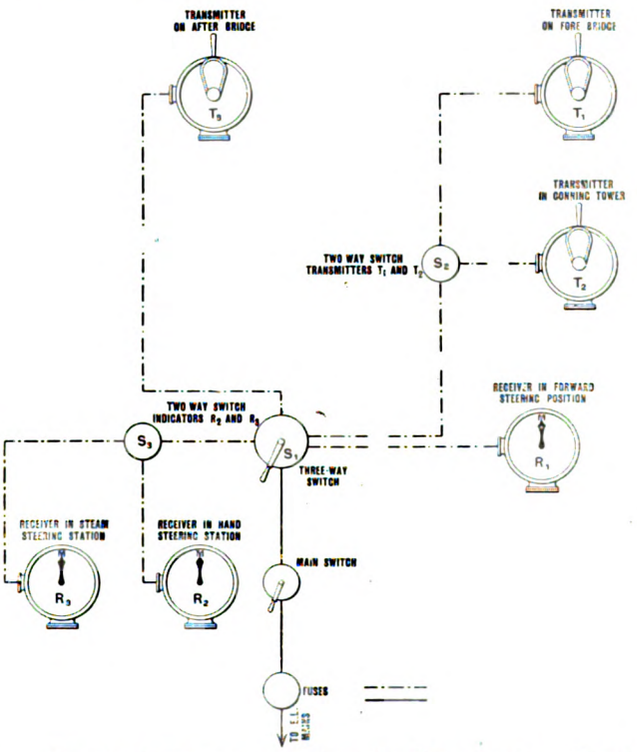

FIG. 2.—CONNECTIONS OF STEERING TELEGRAPH: H.M.S. "SWIFTSURE."

FIG. 3.—ILLUSTRATION OF HAND TRANSMITTER: CHILIAN SHIP "CONSTITUCION" (H.M.S. "SWIFTSURE").

Flashing Lamp for Night Signalling.

The Morse code is used at sea for night signalling, and with a suitable lamp and key a series of rapid flashes can be given. Where a ship is not wired for electric light a shutter must be used in front of an oil light, to send the flashes; but this method is slow and clumsy. The incandescent electric lamp, and especially the metal filament pattern, affords the seaman just the right type of illuminant for Morse signalling. The Wightman flashing lamp, made by Wm. McGeoch & Co., Glasgow, utilises a metal lamp for signalling and a carbon amp as a resistance and a source of light for two sunk glasses

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engraved with the Morse alphabet. The metal lamp is enclosed in a lantern fitted with a circular dioptric lens. The lamp-holder is fixed to a removable brass tray in the bottom of the lantern, the tray being secured by two locking screws. A stout flexible cord connects the lamp with the Morse key, which is enclosed in a watertight box (Fig. 1). This box also provides for the insertion of a two-pin plug which serves to lead in the current from any convenient lamp-holder.

The key projects from the front of the box (Fig. 2) and it may be operated by hand or foot as required. The alphabet is illuminated by the carbon resistance lamp already mentioned, and the metal lamp in the lantern is normally always at a dull glow. When signalling, the depression of the key cuts out the carbon lamp and puts the metal lamp on full voltage. The effect is that the flashes are checked on the illuminated alphabet box by the action of the carbon resistance lamp. Further, the life of the metal lamp is increased because a small amount of current is always flowing, thereby heating the filament to a slight extent.

The entire equipment is extremely simple, as no condenser is necessary; the current consumption is also very low. The lamp has, we understand, been thoroughly tested at sea, and the signals can be distinguished to distances of 10 and 15 miles. Messrs. McGeoch have fitted upwards of 40 ships with this flashing apparatus. They are also makers of the well-known Duplex Patent Ships' Light Indicator, which has been specially designed for use with twin filament lamps, as recommended by the Board of Trade for ships' signal lamps.

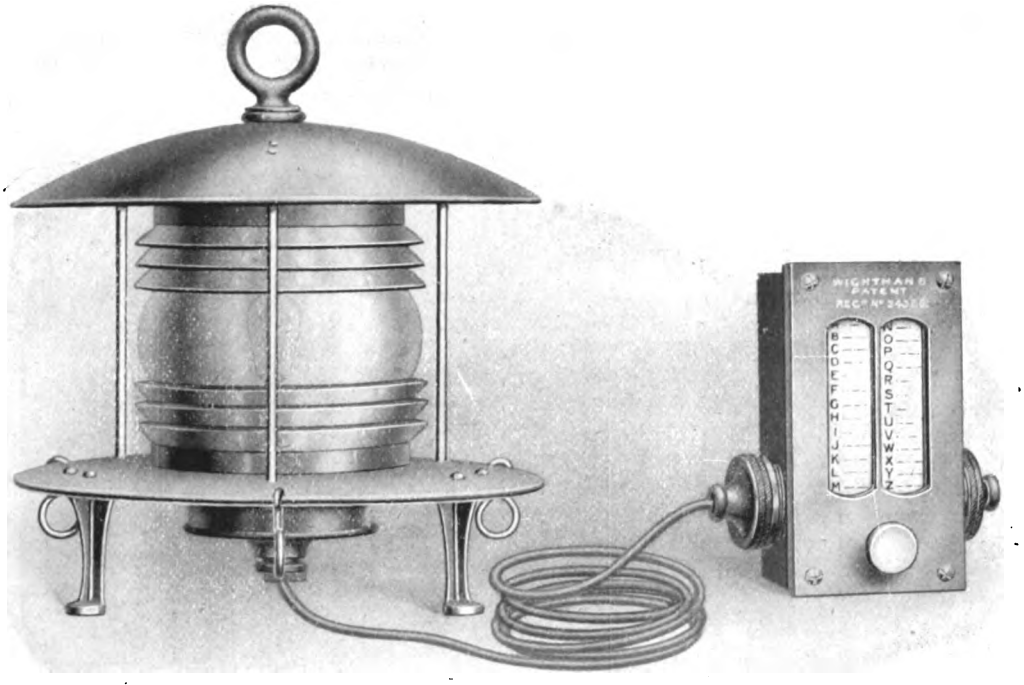

FIG. 1.—WIGHTMAN FLASHING LAMP WITH FLEXIBLE CORD AND SIGNALLING BOX.

FIG. 2.—MORSE KEY FOR USE WITH FLASHING LAMPS.

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Wireless Telegraphy for Marine Inter-Communication.

BY W. W. BRADFIELD.
(Of Marconi's Wireless Telegraph Co., Ltd.)

Summary.—After discussing the advantages and progress of wireless telegraphy for marine purposes, the author describes the Marconi plant used on board ship in detail. This may be classified as transmitting, receiving and emergency apparatus. In conclusion, particulars are given of the number of naval and mercantile marine stations in operation in the various countries.

Wireless telegraphy is now regarded as an essential part of the equipment of large ocean-going passenger vessels. It has reached this position partly through the sensational evidence afforded by the incidents of the ss. "Republic" and the ss. "Slavonia" as to how invaluable it may prove to ships in distress, but mainly through the experience gained regarding the general usefulness of an extended means of marine communication. Numerous cases have been published from time to time showing how passengers have made use of the facilities for sending messages to and from ships on the Atlantic and other routes. In the professional circles of the mercantile marine, however, more importance is attached to the fact that wireless telegraphy has destroyed the isolation of ships at sea. Apart from the anxieties thus relieved and the risks of loss and delay thus diminished, there are many economies, in connection with embarkation and disembarkation, which may be arranged when messages can be sent to ships at any point on their course. These points need not be laboured. The fact that in Lloyd's Register each ship carrying wireless apparatus is specifically marked, and that a special section of such ships has been added, shows that wireless telegraphy has attained an assured position among shipowners and underwriters.

Recent progress to this position has been very rapid. At the beginning of 1909 (after eight years of development) there were 125 ships of the mercantile marine fitted with Marconi apparatus. At the end of 1909 the number had risen to nearly 300, and at the present time the total is about 350, and is continuing to increase at a high rate. This increase has been accompanied by a marked development in the number of land stations erected, in course of erection and under consideration. And, apart from these conspicuous developments, the use of wireless telegraphy has become practically universal in our own and other navies, having been extended from battleships and cruisers to destroyers and submarines. There is every indication that what is now standard practice in the Navy will tend to become so in the mercantile marine—that is to say, the example set by the leading passenger steamship lines will be followed by all ocean-going and Channel passenger boats and also by cargo boats. The advance will probably be cumulative, as each installation on sea or land increases the value of the service to every ship making use of it.

It is interesting at this stage to survey the progress made on the principal trade routes.

North Atlantic.—This is the route where wireless telegraphy has been most developed, owing in a large measure to the chain of shore stations established by the Marconi Company in Great Britain, Canada and the United States. All the leading vessels plying between European ports and North America are equipped, the total being 130, belonging to British, French, German, Dutch, Italian, United States and Greek companies. Under an agreement made last year, the shore stations of the Marconi Company in Great Britain passed into the hands of the Post Office, with the exception of the high-power stations at Poldhu and Clifden, the former being used for the transmission of news to Atlantic liners and the latter for the trans-Atlantic service.

South Atlantic.—The great route between Europe and South America comes next in order of importance. Eighty-five ships are already equipped, owned by the Royal Mail Steam Packet Co., the Koninklijke Lloyd, and the principal Italian companies. With the completion of the long-range station at Coltano and the erection of shore stations in Brazil and the Argentine, further developments in this important trade route are certain to take place. Coast stations have been erected at Guaratiba, Ponta Negra, Ilha Raza and Rio de

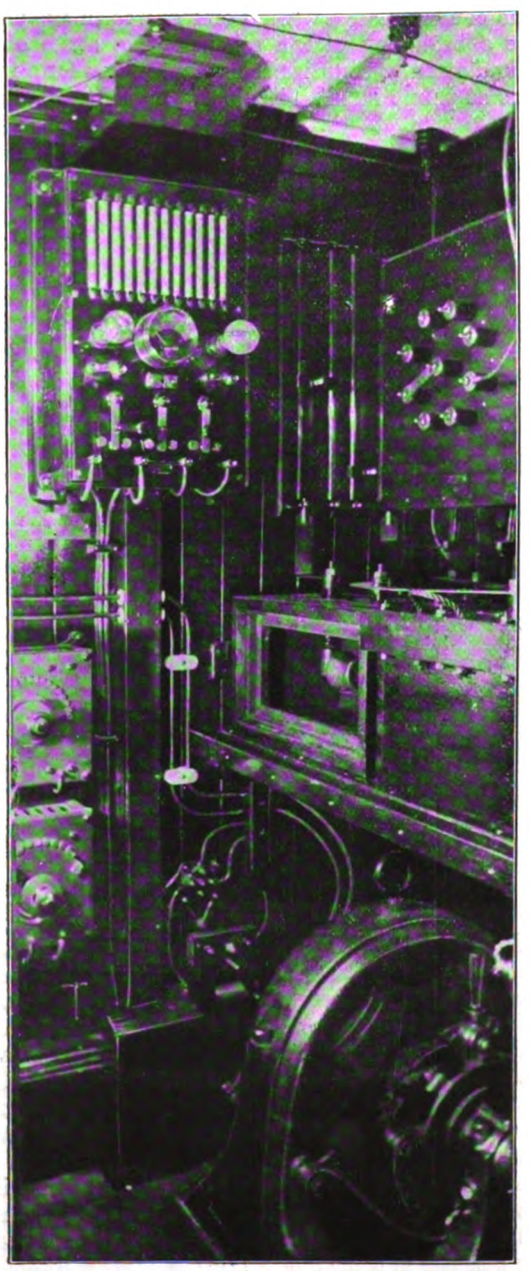

FIG. 1.—TRANSMITTING CABIN ON SS. "LUSITANIA."

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Janeiro, in Brazil; at Punta del Este, in Uruguay; and at Bernal, in Argentina, on the River Plate.

South African.—Substantial progress has been made on this route. The Aberdeen Direct Line (Rennie Brothers) has used wireless telegraphy for some time, and the Union Castle has made a start with the ss. "Balmoral Castle." A Marconi station is in course of erection at Durban, and when it is ready the White Star liners in the New Zealand service will be fitted. The White Star Australian boats are all being equipped. Further advances will follow the erection of shore stations by the Cape Government.

Eastern Route.—The potentialities of wireless telegraph developments on the great route through the Mediterranean to India, China and Australasia are enormous. Eleven P. & O. vessels and 16 Dutch vessels trading to Java are already fitted with Marconi apparatus. The ss. "Otranto," of the Orient Steam Navigation Co., is the first ship of this line to carry an equipment, and it is intended to fit the entire fleet during the coming season. The Commonwealth Government has made a beginning with a scheme for a series of shore stations, and arrangements are being undertaken for a number of stations at points intermediate between Australia and this country.

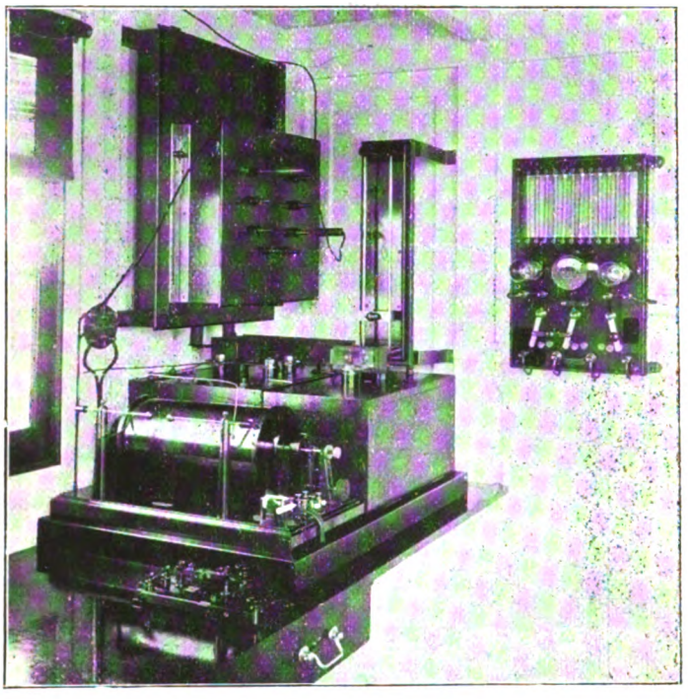

FIG. 2.—EQUIPMENT ON SS. "ONWARD."

The development of regular communication between an increasing number of moving stations has necessitated not only a carefully devised organisation, but a uniform method of working. This, in turn, has necessitated a practical standardisation of apparatus. At the same time, the demand for absolute reliability in the hands of ordinary operators has led to the evolution of a type of apparatus which is free from complications and is constructed to work continuously without derangement. From the accompanying illustrations it will be observed that most of the working parts are contained in solid boxes, which protect them from damage and limit the responsibilities of the operator to superficial adjustments and the ordinary business of receiving and transmitting messages. The advance in electrical design has been accompanied by a close attention to mechanical detail, with the result that failure on the part of the apparatus itself is practically unknown.

WIRELESS APPARATUS.

These points will emerge more clearly from the following detailed description of the standard 1½ kw. Marconi set usually installed on ships. The everyday transmitting range of these sets varies from 70 to 300 nautical miles, according to the height, length and shape of the aerial, these factors being determined in turn by the dimensions of the ship; while the night range may be anything from two to three times the day range, according to the conditions of the atmosphere. They are designed to produce waves of 300 and 600 metres, with a simple change-over; and the receiving apparatus provides for tuned reception of all waves between 100 and 2,500 metres, the range of reception depending upon the aerial available and the power of the corresponding station.

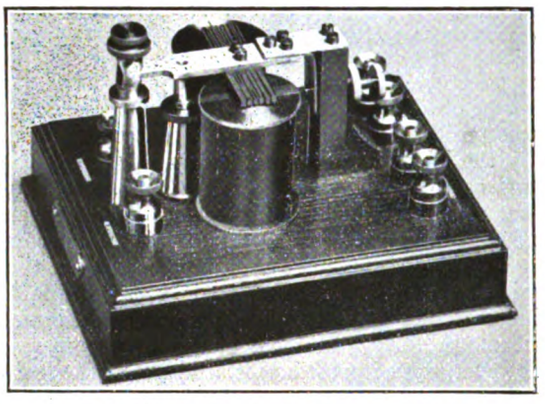

FIG. 3.—GRAY MAGNETIC RELAY KEY.

Current (D.C.) is obtained from the ship's mains and led to a rotary converter, which supplies alternating current to the main terminals of a switchboard. (Emergency apparatus is always installed for working off a battery of accumulators in the event of the ship's supply failing—as was the case with the "Republic" after the collision.) The converter is designed to give an output of 1½ kw., and to take current from the direct-current supply available. It has four poles, and runs at 1,500-1,800 revs. per min., with a frequency of 50 to 60 periods. Variation in speed is obtained by the field regulator.

Transmitting Apparatus.—The low-frequency circuits consist of an adjustable inductance, the coils of a magnetic relay

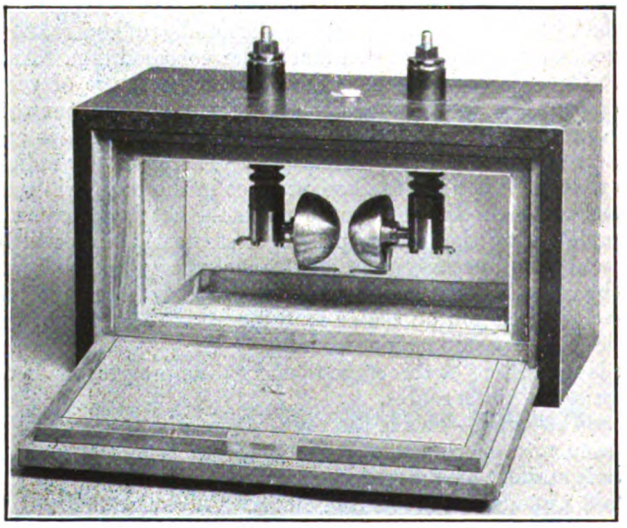

FIG. 4.—SPARK DISCHARGER IN BOX.

key, and the primary of a potential transformer connected in series and then to the two-line terminals of the switchboard. This circuit is opened and closed by the main switch, and operated by a Morse key actuating electrically the relay key. (Figs. 1, 2 and 3.)

The secondary of the potential transformer connects at the discharger through two air core protecting chokes with the primary high-frequency circuit. The transmitting condenser is connected to one side of the discharger and primary high

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frequency tuning inductance to the other side. Between them is connected the primary of an oscillation transformer or transmitting jigger. The secondary of this transformer is connected at one end to the aerial and at the other to the top plate of a micrometer spark-gap, the bottom plate being "earthed" by connection with the iron shell of the ship. A tuning lamp and choke are put in shunt with a short length of the wire connecting the jigger secondary to the micrometer spark-gap. The transmitting set is completed by an aerial tuning condenser, which is used only when it is necessary to decrease the natural period of the aerial circuit in the transmission of the 300-metre wave.

Receiving Apparatus.—The connection of the receiving apparatus with the aerial circuit is made at the top plate of the first micrometre spark-gap. From here a lead is taken to the

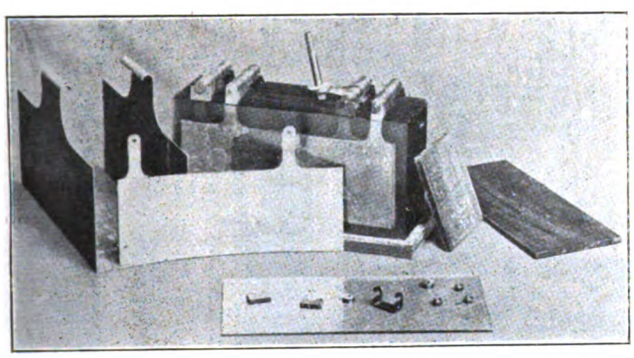

FIG. 5.—INDEPENDENT GLASS PLATE CONDENSER PARTS.

aerial terminal of the tuner, the earth terminal of the tuner being connected to the bottom plate of the micrometer spark-gap.

The primary terminals of a magnetic detector are connected to the tuner, and the secondary terminals to a telephone and shunting telephone condenser.

Emergency Apparatus.—In this a battery of accumulators, charged by the ship's dynamo, provides current to work an induction coil. A separate key is used for operating; or, in the cases where a special change-over switch is provided, one key is used for operating both circuits.

Spark Discharger.—The mushroom-shaped electrodes, which are of cast iron, are mounted on ebonite insulated brass rods and placed in a teak silence box lined with asbestos and lead. (Fig. 4.) Lime is placed in a removable zinc tray to absorb the acid produced by the spark. The gap is adjusted by turning the electrodes on their threaded brass supports. A protective point spark-gap shunting the main gap is set for a fixed gap to protect the condensers against excessive voltage.

Half-plate Condenser.—This is in two parts, each with 36

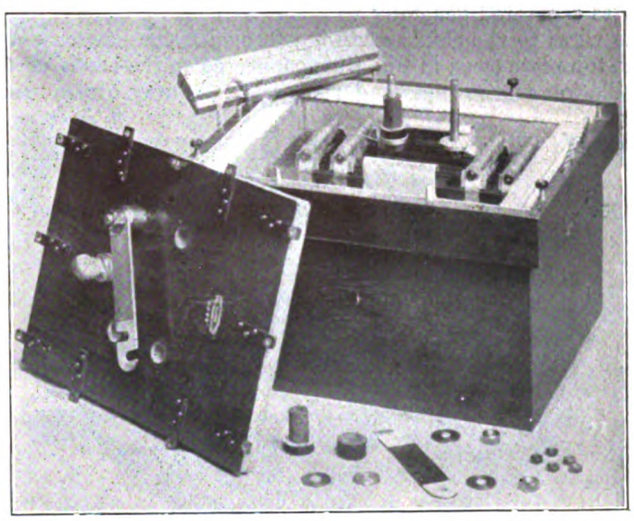

FIG. 6.—INDEPENDENT GLASS PLATE CONDENSER IN CASE, PARTIALLY ASSEMBLED.

glass plates interspaced with 35 sheets of zinc. Ninety-four plates are active, the others being guard plates. They are $\frac{1}{16}$ in. thick, and are individually tested to 27,000 volts. The container is filled with high-flash insulating oil. For the short wave the two parts of the condenser are connected in series, and have a capacity of about 0·016 mfd. With the long wave, in parallel, the capacity is about 0·065 mfd. The condenser is seen in Figs. 5 and 6.

Variable Coupling Oscillation Transformer or Transmitting Jigger.—The primary and secondary windings are provided respectively by two coils of heavily insulated wire, the former

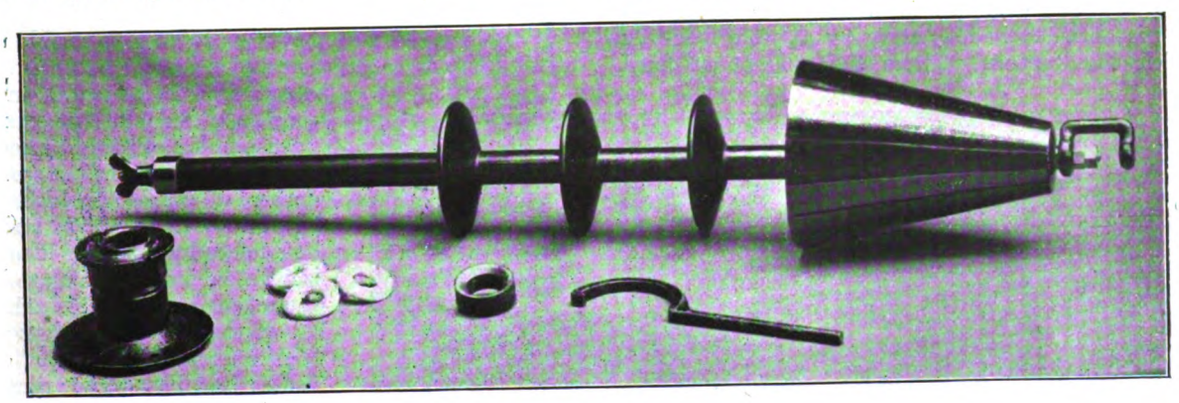

FIG. 7.—BRADFIELD INSULATOR.

The aerial lead-in is connected, by means of a flexible wire, to a socket on an insulating pillar, which in turn is connected to one end of the induction coil secondary, the other end of which is connected to earth. When receiving, the aerial terminal of the tuner is connected by a flexible and plug to the socket on the insulating pillar.

DETAILS OF APPARATUS.

A full description of the details of the apparatus would occupy too much space, but the following particulars include the salient points about the more important parts of the transmitter

of one turn and the latter of seven turns. It is at this point that the wave-generating and wave-radiating circui s are coupled together. For the purpose of adjusting the coupling between the circuits the secondary is made to slide laterally over the primary. On each oscillation transformer is a scale which gives approximately the percentage coupling between the two windings.

Aerial Tuning Inductance.—Tappings are made at various points on 20 turns of insulated wire and brought to eight insulated terminals in front of the box.

Aerial Lead-in.—This is a $\frac{1}{2}$ in. metal rod in a long ebonite

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tube, which passes through a cast-iron gland fixed on the roof of the cabin. A zinc cone is fitted to the external end of the rod to ensure that a considerable length of the ebonite will remain dry in all circumstances. A shackle head on the cone takes the strain of the aerial, and prevents the connection being worked loose by the vibration of the aerial wire. Three ebonite discs spaced along the external part of the ebonite tube prevent surface sparking in event of heavy weather causing the insulator to be wet with salt spray. (Fig. 7.)

Earth Arrester Terminal.—This consists of two round brass plates separated generally to about 0·01 in. by discs of mica. The wires to the ship's earth connect with the bottom plate. The top plate (seen in Fig. 8) is connected to the earth of the oscillation transformer and the aerial terminal of the tuner.

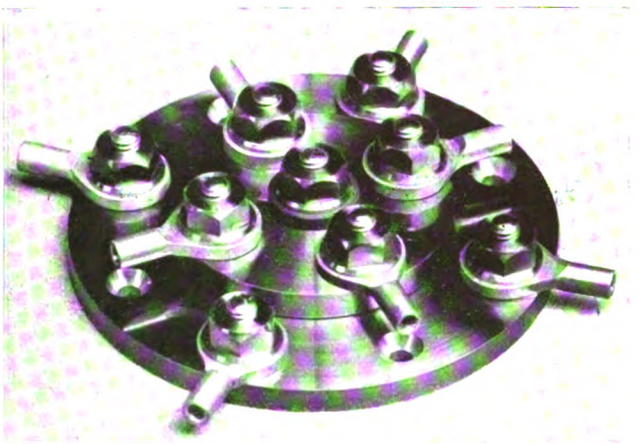

FIG. 8.—EARTH ARRESTER TERMINAL.

When transmitting, the top plate sparks on to the bottom plate and connects direct to earth. When receiving, the top plate remains insulated and the aerial oscillations find their way to earth through the tuner. The terminal, while serving as an automatic switch, also provides protection for the aerial against lightning.

Multiple Tuner.—A means of tuning to the incoming signals of one given wave-length, and eliminating the signals of all other wave-lengths, is provided by three inductively coupled adjustable circuits, the first connected to the aerial and the third to the magnetic detector. The full range of 100 to 2,500 metres is obtained in four steps by a triple four-way switch, which simultaneously alters the amount of fixed inductance and capacity in each circuit. Accurate tuning is obtained by an adjustable tuning inductance and variable condenser in all circuits. Injury to the instrument when transmitting is prevented by a micrometer spark-gap, which automatically shunts the aerial terminal to earth.

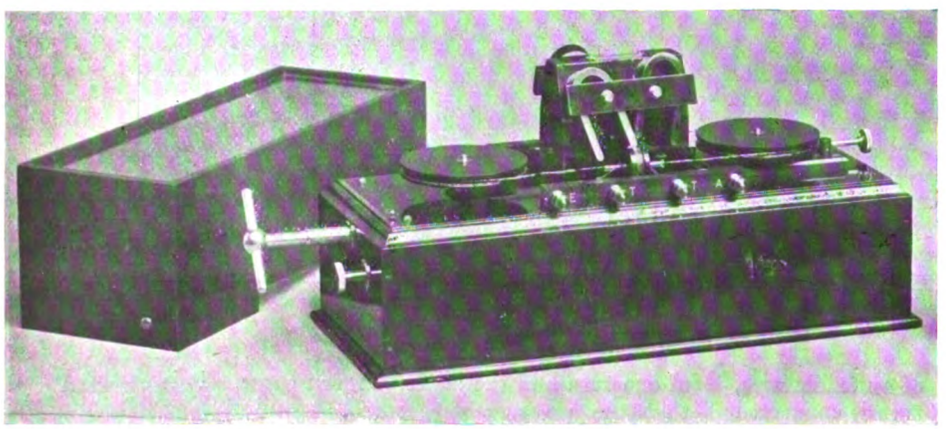

FIG. 9.—MAGNETIC DETECTOR.

Magnetic Detector.—This instrument has been described so often that particulars would be superfluous. It may be mentioned that for the greatest intensity of signals the two permanent magnets should be placed with like poles together over the coils. This arrangement, however, introduces a low noise in the telephone termed " breathing." If the magnets are placed with unlike poles together, one of them well down on the coils and the other with its inside limb at a certain distance up the inside limb of the first magnet (the correct position being found by test), the " breathing " becomes negligible, at the expense of a very slight decrease in the intensity of the signals. The detector is seen in Fig. 9.

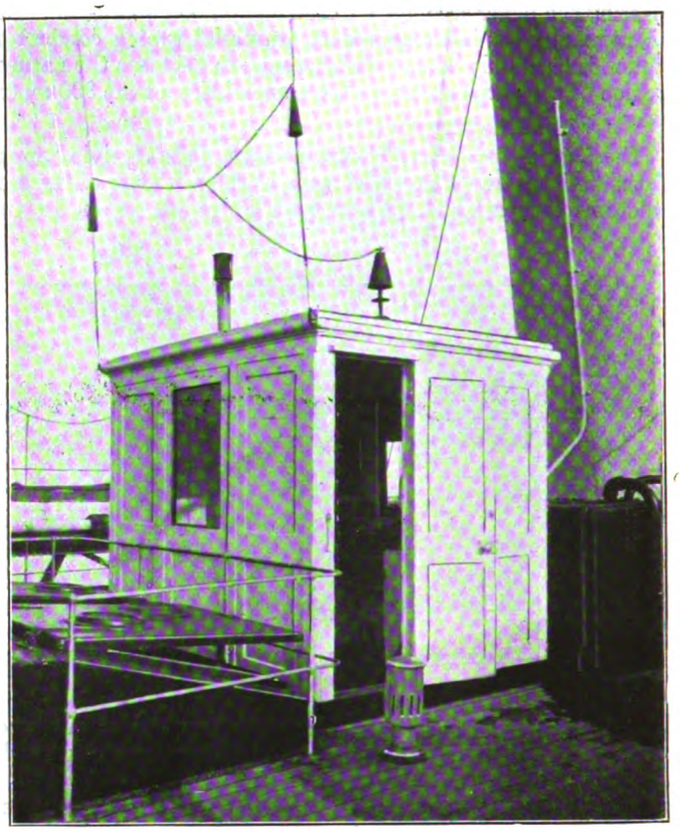

FIG. 10.—WIRELESS CABIN ON SS. " ONWARD."

Wavemeter.—A wavemeter is provided to enable the transmitting circuit to be correctly adjusted to the international waves of 300 and 600 metres. It consists of an inductance coil with a fixed number of turns connected to an adjustable condenser. Across the condenser is shunted a high resistance asymmetrical crystal in series with a double-head telephone. The condenser is adjusted until signals are loudest in the telephone. A table affixed to the lid of the wavemeter gives the wave-length corresponding to each condenser reading. The range of the standard apparatus is from 200 to 800 metres.

Aerials and Aerial Insulators.—Bare silicon bronze wires are used for the aerials. The overall dimensions depend on the design of the ship. In shape the aerials are either a twin L or a twin T, the spacing between the twins being 12 ft. A 12 ft. 6 in. ash spreader usually supports the aerial at each end. The spreader has two bands, each with two lugs, one taking an aerial strain insulator and the other one leg of the spreader bridle, the bight of the bridle being in turn made fast to the halyard. The strain insulator commonly in use for

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short aerials is 3 ft. long and circular in section, composed of Palmer cord encased in rubber and vulcanised. It is designed for a working load of 10 cwt. and a breaking load of 30 cwt. Long aerials are supported on larger insulators in the same manner. Each insulator is covered with a special insulating

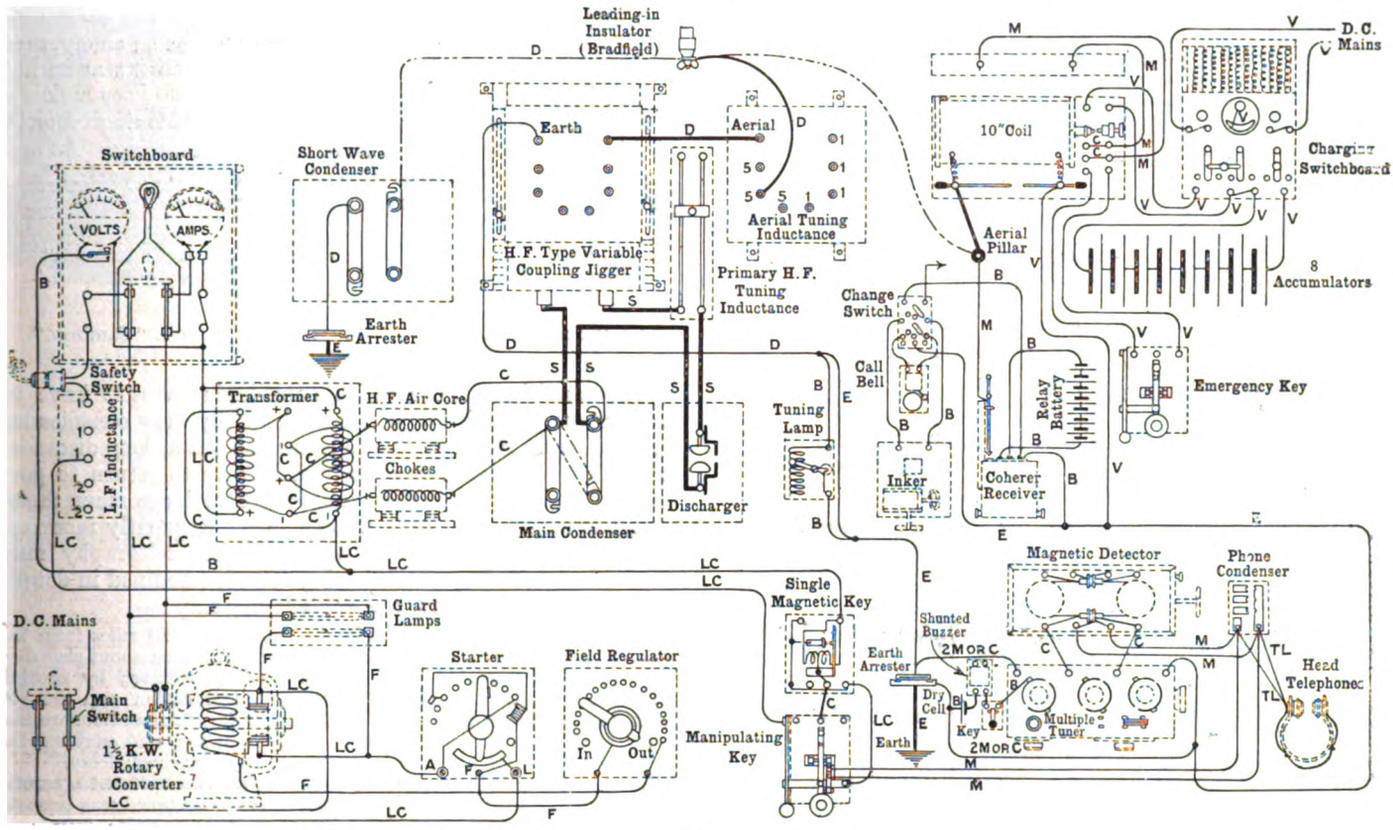

FIG. 11.—CONNECTIONS OF 1½ KW. CONVERTER SET.

Reference to Wiring: LC=⅛ Lead Covered. F=¼ Lead Covered. M=Silk Marone Flex. C=No. 10 Bare Copper. B=Bell Wire.
S=H.F. Copper strip connectors. D=Dynamo Flex. E=Earth Wire. TL=Telephone Leads. V=⅛ I.R.V.B. Cable.

preservative compound to protect the rubber and furnish a non-hygroscopic surface. The arrangement is seen in Fig. 10.

Fig. 11 is a diagram showing the connections of wireless equipment on board ship.

WIRELESS TELEGRAPHY IN OPERATION.

It is practically impossible to give any idea of the extent to which wireless transmission is in operation, not only on passenger vessels, but in the case of cargo boats, cable-laying vessels, lightships, private yachts and other classes of vessel apart from the navies of the world. But the following list of the communications effected day by day in the case of a typical Atlantic vessel will indicate the importance of wireless telegraphy in one of its most conspicuous phases—a trans-Atlantic voyage on a large liner :—

Tuesday, May 3rd.

5.0 p.m.	Ship left landing stage.	
6.55 p.m.	Communicated with	"Cymric."
7.45 p.m.	,,	Rosslare.
7.50 p.m.	,,	"Megantic."
8.6 p.m.	,,	"Campania."
11.30 p.m.	,,	Liverpool.

Wednesday, May 4th.

12.30 a.m.	Communicated with	Rosslare and Liverpool
1.0 a.m.	Receiving Press from Poldhu.	
2.0 a.m.	Communicated with	Rosslare and "Megantic."
2.40 a.m.	,,	Scheveningen.
3.15 a.m.	,,	"Cymric."
4.45 a.m.	,,	Crookhaven.
6.50 a.m.	,,	"Majestic."
7.30 a.m.	Arrived Queenstown.	
9.5 a.m.	Communicated with	Crookhaven.
9.40 a.m.	,,	Ryndam.
10.25 a.m.	,,	"Sardinian."
11.51 a.m.	,,	"Cymric" and "Monmouth."
12 Noon.	,,	Crookhaven.
12.56 p.m.	,,	Crookhaven.
1.20 p.m.	,,	"Iroquois" and Crookhaven.

Wednesday, May 4th.—continued.

1.40 p.m.	Communicated with	Ryndam.
8.0 p.m.	,,	Crookhaven.
10.40 p.m.	,,	Crookhaven.
11.20 p.m.	,,	"La Bretagne."
11.56 p.m.	,,	Crookhaven.

Thursday, May 5th.

12.45 a.m.	Communicated with	"Sardinian" and Crookhaven.
1.0 a.m.	Receiving from Poldhu.	
3.5 a.m.	Communicated with	Crookhaven.
3.20 a.m.	,,	"La Bretagne."
3.45 a.m.	,,	"Victorian."
4.0 a.m.	,,	Crookhaven.
4.10 a.m.	,,	"Sardinian."
8.0 a.m.	,,	"Cymric."
8.50 a.m.	,,	"Cymric."
9.6 a.m.	,,	"La Bretagne."
9.30 a.m.	,,	"La Bretagne."
10.0 a.m.	,,	"La Bretagne."
11.40 a.m.	,,	"Cincinnati."
2.30 p.m.	,,	"Cincinnati."
2.32 p.m.	,,	"Victorian."
4.5 p.m.	,,	"Kaiser Wilhelm der Grosse" and "Cincinnati."
4.15 p.m.	,,	"Numidian."
5.30 p.m.	,,	"Mount Temple."
6.19 p.m.	,,	"St. Paul."
7.15 p.m.	,,	"Mount Temple."
8.30 p.m.	,,	"Mount Temple."
9.30 p.m.	,,	"Mount Temple."
10.40 p.m.	,,	"St. Paul," "Victorian," and "Kaiser Wilhelm der Grosse."
11.40 p.m.	,,	"Cincinnati."

Friday, May 6th.

12 Mid.	Communicated with	"Cedric."
12.55 a.m.	,,	"St. Paul" and "Victorian."
1.0 a.m.	Receiving from Poldhu.	
2.50 a.m.	Communicated with	"Cedric."
3.0 a.m.	,,	Scheveningen.
3.5 a.m.	,,	"Amerika."
3.12 a.m.	,,	"Kaiser Wilhelm der Grosse."
3.15 a.m.	,,	"Cedric."
3.20 a.m.	,,	"Graf Waldersee" and "Kroonland."
3.50 a.m.	,,	"Victorian."
4.40 a.m.	,,	"Cedric."
8.40 a.m.	,,	"Kaiser Wilhelm der Grosse."

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Friday, May 6th.—Continued.

9.20 a.m.	Communicated with	"Kaiser Wilhelm der Grosse."
11.25 a.m.	,,	"New York."
12.6 p.m.	,,	"Cedric."
2.55 p.m.	,,	"Kaiser Wilhelm der Grosse."
8.45 p.m.	,,	"Kronprinz Wilhelm."
9.40 p.m.	,,	"Kaiser Wilhelm der Grosse" and "Kronprinz Wilhelm."
11.50 p.m.	,,	"Kaiser Wilhelm der Grosse."

Saturday, May 7th.

1.0 a.m.	Receiving from Poldhu.	
3.1 a.m.	Communicated with	"Kaiser Wilhelm der Grosse," "Kronprinz Wilhelm," and "Graf Waldersee."
5.0 a.m.	,,	Cape Race.
7.30 a.m.	,,	"Kaiser Wilhelm der Grosse."
8.0 a.m.	,,	"Kronprinz Wilhelm."
11.55 a.m. E.S.T.	,,	"Chicago."
11.35 a.m.	,,	"Kaiser Wilhelm der Grosse."
12.10 p.m.	,,	"Carmania."
12.25 p.m.	,,	"Carmania."
12.38 p.m.	,,	"Zeeland."
7.30 p.m.	,,	"Prinzess Irene."
7.40 p.m.	,,	"George Washington."
9.40 p.m.	,,	"Adriatic."
10.0 p.m.	Receiving from Cape Cod.	

Sunday, May 8th.

12.10 a.m.	Communicated with	"La Lorraine."
12.35 a.m.	,,	"President Lincoln."
12.47 a.m.	,,	Cape Race.
1.5 a.m.	,,	"Adriatic."
2.35 a.m.	,,	"Kaiser Wilhelm der Grosse."
3.17 a.m.	,,	"Oceanic."
3.46 a.m.	,,	"President Grant."
7.12 a.m.	,,	"Argentina."
8.56 a.m.	,,	"La Lorraine."
8.40 a.m.	,,	"Martha Washington."
8.41 a.m.	,,	Cape Race.
8.53 a.m.	,,	"Graf Waldersee."
11.20 a.m.	,,	"Argentina."
12 Noon.	,,	Cape Race, "Graf Waldersee," and "Kaiser Wilhelm der Grosse."
4.20 p.m.	,,	"Rhein."
5.10 p.m.	,,	"Kaiser Wilhelm der Grosse."
7.40 p.m.	,,	"Corsican," "Empress of Britain."
8.10 p.m.	,,	Sable Island.
10.0 p.m.	Receiving from Cape Cod.	

Monday, May 9th.

12.20 a.m.	Communicated with	"Kaiser Wilhelm der Grosse" and Cape Race.
1.29 a.m.	,,	"Empress of Britain" and Sable Island.
1.30 a.m.	,,	"Grosser Kurfust."
2.0 a.m.	,,	"Empress of Britain."
3.45 a.m.	,,	Sable Island and "Prinzess Irene."
6.10 a.m.	,,	"Arabic."
6.10 a.m.	,,	Sable Island.
6.20 a.m.	,,	Cape Race.
7.40 a.m.	,,	"Finland."
8.2 a.m.	,,	"Philadelphia."
8.7 a.m.	,,	Sable Island.
8.45 a.m.	,,	Sable Island.
9.30 a.m.	,,	Sable Island.
9.35 a.m.	,,	"Caledonia."
10.35 a.m.	,,	Sable Island.
11.55 a.m.	,,	"Kaiser Wilhelm der Grosse" and Cape Race.
2.36 p.m.	,,	"Prinzess Irene."
12.50 p.m.	,,	"Neckar."
1.55 p.m.	,,	"Prinzess Irene."
2.16 p.m.	,,	"Neckar."
2.30 p.m.	,,	"Kaiser Wilhelm der Grosse," "Oceanic," and Sable Island.
4.29 p.m.	,,	Sable Island.
6.50 p.m.	,,	"Kaiser Wilhelm der Grosse."
8.50 p.m.	,,	Cape Sable.
9.55 p.m.	,,	Sable Island.
10.15 p.m.	Receiving from Cape Cod.	

Tuesday, May 10th.

12.25 a.m.	Communicated with	"Graf Waldersee."
2.6 a.m.	,,	Siasconsett.
3.28 a.m.	,,	Siasconsett.
8.11 a.m.	,,	"Prinzess Irene."
8.40 a.m.	,,	"Grosser Kurfurst."
8.45 a.m.	,,	Siasconsett.
1.25 p.m.	,,	"Prinzess Irene."
1.40 p.m.	,,	Siasconsett.
1.44 p.m.	,,	Cape Sable.
5.50 p.m.	,,	"Kaiser Wilhelm II."
6.45 p.m.	,,	"Nieuw Amsterdam."
6.50 p.m.	,,	"Oceania."
7.10 p.m.	,,	Sagaponack.
11.55 p.m.	,,	Sagaponack.

Wednesday, May 11th.

12.30 a.m.	Communicated with	Siasconsett.
4.45 a.m.	,,	Sagaponack.
5.10 a.m.	,,	Seagate.
7.19 a.m.	,,	Seagate.
8.10 a.m.	,,	Seagate.
9.40 a.m.	Ship docked New York, station closed.	

It may be of interest to observe that of all the communications effected as above noted, in only one case, namely, that the Scheveningen (Holland) was the corresponding station not fitted with Marconi apparatus.

The use of wireless telegraphy on cable-laying vessels, yachts and other special classes of ship is increasing. At present the following cable-laying boats and private yachts have been equipped by the Marconi Company :—

PRIVATE YACHTS.

s.y. "Iolanda."	s.y. "Cassandra."	s.y. "Atalanta"
s.y. "Lysistrata."	s.y. "Niagara."	s.y. "Florence."

CABLE SHIPS.

c.s. "Mackay Bennett."	c.s. "Colonia."	c.s. "Cambria."
	c.s. "Buccaneer."	

The conditions under which cable-laying vessels have to work make the value of wireless telegraphy very conspicuous in their case. Repairs have to be carried out at long distances from shore, and as a rule the vessels have to return to port before instructions regarding subsequent work can reach them, with the result that expensive delays are frequently incurred. An example of the service which wireless telegraphy may render is supplied by the following extract (modified in details of wording) from the log of a cable-laying ship :—

On one occasion we were repairing a cable some 180 miles from the west coast of England, and required further information about electrical tests from the shore. A message was sent and received by another steamer equipped with a Marconi wireless installation and relayed by her on to England, the result being that in less than an hour we had a reply from London giving the desired information, and enabling the vessel to proceed with her cable-laying operations without delay.

Considering that the inquiry was relayed, and necessitated a careful answer from headquarters, also relayed, the time occupied was remarkably short. On another occasion, when the vessel was on her way home from the completion of a repair off Ireland, a wireless message was received ordering her to the coast of France for another repair, thus saving a useless voyage back to London.

The standard equipment for marine work is either the 1½ kw. set just described or a 5 kw. set, where a disc machine takes the place of the spark discharger. Both sets are capable of exceeding their guaranteed limits. For instance, in the case of certain destroyers, the guaranteed range of transmission was 60 miles, but nearly all of them exceeded 80 miles on their tests. In the case of a larger vessel, the guaranteed range was 100 miles and the realised range was 185 miles. Another war ship fitted with a 5 kw. installation exceeded her guaranteed range of 250 miles by more than 100 miles.

As already indicated, the number of wireless installations on shore and on ships is increasing so rapidly that up-to-date official statistics covering the whole of the world are impossible to obtain. The following figures, taken from the Bulletins of the International Telegraph Bureau, will give some notion of the extent of the business, but they must not be taken as complete, since certain countries have not ratified the Convention or made complete returns.

Country.	Number of naval ship stations.	No. of stations in the mercantile marine.
Great Britain	176	113
Germany	93	67
France	140	10
Austro-Hungary	20	—
Belgium	—	10
Chili	7	—
Denmark	10	4
Spain	5	—
Italy	—	15
Japan	—	15
Norway	12	1
Netherlands	15	18
Roumania	—	5
Russia	—	2
Sweden	27	—
Brazil	16	—
Totals	521	260

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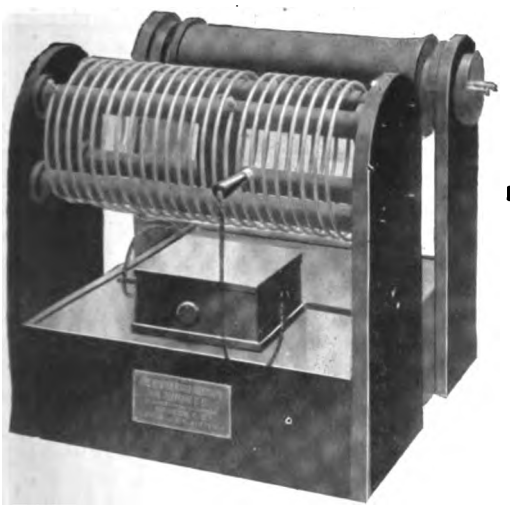

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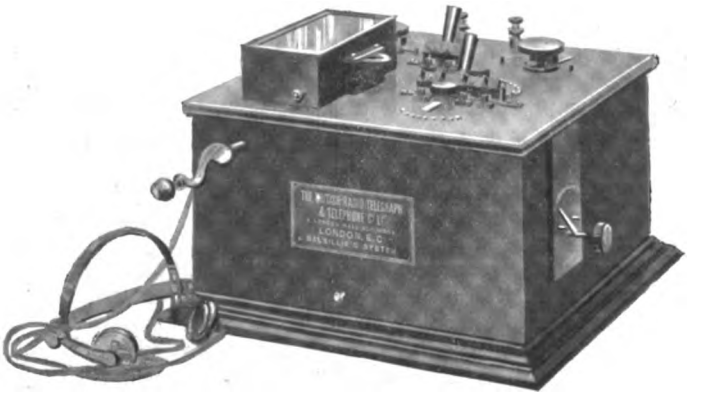

RECEIVER.

Marconi and Others v. The British Radio Telegraph & Telephone Company, Ltd.

Referring to the "Warning" issued by the Marconi Wireless Telegraph Company, Limited, the British Radio Telegraph and Telephone Company, Limited, hereby GIVE NOTICE that :—

(1) They are defending the above-mentioned Action, and will use every means in their power to bring the same to a speedy trial.

(2) They contend that they do not infringe the Marconi Patents.

(3) They are prepared to fully indemnify all purchasers, vendors and users of their apparatus against any claim in respect of the Marconi Patents.

(Signed) G. F. HUDSON MATTHEWS & CO.,
32, Queen Victoria Street, E.C.,
Solicitors for
THE BRITISH RADIO TELEGRAPH & TELEPHONE COMPANY LIMITED.,
of 5, London Wall Buildings, E.C.

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The Helsby Wireless System

The rapid growth of commerce and the provision of improved means of transit has rendered a corresponding extension of our methods of intercommunication a necessity. It has long been realised that, if a system of telegraphy or telephony which does not require the installation of conducting wires or cables were discovered, the field of operation of electrical communication would be vastly extended. It is interesting to note that while the development of our postal telegraph system has always been in the hands of engineers who were previously experts in intercommunication, wireless telegraphy has developed chiefly from the adaptation of results obtained in scientific laboratories, and under the guidance of those who are scientific electricians first and telegraphists—if at all—afterwards. A perusal of recent patents, or an inspection of some modern wireless telegraph stations, shows in a remarkable manner how this "history" has affected the methods adopted, and particularly the form of the apparatus.

While we have the highest appreciation of recent research work, which has so greatly extended our knowledge of electric oscillations, certain engineers maintain that inasmuch as radio-telegraphy is a branch of engineering, and that all engineering design is necessarily a matter of compromise between complexity of construction—with perhaps a higher measurable efficiency in expert hands—as compared with simplicity and reliability on the other, that a higher overall efficiency as regards traffic can be obtained by designing the apparatus to suit the skill of the average wireless operator rather than add refinements of detail and complexity which the operator has neither time nor the necessary knowledge to use effectively.

These facts have been carefully considered in the design of the apparatus used in the Helsby system. It is throughout "telegraph" apparatus adapted both to the requirements and the capacity of the operator into whose charge it will be placed.

The general principles underlying all the various systems of wireless telegraphy are identical, however much they may be disguised by the introduction of subsidiary instruments, and consist in the means for producing, at will, electrical oscillations of great energy in an elevated conductor and means of detecting feeble oscillations set up in the same conductor when a message is being received. Hence the apparatus may be rationally divided into two main groups—transmitting apparatus and receiving apparatus—but what is of equally great importance is the provision of suitable controlling devices by which the station is instantly convertible from one function to the other.

Novelty of design and extreme practicability of the instruments fulfilling each of these functions are claimed to be the distinguishing features of the Helsby system, and they combine to confer upon it a very high efficiency. In common with the majority of electric wave systems, the oscillations used are produced by the sudden discharge of "condensers." The Leyden jar still used in many systems has, the company feel, several disadvantages, *i.e.*, great bulk for given capacity, uncertain contact with tinfoil electrodes, perforation of dielectric, loss of energy by brush discharge, which—together with its fragile properties—make this form of condenser most unsuitable.

The condensers used are built up of flat plates—giving economy of space—and conductors of copper foil to which a permanent and electrically perfect joint can be made. The dielectric consists of specially selected glass plates showing extremely small dielectric losses, the whole being clamped together in a form similar to that adopted in accumulator practice, and immersed in a special insulating compound, which entirely prevents brush losses. Perforation of the plates is rendered impossible by the provision of relief gaps which act as electrical safety valves.

These condensers are charged from a high-tension transformer of improved design. A patent alloy is used in place of iron in the core, and magnetic material is distributed so as to minimise losses due to eddy currents and to prevent hysteresis. The primary windings are so disposed as to allow of the standard instrument being used in connection with circuits at various voltages and frequencies. The secondary windings are so arranged as to obtain the highest insulation and efficiency with minimum resistance and weight of wire. Connection between the transformer and oscillation circuits is effected by "protection plugs," which prevent oscillations passing into the secondary winding. In the portable wireless outfit the above improvements are embodied in an induction coil which is provided with a special form of interrupter, giving a high rate of interruptions with great regularity of action.

The condensers discharge through the primary of an oscillation transformer and discharge gap of original design. Two forms of discharge gap are used by the Helsby Company, and both show a very marked improvement on existing types. The first is a multiple gap, and is practically silent in action. The distressing noise so characteristic of certain systems, and risk of messages being overheard by unauthorised persons, is entirely overcome. The gap is also rendered free from the deleterious effects of moisture and acid vapours. The second spark gap used by this company is of novel design, and confers upon the received signals a clear musical note.

The oscillation transformers consist of two flat spirals, each adjustable as to inductance; mutual induction between them being also adjustable to meet the requirements of the government regulations. Curves are supplied with the apparatus giving the adjustments for the two commercial wave-lengths of 300 and 600 metres. The receiving and controlling devices are contained in one piece of apparatus, which is arranged in an extremely compact form. It comprises an ordinary single current Morse transmitting key, which, in addition to operating the transmitter, records mechanically all signals transmitted on a paper tape, which is only accessible to a duly authorised inspector and cannot be tampered with by the operator. The ammeter, voltmeter and fuses are mounted on the same case within which the resonant circuits for tuning the apparatus to the incoming signals are placed.

The circuits are two in number. The aerial circuit consisting of variable inductance and variable capacity—placed in series or parallel at will—and adapted for reception on either of the commercial wave-lengths. Switches are provided for instantly changing from one commercial wave-length to another when listening for a call. The detector circuit is also variable by a similar method, and can be coupled to a variable degree with the aerial circuit and also with the detector proper. A potentiometer is provided for obtaining a suitable P.D. across the detector terminals. Two types of detector are used. These are mounted in similar ebonite cases provided with plug contacts, and are interchangeable. The entire station is controlled by one "master switch," which, by a single movement, makes all the changes in connection when it is desired to change from "send" to "receive," or *vice versa*.

The whole of the instruments are assembled in separate units which—when in position—form a cabinet; proper connections being made by suitable plugs. This construction enables the apparatus to be very rapidly installed, as the labour of wiring up the various parts is carried out at the factory.

For some considerable time the need has been felt for some method of recording automatically the messages received by "wireless." The receiving recorder originally used had so many disadvantages that it has been practically abandoned in all commercial stations. Its construction is necessarily complicated, consequently it is extremely difficult for the operator to maintain it in perfect adjustment, whilst the slightest variation results in inaccurate recording, which involves repetition and delay. Further, if a high degree of sensitiveness is required, the instrument cannot be rendered independent of atmospheric disturbances.

Under the international regulations, the majority of commercial messages are transmitted at approximately the same wave-length, and the receiving recorder is affected equally by all signals of all stations using a similar wave-length; whereas an operator using aural reception is not only able to effect an accuracy of "tuning," unattainable by the receiving recorder

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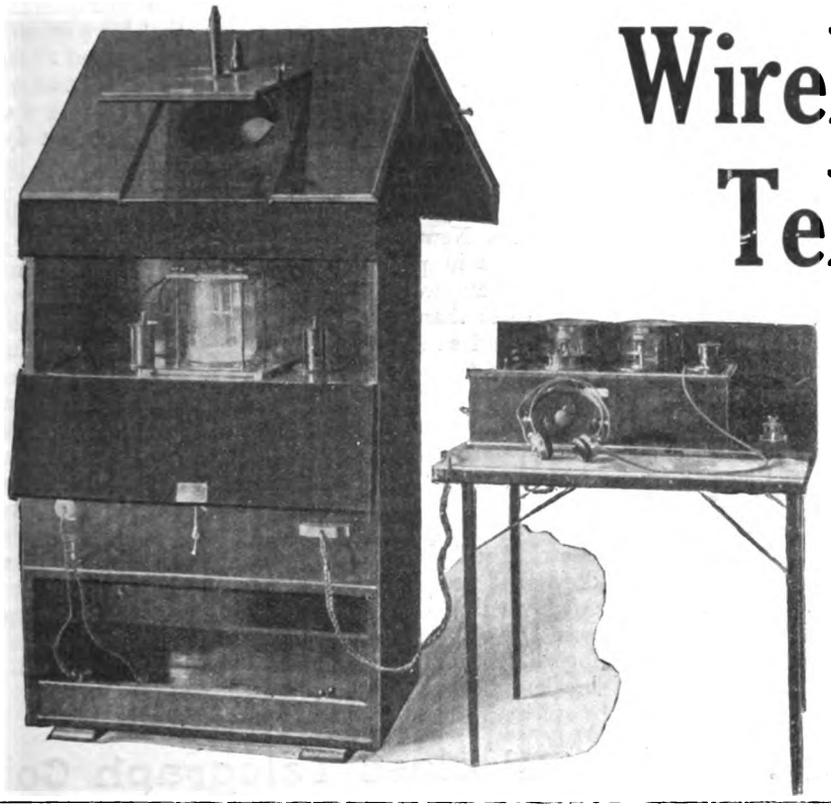
RADIO-TELEGRAPHY



Wireless Telegraph Apparatus

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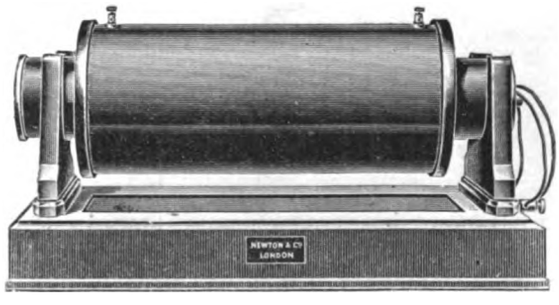
mechanism, but in addition is able to discriminate between signals transmitted from different stations using identical wave-lengths by distinguishing the characteristic sound or tone of his particular station, and is thus enabled to "read through" outside interference. Whilst the aural receiver is absolutely constant in its sensitiveness and requires practically no adjustment, the adjustment of the receiving recorder mechanism is constantly affected by vibration and change of temperature, which necessitates re-adjustment and much waste of time. It is also extremely difficult to maintain with the receiving recorder a speed of 20 words per minute, as required by the government regulations.

The Helsby Company's automatic outgoing signal recorder is used at the transmitting station. This instrument accurately records all signals transmitted by the operator, and furnishes an independent means of detecting any inaccuracies or breach of the rules laid down by the International Convention for the conduct of traffic. The instrument is mechanically operated and is entirely free from atmospheric disturbances. It is impossible for the operator to transmit any signals without actuating the recording device. If desired, the instrument can be locked and be made only available for inspection by a duly authorised official. The standard speed of 20 words per minute is easily recorded, while any variation in that speed is indicated.

This system therefore opens up an entirely new field, and one which is extremely valuable. Among many of the uses to which it can be applied are the following: (1) To establish intercommunication between the several galleries in coal mines, also from the galleries to the station at the mouth of the pit. (2) To establish communication with submarines, enabling the vessel to keep in touch with the parent ship. (3) To establish communication between island forts, also with forts on the coast. (4) No aerial masts being necessary, and the apparatus being extremely portable, it is specially adapted for military service.

Newton's Induction Coils for Wireless Work.

In the development of many of the present-day systems of wireless telegraphy the induction coil has played an important part, with the result that it has ceased to become merely a



"INSTANTA" COIL OF MESSRS. NEWTON & CO.

laboratory instrument and has entered the industrial world. Messrs. Newton & Co. have a wide experience in the design and manufacture of these coils, and some details of the class they have built up for wireless work for the Admiralty, and which we show in the accompanying illustration, will doubtless be of interest.

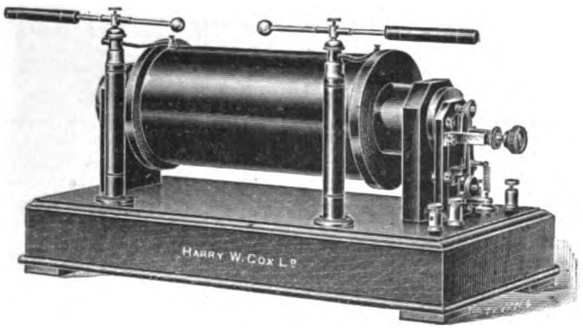
The coil is known as the "Instanta." These coils are chiefly intended for use with mercury breaks, but they can be, and often are, used also with the electrolytic interrupter; but where the latter is intended to be employed, Messrs. Newton have designed a coil of different proportions, though based on the same general principles. Briefly, the "Instanta" coil is an "Apps-Newton" coil with a stronger magnetic field and lower secondary resistance. The importance of a low secondary resistance can hardly be over-estimated. It is impossible to get a really heavy output from a coil if the internal resistance of the winding is too high. This is a point too often overlooked in choosing a coil. The present accepted standard of spark length as a means of measurement is, Messrs. Newton point out, totally misleading, especially as it is both easy and cheap to get a long spark by winding the secondary with very thin wire, but at the expense of great loss of efficiency and output. To take an example: The secondary resistance of a Newton 10 in. coil averages about 5,000 ohms, while two coils of similar size (one quite a new one) by other makers that have recently come into Messrs. Newton's hands measured 15,000 and 21,000 ohms respectively! This is as if one compared a dynamo giving, say, 1 ampere at 100 volts, with a dynamo giving 4 amperes at 100 volts. Both could be fairly sold as 100-volt dynamos, just as both these coils could be sold as 10 in. coils.

The "Instanta" coil can be supplied either on a polished mahogany cradle or on a bracket to fix against the wall. Like all Messrs. Newton's other best quality coils, it is covered throughout in polished ebonite tube, and is an extremely handsome and well-finished instrument. The primary winding has no less than 10 different adjustments, so that it can be exactly and easily "tuned" to the very best conditions for work with the electrolytic break, while a third connection is always in correct adjustment for a mercury interrupter.

The secondary is wound by special machinery, which has been designed and constructed entirely by Messrs. Newton for the purpose. It consists of a great number of thin sections, each containing some hundreds of turns of fine wire. The winding of these sections is so arranged as to distribute the electrical strain evenly throughout the coil, and is so carefully done that breakdowns are said to be practically unknown. After winding, the entire secondary is soaked in an insulating wax, and allowed to cool in a large vacuum tank, thus excluding all air bubbles, and still further ensuring the coil against breakdown.

Wireless Telegraph Coils.

The coils used for wireless telegraphy differ from the medical coils chiefly in their rather heavier winding, which allows a greater quantity of electricity to be charged into the condensers at each interruption. In conformity with prevailing ideas,



COX'S INDUCTION COIL FOR WIRELESS WORK.

Messrs. H. W. Cox & Co. always wind these coils on the multi-section principle, though, as a matter of fact, they consider the advantages of multi-section over two-section winding as somewhat over-rated. There is undoubtedly the advantage in multi-section as regards the smaller electrostatic capacity, but it should be noted that this does not necessarily involve any loss of energy, as it merely means that a slightly greater percentage of the displaced energy is retained in the coil windings and never finds its way to the condenser, but this energy does not escape, and beyond the C^2R loss there is no actual loss involved; on the other hand, the cylindrical winding allows a considerably smaller mean winding diameter to be used on the secondary, thus greatly reducing the resistance for any given spark-length, and the leakage of electricity to air is less in this type of coil than in the multi-section.

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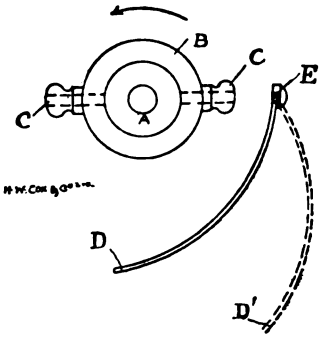
These coils are also made with "taper" insulation, *i.e.*, specially constructed for "earthing" one terminal. This is an important point, as the "earthing" of one terminal doubles the strain on the other, and in many makes of coil this fact is not allowed for, whereas if it is allowed for in the ordinary

COX'S MERCURY BREAK APPARATUS.

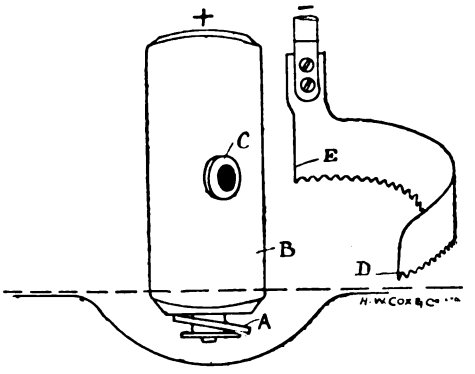
way there is a large amount of useless insulation on one end which brings down the space factor.

The illustration shows the latest form of the well-known Cox jet interrupter, and includes several important improvements, of which the chief are: (*a*) Any current up to 30 amperes may be used without injury to the break, while the regulation is so



PLAN OF COX'S JET BREAK APPARATUS.

complete that the current passing through the coil can be varied from practically zero to the maximum with no other control; therefore no current is wasted through the heating of a resistance. (*b*) By an ingenious mechanism a large resistance, approximately 200 ohms, is put into circuit at the



ELEVATION OF COX'S JET BREAK APPARATUS.

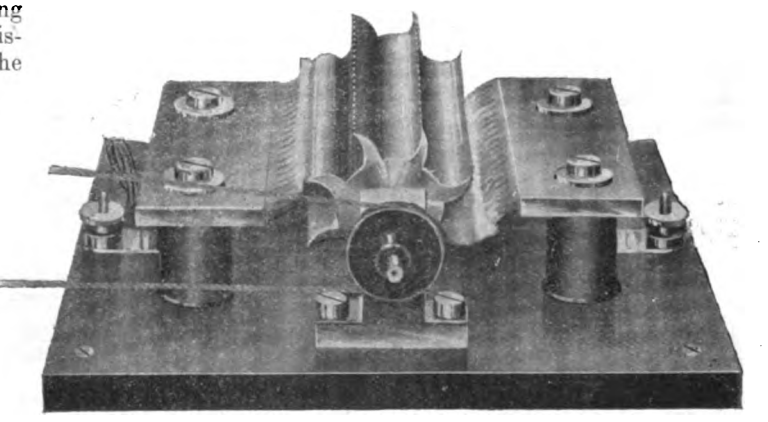
moment current is "made" and is gradually taken out, so that when the current is broken the resistance in circuit is practically nil; consequently a minimum amount of inverse current is induced in the induction coil. This latter is a most important factor in X-ray work. The inverse current hitherto always produced by mercury jet breaks, blackens and destroys the focus tube and also causes the blurring of the image on the plate. Many attempts have been made in the past to suppress this inverse current by switching in a large resistance at the moment of make, but hitherto these attempts have not been successful in practice. In the present case the desired effect is obtained in a simple way, which is explained in the accompanying diagrams.

A quick screw thread, the end of which is shown at A, is cut internally upon the barrel B, which, being driven by an electric motor, pumps up mercury from the reservoir and discharges it from two nozzles C. The mercury stream during parts of its revolution strikes against the fixed blade, making contact at the point D and breaking at E. By swinging the blade the arc of contact is increased or decreased and the time allowed for the current to grow in the primary circuit of the coil is varied at will. The nozzle is shaped in such a manner that, shortly after leaving it, the mercury begins to split up and to form nodes or constricted portions having considerable resistance; consequently at D or D′ the resistance in circuit is very considerable, and this resistance is gradually removed until at the break at E the only resistance is that of a $\frac{1}{4}$ in. of solid mercury jet, which is practically nil.

Wireless Apparatus.

Although only recently introduced, the Balsillie system of the British Radio-Telegraph & Telephone Co. has made considerable progress. The wireless apparatus used by the Company was first shown at the Physical Society's Exhibition last December, and a description of the system was given in THE ELECTRICIAN (January 7, 1910). It is a weakly-damped wave system embodying improvements in sharpness of tuning, freedom from damping and simplicity of apparatus, and its main feature, perhaps, is the rotary spark-gap employed. Attention may be called to the fact that, the tuner and detector being contained in one piece of apparatus, the receiving station is very portable. In fact, the compactness of the apparatus may well be claimed as another feature of the system. We understand that the Company have recently been honoured with a large Admiralty order for wireless apparatus. The rotary spark gap is illustrated herewith.

It may also prove of interest to mention that the Company are now obtaining very promising results with their system for wireless telephony; and we understand that they have been successful over a distance of 30 miles. The wire-



ROTARY SPARK GAP OF THE BRITISH RADIO-TELEGRAPH AND TELEPHONE CO.

less telephone has hitherto been too complicated for ordinary marine work, but the Company are of opinion that adaptation of a spark system to this form of wireless transmission will open up a most promising future

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The Use of Electrical Power for Auxiliary Purposes on Board Ship.

BY JAMES A. SEAGER.

Summary.—The author deals with the use of electricity on board ship for general purposes, and the causes that militate against its adoption. The chief of these are the want, in most cases, of definite specifications for the plant required, the ignorance of electrical matters on the part of engineers on board ship, the lack of skilled attention, the desirability of simplicity in equipment, and the cutting of prices. The voltage used is preferably low for safety, but the use of electric power tends to raise the standard adopted. Although there is a tendency to run all auxiliaries electrically, it is safer to have some of them independent of the electrical plant. To a large extent the adoption of electrical auxiliaries resolves itself into a question of first cost *v.* running cost. The article concludes with a reference to examples of auxiliaries now in use, and emphasis is laid upon the necessity for good workmanship and ample size of plant for the requirements.

The application of electricity to the mercantile marine is a subject which at the present time appears to be exciting a very considerable amount of attention in this country, and in view of the various schemes which have been put forward for this purpose the problems raised have assumed a very complicated aspect. It may, therefore, be of interest to touch briefly upon the various phases of this question, more especially in relation to the use of electricity for auxiliary power purposes.

Such reference, however, cannot be made without previously considering one or two points regarding the generating plant and general lay-out of ships' lighting and power equipment, and also a consideration of some of the human elements which very powerfully affect the more purely engineering aspects of the question. In this article it is proposed to disregard Admiralty practice, except where such practice is coincident with, or has a bearing upon mercantile work, inasmuch as a satisfactory solution of engineering problems has a relation to commercial cost, and in Admiralty work this consideration is subordinated to a very much greater extent than in mercantile work, and conclusions drawn from Admiralty practice might be erroneous if applied to the mercantile marine.

Dealing first of all with the personnel on board a trading vessel or concerned with its equipment, we have to remember that in the majority of cases there is no analogy to the consulting engineer who is so often conspicuous in land practice. The result is that very often the requirements for a ship's electrical equipment, more especially as regards the auxiliaries, are conveyed to the manufacturers in such vague terms that they are left to imagine what these requirements are, and there is therefore a large opening for disparity in the tenders. It is not an uncommon thing, for example, to find an inquiry for an electric winch in which the only information given is that it has to be of equivalent strength to a steam winch whose capacity is given in terms of the size of the cylinders, no data being available as to the speed of rope required or the maximum load to be handled. The result of this is that the maker confronted with such an inquiry sends in a tender for the plant which he thinks will sell best and trusts to luck for the results. Not only is this the case but it can often happen that prior knowledge of the particular line of steamships is a positive disadvantage to a maker who is asked to tender to a loose specification inasmuch as the firm with such knowledge will be expected to quote machinery which will be suitable in the light of their experience, while an outside firm will very probably put in a price for an unsuitable plant which may be sufficiently tempting to make the offer acceptable to the owners of the vessel. In such a case, if trouble occurs, the owners will have no remedy unless they have given explicit instructions to the new firm they have admitted. This explains what may at first appear rather curious, that firms with the most experience of marine auxiliary work frequently put in the highest tenders, the reason being that they know much more fully the special difficulties to be encountered and take adequate steps to insure safety. In this way the highest tender is often the cheapest.

The next point to remember is that either the owner of the vessel, who is a non-technical man, does the buying, or at best advice is taken from a marine superintendent. The distinguishing feature of the latter is often a profound conservatism which excludes not only everything electrical so far as possible, but even such apparatus as water-tube boilers which are now so common in land practice that it is almost a miracle that they are so rarely found on board a merchant vessel. One of the reasons for this is that so far as electrical engineering is concerned the marine superintendent attained his practical sea-going experience on which the present recommendations are founded before electricity was anything more on board even the best boats than a small adjunct for lighting purposes, and hence the electrical manufacturer of to-day has in some cases to fight prejudices created by the behaviour of plant some 15 or 20 years ago. Moreover, the majority of chief engineers on board vessels, who have a very powerful voice in the choice of plant, prefer often not to introduce new engineering features for reasons to be mentioned.

Another thing to remember is that on board ship there is not the same amount of skilled attention as is obtainable ashore. In the stokehold the labour is of the lowest type, and it is difficult to train such men properly to the use of electrical machinery. On deck, such apparatus as winches and capstans are operated by stevedores who are perhaps the most careless set of men it would be possible to find for the manipulation of machinery. The average marine engineer knows very little of electrical power work, and therefore any complication of electrical machinery, however desirable it may be from a technical point of view, is apt to be viewed with suspicion on board ship. As an instance it is well to remember that even ship lighting sets are practically universally run, not in parallel, but on separate bus bars with change-over switches or plugs for the various circuits.

Turning from the personnel of the ship, there are one or two other points which have a very important bearing. The first is that on board ship minor accidents are always occurring, and the facilities for repair while at sea are very limited. This tends to the utmost simplicity of parts and the elimination of highly technical apparatus. The continual racking and straining of a vessel tends to displace the mechanical and electrical parts of its equipment in a way that is unknown on shore, and hence everything must be as simple and as strong as possible. In many instances plant has to be crowded into a space which is almost inadequate for it and cannot be subject to regular inspection, more especially in the case of auxiliary and spare plant, which suffers extremely in this way. Such plant has therefore to be made so as to be almost automatic in maintenance and capable of long and hard usage without adequate supervision.

In many instances plant is shut up in close spaces at high temperature and the heating limits of the motors have, therefore, to be very low. Unfortunately, this is not always attended to, inasmuch as British ship owners are beginning to feel the keen edge of competition in a way to which they have been unused and they are therefore cutting prices on electrical

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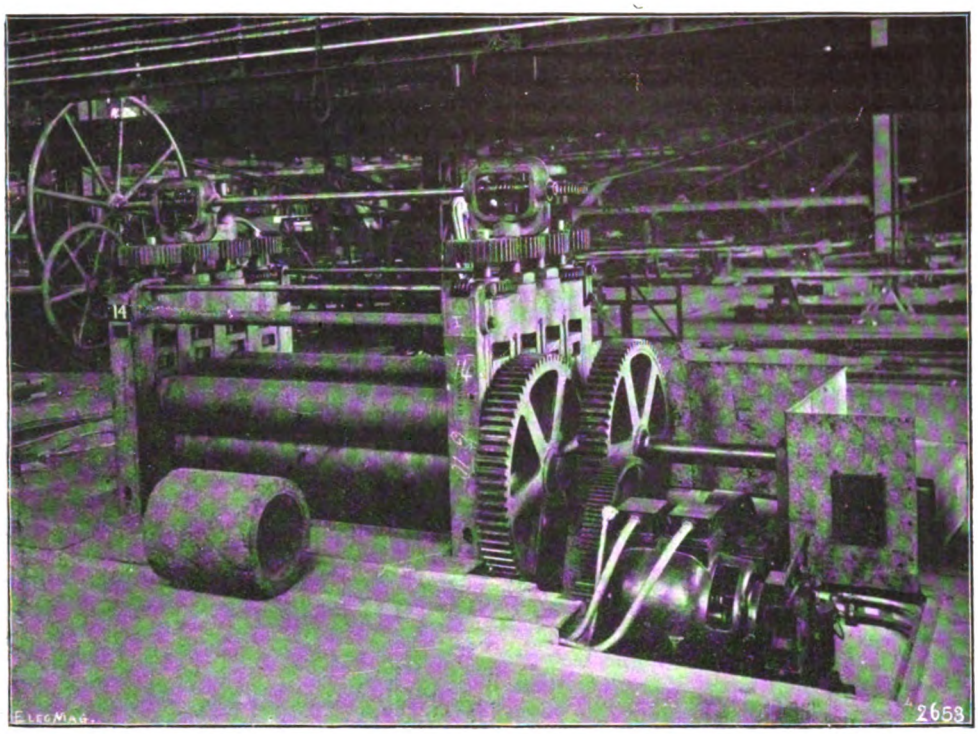
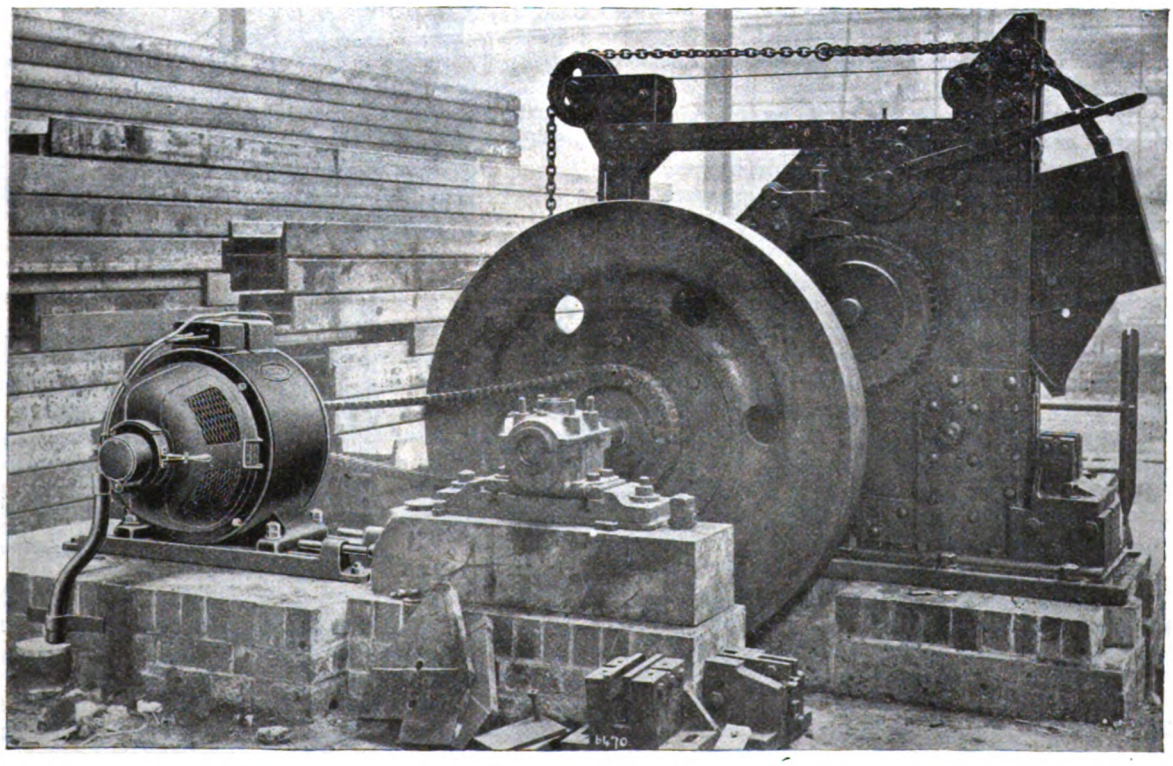


Witton MOTOR driving Plate Straightening Roller. 20 H.P., 500 revs. per min. Through gearing. Straightening Plates 1 in. thick and 8 ft. wide.



Witton MOTORS driving Lever Angle Shearing Machine. 10 H.P., 700 revs. per min. Through chain belt.

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equipment for auxiliaries in a manner which is very baffling to good design. Besides all this is the constant trouble of water combined with salt which unless carefully guarded against causes leakage and corrosion. Auxiliary apparatus must, in addition, be so strongly insulated and protected as to withstand moist and yet hot atmospheres, particularly in vessels designed for the Indian and African trading routes.

A recapitulation of the above points will seem to be necessary when one comes to consider the first problem with regard to the design of the auxiliary power equipments of a vessel, namely, that of the most suitable voltage. Prof. Gisbert Kapp, in his address at the dinner of the Newcastle local section of the Institution of Electrical Engineers last winter, referred to the important point of the standardisation of voltages on board a vessel, and laid special emphasis on the necessity of this work in order to standardise manufacturers' products and cheapen the cost of ship installation work. He then stated that so far as the Newcastle area was concerned there appeared to be an informal standard of voltage of either 65 or 110. Though this at present is correct it appears that various causes are combining to render it a transition stage. We are finding in modern ship equipments the effect of a compromise between the most suitable lighting voltage which in view of the constant vibration and the use of portable lights should be as low as possible, and the power requirements, the voltage for which in view of the heavy transmission loss of large power should up to a certain point be high. It will be remembered that the Admiralty, which has adopted electric power to a very considerable extent for auxiliary purposes, have recently used 220 volts, while in at least one instance a voltage of 500 has been adopted on board a foreign vessel. This is, however, in view of the confined space and the possibility of leakage, a high voltage to use. It would appear that 220 volts is about the superior limit which should be adopted for power purposes, and if the problem were limited to a question of what proportion of lighting and proportion of auxiliary power is to be placed on the ships' generating set, the theoretical solution would be a mathematical compromise between the two convenient voltages for the purpose. At the present time, however, the problem is not so simple as this, inasmuch as quite apart from the long series of odd voltages which a mathematical compromise in every case would induce, there appears to be a strong probability that in the comparatively near future high-speed turbine power, combined with electrical main propulsion, or the use of suction producers and gas engines, may find their place. In the latter case, all auxiliaries will perforce be driven electrically, and the question of lighting supply will be subordinated to the problem of the most convenient means of auxiliary power supply. At the present time it may be suggested that, at any rate for the larger vessels, two separate systems may be introduced, one at a low voltage for lighting, the other at a higher voltage for power, and run by separate generating sets.

This discussion leads us to a consideration of the extent to which electric power can be safely used for the purpose of driving auxiliaries. On large liners the tendency is becoming more and more in the direction of operating the condensing plant, forced or induced draught fans, pumps, &c., as well as the deck plant, by means of electric power, and reference need only be made to the very complete fan equipment of the "Lusitania" and "Mauretania," by Messrs. W. H. Allen, Son & Co., of Bedford, who supplied 32 69 in. single inlet fans to each of these vessels, all electrically driven, in order to emphasise this point. There is, however, a feeling that this wholesale substitution for steam plant must not be pushed too far, as in the event of a breakdown of the generating sets or the switchboard the whole of the auxiliaries would be at once thrown out of action. That this feeling is only reasonable is shown by the fact that many land engineers responsible for the construction of electrical generating stations take the same view and a middle course is adopted, as for example at Birmingham, where half the condensing plants are operated by means of steam and half by electricity.

Another factor which determines the extent to which auxiliary plant may be run electrically is the question of the proportion which an owner of a vessel is prepared to place between first cost and economy in running. Unfortunately, at the present time ships are being built and equipped at such a cut price that it is impossible to carry out everything electrically, even if this were approved on technical grounds. The question of working the winches by steam or electricity, for example, very largely depends on the kind of trade for which the boat is intended. If the vessel is meant for making short trips and frequent calls the economy in working the cargoes by having electrical installations is very marked, inasmuch as the hours per year during which the winches are run are very considerable. On the other hand, if a vessel is making long voyages, the question of economy in running plant which is idle except at the beginning and end of a voyage becomes of minor importance, and the increased first cost of electrical, when compared with steam, winches is then the most prominent factor.

Speaking broadly, the question of extent to which auxiliary electrical power may be applied, resolves itself into an estimation of the amount which the owner of the vessel is prepared to pay, and this will probably first be spent on electrical plant which is in continuous or frequently intermittent use such as condensing plant, pumps, draught fans, &c., and then, if there is still money to spare, the question of the more intermittent load will be considered and the question of equipping the deck machinery electrically will follow. At the same time, it is well to bear in mind that marine engineers are fully alive to

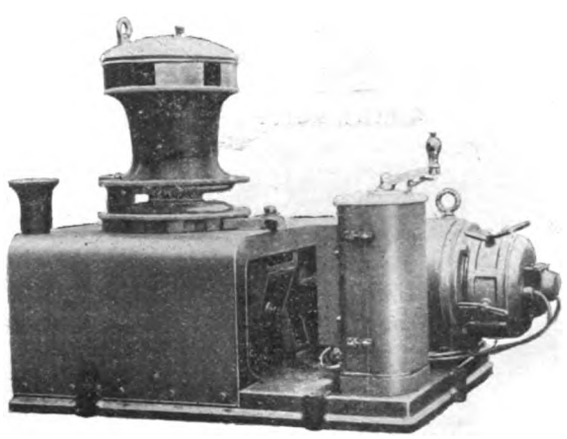

FIG. 1.—ANCHOR CAPSTAN. 1 TON AT 45 FT. PER MINUTE.

the inconvenience of having long lengths of steam piping on deck subject to stand-by losses, possibility of fracture due to frost or bad warming up or draining, and careless handling by the deck hands. Marine engineers are at present very well aware that, especially on passenger vessels, the steam pipe distribution to auxiliaries is an inconvenience which should be avoided as far as possible, both from the point of view of possible explosion in which passengers may be involved, and also in many cases because such steam pipes heat up confined spaces to an uncomfortable degree. Other considerations in favour of the electrical drive of auxiliaries on board passenger vessels are the high degree of silence and cleanliness in the electric motor compared with its steam rival.

Another point which has a bearing on this question is the load-factor which is to be placed upon the generating plant. It is evident that so far as possible the electric load on the generator should be kept as uniform as possible, in order that a small generating set should be used which will nevertheless fulfil the maximum requirements placed upon it at all times. With the increase of the number of purposes for which electric power is required on board ship, there is an increased chance that the load factor on the generator will become greater, and in this connection the steady run of induced draught fans exercises a beneficial effect, quite apart from the possibility of the delicate control of the steaming performance of the vessel by electrical regulation of forced or induced draught. At the

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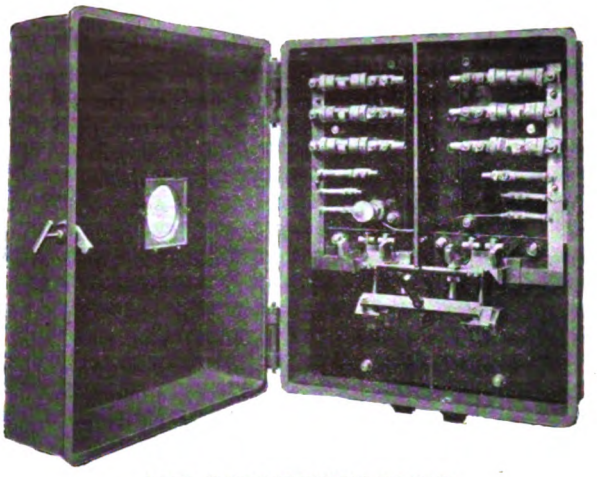

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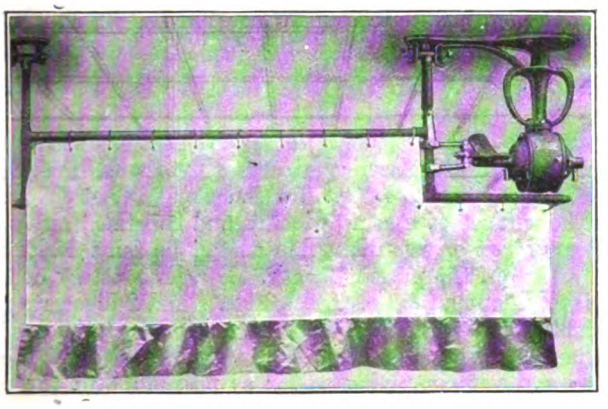

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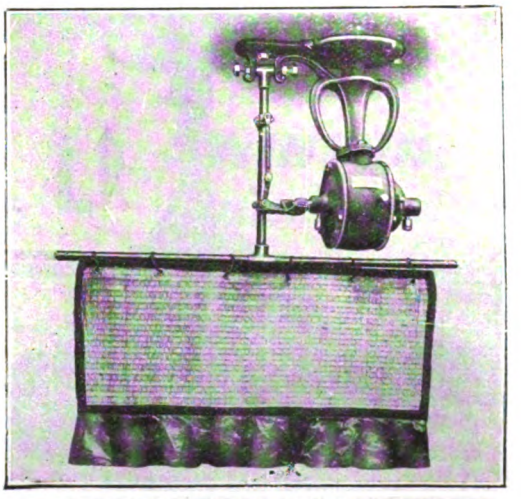

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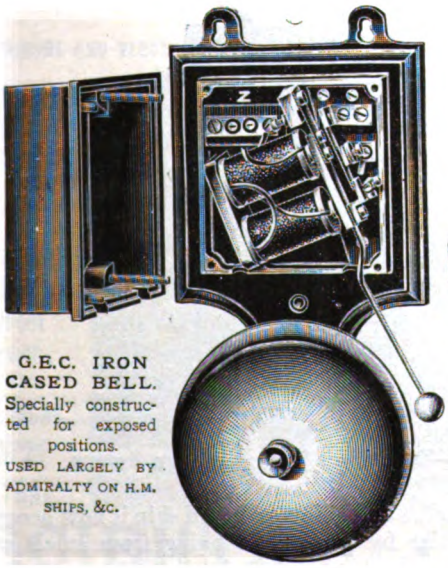

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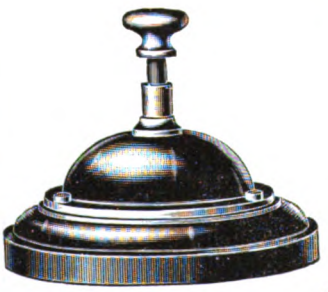

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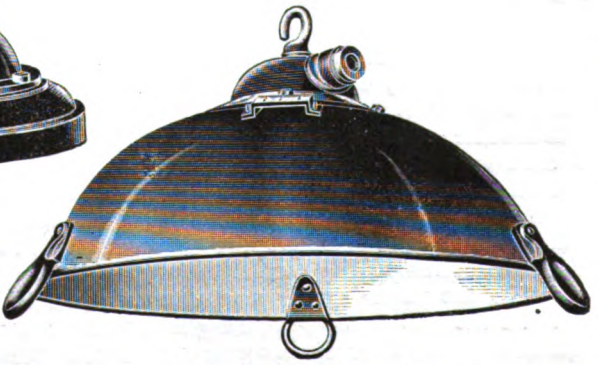

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other end of the scale, an electrical steering gear is, and has been, quite a feasible thing inasmuch as a motor can easily be arranged to drive through a worm-wheel gear the usual right and left-handed screw steering gear, or to operate a hand-steering gear by means of placing a motor in the position usually occupied by the steam steering gear which is at present attached, but when the helm is placed hard over a heavy "peak" load is thrown on the generator.

Turning now to the question of the transmission of power from a generator to the auxiliary electrical plant, this has already been incidentally touched upon above. The obvious solution to the voltage difficulty would be the adoption of a simple three-wire system, and it would at first sight appear that this would find favour among marine men, inasmuch as the single-wire system with earth returns which was once so popular is now almost entirely out of favour, partly on account of the necessity of a mixed system near the ship's compasses, and also because an earth return has led to serious earths and short-circuits. In a single-wire system any fault would immediately produce a short-circuit, while with the two-wire a fault to earth on one pole could be located and removed before anything occurs on the other pole to cause a short-circuit. It is, however, doubtful whether in a power installation where parallel running appears to be too complicated a three-wire

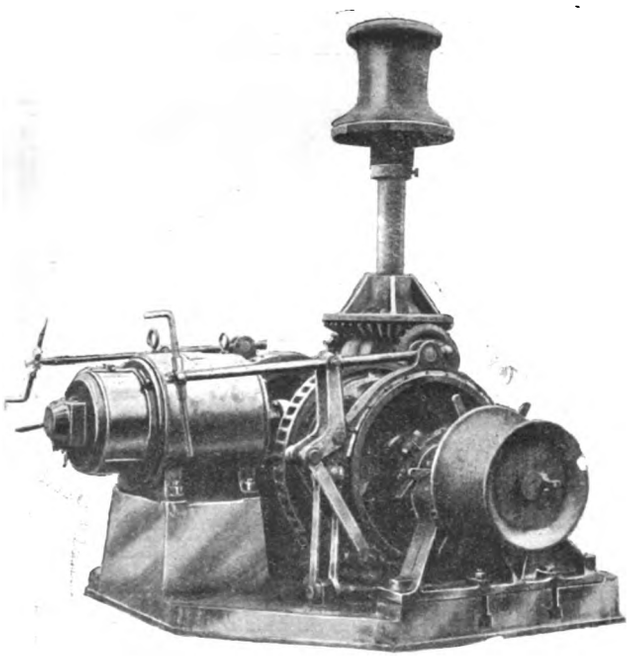

FIG. 2.—WINDLASS AND CAPSTAN FOR $1\frac{5}{16}$ IN. ROPE.

system could be introduced, inasmuch as the engineers on board ship are continually changing, and no sooner would a man be brought up to the standard of three-wire running than he would get another berth. Probably the best arrangement if this were tried on a ship's equipment of considerable size would be to arrange for each set to consist of two generators driven by one engine, these two generators being connected in series with one another, the middle wire being connected to the junction, the lighting being carried equally on the two generators, while the power supply was obtained from the outer wires. As the out-of-balance lighting load with proper distribution arrangements would never be considerable this arrangement should operate with simplicity and satisfaction.

The chief points to insist upon at present with regard to the power and lighting connections are that every circuit shall be brought back to an efficient dividing box, that mechanical joints only should be allowed, and that the system of fusing shall be comprehensive, complete, and so locked as to be only accessible to the electrician in charge. The control mechanism must be of an extremely solid and substantial description, and all rheostats should be constructed of material which will not deteriorate in a moist and salt atmosphere.

The question of controllers is one most vital to the reputation of electrical auxiliary machinery. Owing to the price cutting to which reference has been made above, a good many controllers supplied to the mercantile marine are foolishly inadequate for the work they have to do. The current-carrying capacity is far too small, and in some cases their manufacture is of a most flimsy description, when the conditions under which they will be used by, say, deck hands, is considered. An examination of some of the winches at present on the market will show that, owing to the desire to skimp prices there is absolutely no room left for the provision of a controller of a decent size, and this condition of things is likely to continue until either ship owners see the necessity for having

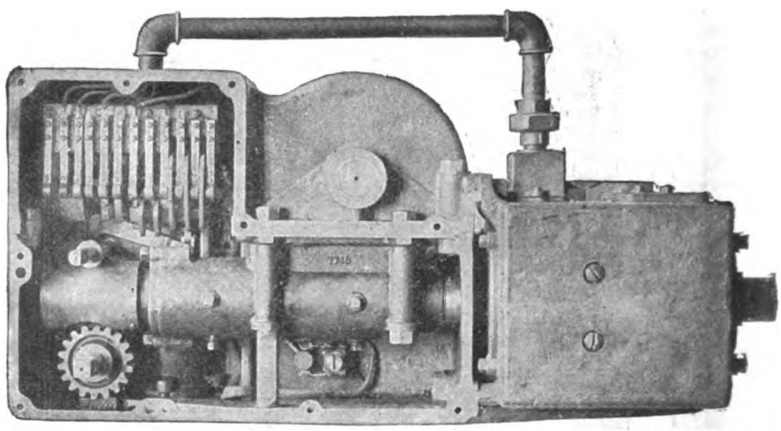

FIG. 3.—MOTOR AND SAFETY CONTROLLER FOR WATERTIGHT DOORS.

consulting engineers capable of specifying adequate provisions for safety, or until electrical manufacturers combine to produce a standard specification from which they will not depart.

The subject of electric winches and capstans, although an integral part of this discussion cannot be fully dealt with in an article of the present length. By the courtesy of Messrs. Clarke, Chapman & Co. (Ltd.), Figs. 1 and 2 illustrate typical forms of capstans which are designed to meet the conditions of marine practice found as the result of considerable experience and yet complying as far as possible with the marine demand for low cost. Fig. 1 shows an anchor capstan capable of operating a weight of 1 ton at 45 ft. per minute, while Fig. 2 shows a combined windlass and capstan for $1\frac{5}{16}$ in. rope. The

FIG. 4.—EMERGENCY STATION ON THE BRIDGE.

use of electric winches and hoists on board ship is now becoming increasingly popular for purposes ranging from small whips for light baggage and provisions to elaborate passenger hoists, equal to those found in hotels, and which are now installed in many of our liners. The same trouble of price cutting is, however, becoming increasingly apparent, and unfortunately a winch for cargo working lends itself admirably to high rating. A winch may be specified to deal with 30 cwt. at 100 ft. per minute, and an unscrupulous manufacturer may put in a motor which would only do this work at a cost of

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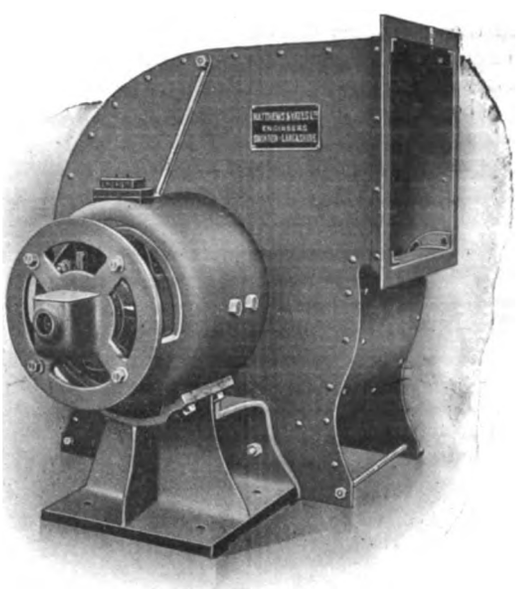

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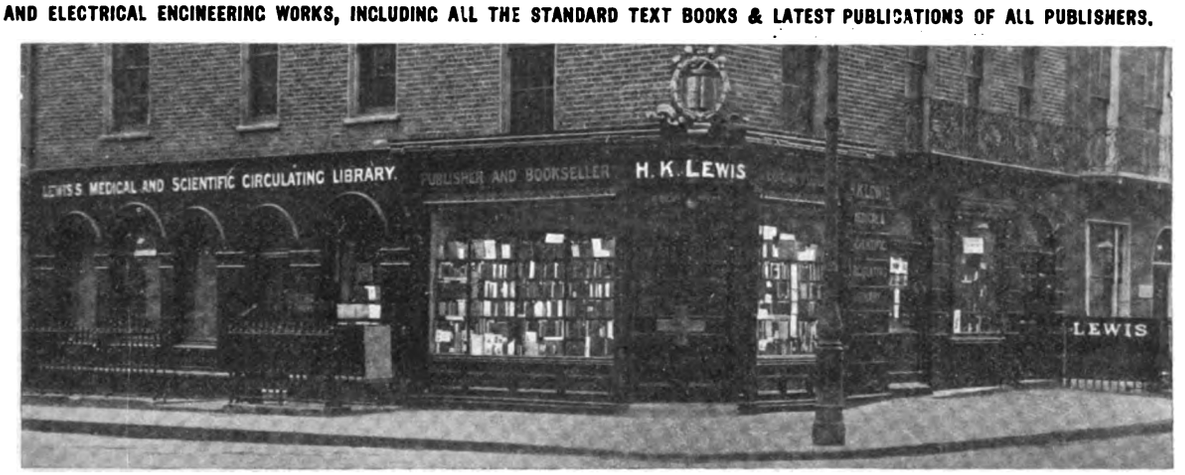

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immense over-heating. As, however, the majority of the packages carried by a vessel on several consecutive voyages may be only 15 cwt., the trouble may not be found until by some chance the ship is loaded with cargo up to or even above the normal rating of the winches. The electrical gear then, of course, fails, and odium is cast not only on the maker who has supplied inadequate plant, but on the whole electrical industry. As, however, the plant by this time will be paid for and the guarantee time expired, the owner of the vessel has no remedy. Other points in connection with winch design are that winches, capstans and whips should be waterproof, which is best effected by making each separate part such as the motor and controller entirely waterproof; but the minimum degree of safety with regard to deck machinery should be that weather and water washing about the decks should not be able to get at the electrical conductors. For electrical plant which, is to be installed in such situations as the well of a cargo steamer, it is necessary to guard against the possibility of total immersion of the gear. Such apparatus should also be as "fool proof" as possible, that is to say, that in view of unskilled handling by stevedores and similar types of labour, the controllers of such gear as winches and capstans should not only have arrangements whereby the stops of the controller are indicated, such as the star wheel device on the ordinary tramway type of controller, but if possible, arrange-

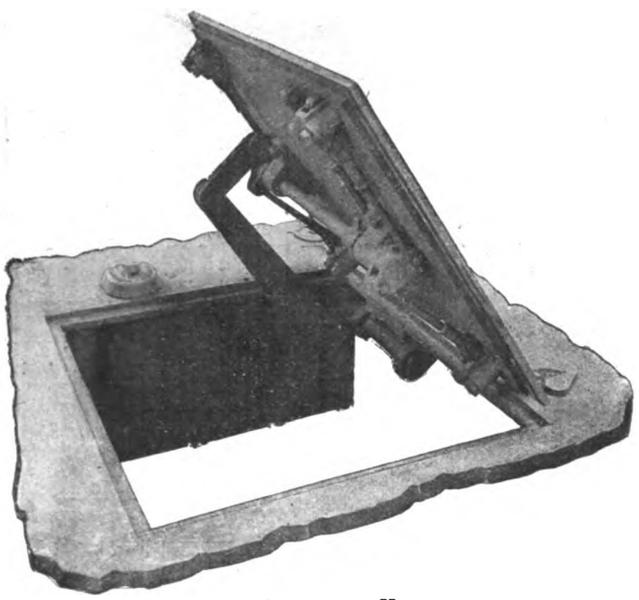


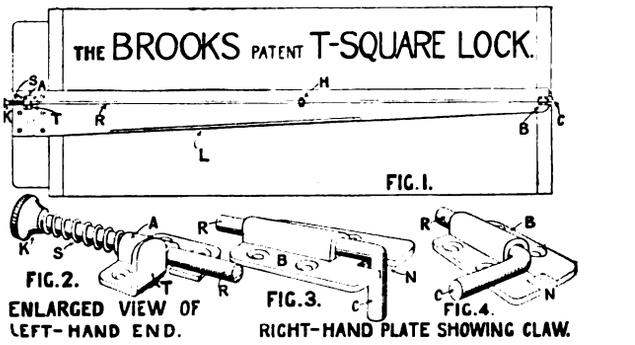
FIG. 5.—WATERTIGHT HATCH.

ments should be fitted so that it is impossible to hold the controller in intermediate positions in order to avoid the burning on contacts due to careless usage. An appliance of this description has recently been placed on the market. A recommendation which may be of value is that magnetic brakes, although more costly than the ordinary foot brake, are of considerable value in increasing the life of winches and capstans, inasmuch as by this means the control of an electric winch approximates more nearly to that of the steam winch.

There are a considerable number of minor applications of electric power for auxiliary purposes on board ship to which reference could be made if space permitted; but perhaps one example will be sufficient to show the possibilities in this direction when marine engineers have been educated up to them. This is the electrical operation of watertight doors which has been developed by the British Thomson-Houston Co. (Ltd.), a feature which, if adopted, will go far to increase the practical availability of the watertight bulkheads of a vessel in case of collision or grounding. The electrical system to which reference is made has a central emergency station on the bridge for closing all the watertight doors, together with a lever action on each door, whereby a man at any door can open it at any time during an emergency period, the door then automatically closing again. Means are also provided whereby the current is automatically shut off when an obstruction fouls the doors, the circuit being then automatically closed again, and so closing the doors the moment the obstruction is removed. This renders the burning out of fuses avoidable. The watertight doors are provided with a specially designed electrical motor and safety controller, shown in Fig. 3, while the emergency station on the bridge is shown in Fig. 4. Indicator lamps fixed on this show at any time the position (open or closed) of any door, and in the case of local obstruction will point out the door to be cleared. The switching mechanism does not start all doors operated by the emergency station at the same time as this would impose a very heavy load on the generator in the event of a large number of doors being installed. There is a time difference of about three seconds between the operation of each motor. The operation of a single door requires about $\frac{3}{4}$ H.P. for 15 seconds, while by the delay action a group of 24 doors can be closed in under 70 seconds with about 5 H.P. on the generator. Similar mechanism can be adopted for watertight hatches (Fig. 5).

Another application of electric power to auxiliary purposes which has not up to the present received the amount of attention which it deserves is the operation of refrigerating plant. Nearly all modern passenger vessels of medium and large capacity, together with the important class of freight vessels engaged in the produce carrying trade are fitted with systems of refrigeration worked on the carbonic acid or ammonia process. This involves the more or less continuous use of power for the pumps, and it is here suggested that this use of power which is of a continuous nature should be one of the useful applications of electricity on board ship.

Enough has been written to show that the installation and operation of auxiliary plant on board ship is by no means the easy proposition which some electrical engineers appear to imagine. At the same time there are possibilities of immense advances to be made in this direction and it would therefore be to the advantage of electrical manufacturers and engineers to interest themselves more largely in determining the conditions in which power may be applied as auxiliary service in the mercantile marine.



The BROOKS Patent T-square Lock is a simple device, which can be attached in a few minutes by means of a few small screws (supplied) to any ordinary T-square, enabling the latter to be locked in any position on an inclined or vertical drawing board, thus setting both hands free to manipulate the set square, &c. The T-square may, nevertheless, be shifted with the same freedom as an ordinary T-square. Provided with this attachment the draughtsman has all the convenience of an expensive drafting machine, together with the accuracy of the T-square.

No alteration or addition to the drawing board is necessary.

The metal parts are all nickel-plated and polished.

The rod R slides in plates A B; spring S presses knob K to the left, thus pulling claw C against one edge of board and the stock of the T-square against the other. To release, the finger presses K to the right, the thumb resting against T, thus pushing C out of contact with the edge of the board. The ledge L is provided for attachment to the blade of the T-square for holding compasses, &c.

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"Witton" Power Plant for Ship Work.

The modern battleship and passenger carrying vessel are built by the aid of electrical machinery and equipped with electrical plant of one class or another. The electric driving of large tools in shipyards is now regarded as a sign of progress, and any shipbuilding establishment is considered incomplete if it is lacking in this respect. Similarly on board ship it is not sufficient that the vessel be electrically lighted. The auxiliary plant and machinery must be electrically driven.

The General Electric Co. has completed numerous installations of "Witton" dynamos and motors in shipyards and on many important passenger boats. At its large engineering shops at Witton, near Birmingham, the Company is able to produce the whole of the heavier pieces of electrical machinery for ship and dock and harbour power plants. Generators, switchgear, motors, and starting apparatus all emanate from Witton, and bear that distinctive name. It would quite naturally be difficult to describe the many examples of "Witton" dynamo and motor installations in connection with marine work, but the adjoining illustrations are of interest in that they depict some of the latest work done with "Witton" plant.

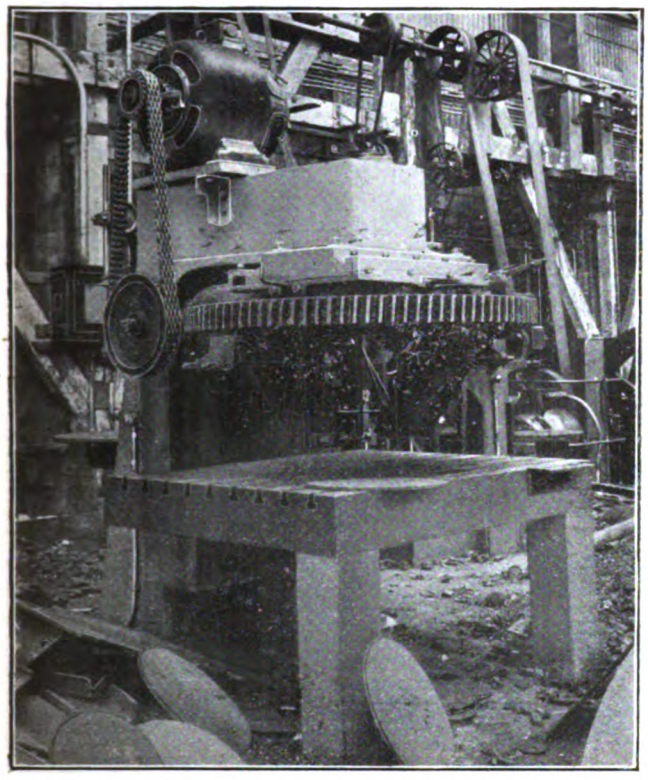

FIG. 1.—PORTHOLE CUTTING MACHINE DRIVEN BY "WITTON" MOTOR.

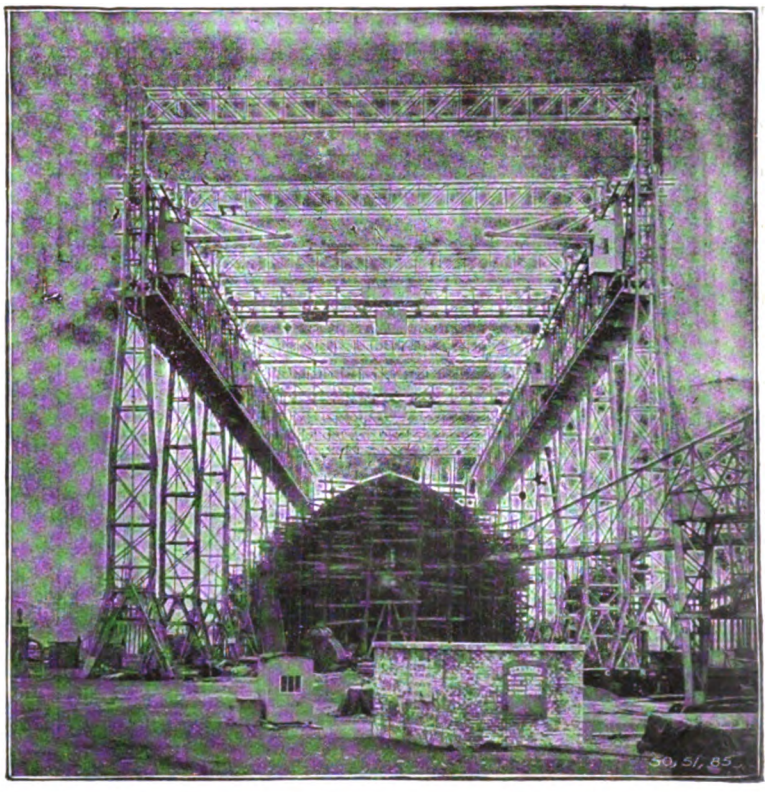

FIG. 2.—TWO OVERHEAD TRAVELLING CRANES DRIVEN BY "WITTON" MOTORS IN SHIP'S BERTH.

In shipyards and marine engineering shops it is customary to drive all the heavy tools with an independent motor. Fig. 1 shows an interesting tool operated by a "Witton" motor, which is mounted directly on the frame of the tool. The motor develops 10 H.P., and is chain-geared to one of the lay shafts, from which the power is suitably transmitted to the rotary

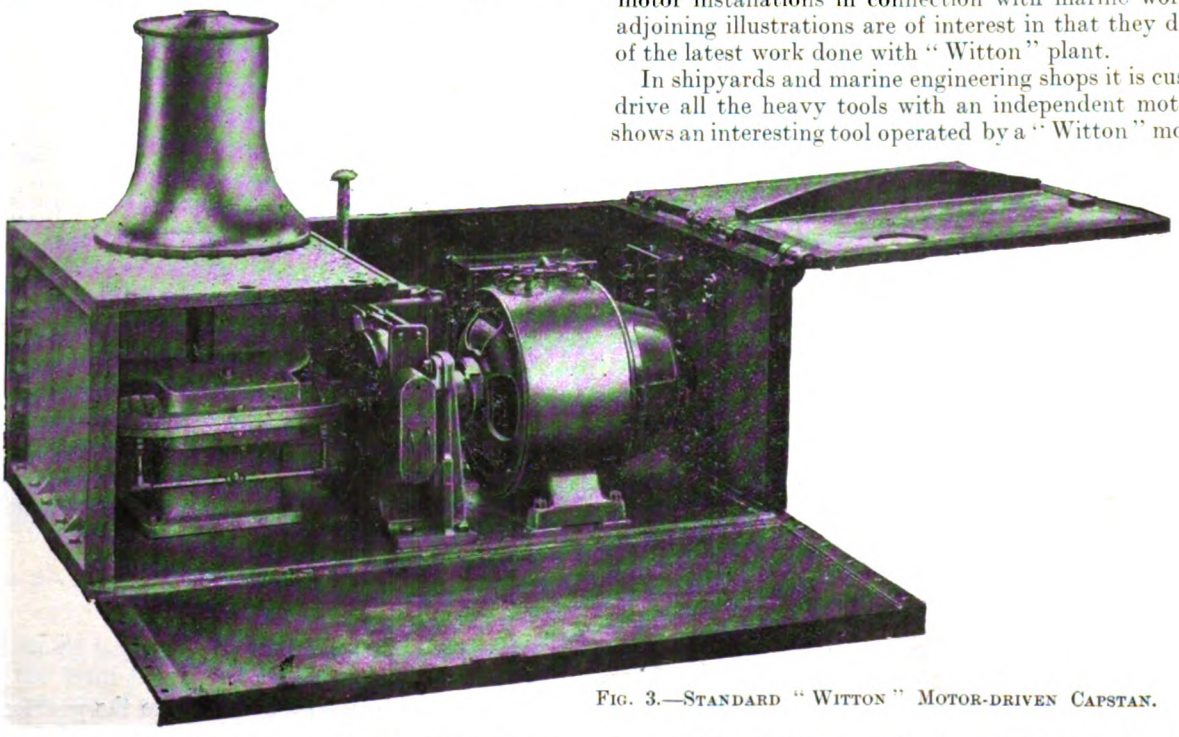

FIG. 3.—STANDARD "WITTON" MOTOR-DRIVEN CAPSTAN.

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cutting tools. This machine is interesting in that it is employed for cutting portholes out of ship plates. The holes are clean cut and completed in this tool, as the discs lying at the side of the machine clearly show.

"Witton" motors are also installed to a considerable extent for crane operation, and Fig. 2 shows a ship's berth which is fitted with two overhead travelling cranes driven by "Witton" motors.

Fig. 3 shows a standard pattern capstan fitted with "Witton" motor. This has been installed in large numbers on docksides railway sidings, goods yards, &c. It is noteworthy among devices of this kind for the accessibility of the motor and driving gear. The top cover is hinged in two sections, and may be swung clear of the motor and starting gear. The latter is totally enclosed, and is operated by a pedal at the side of the capstan bollard.

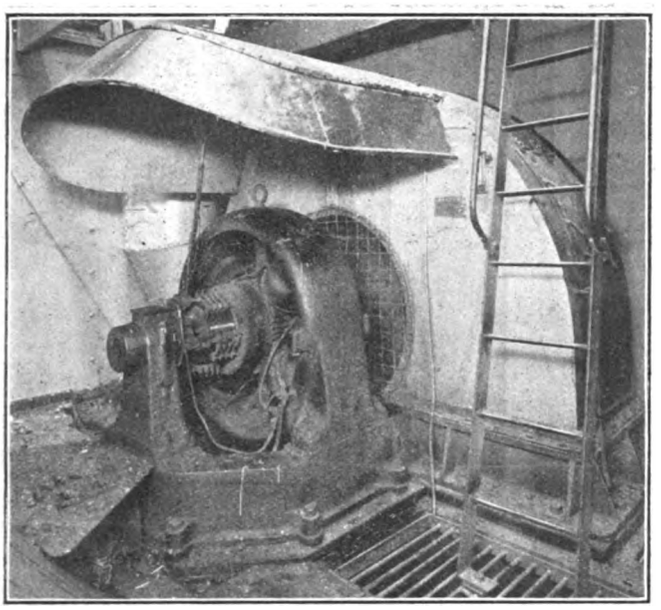

FIG. 4.—FORCED DRAUGHT FAN DRIVEN BY "WITTON" MOTOR ON R.M.S. "MALWA."

Fig. 4 shows one of the forced draught fans installed on this vessel and driven by a 25 H.P. variable speed "Witton" motor. The fan is direct-coupled to the motor, and a large hood is placed above the motor to protect it from falling water. All the auxiliaries on board this vessel are driven by "Witton" motors, which are directly coupled wherever possible to the machines driven.

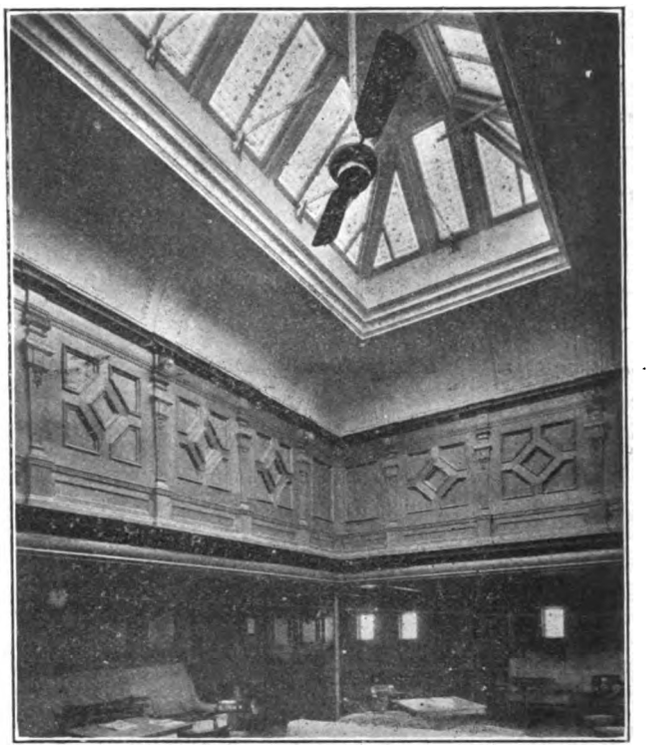

FIG. 6.—70 IN. "FREEZOR" FAN IN SMOKING ROOM OF R.M.S. "MALWA."

The cooling arrangements on the R.M.S. "Malwa" are very complete, and G.E.C. "Freezor" fans are installed. Fig. 5 depicts the interior of the saloon in which 12 70 in. and 16 20 in. fans are fitted. These fans are fixed to the ceiling, and are of the long or short stem type, according to the position of the fan. Fig. 6 shows the first-class smoking room of the same vessel, and a 70 in. "Freezor" fan depending from the skylight. In the same room four 16 in. bracket fans are in use.

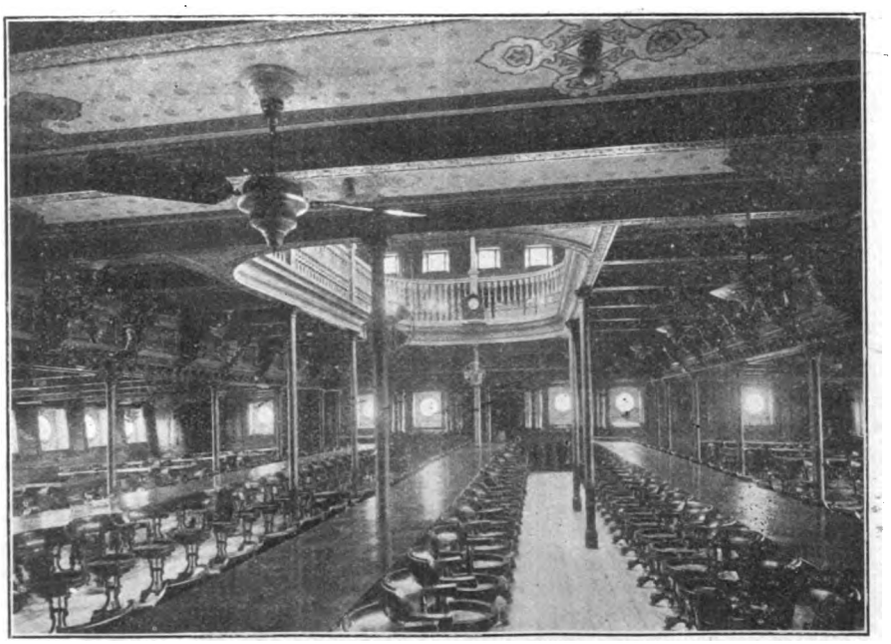

FIG. 5.—SALOON OF R.M.S. "MALWA," FITTED WITH "FREEZOR" FANS.

Of numerous ship installations employing "Witton" plant, that carried out recently on the R.M.S. "Malwa" is of interest. The whole of the electric power equipment comprises "Witton" dynamos and motors, switchgear and starting apparatus.

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Bilge Pumping.

Not the least important of the operations on board ship is to keep the holds and lower parts generally free from bilge water, both for marine and hygienic reasons. To do this some sort of pump is required, and, all things being considered, an electrically-driven pump has some distinct advantages for this purpose. It is, therefore, not surprising to find many firms exercising their ingenuities in this direction.

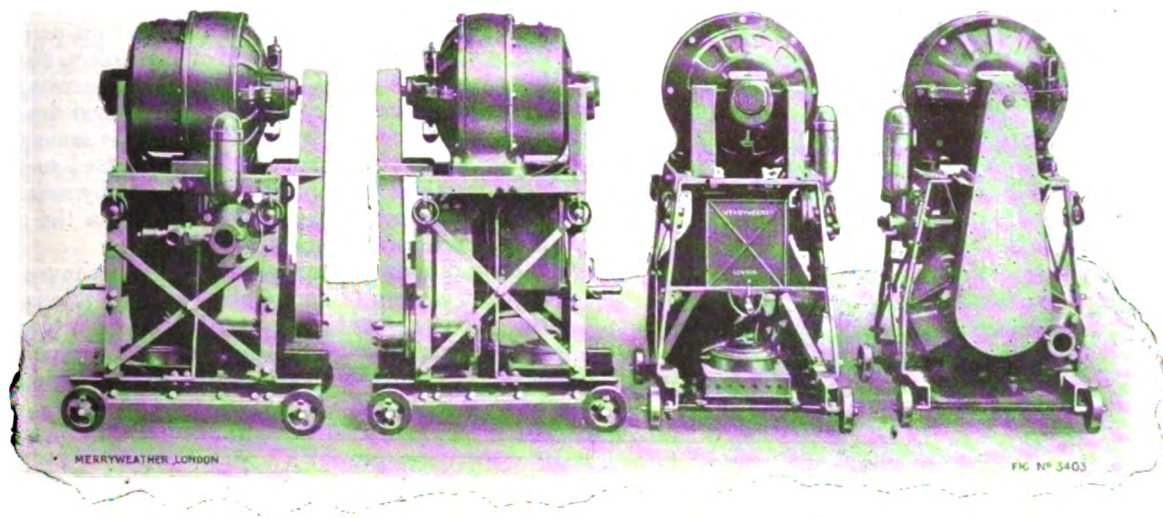

FIG. 1.— ELECTRICALLY-DRIVEN BILGE PUMPS.

Our illustration (Fig. 1) shows an electrically-driven bilge pump recently introduced by Messrs. Merryweather & Sons, of Greenwich. The "Hatfield" treble barrel pump has been employed under all sorts of conditions where water supply, general pumping or fire extinction is concerned, and the arrangement here shown has been designed for service on board ships as an auxiliary to the stationary steam bilge

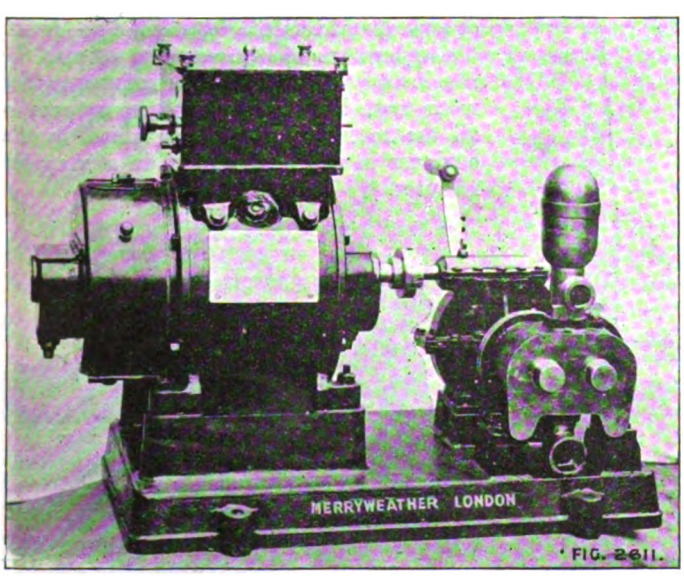

FIG. 2.—ELECTRICALLY-DRIVEN ROTARY OIL PUMP.

pumps, and should be found specially useful in harbour, when the fires in the main boilers are drawn so that the ordinary bilge pumps are out of service. For dockyards, and shipbuilding yards also, such a pump would prove a most valuable acquisition for keeping clear of water after launching, pumping out compartments after testing, &c., whilst a further point that merits consideration is the knowledge that it is always available as a fire pump, being capable of throwing powerful jets with the aid of flexible hose pipe.

The pump itself is constructed entirely of gunmetal, with three barrels arranged symmetrically round a steel crankshaft, and a polished copper air vessel is provided both on the suction and delivery. The electric motor is of the latest and most approved construction, and drives the pump by means of a special silent chain provided with suitable wrought-iron guard. The motor is fitted with controlling gear, arranged so that the pump can be worked at half or full power. The motor and pump are mounted upon a light and strong steel framework securely braced and stayed. Four rings are fitted to the frame for slinging purposes, and four small gunmetal wheels are provided for travelling.

The special features of the plant are lightness (the weight being about 9 cwt.), compactness in design and small floor space occupied. It can be lowered through a hatchway 3 ft. by 2 ft. 6 in., and its portability enables it to be easily conveyed to any compartment of a vessel where its services may be required. The pump has a capacity of 10 tons of water per hour, and will raise water by suction from a depth of 20 ft. or more without the aid of priming devices. It will deal effectively with water laden with oil or grease, a condition of things which is more likely than not to prevail in the case of bilge water.

Another interesting pumping equipment made by this firm is the electric and hand driven rotary oil pump shown in Fig. 2. It was supplied for use on H.M.S. "Russell." Its duty is to fill the supply tanks for an oil-engine generating set. The pump is capable of lifting oil fuel from a depth of about 10 ft. to a height of about 40 ft. above the pump.

A feature of this apparatus is that it can be worked by hand when inconvenient to run the electric motor, the pump being readily interchangeable from hand to motor gear, or vice versa. Another important advantage is that it is "silent" in working; and as the pump is equally adapted for pumping water, this point should commend it to those requiring a pump for service inside a building where the noise occasioned by the "thump of the pump" is objectionable. The pump is driven by means of a worm gearing with gunmetal wheel, steel worm with ball bearing thrust blocks, and running in an oil bath. The motor is an improved totally enclosed type, specially constructed to pass Admiralty requirements. It is watertight, and complete with double-pole switch and starting switch. The whole apparatus is mounted on a cast-iron bedplate, and forms a very neat and compact machine, the space occupied being only 3 ft. long by 1 ft. 8 in. wide, the extreme height being 2 ft. 3 in.

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"Cyclone" Fans.

The ventilation of ships up to within a recent date was not looked upon very seriously, and the cowl fixed on the top deck, through which the foul air from below meandered in a lackadaisical fashion, was thought to be ample for all requirements. This fallacy, however, has now been exploded, and, thanks to the rapid strides which have been made in electricity, it is now possible to obtain that perfect ventilation on board ship which is so very necessary where hundreds of people are crowded together 'tween decks. The electrically-driven fan has remedied these one-time drawbacks, and among the most suitable for this purpose may be placed the "Cyclone," manufactured throughout by Messrs. Matthews & Yates, of Swinton, Manchester.

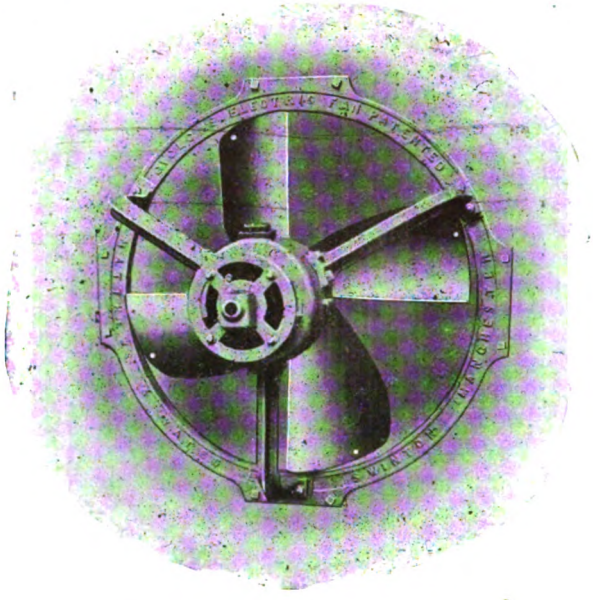

FIG. 1.—THE "CYCLONE" PORTHOLE FAN.

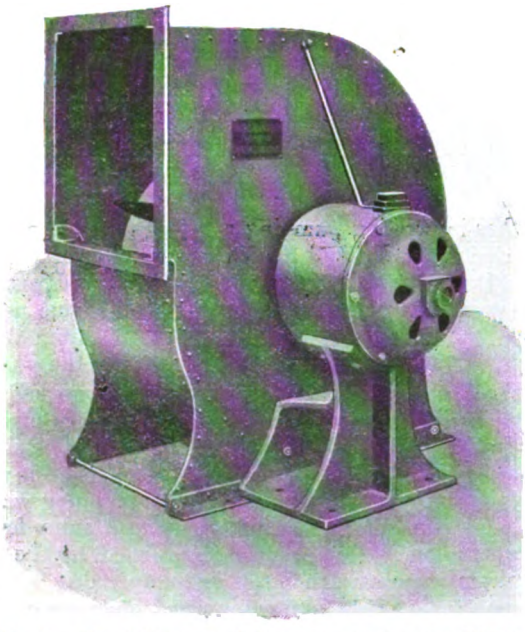

FIG. 2.—THE "CYCLONE" BLOWER FOR MARINE WORK.

This firm make two types of fans, viz., the open propeller and the cased or centrifugal, the former being used when it is possible to get a free outlet and the latter where it is necessary to overcome the resistance of ducts, &c. Both types are fitted with the firm's high-class motors, now so widely known. They are compact, liberally designed and of sound construction, the parts being interchangeable and both armature and coils are former wound. The fans themselves are the outcome of years of experience and are guaranteed to be equal in efficiency and output to any on the market; in fact, the makers claim that the power consumed is less than any other make for a given output.

The "Cyclone" blower and exhauster is, it is claimed, the exact thing for the ventilation of the stokehold, or for cooling the engine room, and this particular type of fan can also be adapted for supplying draught to the boilers. Mechanical draught is now being adopted largely for marine work, both on the forced and induced principles. The former is accomplished by delivering a pressure of air under the ashpit and the latter by fixing a fan on the funnel side of the boilers, which draws the hot gases through the furnaces, and also increases the draught in the grate bars, &c. With the increased draught a greater quantity of fuel can be consumed on the same grate area and a greater heat obtained. This, transmitted to the boiler furnace, increases the capacity of the latter by raising more steam in a given time, and, in addition, renders the amount raised independent of the funnel.

An additional advantage obtained from the use of mechanical draught is the abolition of black smoke; this is prevented by the correct amount of oxygen being drawn through the fires, and combining with the carbon at the proper temperature. Seeing that black smoke is due to incomplete combustion, a saving is thereby effected.

Electrical Resistance Thermometers for Cold Stores.

The importance of keeping a careful watch over the temperature in cold storage chambers is evident to all. In some large stores a man is employed whose sole duty it is to read and keep a record of the temperatures of the various thermometers distributed over the buildings. If ordinary thermometers are used this necessitates the opening and shutting of a large number of doors, which, in addition to the labour cost, is very wasteful of power, and tends to destroy the uniformity of temperature of the various rooms. By the installation of electrical resistance thermometers, however, the temperatures of all the rooms may be ascertained by the engineer in the engine room in a very few minutes.

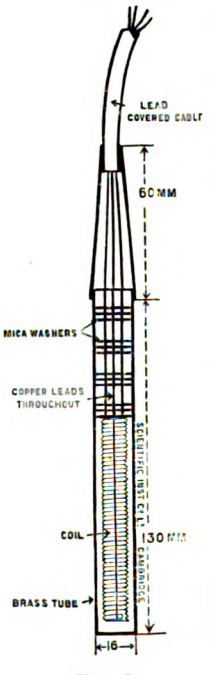

FIG. 1.

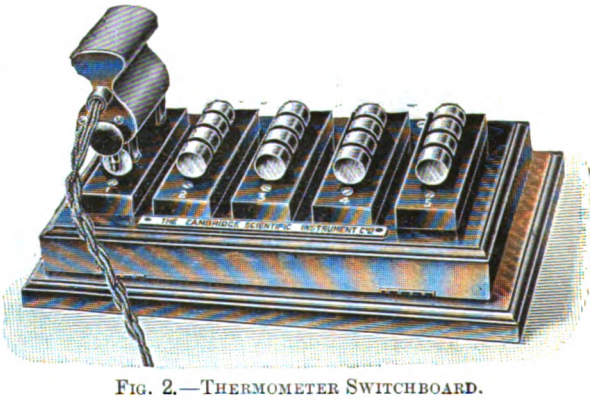

FIG. 2.—THERMOMETER SWITCHBOARD.

The Cambridge Scientific Instrument Co., who supply electrical thermometers and pyrometers of many patterns, have also developed a special design for use in cold stores. These work on the Wheatstone's bridge principle, the indicator (Prof. Callendar's patent) being a combination of a galvanometer with a bridge of the Callendar and Griffiths' type. A

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number of outfits similar to that described below have been installed by the Company at docks and other places; and a modified design for use on board ship is to be placed on the market in the near future.

A four-way lead-covered cable runs from the indicator to the thermometer, two of the wires being connected to the resistance coil of the thermometer, whilst the other two are "compensating leads." These latter are connected to the bridge so as to neutralise the effect of the other two wires, and so render the reading of the indicator entirely independent of the length of the leads or of changes in their temperature. As the resistance of the thermometer changes with the temperature, the galvanometer is deflected. This deflection can be brought back to zero by moving the galvanometer contact point on the slide wire of the bridge. The position of the contact point may, therefore, be calibrated to indicate directly the temperature of the thermometer. Leads are run from the refrigerating rooms to the engine room, and connected to a switchboard (Fig. 2). By means of a plug connection is made from any of the thermometers to the indicator. An electrical resistance thermometer suitable for use in cold stores is shown diagrammatically in Fig. 1. Being enclosed in a brass tube it is readily responsive to changes of temperature and practically unbreakable.

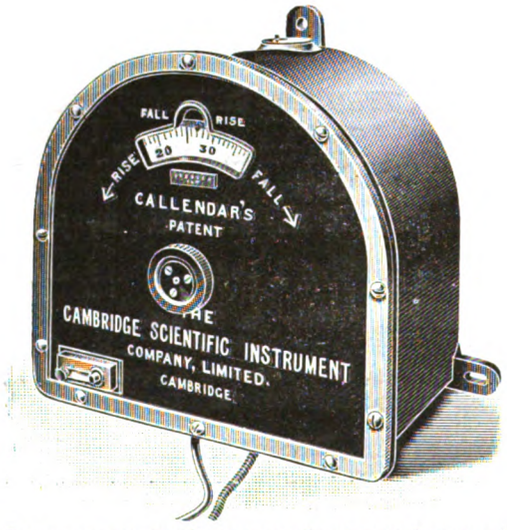

FIG. 3.—INDICATOR OF THE CAMBRIDGE SCIENTIFIC INSTRUMENT CO.

The indicator illustrated in Fig. 3 is fixed on the wall near the switchboard. It is enclosed in a cast-iron case, on the face of which are placed a key and handle. When the key is pressed, if the galvanometer needle (seen at the top of the window) is deflected either way from the zero position, the handle is turned in the direction opposite to that of the needle's deflection, until the needle arrives at the zero. This shows that the bridge is balanced and the temperature of the thermometer can then be read directly from the dial. A small battery of dry cells completes the equipment.

As mentioned above, the Cambridge Scientific Instrument Co. have fitted up several large cold stores with thermometer outfits of this type. In one case, where 34 thermometers were installed with one indicator and switchboard, it was found that the temperatures of all the rooms could be read in 10 minutes. Before this installation was adopted the same operation took 55 minutes. As the readings are taken eight times in the 24 hours, the time saved amounts to six hours per day. In the majority of cases, therefore, an installation will more than pay for itself in 12 months.

A very complete system of electrical thermometry, known as the "Telethermometer," has been worked out by Messrs. Nalder Bros. & Thompson, Ltd. This system was originally suggested by Mr. A. B. Chatwood. Whilst being generally applicable to measuring temperatures under various conditions, it has been especially designed for use in cold stores and in vessels carrying refrigerated produce, and has proved very useful in magazines and coal bunkers on board ship. It is perfectly simple in operation, needing no technical skill or knowledge whatever, all that is required to be done being to turn a handle (or press a button) and read the dial.

Amongst many advantages connected with the use of this system on board ship is that thermometer tubes from the holds to the deck may be entirely done away with, which is a great advantage, inasmuch as there is no interference with the cargo, and no risk of carrying water from deck into the holds. All the thermometers in the ship can be read from one central point, and this point may be anywhere that is convenient, such as the engineer's cabin. Also, as each thermometer is never

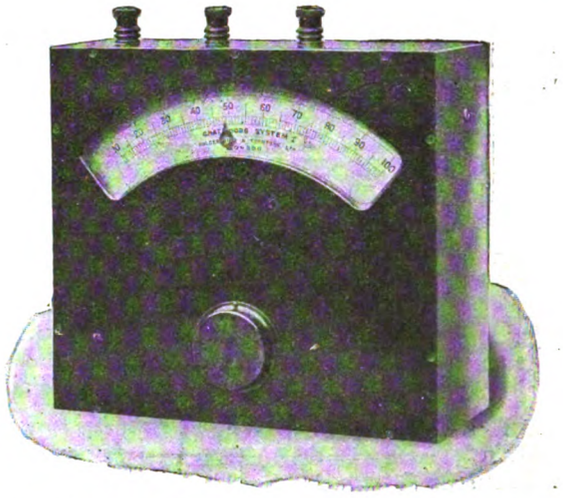

FIG. 4.—INDICATING INSTRUMENT OF MESSRS. NALDER BROS. & THOMPSON.

moved from its position, the results obtained must be far more accurate than where the thermometer has to be moved in order to read it.

Fig. 4 shows the indicating instrument; this is mounted in a polished wood or cast-iron case, and is of the moving coil type. An electrical resistance thermometer is used, mounted in a hollow metal tube, as shown in Fig. 5, thus ensuring a quick response to any change of temperature. From each of these tubes a lead-covered cable of suitable diameter is run to a distributing switch and the indicating instrument. A hand magneto is provided as a reserve in case there should be a breakdown in the electric lighting system, and excepting under this circumstance the apparatus is worked from the lighting mains. The actual pressure required is about 30 volts continuous current, and a resistance is provided to enable the correct voltage to be applied to the terminals of the instrument.

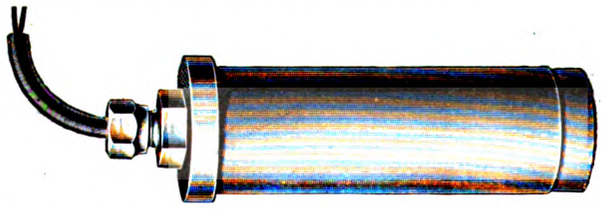

FIG. 5.—ELECTRICAL THERMOMETER OF MESSRS. NALDER BROS. & THOMPSON.

The features claimed by Messrs. Nalder Bros. & Thompson for this system are its great simplicity and the speed with which the temperature at a large number of different points can be measured.

In practical resistance thermometry it is a great advantage to use an indicator reading directly in air scale temperatures by the movement of a pointer over a dial, rather than to have to balance a galvanometer to zero and take the reading from the balancing resistance. The latter method renders it impossible to watch a varying temperature without constant manipulation, and it is always desirable to avoid this in commercial measuring appliances. In our issue of December 25, 1908, we briefly described an instrument for effecting this, namely the

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Harris resistance thermometer indicator, shown by Mr. Robt. W. Paul at the Physical Society's annual exhibition of apparatus. Since then improvements have been effected in the construction, and a full scale deflection can now be obtained for a variation of 50°C. or less, in the temperature of a platinum thermometer of 1 ohm fundamental interval, employing an indicator with a balanced movement suitable for use at sea.

The indicator is constructed upon the principle of the differential galvanometer with an electrical control. One of the differential windings (X in Fig. 6) is shunted with a platinum thermometer, the other winding, S, being shunted with a

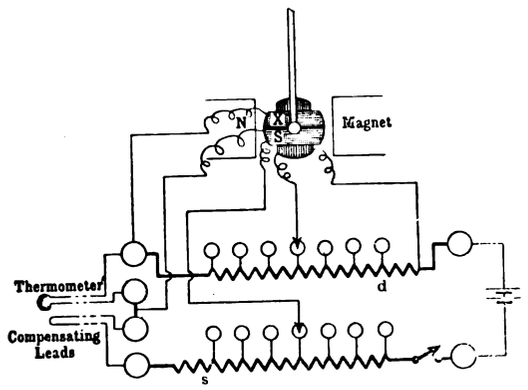

FIG. 6.—DIAGRAM SHOWING ELECTRICAL THERMOMETER CONNECTIONS.

resistance *s*, which is made variable so as to equal the resistance of the thermometer at certain fixed temperatures. The control coil of the ohmmeter system is also shunted with the resistance *d*, the value of which is determined by the degree of sensitiveness required, and may be made variable with *s*. These shunted windings are connected in series, and the circuit is completed through a battery and switch. By using a differential winding (the currents in which are respectively due to the resistances of the thermometer and *s*) in conjunction with a control coil (in which the current is proportional to a selected difference unit *d*), the advantage is gained of making the indicator read on both sides of what would be the zero point

FIG. 7.—ELECTRICAL THERMOMETER BY R. W. PAUL.

in an ohmmeter of the usual construction, thus increasing the open length of the scale from about 45 deg. of arc to more than a right angle. Moreover, as the deflection is proportional to the ratio of the *diffe ence* of the currents in the differential windings to the current in the control coil, the sensitiveness for a given variation in the temperature of the thermometer may be made as large as desired by giving a suitable value to *d*, and is only limited by practical considerations.

The instrument, which is illustrated in Fig. 7, may be constructed to cover a full range of temperatures up to 1,200°C. By means of a switch the range covered by the deflections may be moved along the temperature scale, *e.g.*, an instrument covering by deflection, say, 200°C. may be set to read from 0–200°C., 200–400°C., &c., at will; and when so constructed the movement of the switch simultaneously varies *d*, thus automatically compensating for the decreased change of the resistance of the thermometer at higher temperatures and maintaining the accuracy of the readings on the air scale.

It is not to be expected that an instrument reading by deflection will attain the high scientific accuracy of null methods. The first commercial instrument of this type made up, however, showed a quite remarkable accuracy, which was confirmed by tests made at the National Physical Laboratory, where the error was found in no case to exceed one-third of 1 per cent. At the National Physical Laboratory the errors, with a 4-volt accumulator whose E.M.F. was 4·2 volts, were found to be as follows :—

Temperature (degrees).	Error.
0·0	0·0
100·0	0·0
203·1	−0·1
420·2	−0·2
779·4	+0·8
1,196·9	−1·9

To study the effect of the measuring current, a series of readings were taken with a secondary battery, whose E.M.F. was only 3·7 volts, and also with the 100-volt lighting circuit mains with 1,000 ohms in series.

True air temperature.	Readings of indicator. Battery E.M.F. 4·2 volts.	Battery E.M.F. 3·7 volts.	100-volt lighting circuit.
100·0	100·0	100·0	100·0
654·4	656·0	656·0	656·0
1,196·9	1,195·0	1,198·5	1,197·0

A calibration of the scale was made for every 20 deg. for the range 200°C.

Indicator reading	0·0	19·8	39·3	59·4	79·4	100·0	120·5	140·8
Error	0·0	0·0	−0·3	−0·2	−0·3	−0·0	+0·1	−0·1
Indicator reading				161·4		182·0		203·0
Error				−0·1		−0·2		−0·1

It will be noted that the instrument is practically independent of the applied voltage within the range of charge and discharge of a 4-volt accumulator battery. Where available, current may be taken from the direct-current electric light mains by using a resistance, usually about 10 ohms per volt, in series with the indicator.

The thermometers for use with these indicators are provided with the Callendar & Griffiths compensating loop, and are brought to a standard resistance by means of a series coil of negligible resistance, in the head of the mount, thus securing electrical interchangeability without the necessity of using any adjusting or compensating device.

Capstan and Other Controllers.

The conditions under which electric power is employed on ships, docks and wharf sides differ materially from those which are presented in industrial service. Not the least important element to be considered is that of labour. The average man in charge of a capstan or ship's winch has no respect for things terrestrial. If the machinery under his control cannot perform its functions in the particular manner which he himself prescribes, then the sooner it is broken up the better. Further, the loading or unloading of a ship is not a matter into which the technical refinements of motor control can possibly be made to enter. Affairs maritime are usually conducted on the "get-there-somehow" principle. Electrical apparatus must accordingly expect the same ruthless treatment at the hands of the men as is served out to steam machinery.

The manufacturer of motor control gear must have these important facts in mind. His products must, as nearly as possible, meet the previously existing conditions, and be cabable of exactly similar treatment.

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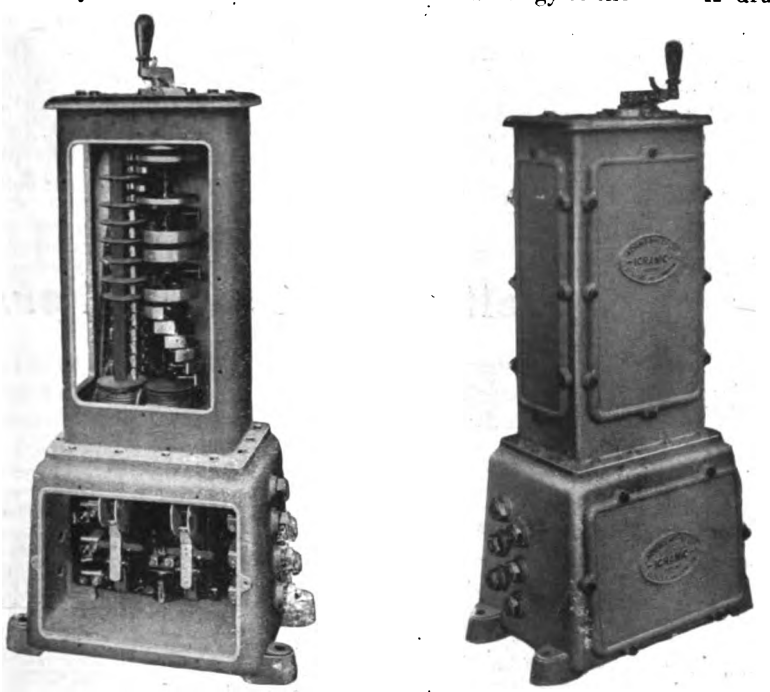
The Adams Manufacturing Co. have been paying special attention to the subject of electric control for shipboard work. They have devoted considerable time and energy to the apparatus, they have produced some excellent pieces of apparatus for mercantile and passenger service.

A drum type controller which possesses some novel and



FIGS. 1 AND 2.—"IGRANIC" DRUM TYPE CONTROLLER FOR MARINE WORK.

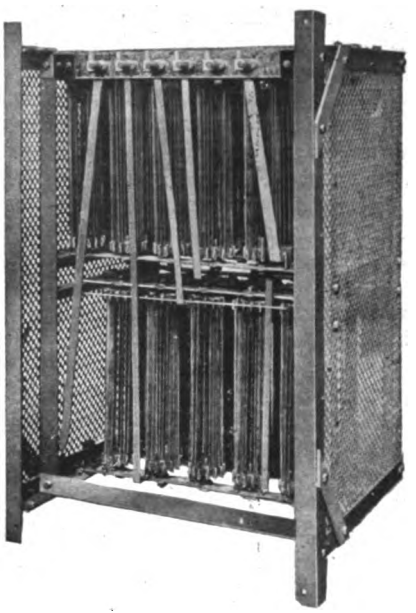


FIG. 3.—"IGRANIC" RESISTANCES FOR MARINE WORK.

design and construction of controllers, and their aim has always been the production of apparatus whose keynote is rugged strength. Apart from the Company's Admiralty interesting features is illustrated herewith (Fig. 1). This can be used for heavy cargo winches, windlasses, or similar duties. It reproduces the characteristics of the steam drive for the

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same operations. It is instructive to compare the operations of a steam engine with the electric motor on, say, a heavy cargo winch.

It is a common occurrence for the engine or motor, as the case may be, to be overloaded until it stops. The steam engine is able to meet this condition easily, for it just comes to rest with steam behind the piston waiting for the load to go off. With the ordinary electrical control, however, the over-load opens the circuit breaker, which has to be re-set before starting again. This continual opening of the circuit breaker has been a source of annoyance and weakness in the electrical drive, and the Adams controller has been designed to avoid this.

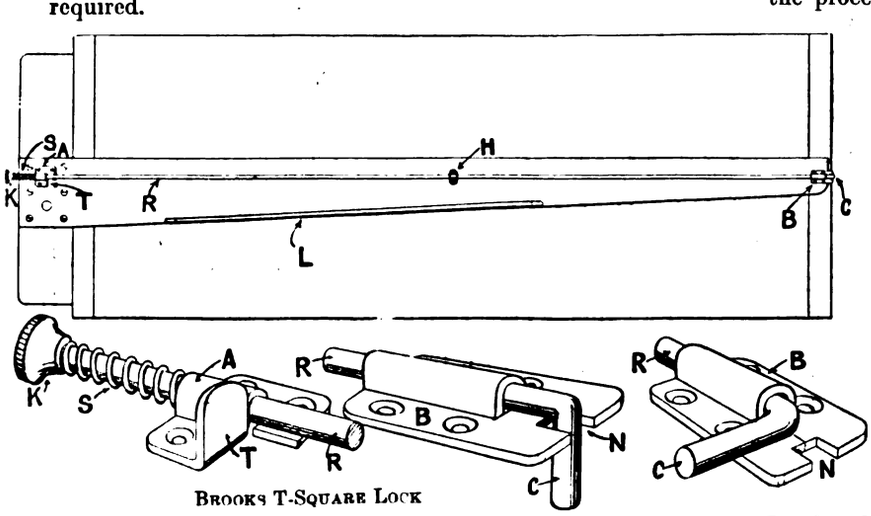
Fig. 2 shows the massive design of the controller, which gives a watertight construction, possessing great strength. The internal parts are shown in Fig. 1. They consist of the ordinary drum contacts and fingers for starting and speed control of the motor, but with the addition of two Igranic patented magnetically operated clapper switches or circuit breakers fitted with no-voltage and overload release.

With this construction, when a heavy overload comes on the motor, the clapper switches "trip" and open the circuit of the motor, bringing it to rest, the load being sustained either by a solenoid brake, or by the latest electrical resistance method. Then, to re-start the winch when the overload is taken off, it is only necessary to bring the handle back to the starting position to re-set automatically the clapper switches and start as before.

Another special Adams product for shipboard use, is a patented sea-going resistance. A bank of these resistances is shown in Fig. 3, and the essential feature of these units is that only iron, mica, and resistance alloy are used in their construction, so that there is nothing to deteriorate. The resistances can be momentarily overloaded to red heat without damage, and the complete resistance is a much stronger and more compact and at the same time a lighter unit than the ordinary grid type.

Brooks T-Square Lock.

An interesting piece of apparatus, which has been designed by Messrs. W. J. Brooks & Co., for drawing office work is the T-square lock. This is a simple device which can be attached to any ordinary T-square, enabling the latter to be locked in any position on the drawing board, thus setting both hands free to manipulate the set square. The arrangement does not, however, prevent the T-square being easily shifted when required.

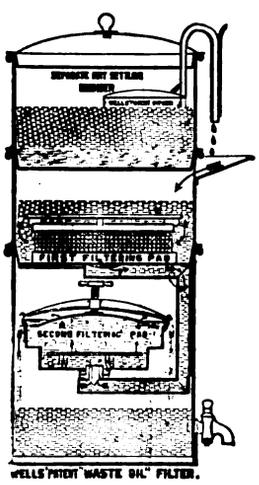


BROOKS T-SQUARE LOCK

The device consists of a thin steel rod extending the whole length of the T-square blade and sliding in bearing plates at each end. These plates are screwed to the blade and stock respectively. One end is bent at right angles to form a claw and the other terminates in a knob. A helical spring bears against this knob and presses the rod to the left, which causes the claw to bear against the right hand edge of the board and to pull the stock of the T-square firmly against the other edge and thus prevent it slipping down. Both hands are thus set free. To shift the T-square the stock is grasped with the left hand, the thumb pressing against the thumb piece and the fore finger pressing the knob to the right. This causes the claw to stand slightly away from the edge of the board, permitting the T-square to be moved by the left hand alone with precisely the same freedom as if no attachment was there. On releasing the pressure on the knob the T-square again becomes locked.

Wells' Waste Oil Filters.

On shipboard it is not expedient to carry any more of one commodity than is absolutely necessary. The space available is so small that "cutting" in all possible directions is necessary to obtain comfort for the personnel. We are not, therefore, surprised to find that oil filters are extensively used in connection with the machinery employed on shipboard, for both an economy in oil consumption and a less space for storage become possible by their use. Messrs. A. C. Wells & Co. make a very efficient filter for this purpose, a section of which we give herewith. The method of operation is sufficiently clear from the illustration. The construction is of the simplest, all parts being easily accessible for cleaning. The filtering pads can be quickly and cheaply renewed. The new patent sight-feed syphons, which are also supplied on the larger sizes, are a valuable addition, as by this method the best surface of the oil only is syphoned over to the filtering pads, giving time for the dirt and water to settle naturally to the bottom of the collecting chamber.



SECTION OF WELLS OIL FILTER.

Mirrors for Searchlights.

The Cowper-Coles process for the formation of mirrors by electro-deposition is now well known, so that a description of the process is unnecessary; it may be mentioned, however, that the Reflector Syndicate (Ltd.), who operate the Cowper-Coles patents in all the principal countries of the world, have recently introduced gold deposited mirrors for searchlights.

Light reflected from a gold-coloured reflector is found to illuminate a distant object more clearly and to be more penetrating in thick and foggy weather, the probable r ason for this being that the beam from a gold reflector contains a very high percentage of red and yellow rays, which are least absorbed by the atmosphere. Another advantage of gold mirror rays is the absence of white halos and consequent deep shadows of objects close to the source of light; in other words, there is a softer and more even illumination of fore and background. It has also been found easier to distinguish colours which are very similar. For instance, a grey object, such as a torpedo boat on a grey sea with a grey sky, is more clearly seen with the gold than with the silver mirror. Lastly, the gold, unlike the silver deposit, is unaffected by chemical or climatic conditions, so that the reflective surface remains highly efficient. This is a distinct advantage for heliograph work, for in damp and tropical countries the silver mirror rapidly deteriorates. These gold-deposited mirrors should, therefore, prove of considerable advantage in marine work.

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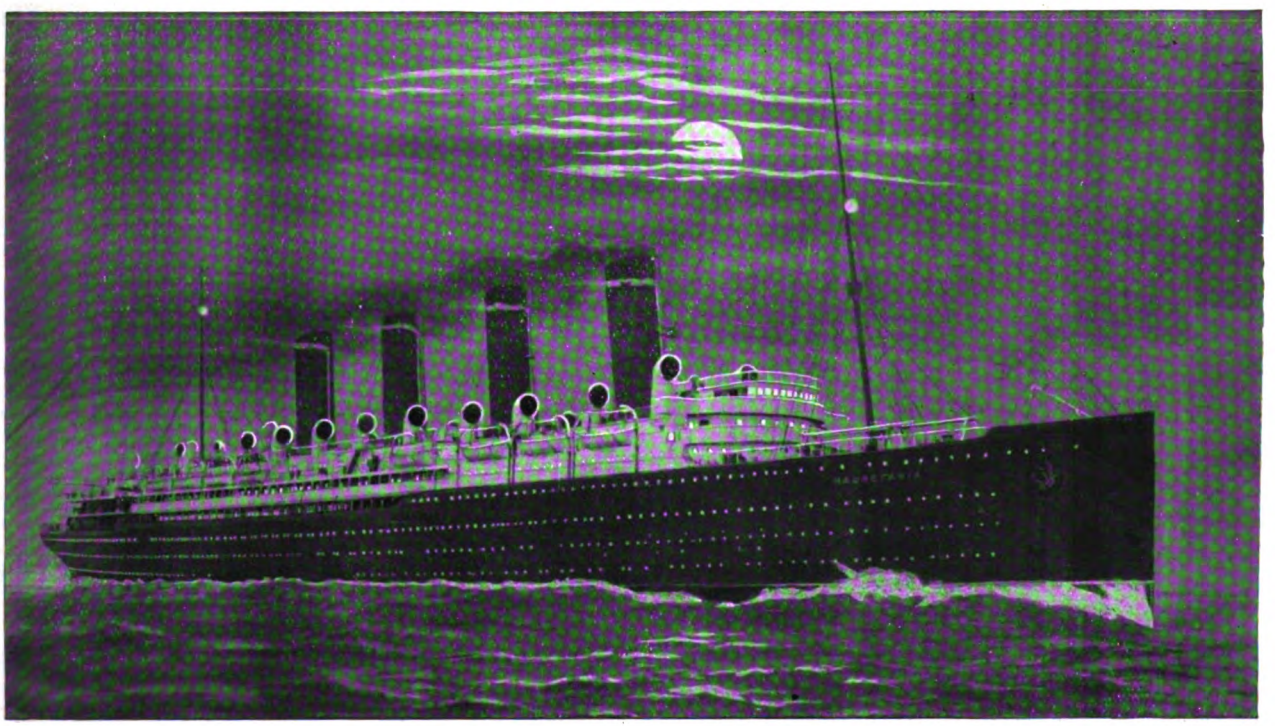

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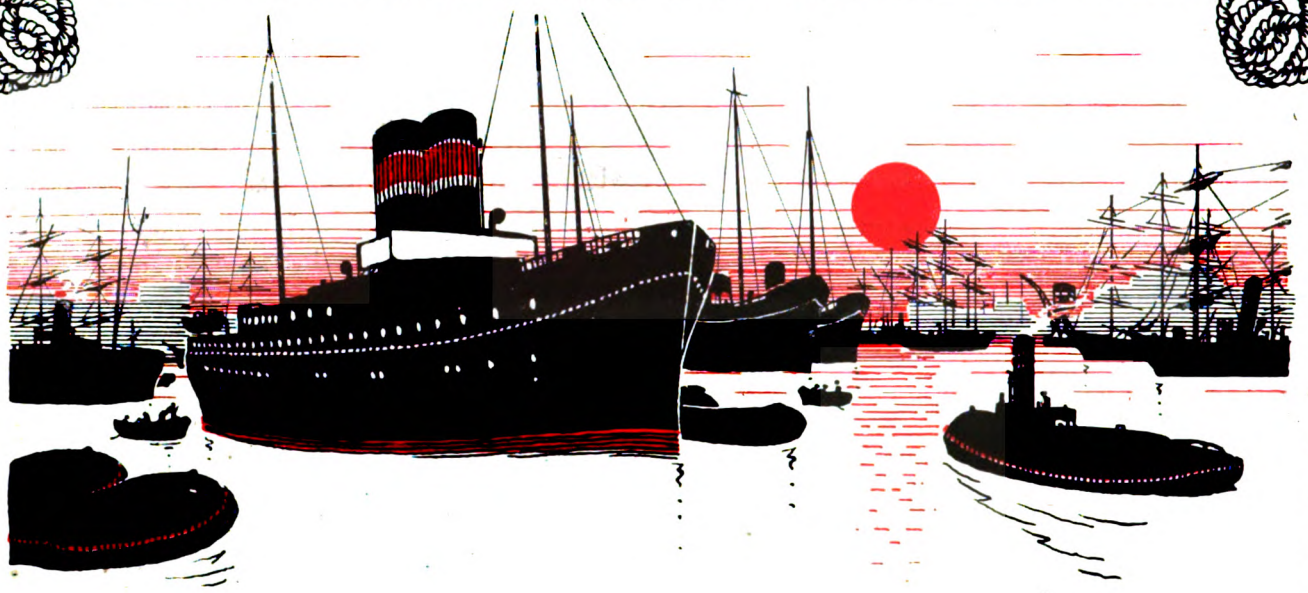

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Printed and Published by GEORGE TUCKER, at the Editorial, Printing and Publishing Offices, 1, and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, JUNE 10, 1910.

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THE EFFECT OF FREE TRADE OR PROTECTION UPON THE ELECTRICAL INDUSTRY.

At the adjourned meeting of the National Electrical Manufacturers' Association, which was held on Monday last, at Caxton Hall, the very interesting discussion on the above subject was continued. An account of this is given below :—

Mr. E. GARCKE, in opening the adjourned discussion, called attention to the fact that what Sir Alfred Bateman, the Comptroller-General of the Commercial, Labour and Statistical Department of the Board of Trade, said in 1902 applied with very great force at the present time, viz., that we were still ahead of Germany and the United States in our power of manufacture for export. But, beginning from a lower level, other countries were travelling upwards more rapidly than we were to get a higher eminence. If peace were maintained, both Germany and the United States were certain to increase their rate of upward movement, and their competition with us in neutral markets would probably become increasingly serious every year. It was necessary, therefore, more than ever, that a change of condition should be recognised, and we could scarcely expect to maintain our pre-eminence without strenuous efforts and careful and energetic improvement in method. Sir Alfred Bateman could not be accused of being a Tariff Reformer. As an official of the Board of Trade he spoke without bias. What was the position at the present time ? For some years past the rate of unemployment in England had been approximately double that in Germany. All nations had suffered in National credit, but England had suffered in a larger ratio than any other countries. Emigration, which was an important factor, was greater from England than from other countries. Those were the conditions that had to be dealt with at the present time in this country. They, however, had met, not to solve the problem of unemployment, but to consider the alternative fiscal systems of Tariff Reform and Free Trade. He wished, first of all, to point out that their views were not diametrically opposed. There was a basis for an arrangement, and he thought he could not do better than to make a general statement of the points of divergence. His argument was that Free Trade and Tariff Reform were very much interwoven in every country and even in every individual. Everyone wanted to have Free Trade in regard to the commodities he purchased, and yet to be a Protectionist in regard to his manufactures. That could not be better exemplified than by referring to the English Labour Party. There was no more protectionist body in the world than our trade unions. It was because the arguments had been so ably expounded by economists that so many educated men were Free Traders at the present time. Moreover, England had enjoyed a period of exceptional prosperity concurrently with the practice of Free Trade. As Mr. Hirst pointed out at the last meeting, it had not been by the aid of Free Trade, but in spite of it. Mr. Cowan had stated that we had too much competition and that it should be regulated. Would Mr. Kingsbury, in reply, say how competition could be regulated, so far as foreigners were concerned, except by means of a tariff ? By referring to the writings of economists one would find that what they meant by Free Trade was free exchange of commodities, and no one could doubt that that between all nations was an ideal system of trade ; but, unfortunately, we had never had that system, and the world did not appear ready for it, any more than for universal peace. We might not need tariffs, but we must have them because other countries had them. Again, the Free Trade statement that exports were balanced by imports was nothing more than a fallacy. It was exactly the same as the book-keeper's phrase that "every credit has a debit," but no accountant would be so foolish as to carry that argument to the other extreme, that every loss was balanced by a profit. The effect of the policy of Free Trade was that our profits were being gradually eliminated. He did not agree with Mr. Kingsbury that our ability to buy in the cheapest market increased efficiency, if we also had to sell in the cheapest market. The principle of all economists was "buy in the cheapest market and sell in the dearest market," but they could not do that. We made no profit on our considerable turnover because our imports from abroad decreased the prices of our own productions, which, as shown by Mr. Hirst, cost us more to produce. Free Traders said that reduction of price was a benefit to the consumer and they stated that we were all consumers and therefore everyone benefited ; but the argument overlooked the obvious fact that no country could consist of consumers alone and that in the end all consumers were dependent upon the producers. Free Traders were defeating their own objects. They were encouraging the formation of trusts and monopolies abroad which tended to destroy all freedom of exchange in commodities, and in course of time they would control our markets and we should be at their mercy in regard to prices. They would be told that the foreigner would not be so absurd as to destroy a good customer, and we were bound to send out some goods in order to buy. As a result of the prosperous period we had enjoyed, we had amassed very considerable wealth, and whether we were producers in the future or producing at a profit now we should for some time to come be able to purchase largely from other countries. Until that time came, foreigners would not worry themselves by what means their good customer was maintained for the future. Meanwhile, we were getting feebler and poorer. At present our exports of home produce to France, Belgium, Germany and the United States (our principal competitors) were less than half our imports from those countries. That was not all. Nothing had been said about imperial preference and keeping hold of our colonial trade. He therefore referred to an account of the Congress of the Chambers of Commerce in Australia, in which the Commonwealth Minister for Trade and Commerce said that Australia found, with grave misgivings, that her trade with Great Britain was decreasing, and that she was becoming more and more dependent upon foreign countries. Had Great Britain retained the proportion of Australian trade which she possessed in 1880 she would have exported to Australia in 1908 £10,000,000 worth more goods than she actually did. Mr. Garcke finally appealed to them not to discuss the question on political lines.

Mr. H. OPPENHEIMER thought that both Mr. Garcke and Mr. Hirst, in their endeavours to show that the electrical industry was suffering under Free Trade, had failed to produce a single argument which supported their opinion. Mr. Hirst, in asking why it was that since 1881 we had lost the supremacy we held then, should have told them that at that period events were happening on the Continent, especially in Germany—and he laid stress on that point, because during the whole discussion they had not once heard an argument relating to France ; it was invariably Germany which took the foremost place. Germany, before the creation of the Zoll Verein, was industrially no power whatever, and other countries at the time began to find out that they could do something and that the only country which was doing anything was England. In 1887—the time of our greatest distress—no one knew where our supplies came from. An attempt at so-called Protection was made in order to guard against the possibility of foreign-made goods being mistaken for English goods. The result was that we gave the most extensive and expensive free advertisement to the Continent. The electrical industry was not what it should be. It was ill and suffering in spite of Free Trade, but it would be ill beyond recovery if Tariff Reform were ever to come to its rescue.

Mr. G. BYNG thought the most important statement in Mr. Kingsbury's address was where he referred to the cost of production and in which he said that Free Trade gave us advantages for cheap production. Mr. Kingsbury said that under Protection the cost of production would increase. Mr. Byng joined issue with him and challenged him to produce one single proof. The first factor for production was material. He was acquainted with a great many industries and he had never found Mr. Kingsbury's statement to be true. For example, in the electrical industry. Did he get his copper, iron, platinum, &c., to any degree cheaper than his competitors in New York, Berlin or Paris ? His experience was that he did not. Another point : it was said that under Free Trade one got cheap food and therefore cheap labour. It was well to be clear upon those points, and to understand the attitude of Free Traders upon the question of wages. They talked about cheap production and cheap labour, and then on the political platform they said that under Free Trade wages were much higher than in protected countries. They could not have it both ways. The truth was that wages must come down under Free Trade. It was impossible for our workmen to allow the whole world to compete with them—nations where wages were very low—without themselves in the long run coming down to the level of those nations. Again, low wages did not necessarily mean cheap goods. When machinery was now used for every sort of production the experienced manufacturer knew that he got the best return from his machinery if he used the best-paid labour. It was not only labour and material which made up the cost of production, but there were other equally potent factors that went towards cheapness of production, such as skill, invention, and above all the quantity manufactured. In all those factors the protected foreign manufacturer had immense advantages. No new industry could be established under Free Trade and no industry could grow under Free Trade. We were not a free country : it was the foreign manufacturer who had got to say whether an English industry was to exist or not. Free Trade meant dear production, and dear production meant decay and ruin.

Mr. R. HAMMOND found it was acknowledged that they could not protect their industry without protecting some others. He was glad to find that the object of the meeting was to discuss the question whether Free Trade or Protection was best for England, and not to see whether they could get protection for the electrical industry alone. He dwelt upon that point, because England stood in a unique position. It possessed 44 million people on an area that would only grow food for half of them. Mr. Garcke seemed to be very well acquainted with 60 years ago. For him, the speaker, England was the living England of to-day. Food stuffs to the extent of 242 millions came into this country last year. There were some people who thought that instead of covering our ground with Osram works we should grow wheat everywhere. If they did that what would become of our manufacturing supremacy ? England was no country for growing corn. At the beginning of the controversy it was said that we poured our gold from England, but he was pleased to hear that last year we received 6½ millions more gold than we paid out. Some people said we paid in securities, but that also was not correct. The only way to pay was by our manufactures. Everything was paid for in cheques. There was no reason why exports should be paid for by imports. Thus, Free Trade England, to the extent of all its exports, competing with the world, proved to Mr. Byng that we could beat the world in price and quality. The instant imports were kept out the exports would fall off and our power of competing with the world in open markets would suffer accordingly.

Mr. H. H. BERRY doubted whether Mr. Hammond had ever manufactured anything in his life in this country.

Mr. R. HAMMOND, interrupting, said that he was a manufacturer for a good many years.

Mr. BERRY, continuing, said that without our manufacturing industries we could be nothing but a body of importers. He wished to introduce himself as an unfortunate example of the effect of Free Trade on the

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electrical industry. If, in later days, he had achieved any slight financial success it was entirely due to the fact, in spite of Free Trade, that he had found his own protection in the medium of the Patent Office. He thought Mr. Kingsbury's remarks that in the electrical industry our Free Trade policy had enabled us to apply at once any advance elsewhere and to give the industry a start on the most practical lines, and as soon as the demand became large enough we abandoned imports and manufactured ourselves, thus obtaining the benefits of successful improvements at a small cost, whereas Protection would have delayed us for years and enormously increased the cost, were ridiculous. Take lampholders, for example. The foreigner actually came in and took our speciality and supplied it to the extent of 80 per cent. Free Traders would not see that they were fighting on unequal terms. What were our Continental friends doing? They sent us Mr. Oppenheimer to come on the platform to confuse the issue by talking about hay.

Mr. W. G. Bond mentioned some Board of Trade figures, from which it seemed that in seven years, since 1902, this dying country increased its trade by 19 per cent. Mr. Garcke said we were making no profits. Official figures again showed that our profits had gone up from 487 millions to 508 millions, which was about 5 per cent.

Mr. Garcke asked if that was per year.

Mr. Bond said he was taking the figures for 1902 against 1908. Again, Mr. Garcke seemed to think that it was very wrong to import. If he would look at the figures for a long term of years he would find that the years of greatest imports coincided with what were known as "boom" years. Assuming that imports were all wrong and that exports were the thing, he would refer to figures for 1908. The English exports per head were £9. 10s., compared with £5. 8s. in Germany. He thought that a large number of speakers on the Protectionist side believed that a Protectionist Government would get a scientific tariff absolutely adapted to the needs of each individual industry. Did anyone mean to say that what happened in Washington a few months ago was scientific taxation for each industry? It was the industry with the largest price that got the biggest slice. The electrical industry was poor and would come off worst. He asserted, without fear of contradiction, that they could not protect any sensible proportion of the people of this country. If higher wages were to be paid under Protection, then how could the cost of production be kept down. Apart from their own industry, how were they going to protect shop-girls, &c. In conclusion, Mr. Bond quoted from an English contemporary "that in every country it always was and must be the interest of the great body of the people to buy whatever they wanted of those who sold it cheapest." The proposition was so very manifest that it seemed ridiculous to take the pains to prove it.

Mr. A. Bruce Anderson agreed with Mr. Hirst's remarks. The only point on which he could agree with Mr. Kingsbury was that he wished it were possible to get a more reasonable attitude on the question of foreign trade. The meeting was called for the purpose of discussing the effect of the fiscal policy of the country upon the electrical industry; Mr. Kingsbury accepted the invitation to expound the Free Trade point of view, but made no attempt to do so from the very outset. He said that one must look at the good of the nation as a whole and therein one would find the good of the electrical industry. It had been said that no man could be a good citizen of the world who was not a good citizen to his own country. He (Mr. Anderson) would go further and say that no man could be a good citizen of his own country who was not a good citizen of his own industry. If the interests of the electrical industry and the nation as a whole were identical under Free Trade it was extraordinary that a man of Mr. Kingsbury's long and wide experience in the electrical industry was unable to produce one single practical illustration of where they coincided. Unemployment in this country was now greater than in any other country, from which we had returns. The only returns we had, however, were trade union returns. Trade unions numbered only one-tenth of our working population. Amongst the other nine-tenths unemployment was appalling, and on the top of that we had 12 millions of people living on the borders of starvation, and on the top of that again we had exported during the last two years over two millions of our workmen. If those were the conditions necessary for the completion of our wealth then, he said, let us get poorer. As Tariff Reformers, what they agitated for was a fairer field against their foreign competitors. When that fair field was obtained they would not be afraid of the result.

Mr. J. E. Kingsbury, in replying for Free Trade, said that the tendency of the speakers had been to depart from the line upon which they started their discussion, and they had brought in all sorts of side issues, such as Mr. Anderson's. Mr. Anderson surely knew that unemployment was not a matter which depended upon Free Trade or could be cured by Protection. It was a social question which required the most careful investigation; and a Tariff Reformer who said that Tariff Reform meant work for all was taking a very narrow view of the question. Mr. Garcke had said that the idea of Free Traders that imports were paid for by exports was all wrong. Free Traders did not all say that imports were specifically paid for by some definite export. In reply to Mr. Garcke's question as to how competition could be regulated except by means of a tariff, he (Mr. Kingsbury) said that to regulate competition was a very difficult thing, but to be prepared for competition was an easy matter. All that one had to do in order to be able to compete was to be efficient. Mr. Garcke said we did not sell to certain countries as much as we bought from them. Did any of them buy as much from the man they sold to as they sold to him? Of course they did not, nor need we as a country. Mr. Byng had asked what materials he could buy more cheaply than his competitors in a foreign country? If Mr. Byng had given him notice of that question, he could have given him a pretty long list. Mr. Byng could buy his copper wire cheaper at home than his competitor in Paris and he could buy his lead £5.16s.8d. in London cheaper than his American competitor.

Mr. Byng remarked that he did not say copper wire. This was a manufactured article.

Mr. Kingsbury, continuing, said that unless Mr. Byng drew his own wire the value of the price of copper was nothing to him. His raw material was copper wire. At the last meeting, Mr. Raworth told them that 90 per cent. of the tramway material came from America. He (the speaker) was startled by that, and asked some friends of his whom he considered likely to know what they thought it would be. They gave him a very modest figure, and one said it could not exceed 5 per cent. They would see that there was a wide discrepancy between the two figures, but he had information which he believed to be precise, viz., that in a large tramway system constructed within the last 10 years there was not a particle of electrical material from abroad. England could supply all the tramway material that was required. Mr. Raworth had told them about some friends of his who subscribed capital and had it returned in the early days. This was due to an ill-considered Act, but had nothing to do with Free Trade.

If there was one thing in the world that he (Mr. Kingsbury) did not know anything about, it was cotton, and he did not think Mr. Hirst knew much more. He (Mr. Hirst) was quite concerned about the cotton industry and was anxious as to whether it was in a quite healthy state, and he somewhat unwisely considered that the cotton industry and the electrical industry were not just on parallel lines as they should be. He (the speaker) had no doubt that the electrical driving of cotton mills was bound to come. He also had no doubt—Mr. Raworth had told them so—that the Lancashire men knew their business, but he believed electrical driving in cotton mills would come the sooner if they treated the manufacturer of Lancashire as if he did know his own business. Mr. Garcke talked about Free Trade as a religion. He was not there to speak about religion, but to talk business. How were they to deal with any question of business that did not first of all take into account facts, then deductions from those facts and arguments on those facts. That was what he was going to do, and with a view to reaching that conclusion he was going to examine Mr. Hirst's facts, his arguments and deductions. As to history, he would like to know why 1880 was selected as an epoch-making year in the history of English commerce. Our business was in a sound condition in 1880 and as sound to-day as ever it was. Mr. Hirst then touched on what might be called the depreciation of Free Trade, and told us that our prosperity was not due to Free Trade. It so happened, said Mr. Hirst, that the introduction of Free Trade in this country tallied with the developments of steam as a power to reduce the cost of production, and Mr. Hirst implied that the progress resulted from steam and in spite of Free Trade. Was it not reasonable to say when one found that Free Trade and steam ran along parallel lines that the development of the steam resulted from the freedom of the trade, rather than that the freedom of trade acted as a bar to the full development of the steam? Mr. Bennett Fitch told them that the hunger of the forties was not due to the scarcity of food, but to the superabundance of machinery. In reply he would read an extract from "The Times" of the last day of the year 1853. [This extract refered to the scarcity of corn as being the result of Protection.] It was important that it should be realised that the workman had no need to fear labour-saving machinery. History told them that every machine which reduced work had increased production and employment. Such methods of promoting Protection could do nothing but harm to the cause.

Mr. Hirst had told them that nearly every electrical invention up to 1884 originated in this country. That was a pretty wide statement, but surely it was not presumed to cover the whole ground. The telephone, the accumulator and Gramme's dynamo were notable exceptions. The first arc lamps that were installed here bore the names of Jablochkoff and Rapieff. Those were followed by the Lontin, Werdermann brush, the Pilson and so on. Did France and Russia trouble us now? If not, was it because Russia and France had Free Trade? The fact was that the English contribution to the arc lamp development was more important in the fifties than in the early eighties. There was not a single statement in Mr. Hirst's remarks regarding the electrical industry which was not either incorrect in itself or might reasonably be read in an incorrect way.

Turning to the question of general engineering, American literature did not support the idea that our rail mills were losing ground. Mr. Hirst asked why a manufacturer in protected countries could produce in larger quantities? It stood to reason, Mr. Hirst said, that a manufacturer who had a market of 60 million of inhabitants sending to them must be better off than anybody else. If that be a fact, had they not better put up the shutters, because one must not overlook the fact that our population would not permit us to complete on such terms. We had 40 millions and America had double; how could we manufacture as cheaply as America? It did not stand to any such reason. If it did, why did America have any imports at all? In 1907 they imported £209,000,000 worth, of which £133,000,000 were manufactures. The manufactured article in quantities involved the expenditure of capital, which was dependent upon the quantity required. Mr. Hirst said that with his proposed 10 per cent. protection on lamps, no one would be a penny the worse, but he (the speaker) undertook to say that nobody would be a penny the better. What was got with one hand would be lost with the other. The prime factor in determining cost price, said Mr. Hirst, was the quantity that could be produced. This the speaker regarded as emphasising the variable condition and omitting entirely

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the vital and invariable conditions, such as the costs of materials, food, clothing, house rent, and all the amenities that went to make up existence. He gave examples of exports which the "aims and ideals of Tariff Reformers," as expounded by Mr. Hirst, would interfere with, and alluded to the detrimental effect which the loss of such manufactures must necessarily produce on the electrical industry.

Mr. H. HIRST, in replying for Protection, thanked his supporters for having brought such interesting matter forward with such fervour and conviction. He more particularly recommended to their earnest consideration the interesting contributions of Mr. Garcke and Mr. Bruce Anderson, with whom he was in full accord. Passing to other points, he congratulated Mr. Hammond on his humorous rendering of his contribution to the debate, but he would remind him that his (Mr. Hammond's) experiences as a producer dated back 30 years. When Mr. Hammond spoke of the 242 million pounds worth of corn that we imported he could only reply that if we produced in this country all the corn that this country is capable of producing—say fifty million pounds worth or more—we could obtain the balance that we wanted at a very much cheaper rate. The present prices ruling in England were fixed, in the opinion of the speaker, irrespective of the cost of production or of supply and demand, but were largely based on the helplessness of this country as a non-producing nation, for we must have wheat at any price. The prices for too many commodities that were regulated by supply and demand in Protected countries were fixed in conference by foreign producers for the buyers in a so-called Free Trade country. Mr. Bond had suggested that Protection might be good for the manufacturer or industrial worker, but asked what about the working man in the building trades, printing trades, professional men, postmen, schoolmasters, &c.? The answer was by facts which occured in other countries. In Germany, after the introduction of the tariff, there was such a rush of brain and muscle from all professions and trades into industrial enterprises that the wages of all other trades had to be raised periodically, as had also been raised periodically by Act of Parliament the remuneration of civil servants, schoolmasters, professors, municipal servants, &c. That process of levelling up was going on constantly.

In his pleading for Free Trade, Mr. Oppenheimer referred, as one of the causes of Germany's present greatness, to the Zoll Verein, which broke down the customs barrier within the German States. The speaker agreed that that was the beginning and that was all that we wanted. We also wished to have internal walls broken down and barriers round the whole of the British Empire just as in Germany and America. Again, Mr. Kingsbury had asked why he had selected the year 1880. He (Mr. Hirst) took it for granted that Mr. Kingsbury knew that Bismarck introduced Tariff Reform into Germany in 1878 and 1879. It took, of course, a number of years before the effects of this change made themselves felt, and for the purpose of taking a round figure he had selected 1880. He might as well have taken any year between 1878 and 1885, when we first felt, in a slight degree, German competition.

Mr. Kingsbury suggested that he (Mr. Hirst) was so narrow minded as to think only of the benefits to the manufacturer, and that there was no word about dearer clothing and food for the working men. If food and clothing should be dearer, it could well be defrayed by the higher wages which every manufacturer would willingly pay to the working man, if there were security of market. He had no hesitancy in declaring and proving by a practical illustration that if our wages were to go up 33⅓ per cent., if we could make the larger quantities which we should require through the security of our home market, we should still be able to produce more cheaply than under present conditions. Our foreign competitor would make less, we should make more, our cost of production would be more equal, and we should be better armed for the fight on the neutral markets. Mr. Kingsbury had remarked that in no protected country could an engineer extend his horizon beyond the frontier. That did not seem to be the case in Belgium, America, Germany and Switzerland. Further, most developments, if not all, originated in protected countries. They were either common property, and in that case other protected countries would avail themselves of them, as well as a Free Trade country, or they were new inventions and were patentable.

Mr. Kingsbury made a point of 6s. 10d. per head of the production of the American population, and 6s. 2d. per head of the English population, but he had included in the American figure the large Western States of black population.

Mr. Kingsbury had referred to the condition of the population of Great Britain as satisfactory. There were many, even Free Traders, who would disagree with this view. The position of the working classes in this country was a source of anxiety, the state of unemployment, the emigration and the great destitution in the big towns of this country not being approached at present in any other civilised country. Apart from such vague statements, Mr. Kingsbury did make a few definite assertions he would like to group into a short survey of the telephone industry. Mr. Kingsbury had said that protected States were behind in the development of enterprises originating in other countries. There might be a doubt whether the telephone was first invented in the States or in England, but there was no doubt that the industry started about the same time in both countries, and whilst our early factories had been compelled to shut down, what happened in the protected States, in America, in Germany and in Sweden? Did not the history of this enterprise in this country prove that an industry which originated in one protected State had flourished in other protected States more than under Free Trade? Could Mr. Kingsbury conscientiously tell them that telephones in this country were cheaper than in Germany, Sweden or America? We knew they were not.

Mr. Kingsbury said that "to start a factory for the purpose of serving as a school was an expensive form of education." Was it not a fact that all important improvements in telephony had come from the protected countries just mentioned? Did not the history of this industry prove clearly the statements in the speaker's opening address that inventions followed in the wake of busy workshops? The factory might be an expensive school, but it was the only proper school for technical and industrial education. Mr. Kingsbury then suggested that it was an advantage to have the market developed in a country before starting a factory. Well, we had the market for telephones for many years, but factories were not forthcoming. It was true that there were now several factories in this country, but, in Mr. Hirst's opinion, they had not come to strengthen Mr. Kingsbury's argument, but for quite another reason. He (Mr. Hirst) maintained that these factories had been established because during the last three or four years Tariff Reform or Protection had been in the atmosphere. So many manufacturers in this and other countries were quite certain that we must have Tariff Reform and were making their preparations. As a natural sequence to our ability to produce, Mr. Kingsbury would agree that orders had been placed in this country from the colonies, distinctly requisitioning British made telephone exchange material, as also orders from neutral countries. Was not this a splendid reply to Mr. Kingsbury's statement that if the home market went up the export might go down. He, the speaker, had always found that one influenced the other, and they went hand in hand if the production was sufficient. Thus it was that Germany to-day exported nine millions worth of goods whilst this country only exported three and a half millions, and German imports were less than half a million, while the imports into this country were one and three-quarter millions. If American exports had not increased to the same extent it was only owing to the fact of the protection of that country and to the absorption by their own market of everything they could produce.

Mr. Kingsbury compared dumping with underselling by the home manufacturer. This betrayed absolute want of understanding of the principles of dumping. The home manufacturers produced under equal conditions. If he sold below the cost price it could only have one end. The buyer for a time benefited, but it must ruin the producer. If the foreign importer imported into England below the English cost price, it was a different story. It was quite possible that such a price might still leave the foreign importer profit. If an industry were killed by dumping, then the benefit to the buyer in a Free Trade country would be gone; he would have to buy on the same terms as the buyer in a protected country, and, as recent experiences had shown us, he might even have to pay more.

Summarising, the effect of Protection would be:—

1. It would give us greater security in our home markets and enable us to produce in larger quantities.
2. By thus producing in larger quantites we should be able to produce more cheaply.
3. Cheaper production would enable us to make better preferential arrangements with our colonies and thus create more bonds of common interest between the different parts of the Empire.
4. By the imposition of duties we should have greater bargaining powers with foreign countries and in foreign markets.
5. We should train our working population to be skilled artisans to enable them to earn higher wages and add to their comforts in life.
6. We should become more strong and self-reliant for defensive purposes.
7. We should attract to the aid of the manufacturer the capital of the country for the life-blood of the industry.

Surely whilst the foreign manufacturer had all these benefits, supported by the whole machineries of their particular Governments, the British manufacturer in his compulsory self-reliance was at a great disadvantage.

The CHAIRMAN (Mr. H. W. Butler) said that the success of the meeting had been so great that their energetic secretary had decided to organise at an early date next winter further discussions on possibly that or similar subjects which were of equal interest to the electrical manufacturing industry.

ELECTRICITY IN AGRICULTURE.*

At the meeting of the German Agricultural Council, a good deal of information as to the results of various experimenters in the application of electricity to agriculture was made public. Dr. Höstermann reported on the work he had done at Dahlem, near Berlin, where apparatus manufactured by the Allgemeine Elektrizitäts Gesellschaft was used. Prof. Gerlach took part in the discussion, and described the experimental work he had carried out in conjunction with Siemens & Halske on the experimental farm at Mocheln, near Bromberg.

Dr. Höstermann's method consisted in treating vegetables by electrical radiation in four different ways. The vegetables included

* Abstract of a report in the "Elektrotechnische Zeitschrift," March 24, 1910. The full text of Dr. Höstermann's report appeared in the "Archiv des deutschen Landwirtschaftsrates," published by Paul Parey, Berlin, S.W. and Prof. Gerlach's experiments are described in the "Illustrierte Landwistschafttiche, Zeitung," Feb. 19, 1910.

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spinach, lettuce, radishes, carrots and strawberries, each plot being as nearly similar as possible to the others of its kind, the only difference therefore being in the matter of electrical treatment. The radiation was effected by means of telephone wires, about 2 yds. above the ground level, and arranged at distances of 4 yds. apart. The different methods of treatment were as follows. (1) Certain plots were exposed to the normal atmospheric influences, and beyond this there was no special treatment. The yield in this case was taken as being 100 per cent., for purposes of comparison. (2) The plants of the second group were exposed to an artificial radiation by means of static electricity. The yield in this case varied from 115 to 140 per cent. (3) The plants of the third group were exposed to high tension oscillating direct current, which was furnished by dynamos and transformers. With a high voltage and lengthy treatment, the yield varied from 90 to 105 per cent.; with a milder form of treatment, the yield varied from 100 to 125 per cent; (4) The last group contained plants which were shielded from such electrical radiation as might be present in the atmosphere by covering them with earthed wire cages. The yield in this case was only 86·5 per cent.

These experiments show clearly that under certain conditions the growth of plants may be favourably influenced; but that everything is likely to depend on the type of treatment. It is curious that electric current, relatively speaking of considerable amount and high tension, and employed over very extended periods of time, appears actually to have an unfavourable influence. A better result was obtained with a milder form of treatment. It is needless therefore to aim at very high voltages and heavy currents; it is better merely to imitate ordinary atmospheric effects.

Group (2) appears to have given the best results. Here electricity was conveyed from the atmosphere by anchoring a captive balloon or several kites, at heights of 800 ft., to a steel wire rope. Assuming a variation of 100 volts per yard, we should have in this case a pressure of 25,000 volts, or thereabouts at our disposal. Whether such a pressure was actually reached, it is not possible to say, as there was no means of reading on the instruments beyond 5,000 volts. There are always periodic variations in the fall of potential in the atmosphere; it varies from hour to hour, and day to day. Moreover the time of year affects the matter: the falls are greater in winter than in summer, and are consequently greater with a low temperature than with a high one. The maximum occurs between December and February. In the course of a day, there is a minimum at the warmest time in the afternoon, and another less pronounced minimum during the night. The maxima occur shortly after sunrise, and about the time of sunset. There is a considerable rise in the fall of potential during fog, snow, hail or rain, and especially during thunder-showers. Dr. Höstermann thinks that the dampness of the atmosphere is as important as the dampness of the soil. The damper the air, the better the result is likely to be with electrical treatment; electrical radiation is likely to injure the plants in a dry atmosphere. It is better, therefore, to conduct operations in the early morning or in the evening, or on dull cloudy days. It is quite possible that the damp climate of England gives better results than the drier air of the continent.

As the result of his experiments, Dr. Höstermann gives the following rules. The radiations should never be carried out in hot sunshiny weather; at any rate, not in the middle of the day in the heat of summer, unless it is possible at the same time to keep the crop well watered. It is better to limit the work to the early morning, and late afternoon. In summer, soon after sunrise (the action of light is necessary for a proper assimilation), say, from 5.30 a.m. to 7.30 a.m., and then from 7 p.m. to 9 p.m., shortly before twilight; in spring and autumn, from 7.30 a.m. to 9.30 a.m., and in the evening for an hour or so before twilight; in winter, from 9.30 a.m. to 11.30 a.m. If the atmosphere is too dry, this may largely prevent the proper radiation. If higher voltages are used, other decomposition products may be produced from the atmosphere, which are not beneficial to plant-life, and may even be harmful. The radiation is unnecessary in rainy weather, seeing that any kind of downpour always brings with it decided electrical charges. The most favourable condition is a misty day. In England, with its damp, misty, and somewhat sunless climate, due to its insular position, it is not possible to notice any harm arising from too long or too heavy radiation. In a wet year, it is not improbable that an increase in the length of time during which the radiation is continued, might compensate for a deficiency in the amount of energy, radiated in the form of light from the sun. The influence of the wind must not be neglected on such experimental patches as may be under examination. The patches which are supposed to be merely exposed to the ordinary atmospheric influences, must be situated at a sufficient distance from those which are subjected to the radiation treatment. This distance depends partly on the height of the radiating wires, which should be at a distance of 20 to 50 yds. from any patch not supposed to be under their influence; and regard must also be had to the direction of the usually prevailing winds.

Prof. Gerlach and Dr. Erlwein also give the following results of the work which they have carried out at Mocheln. The ground was sown with oats, and 18 plots, each of 1,000 sq. yds., were taken. Twelve of these plots were exposed to electric radiation, while the remaining six, which were at a distance of 100 yds., were cultivated without any special treatment, and served as a standard of comparison. The radiation was either (1) through high-tension single-phase current, or (2) through high-tension static electricity, distributed through a positively charged wire-network, or through a negatively charged one. The high-tension alternate current was produced through a direct-current motor coupled to an alternator and a 20,000 volt transformer; the static electricity was generated by influence machines, driven by motors. The tension at the terminals of the influence machine was about 80,000 volts. The wire network was at a distance of 6 yds. from the ground. The space that was submitted to alternate current radiation was 6,135 sq. yds. in extent; that exposed to static electricity consisted of two plots, each 3,068 sq. yds. in area. One pole of the high-tensions generators was earthed, the alternate current voltage being about 20,000, and of the static discharge about 30,000. The energy in the alternate current radiation was 770 volt-amperes, whereas each static machine absorbed 30 watts. The radiation was continued for 45 days of 24 hours each. The total cost of the radiation amounted to £23 per acre in the case of alternate current, and £17 per acre with static electricity. These costs would be very much lower if it were possible to take current from a power station, which had high tension conductors at 60,000 volts. Supposing, for instance, that it were possible to connect up to a central station, having a voltage of 5,000, a special transformer being used to generate about 100,000 volts. Then if energy were charged at the rate of 1d. per unit, the cost per acre for the alternate current treatment, extended over 45 days of 24 hours, would be about £2. 18s.; at ½d. per unit, the cost would be about £2. 7s.

Prof. Gerlach reports that as the result of this treatment, there was no noticeable difference during the growth nor in the yield of the plots so treated. The experiments were, however, continued with oats, the height of the network being lowered to 1½ yds. Further experiments were made during the summer of 1909 with direct current of low voltage. In this case, there were 7 plots, each of about 200 sq. yds.; three of these were subjected to the treatment, while the remaining four were untreated. At the sides of the plots, which were 10 yds. broad, strips of sheet iron, 20 yds. long, and 1 ft. broad, were buried in the ground, and connected to the rails of the local tramlines. The pressure amounted to 6 volts, and the current varied from 0·2 to 0·4 amperes. Some of the plots contained barley, and others were planted with potatoes. It was impossible to discover that this treatment produced any effect.

These reports therefore seem to show that Gerlach's treatment produced negative results, while Höstermann, on the other hand, found that under given conditions it was possible to produce a favourable result. The experiments in Dahlem are therefore being continued at the present moment. The work is in the hands of the Government authorities, who receive assistance from the Allgemeine Elektrizitäts Gesellschaft, from the Gesellschaft für Drahtlose Telegraphie, and from the firm of Alexander Siewert.

Temperature Measurements of Concrete by Electrical Methods—The "Electrical Review and Western Electrician" gives an account of measurements that are being made in the Panama Canal Zone of the heat generated by the hardening of Portland cement. For this purpose, six resistance thermometers will be embedded in the walls of the locks at Gatun and readings will be taken of the temperature at various stages of the hardening of the concrete. The following account of the arrangement is taken from the "Canal Zone." "From the time concrete begins to crystallise until it reaches its final set the increase in temperature is rapid. From the setting point the increase is slow, but usually continues during the whole of the hardening process, which is indefinitely long, probably lasting for several years. It is to gather data with regard to this hardening, and the heat produced by the chemical changes that accompany it, that the thermometers will be embedded in the concrete. In the thermometer here used an iron cup is employed to contain the resistance, and the wires are lead covered. The results will be plotted and a complete record of the hardening and cooling of the cement thus obtained."

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COMMUTATION PHENOMENA AND MAGNETIC OSCILLATIONS IN D.C. MACHINES.

We give below an account of the discussion that took place at the meeting of the Birmingham local section of the Institution of Electrical Engineers when Mr. G. W. Worrall, M.Sc., read his Paper on the above subject. An abstract of this Paper appeared in our issues of May 13th and 20th.

The CHAIRMAN (Mr. R. K. Morcom) complimented the author on his Paper and on the interesting lecture in which he had dealt with the subject; this lecture had been far more useful than the usual abstract. Commutation was an intricate subject; this was obvious to anyone who watched dynamos under test and saw the empirical way in which many representatives of electrical firms set to work to cure heating of brushes and sparking.

Dr. KLOSS noticed that in the oscillograms there was always a combination of two different kinds of oscillations; one due to the movement of the armature teeth in the magnetic field, the other due to the commutation of the current in the coils. He thought it would be an advantage to be able to get rid of the first of these oscillations, and this might be done as follows:—If a four-pole lap-wound machine were taken and run with only two brushes, then the oscillations induced in a search coil on one of the poles opposite the brushes would contain both sets of oscillations, while that induced in a coil on one of the other poles would contain oscillations due to the movement of the armature teeth only. By connecting these coils suitably it should be possible to annul and leave only the oscillations due to the commutation currents. He did not know whether such a method would be possible, but he suggested it for Mr. Worrall's consideration. There was another point in connection with the research. Mr. Worrall had used a brush whose width was equal to one segment plus insulation. Now, in practice the brushes used covered more than one segment, and he would like to ask whether the author could give any information as to what happened in that case. Mr. Worrall had in his theory of commutation assumed that the specific resistance per square centimetre of surface of the brush was constant, whereas actually this was not the case. Would Mr. Worrall's results be modified by this fact? He endorsed the author's remarks about the possibility of improving the performance of a machine by decreasing the contact area of the brushes and increasing the current density. He had known specifications which had stated that the current density in the brushes must not exceed a certain figure, and which left the designer of the machine with the alternatives of either supplying a poor machine, in accordance with the specification, or a good one in which the specification was departed from. He thought that in preparing their specifications consulting engineers should leave points like this to the discretion of the designer. He also drew attention to the importance of keeping down the temperature of the commutator both from the point of view of commutation as shown in the Paper, and also in order to prevent mechanical trouble due to expansion and contraction of the commutator bars, especially in the case of turbo-generators. This could be done by making the segments hollow and arranging for the passage of air through them, as was done in the Siemens ventilated high-speed commutator, which had given so great satisfaction.

Mr. T. F. WALL, referring to Fig. 1 of the Paper, said that large oscillations were obtained in coil 5, whereas in coil 8 there were practically none. He thought this probably meant that they had been damped out by the field winding, and that if the oscillograph had been connected across the terminals of the field coil similar results might have been obtained as were obtained from coil 5. Another suggestion he had to make was that the damping action of the field coils might possibly materially decrease the inductance of the short-circuited coils and thereby improve the commutation of the machine. He would like to point out that the pulsating flux due to commutation traversed the main axis of the coil, and thereby induced in the armature winding an E.M.F. due to rotation which was in phase with the flux and therefore with the current producing that flux. If, therefore, records were taken of the E.M.F. induced between the main brushes, the variations of the commutation current might be examined and compared with the records obtained by means of coil 5, which latter showed the rate of change of the commutation current. A great deal of discussion had recently occurred as to what really happened in a coil undergoing commutation. It seemed to him that taking a conductor approaching the commutation zone the lines of force were crowded together behind it and spread out in front. As it passed through the region of commutation this distribution was changed so that the conductor finally left with the flux crowded up in front and spread out behind. As the conductor moved along, the lines followed but did not cut it, so that the actual field in which the coil was moving might well be zero.

Dr. Ing. E. ARNOLD (Karlsruhe, Baden), in a written communication, thought the influence of magnetic oscillations on the commutation of direct-current machines was often underestimated. With reference to the first part of the Paper, in the writer's opinion, a commutating field was always necessary in order to compensate the self-induction. Commutation could not take place in a neutral zone, because the self-induction of the end connections could only be compensated by a field, to which a coil side was subject. The different fields did not coincide, and consequently they did not combine to form a resultant field. He agreed with the author's remarks about the effect of a brush, the resistance of which increased from the rear tip to the forward tip, but such an increase of resistance occurred also, automatically, with brushes of rectangular section. Experiments had shown that the current density in those parts of a brush that sparked was very small and the tension high, thus the contact resistance was very high. Because of very small, almost invisible, sparks at the forward tip the contact resistance per square millimetre of brush surface at this tip might increase to 50 times that at the rear tip, or even more. Bad contact, as a result of sparking, was the cause of this phenomenon. The specific resistance varied, automatically, between wide limits, preventing too large an increase of the short-circuit current. As long as the sparking was not excessive, the current density was always small. Sparking with a high current density was so violent that the commutator was damaged very rapidly and further service became impossible. For the above reasons an artificial disposition of the resistance over the contact surface (as in Fig. 8) would not be as successful as one would expect from theory, based on a constant value of the specific resistance. What the author called "the natural period of commutation," which must be smaller than the "available period," was not sufficiently well defined. The natural period depends upon the commutating E.M.F.s, and was consequently a quantity which could be varied with one and the same armature. According to theory * one condition for sparkless commutation was $\frac{s_T \cdot T}{a \cdot L} > 1$, where s_T specific resistance of the brush at the forward tip, T = duration of short-circuit of coil in seconds, a = total surface of brush, and L coefficient of apparent self-induction of coil. Let $T_u = \frac{a \cdot L}{S_T}$ be the duration of a natural period. The condition for sparkless commutation was then $T_a > T_u$, where T_a = the duration of the available period. For small values of T_a (high-speed machines) this condition could only be fulfilled by the introduction of a commutating E.M.F., which compensated part of the self-induction. Mr. Worrall's remarks about the construction of brush-holders and the cooling of brushes were very interesting and important. His experience materially facilitated the design of a good brush-holder. Results of elaborate experiments on commutation had been published by E. Arnold and F. Jordan in "Arbeiten aus dem Elektrotechnischen-Institut der Technischen Hochschule zu Karlsruhe, 1908-1909." This dealt with current density, variation of the specific resistance of the brushes, duration of commutation, losses under the brushes, reaction of the short-circuit current on the main field, and with field pulsation. The inconstancy of the magnetic field was partly due to pulsations, *i.e.*, alterations in the intensity of the field, and partly to oscillations, *i.e.*, to a movement of the field alternately with and against the direction of rotation of the armature. The oscillations were caused by the armature teeth passing the poles, and were described as "flash" and "drag" in a previous Paper by Mr. Worrall. Equipotential connections damped the pulsations of the field effectively, but not the oscillations, because the plane of the induced equipotential loop coincided with the direction of the field. Solid pole shoes, or better, short-circuited windings in the pole shoes (amortisseurs), damped the oscillations. Such oscillations particularly affected the commutation of machines with a large flux per pole. For such machines solid pole shoes and a long air-gap were thus to be preferred to laminated pole shoes and a short air-gap. It appeared that the kind of magnetic oscillations and pulsations and also their magnitude depended upon individual features of the machines. They might be very different for two machines of the same design and with the same dimensions. Sometimes a kind of resonance took place, *i.e.*, the oscillations from various causes strengthened one another. In other cases they might oppose one another. To show the detrimental effect of these pulsations and oscillations of the field, he mentioned two cases which had come to his notice. In both cases the addition of equipotential connections cured the sparking trouble.

Prof. E. W. MARCHANT (communicated) remarked that Mr. Worrall was to be congratulated upon having devised a brush-holder which would give consistent results for the surface resistance of brushes. With reference to the contact maker described, Mr. Duddell and the writer did a great deal of work with contact makers about 12 years ago and found that the most satisfactory form was one in which two pieces of watch spring clamped to a piece of ebonite supported on the end of the frame of the machine were short-circuited by a copper plate attached to the rotor. The springs projected radially inwards and were about an inch long, soldered into brass rods. This contact-maker was exceedingly simple, and gave excellent results. The emphasis which Mr. Worrall laid on the difference between commutation at a positive and at a negative brush was of great importance. The results given for the Le Carbone Z brush were considerably modified by current density and by the type of brush. In some tests made in the Electrical Engineering Laboratories of the University of Liverpool by Messrs. Cottle and Rutherford, it was found that the ratio of drop on positive brush to drop on negative brush varied within wide limits for different current densities, being greater than 1, equal to 1 or less than 1, according to the current used. These results would, he hoped, be published shortly, so that he would not refer to them at greater length. The greater sensitiveness of negative brushes to variation in temperature, current density, &c., had been frequently noticed, but Mr. Worrall's method of getting rid of chattering was most ingenious. It seemed almost incredible that changes in temperature of the brush could be sufficiently rapid to cause chattering. He asked Mr. Worrall whether he was quite certain that the result obtained was not due to a mechanical effect caused by the addition of the copper and copper foil to the brush. The copper foil was insulated from the carbon by mica, and this material, of course, besides being a bad conductor of electricity was also a bad conductor of heat.

* E. Arnold, "Die Gleichstronmaschine," Vol. 1., p. 455-508.

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Prof. D. ROBERTSON (communicated) thought Mr. Worrall had made the theory of commutation appear needlessly obscure. The following was the method of putting it, which the writer had adopted for years. During the time that a coil was short-circuited by the brush, she current in it had to die away and a new one to grow in the opposite way. If it had exactly the proper value at the instant the short circuit ceased, the current in the segment leaving the brush would be zero and there would be no spark on breaking contact. It if had not reached that value, or if it had grown too large, there would be a current in the old segment, which, since the current in the coil refused to change instantly, continued to flow in a spark after the brush had left the segment. This was the spark that did most of the damage, and was the only spark possible if the brushes were making perfect contact. The condition for the avoidance of this spark was the simple one that there should be no current in the old segment at the instant it left the brush, and it did not greatly matter how the current had changed during the short-circuit so long as this final condition was satisfied. Any other sparks at the brushes could only be caused by faulty contact between the brush and segments due to bad surfaces, or to mechanical vibration caused by unsuitable brush gear, or by the thermal effects referred to by the author. The sparking at the rear tip mentioned must be due to these causes. Sparking took place at the forward (breaking) tip whether the commutating E.M.F. was too small or too great. The inductance of the coil opposed the change of the current and was the prime cause of the trouble. The mutual inductance between adjacent coils simultaneously undergoing commutation was also a good second, particularly when they were in the same phase at the same instant. The resistance of the coil itself and of the lugs helped to kill the old current, but also hindered the growth of the new, and so did not produce much direct effect on the commutation of continuous current machines. It was, however, useful and even necessary in alternating-current machines, as it reduced the short-circuit current caused by the transformer E.M.F. In all cases it reduced the effectiveness of the brush contact resistances, by diminishing their ratio to the total, and to that extent it was harmful. Brush contact resistance promoted the change of current because it was gradually shifted from the new segment to the old one. If its effect were so large as to make all the others negligible, the current entering each segment would always be proportional to the area of contact on that segment (assuming uniform contact resistance), and the commutation would be a straight line or a series of straight lines, according to the width of the brushes. This distribution of the current, which might be termed the natural one, gave smaller contact losses than any other. Actually the inductance E.M.F.s were not negligible, and the current departed from this distribution and the losses were increased. To counteract the inductance E.M.F. a *motion* E.M.F. was induced in the short-circuited coil by giving the brushes a lead in the right way, by adding commutating poles, or by putting special coils between the segments and main winding (Sayers). Commutating poles were the most effective, because they could be excited in series with the armature and their effect made proportional to the work to be done. Many problems could be much simplified if we could get away from some of the conventions of our predecessors, such as the addition of fluxes instead of the excitations producing them. The author's explanation of the action of commutating poles was an example. The commutating pole reduced the reluctance in the path of the armature cross flux, and would therefore increase that flux if the commutating poles were not excited. But the excitation required to balance the armature reaction was not affected by that fact, and would be exactly the same whether the commutating pole were made of iron or of wood. The commutating pole coil must have sufficient additional excitation to magnetise it and the air-gap and teeth to the degree necessary to induce the required commutating E.M.F. and this additional excitation was, of course, very much smaller with an iron core. The "relative movement" idea (on p. 13) was a rather dubious one, as the two induced E.M.F.s were of quite different natures, one being due to change of position and the other to change of current. Also, the mathematical theory and the brush shape deduced from it were not of much real value, for the conditions assumed were not those usually found in practice, and several important factors had been left out of account altogether. It was seldom that the brushes were as narrow as one segment width; and the mutual inductance of the neighbouring coils being commutated at the same time, even when the phase of commutation was not the same for both, was only a little less important than the self-inductance of the coil itself; and the resistance of the coil and lugs was not usually negligible. The author's "natural period" was a rather indefinite sort of thing. Even the "time constant" of the circuit (inductance÷resistance) had hardly a definite meaning here owing to the change both of the inductance and of the resistance of the short-circuit as commutation proceeded. The oscillograms were most interesting, but it was doubtful, however, whether they gave much information as to the process of commutation itself, beyond indicating the maximum rate of change of current; and even that was marred somewhat by tooth ripples. The usual way of applying the oscillograph to show the armature current, by splitting a coil and adding the oscillograph shunt through slip rings, was of little use, as the behaviour of the current must then be very different from that under normal conditions. In 1903 the writer devised a method of making the armature coil itself act as the shunt. The intended research, which had been delayed by the unfortunate fire at the Merchant Venturer's College, was now only in its preliminary stages. The principle used was exactly the same as had since been applied by Campbell to the design of non-inductive shunts. The method had been used with the tracing desk outfit for class demonstrations during the past three sessions, with most instructive results.

Prof. SILVANUS P. THOMPSON (communicated) considered the Paper one of the most important contributions that had been made for some years to our knowledge of commutation. Dealing first with a practical point, he praised the particular work on the irregularities of commutation which had been traced to the surface irregularities of the commutator and the vibration of the brushes, leading to the invention of a new type of brush and brush-holder. This would probably find a much wider application than in a mere experimental machine. Also the advice to plough out the lines of the mica insulation as they appeared at the surface of the commutator was wholly good. The writer had for many years found this treatment to improve the commutation in doubtful cases. At first it seemed a pity that Mr. Worrall's chief work had been carried out on a machine with an odd number of commutator segments, so that commutation did not occur simultaneously at the positive and negative brushes, the machine thus being not representative of the majority of continuous-current generators. But really this feature had been of advantage, as it separated the effects due to commutation at the positive brush from those at the negative brush. This part of the research was very instructive. The results emphasised the analogy existing between the processes going on in the contact resistances beneath a carbon brush and those going on in an arc lamp. In both cases there was a resistance which decreased with the current density, and in both cases the resistance was greater for currents leaving carbon than for currents entering carbon. The passages relating to the shaping of the carbon brush to give greater resistance at the forward tip were both instructive and convincing. They justified the old practice of using carbon tips to copper brushes, or the use of combined sets of brushes, in which one carbon brush was set in advance of the row of copper brushes. Equally important was the suggestion to furnish tips of all carbon brushes with cooling appliances of metal.

Mr. W. ARMISTEAD thought the theoretical considerations of commutation were quite burdensome, and it was only by attacking the subject practically that it was possible to come to any results likely to be of use to the manufacturer. The machine on which the author carried out his experiments was very large for the output. The author observed that there might be an actual reduction of temperature when the area in contact between the brush and the commutator was reduced. The experience of the writer's firm bore this out. Though so far as sparking was concerned they had not found that dividing up the brush by means of a slot or slots parallel to the shaft had been of any use. Large brushes appeared to be almost useless, no doubt largely owing to the bad conductivity of the carbon and the impossibility of radiating the heat. The contact between two surfaces such as the brush and the commutator could not be made at more than three points for each brush, no matter what size. He asked if the author knew Mr. R. V. Marshall's patent brush and holder. Bearing these points in view, this designed brush-holder was only ¼in. long along the axis of the commutator. They had tried this arrangement in practice and found that a large current could be collected per brush with the smaller brushes without an increased rise in temperature either of the commutator or of the brushes. This small brush would collect practically the same amount of current as one four times the dimensions. Unfortunately, practical difficulties came in the way of its universal adoption. The author spoke of the increased inductance in machines fitted with commutating poles; this actually seemed to be very much exaggerated. To begin with, the commutating poles were for the most part solid, and the very high frequency of the fluctuating currents in their vicinity precluded the possibility of any serious conduction of lines of force through this path. The writer had not been able to test the matter experimentally as the author had done, but had found that facing poles with sheet copper, and surrounding them with a stout band of the same material did not make the slightest difference so far as sparking was concerned. Of course, if the commutating poles were not excited properly there was bound to be a large amount of magnetic leakage when the armature was generating or receiving current, owing to the displacement of the neutral magnetic zone on the armature relatively to the yoke. He asked if the author could say that the contact resistance between the carbon and the copper of the commutator was reduced by an increase of temperature.

Mr. C. C. HAWKINS (communicated) said the question of whether the self-induced E.M.F. in the case of satisfactory commutation existed and was compensated for, or was rendered non-existent, resolved itself finally into the question of what was the actual physical field in which the short-circuited coil moved. The author's analysis, resting upon the component fields and planes normal to each other, did not at first sight seem to give clear guidance, owing to the great complexity of the actual practical case of the slotted armature. It appeared that a resultant commutating field must always be present at least in such amount and density as to compensate for the inductance, self and mutual, of the end connections; for the flux linked with the latter followed a path entirely different from that of flux entering or leaving the surface of the core. The remainder of the inductance of the short-circuited coils might be resolved into a certain amount due to lines crossing the air-gap and a certain amount due to the bending of the final field within the slot and about its neighbourhood. The former part was cancelled by opposing lines, so that it became non-existent in the resultant field. The latter part would call for some commutating flux sufficient to counterbalance the rate of change of bending of the actual lines so far as they cut the armature coils, the reason being that the M.M.F. of the commutating poles would never by itself straighten the distorted lines near the coils within the slots, so that the third part of the inductance could not be strictly annulled but must be compensated for. Although the distinction between the material and the available period of commutation was up to a certain point useful and valid, yet it contained an

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element of indefiniteness which rather limited its usefulness. What was a sufficiently close approximation to the final value to warrant us in regarding the time in which it was reached as the natural period? Even if successful in obtaining a natural period appreciably less than the available, then the difficulty arose of keeping the current at the required value during the remainder of the available period. The above criticisms which suggested themselves on first reading Mr. Worrall's Paper might, however, yield to a further study of it. The shape of brush, too, recommended by the author might be compared with the serrated edges which Mr. Carter (in the "Electrical World," March 31, 1910) recommended from an analogous point of view, viz., as valuable in unfavourable cases for keeping the current density at the last moment finite.

Mr. F. J. Moffett (communicated) mentioned that a case of the difference in behaviour of the positive and negative brushes recently came under his notice. The machine was designed for an output of 1,000 amperes at 80 volts and 700 revs. per min., and was provided with commutating poles. The brushes used consisted of a mixture of copper dust and carbon (Morganite Link 2/538), the current density being 85 amperes per square inch. When running at full load the commutation at the positive brushes was very good, but trouble was experienced at the negative brushes. The wearing surface of the negative brushes not only showed the brown bands mentioned by the author, but the copper was removed leaving the carbon alone. With an overload of 20 per cent., or 1,200 amperes on the machine, the commutation at the positive brushes was still fairly good, but at the negative the sparking became so vigorous as to make it impossible to continue the run. The removal of the copper from the negative brushes was even more marked at the overload than at normal full load, and the brushes became extremely hot. In order to remedy this trouble it was decided to substitute soft carbon (Morganite Link 1/289) for the copper carbon negative brushes, although these were naturally of higher resistance. The effect of the change was remarkable; not only was the commutation at normal load almost perfect, but even at 1,200 amperes there was no serious fault to find, and the alteration was quite successful in permanently curing the trouble. From an examination of the copper-carbon brushes on the positive and negative poles respectively, there appeared to be some justification for the assumption that the copper was carried along by the current by a kind of electrolytic action, but it was possible that the temperature at the contact surface of the negative brush reached so high a value as to render the copper molten, in which state it was carried away by the commutator segments. In support of this explanation, in the space between the commutator segments there was a considerable amount of copper which did not appear to be derived from the commutator bars.

Mr. H. G. Stephens (communicated) expressed his appreciation of the Paper, and suggested that the experiments be carried further. For instance, the case when only one coil was short-circuited was the simplest possible case and was comparatively rare in practice. Regarding equation (1) on page 9 of the Paper, it appeared that this was incomplete even for the purely hypothetical case considered. If r represented the resistance of the one coil, he thought the equation should be $E = ir + L\frac{di}{dt} + i_2 r_2 - r_1 r_1$. If this were so, the shape of the ideal brush would apparently be altered. Further, straight line commutation was not always a desideratum, as in the case of high-speed machinery, *e.g.*, turbo-generators, accelerated commutation was sometimes found to give better results.

Mr. Worrall, in reply, stated that the method of cancelling the tooth oscillations suggested by Dr. Kloss would only be possible in the case of a machine in which the workmanship was perfect and the magnetic quality of the iron uniform. No oscillograms were taken of the field exciting current, but from previous experience with laminated pole shoes and limbs it was evident that the non-existence of magnetic oscillations in coil 8P was due mainly to the use of solid poles and limbs. If the oscillograph were connected across the brushes the main E.M.F. would be so large that all commutation ripples would be invisible on the record: this, however, could be easily overcome by the use of a constant opposing E.M.F. Even then, however, the result would be confused by the variations of E.M.F. due to the spacing of the winding. The theoretical aspect of the question would probably always form a safe battle ground, for so much depended upon the terms employed, upon the way in which the problem was attacked and most of all upon the assumptions made. The results theoretically deduced could, at the best, only be approximate, but, as stated in the Paper, they might "point the way" to something practical. Such had been the case in this research, and, although for the sake of simplicity much had been intentionally left out in the theory, the theoretical result in Fig. 7 suggested and explained the practical result in Fig. 8. The explanation at the commencement of Section 1 of the Paper was only given to reconcile in some measure apparently conflicting statements and did not form part of the theory which followed. The remarkable confirmation of the results by Mr. Moffett was of very great interest, and it was to be hoped that others in charge of running plant would experiment in the same direction. The The suggestion of Prof. Marchant regarding the vibration of the negative brush did not explain the fact that the brush when positive did not vibrate even without the cooling device. The researches of Prof. Arnold had greatly assisted the work, and Prof. Robertson's research would be looked forward to with interest. Prof. Thompson had given a sufficient answer to all criticisms regarding the type of machine and brush employed, and it only remained to add that were two more years available they could be usefully employed in extending the research on the lines suggested by several speakers.

VARIATION OF THE HALL EFFECT IN METALS WITH CHANGE OF TEMPERATURE.

In a recent issue of the "Physical Review," Mr. A. W. Smith describes experiments on the temperature coefficient of the Hall effect. The author finds that the effect in gold, zinc, platinum and silver decreases as the temperature is raised from −190° to about 22°C. In the case of aluminium there is an increase. The Hall E.M.F. in each of these metals at the temperature of liquid air has been found to be proportional to the magnetic field. In silicon it has been found to have sometimes the direction of the effect in iron and sometimes the direction of the effect in bismuth. The purer specimens gave the effect in the direction of that in iron. A reversal of the thermo-E.M.F. in silicon has been found to be associated with a reversal of the Hall effect, and the Hall E.M.F. in silicon is shown to be proportional to the magnetic field.

The relation between the Hall E.M.F. and the magnetic field has been examined in iron, nickel and cobalt for a number of temperatures between −190° and 1100° C. For a given magnetic field the Hall effect in these metals has been found to increase with rising temperature until the critical temperature of the metal in question has been reached. The rate of increase becomes the greater the nearer the critical temperature is approached.

In passing the critical temperature the effect sinks rapidly to a small fraction of its original value, and then in the case of iron and nickel, and probably in cobalt, decreases slowly with further rise of temperature. In the magnetic metals for any particular temperature the Hall E.M.F. is proportional to the magnetic field, until the maximum intensity of magnetisation in the plate has been reached. After this condition, which has been called saturation, has been reached, the curves showing the relation between the Hall E.M.F. and the magnetic fields are nearly parallel to the axis of magnetic fields.

With increasing temperature the fields necessary to produce saturation become less in nickel and iron. In cobalt, however, the fields for saturation become greater with rising temperature until 300° is reached; and with further rise of temperature the fields for saturation become less. In nickel, iron and cobalt at temperatures a few degrees above the critical temperature the Hall E.M.F. is proportional to the magnetic field over its range in these experiments.

It is also pointed out by the author that the explanation of Sir J. J. Thomson, that the reversal of the Hall effect in iron may be due to the fact that the field actually acting on the free electrons is not only the impressed external field but also the field due to the orbital motion of the electrons in the metal, is improbable, in view of the fact that the effect in iron does not reverse sign at temperatures above the critical temperature where it has lost nearly all of its magnetic properties.

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"Miscellaneous Tests of Electric Car Equipment." By E. C. Parham and J. C. Shedd. (London: Hill Publishing Co.) 4s. 6d. net.

"Vibrations of Systems having One Degree of Freedom." By B. Hopkinson. No. I. of "Cambridge Engineering Tracts." (London: Cambridge University Press.) 2s. 6d. net.

"Annual Report of the Board of Regents of the Smithsonian Institution" for the year ended June 30, 1908. (Washington: Government Printing Office.)

"Elektrotechnik in Einzeldarstellungen." Edited by Dr. G. Benischke. Part I., "Die Schutzvarrichtungen der Starkstromtechnik Gegen Atmosphärische Entladungen," by Dr. G. Benischke. Part IV., "Die Vagabundierenden Ströme Elektrischer Bahnen," by Dr. C. Michalke. (Brunswick: F. Vieweg und Sohn.) Part I., M.1.60; part IV., M.3.

"Agenda de l'Electro." Third year, 1910. (Brussels: "Electro.") 3.50 fr.

"Controle des Installations Electriques au Point de Vue de la Sécurité." By A. Monmerque. (Paris: Ch. Béranger.) 15 fr.

"Leitfaden zum Elektrotechnischen Praktikum." By Dr. G. Brion. (Leipzig: B. G. Teubner.) M.11.

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ELECTRICITY IN AGRICULTURE.

There has of late years been a development of activity in Germany in a direction which has been but little exploited in this country, and which seems likely to lead to the profitable employment of capital. This is in connection with the supply of power for agricultural purposes; and though it might seem at first sight that the scope for this form of work is rather limited, in so far as financial considerations are concerned, it is not at all certain that this is the case. At any rate, those in Germany who are responsible for the further development of their distribution networks are not of this opinion, and a large amount of capital is being sunk in enterprises of this kind, which often enough are subsidiary to others already in existence. The tramway systems connecting Hanover with its outlying villages may be cited as a case in point. These tramways, which have been gradually extended in a variety of directions, have now spread so far into the country districts that the original scheme has been entirely revolutionised, and current is being transmitted to outlying points at very considerable distances from Hanover on the three-phase system, where it is converted to such other form of energy as is most suitable to the needs of the particular case. It is here that the opportunity arises of undertaking the distribution of energy to the agricultural districts. A large demand has in this way grown up, and the amount of power that is being used for

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driving agricultural and village machinery of different types has become very considerable. This is not an isolated instance. These stations are becoming quite a common feature, and to the demands so created the large manufacturers are able to trace a notable portion of their output. It seems likely that high-tension alternating current, preferably of the polyphase type, is an almost necessary feature in the design of such undertakings, and there must be many places in this country where polyphase mains are suitably placed for such work, which might with careful handling be made to add to the output of the central station of the district. The German banks apparently think well of the outlook for this kind of enterprise, and there is no reason why a little experience should not be able to assure us that this spirit of hopefulness is indeed justified.

There is also another direction in which it seems likely that in the course of time electricity will be found to be a useful auxiliary to the farmer. Agriculture is the most ancient form of human activity, if we exclude the possibly pre-existing stage in which the human being was tempted to live by his wits as a hunter. It is not, therefore, surprising that in the course of centuries the industry should have become somewhat stereotyped. Experience in one form or another has always been the mainspring of the farmer's methods, and there are not lacking those who say that, in these days, rule-of-thumb methods must everywhere be considered antiquated. Of late years the stress of competition has led to the introduction of some new ideas, and chief among these is probably the welcome that has been extended to systems of artificial manuring. The fixation of atmospheric nitrogen has developed out of this, and in this field electricity seems likely to play a very successful part. But apart from this, or possibly as an extension of this, there is another direction in which the experimental enthusiast seems to be able to do useful work. A good deal has been done in the way of improving the yield in agricultural districts by the use of electrical methods. The abstract, which we publish in another column, of the reports presented by Dr. HÖSTERMANN and Prof. GERLACH shows that some of these plans are giving good results. As far as Prof. Gerlach's methods are concerned, it does not seem that he is able to show any results sufficiently satisfactory to lead further workers along the same lines. His plan seems to be to make use of the stray currents from tramway lines, in the hope that the electrolytic effects which are so disastrous to underground pipework may be beneficial to growing crops. On paper such an idea does not sound very hopeful, and in practice the results have been equally unpromising. On the other hand, Dr. HÖSTERMANN seems to have produced results which show that some of his methods are worth careful study. His most successful plan seems to have been to collect atmospheric charges by means of kites, somewhat on the lines of FRANKLIN'S classical experiments, and then to distribute these charges by means of wires stretched parallel to the ground at a small distance above the crops. He calculates that with a kite flying at a height of 800 ft. he is able to get a pressure of 25,000 volts; and, reading between the lines, he seems, as we imagine, to think that the effect is produced by some sort of automatic fixation of atmospheric nitrogen. This may quite possibly be the case, and if methods so simple as this avail to produce a desirable result it seems that the problem is scarcely an engineering one. He has made a variety of experiments in other directions, with different methods of producing the discharge, but none has given equally good results. Still even so, there is much that he quite willingly admits to be obscure. Whether or not some artificial method of obtaining the desired voltage will be an improvement on the kite system, a good deal of discretion and experience is needed before such a simple method even as this can be properly applied. A small amount of treatment goes a long way, and it is easily possible to overdo it. Indeed, he has himself drawn up a system under which he considers that the treatment can be most usefully applied. All sorts of organic reactions require or imply the presence of moisture in some form or another, either as a product of the reaction, or as a necessary preliminary before any reaction takes place. It is on this fact that he lays most stress, and he points out that the electrical treatment is useless, if not positively harmful, when applied in such a way that there is not sufficient moisture present in the atmosphere or in the soil. Still, it is quite possible that this moisture may not be required as an active agent in the stimulation of the growing crop, but as some sort of intermediary in the shape of a carrier. However, in whatsoever manner it acts, it is quite certain that without it little effect is produced.

From the point of view of the engineer, much of this is devoid of interest, and if the whole thing is merely likely to stimulate the manufacture of kites it does not seem likely to bring much grist to the mill of the electrical manufacturer. Still, all phases of electrical activity are of interest, and it is well known that there are many in this country who are already at work on the subject. It may be that other and more hopeful methods will be discovered as the outcome of human ingenuity, but, at any rate, it does not seem to be difficult to determine the directions in which time and money can easily be wasted. In any case, the amount of power which is needed for this kind of work seems to be very small, and we do not think that any station need hope to increase its output by delusions on that account.

SOME EXPERIMENTS WITH THE NEW TELEFUNKEN SYSTEM.*

BY GRAF ARCO.

Summary.—After showing how a singing spark signal is analogous both to a clear musical tone and a regular electrical discharge, the author goes on to describe a number of experiments which he has made with an 8 kw. apparatus working on the new system. He next gives figures for the efficiency of a somewhat smaller station working on the same system, and lastly shows how, by means of a special apparatus, the messages from two sending stations can simultaneously be picked up in one receiver.

I am taking it that the phenomena occurring in Wien's quenched spark-gap are sufficiently well known after my lecture at Cologne,† and I will, therefore, confine myself on this occasion to the peculiarities of sound generation and their use at a receiving station. These are the more important, for

* A lecture delivered before the Verband Deutscher Elektrotechniker, on the occasion of the awarding of the Siemens-Stefan Medal to Prof. Dr. E. Warburg, of Charlottenburg.

† THE ELECTRICIAN, Vol. LXIII., p. 370.

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a number of improvements in the Telefunken System have been based upon them. In order to make the signals, such as would be received in the usual detector employed in connection with a telephone receiver, audible to a large audience, I have arranged the following small apparatus, which is shown in Fig. 1. This consists of a shaft driven by a small electric motor whose speed can be altered by means of a resistance, giving a variation from 3 to 1. On the shaft are fixed three wheels, one behind the other, which in the present case are taken from an ordinary cheap clock.

For the generation of signals similar to sound tones a visiting card or thin small wood plate is held against the teeth. At a

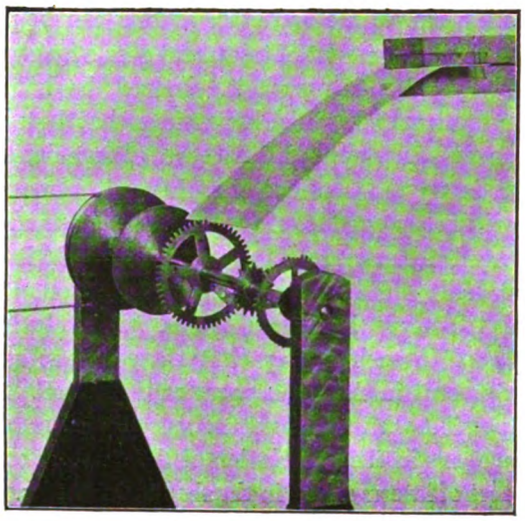

Fig. 1.

speed of two revolutions a second a wheel fitted with 20 teeth causes a sound similar to that obtained with a spark frequency of 40 per second. By altering the distance of the card from the wheel the Morse alphabet can be tapped out. The next wheel has about 90 teeth, about 20 per cent. of which are broken at irregular intervals. This wheel is used for generating sounds such as would be obtained by the irregular discharges obtained from atmospheric electrical phenomena. If spark signals and atmospheric disturbances are at work at the same time, and occur in different strengths, it is easily possible to discover in what relation the two intensities must stand for the Morse signals to be just readable. The third wheel has about 65 teeth regularly spaced round its periphery. This gives at about a speed of 16 revs. per second a clear sound of 1,000 frequency. This represents a singing spark station of normal pattern. It can thus be shown that signals with this sound can be recognised, even when the disturbances are more than 10 times as loud as the sound itself.

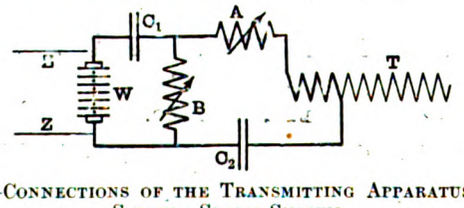

Fig. 2.—Connections of the Transmitting Apparatus in the Singing Spark System.

A similar sound was generated throughout the whole auditorium by means of an 8 kw. sender, working on the sending spark system. This apparatus is of a new pattern, the connections of which are shown in Fig. 2. The high-tension winding of the transformer charges the series quenched spark-gap which is connected with a surface condenser and variometer. These make up the quickly quenched primary circuit. The artificial antenna is coupled up with this circuit through a variometer and surface capacity, and a discharge coil is also connected with the antenna through a galvanic and inductive coupling. The discharge coil works in the well-known way, so that the capacity of the inductor is used as a counterweight instead of the earth. As soon as a voltage amplitude with about 20 cm. spark length is obtained at the free end of the coil, acoustic oscillations, corresponding to the different discharge conditions in the spark-gap, are transmitted from the point and are audible throughout the whole auditorium. When the sparks follow each other regularly a clear musical tone is obtained, while when the series is irregular there is simply a noise. The sound can, in the space of a second, be altered over as much as 22 octaves.

A further arrangement was connected up with this apparatus which made it possible at the same time absolutely to regulate the frequency, and thus to show that the clear sound only occurred when the sparks were regular, and a noise when they

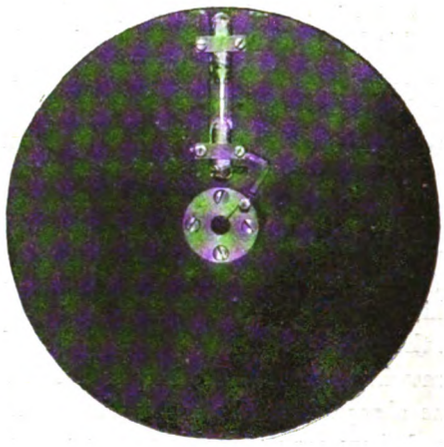

Fig. 3.—Rotating Geissler Tube.

were irregular. This arrangement consisted of a Geissler tube which, as shown in Fig. 3, is connected to a disc revolving in a radial direction. The disc revolved at 50 revs. per second while a high-frequency alternating current was passed through the tube. When a regular spark discharge with a frequency of about 1,000 is obtained, that is a clear sound, the rotating tube appears, as shown in Fig. 4A, in the form of a clear 20 pointed star, there being at each revolution exactly 20 discharges. As the photographic exposure was about one-fifth of a second,

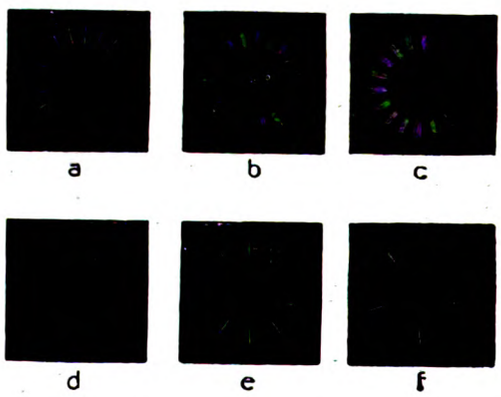

Fig 4.

there were in this period 200 discharges, that is each of the 20 points had glowed 10 times. In spite of this, on account of the great regularity, each ray is shown as a simple sharp line. The same holds good for all the following illustrations, with the exception of Fig. 4D. In Figs. 4A and 4F the frequency of the alternating current was constant, and equal to 500. When the alternator is more strongly excited a second discharge per alternation is set up, that is there are two partial discharges, as shown in Fig. 4B. With a still stronger excitation there are three partial discharges, as shown in Fig. 4C, the discharges per second in Fig. 4B being 200, and in Fig. 4C, 3,000 per second. In all these cases a musical tone was obtained. When the excita-

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tion is considerably increased the discharges first become irregularly grouped, and instead of a musical sound a hissing is obtained, the discharge in this case being shown in Fig. 4E. If

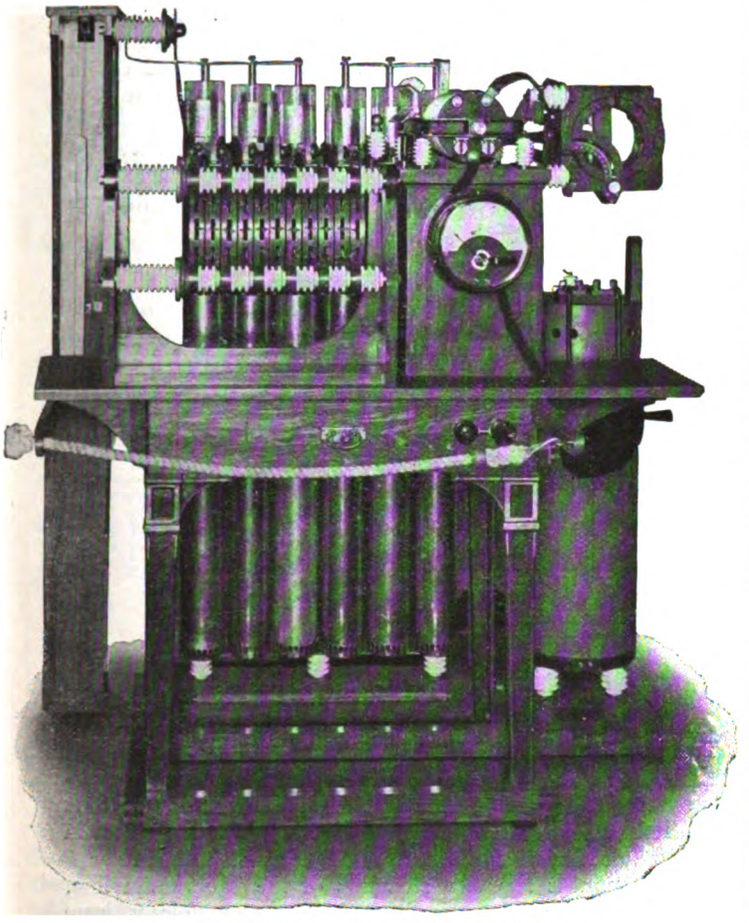

FIG. 5.—8 KW. SINGING SPARK STATION.

the generator is less excited, only one discharge is obtained every two, three or four alternations. Fig. 4E shows, for instance, a 10 pointed, Fig. 4F a five pointed, star, corresponding respectively to 500 and 250 discharges per second. In this way a clear tone can be obtained lying between two and three

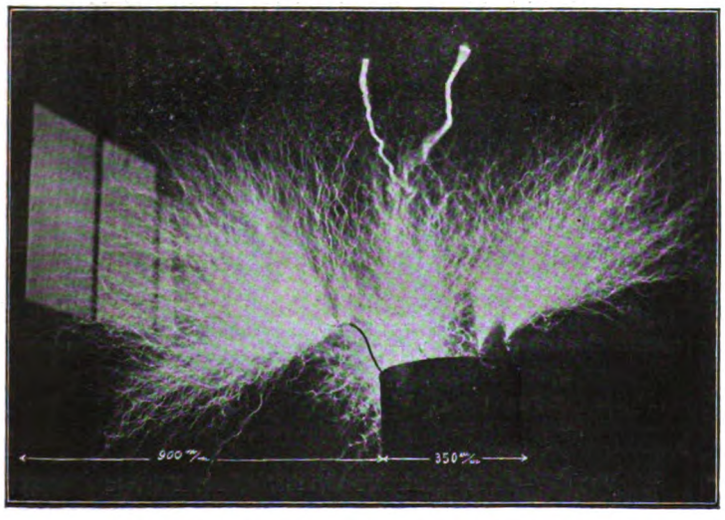

FIG. 6.—THE TRANSMITTING COIL IN OPERATION.

octaves under the fundamental, and the conditions of the obsolete spark telegraphy are very nearly reproduced, when an inductor resonance coupled loosely with a machine having a frequency of 100 alternations and giving out sparks up to frequencies of 25 and 50 is being used.

The standard 8 kw. station can be made to give any desired number of fundamentals, within the half octave above or below the normal, by a continual alteration of the speed of the alternator, and for each fundamental by means of faster discharges the first two overtones, and at the same time by slower discharges, the sounds of the three lower octaves can be obtained.

Dr. Fleming has made experiments on the regularity of spark discharges across spark-gaps subjected, and not subjected, to air draughts, as well as quenched spark-gaps, by using a rotating mirror, and he has photographed the results. As a result of his observations he came to the conclusion that a great regularity could not be obtained. He is only right in the cases when he is dealing with pressure discharges, as shown in Fig. 4D, otherwise with three discharges per alteration, and taking into account all the conditions, it is quite possible to obtain an absolutely regular and constant stream of discharges. This is shown by the photographs reproduced herewith, and by the experiments that I shall perform later.

I come now to the construction of the 8 kw. station, which is shown in Fig. 5. The transformer which steps up the machine pressure to about 20,000 volts and charges the exciting capacity is seen in the right background. A variable high-tension choking coil is placed in the secondary circuit, arranged for the correction of the resonance phenomena when it is desired to generate another tone by raising or lowering the speed. A variation of the sound over a whole octave continuously is possible, and the next three lower octaves can be obtained by altering the generating voltage at each speed.

The exciting capacity consists of Leyden jars which are arranged behind the table and an air-cooled series spark-gap, arranged in 12 parts placed higher up on the right. This is cooled by a ventilator not shown, and is connected to the variometer with a scale on the right. To one of the poles of this is connected a hot-wire ammeter and the earth, and on

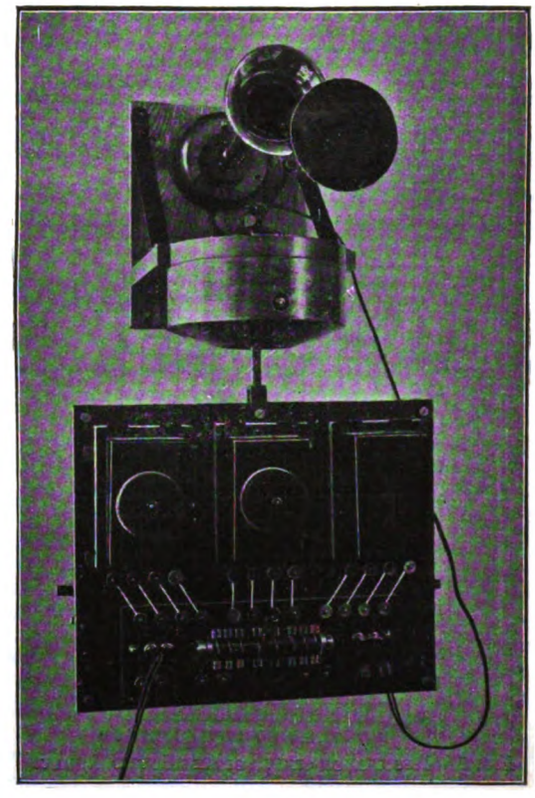

FIG. 7.—RESONANCE SOUND AMPLIFIER.

the other side through a series variometer, the antenna. The wave scale of this station rises continuously from 300 to 2,500 metres. Any desired wave-length can be obtained by altering the variometer while the coupling of the antenna remains absolutely constant at all wave-lengths. The 8 kw. delivered from the machine is divided up as follows :—In a

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T-shaped ship antenna the current is 38 amperes, and the resistance of the antenna at 600 metre wave-length is 4 ohms. The energy delivered is therefore 5,800 watts, resulting in a total efficiency of 72·5 per cent. In my Cologne lecture I gave 60 per cent. as the efficiency of the new Telefunken System, and as this figure was questioned on different sides I propose now to give the several losses which occur in the 2 kw. type used at Cologne. These are set out in the following table :—

1.—Motor-generator.		
(*a*) Energy supplied to the motor		2,950 watts
Loss in the motor		450 „
		2,500 „
(*b*) Energy supplied to the 500 frequency generator.		2,500 „
Losses in generator		650 „
		1,850 „
2.—Transformer Circuit.		
Energy supplied to inductor		1,850 watts
Losses in inductor	180 watts	
„ in choking coil	60 „	
		240 „
		1,610 „
3.—High-Frequency Circuit.		
(*a*) Energy supplied to exciter circuit		1,610 watts
Losses in the Spark-gap	155	
„ „ „ Condenser	63	
„ „ „ Induction coil	42	
		260 „
(*b*) Energy supplied to antenna		1,350 „
Antenna current 13·5 amperes		
Antenna resistance wave-length of 1,200 m		8.5 ohms
Oscillation Energy in the antenna $= I^2W$		1,350 watts
(4) Efficiency of high-frequency transformation	$\frac{1350}{1610}$	= 84 per cent.
(5) Efficiency of low-frequency transformer	$\frac{1610}{1850}$	= 87 „
(6) Efficiency of A.C. Generator	$\frac{1850}{2500}$	= 74 „
(7) Efficiency of motor	$\frac{2500}{2950}$	= 86 „
(8) $\frac{\text{Antenna energy}}{\text{Motor energy}}$ Efficiency	$\frac{1350}{2950}$	= 46 „
(9) $\frac{\text{Antenna energy}}{\text{Generator energy}}$ Efficiency	$\frac{1350}{1850}$	= 73 „

In this connection I may call attention to a remark of Dr. Fleming's in an article published in THE ELECTRICIAN, of

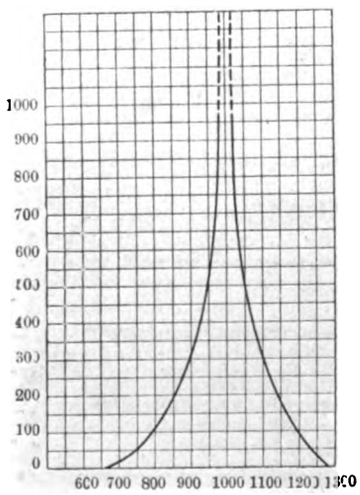

FIG. 8.—RESONANCE CURVE OF THE SOUND RELAY.

December 24, 1909, in which he gives a very low efficiency for a laboratory station, without wishing in any way to compare it with a station erected on technical lines. In our case antenna energy always means the sum of the actual amount transmitted from, and that lost in, the antenna, while Dr. Fleming understands by the efficiency the energy transmitted alone. It is not possible to determine the difference between these two values by measurement, as no exact method of doing so is at present known. Under certain conditions the efficiency of a good ship's antenna, when it is working with about 1·3 times the fundamental wave-length, should reach 50 per cent. The total efficiency between the transmitted oscillations and the load on the machine should be then about 40 per cent. It is quite possible to measure exactly the total energy in the antenna, and these values will in future be used by the Telefunken Co. in describing the sender energy. For these measurements it is not necessary to use any instrument beyond a hot-wire ammeter in the antenna, and to know the total antenna resistance at a given frequency, the latter value being obtained from the antenna resonance curve, or by measuring the current through it at different resistances.

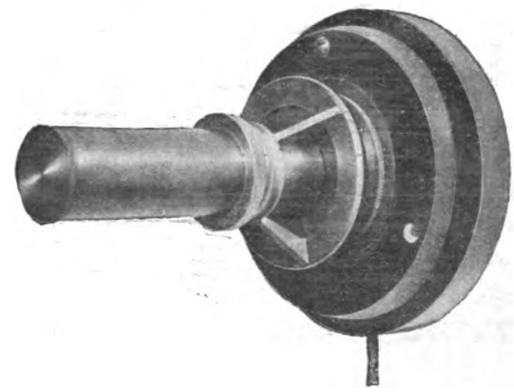

FIG. 9.—VARIABLE ACOUSTIC RESONATOR.

Turning once more to the experiments, the 8 kw. station is excited with about 5 kw. to 6 kw. in the primary, and the discharges are thus quite considerably increased. The thick bush discharge reaches a length of nearly 1 metre, as shown in Fig. 6, a quite impressive operation being thus obtained.

Several months ago two steamers of the Woermann line, which ply between Hamburg and the Cameron Colony, were fitted with stations of this type. Owing to the small mast height, the antenna was only 28 metres above the deck, and the masts being but a short distance apart, the length was only 67 metres, so that the conditions were unsuitable. But in spite of this it was possible to obtain communication at night between the two steamers over a distance of 3,200 kilometres in the region between the Canarian Islands and Cape Palmas. Communication was made more difficult by the presence of the

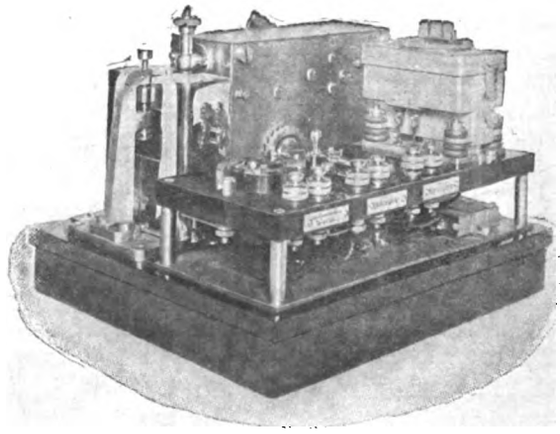

FIG. 10.—MORSE WRITER FOR SINGING SPARK WORK.

African Continent, whose length was about two-thirds of the distance covered. On January 23rd the two steamers were 3,700 kilometres apart at 10 o'clock in the evening, and were then able to get into good communication.

The use of a sound at the receiving station may now be shown by using the new resonance sound amplifier invented by the Company. Fig. 7 shows this apparatus adapted for ships use. On a board balancing in an elastically damped cardan suspen-

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sion are mounted three sound resonance relays in series fitted with microphone contacts. The system is protected during the sending from the inductive working of the nearby sender by means of an automatic electromagnetic relay working in conjunction with the receiving apparatus.

The sound amplifier contains a well-known mechanical resonance system with small damping. Fig. 8 shows the mechanical resonance curve obtained from the amplifier. The curve shows the sensitiveness of the amplifier as a function of the increasing sound. In this way it is possible for different sounds from the senders to obtain a constant sound from the amplifier. It is evident from the curve that with a certain resonance the primary sound can itself be increased when it

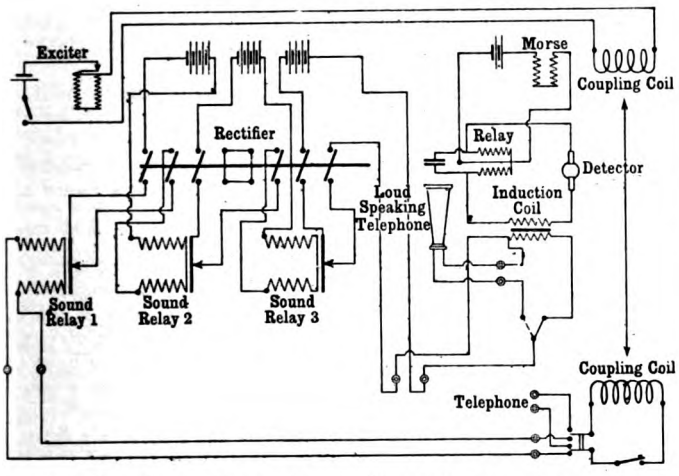

FIG. 11.—CONNECTIONS FOR THE MORSE INSTRUMENT ON THE SINGING SPARK SYSTEM.

does not exceed 1,000 ohms. By a sound of 1,000 ohms is meant that when a coil of 1,000 ohms is connected in parallel with a telephone of 1,000 ohms resistance the latter becomes inoperative. With a sound dissonance of about 5 per cent. a primary sound of about 500 ohms is necessary in the amplifier, and with a dissonance of 20 per cent. 100 ohms are necessary; that is, very much more primary energy is required. Practice has shown that sounds of only 500 ohms can be increased for as long as desired, thus proving that the frequency of the sparks, clearness of tone and constancy of the sender are extraordinarily high. To increase the selection an acoustic arrangement is used as well as a mechanical one. The loud-speaking telephone has, instead of the usual mouthpiece, a continually variable acoustic resonator in the shape of a tube which can be drawn out, as shown in Fig. 9.

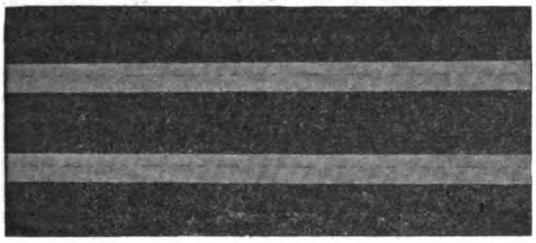

FIG. 12.—TWO TELEGRAMS RECEIVED BY THE MORSE APPARATUS.

The sound amplifier can be arranged to work as in Fig. 10, with a Morse writer, which had disappeared from wireless telegraphy together with the coherer.

The arrangement of connections at present used by the Telefunken Co. is shown in Fig. 11. The current flowing through the microphone contacts of the three amplifiers is composed of direct current and superposed current pulsations. This current passes through a telephone transformer, from which ordinary alternate current is obtainable. An electric valve connected in this circuit transforms this current into a pulsating direct current, and by means of this arrangement a highly senstive polarised relay is worked which operates the local current for the Morse instrument.

I have taken the opportunity in this lecture to show for the first time that double receiving by means of a receiving apparatus in connection with two senders using equal wave-length is possible. The senders differ only in that their tones vary by 20 per cent. At the receiving station the sender oscillations are picked up at the same time by a detector, and the receiving current passes through two primary windings connected in series and tuned in accordance with the sounds. One of these works with a higher, and the other with a lower, sound. Telegrams can thus be distinguished by sound as well as on the Morse instrument. The Morse dots and dashes were during receiving projected on the wall. Fig. 12 shows tests of this arrangement.

We have, in fact, in certain cases used a receiving station to collect three messages at the same time, using a high frequency and both mechanical and acoustic resonance. By this arrangement any fear of disturbance from outside conditions is nearly prevented, and I am of the opinion that by the use of sound arrangements a great improvement in the selection will be made in the near future, and a very important step forward will thus be taken.

TRAMWAY ECONOMICS.*

BY J. R. SALTER.

Summary.—The author here deals with the relationship between the receipts, car-mileage and working expenses of a tramway undertaking and the general commercial principles involved in its operation. A basis of comparison for the results obtained on different undertakings is discussed, and also the point at which the construction of a tramway is justified. The author considers that up to a 30-minutes service, tramway undertakings need have no fear of being replaced by self-propelled vehicles unless the cost of operating the latter is halved or the carrying capacity is doubled without increasing the cost.

The expenses of operating a tramway, as indeed of almost any commercial undertaking, can be divided into two broad classes. There are, first, the "standing charges," which charges remain constant whatever the number of car-miles run may be; and there are the "running expenses," which are for all practical purposes proportional to the car-mileage run. The standing charges are those for interest, sinking fund and, partly, depreciation upon the capital cost of the equipment, whilst the running expenses are those for traffic, general expenses, power, maintenance of cars, track, overhead equipment and cables. To electric supply engineers the necessity for basing the charge for a given supply upon the cost of giving that supply has long been realised, this principle being enunciated by the late Dr. John Hopkinson in a Paper read in 1892. Dr. Hopkinson contended, taking the Metropolitan District Railway as an example, that as that railway must be prepared to bring in its thousands of passengers to the City at the beginning of the day, and to take them back in the evening, and for the rest of the day it must be content to be comparatively idle, it would not be inappropriate to charge more for carrying a person in the busy time than in the slack time, as it really cost more to carry him. This may be a general statement of the operation of the principle involved, but I venture to suggest that it has not full application in the case either of a railway or a tramway, for the reason that in these undertakings a very great proportion of the capital charges to which the standing charges belong must of necessity be incurred whatever the service may be, and that the only capital expense which is separately incurred for dealing with the heavy traffic is the cars and the power plant for driving them. In a tramway undertaking, too, the supplier may, by increasing his supply—*i.e.*, the number of car-miles run—provide an extra inducement to his customers or passengers, whilst in an electric supply undertaking, the consumer must be first obtained before the supply can be increased. Further than this, although probably the cars are idle for a great portion of the day, during the "rush" hours they actually provide themselves with an extra return owing to the very much higher receipts obtained per car-mile during those periods.

The diagram herewith shows the relation between the number of car-miles run per route-mile per annum and the service in minutes. The ordinates represent the car-miles per route-mile per annum, the abscissæ the services in minutes, the car-miles per route-mile per

* Abstract of a Paper read at the Congress of the Tramways and Light Railways Association at Dublin.

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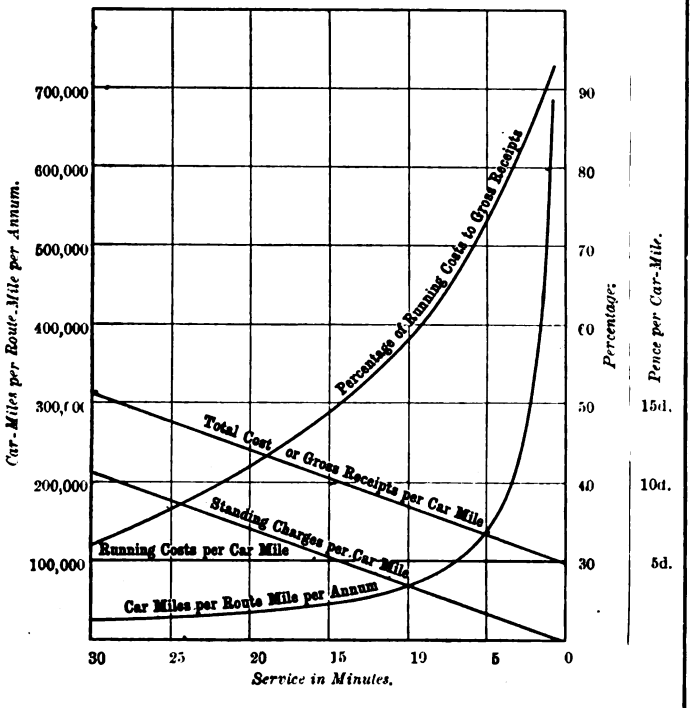
annum being on the basis of a slightly under 16-hour-day, in order to get approximately round figures for the different services. There is also shown in this diagram the proportional or running cost per car-mile, the standing charges per car-mile, and the total cost of operating or equivalent gross receipts per car-mile necessary to obtain a given result. The running costs per car-mile have been assumed at 5d., whilst the standing charges have been assumed at £1,000 per route-mile per annum. The figures which have been assumed are, of course, only general in their application, but may be taken as average figures which can readily be modified to suit any particular system, and they are intended to apply to a case where the undertaking generates its own supply of electricity. If the electrical energy is purchased, and the price is based upon the working costs at the power station, plus a charge for the plant capacity used for giving the supply, then the running costs may still remain the same as in the case when the supply is generated by the tramway undertaking; but if, as is more often the case, there is a fixed price per unit which is more or less independent of the car-mileage run, then the capital charges on the electricity portion of the undertaking become, so far as the tramway undertaking is concerned, a proportional or running charge. It may here also be pointed out that the increase in the number of the car-miles run by no means involves a proportional increase in the plant capacity required to give a supply to the tramways, since the greater the service the less the fluctuations upon the power station, and consequently the better the load factor. The charges have been worked out on the route-mile basis, and not upon the track-mile, for the reason that a given service, of course, remains the same whether the track be single or double.



It will be seen that there is a critical point in the service at which the standing charges per car-mile are equal to the running costs per car-mile—viz., at a 14 minutes' service. Again, the increase in the total costs per car-mile above the critical point is very much more rapid than is the decrease in the total costs below the critical point, and in consequence, the more frequent the service, the less important do the capital charges become. Probably one of the most interesting features is the percentage which the working or running expenses bear to the total receipts; the total receipts in this case being assumed as the same as the total costs, or, that is, sufficient to meet the capital charges upon the undertaking on the basis adopted.

I have always thought that the relationship between the working expenses and the gross receipts expressed as a percentage was of no practical value, and gave no idea of the commercial value of the undertaking. The working expenses in most tramways vary so slightly that the percentage between these and the receipts depends entirely upon the receipts, and as it has been shown that, with an increase in the number of car-miles, the receipts per car-mile can be rapidly diminished to obtain the same result, it is evident that no idea can be formed of the remunerative capacity of the undertaking from this relationship. It is apparent that with the rapidly increasing capital charges due to the reduction in the service, and with a practically constant running charge, the less frequent the service the less is the proportion or percentage of the working expenses to the total costs or equivalent gross receipts; and, as a corollary, the more frequent the service, the greater is the percentage of the working expenses to the gross receipts to obtain a given result. It would seem, therefore, from a consideration of these points, that tramway undertakings must look rather to an increase in the gross receipts by increasing the car-mileage and thus reducing the standing charges than to a reduction in the working expenses to improve their financial position. This dictum was advanced, I believe, by Mr. H. Mozley, manager of the Burnley Corporation tramways, in October, 1903, but was not given that credence which a close investigation of the problem seems to entitle it. The diagram shows the error of striving after high receipts per car-mile which one so frequently finds. In the case of one undertaking, where the number of car-miles per route-mile per annum was of the order of 60,000, being equivalent to an average 11 minutes' service, and with receipts of 10·3d. per car-mile, the service was reduced to 52,000 car-miles per route-mile per annum, increasing the receipts per car-mile to 11·53d., and in consequence, increasing the loss on the undertaking from £2,000 to £6,000 per annum.

In the foregoing considerations, the number of car-miles per route-mile per annum seems to be the determining factor, and it is somewhat extraordinary that so little use is made of this factor. Objection has from time to time been taken, and justly so, to the car-mile as a comparable unit. Mr. J. H. Rider has proposed a figure of merit $= \frac{\text{Units per car-mile} \times 100}{\text{Average weight in tons} \times \text{average speed in m.h.p.}}$. This undoubtedly gives a true scientific comparison of the conditions, so far as the current consumption is concerned; but from a commercial point of view such a comparison is of little value, and I think if we take the number of car-miles per route-mile per annum divided by 10,000, and multiply this by the receipts per car-mile, we have a figure which the better enables systems to be compared from a commercial point of view. The number of car-miles run per route-mile per annum is, to my mind, so important that I think it is a figure which could well be introduced into tramway accounts, and if it is divided by 10,000 we could obtain what might be called the "density factor."

This, multiplied by the receipts per car-mile, would give a figure of merit which could be used for comparing different undertakings, if taken in conjunction with the capital cost per route-mile, whilst if it were multiplied by the difference between the receipts per car-mile and the working expenses per car-mile, it would give the relative financial value of the undertaking.

It may be objected that this basis of comparison does not take into consideration the speed, the weight of the car, or the seating capacity, but the seating capacity and the fares determine the receipts per car-mile, whilst the speed mainly affects the power consumption and does not alter the number of car-miles per route-mile per annum—the density factor. It is true that the portion of the standing charges per car-mile represented by capital invested in cars varies in inverse proportion to the average speed. With a low cost per mile (for everything except cars) this becomes of importance, but with heavy cost per mile (for everything except cars) it becomes of less and less importance. With an increase in speed, however, and consequent reduction in the number of cars, and in the standing charges upon the cars, it will be found that there is an increase in the proportional charges due to extra wear and tear and extra power consumption, and as the variation in the average speed on systems in this country is not very great, the number of cars affected by the speed has not been taken into consideration. It is interesting to note that the income tax authorities, as a result of the efforts of thiss Asociation, in fixing the allowances for maintenance and depreciation assumed as a basis the number of car-miles per mile of track per annum. They allowed a life of 16 years for a density factor of 10, of 14 years for a density factor of between 10 and 15, 12 years for a density factor of between 15 and 25, and offered to give special consideration to cases of a density factor above 25.

I may further point out that the density factor could be usefully employed to compare the cost per mile of construction. This brings me to a consideration of the question as to the point at which, having regard to the increasing capital charges, with a reduction in the service, the construction of a tramway is justified. We need only for this object consider what receipts per car-mile with a somewhat infrequent service are likely to be obtained. With a service of this character, and with the fares obtaining in this country, it is unlikely, except in very special circumstances, that the receipts per car-mile will exceed 11d.; this being the case, it would appear on the basis of the curves that an average 17½ minutes' service is in the neighbourhood of the limit at which a tramway undertaking can be remunerative. This limit, of course, may be increased if the capital cost of construction is reduced, or if the character of the undertaking will permit of higher fares than are generally obtained in this country.

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Of course, this limit of a 17½ minutes' service at which a tramway undertaking can be remunerative, applies to the undertaking as a whole, and the results which may be obtained from an extension of an existing system, or even from the terminal ends of an existing system, should not be considered separately.

Having then arrived at the limit for a remunerative tramway undertaking, it may not be out of place to consider whether some other means of transit, such as motor omnibuses, or the railless traction system, can be utilised, as capital is largely absent from these later modes of transit. In considering this, however, it would be well to ascertain in what way the average receipts per car-mile on a tramway undertaking are obtained. We find almost universally that the traffic upon tramways is of a very varying character. There are what are known as "rush hours," when the traffic often taxes the utmost capacity of the undertaking, and, in addition to this, provision has to be made for week-end and holiday traffic. Were it not for the ample carrying capacity which a tramcar provides for dealing with this extra heavy traffic, it would, of course, be impracticable to earn the average receipts which are now obtained. In this connection reference is made to the traffic on the Liverpool Corporation tramways, showing the enormous carrying capacity which has constantly to be provided if average receipts of even 11d. per car-mile are to be obtained. In an inter-urban tramway where the mid-day traffic is not of so constant a character as is to be found in a large city, the variation in the carrying capacity required upon the system is of a still greater order. On the Liverpool and Prescot Light Railway the receipts vary from 3½d. to 26d. per car-mile, the average receipts throughout the year being in the neighbourhood of 9d. per car-mile.

In considering, therefore, any means of transit which is to be compared with a tramway undertaking, the enormous variation in the number of passengers to obtain given receipts must be taken into consideration, and provision must be made, if the same fares are charged, to deal with extraordinary or "rush" traffic. It would therefore seem, having regard to the fact that the carrying capacity of any self-propelled vehicle is only half the carrying capacity of a tramcar, that at least double the number of vehicles will have to be provided. With motor omnibuses it is unlikely that the expenses per car-mile will be less than 10d., and to compare, therefore, the expenses of running such a system with that of a tramway, the cost per car-mile for operating must be doubled to provide the seating capacity. Although, therefore, the motor omnibus is relieved from many of the capital charges which are so serious to a tramway with a small service, the working expenses are so high that this method of transit is not as remunerative as a tramway, even at a 30 minutes' service, the expenses per car-mile on a tramway at this service being 15·5d. and the expenses per double 'bus mile to obtain the same capacity being 20d. It must not, however, be overlooked that the provision of the two 'buses, or the splitting up of the capacity, would result in a very much quicker service, and would undoubtedly conduce towards increasing the number of passengers during the slack periods.

With the railless traction system, the carrying capacity is only about one-third of that of a tramcar, and the expenses on this system may be assumed at 5½d. per car-mile; but in this case, if we are to provide for the excessive carrying capacity to obtain the average receipts, we find again that the systems are incomparable until a 30 minutes' service is reached. We have, as before, the extra service due to the triplicate number of cars, with an inducement to extra travel, but too much importance should not be attached to this, for the reason that in places where a 30 minutes' tramcar service is not justified, a 10 minutes' railless traction service will still less be justified. This, therefore, leads one to the conclusion that tramway undertakings need have no fear of being replaced by self-propelled vehicles unless the cost of operating them is reduced at least one-half, or unless, with the same operating costs, the carrying capacity can be doubled, until we arrive at a 30 minutes' service, assuming that the same fares are obtainable in each case. This conclusion may be modified by other considerations—that is, where the running of the omnibuses may obviate the necessity for changing cars, which becomes an important consideration, especially with an infrequent service. As an instance of a motor omnibus service which shows very gratifying results, the 'buses of the Scotch Motor Traction Co., which run in Edinburgh out to the Forth Bridge, are mentioned. Here, with a mileage of a little over 360,000 per annum, and with receipts per car-mile at 14·54d., very satisfactory results are obtained.

The clauses embodied in the Heywood Corporation Act, 1909, upon which through running between Bury, Heywood and Rochdale operates, are finally set out in the Paper. This is, I believe, the only instance in which detailed terms have been embodied in an Act of Parliament, and Mr. Stephen Sellon and myself were largely responsible for the drafting of these clauses.

CORRESPONDENCE.

INSTITUTION OF ELECTRICAL ENGINEERS ELECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow me to make a few comments upon the recent election of the Council of the Institution of Electrical Engineers, from an entirely detached point of view.

The editorial criticisms in your paper and the comments made in a letter contributed to your columns show, to my mind, conclusively one thing, and that is that the alterations which were made in the Articles of Association of the I.E.E. in 1903 and 1904 do not quite meet the needs of the situation. If it is considered to be desirable that the general body of members should have a direct voice in the selection of candidates for office, the rules should provide that that choice can be exercised without offence being given in any quarter and upon terms which will make that choice equally effective with the choice made by the Council.

That the exercise of this choice should be interpreted by any members as involving a vote of want of confidence in the Council is most unfortunate, and yet, according to my experience, action under these rules always is so interpreted.

The chief criticism has been directed against the suggestion that the name of a particular nominee of the Council should be scratched out on the polling paper. We can all be agreed as to the unpleasantness of such a method of furthering the object in view, but it appears to me that it is the system of election which is at fault, and it, and it alone, must be directly blamed for all the unpleasantness.

If we analyse the situation without regard to any personal element, we find that, in effect, the general body of members are divided into two parties by any action taken under the rules relating to nominations made by members outside the Council. The division is between those who desire to support the Council and those who do not. Of course, in the abstract, this should not be the case, but speaking as one who has been hon. sec. of quite a number of clubs and societies, athletic and scientific, I have found that, among those who are sufficiently interested to vote at all, the voting all takes place on these party lines under such conditions. Now, if this be admitted, every supporter of the Council knows what nominee to scratch out on his polling paper, and knowing that, a little elementary mathematics will demonstrate that the supporters of the Council are placed at a great advantage compared with the supporters of the outside nominee unless the latter also agree among themselves which nominee to scratch out. The movement on the side of the Council is automatically organised, so that such voting power as they can command is concentrated to produce the best effect. If the conditions are to be equal the supporters of the outside nominee must also organise for the maximum effectiveness. I am not defending Mr. Chamen; those who know him realise that he would be incapable of acting otherwise than according to his conception of the highest standard of conduct in such matters, but I am concerned, and I am sure that you are, Sir, as well as others who have taken part in this discussion, that the most complete harmony possible should rule amongst the members of the Institution and its Council. It is upon that harmony that its vitality and well-being so largely depend.

I, therefore, plead for an alteration of the Articles of Association upon some such lines as those adopted by the American Institute of Electrical Engineers. I think that a "General Proposal List," made up from proposals put forward by all the members, from which the Council can make their own selections, might meet the case. As many of your readers will know, the "General Proposal List" is printed side by side with the directors' nominees in the case of the American Institute.

There will no doubt be some who will regard the arguments of this letter as consisting of a kind of specious sophistry, but

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I trust that others will think differently, and that we may find a common basis of agreement which will strengthen the Institution of Electrical Engineers which most of us value very highly.—I am, &c., EDW. W. COWAN.

4, Queen Victoria-street, E.C.,
June 8th.

SHORT-CIRCUIT LOSSES IN ALTERNATING CURRENT COMMUTATOR MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Worrall's letter published in THE ELECTRICIAN, June 3rd, we wish to say that the experimental curves given in our Paper were determined both with ordinary brush holders and with those described by Mr. Worrall.

The results obtained with the different brush holders were quite the same when the necessary amount of care was taken in each case. So far as the aims of the work were concerned it was naturally quite immaterial what particular type of brush holder was used, and a description of the different types was superfluous. We intended to make a reference to Mr. Worrall's work, which, however, has only just recently been published, and, not knowing when it would appear, we were not in a position to refer to it. Moreover, at the time when our Paper was being written, Mr. Worrall was applying for a patent, and consequently a description in our work of his brush holder would have been out of place.

We take this opportunity to mention that the brush holder proved itself to be useful for experimental purposes.—We are, &c.,

Baden, June 7. A. FRAENCKEL.
B. J. M. LANE.

EFFICIENCY OF SHORT SPARK METHODS OF GENERATING ELECTRICAL OSCILLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Dr. Eccles I should like to point out that if the efficiency of transformation from a primary oscillatory circuit to aerial is less than 20 per cent., then on disconnecting the aerial the primary current should not increase by more than 11 per cent., so long as the gap resistance remains constant. $\frac{i_1^2 - i_2^2}{i_1^2} < 0{\cdot}2, \qquad i_1 < 1{\cdot}11 i_2,$

Nor will the gap resistance change appreciably on account of so small a variation of current in the practice of wireless telegraphy. (N.B.—See also Rempp's observations, Fleming's "Principles of Wave Telegraphy," p. 186, Fig. 2.)

It follows that the loss in the primary circuit is Ki^2 for low and average efficiencies and that the simple formula

$$\frac{i_1^2 - i_2^2}{i_1^2}$$

is quite applicable.

For the particular case of high efficiency referred to by myself, I had experimental proof that the coefficient K remained constant for double the primary current if I am allowed to assume that the power consumed and emitted by a given aerial (having no gap), all conditions being identical, is proportional to the square of its r.m.s. current.

Indeed, on quadrupling the power supplied to the primary circuit, both aerial current and primary current doubled, which showed on writing the following proportion that K had not varied: $P - Kb^2 : 4P - K(2b)^2 = a^2 : (2a)^2$, P = power supplied to primary, b = primary r.m.s. current, a = aerial r.m.s. current.—I am, &c.,

Lyons, June 4. R. C. GALLETTI.

TELEPHONE RELAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Many readers of Mr. Brown's Paper on the "Telephone Relay" must have felt that his modest claims are likely to be far surpassed. By its aid timid speakers at our meetings may soon hear themselves bellowing from the back of the hall, while politicians may be able to address audiences 100,000 strong by means of a number of instruments placed suitably, provided only that listeners turn up. Indeed, the relay may eventually do for hearing what the microscope has done for seeing. It may, therefore, not be thought intrusive to suggest a name. We have the ultra-microscope, which might be called the ultrascope, and this instrument might be called the ultra-microphone, or ultraphone, if a purer word be not discoverable.

The instrument provides an excellent example of the use of method in invention, about which I had the pleasure of giving a Paper some time ago. Working methodically on the problem, one would write down a list of every conceivable variety of contacts, solid, liquid, gaseous and vacuous. The mere fact of keeping such a list by one would be an inspiration in itself; people are so apt to keep to the kind of thing already in use that the idea of using a single small air-gap does not readily suggest itself to the mind working aimlessly. When giving my Paper someone challenged me to produce a relay. It was an awkward challenge, for evidently I would not be likely to give away a good idea at a meeting, whereas want of an answer looked like defeat. I did, however, think of the use of a homopolar dynamo, which will give alternating currents when excited with same, independently of the speed of revolution. Perhaps this might have developed to a practicable machine in the hands of, say, Mr. Brown, but it does not now seem to be wanted.

Could any of your readers give details of the other relays in use? These were mentioned in the discussion, but not described—Yours, &c.,

North Shields, June 3. C. TURNBULL.

LEGAL INTELLIGENCE.

Home Office Regulations for Electricity Works.

In the Sheriff Court, Hamilton (N.B.), on Thursday last week the Clyde Valley Electric Power Co. were charged with having had on March 3 last, in their electrical sub-station at Cambuslang, extra high-pressure conductors in the switchboard passage ways from the front and from below, so that it was not adequately protected while dangerous work was being done by one James Noble, an electrician's labourer; also, with having failed to make such switchboard dead, or to separate the section of such board by removal screens while repairs were being made by a person without technical knowledge or experience, in consequence of which the said James Noble was killed.

An agent from Messrs. Wright, Johnston and Mackenzie, writers, pleaded guilty on behalf of respondents, and asked the Sheriff to dismiss the case with an admonition or the imposition of a nominal penalty. He stated that it was impossible to make the switchboard dead, as the current was running continuously. With regard to screens not having been provided, he said it was the company's practice in the past to provide screens, and the responsibility for their use rested with the engineer in charge. In that instance the work was being carried through without the cognisance of the company. It was also explained that Noble had served his apprenticeship as an iron turner, had been in the employment of electric supply companies for some time, and had been employed at the erection of a sub-station at Catheart, which was completed in 1906 in compliance with the then existing regulations. Since then, however, the Home Secretary had prescribed further regulations which had only come into force on January 1, 1910.

The FISCAL explained that his instructions from the Home Office were, in view of that being the first case in Scotland, to press for a penalty which, while not severe, would yet be more than nominal. As to the Regulations only having recently come into operation, he pointed out that they had been drawn up after long negotiations with the various industrial companies, including the Clyde Valley Co. The room in which the accident occurred was a small one (14 ft. square) and passing through it there was a current of 11,000 volts.

Sheriff THOMSON said those accidents were becoming lamentably frequent. He thought the ends of justice in this case would be served if a penalty of £20 was imposed. Judgment accordingly.

Osram Lamp Works (Ltd.) v. G. M. Boddy & Co.

This action was before Mr. Justice Parker on Friday last upon interlocutory motion.

Mr. WALTER, K.C., representing plaintiffs, said he was instructed to move for an interim injunction to restrain an alleged infringement of patent, but defendants had raised the defence of non-infringement and invalidity, and he agreed it was not a case that could be usefully gone into on interlocutory motion. Defendants had undertaken to keep an account and on that undertaking he was willing that there should be no order on the motion except that the costs of the motion be costs in the action.

Mr. H. T. TERRELL, K.C., appeared for defendants and gave the undertaking mentioned, and his lordship accordingly made an order as agreed.

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Re Sunderland District Electric Tramways (Ltd.); Capes v. The Company.

On Thursday last week Mr. Justice Swinfen Eady appointed Mr. Charles Eves, C.A., receiver and manager of the property charged by the first mortgage debentures of this company.

Mr. Micklem, K.C., for plaintiffs, said the company was formed to construct and work a tramway from Houghton-le-Spring to Sunderland. There were £160,000 of first mortgage debentures outstanding and £20,000 of second mortgage debentures. The company had been carrying on business for the last eight years, and always at a loss. No interest had been paid on the preference shares, of which there were £90,000, or on the £74,000 ordinary shares. Though no interest on the debentures was in arrear, it was admitted that there would not be sufficient to pay the interest which became due on July 1 next.

The company, the second debenture holders and trustees for first debenture holders all consented to the order.

Price Bros. v. Cuban Telephone Co. (Ltd.) and Others.

Mr. Justice Parker had before him a motion by plaintiffs for an interim injunction to restrain the second defendants (Messrs. Chaplin, Milne, Grenfell & Co.) from paying over to the first-named defendants £3,864 in their hands.

Mr. Mark Romer, who (with Mr. Howard Wright) appeared in support of the motion, said that the sum was paid to Messrs. Chaplin, Milne & Co. by plaintiffs in payment for 5 per cent. first mortgage bonds issued by the Telephone Co.

Counsel for the second defendants said they were willing to give an undertaking until the trial of the action.

Mr. Wright, for the Telephone Co., said that he would give an undertaking until the trial if the aspersions were withdrawn.

Mr. Romer said that he could not withdraw them at this stage.

His Lordship suggested that the defendants should give the undertakings proposed until the trial, "not admitting the allegations in plaintiffs' affidavits," and that was acceded to.

Babcock & Wilcox (Ltd.) v. Water Tube Boiler & Engineering Co. (Ltd.) and E. Danks & Co. (Oldbury) (Ltd.)

On Monday Mr. Justice Warrington had in his list an action brought by plaintiffs for alleged infringement of patents, but Mr. Colefax (led by Mr. A. J. Walter, K.C.) said the action was launched at rather an early date, and they felt they were not at present in a position to put the case before the Court upon their claim. Their evidence was in such a state that they would not be justified in occupying the time of the Court. But there was a counter claim for revocation.

His Lordship: You submit to have judgment against you on the claim?—Yes.

Mr. Bousfield, K.C., who appeared (with Mr. Gray) for defendants, said the counter claim was put in as part of the defence. He had not had time to consider the matter as it now stood, but he would be averse from fighting these three patents in the face of plaintiffs withdrawing their case. It was practically equivalent to a discontinuance of the action. His Lordship would see that the counterclaim would never have been put in except for the allegation of the plaintiffs that upon the construction of the patent defendants were infringers. He suggested that defendants should be allowed to withdraw the counterclaim, and that each party should pay their own costs in respect thereof.

Mr. Walter said he thought is was an entirely unwarranted counterclaim.

His Lordship said this was an action for infringement of certain letters patent. There were two actions, which were consolidated, and were against different defendants. After reviewing the facts he considered the proper method of dealing with the matter was: The plaintiffs, not asking for judgment in the action and defendants not asking for judgment on the counterclaim, the action be dismissed, with costs, and the counterclaim, with costs.

Compensation Claim for Miner's Death.

Sheriff Thomson (Hamilton) has concluded proof in a case in which compensation is claimed by relatives from Messrs. Archibald Russell (Ltd.) in respect of the death of a miner (John Wallace) killed in Dechmont Colliery, Cambuslang, by coming in contact with an electric cable in the underground workings of the colliery.

David Wallace, night oversman at the colliery and a brother of deceased, said he had authority from the management, if there was a pressure of oncost work, to take ordinary miners from the coal face to render assistance so as to expedite the general working of the pit. On the night of the accident the oncost staff were making excavations in a chamber in which it was proposed to instal an electric motor. Due to the blasting a mortar board used by the bricklayers was badly damaged in the course of the shift. Witness suggested to deceased that he might fill up the time for the remainder of the shift by doing certain work, including lending a hand in repairing the mortar board. Three electric lights were fitted up in the chamber, but only one was lighted. Two of the terminals were thus exposed, while a cable was coiled up and hung on a prop close to the engine seat. While the hutches of sand were being slewed on an iron plate witness heard his brother utter a cry. Instinctively believing that the cable was to blame for the accident witness took off his cap and pulled the coil down from the prop. His brother was almost instantaneously killed. The only theory he could put forward as to the cause of the fatality was that deceased while removing the hutches had come in contact with a live wire.

Prof. John Glaister said he had seen a piece of cable which was used in Dechmont Colliery on the night of the accident, and since the wires were exposed he thought its condition was such as to cause a shock to any man coming in contact with it. He was aware that that chamber was heated, and it was an established fact that sweated hands offered much less resistance to electricity than dry hands. He knew cases where current of a similar voltage to that in the pit (230) had caused death.

Alex. Mathie, electrician in charge of the electric plant in No. 1 pit Dechmont Colliery, said that on the day previous to the accident he removed two of the three arc lamps, but he left the terminals exposed. The cable was coiled upon a prop about 4 ft. 6 in. from the ground. The distance of that prop from the iron plate where deceased was working with the hutches would be from 2 ft. to 3 ft. He agreed that a person coming in contact with a piece of cable in which the wires were exposed would receive a shock. He was not qualified to say whether that voltage would cause death to a man who was perspiring freely on an iron plate, because as a matter of fact he had himself received a higher voltage than that.

Defendants' case was that deceased, being a miner, ought not to have been taken from the face to do such oncost work as removing hutches of sand and a water-chest; that there was no immediate urgency to justify the employment of deceased at that work, and that, moreover, the whole task of shifting the hutches could have been completed in little more than 10 minutes.

Judgment was reserved.

Wakefield & District Light Railway Co. v. John Sharphouse & Co.

At Wakefield County Court on Tuesday Judge Greenhow heard this action, in which plaintiffs claimed £6 damages from defendants for obstruction to their line.

The case for plaintiffs was that on Feb. 2 last Messrs. Sharphouse's motor waggon broke down on plaintiffs' track between Lofthouse and Leeds, and there was a total or partial obstruction for 50 minutes. The motor waggon was got going again in the direction of Lofthouse, but broke down again, causing further obstruction for an hour. When the line was totally obstructed passengers had to be transferred, and the cars reversed, and when the obstruction was confined to one line the cars went back to a bye pass and thus crossed over. The car traffic was greatly disorganised, and much inconvenience caused. There had been numerous prior breakdowns of that motor waggon.

Mr. Shepherd, for defendants, urged that unless it could be shown that defendants ran a motor waggon which they knew would break down and delay the traffic there was no case to answer. This breakdown was an accident. There had been several prior accidents, but none of these was caused by the motor waggon being defective.

After hearing evidence, his Honour said he could not find there had been negligence, and he entered judgment for defendants, with costs.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the vacant posiiton of assistant lecturer and demonstrator in the physics department of the Technical School, Sunderland. Salary £150 per annum. Applications to the secretary to the Education Department, Mr. T. W. Bryers, 15, John-street, Sunderland, by Tuesday, June 21. See also an advertisement.

A first-class electrical engineer is wanted, with experience in the design of c.-c. machinery. See advertisement.

A machine draughtsman, experienced in a.-c. and d.-c. works, is required by the Electric Construction Co., Bushbury Works, Wolverhampton. Applications to the manager. See an advertisement.

Applications are invited for the position of borough electrical engineer at Salford. Salary £500 per annum, rising to £700. Applications to the town clerk, Mr. L. C. Evans, by June 13.

The Council of the University of Manitoba, Winnipeg, Canada, require a lecturer in electrical engineering. Salary $1,500 a year. Applications to the Registrar by June 25.

Kent Education committee require an assistant master in the electrical engineering department of the Technical Institute, Gillingham. Forms of application from Mr. J. Thompson, Town Hall, Chatham, and applications to the Director of Further Education, Mr. R. L. Wills, M.A., Technical Institute, Gillingham, by June 20.

Hull Education committee require a chief lecturer on engineering for the Municipal Technical College. Commencing salary £250. Forms from the Secretary, to whom applications by June 17.

An assistant engineering lecturer is required at Coventry Municipal Technical Institute. Salary £150, rising to £180. Forms from the Secretary. Applications by June 14.

Professors of engineering, chemistry and mathematics and physics are required for Queensland University. Salary, in each case, £900. Applications to Agent-General for Queensland, London, by Aug. 31.

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Bermondsey (London) Council want a man to take charge of public arc lamps. Wages £2. 5s. Applications by June 17 to the Town Clerk.

Mr. Chas. Merrall has been appointed engineering clerk of works at the new asylum, Colchester.

Mr. G. J. Walmsley, M.Sc., of the Grammar School, Ashbourne, has been appointed lecturer in mathematics at the Municipal Technical Institute, Belfast.

Dr. F. Gnauth has been appointed general manager of the Felten & Guilleaume-Lahmeyerwerke, A.-G., Mülheim-on-Rhine.

EDUCATIONAL NOTICE.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, and the City and Guilds Technical College, Finsbury, are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years. The Finsbury College is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

Accrington.—On the recommendation of the Electricity committee £550 has been appropriated out of the past year's profits on the electricity works to a relief of rates.

Aldershot.—The Council have applied for sanction to a loan of £2,000 for extensions of the electricity supply cables, &c.

Argentina.—The "Review of the River Plate" states that a company has been formed at Olavarria with a capital of $200,000 to acquire Mr. A. Brumana's concession for electricity supply.

The Cia. de Electricidad de la Provincia de Buenos Ayres have purchased the Mar del Plata electricity works of the Cia. de Electricidad del Plata for $1,000,000 (m.n.) of which $300,000 is to be paid in cash, $610,000 in 6 per cent. bonds and $90,000 by a mortgage taken up by the purchasing company.

The Red Telefonica del Norte, Ltda., has been formed to acquire the telephone system of Herdalo & Co. at Colon and the extensions to the Pergamino and Rojas districts, and also to connect all the northern districts of Buenos Ayres and the southern districts of Santa Fé with Rosario, Buenos Ayres, &c.

Atlantic Cable Rumours.—We have received the following note in regard to certain statements published in the daily journals:—

One or two London newspapers have questioned the correctness of the statement made by the President of the Commercial Cable Co. (Mr. Clarence H. Mackay), in which he denied the existence of any foundation whatever for the rumours of a combination between the Commercial Cable Co. and the Anglo-American Telegraph Co. The Vice-President and General Manager of the Commercial Co. (Mr. George G. Ward) emphatically and positively reiterates all former statements that neither the Commercial Cable Co. nor the Postal Telegraph Cable Co. (its landline connection in the United States) have ever contemplated, or now contemplate, such combination or any other.

Australasia.—The residents of Hay (N.S.W.) have endorsed the proposal of the Town Council to light the town electrically and use electric power at the waterworks and sewage works.

A committee has been formed at Toowoomba (Queensland) to promote an electric tramway scheme. The manager of the Toowoomba Electric Lighting Co. (Mr. A. Gibson) has prepared estimates of cost, &c.

Geelong (Victoria) local telephone system is being re-arranged by the Postmaster-General's department, and a new switchboard framework is being installed. A further improvement will shortly be made by the adoption of a modern branching multiple switchboard.

Austria-Hungary.—Agram Municipality are purchasing additional plant for their electricity works at a cost of about 420,000 kroner (£17,500).

Aussig municipal authorities are about to construct an electric tramway from Pokau to Tellnitz.

Battersea (London).—Subject to the L. & S.W. Rly Co. bearing cost of work, services are to be laid to four of the company's signal cabins for electrically operating the signals at an estimated cost of £296. 5s.

Bethnal Green (London).—Last week the Council were again recommended to take steps to afford to occupiers of premises within the borough a supply of electricity by entering into an agreement with Shoreditch Council, on the basis of the alternative flat rate scheme of the latter authority, for seven years. The recommendation was adopted by the casting vote of the Mayor.

Bognor.—The Chichester Electric Light Co. will apply for a provisional order.

Bournemouth.—On Tuesday the Council referred to a committee of the whole Council a recommendation from the Tramways committee that, subject to approval of the Board of Trade, the present conduit system in the centre of the borough be abandoned and the overhead system substituted.

Braunton.—The Parish Council which is negotiating with Edmundson's Electricity Corpn. for the electric lighting of the district, has decided to consult an electrical engineer on the proposed scheme.

Bridlington.—The Council have decided to carry out further electrical illumination work at a cost of £200.

Burnley.—The Electric Tramways committee have decided to purchase two tramcars at £753. 13s. 6d. each.

Camborne.—The Urban Electric Supply Co. have submitted to the Council details of a scheme for supply of electricity for power in this and adjoining districts. Overhead cables will be employed, and the proposed route has been sanctioned by the Highways committee.

Canada.—An electric railway from False Creek to Point Grey and New Westminster is to be constructed by the Vancouver-Westminster Terminal Railway Co.

Carlisle.—The Council will apply for a provisional order to extend the electricity supply area into the rural districts.

Costa Rica.—A private company has obtained a concession for the electric lighting of the Port of San José.

Coventry.—On Wednesday an inquiry was held into the application of the Corporation to borrow £54,200 for extensions of the electricity supply undertaking.

Part of the proposed loan was stated to be to cover cost of obsolete plant and part for new plant, there being applications for power from the Daimler Motor Co. and other manufacturers, and it was estimated that the proposed expenditure would be sufficient for five years. The town clerk (Mr. G. Sutton) gave a sketch of the financial position of the undertaking, and said the Council had adopted the policy of endeavouring to sell the current at such a low figure as would attract customers and it was intended to reduce the charge to both manufacturers and private consumers.

Cuba.—The "Chamber of Commerce Journal" states that the average annual value of the imports of electrical machinery into Cuba from 1905 to 1907 is officially stated at $70,000.

Of this the U.S.A. sent $50,000 worth, and the U.K. $18,000. Electric lamps imported averaged $40,000 per annum, of which the U.S.A. supplied $24,000 and Germany $10,000 worth. Dynamos from 10 kw. to 50 kw. and single phase motors of ¼ to 7 H.P. are most in demand. There is an opening for metal filament lamps. The best means of securing business is to appoint a tr veller speaking English and Spanish, and representing one or more firms, and to establish a depot at Havana, it being practically useless to canvass for orders by correspondence, as the country is well worked by Americans and Germans.

Customs Duties.—A recent supplement of the Customs Tariff Guide states that the following duties are leviable (according to recent decisions) on wireless telegraph plant imported into the Australian Commonwealth States:—

Stepdown transformer, induction coil (for a.c. motor), variable coil (for a.c. motor), motor (under 200 H.P.), resistance coil, impedence coil (for a.c. motor), and resistance starter 20 per cent., ad val. (for British or foreign goods); spark gap, receiving instrument, morse key, leyden jars, high frequency protector, lightning arrester, and zinc insulators (so-called) 17½ per cent. for foreign and 10 per cent. for British goods; porcelain insulators, 25 per cent. (British 20 per cent.); ammeter, 5 per cent. (British free); voltmeter, switches, cut-outs, and wire, n.e.i., free (British or foreign).

The following are import duties under the Tariff which has been approved by the Japanese Diet, and come into force on a date to be fixed by Imperial Ordinance:—

Insulated electric wires, armoured with metals (other than submarine): Combined with india-rubber or gutta-percha, 11 yens per 100 kin (19s. per cwt.), ditto, not combined with rubber or gutta-percha, 5·50 yen per 100 kin. (9s. 6d. per cwt.); flexible cords combined with silk, 25 per cent. ad val; ditto not combined with silk 18 yen per 100 kin (£1. 11s. 1d. per cwt.); other electric wires, combined with india-rubber or gutta-percha 14·50 yen per 100 kin (£1. 5s. 0½d. per cwt.); ditto not combined with india-rubber or gutta-percha, 25 per cent. ad val; tyres for locomotives and other vehicles, running on rails, 1·50 yen per 100 kin (2s. 7d. per cwt.); parts of automobiles, excluding motive machinery, 30 per cent. ad val.

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Darlington.—In future, theatres and music halls, which are not likely to make a large demand on the electricity works until after 6:30 p.m., and which use not less than 10,000 units per annum, are to be charged at a flat rate of 2½d. per unit for lighting.

Dundee.—The additions to the public baths are to be wired at a cost of £129. 15s.

Eastbourne.—The L.G. Board has sanctioned the borrowing of £1.835 for condensing plant.

Edinburgh.—The electric tramway from Ardmillan-terrace to the new markets at Gorgie was opened for traffic on Wednesday.

Electricity Supply in Hanley.—Mr. C. H. Yeaman, chief electrical engineer at Hanley, forwards a pamphlet which he is issuing in pushing the claims of electricity in that town. The first few pages give some very good reasons why electricity should be used rather than gas, and two illustrations show what has been done in the way of lighting in that town. The remaining pages of the booklet are on power supply, and consist principally of illustrations showing where and for what purposes motors are being used in Hanley.

As might be expected, pottery works figure largely amongst the consumers, though such apparatus as sausage-making machines are also to be found. The book, in general, is excellently got up, and if there is one criticism to make it is that the paper used should in future be of rather better quality, as the half tone blocks do not come out quite so well as they might.

Exhibitions.—The fourth annual Business Exhibition will be held at Olympia, London, from Oct. 13 to 22 next. Particulars from the Secretary, 2, Breams-buildings, London, E.C.

At the British Consulate at Colima (Mexico) a room has been set apart for the exhibition of specimens and samples of British goods. These must not be large and must be accompanied by cards giving prices and address of exporter or agent.

Particulars may be obtained from Signor R. Martinenghi, Societa Mostra Politecnica, Milan, as to charges for space, &c., at the Permanent Technical Exhibition at Milan.

Felixstowe.—Some time ago the Council applied for sanction to a loan of £4,500 for a Diesel oil engine, dynamo, &c., but before complying with the request the L.G. Board ask that the balance of £2,636. 18s. 3d., borrowed under the authority of previous sanctions and not spent, should be invested in authorised securities and treated as a sinking fund.

France.—A concession for constructing and working about 88 miles of tramways at Bayonne has been granted to a French company.

Frome.—The Council have decided to transfer their electricity undertaking to Edmundson's Electricity Corpn., which has hiterto worked it on lease, the Council providing the capital and paying interest and sinking fund charges.

German East Africa.—The "British and South African Export Gazette" states that a 30,000 H.P. plant is required in connection with the projected electric power installation at the Pangani Fields.

Grimsby.—The Lighting committee recommend the Council to apply for sanction to borrow £4,000 for mains extensions and £1,500 for services.

Holland.—An application has been lodged for a concession for electric tramways from the Hague to Leyden, via Wassenaer.

It is probable that Nijmegen Council will shortly take over and convert to electric traction the steam tramways of the Nymeesche Tramweg maatschappij.

India.—"Indian Engineering" says the Railway Board have sanctioned the commencement of the work of electric lighting and ventilation of the southern portion of the station buildings and two platforms at the Howrah station of the East Indian Railway.

In connection with the working of the Mysore Cauvery Falls power undertaking, the outlay on the scheme exceeded the budget grant for the past year (R.5,40,000) by R.10,33,040, owing to the adjustment of a sum of R.11,27,685 towards the new depreciation fund. Revenue during the year was R.17,46,295 and working expenses were R.2,97,000. Out of R.79,97,234 spent on the scheme up to June, 1909, a net revenue of R.56,11,697, or 70·17 per cent. of the capital expenditure, has been realised. The third installation of the works was practically completed during the year.

A proposal is before the Cochin Durbar to connect Tripunitrah, the seat of H.H. the Rajah's family, with Ernadulam by means of an electric tramway.

I.M.E.A. Glasgow Convention.—We are asked to state that the special arrangements made by the Electrical Press (Ltd.) for journeying to Glasgow from Euston next week is extended to all who are journeying by the 2 o'clock train on Monday, June 13. Saloons will be provided on that train, which, leaving Euston at 2 p.m., calls at Willesden at 2:10, Rugby 3:40, Crewe 5:55, Preston 6:18 and Carlisle 8:8. Apply immediately to Mr. W. Alderson Smith, 37-38, Strand, London, W.C.

Inquest.—An inquest was held on Friday into the death of Edward Abbott, who was killed at the Glamorgan Colliery, Llwynypia, on 1st inst.

The evidence showed that a haulier named Doel was driving a horse attached to two trams at the brickyard, when the horse fouled two stay wires supporting a derrick, and received an electric shock which killed it. Abbott was seen clutching hold of the hind tram, to which the horse was attached. The power was cut off at the power station, but it was found that Abbott was dead.

Mr. DUNCAN M'DONALD, electrical engineer, thought the accident was caused through the breakage of an insulator at the top of the derrick, supported by wire stays. The horse received a shock and fell against the stays. The stays attached to the derrick holding the electric cable were evidently affected by the broken insulator. A part of the rubber casing being broken caused a surface leakage, and it was evident that Doel's horse came within the influence of the leakage, causing it to plunge and fall across the stays.

The CORONER, in summing up, said the question was whether the system now working was a good one.

The jury returned a verdict of "Accidental death," adding that no blame was attached to anyone.

Islington (London).—The Council have decided to obtain the opinion of Sir Alex. Kennedy, at a fee of 50 guineas, on the report of the borough electrical engineer (Mr. A. Gay) recommending an increase of the capacity of certain of the electric supply mains.

Italy.—The Ministry of Public Works have approved the application of Andreucci, Allegra e Cia for a concession for the construction and working of an electric railway from Rome to Nettuno, via Anzio.

Japan.—The Musaski Electric Railway Co. have obtained a charter to construct an electric railway on the standard gauge from Yokohama to Tokio. It is stated that this will be the first standard guage railway in Japan.

Kent Tramway Scheme.—Maidstone Corporation are considering a scheme for constructing an electric tramway between Maidstone and Chatham, a distance of nearly 7 miles. It is estimated that the cost of the scheme would be £60,000, and the yearly net profit about £2,000. The consulting engineer is Mr. S. Sellon.

Leyton.—The engineer and manager of the Lea Bridge Gas Works has applied for a supply of electricity for a 7 H.P. motor at the gas works for increasing the pressure of gas, and having regard to the fact that the motor will be chiefly used in the evening, a charge of 4d. per unit is to be made for current.

Mr. D. H. Boggis-Rolfe, district auditor, has made various recommendations, in his report on the accounts of the tramways and electricity supply departments for the year ended March 31, 1909, and especially in regard to the keeping of stores.

The Electric Light committee, while admitting that improvements, to secure which steps have now been taken, may be effected they are unable to agree with the auditor's conclusions.

Lincoln.—At the meeting of the City Council on Tuesday it was reported that the net profit on the electricity undertaking during the past year was £2,503, or £5 less than in 1908-9, and on the tramways a deficit of £44.

Metropolitan Association of Electric Tramways Managers.—A meeting of the members of this association was held on the 3rd inst., at the offices of the Metropolitan Electric Tramways, Ltd. (Finsbury Park, N.). Among those present were: Messrs. H. E. Blain, West Ham (acting chairman), F. Schofield (Leyton), C. Mittelhausen (Bexley), Mr. Ullmann (East Ham), W. Murray (Walthamstow), T. B. Goodyer (Croydon) (hon. secretary), A. H. Stanley (managing director, London United Tramways), W. F. Hammond (Metropolitan Electric Tramways), and V. Mason (South Metropolitan Electric Tramways); W. Binns (Reading) being also present by invitaiton.

Letters regretting inability to attend were received from: Sir Clifton Robinson and Messrs. J. K. Bruce (L.C.C.), A. Covenay (Erith) and A. G. Balfour (Dartford).

The HON. SECRETARY reported that he had received further communications from America respecting the registration of accident claims; that, on request, he had supplied a schedule of the "Through running arrangements" in the metropolitan area to the Public Service Commission, Fourth District, New York, and that he had been invited to join, as representing the Association, a committee for the protection of electrical industries.

Mr. H. E. BLAIN explained the views of the hon. secretary and himself as to the preliminary course which should be adopted in connection with the proposed central bureau for the registration of claims, and the proposition was agreed to.

The company then left by special car (provided by the Metropolitan Electric Tramways, Ltd.) for a visit of inspection to the car repair works at Hendon. They were shown over the shops by Mr. J. Devonshire managing director of the company, and Mr. A. H. Pott, the chief engineer; and the members were extremely interested in the various appliances and arrangements which they inspected. Mr. Pott demonstrated

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the methods used in the company's motormen's training school, by which the visitors were very much impressed.

Mr. BLAIN, on behalf of the association, requested Mr. Devonshire to convey the appreciation of the members to his fellow directors for their kindness in both facilitating the reception and also for kindly providing tea. He also thanked Mr. Pott for his courtesy in giving the necessary information in connection with the exceptionally interesting and instructive inspection just completed.

Mr. DEVONSHIRE suitably replied, and subsequently the members returned to London and were entertained to dinner by Mr. Stanley, who was accorded a hearty vote fo thanks for his hospitatty.

Middlesbrough.—The borough electrical engineer (Mr. H. M Taylor) has reported upon the present scale of charges for electric current.

In view of the future use of metal filament lamps Mr. Taylor thinks it unwise to make a general reduction in prices. He suggests that they should make a reduction this year to large consumers by reducing the price per unit after the first 1,000 units per quarter from 3½d. to 3d. A further reduction might also be made to theatres and music halls after the first 1,500 units per quarter from 3d. to 2¾d. per unit. The general use of metal filament lamps in theatres and music halls is impossible (continues Mr. Taylor) owing to the amount of vibration, and thus they were unable to obtain the reduced cost of light by which private consumers were able to benefit. Power charges should be reduced from 2d. per unit for 250 hours' use of the maximum supply demanded per quarter and 1d. thereafter, to 2d. for 200 hours' use and ½d. thereafter.

Mr. Taylor's suggestions have been adopted by the Electric Supply committee.

North Berwick.—Messrs. Crompton & Co.'s terms for the erection of electricity supply works were considered by the Council on Tuesday, but it was decided to adjourn consideration of the matter until a formal agreement is prepared.

Northampton.—The extension of the tramways to Far Cotton is projected at an estimated cost of £14,560.

Nuneaton.—The Council have decided to withdraw their application to the L.G. Board for sanction to a loan of £2,155, and to substitute an application for £4,804, so as to provide extensions of the electricity undertaking during the next three years.

Peterhead.—Recently Messrs. Jas. Simpson & Son asked the Council to allow an underground pipe to be laid to enable them to give a supply of electricity to a shop in the new post office buildings, but the Council insist, as a condition, that the firm must generate electricity by gas-driven plant, the town gas being used.

Rotherham.—The Council is to apply for sanction to borrow £27,832. 7s. for the electricity undertaking, including £10,000 for mains and transformers, £3,000 for a 1,000 kw. turbo-alternator, condensing plant and switchboard, £6,175 for 3½ miles h.t. feeder cable, £2,222 for feeder and distributor mains for Broom district, £1,050 for a 250 kw. rotary converter set, £1,172 for a 250 kw. transformer set and h.t. switchboard set (for generating station), and £975 for equipment at Howells, Wincobank.

Russia.—A German Consular report states that there is an increasing demand in the Saratoff district for electrical material and accessories, and the inhabitants evince a desire to have electric light in their houses.

Shoreditch (London).—The Council will give a bulk supply to Bethnal Green at one or more points on the boundary at the following rates:—

250,000 units per annum, and under 500,000, 1·15d. per unit; under 750,000, 1·1d.; under 1,000,000, 1·05d.; 1,000,000 and over, 1d., subject to a seven years' agreement and a coal clause providing for any rise or fall in coal to be followed by a corresponding rise or fall in charges.

Sheffield.—An inquiry was held on Tuesday into the application of the Corporation for sanction to borrow £78,207 for extensions of the electricity undertaking.

The Inspector (Mr. H. Ross HOOPER) said he understood the application was for the extension of the buildings at the Neepsend station and the installation of additional generating plant. At Neepsend the capacity was 7,000 kw., and at Sheaf-street 4,000 kw., total 11,000 kw., and the maximum demand last winter was 6,980 kw., which showed that there was barely sufficient plant to be able to meet the demand if anything happened to the 4,000 kw. machines. The estimated demand next winter would be approximately between 8,000 kw. and 8,500 kw. That being so, he thought it was clear that some additional plant was necessary, and the proposal was to duplicate all the existing large plant. They had five boilers at Neepsend, with a steam capacity of 155,000 lb. On that they had at present a load of 5,500 kw., and, taking that as a mean of 18½ lb. per kilowatt, there was necessity for additional boiler power. The buildings would be erected on land purchased for electric lighting purposes. They conformed to the by-laws, and the work would be carried out by contract. No tenders had been as yet invited. Continuing, Mr. Hooper said: "I told Mr. Fedden last night that the policy of the Board now in regard to these large applications for additional plant was, in the first instance, to approve the expenditure, but to defer the issue of sanction until furnished with an amended estimate based upon the tenders which had been accepted, their object being that the amount of the sanction should approximate as closely as possible to the expenditure, and thus do away with the old method of not having enough or having too much." Mr. Fedden had informed him that £7,450 would be required this year, and that, therefore, it was desirable for sanction for that amount to be given at once. When the tenders had been accepted for the buildings and plant an amended estimate would be furnished, and the Board would be asked to issue sanction on those lines.

The TOWN CLERK concurred, and said he could not do better than accept the outline of the position given by the Inspector.

The Electric Supply Committee have decided to reduce the price of electric current from 4d. to 2d. per unit.

Mains extensions are to be carried out at an estimated cost of £490.

The Glossop-road new baths are to be illuminated by incandescent electric lamps.

The tramway track in a portion of Attercliffe-road is to be relaid at a cost of £4,700, the centre poles are to be taken out, and span wire construction erected.

The old music hall in Surrey-street, which is being fitted up as a lending library and reading room, is to be wired by the electric supply department of the Corporation at a cost of £81. 9s. 6d.

South Africa.—The "British and South African Export Gazette" states that orders from South Africa have been placed with Butters Bros. & Co. (Glasgow) for electric cranes and with H. Simon Limited (Manchester) for electric motors.

Johannesburg Corporation are on the market for 1,000 5-ampere, 153 10-ampere, 80 20-ampere and 20 40-ampere meters.

The Consolidated Goldfields of South Africa will shortly require a number of electric pumps.

An electric pumping plant was recently imported for the Ruia Mine, Rhodesia.

Stevenage.—The Board of Trade are inquiring of the Council as to the steps taken to carry out the provisions of the electric lighting order of 1902.

Swansea.—The Electricity committee has discussed the possibility of competition with the Harbour Trust in the supply of electricity, and a conference is to take place on the subject.

The assessment of the electricity works has been increased from £1,300 to £3,300.

Warrington.—An inquiry was held on Wednesday into the Council's application for sanction to borrow £7,420 for extensions of the electricity works.

The deputy town-clerk (Mr. A. T. Hallaway) said the money was required for additional generating plant at the electricity station. There was an increased demand for current, and no extensions to the present buildings would be required, with the exception of a shed for the switchboard.

Technical details were given by the borough electrical engineer, Mr. F. V. L. Mathias.

Wednesbury.—The Council are recommended to apply for sanction to a loan of £4,600 for the extension of the plant at the electricity works.

The Council have received sanction to a loan of £2,858 for the electricity undertaking, viz., £1,300 to defray expenditure on mains from April 1, 1909 (loan to be repaid in 25 years); £750 for services (15 years), and £808 for meters, to defray excess expenditure up to April 1, 1909 (£208), and expenditure from April 1, 1909 (£600), the loan to be repaid in five years.

West Bromich.—The Council have applied for sanction to a loan of £11,386 for extensions of the generating plant at the electricity works, additional feeder and distribution cables, &c.

Wimbledon.—At the last meeting of the Council the new chairman of the Electric Lighting committee, Coun. Dudley Stuart, made an interesting statement on the position of the electric supply department.

He said he wanted it to be understood that the electric light undertaking was started purely for street lighting, at a time when the town was having some difficulty with the gas company. Since then they had not come on the rates for a single penny. Last year they made a gross profit equal to 9·14 per cent. on the capital outlay. If they put 4·57 per cent. (£7,653. 6s. 6d.) away for depreciation and to reserve, they would have still an equal amount to pay shareholders' dividend if they were a private company. The surplus, to the extent of £10,080, had been applied to reserve, which was equal to 5·07 per cent. on the capital. In addition, they had paid over £6,000 in relief of the rates.

Wireless Telegraphy.—It is announced that a wireless telegraph station is to be erected on the top of Pike's Peak, Denver, Colorado, U.S.A., to be employed as the midway transmitting and receiving point for wireless telegraph transmission from the Atlantic to the Pacific Coast.

Wireless Telephony.—The "Western Daily Press" (Bristol) on June 6 contained a lengthy report of some experiments which are being carried out at New Passage, near Bristol, by Mr. Grindle Matthews. It was at New Passage where Mr. Raymond Phillip's "wireless controlled airship," which has been on view at the London Hippodrome, was constructed. The object of the experiments

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described in the Bristol journal is the development of the wireless telephone and the wireless operation of torpedos.

L.C.C. Electrical Staff Dinner.—The first annual dinner of the L.C.C. Tramways electrical staff (Greenwich North and South sub-stations) was held on June 1, Mr. John H. Rider, M.I.E.E., presiding, supported by Mr. J. Shepherd, Mr. E. L. Pope, Mr. T. L. Horn and Mr. Walker.

About 70 members of the staff were present. After the loyal toasts an excellent musical programme was carried out, the whole of the contributors being members of the staff.

The toast "Our Chairman" was proposed by Mr. C. S. WRIGHT, who referred to the excellent design of the electrical system under Mr. Rider's charge. The toast was drunk with musical honours.

The CHAIRMAN responded, and in the course of an interesting speech advised his hearers that the only way to attain success in the electrical profession was to keep plodding on steadily, and to seize every opportunity that presented itself. He impressed on the staff the necessity for debating electrical problems amongst themselves, and urged as many as could to join the Institution of Electrical Engineers, concluding by stating that the success of the L.C.C. tramways was due in a great measure to the efficient way in which the staff carried out their duties.

In proposing "The Committee," Mr. WALKER referred to the difficulty in arranging a function of that kind, owing to the majority of the staff being on shift work, and the large area covered by the system.

Mr. A. L. JOHNSON responded, and expressed gratification that so many were able to be present. The representatives of the committee present included Messrs. F. Scott, C. S. Wright, H. Storey, C. A. Butcher and A. L. Johnson (hon. sec.).

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Aberdeen.—The traffic receipts of the tramways department for the past year were £70,076, compared with £70,744 in 1908-9, and the total receipts were £71,116, a decrease of £563.

Bootle.—The accounts of the electricity department for the year ended March 31 show total revenue £19,194, including £10,839 from sale of current by meter, £5,837 for current supplied by contract and £2,476 for public lighting.

Total expenditure was £9,016. Out of the gross profit of £10,177, interest on mortgage debt (£2,620), instalment of principal moneys (£2,044), and sinking fund (£2,194) were paid, leaving a net profit of £3,365 (compared with £1,805 in previous year). £1,926 was transferred to reserve, and £1,440 applied in relief of local rates. 3,143,501 units were generated, 1,250,937 sold to private consumers by meter, and 1,213,355 by contract and 297,644 were supplied to the public lamps, of which there are 174 arcs and small lamps, equivalent to 680·8 c.p. The total maximum supply demanded was 1,269 kw. £112,633. 14s. 9d. has been borrowed, of which £34,036 has been repaid. Works costs were 0·58d. per unit sold (against 0·67d.) and total costs 0·78d. (0·89d.); interest required 0·23d. (0·24d.) and instalment of capital and sinking fund 0·37d. (as in previous year). Total 1·38d. (1.5d.)

Bradford.—The total revenue of the tramways department for the past year was £259,096, an increase of £15,462.

The total expenses were £170,699, an increase of £503, and after paying interest (£22,407), income tax (£2,250), rent of leased lines (£4,137), repayment of mortgage loans (£1,112), and sinking fund (£29,342), there was a net profit of £32,365, of which £20,000 is to be allocated to relief of rates and £12,365 to reserve and renewals account. The increase in the receipts was due to improved traffic (£14,208) and increase in parcels department (£819). Receipts per car-mile were 10·977d., against 10·456d. Passengers carried were 50,518,813, against 47,660,011. The increased receipts were mainly due to the institution of through running between Leeds and Bradford, the takings for through tickets being £5,454. The number of tickets issued free to blind passengers was 43,852. The total capital expenditure is £930,113.

Burnley.—The total capital expended on the municipal tramways at March 31 was £198,365, an increase of £5,269 on the year.

The traffic revenue was £65,295 and the total receipts £65,525. Deducting the working expenses (£41,570), the gross profit was £23,955. Interest and sinking fund came to £10,834, and after paying rents for leased lines, income tax, &c., placing £6,000 to reserve and £1,000 to contingencies, the balance (£3,232. 13s. 11d.) was transferred to the Borough Fund account. 12,911,113 passengers were carried, against 12,176,782; and 1,263,118 car-miles run, against 1,229,224. The average fare per passenger was 1·22d., against 1·20d., and the traffic receipts per car-mile were 12·22d., against 12·41d.

Canterbury.—The total revenue of the electricity department for the year ended March 31 was £9,370, including £8,840 net for electricity for public and private lighting and power.

Working expenses were £4,785 and gross profit £4,585. Interest on loans £1,564 and repayment of loans and sinking fund £2,415, and after paying one or two small items the net profit was £562, against £94. Total capital expended is £67,593, an increase on the year of £1,214. 796,358 units of electricity were generated; 309,802 were supplied for private lighting and 172,907 for power and 206,143 for public lamps (12 arcs and 655 incandescents). The total maximum supply demanded was 465 kw.

Colchester.—The net revenue from the sale of current for the year ended March 31 for private lighting and power was £10,990.

The receipts from public lighting were £959 and from traction £2,948, the total receipts being £15,146, against £14,302. The total costs were £8,410, against £8,153, and after deducting interest (£2,195) and sinking fund, &c. (£3,073), writing off £872 for mechanical stokers and prepayment installations, and applying £240 in purchase of arc lamps for hire, there was a net profit of £414, against a deficit of £21. 16s. 11d. Of the net profit, £214 has been placed to depreciation and the balance applied in relief of rates. The capital expended is £83,049, an increase of £2,815. The total costs were 1·47d. per unit, against 1·46d. 1,372,340 units were sold, against 1,344,177. The equivalent of 56,191 8 c.p. lamps is connected (against 51,595 8 c.p.), and the maximum load was 895 kw., compared with 881 kw.

Croydon.—For the year ended March 31 the total receipts of the electricity supply department were £64,982. 10s. 2d., including £56,200. 10s. 8d. from the sale of electricity for private lighting, power and traction, and £7,302 from public lighting.

Total expenditure was £31,549 and gross profit was £33,433. After paying interest (£10,681), sinking fund and instalment of loan repaid (£11,614), and income tax (£1,353), the balance profit was £10,466, against £9,443. Total capital expended is £348,341, an increase of £4,877. 7,961,395 units were generated; 621,008 were supplied to the public lamps and 3,600,941 to the tramways department, and 2,349,646 were sold to private consumers. There are 419 public arcs and 317 incandescents, and the total maximum supply demanded was 3,319 kw.

In the report of the borough electrical engineer (Mr. A. C. Cramb) it is stated that the use of the metal filament lamp has continued to exercise a marked effect on the output, and although the net increase in consumers compared with two years ago is 617, the electricity sold for lighting is only 18,000 units more. Reductions in prices have also affected the tariff. Although the output increased by 531,044 units, the increase in revenue was only £332. 2s. 7d. The cost of generation was £2,989 less, and the cost of coal decreased from £13,566 to £10,528. The load factor was 22·85 per cent., an increase of 1·93 per cent. There are 3,593 consumers, an increase of 338. During the year 253 arc lamps have been replaced by high candle power metal filament lamps with satisfactory results. There has been a satisfactory increase in the demand for power, the total horse-power in motors being now 1,070, and there have also been as number of inquiries for electric cooking and heating.

Eastbourne.—The accounts of the electric supply department for the year ended March 31 show total capital expenditure of £173,533 an increase of £2,546 during the year.

The total income was £25,144 (against £25,109), and included £21,121 from the sale of electricity for private lighting and power and £2,020 from public lighting. The working expenses were £11,282 (against £11,517), leaving a gross profit of £13,861, and after paying interest, sinking fund, &c. (£11,661), there was a net profit of £2,200 (against £1,938), which was added to the balance in hand from which £1,509 has been placed to reserve, leaving £6,147. The works costs were 1·36d. (against 1·40d.) per unit, and the total costs 1·92d. (against 1·98d). 1,640,200 units were generated and 1,249,718 units sold (960,120 for private lighting, 140,506 for power and 149,092 for public lighting). The load factor was 12·99 per cent. (against 13·13), and the maximum load was 1,098 kw., against 1,096 kw. The total connections to the mains (including 117 motors and 97 arc lamps) are equal to 111,755 30 watt lamps (against 105,719), and the consumers number 1,584, against 1,426. The units sold for private lighting decreased by 2·6 per cent. (against an increase of 0·3 per cent.), and the revenue from private lighting decreased by £165, but power showed an increase of £107. There are 117 motors of 311 H.P. (including 74 on hire) connected.

Glasgow.—During the year ended May 31 the tramways department carried 222,730,571 passengers, an increase of 986,002.

The average track (single) mileage open was 188¼ miles, an increase of 8 miles; traffic receipts per car-mile were 10·225d., decrease 0·037d. A number of extensions (2·8 miles) were opened for traffic since June 1.

Gloucester.—The total receipts of the light railways for the year ended March were £16,372, including £15,342 traffic revenue.

The operating expenses were £12,268, and the gross profit was £4,104. Interest required £4,833 and repayment of loans £2,217. 3,843,553 passengers were carried and 603,211 car-miles run. 597,739 units of electric current were consumed for traction and car lighting. The capital expended is £131,300. 19s. 4d.

Nottingham.—The accounts of the electricity department for the year ended March 31 were adopted by the Corporation on Monday.

The city electrical engineer (Mr. H. Talbot) reported that during the past year two additional steam dynamos were installed at St. Ann's station, thus completing the equipment of the first half of the station. The total horse-power installed at the three generating stations is 17,345 H.P. (Talbot-street station 8,925 H.P., St. Ann's 7,700 H.P. and Eastcroft destructor works 720 H.P.) There were 39 extensions of distributing mains, making the total length 58·91 miles, an increase of 1·69 miles. The number of applications for electricity was 3,801, compared with 3,608, an increase of 193; the equivalent of 17,709 additional 32 watt lamps were connected, making a total of 386,887. There has been a steady increase in the use of electricity for power, 84 motors aggregating 349 H.P.) having been connected during the year, bringing the total up to 1,040 motors and 4,169 H.P. The number of units sold was as follows, viz.:—For lighting 3,893,241, power 2,164,277, traction 5,412,217, total

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11,469,735, an increase of 16,939 units, 52·48 per cent. of the units for private lighting were sold at the reduced rate of 1½d. per unit. The total works costs were 0·99d. per unit (the same as in 1909), and the total costs were 1·69d. (1·59d.) Although there were many additional users of electricity for lighting there had been a still further decrease in the number of units sold for that purpose, due to the increased use of metal filament lamps. In some cases consumers have made a saving of 50 per cent. in the cost of lighting (with an increased light), compared with the corresponding account when carbon filament lamps were used. The gross income was £92,459, and the expenditure £47,489, the gross profit being £44,969. The sale of current produced £89,607; and generation and distribution costs were £31,964 and £1,882 respectively. The total net income was £45,742. Interest on consolidated stock and loans, with contributions to sinking fund and instalment for repayment of loans (£13,204), &c., absorbed £28,957; and £16,700 is to be contributed to the general district rate, leaving £83. 9s. 10d. to be carried forward.

In moving the adoption of the report the chairman of the Electricity committee (Sir John Turney) said that the increase in the sale of current during the year had been the smallest since the undertaking was started. They regretted that the profits for the year was not larger, especially when they took into consideration the fact that they paid £1,800 less for coal. But for that good slice of luck, there would have been a big falling off. They had received an intimation from the Assessment committee that, although they were paying £6,000 out of their earnings in rates and taxes, the assessment was to be increased by £10,000, which meant that another £4,000 would have to be taken out of their earnings if the assessment was insisted upon.

Peterborough.—The accounts of the electricity department for the year ended March show a deficit on the year's working of £1,801, compared with a surplus of £89 in 1908-9

The deficit is mainly due to costs in the arbitration proceedings with the Tramway Co (£1,016), and as a result of the case £267 was refunded to the company. Though the Corporation are supplying current to more lamps than ever before, the consumption was less owing to the extended use of metal filament lamps.

St. Helens.—On the past year's working of the electricity undertaking the net profit was £1,031, of which £600 has been placed to plant renewal and accident fund and £431 carried to reserve fund. 2,779,464 units were sold, an increase of 12 per cent.

West Bromwich.—The capital expenditure on the electricity undertaking at March 31 was £75,118, an increase of £1,509 compared with 1909.

The income from the sale of current was £12,662. 17s. 3d., a decrease of £409. 1s. 10d. The total number of units sold was 2,010,608, a decrease of 1,377. The annual expenses were £6,902. 3s. 2d., against £6,740. 5s. 11d. The gross profit amounted to £6,348. 16s. 3d., against £6,855. 19s. 8d. Net profit was £1,756. 3s. 6d., decrease £686. 3s. 5d.

The net capital expended on the tramways is £134,786. The South Staffordshire Tramways (Lessee) Co. paid as rent of lines £8,606, less £502 for income. After providing for sinking fund, &c., and taking into account bank charges and sundry expenses, the net profit on the rental of the lines was £246.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding **that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.**

TRADE NOTES AND NOTICES.

TENDERS INVITED.

BELFAST Harbour Commissioners are prepared to receive tenders for the construction, delivery and erection in their electric light station, Abercorn Basin, Belfast, of a direct-coupled steam engine and dynamo, with all requisite accessories. Specifications and form of tender, &c., from the harbour engineer, Mr. W. Redfern Kelly, M.Inst.C.E. Tenders to the secretary, Mr. W. A. Currie, Harbour Offices, Belfast, by June 22. See also an advertisement.

The Electricity committee of the County Borough of NEWPORT (Mon.) invite tenders for the supply and erection of l.t., h.t. and e.h.t. switchboards. Specifications, &c., from the borough electrical engineer and tramway managers, Mr. H. Collings Bishop, M.I.E.E. Tenders to the Town Clerk, Town Hall, Newport, Mon., by Monday, June 27. See also an advertisement.

Tenders are invited for supply of 36,000 incandescent electric lamps to the City of MELBOURNE. Specifications, forms of tender, &c., from the agents for the City Council (Messrs. McIlwraith, McEacharn & Co. Proprietary, Ltd.), Billiter-square Buildings, London, E.C., to whom tenders by noon July 1. See also an advertisement.

Tenders are invited by July 6 for the supply of cordless switchboards to the Postmaster-General's Department in SOUTH AUSTRALIA. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

The Electric Lighting committee of HULL Corporation invite tenders for supply and laying of electric mains, &c., required in connection with the extension of the electric lighting mains during the period ending March 31, 1911. Forms of tender and specification from the City treasurer, Mr. T. G. Milner, and tenders, addressed to the chairman of the committee, must be delivered at the Town Hall, Hull, by noon June 20.

WEST BROMWICH Electricity committee invite tenders for the supply, delivery and laying of paper-insulated lead-covered feeder and pilot cables. Specifications, forms of tender, &c., from the borough electrical engineer and manager, Mr. W. A. Jackson, Electricity Works, West Bromwich. Tenders to the chairman of the Electricity committee, Town Hall, West Bromwich, by noon June 20.

BARNES Urban District Council invite tenders for supply of 4,000 yds. of 0·25, 0·25, 1·25 sq. in. triple concentric cable, paper insulated, lead sheathed and jute served, suitable for a working pressure of 660 volts, manufactured in strict accordance with the British Engineering Standards committee's specifications. Tenders to the Clerk to the Council, High-street, Mortlake, by noon June 14.

ERITH Council want tenders by noon June 20 for supply of a Lancashire boiler, mechanical stokers, superheater and pipework; a 750 kw. three-phase turbo-alternator, with surface condenser, air and circulating pumps and pipework. Specification from the Electrical Engineer.

DEVONPORT Corporation want tenders by noon June 15 for 12 months' supply of d.c. meters, paper-insulated cables, rubber-covered wires and cut-outs, lubricating oils., &c. Forms of tender, &c., from Borough Electrical Engineer.

The Council of the University of BRISTOL want tenders by noon June 11 for electric lighting and other electrical work in connection with the new chemical and physiological buildings. Specifications, &c., from the Registrar.

LONDON County Council require tenders by 11 a.m. July 5 for supply of 250 electric tramcar bodies and 250 electrical equipments for conduit and overhead systems. Specifications, &c., from the Clerk.

RAWTENSTALL Corporation want tenders by July 1 for permanent way construction and supply of steel poles, overhead equipment, cables, conduits, &c., for a tramway. Specification from the Borough Engineer.

BATLEY Council require tenders by noon June 23 for supply of a battery of accumulators, an automatic reversible traction booster and a battery charging booster. Specifications from Borough Electrical Engineer.

STOCKPORT Electricity and Tramways committees require tenders by noon June 22 for supply of carbon brushes, overhead line material, tubing, ironmongery, oils, &c. Forms of tender from Borough Electrical Engineer.

TONBRIDGE Council want tenders by July 1 for supply of a Lancashire boiler, economiser extension and pipework. Specification from Mr. M. P. Plunkett, Electricity Works, Tonbridge.

Tenders are required by June 28 for supply of electric light and power plant and wiring at the County Asylum, Knowle, FAREHAM. Specification from the County Surveyor, The Castle, Winchester.

MANCHESTER Electricity committee want tenders by 10 a.m. June 22 for meters, service cables, motors and starters. Forms of tender from Mr. F. E. Hughes, Town Hall, Manchester.

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Tenders are required by June 11 for wiring and fitting a new Police Court at BARGOED (Glam.) for electric lighting. Specifications from Council offices, Cardiff.

EALING Corporation require tenders by noon July 4 for supply and erection of surface condensing plant, &c., at the electricity works. Specification, &c., from Town Hall, Ealing.

WEST HAM Education committee require tenders by 6 p.m. June 20 for wiring three schools. Specifications, &c., from Mr. Wm. Jacques, 2, Fen-court, Fenchurch-street, London, E.C.

BRISTOL Sanitary and Improvement committee want tenders by 10 a.m. June 13 for supply and erection of electrical plant and fittings at the proposed refuse destructor, Eastville, Bristol. Specification, &c., from City Engineer.

Tenders are wanted by noon June 13 for the electric lighting of the new asylum buildings on the Purdysburn estate, BELFAST. Specifications from Messrs. Watt, Tulloch & Fitzimons, 77A, Victoria-street, Belfast.

SOUTH SHIELDS Corporation want tenders by 10 a.m. June 13 for 12 months' supply of stores to the tramway department. Specification, &c., from the Tramways Manager.

WALLASEY Council require tenders by noon June 14 for the supply and erection of a water cooling tower. Specifications from engineer and manager of electricity department, Liscard.

PORTSMOUTH Corporation want tenders by 10 a.m. June 22 for one or two years' supply of coal to the electricity department.

Tenders are invited up to July 19 for supply and delivery of 4,200 telephone sets (as per schedule No. 231) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, BRISBANE (Queensland), will receive tenders until noon June 22 for supply of 130 miles copper tinned wire and 25,000 insulators. Local representation is necessary. Specifications, &c., from 72, Victoria-street, London, S.W.

Tenders are also invited for supply of 941,000 arc lamp carbons to the city of MELBOURNE. Tender form, specification, &c., from the agents (Messrs. McIlwraith, McEacharn & Co. Propty., Ltd.), Billiter Square-buildings, London, E.C., to whom tenders by Friday, June 17.

Tenders are invited up to June 14 for supply of 100 party line common battery telephone wall sets, 10 party line common battery table sets, 100 switches, common battery, single extension and intercommunication, and 3,000 telephone protectors to the Postmaster-General's department in VICTORIA. Tender forms and specification at the Commonwealth office, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, BRISBANE (Queensland), will receive tenders until noon June 22 for supply of copper wire and accessories, covered wire, iron wire, insulators, ironwork and sal ammoniac and zinc for batteries. Local representation is necessary.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

London County Council have received the following tenders :—

39 double-deck car-bodies, with roof covers :—

Hurst, Nelson & Co. (*accepted*)	£14,040 0
Metropolitan Amalgamated Rail. Car. & Wagon Co.	15,366 0
United Electric Car Co.	14,742 0
Brush Electrical Eng. Co.	14,469 0

39 sets of electrical equipments :—

British Westinghouse Co. (*accepted*)	£12,753 0
British Thomson-Houston Co.	13,045 10
Dick, Kerr & Co.	13,006 10

40 centre-bearing four-wheeled bolster trucks :—

Hurst, Nelson & Co. (*accepted*)	£4,930 0
Metropolitan Amalgamated Rail. Car. & Wagon Co.	5,040 0
United Electric Car Co.	4,880 0

The Highways committee of London County Council have also accepted the tender of the British Westinghouse Co. for the supply of 40 sets of magnetic track and wheel brake equipments for double-deck cars at £2,280.

The Metropolitan Water Board have accepted the tender of the Appleby Crane & Transporter Co. for the erection of a motor-generator (to be manufactured by the General Electric Co.) for coal transporter apparatus at £105 ; and that of the Rees Roturbo Co. for a centrifugal pump and electric motor for Ealing, £55. 10s.

Tunbridge Wells Council have accepted the following tenders :—

Underfeed Stoker Co., mechanical stoker, £199 ; Fuller Mfg. Co., motor, £28. 5s. 6d. ; W. E. Burnand & Co., transformer, £3. 10s. ; Ross, Hotchkiss & Co., circulator, £60 ; and J. Bennett Lawes & Co., lagging, £5.

Leyton Council have accepted the following tenders :—

Headland & Headland, fire alarm post and single wire connection, £30 ; Reason Mfg. Co., annual supply of electrolytic ordinary meters ; Mordey, Fricker & Co., annual supply of electrolytic slot meters.

Kilburn & Co. (Calcutta) have supplied about 137 "Russa" electric fans to the electrical department of the East Indian Railway.

Burn & Co. have orders for gearing, &c., required in connection with the conversion of the Malakand Fort (India) water supply pumps to electric driving.

Dublin Corporation have accepted the tender of Fletcher & Phillipson for electric wiring at Bolton-street technical schools at £1,273. 7s. 6d.

Belfast Tramways and Electricity committee have accepted the tenders of J. H. Holmes & Co. for a motor booster and switchgear, and Cowans, Ltd., for switchboard extensions.

The Isle of Wight Joint Isolation Hospital Board have accepted the tender of the local electric light company for wiring the new hospital at Fairlee, Newport, at £113. 12s.

Wrexham Council have accepted the tender of the British Economical Lamp Co. for supply and renewal of metal filament lamps at 7s. 6d. per pillar for the first year and 5s. after.

Burnley Corporation have accepted the tenders of the United Electric Car Co. for two tramcar bodies at £292. 5s. each, and of the British Thomson-Houston Co. for car electrical equipments at £264. 8s. 6d. each.

Colchester Corporation have accepted the tender of W. T. Henley's Telegraph Works Co. for cable at £37.

Sheffield Council has accepted the tender of their electric supply department (at £45) for a 10 H.P. motor and wiring at the baths.

Heckmondwike Council have accepted the tender of E. Deane & Beale for condensing plant at £2,418.

Wednesbury Council have accepted the tender of the British Westinghouse Co. for a 230 kw. dynamo and gas engine.

Burton Council have accepted the tender of the Brush Co. for a synchronous motor-generator at £257. 10s.

Eastbourne Council have accepted the tender of W. T. Henley's Co. (at £130) for cable.

Blackpool Council have accepted the tender of the British Thomson-Houston Co. for h.t. switchgear for the South Shore sub-station.

Commonwealth Tenders.—The Australian Postmaster-General's Department have accepted the following tenders :—

Victoria.—W. T. Henley's Telegraph Works Co., telephone cable ; British Insulated & Helsby Cables, copper wire ; India Rubber, Gutta Percha & Telegraph Works Co., zincs for gravity cells ; Hellesens Enke & V. Ludvigsen, Hellesens' dry cells ; J. Bartram & Son, micro-telephones, wall sets and table sets.

N.S.W.—British Insulated & Helsby Cables, copper wire ; R. Johnson, Clapham & Morris, g.i. wire ; T. Zwicker & Co., g.i. spindles ; Noyes Bros., stay rods ; Dalgety & Co., porcelain insulators.

W. Australia.—British Insulated & Helsby Cables, bronze and copper wire ; Dalgety & Co., porcelain insulators.

S. Australia.—British Insulated & Helsby Cables, phosphor bronze wire.

Tasmania.—British Insulated & Helsby Cables, wall telephone sets, telephone cable and copper wire ; India Rubber, Gutta Percha & Telegraph Works Co., shackle insulators ; Western Electric Co., telephone cable ; J. Bartram & Son, wall telephone sets ; Gibbs, Bright & Co., copper wire.

BUSINESS NOTICES

Messrs. Clark, Forde & Taylor, 4, Great Winchester-street, London, E.C., notify that they will take into partnership, as from July 1, Mr. Reuben Marchant Sayers, A.M.I.C.E. There will be no change in the style of the firm.

The partnership between W. H. Trentham, Jas. Saunders and John Saunders (carrying on business as Trentham & Saunders), consulting and civil engineers, 39, Victoria-street, London, S.W., has been dissolved so far as concerns Mr. Trentham. Messrs. Jas. and John Saunders continue at the same address as Saunders & Saunders.

The partnership between John Anthony Littlewood and Fred. H. Beaumont (trading as Littlewood, Beaumont & Co.), electrical and motor engineers, Thirstin Ironworks, Honley, near Huddersfield, has been dissolved. Debts by Mr. Beaumont.

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Sale by Auction.—Messrs. Horne & Co., 35, Old Queen-street, Westminster, S.W., will sell by auction at the Royal Arsenal, Woolwich, on 23rd inst., at 11 a.m., some unserviceable and obsolete stores, including quantities of iron and steel, brass, gun metal, lead, zinc, &c., electric cable, steam engines, lathes, machine tools, telegraph instruments, electric lamps, dynamos, &c. The lots may be viewed at the Royal Arsenal, Woolwich, on the Monday, Tuesday and Wednesday previous to and on morning of sale. Catalogues at the War Office, Whitehall; the Ordnance Office, Tower; and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Patent Development.—The proprietor of patent No. 13,891/1907, for "Apparatus for treating liquids electrolytically," desires to enter into arrangements for exploiting and working the same in this country. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

Electric Fans in Marylebone.—Mr. A. H. Seabrook, general manager of the Marylebone electricity department, has sent us a copy of a pamphlet dealing with the appropriate subject of electric fans. All the cogent reasons as to why electric fans should be used are given, and various ways in which they may be employed in business and in domestic use are also provided. Illustrations of standard, desk and ceiling fans are shown.

New Shaped Osram Candle Lamps.—We learn that the General Electric Co., after careful consideration and attention to the manufacture, have been able to produce a standard pattern 10 c.p. Osram candle shape lamp, suitable for working on 25, 33, 50 and 55 volts, in a globe measuring 26 mm. in diameter. The shoulder of the cap measures 23 mm. The lamp is, therefore, suitable for using in practically all designs of candle fittings. The size and shape of the lamps will be found particularly attractive, and being all of one size they are interchangeable. The price remains as before (3s. 3d. each). As the appearance of this lamp is now so much altered, we are showing an illustration of it.

Equipment of a Modern Elementary Electrical Laboratory.—A small booklet issued by Mr. R. W. Paul contains some criticisms and views on the equipment of an electrical laboratory suitable for first year students.

It is pointed out that too much of the apparatus used in such cases is obsolete and generally in bad order, so that the student becomes disheartened and his attention is diverted from the laws which he is studying to the repair of the apparatus which are to prove them for him. It is also contended that all the apparatus required can be made up from eight very simple components, and that these components should be all interchangeable, an advantage which by no means obtains at present. The apparatus required is a unipivot galvanometer, a volt range multiplier and current shunt, resistance box, rheostat, selector switch, tapper key and a single-pole switch.

The remainder of the booklet contains details and descriptions of these items of apparatus, while a list of the various experiments which can be carried through by their aid is also given. Whether all the statements made by Mr. Paul will be approved by teachers of technical students is, perhaps, open to doubt, but we understand that Profs. S. P. Thompson and T. Mather, as well as Dr. Drysdale and Dr. Sumpner, are in agreement with him.

CATALOGUES, &c.

Siemens Supplies List.—Messrs. Siemens Bros. Dynamo Works (Ltd.) have ready a price list of electrical supplies covering all the articles used by an electrical contractor in his business. All these goods can be obtained from Messrs. Siemens Supplies Department, 39, Upper Thames-street, London, E.C., and at their various branches at home and abroad. The principal features of the catalogue to which attention may be called are the reduced prices for Tantalum lamps and particulars regarding Zed cartridge fuses. The latter useful apparatus was described in a recent issue of the Industrial Supplement. Particulars may also be found of watertight switch boxes, wires and cables, as well as, of course, details of the well-known standard system which is now being extensively used in installation work by some of het leading contractors. A description of a cheap knife switch which is being made in large quantities at Messrs. Siemens' Stafford works and the latest forms of horn lightning arresters are also to be found.

Paraffin and Spirit Engines.—Messrs. Chas. Price & Son, Broadheath, Manchester, are issuing a pamphlet dealing with paraffin and spirit engines. Full specifications of the engines are given along with illustrations showing the working parts. These engines are now being constructed for use on inspection cars for marine work and for various other industrial purposes. An interesting engine is the 1-cylinder air-cooled engine, which has been supplied for Admiralty work. These iengines are also admirably adapted for use with electric lighting sets for country house work.

Moving Iron Electrical Instruments.—From Messrs. Crompton & Co. we have received a copy of a catalogue dealing with moving iron electrical instruments both for alternating and continuous current work. These are made in the usual round, sector and edgewise types, while a special modification is designed with a bottom flange for fixing on the top of controller pillars. Portable instruments working on the same system are also made.

Siemens Central Battery Instruments and Telephone Condensers.—Messrs. Siemens Bros. & Co. forward a pamphlet in which are described central battery telephones arranged to work with every type of central battery switchboard, the patterns being suitable for fixing on walls and sides of tables, as well as for standing on desks or tables. The hand micro-telephone supplied with most of the types is similar to the latest P.O. standard instrument. The condensers are of the rolled type, being built of tinfoil and specially prepared and impregnated paper. They are very compact, and are made in several sizes and shapes to suit general conditions and requirements of telephone and telegraphic work.

Gearing.—The Power Plant Co. has ready a pamphlet dealing with the use of their gears in colliery and mining work.

Rivets, Bolts and Nuts.—The Rivet, Bolt & Nut Co., of Glasgow, forward a very handsome book containing details of their manufactures. In addition to prices and illustrations, particulars are given of the approximate weights of bolts, nuts, rivets and bars. Details of the British standard tests, and hints on heating rivets can also be found, while the inclusion of stamped dimensions and other information make up a handy book of reference for everyday use.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during May, 1910, and (*b*) during the current year from Jan. 1 to May 31, with the increases or decreases compared with the corresponding periods of 1909:—

Electrical machinery (*a*) £51,493 (increase £14,198), (*b*) £233,082 (increase £41,859); telegraph and telephone cables (*a*) £8,358 (decrease £154), (*b*) £6,1279 (increase £20,409); telegraph and telephone apparatus (*a*) £15,882 (increase £1,288), (*b*) £74,678 (decrease £443); other electrical wires and cables, rubber insulated (*a*) £19,765 (increase £15,961), (*b*) £68,992 (increase £47,166); with other insulations (*a*) £3,943 (decrease £3,573), (*b*) £12,837 (decrease £32,540); carbons (*a*) £11,569 (increase £2,869), (*b*) £57,860 (increase £3,095); glow lamps (*a*) £54,856 (increase £31,293), (*b*) £227,810 (increase £42,576); arc lamps and electric searchlights (*a*) £148 (decrease £767); (*b*) £1,549 (decrease £6,996); parts of arc lamps and searchlights (other than carbons) £6,049 (decrease £75), (*b*) £30,248 (increase £8,002); primary and secondary batteries (*a*) £3,407 (increase £575), (*b*) £17,248 (decrease £3,865). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (*a*) £131,814 (increase £46,345), (*b*) £592,532 (increase £74,563).

Exports.—The exports of electrical machinery, material, &c., (*a*) during May, 1910, and (*b*) during the current year from Jan. 1 to May 31, and the increases and decreases compared with the corresponding periods of 1909, are as follows:—

Electrical machinery (*a*) £106,215 (increase £566), (*b*) £568,713 (decrease £11,101); telegraph and telephone cables (*a*) £66,185 (increase £24,640), (*b*) £870,321 (increase £683,042); telegraph and telephone apparatus (*a*) £13,383 (decrease £15,569), (*b*) £65,863 (decrease £28,714); other electrical wires and cables, rubber insulated (*a*) £34,954 (increase £13,608), (*b*) £172,380 (increase £62,220); with other insulations (*a*) £34,378 (increase £9,506), (*b*) £113,509 (increase £8,714); carbons (*a*) £1,223 (increase £333), (*b*) £7,413 (increase £4,052); glow lamps (*a*) £9,688 (increase £2,620), (*b*) £51,495 (increase £21,896); arc lamps and searchlights (*a*) £844 (decrease £537), (*b*) £7,766 (decrease £679); parts of arc lamps and searchlights (other than carbons) (*a*) £1,031 (decrease £219), (*b*) £5,711 (decrease £1,833); primary and secondary batteries (*a*) £7,747 (decrease £53), (*b*) £41,317 (decrease £4,884). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (*a*) £206,549 (increase £43,765), (*b*) £1,524,628 (increase £785,535.)

BANKRUPTCIES, LIQUIDATIONS, &c.

The estates of Wm. Chalmers, electrical engineer, 142, Bath-street, Glasgow, have been sequestrated. A meeting to elect trustee and commissioners will be held on July 10 at the Faculty Hall, St. George's-place, Glasgow.

A receiving order has been made against John P. L. Donlevy, consulting electrician, 123, Tulse-hill, London, S.W. First meeting of creditors at Bankruptcy-buildings, London, W.C., on June 16, and public examination on July 14.

A meeting of creditors of Thornton & Crebbin (Ltd.) will take place on June 13 at the Queen's Hotel, Leeds.

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An application for the discharge of Alfd. Horswill Gibbings, engineer, 17, Gambier-terrace, Liverpool, will be heard on July 1 at the Court House, Victoria-street, Liverpool.

A dividend is to be paid to creditors of Joseph Platt and Richd. Bleasdale, electrical engineers, Victoria-square, Bolton, and also in respect of the separate estate of Richd. Bleasdale. Claims to Mr. H. Mather, 10, Acresfield, Bolton, by June 28.

The Electric Sterilizing, Carbonizing & Stripping Co. (Ltd.) is being wound up voluntarily. Mr. H. Appleyard, Prudential Buildings, Market-place, Dewsbury, is liquidator. Creditors will meet at his office on June 20.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.

March 24, 1910.

7,361 Cooper & British Insulated & Helsby Cables. Automatic cradle switches for table and wall instruments and the like.
7,373 Horvath. Incandescent electric lamps.
7,414 Taylor. Limiting the flow of current on a short-circuit.
7,428 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Circuit controlling devices.*
7,463 Felten & Guilleaume Lahmeyerwerke Akt.-Ges. Preventing shaft voltages or bearing currents in electric machines. (Date applied for, 27/4/09.)*†
7,465 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Electromagnetically controlled electric switches.*

March 26, 1910.

7,489 Crompton & Co., Macfarlane & Budgé. Dynamo-electric machines.

March 29, 1910.

7,573 Black. Single-phase alternate-current motor.
7,574 Macalister. Determining the position of faults in electric mains.
7,587 Goddard. Prepayment electricity meters.
7,589 Gorham. Resuscitating the negative plates of secondary batteries and assisting in their formation.
7,593 Smith. Charging electrical accumulators.
7,617 Pecszus. Electric igniter for explosion motors.*
7,621 Prentice. Electric train control system.*
7,641 Bloxam. (E. Hoorickx & A. Hindeb, Belgium. Current terminals for use in the manufacture of mirrors by electro-deposition. Addition to No. 2,493/09*
7,656 Egner & Holmstrom. Cooling devices for telephone transmitters for strong current. (Date applied for, 3/4/09.)*†
7,659 Neuhold. Automatic telephone systems. (Date applied for, 20/4/09.)*†

March 30, 1910.

7,714 Goulet. Hydrocarbon incandescent lamps. (Date applied for, 16/9/09.)*†

March 31, 1910.

7,808 Frost. Electric current generating and motive power machine.
7,821 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H., Germany.) Arc lamps.*
7,822 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H., Germany.) Starting of polyphase electric asynchronous motors.*
7,823 Conradi & Conradi. Electrical distribution boards and safety switch fuses and fuse carriers.
7,860 B.T.-H. Co. (G.E. Co., U.S.) Electric heating apparatus.*

April 1, 1910.

7,868 MacDonald. Electrical generators or motors.
7,892 Hopkins. Junction points for railways, tramways and the like.
7,929 Highfield. Electric fittings.

April 2, 1910.

7,963 Ross & Co. Electric lamp.
7,966 Sutton. Anti-vibratory devices for electric and other lamps or burners.
7,995 Woollard & Evans. Adjustable coupling for magnetos and other machines.
8,014 Buck. Electric lampholders.
8,018 Thompson. (George, Graf von Arco, Germany, and Ragnar Hakan Rendahl, Sweden.) Variometers for electrical oscillations.*
8,024 Graham. Telephonic transmitters.*
8,031 B.T.-H. Co. (G.E. Co., U.S.) Tungsten and the manufacture thereof.

April 4, 1910.

8,076 Zweigberck. Controllers for electric motors.
8,083 Lundberg, Lundberg & Lundberg. Electric switches.*
8,125 Heraeus G.m.b.H. Starting alternate-current mercury vapour lamps. (Date applied for, 17/1/10.)*†
8,126 Heraeus G.m.b.H. Shunt circuit-tilting devices for mercury vapour lamps. (Date applied for, 24/1/10.)*†

April 5 1910.

8,167 Nasmith. Enclosing the arc of arc lamps. (Tito Livio Carbone, Germany.) (Addition to No. 17,448/09.)*
8,219 Leitner. Reversible variable speed dynamos. (Date applied for, 31/7/09. Comprised in No. 17,847, dated 31/7/09.)
8,225 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Electromagnetic breakers and means for resetting the same from a distance, and in signalling devices combined therewith.*
8,226 Taylor. Switch for use on motor cars lighted by electric lamps.
8,228 Neuhold. Telephone exchanges. (Date applied for, 10/6/09.)*†

April 6, 1910.

8,257 Ayton. Electric sparking plugs.
8,274 Barry & Clarke. Rheostats.
8,286 Lehmann, Harvey & Inrig. Variable-speed dynamo for motor-car lighting.
8,288 Warmbold. Overhead electric cables.
8,294 Chalmers & Co. Magnetic clutch. (Date applied for, 6/4/09.)*†
8,332 Chisholm. Telephone system and individual transmitter.*
8,341 Cervenka. Incandescence filament or body and process for manufacturing same. (Date applied for, 23/10/09.)*†

SPECIFICATIONS PUBLISHED.

1909 Specifications.

7,576 Brookes. Couplings or connections for electric conductors or cables and the like.
7,593 Handcock, Dykes & Rawlings. Connecting or jointing of electrical conductors and means therefor.
7,995 Simplex Conduits, Ltd., & Waterhouse. Junction and the like boxes.
8,111 Sharman. Discharge gaps for the production of electric oscillations.
8,165 Spencer. Electrical distributing systems. (Request under sec. 19 not granted.)
8,382 Hanna & Hanna. Manufacture of bushes or bearings. (Cognate Application, 22,869/09.)
8,419 Gray. Electric conductors.
8,489 Burks. Magneto-electric machines. (Date applied for, 5/3/09.)
8,694 Thomson. Electric coal-cutting machines.
8,781 B.T.-H. Co. (G.E. Co., U.S.) Manufacture of rods or filaments of refractory material.
9,133 Mayor & Mayor & Coulson. Enclosed electrical machines. (Cognate application, 16,174/09.)
9,456 Hawker. Electric switches.
9,686 Sharman. Out-going telegraph signal recorders.
9,812 Mackay. Shade-holders for incandescent electric lamps.
10,586 Rymer-Jones. Wireless telegraphy.
10,729 Cochrane. Through control magnetic switches.
10,940 Marsh. Electric time switches.
11,060 Johnson. (Chemische Fabrik Griesheim-Elektron.) Production and maintenance of long electric arcs for effecting reaction between gases.
11,135 British Insulated & Helsby Cables, Cole & Shaw. Insulating of electric cables.
11,338 Spalazzi. Electrical device for transmitting angular movements to a distance. (Dated 13/5/09.)
11,400 Allgemeine Elektricitats Ges. Electric systems for power transmission. (Date applied for, 13/5/08. Addition to No. 11,339/09.)
11,634 Siemens Schuckertwerke Ges. Electric motor meters. (Date applied for, 6/6/08.)
11,773 Johnston. Ceiling roses, junction boxes, conduit boxes, and like electric fittings.
12,254 Bluhm. Third rails for electric traction systems.
12,878 Akt.-Ges. Kostin's Elektricitatswerke. Electric motor meters. (Date applied for, 9/11/08.)
13,142 Curtis, Mould & Adams Mfg. Co. Electric rheostats, motor-starters and the like.
13,612 Kemble. Insulators for supporting electrical conductors.
13,798 Allgemeine Elektricitats Ges. Electric systems for power transmission. (Date applied for, 12/6/08. Addition to No. 11,339/09.)
15,371 Houghton, Allman & Gray. Collector shoes or skates for electric traction systems. (Date applied for, 2/6/09.)
15,544 Thomas & Thomas. Electrically-controlled brakes for cranes.
15,792 B.T.-H. Co. & Samuelson. Packings for elastic fluid turbine shafts. (Addition to No. 24,936/08.)
15,880 Jaburg. Arc lamps. (Date applied for, 26/5/08, originally included in 7,471/09.)
15,891 Huth. Generators for wireless telegraphy and telephony with continuous oscillations.
16,095 Hill. Electromagnetic clutches.
16,642 Aitken & British Insulated & Helsby Cables. Telephone switchboards.
16,855 Ges. fur Elektrotechnische Industrie & Gyuris. Production of electric licht between the electrodes of arc lamps.
17,107 Romer. Intercommunication telephone instruments.
17,561 Baker. Electric fly switches.
17,620 Siemens Schuckertwerke Ges. Indicating differences of pressure. (Date applied for, 6/8/09.)
17,627 Kuzel. Electric incandescent lamp with metal filament loops. (Date applied for, 4/1/09. Request under sec. 19 not granted.)
17,742 Giglio. Rectifying alternating currents. (Date applied for, 29/4/09.)
17,932 Karolyi, Klupathy & Berger. Process and apparatus for wireless operation of switches and other apparatus at a distance by sound waves and other vibrations. (Rights under sec. 19, Patents, &c., Act, 1907, not granted.)
18,193 Newton. (Farbenfabriken vorm. F. Bayer & Co.) Insulation of metallic threads, wires and bands. (Date applied for, 13/5/09.)
18,228 Conradi & Conradi. Safety electric connector plug.
18,511 Holdsworth. Self-driving electric heat and fluid pressure motor.
19,024 Unterberg & Helmle. Distributor for high-tension sparking apparatus for multi-cylinder internal-combustion engines. (Date applied for, 19/8/08.)
19,368 Dane & Perks, Dane & Co. Proprietary. Drying of or abstraction of moisture from insulated electric cables.
19,914 Fuller. Electric batteries.
21,854 Gray. (Seabolt.) Electric lamp fittings.
22,596 Neuhold. Automatic telephone exchanges. (Date applied for, 7/4/09.)
22,897 Lundberg, Lundberg & Lundberg. Electric switches.
23,316 Green. Cathodes for Röntgen-ray tubes and like appartaus.
23,628 Rossi. Detector of electromagnetic waves.
23,821 Siemens Bros. & Co. & Riber. Clamping and supporting devices for electrica l condensers.

COMPANIES' MEETINGS AND REPORTS.

ANGLO PORTUGUESE TELEPHONE CO. (LTD.)—The directors' report for the year ended Dec. 31 last states that the gross revenue was £49,489. 18s. 2d., of which operating, management and general expenses absorbed £27,235. 3s. 9d., and royalties to the Portuguese Government £1,487. 3s. 4d., leaving gross profit £20,767. 11s. 1d. After providing for debenture interest (£2,302. 18s. 4d.), sinking fund (£1,297. 1s. 8d.), income tax (£596. 8s. 2d.), and appropriating £7,500 to reserve and £500 to exchange fluctuation account the amount available for disposal, including £4,820. 18s. 2d. brought forward is £13,392. 1s. 1d. An interim dividend of 3 per cent. (tax free) has already been paid, and the directors recommend a final dividend of 5 per cent., tax free (making 8 per cent. for the year), leaving £5,392. 1s. 1d. to be carried forward. With a view to ensuring the Company's service and plant being maintained in the highest state of efficiency, the directors arranged for an inspection of the system by Mr. Frank Gill, chief engineer of the National Telephone Co. Mr. Gill, accompanied by Mr. Kerr and Mr. Kingsbury, two directors, recently visited Portugal, and recommendations resulting from that visit are now being carried out. The directors express their appreciation of the value of the engineering experience thus placed at the disposal of the company.

BIRMINGHAM & MIDLAND TRAMWAYS (LTD.)—The total revenue for 1909 was £99,713. 11s. 2d., compared with £97,004. 9s. 1d. for 1908. Expenses were £48,710. 6s. 7d., compared with £45,639. 16s. 6d. After providing for expenses chargeable to revenue (including repairs, maintenance, sums payable to corporations, and placing £3,000 to renewals account) there remains £48,003. 4s. 7d., added to £92. 7s. 6d. brought forward, making £48,095. 12s. 1d. Deducting interest (£28,483. 11s. 11d.) the balance was £19,612. 0s. 2d. Debenture sinking fund required £3,550 and preference dividend £11,537. 18s., leaving £4,524. 2s. 2d., and the directors recommend a dividend on the preferred ordinary shares of 1¼ per cent. for the year (£4,375), leaving £149. 2s. 2d. to be carried forward. Gross receipts from the tramways were £46,477. 17s. 4d., compared with £45,826. 1s. 2d. Gross receipts from the lighting and power departments amounted to £19,795. 1s. 8d., an increase of £4,834. 1s. 6d. Dividends received from investments were £27,228, compared with

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£33,551. Capital expenditure during the year was £8,544. 2s. 3d., of which £1,590. 9s. 1d. was spent on the tramway and £6,953. 13s. 2d. on the lighting undertaking. The purchase by Dudley Corporation of the tramways and light railways in Dudley was completed in November last, and the price (£10,631) paid by the Corporation. A lease of the lines has since been granted to the company for 30 years from Jan. 1, 1909. An arbitrator has been appointed to determine the price to be paid for five years commencing July 1 last to Dudley Corporation for electricity for working the tramways. The supply of electricity to consumers in Oldbury has made good progress. The number of units sold to the Shropshire Co. for distribution by that company during the year was 4,386,341. The Board of Trade has granted the order authorising the transfer of the Smethwick electric lighting order, 1898, to the Shropshire, Worcestershire & Staffordshire Electric Power Co.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—At the meeting on Monday the chairman, Mr. E. Garcke, said the past year had been one of great anxiety to the directors and staff. The troubles of the company and of other similarly-situated manufacturing companies were largely due to excessive competition. The cost of obtaining orders was enormously increased by such competition, and so greatly intensified the competition among English firms. The advent of the metal filament lamp had reduced the necessity for power-house extensions and additions to plant. They had been particularly hit during the last few years by the fact that there had been very few expansions of railways, tramways or light railways in this country. All electrical manufacturing companies in this country were in a similar position. They had during the past two years made very substantial reductions in expenses. During the current half-year business had been to some extent better. The engineering shops were more full of orders at present than they had been for some time past. He could not speak in too high terms of praise of the services rendered by their officers.

COMPANIA INDUSTRIAL DE ELECTRICIDAD (BUENOS AYRES).—For the year 1909 the gross profit was $78,932 (gold) and $1,930 was brought forward. After placing certain sums to reserve, &c., a dividend of 6 per cent. was paid and $523 carried forward. The directors have taken part, on behalf of the company, in the formation of two electric companies in the interior.

KALGOORLIE ELECTRIC POWER & LIGHTING CORPN. (LTD.)—At the meeting last week Mr. Roger W. Wallace, K.C., said that one of the difficulties the company had to encounter was that Continental firms offered to put down small plants in the mines—not only electrical plants, but also at the present time they were putting down a great many suction gas plants. That was extremely unfortunate, because Kalgoorlie was not a good place in which to use gas engines, and those who did use them would find out eventually that they would lose money by not buying electricity direct from the company. That referred principally to the smaller companies, but in addition to that they were always being threatened by the larger mining companies that they would put down their own plants. They had been extremely fortunate in their manager, and under his management they had never had any breakdown except from the effect of lightning storms, and such things as could not be contemplated. They had entered into larger contracts, which necessitate putting down a new unit of plant. They had issued sufficient debentures to clear off their bankers' overdraft, and to pay for that new unit. The duty charged on new plant which could not be bought in Australia was exceptionally high, and made it rather difficult to incur the expenditure they would like to incur for additional plant, &c.

UNITED ELECTRIC TRAMWAYS OF MONTEVIDEO (LTD.) — The directors' report for the year ended March 31 last states that the gross receipts of the tramway system for the year to Oct. 31, 1909, were $1,190,310, an increase of $96,440 compared with 1907-8. Operating expenses were $694,588, against $701,009, the net receipts showing an increase of $102,861 (or £21,885). Passengers carried were 29,293,804, an increase of 3,392,365, and the car-miles run 6,282,240, against 6,036,669. The extension of the power house and the installation of new plant are almost completed. Further extensions to the main car shed and store shed and other improvements have been authorised. The amount received from La Sociedad Comercial de Montevideo in respect of dividend and interest was £106,197. After providing for administration expenses and charging £39,800 for debenture interest, the credit balance is £63,863. 2s. 2d. making, with £11,118. 3s. 2d. brought forward, £74,981. 5s. 4d. After setting aside £2,200 for debenture stock redemption fund, transferring £15,000 to renewals and contingency account and paying interim preference and ordinary dividends (£18,731. 4s. 2d.), the directors recommend the balance dividends, absorbing £27,202. 9s. (making 6 per cent. on both shares for the year), carrying forward £11,847. 12s. 2d.

NEW COMPANIES, STATUTORY RETURNS MORTGAGES AND CHARGES.

NEW COMPANIES.

NEW LIVERPOOL RUBBER CO. (LTD.) (103,933.)—Reg. May 31, capital £150,000 in £1 shares (52,000 5½ per cent. cumulative preference), to take over business carried on at Liverpool, and elsewhere, by the Liverpool Rubber Co. (Ltd.) (incorporated in 1894), and to carry on the business of manufacturers of and dealers in indiarubber and other gums, rubber goods, electricians, &c. First directors, F. H. Smith and P. A. Birley.

T. E. MORGAN & CO. (LTD.) (109,957.)—Reg. June 1, capital £100 in £1 shares, to carry on the business of electrical, mechanical, gas and general engineers, light, heat and power suppliers, founders, &c. Private company. First directors, T. E. Morgan and O. Huxley.

STATUTORY RETURN.

SOUTH METROPOLITAN ELECTRIC LIGHT & POWER CO. (LTD.)—In return dated March 14 capital is £500,000 in 250,000 ordinary, 100,000 second preference and 150,000 first preference shares of £1 each. 123,000 ordinary, 50,000 second preference and 142,968 first preference shares taken up. £1 per share called up on 120,500 ordinary, 50,000 second preference and 137,600 first preference. £308,100 paid. £7,868 considered as paid on 2,500 ordinary and 5,368 first preference. Mortgages and charges, £240,000.

MORTGAGES AND CHARGES.

CRYSELCO (LTD.)—Trust deed, dated May 6, to secure £7,500 first and £7,500 second debenture stock. Property charged, land, factory and other buildings at Kempston, and company's undertaking and property, including uncalled capital. Trustees, A. Baker and H. S. Deacon.

RADYR ELECTRIC CO. (LTD.)—Issue on May 14 of £300 debentures, part of a series of which particulars have already been filed.

COMPANY INCORPORATED OUTSIDE UNITED KINGDOM.

UNIVERSAL WIRELESS TELEGRAPH SUPPLY CO. (LTD.)—Particulars filed May 28. Capital stock $100,000 in $5 shares. Reg. in New York May 14: Directors, S. F. Cuthbertson, T. Stockdale (England), and D. C. Munson (New York). Principal office, Manhattan, New York City. British address, Avenue-chambers, 42, Bloomsbury-square, W.C., where S. F. Cuthbertson is authorised to accept service.

CITY NOTES.

MEMORANDA (June 9).—Bank rate 3 per cent. (June 9, 1910). Price of silver, 24½d. per oz. Consols 82—82¼ for money; 82⅛—82⅜ for account. **Consols Pay Day, July 1; Stock and Shares Continuation Days,** June 27 and July 12; **Ticket Days,** June 28 and July 13; **Pay Days,** June 10 and 29; **Mining Shares Carry Over Day,** June 24.

PRICES OF METALS (London).—*Copper*, cash, 56⅜; three months, 57⅛. *Lead*, English, 12⅝—13⅛; foreign, 12⅝—12¾. *Spelter*, 22½—22⅝. *Tin*, English, 148—149; foreign cash, 148½; three months, 150¼. *Iron*, Cleveland, cash, 49/4, three months, 50/3.

BRITISH THOMSON-HOUSTON CO. (LTD.)—A meeting of the debenture stockholders will be held at 83, Cannon-street, London, E.C., at noon on 15th inst., for approving the appointment of new trustees—Messrs. Cosmo Bevan and Lewis Kerrison Jarvis, bankers, 54, Lombard-street, E.C.

DIESEL ENGINE CO. (LTD.)—For the year ended March 31 the credit balance was £2,956, making, with £6,075 brought forward, £9,031. The directors recommend payment of the preference dividend and the placing of £5,000 to general reserve, carrying forward £3,093.

DOULTON & CO. (LTD.)—The accounts for the past year show a debit balance of £16,010.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—The trustees recommend a final dividend of 5s. 9d. per share net on the ordinary shares, making 5¾ per cent. net on the ordinary shares for the year.

HAVANA ELECTRIC RAILWAY CO.—The gross receipts for 1909 were $2,488,647, increase $211,840. The surplus earnings available for dividends were $816,331. 3 per cent. has been declared on the common shares, leaving $292,420.

LONDON ELECTROBUS CO. (LTD.)—Mr. R. D. Yelverton desires to hear from debenture holders or shareholders of this undertaking. He complains that he is experiencing a difficulty in obtaining information concerning the present position of the company, or of the syndicate which is supposed to have been formed to take over its business.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—The directors' report for the year ended Dec. 31 last states that, after providing for debenture interest, depreciation, &c., the credit balance of £9,661 brought down was reduced to £6,322.

SAO PAULO TRAMWAY LIGHT & POWER CO. (LTD.)—This company has declared a quarterly dividend of 2½ per cent.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have been asked to grant quotations to a further issue of 20,000 £5 (fully-paid) and 20,350 £5 (£2 paid) 5 per cent. cumulative preference shares of the *Calcutta Electric Supply Corpn. (Ltd.)*

TRACTION & POWER SECURITIES (LTD.)—For the year 1909 the credit balance was £24,848, which, added to £5,775 brought forward, made £30,623. The directors have transferred £25,000 to investment reserve account, leaving £5,623 to be carried forward.

WESTERN TELEGRAPH CO.—The directors have declared the third quarterly interim dividend of 3s. per share (tax free) for the year ending June 30, being at rate of 6 per cent. per annum. The transfer books will be closed from 17th to 23rd inst. inclusive, and the dividend will be payable on 24th inst.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	May 27	228	+ 3	21	4,568	+ 95
Anglo-Argentine	June 3	43,902	+ 4,021	22	971,785	+103,937
Ayr Corporation	,, 4	287	— 28	3	807	— 21
Baker St. & Waterloo Ry.	,, 4	3,265	— 225	22	75,390	+ 1,790
Barnsley	May 27	157	— 17	21	3,600	+ 156
Barrow	,, 27	291	+ 71	21	5,012	+ 674
Bath Electric Trams, Ltd.	June 1	769	— 343	22	16,412	+ 1,189
Birmingham Corporation	,, 4	6,532	— 903	9	62,710	— 487
Birmingham & Midland	May 20	1,244	+ 442	20	16,625	+ 699
Blackburn Corporation	June 1	942	— 479	‡10	10,579	— 949
Blackpool and Fleetwood	,, 4	479	— 963	..	..	..
Bolton Corporation	,, 5	2,328	— 106	10	22,009	— 1,263
Bombay	May 6	2,869	+ 222	18	49,742	+ 3,940
Bournemouth Corporation	June 1	1,533	— 498	9	14,524	— 918
Bradford Corporation	,, 4	4,992	— 985	10	46,955	— 263
Brighton Corporation	,, 6	904	— 343	§9	8,449	— 684
Bristol Trams & Carriage	,, 3	7,632	— 1,653	22	123,873	+ 11,634
Burnley Corporation	,, 4	1,183	— 220	22	27,908	+ 622
Burton Corporation	,, 5	267	— 51	9	2,471	— 61
Bury Corporation	,, 5	1,183	— 131	§9	11,079	— 573
Calcutta Tramways Co.	,, 4	₹49,840	+ ₹1,040	22	₹1,139,146	+ ₹38,338
Camborne-Redruth	,, 4	112	— 73	22	2,654	— 69
Cardiff Corporation	May 28	2,240	+ 53	9	18,113	— 62
Cavehill	,, 27	116	+ 14	21	1,655	+ 179
Central London Railway	June 4	6,044	+ 95	22	123,957	+ 2,315
Charing C., Euston & H'stead	..	..	..	..	..	..
Chatham & Dist. Lt. Rys.	,, 2	909	— 266	22	17,397	+ 670
City & South London Rly.	,, 5	3,215	— 36	22	71,546	— 193
City of Birmingham	May 27	2,807	— 96	21	59,707	+ 3,382
Colchester Corporation	June 1	187	— 94	22	3,699	+ 470
Cork Electric Trams Co.	,, 2	516	+ 15	22	10,058	+ 1,617
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	May 27	411	+ 39	21	8,564	+ 960
Dover Corporation	June 4	212	— 58	9	1,832	— 86
Dublin & Lucan Railway	,, 3	139	— 63	22	2,731	+ 29
Dublin United	,, 3	5,381	— 909	22	114,705	— 3,556
Dudley-Stourbridge	May 27	767	— 34	21	15,469	+ 32
Dundee Corporation	June 1	1,210	— 52	§2	2,963	+ 10
East Ham Council	,, 4	1,018	— 216	¶9	9,575	— 63
Exeter Corporation	,, 3	317	— 363	9	2,851	— 708
Gateshead & Dist. Trams	May 27	955	— 86	21	20,069	— 308
Glasgow Corporation	June 4	18,424	+ 297	1	18,424	+ 297
Glossop Trams	,, 4	110	— 20	22	2,451	— 129
Gloucester Corpn.	..	..	..	..	..	..
Gravesend-Northfleet	May 27	196	— 12	21	4,053	+ 178
Great Northern & City Rly.	June 4	1,409	+ 27	22	32,672	— 415
Gt. Northern, Piccadilly, &c.	..	..	..	..	..	..
Greenock & Port Glasgow	May 27	775	+ 158	21	11,911	+ 1,664
Hartlepool Tramways	,, 27	235	— 33	21	4,530	+ 222
Hastings Elec. Trams Co.	June 2	894	— 489	22	18,669	+ 258
Hong Kong	,, 4	$8,231	+ $25	22	$189,730	+ $17,514
Huddersfield Corpn.	,, 4	1,755	— 317	9	16,263	+ 529
Hull Corporation	,, 4	2,680	— 16	9	24,733	+ 1,018
Ilford District Council	,, 4	523	— 147	9	4,897	+ 38
Ilkeston District Council	,, 1	121	— 54	9	1,118	— 94
Ipswich Corporation	,, 4	407	— 124	9	3,582	— 22
Isle of Thanet Co.	,, 4	526	— 376	¶34	11,723	+ 53
Jarrow	May 27	118	— 6	21	2,406	+ 154
Keighley Corporation	June 2	169	— 51	9	1,569	— 1
Kidderminster & District	May 27	102	+ 5	21	1,933	+ 180
Kilmarnock Corporation	June 4	146	— 5	3	433	— 17
Lanarkshire Trams Co.	,, 2	1,378	+ 147	22	29,749	+ 3,262
Lancashire United	,, 1	1,215	— 247	22	27,690	+ 256
*Leamington	May 27	157	— 16	21	3,119	— 16
Leeds Corporation	June 4	6,868	— 1,133	9	65,012	+ 1,728
Leicester Corporation	,, 4	2,297	— 390	..	..	..
Leith Corporation	,, 4	608	— 7	3	1,795	— 20
Lincoln Corporation	,, 4	114	— 28	10	1,257	+ 5
Liverpool Corporation	..	..	..	..	..	..
Liverpool Overhead Rly.	,, 5	1,343	— 194	23	30,693	+ 595
Llandudno&ColwynBayRy.	..	..	..	..	..	..
*London County Council	May 28	42,059	+ 5,467	¶8	347,262	+ 49,834
London United	June 4	6,667	— 2,983	22	132,284	+ 7,228
Lowestoft	,, 4	174	— 88	35	5,412	+ 254
Maidstone Corporation	,, 4	160	— 91	9	1,530	— 233
Manchester Corporation	,, 4	15,266	— 1,933	9	141,936	— 291
Mersey Railway	,, 4	1,994	+ 13	22	44,468	+ 1,112
Merthyr	May 27	210	— 4	21	4,135	— 130
Metropolitan Dist. Railway	June 4	10,778	+ 447	22	239,799	+ 23,424
Metropolitan Elec. Trams	May 27	7,621	+ 935	21	148,413	+ 29,380
Middleton	,, 27	495	+ 147	21	6,216	— 317
Nelson Corporation	June 4	135	— 24	§9	1,316	— 40
Newcastle-on-Tyne Corp.	,, 4	3,825	— 345	¶9	35,184	— 1,973
Newport (Mon.)	,, 4	673	— 160	10	6,777	+ 114
Northampton Corporation	,, 3	494	— 73	§9	4,469	— 164
Oldham, Ashton & Hyde	May 27	636	+ 62	21	11,335	+ 6
Oldham Corporation	June 5	1,777	— 45	10	19,143	— 1,147
Perth (N.B.) Corporation	,, 1	159	— 6	§2	405	+ 15
Perth (W.A.) Elec. Trams	,, 3	1,494	+ 162	22	34,433	+ 2,640
Peterborough	May 27	105	— 15	21	2,198	+ 34
Portsmouth Corporation	June 4	2,035	— 582	9	17,796	— 1,403
Potteries	May 27	1,634	— 260	21	36,322	— 281
Preston Corporation	June 1	600	— 357	..	..	..
Rotherham Corporation	,, 2	568	— 233	9	5,527	— 135
Rothesay	May 27	206	+ 75	21	1,791	+ 6
Salford Corporation	..	..	..	..	..	..
Sheerness	,, 27	45	— 7	21	909	— 11
Sheffield Corporation	June 5	5,763	— 561	¶10	61,378	+ 2,900
Singapore Trams	,, 4	$9,079	— $438	22	$218,411	+ $4,765
South Metropolitan	May 27	859	— 75	21	16,153	+ 1,144
South Staffs	,, 27	770	— 48	21	17,183	+ 227
Southend Corporation	June 1	522	— 206	9	4,354	+ 168
Southport Tramways	May 27	387	+ 113	21	5,519	+ 423
Stalyb'dge, Hyde, &c., Jt. Bd.	June 4	673	— 265	¶9	6,475	— 1,047
Sunderland Corporation	,, 5	1,133	— 266	10	10,294	— 644
Sunderland District	,, 1	407	— 244	31	13,883	— 1,080
Swansea Trams	May 27	1,038	+ 91	21	21,204	+ 2,659
Swindon Corporation	June 1	126	— 32	..	..	..
Taunton	May 27	41	+ 2	21	844	+ 113
Tynemouth and District	,, 27	241	+ 14	21	3,654	+ 490
Tyneside Trams Co.	June 1	400	— 148	22	8,623	— 328
Wallasey District Council	,, 4	908	— 208	§9	8,367	— 558
Walsall Corporation	,, 4	495	— 164	22	11,726	+ 569
Warrington Corporation	May 26	371	— 8	8	3,030	+ 50
West Ham Corporation	,, 26	2,525	+ 100	8	19,430	+ 528
Weston-super-Mare	,, 27	128	+ 21	21	1,328	+ 179
Wolverhampton Co.	,, 27	377	— 27	21	8,665	+ 406
Wolverhampton Corpn.	June 1	833	+ 469	9	8,039	+ 1,393
*Worcester	May 27	282	+ 7	21	5,343	+ 202
Wrexham	,, 27	96	+ 2	21	1,993	+ 52
Yorkshire W.R. Trams	June 5	1,142	— 534	23	28,191	..
Yorkshire Woollen District	May 27	940	— 3	21	20,095	+ 2,110

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	NAME.	Price Wed., June 8	Rate per cent. Yielded.	Dividend Due.	Business Week to June 8 Highest.	Business Week to June 8 Lowest.
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9½	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 15 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼—7¾	6 9 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7 —7½	4 13 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	98 —101	3 19 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾—4½	5 18 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 17 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —100	4 0 0	Jan, July	98½	98
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101⅛—103½	4 7 0	..	103	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¾—4½	5 3 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜—4½	5 9 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	102½	102
10	9/0	City of London Electric Lighting Ord.	11¼—11½	5 19 0	Feb, Aug	11⅞	11½
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 —103	4 7 6	Jan, July	101¼	..
5	..	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾—3½	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7½—8	6 0 0	Feb, Aug	7⅛	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾—11⅛	5 5 0	Mar, Sept	11⅛	11⅛
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	105 —108	4 3 6	Jan, July	107½	105
St.	4½%	Do. Second Deb. Stock	98 —101	4 9 0	May, Nov	100½	100
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4½	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	7⅜	..
5	4/0	Kensington & Knightsbridge Ord.	6¾—7½	5 10 6	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5¾—6½	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94½—96½	4 3 6	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —99	4 1 0	April, Oct	98½	98
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4¼—5½	5 14 6	Mar, Sept	4⅜	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	92 —94	4 4 0	Jan, July	93½	..
5	2/6	Metropolitan Electric Sup. Ord.	3¼—4	5 9 0	April, Oct	3⅝	3½
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¼—4½	4 12 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	86	..
St.	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	97 —99	4 11 0	June, Dec	..	..
100	4/0	Newcastle Elec. Supply Ord.	4¼—4½	4 7 6	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾—4¾	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	99 —101	4 19 0	..	..	..
10	9/0	Notting Hill Electric Ord.	11⅞—12¼	5 17 6	March	..	..
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	6⅞	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8¼—8½	5 9 6	Feb, Aug	8¼	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7¼	4 15 0	Feb, Aug	7	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	85 —88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2½—3½	6 11 0	April	..	..
St.	5%	Do. 5 % 1st Mort. Stock (red.)	101 —104	4 16 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—⅜	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1 —1¼	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	¾—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	2⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oc	81	..
5	5/0	Westminster Elec. Sup. Ord.	7⅞—8½	5 14 6	Mar, Sept	8⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	5⅛	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97	96½
1	..	Bath Elec. Trams Pref. Ord.	¾—⅞	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅞—1	6 13 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock	83 —86	5 5 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6¾—7	8 11 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7¾—8	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¾—1¼	..	June, Dec	..	..
10	3%	Do. 6 per Cent. Cum. Pref.	2¾—3¼	8 10 0	Feb, Aug	..	..
St.	5%	Do. 5 Cent. Perpetual Debs.	89 —92	5 8 9	April, Oct	90	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	66 —71	6 7 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	71 —73	5 3 6	Feb, Aug	71	70½
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	87⅛	87
St.	2%	Do. Deferred Stock	53 —55	3 12 0	Feb.	53½	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	95 —97	4 2 6	Jan, July	96⅛	96
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4½—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	33 —34	3 12 0	Feb, Aug	33½	33½
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	103½	102
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	98 —100	4 0 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 —97	4 2 6	Jan, July	96½	96
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	74½	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	69 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞—1⅛	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	60 —65	6 3 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9½—10	6 0 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2½—2¾	..	Jan, July	2⅜	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 —71	5 12 0	Jan, July	68½	68½
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅞—1⅛	..	..	..	..
1	..	Do. Deferred	⅞—1⅛	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	5 11 6	Feb, Aug	⅞	¾
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 —100	5 0 0	Jan, July	..	..
St.	1%	Metropolitan Railway Consolidated	41⅞—42¼	2 6 6	Feb, Aug	42⅛	41⅛
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	67½	66
St.	3½%	Do. 3½ per Cent Preference	89 —91	3 17 0	Feb, Aug	90½	89½
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	86½	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87½	86½
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	J	93½	92½

* In calculating he yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. . ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Wed., June 8	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to June 8. High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 0	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.	23⅛—23⅜	..	Feb, Aug	23⅛	23⅛
St.	..	Do. Extension Pref. (5 per Cent.)	70 —72	..	Feb, Aug	70½	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	71⅛	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	103	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	103½	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	142 —144	4 3 3	Jan, July	143½	..
St.	4%	Do. 4 per Cent. Ditto	96 —98	4 1 0	Jan, July	..	..
1	4½	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—¼	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	82 —85	5 5 3	May, Nov	..	..
1	..	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	¾—1	..	..	..	..
St.	4%	Dc. 4 per Cent. Deb. Stock	68 —72	5 11 6	Jan, July	69½	69
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	58 —63	7 18 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoups	38 —40	..	June, Dec	38⅛	..
..	5%	Do. 5% Prior Lien Bonds	100½—101½	4 18 6	..	101¼	100¼
..	4½%	Do. 4½% Bonds with coup. 5	89 —91	4 19 0	..	89⅛	89⅛
..	4%	Do. 4 per Cent 1st Power Ho. Dbs.	97 —99	4 1 0	..	99	98¼
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¾—1	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—2¼	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	79 —82	5 10 0	Jan, July	80½	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101½—103½	4 7 6	..	..	..
1	..	Aron Electricity Meter Ord.	⅛—⅜	..	..	..	..
1	7½d.	Do. 6% Cum. Pf.	⅜—½	6 8 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.	5⅛—5⅜	5 15 9	April, Oct	5⅛	5⅛
1	0/7½	Do. Pref.	1⅞—1⅞	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7	7 3 0	July, Feb	6⅝	..
5	3/0	Do. 6 per Cent. Pref.	5⅞—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅜—⅝	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	98½—100½	5 19 6	..	99⅛	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	59 —62	3 4 6	Jan, July	59⅛	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	25 —29	15 10 0	Jan, July	..	..
5	10/0	†Callender's Cable Con. Ord.	9½—10½	6 8 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 13 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	102½—104½	4 6 0	Nov, May	..	..
1	1/3	†Castner-Kellner Alkali Co.	2⅛—2⅛	5 7 6	May, Nov	2⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	106 —109	4 3 6	Feb, Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
1	0/7½	Consolidated Electrical Co.	¼—½	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.	¼—1	7 0 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	¼—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	⅛—¼	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¾—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	⅞—1⅛	5 0 0	Sept. ..	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	¾—1¼	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	⅛—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1½	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	74 —77	5 16 6	Jan, July	..	..
2	..	Electric Construction Co.	¾—⅞	..	Jan, July	⅞	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	61 —66	6 1 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅛—8⅛	6 1 6	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	11⅞—12⅛	6 6 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5⅛	4 3 9	Feb, Aug	5⅛	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. Stock	103½—105½	4 5 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Works	14½—15½	6 9 0	Feb, Aug	14⅛	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10⅛—10⅝	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	98⅛	..
1	..	National Elec. Construction Co.	¼—½	..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—¼	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	30/0	Telegraph Construction & Maintenance	32½—34½	5 17 0	Mar, July	34	33½
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100½—102½	3 17 6	Jan, July	101	100½
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	4 11 0	..	2⅛	2⅛
1	0/6	Dc 5 per Cent. non-Cum. Preference	1⅛—1⅛	4 0 0	..	1⅛	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108 —111	4 10 0	..	110½	109½
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	101 —103	3 7 6	June, Dec	..	101½
100	4½%	†Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	104½	103½
100	5%	†Do. 5 per Cent. 3rd Mort. Debs Scrip.	103½—105½	4 15 6	..	104½	..
10	8%	J. G. White & Co. 6% Cum. Pref	9½—10½	7 12 0	..	..	..
1	..	Willans & Robinson Ord.	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1½—1⅝	10 13 6	Apr, Oct	1⅝	..
St.	4%	†Do. 4 per Cent. 1st Mort. Debs.	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3¾—3¾	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100½—102½	4 17 6	June, Dec	..	..
St.	15/0	Anglo-American	64 —66	5 11 0	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	104 —105	5 14 6	F,My,Ag,N	105½	105
St.	25/0	Do. Deferred	27½—27⅝	4 14 0	F,My,Ag,N	25⅛	27
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	86 —88	4 10 9	Jn,Ap,Jy,O	87	86
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	8½	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 12 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3½—3¾	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable	14⅞—15½	5 16 3	Ja,Ap,Jy,O	16½	14⅞
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.)	100 —102	4 18 0	June, Dec	..	..
St.	65/0	Eastern Ordinary	133 —136	5 3 6	Ja,My,Jy,O	135	133
St.	17/6	Do. 3½ per Cent. Pref. Stock	85 —87	4 0 6	Ja,My,Jy,O	86½	85½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	101 —103	3 17 6	May, Nov	..	..
St.	6/6	Eastern Extension	12⅞—13½	5 7 6	Ja, Ap, Jy,O	13⅛	12⅞
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101½	3 18 6	May, Nov	99⅛	..
10	26/0	G.N (of Copenhagen), with Coupon 79	30½—31½	6 0 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt.Db.(red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	Mackay Companies Common	90 —93	4 16 6	Ja,Ap,Jy,O	..	..
100	4%	Do. Preference	77 —80	5 0 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛—⅜	..	April	⅛	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	97 —99	3 19 0	June, Dec	96	..
2½	1/3	West Coast of America	1⅞—1⅞	4 1 6	May	..	..
100	4%	Do. 4 per Cent. Debs.	98½—100½	3 19 0	Jan, July	..	..
10	..	West India & Panama	⅛—⅜	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9½	6 11 3	May, Nov	..	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	100½—102½	4 17 6	Jan, July	102⅛	102
10	3/0	Western Telegraph	13¼—14½	4 18 0	Mr,Jn,O,D	14⅛	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	..	..
—	1%	Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	—	—	—
		Telephones.					
		Amer. Telephn. & Telegh. Cap. St.	138 —140	5 14 6	..	..	..
		Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	..	..
		Do. 4% Cons. Bonds 1936	103 —105	3 15 6	..	..	..
		Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
		Chili Telephone	7½—8⅛	4 15 9	August ..	..	..
		Monte Video Telephone Ord.	⅛—¼	7 0 0	Nov	..	..
		Do. 5 per Cent. Pref.	⅜—½	5 14 6	May, Nov	..	..
		National Co. Pref. Stock	104½—105	5 14 6	Feb, Aug	105	104⅜
		Do. Def. Stock	124 —126	4 15 0	Feb, Aug	125	124
		Do. 6 per Cent. Cum. 1st Pref.	10 —10⅜	5 10 6	Feb, Aug	10	..
		Do. 6 per Cent. Cum. 2nd Pref.	10 —10⅜	5 10 6	Feb, Aug	10⅜	10
		Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5½	4 11 0	Feb, Aug	5⅛	5⅛
		Do. Deb. Stock 3½ per Cent. (red.)	97½—98½	3 11 0	June, Dec	..	..
		Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	Jan, July	100½	100
		New York Telephone Co. 30 yr. Bnds.	97½—98½	4 11 9	..	98⅛	97½
		Oriental	1⅛—1⅛	4 15 0	April, Oct	1⅛	..
		Do 6 per Cent. Cum. Pref.	1⅛—1⅛	4 11 0	April, Oct	..	..
		Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	..	..
		Telephone Co. of Egypt 4½%Db.Stk.(red.)	100½—102½	4 8 6	Jan, July	..	..
		United River Plate	7½—7⅜	5 9 0	July	7⅜	7½
		Do. 5 per Cent. Cum. Pref.	5⅜—5⅞	4 12 3	June, Dec	..	..
		Do. 4½ Deb. St. Red.	103 —105	4 5 6	Jan, July	..	..
		Financial, Investment, &c.					
		Elec. & Gen. Investment 6% Cum. Pref.	2⅞—3⅜	8 18 0	Jan, July	..	..
		Globe Telegraph & Trust	10⅛—10⅝	5 11 6	Sp,DcMrJu	10⅜	10⅛
		Do. 6 per Cent. Pref.	13 —13½	4 8 9	Sp,DcMrJu	13⅜	13⅛
		Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4⅜—4⅜	5 3 9	April, Oct	4⅜	4⅜
		Do. 5% Cum. 2nd Pref.	4⅛—4⅜	5 9 6	Jan, July	..	..
		Do. 4% Deb. Stock	90 —91½	4 7 6	June, Dec	91½	90½
		Do. 4½% Deb. Stock	96 —98	4 12 0	..	97½	..
		Auckland Elec. Trams. 5% Deb. (red.)	105 —107	4 13 6	Jan, July	105	..
		Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	..	..
		Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 13 9	May, Nov	5⅜	..
		Do. 4½ per Cent. Db. Prov. Certs.	101 —104	4 6 6	Jan, July	104	103½
		British Columbia El.. Rly. Df. Ord.	142 —147	5 9 0	Mar, Sept	143½	..
		Do. Pref. Ord. Stock	122 —126	4 15 0	May, Nov	125⅜	123⅞
		Do. 5% Cum. Perp. Pref. Stock	109 —112	4 9 6	Jan, July	111	110½
		Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
		Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
		Do. 4½% Perp. Con. Deb. St.	104 —105	3 19 0	..	105¼	105¼
		Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	..	..
		Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	..	..
		Calcutta Tramways (1 to 137,610)	4½—4⅜	4 4 3	Mar, Sept	4⅛	4⅛
		Do. 5 per Cent. Cum. Pref.	4⅜—5	5 0 0	Jan, July	..	..
		Do. 4½% 1st Deb. Stock (red)	98 —101	4 9 0	Jan, July	..	..
		Cape Electric Tram Shares	⅛—¼	..	..	⅛	..
		City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 9 6	F,My,A,N	5⅜	..
		Do. 4 per Cent. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
		Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 —97	5 2 6	May, Nov	..	..
		†Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	78 —81	6 3 6	June, Dec	..	..
		Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	96 —99	5 1 0	Feb, Aug	..	..
		Kalgoorlie Elec. Trams Sh.	⅛—⅜	..	..	..	..
		Do. 5 per Cent. "A" Deb. Stock	96 —98	5 2 0	Jan, July	..	..
		Do. 6 per Cent. "B" Ditto	74 —78	3 17 0	Jan, July	..	..
		Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
		Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
		Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
		Manaos Trams and Lt. Co. 5% Debs.	88½—90	..	..	89¼	89
		Manila Elec. Ry. $1,000 Gold Bonds	95 —97	5 2 6	Feb, Aug	..	..
		Mexico Trams Co. Com. St.	127½—129½	4 18 6	..	128⅛	127½
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	98 —99	5 1 0	..	99⅛	97⅝
		Do. 6% 50 yr. Mort. Bds.	100 —101	5 19 0	..	101	100
		Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	..	..
		Perth Elec. Trams Ord.	⅛—⅜	5 14 0	May	..	..
		Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
		Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 2 6	..	..	..
		Do. 4½% 1st Mort. Deb. Stk.	99 —101	4 19 0	..	..	..
		Ric Janeiro Tram. Lt. & P. Co.	95 —97	4 2 6	..	95⅜	95⅛
		Do. 30 yr. Gold Bnds.	98½—99½	4 0 6	..	99⅛	98⅜
		Do. 50 yr. Mt. Bnds	87½—88⅜	5 13 0	..	88⅛	88
		Sao Paulo Tramway, Light & Power Co. $100 Stock	149 —151	6 13 6	..	149⅜	..
		†Do. 5 per Cent. 1st Mt. $500 Db.	101½—102½	4 16 6	June, Dec	102⅛	102⅛
		Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
		Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅜—5⅞	5 2 0	Mar, Sept	..	..
		Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 9 0	..	10⅝	10⅜
		Do. 4½ per Cent. Deb. Stk. (red)	95 —97	4 12 6	Jan, July	96	..
		Do. 5 per Cent. 2nd Mort. Deb. Stock	96 —98	4 18 0	..	..	..
		†Calcutta Elec. Supply Ord.	6⅛—7⅛	5 12 6	April, Oct	7	6⅛
		Canadian Gen. Elec. Co. Com. St.	107 —111	6 6 0	..	..	..
		Do. 7% Cm. Pf. Stock	119 —122	5 14 6	..	119½	..
		Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	99 —103	4 17 6	Jan, July	..	..
		Elect. Development Co. of Ontario	82½—85½	5 15 6	..	84½	..
		Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	89	..
		Indian Elec. Sup. & Trac. Co.	1⅜—1⅞	..	..	..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	⅜—½	..	..	..	..
		Do. 6 per Cent. Cum. Pref.	⅜—½	8 0 0	April, Oct	..	..
		Kaministiquia Power Co.5% Gold Bnds.	102 —104	4 16 6	..	103½	102½
		Madras E. S. Corp. Ord.	2½—3½	..	..	2⅝	..
		Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
		Do. 5% 1st Mortg. Deb. Stock	92 —94	5 6 9	..	..	..
		Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	83 —85	5 16 3	..	85⅜	..
		Mexican Lt. & Power Co. Com. St.	80 —82⅛	4 17 6	..	81	79⅛
		Do. 7% Cum. Pref. St.	103 —105	6 13 6	..	104⅛	104
		Do. 5% 1st Mort. Gold Bnds.	90 —91	5 10 0	..	91	89⅞
		Montreal Lt. Ht. & Power Co. Cap. St.	133 —137	4 18 0	F,My,A,N	134⅛	..
		River Plate Electricity Co. Ord.	2⅛—2⅜	5 12 9	April	2⅛	..
		Do. 6 per Cent. non-Cum. Pref.	1⅜—1⅜	4 17 0	May	..	..
		Do. 5 per Cent. Deb. Stock	103 —105⅜	4 15 6	Jan, July	..	..
		Rosario Ele . Co. Ord.	8½—9	..	..	..	..
		Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
		Do 2nd Pref.	8¾—8⅞	6 14 6	..	..	..
		Shawinigan Water & Power Co.Ca.	101 —103	4 [illegible]	..	101⅜	101⅛
		Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	108⅛	108
		†Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102⅜	102
		Toronto Power Co. 4½% Db. St.	101 —103	4 7 3	..	102	101⅛
		Victoria Falls Power Co. Pref.(1 to 803,000)	⅞—1	5 6 6	Jan, July	..	..
		Do. (803,081 to 1,700,000)	⅞—1	..	..	..	..

[illegible] the yield allowance has been made for accrued interest but not for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,674. [No. 10, Vol. LXV.] FRIDAY, JUNE 17, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90s., or 80m.

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NOTES.

Mr. Lackie's Address.

As was only natural, Mr. W. W. LACKIE, in his presidential address to the Incorporated Municipal Electrical Association, touched upon some of the "burning questions" of electricity supply. One of these was depreciation. Mr. LACKIE'S view is that depreciation should be met by a sinking fund properly calculated. Any loss in efficiency should be met by the depreciation fund if the ordinary maintenance out of revenue is not sufficient to provide for this; in other words, loss in efficiency should be a running charge, such as repairs and maintenance. Obsolescence, in Mr. LACKIE'S opinion, does not involve depreciation, but a prudent authority may see the advantage of setting aside a sum for providing more up-to-date plant as may seem desirable. Perhaps the only difficulty in a classification of this kind is to distinguish sharply between the different classes in every case.

IT is well known that American engineers make a point of supplying light rather than energy. Mr. LACKIE is inclined to support this policy, and he suggests that a new lamp might be given to the consumer for every 100 or 200 units used. Since satisfaction depends, partly at least, on the goodness of the illumination, there is certainly something to be said in favour of the idea. The British public, however, are essentially conservative, and for that reason it is doubtful if the change would be welcomed. It might, perhaps, be felt that the liberty of the subject was being molested. What, we wonder, would have been the attitude of the supply authority if this system had been in force when the metal filament lamp made its appearance, and to what extent would the consumer have benefited? The subject is, of course, closely connected with tariffs, on which Mr. LACKIE also made some remarks. He evidently thinks that flat rates may make progress, but they must be based on the maximum demand of each particular class. There is no doubt that a flat rate appeals to the consumer, who, as Mr. LACKIE remarks, is liable to remember the high-priced units at 3½d. for 730 hours per annum and to forget all the cheap units at ¾d. In such cases a flat rate of, say, 2½d. per unit might seem a much better bargain.

Reflectors for Street Lighting.

THE technical success, or otherwise, of street lighting, so far as electric lamps are concerned, is to no small extent connected with the distribution of the light; and whilst popular impressions will not entirely be disregarded, the increasing attention now being paid to the science of illumination is likely more and more to make itself felt when decisions have to be reached between the claims of electrity and gas for street lighting. That this should be the case is certainly the wish of electrical engineers, since questions of the minimum illumination provided and the effective distribution of light have in the past been frequently discounted, if not entirely disregarded, by committees in coming to a decision on the merits of different schemes for public lighting. The introduction of dioptric globes has undoubtedly placed the flame arc lamp in a stronger position by enabling the rays of light to be distributed more effectively over the area illuminated. Now that metal filament lamps are coming into very extensive use for street lighting and lamps of higher candle-power are being employed, the question of reflectors is likely to become increasingly important. This point is emphasised by a Paper (given in abstract elsewhere) in which Dr. CLAYTON SHARP describes a novel form of reflector.

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THIS reflector has been designed primarily for the illumination of suburban streets and sparsely populated districts, where the lamps are necessarily spaced rather far apart, and where it is very important that the illumination should be effective at some distance from the sources of light. In this particular, gas lamps are very deficient, the illumination, as shown by a photometer, being very patchy. The facilities afforded by electric lamps for distributing the light by means of reflectors are likely to be more and more appreciated in the future, and the type of reflector introduced by Dr. SHARP for securing the most effective illumination is certainly worthy of careful consideration by illuminating engineers. By using the polished metal type of reflector the author claims that a gain of from 200 to 300 per cent. is obtained in the effect. Engineers, however, will probably have to experiment with these reflectors for some time to ascertain if the glare is a serious disadvantage. In this connection, it was mentioned in the discussion following the reading of the Paper that when a lamp is placed so high that its light reaches the eye at an angle from the horizontal of not less than about 26 degrees, tests showed the glare to be practically nil.

Metering Large Demands.

WHERE the price of electrical energy involves a charge based on the maximum demand of the consumer it is obvious that the method of determining the demand is of considerable importance to large power users. As overloads of short duration are not usually of great consequence to the supply authority, it is customary to use demand indicators having a considerable time lag—that is to say, the instruments do not attain their full reading unless the load is maintained for several minutes. The Commonwealth Edison Co., of Chicago, who are one of the largest suppliers of electrical power in the world, and who sell energy in bulk to several large traction undertakings, have, in the case of large consumers, for some time based their annual fixed charge per kilowatt (occasionally as low as £3) on the maximum demand as given by the greatest consumption of energy in any individual hour; an additional charge based on the number of units used (and ranging from about 0·2d. upwards) being also made. For ascertaining this demand it is necessary to read the energy meters registering the supply at intervals of one hour, such intervals having, of course, to be observed with great accuracy. Efforts have naturally been made to record the meter indications automatically, with the result that a printing attachment has now been developed. This attachment can be applied to most types of meters, and prints on a strip of paper the actual reading in kilowatt-hours at any desired intervals, say, five minutes, quarter of an hour, or longer periods. From these readings the consumption during the periods in question can be ascertained. In its latest form this attachment can be fixed on a separate panel and is electrically connected to the meter of which the indication is to be recorded. It is interesting to notice that by means of these readings it is easy for the supply authority to ascertain the period of the day at which the maximum demand of the consumer occurs; and this information will, undoubtedly, prove of considerable value in determining the price at which energy can be supplied.

Transatlantic Cable Negotiations.—Many rumours have appeared in the public press during the past week concerning the alleged outcome of negotiations between the Anglo-American Telegraph Co., London, and others. We are able to state that, so far as any result is concerned, there is no accuracy in any one of the statements made. Certain negotiations are in progress, but no result had, at the time of our going to press, been reached.

Electricity Meter Approved by the Board of Trade.—On June 8th the Board of Trade approved of the pattern and construction of the continuous-current meter, No. 50,015, deposited at the Board of Trade on Nov. 26, 1908, by the Aron Electricity Meter, Ltd., and known as the Aron D.C. Watt Hour Meter, Type W.M., provided that the meter be tested, fixed and used as described in the specification and instructions dated June 3, 1910, and numbered H.7493.

Electric Traction in Germany.—According to the "Railway Gazette," plans are being drawn up for the construction of a new high-speed electric railway in Berlin and environs, which, starting in the north of the city, will extend to the suburbs of Reinickendorf, Wittenau, Tegel, Waidmannslust, Hermsdorf and Frohnau. The local authorities concerned have declared themselves willing to give the necessary land free of charge for any portions of the railway built as a surface line, and also to contribute part of the capital expenditure. The question of an interest guarantee is also being discussed. The line is being promoted by the Bergmann Electrical Co., of Berlin, and will, if constructed, form a useful supplement to Berlin's traffic facilities.

The Royal Society—On Thursday June 9th H.M. the King received an address from the Royal Society, which was presented by a deputation consisting of Sir A. Geikie, president, Sir A. Noble, vice-president, Mr. A. B. Kempe, treasurer and vice-president, Sir Joseph Larmor and Prof. J. R. Bradford, secretaries, and Sir W. Crookes, foreign secretary, with Mr. R. Harrison, assistant secretary, bearing the mace.

In the address the following interesting passage occurs :—

We are proud to remember that no less than 47 years ago King Edward was graciously pleased to enter the Fellowship of the Royal Society, and later, on his Accession to the Throne, to become our Patron.

Your Majesty enters upon the duties of your high station with a wider personal knowledge of the Empire and its various peoples than was ever possessed by any previous Sovereign of this country. Your subjects have had many proofs that this extended knowledge has been accompanied by an active sympathy with every cause and movement that will promote their welfare and happiness. The interest which your Majesty has shown in the progress of discovery and invention assures us that these elements of national greatness will continue to receive your favour and protection.

His Majesty replied as follows :—

I thank you for the loyal address of condolence from the president, Council and Fellows of the Royal Society on the death of my beloved father. It is a consolation to feel that your Society, numbering amongst its Fellows the most distinguished men of science of this country, sympathises with me in my terrible bereavement.

Your words of appreciation of the character of the late King are very welcome to me. He always regarded with the deepest interest those scientific discoveries and those applications of discoveries already made, which have been of such supreme importance in the advancement of civilisation. I also have watched with close attention the work of your Society, and it is my sincere hope that its prosperity will continue, and that a Fellowship of the Royal Society will always be esteemed one of the highest honours which can be earned by devotion to the cause of science.

I desire to thank you most cordially for your congratulations on my Accession to the Throne, and to assure you of my sympathy and support in your beneficient efforts for the promotion of natural knowledge. I gladly accede to your request that I should inscribe my name as Patron in your charter book.

Cable Interruptions and Repairs.

	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Suakim—Jedda	May 6, 1910
Madagascar—Reunion	May 12, 1910
Reunion—Mauritius	May 20, 1910
Lattaquie—Talura	May 26, 1910

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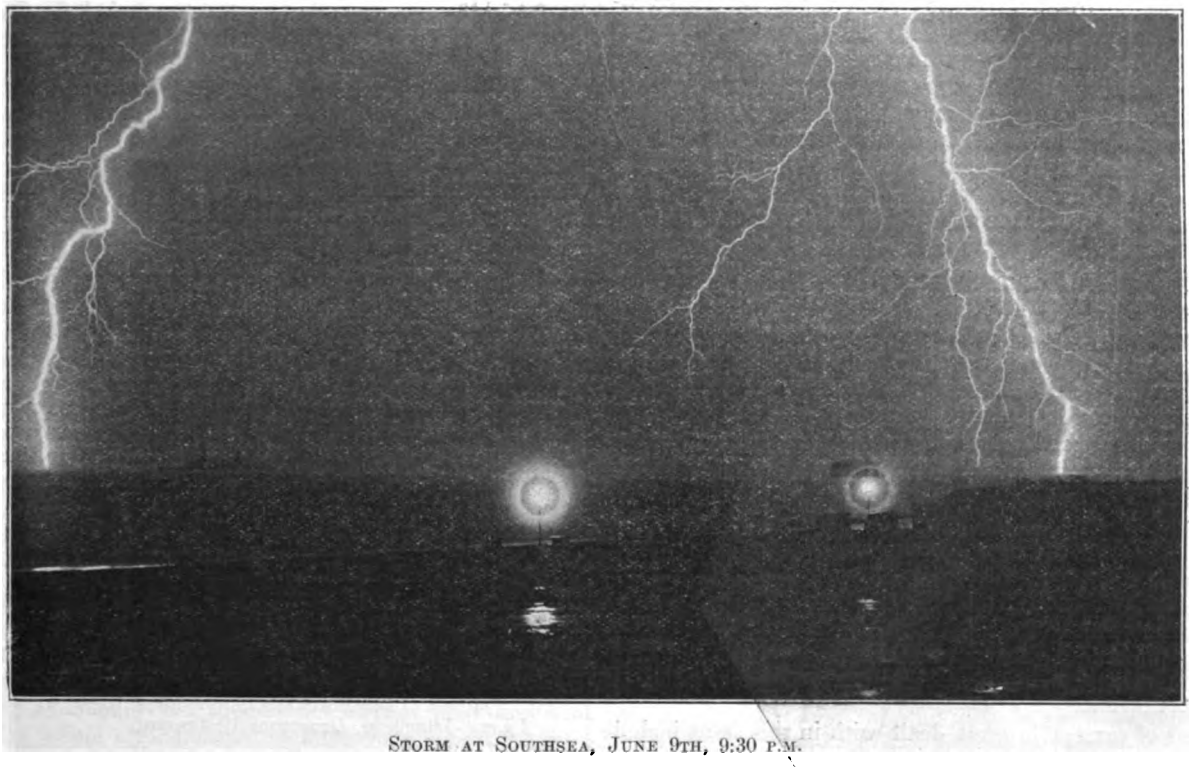
Tramway Development in Germany.—In an article in a recent issue of the "Elektrotechnische Zeitschrift" Mr. G. Dettmar gives statistical data of the position of electric tramways in Germany in 1908. The total length of the electric tramways is 2,575 miles, the total rating of the generators, 143,822 kw.; that of the storage batteries, 39,262 kw.; the number of cars, 20,249; the capital invested, £54,580,600. The average interest earned on the capital invested is 4·34 per cent. The values of interest in different parts of Germany vary greatly; the interest is lowest in the Province of Eastern Prussia, namely, 2·29 per cent., and highest in Hamburg, namely, 8 per cent. The average interest earned by tramways not operated electrically is 3·19 per cent. The total number of annual car-miles is 362,118,750, the total number of seats in the cars 622,635, the total number of passengers per year 2,103,119,000, the average number of passengers per kilometre 555,200, the average receipts per mile £2,800, the average cost of operation per mile £2,080, the average receipts per passenger 1½d., and the average cost of operation per passenger 1d.. About 82 per cent. of the German street railways are operated electrically.

Lightning Flashes.—The thunderstorms of unusual severity which were experienced in most parts of this country last week doubtless provided many opportunities to photographers for obtaining interesting records of lightning flashes. A striking example is reproduced herewith. This was taken at Southsea at 9:30 p.m. on Thursday, June 9th, by Mr. W. H. V. Marshall. The plate was exposed for five or six seconds, so that the lights on the ship (H.M.S. "Invincible"), on the Spit Fort and on the parade are clearly shown in the photograph. The two main lightning flashes in the field of view were practically simultaneous, and a very fine record of electric discharges has undoubtedly been secured. Attention may be called to the fact that the halos surrounding the arc lamps are due to the rain and could be seen with the naked eye, being similar to the familiar lunar halo.



Storm at Southsea, June 9th, 9:30 p.m.

Electric Heating and Pyrometry.—The Tyndall lectures at the Royal Institution have this year been delivered by Prof. J. A. Fleming, F.R.S., and where on the subject of electric heating and pyrometry. In the first lecture, on June 4th, Prof. Fleming considered electric furnaces based on resistance heating, describing their many applications, such as the production of carborundum, quartz glass, the reduction of aluminium from its ores, &c. After discussing induction furnaces and arc furnaces the lecturer passed on to electric heating apparatus, in which moderate temperatures are required. In this connection, "Silundum" heaters, the Bastian heater, the "Tricity" cooker, the Siemens heater and others were referred to; and the question of relative cost of electric and gas heating was then considered. To raise one pint of water from 60 deg. to boiling point requires about 56 watt-hours; for this work the "Prometheus" saucepan, Prof. Fleming stated, required about 60 watt-hours, a "Prometheus" kettle 65 watt-hours, and a large Isenthal immersion heater 66 watt-hours; whilst a gas ring with "Kwik" kettle used the equivalent of 89 watt-hours and a gas ring with ordinary kettle 99 watt-hours. Theoretically, the combustion of 1 cubic ft. of ordinary gas produced an amount of heat equivalent to 160 watt-hours; on this basis, with gas at 2s. 9d. per 1,000 cubic ft., the cost of heating a pint of water from 60°F. to 212°F. would be about ¼d. In practice, however, this figure was increased three times, making the cost about the same as with a good electric heater using electrical energy at 1d. per unit. To obtain the best results, the supply companies would favour some system of thermal storage, such as the "Therol" heater. In conclusion, the lecturer stated that until the price of current fell there was little prospect of an extensive adoption of electricity for domestic heating, but so far as cooking was concerned much depended upon the cost and durability of the apparatus. In the second lecture, on Saturday last, Prof. Fleming dealt with pyrometry. The two usual electrical methods of measuring temperature were by means of changes in electrical resistance and by the production of an E.M.F. at the junction of two metals. The various apparatus based on these two methods, viz., resistance thermometers and electric pyrometers, were described by the lecturer, who showed examples supplied by various firms. Amongst this apparatus was a direct reading thermo-couple pyrometer of Messrs. Crompton & Co., a quartz tube platinum thermometer of Messrs. Griffin & Son, the Féry radiation pyrometer of the Cambridge Scientific Instrument Co., and a platinum thermometer of Mr. R. W. Paul.

International Electro-Technical Commission.—We have received from the central office of this Commission a copy of the first annual report, which contains an account of the activities of the Commission up to December 31, 1909. The report is prefaced by a portrait of Col. R. E. Crompton, to-

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whose efforts towards the formation of the Commission a tribute is paid in the preface, while in the same preface attention is called to the work which the general secretary, Mr. C. Le Maistre, is doing. This preface is signed by Prof. Elihu Thomson, who has been president of the Commission since 1908. The annual report proper begins by an account of the preliminary meeting held under the presidency of Mr. Alexander Siemens in June, 1906, and also briefly describes the formal election of officers and the first council meeting held in London in 1908. The report goes on to point out that at the present time there are 15 properly constituted committees, of which two, however, are not in full operation. Most of these committees are formed under the co-operation and assistance of the government of the country. With regard to the progress of the work during the year under review, there has been a large amount of correspondence dealing solely with the general work. Besides this, progress has been made in the purely technical work, especially in regard to nomenclature, the unit of candle-power, symbols and standards of electrical machinery. Summaries of the annual reports of the various committees are also given. We may say that the report is printed in two languages, English and French, the former language being confined to the left, and the latter to the right hand pages, so that it becomes truly international in character. We are asked to call attention to an invitation from the Belgian Electro-Technical Committee, stating that they are organising a reception to be held at Brussels from August 8 to 13, and will take this opportunity to bring together the various members of the committees at two or three unofficial meetings, so that they may exchange views, and in this way assist in the preparations for the official meeting which is to be held at Berlin in 1911. Members of the committee in this country are requested to inform the Belgian authorities as soon as possible of their intention to attend.

Operation of an Accumulator Lorry.—According to the "Electrical World" a 4,000 lb. electric lorry was run from Boston to Manchester, U.S.A., recently on a single charge, the distance being 59 miles. Throughout the trip a load of 2,500 lb. was carried. The lorry made an average speed of 8·57 miles per hour on the trip. Between Boston and Nashua the roads were in good condition, but on the last part of the journey, 19 miles, hilly and sandy highways were encountered. No boosting of the battery was resorted to on the way. The lorry is the seventh machine of its kind to be purchased by the Amoskeag Co., who are understood to be securing decided economies with electricity compared with the horse traction formerly used in their yards. The lorries are used mainly for inter-mill service, and a feature of the work is the constant overcoming of heavy grades.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

We give a complete account, up to last evening (Thursday), of the proceedings at the Convention of the Incorporated Municipal Electrical Association, held this week at Glasgow. The presidential address was delivered by Mr. W. W. Lackie, and the following Papers were read: "Commercial Advancement of Electric Supply," by Mr. A. C. Cramb; "The Commercial Progress of Electricity Undertakings," by Mr. H. Collings Bishop; "Exhaust Steam Turbines and Condensing Plant at McDonald-road Station," by Mr. F. A. Newington; and "Mixed Pressure Turbines," by Mr. A. Bremner. Discussions also took place on "The Advantages of Continuous Records of Costs and of Steam Consumption," opened by Mr. G. Wilkinson and Mr. C. E. C. Shawfield, and on "Cheapening of the Cost of Mains and Services," opened by Mr. S. E. Fedden and Mr. S. J. Watson.

Mr. R. M. Neilson contributes an article on "The Effect of Vacuum on the Economy of Steam Turbines."

Mr. F. Fernie continues his article on Electrolysis of Underground Mains.

At a recent meeting of the New York Section of the American Illuminating Engineering Society, Dr. Clayton H. Sharp read a Paper on "A High Efficiency Reflector for Street Lighting."

Messrs. Harper Bros. are reporting upon a proposal to erect a large power station in the Kroonstad mining district, near Klerksdorp, and for the transmission of electrical energy to Kimberley, Jagersfontein, Bloemfontein, &c., for mining, traction, power and lighting.

Several L.G. Board inquiries were held during the past week into applications for sanction to loans for electricity supply extensions, including Newport, for £31,255; St. Helens, £10,230; and St. Anne's-on-the-Sea, £3,000.

Legal.—Mr. Justice Neville commenced the hearing of an action on Monday brought by the Attorney-General (at the relation of a Leicester ratepayer) against Leicester Corporation to restrain them from undertaking wiring work, &c. Judgment was reserved.

Companies' Meetings, &c.—The directors' report of the British Electric Traction Co. for the year ended March 31 (abstracted on another page) contains particulars of the financial position of the tramway undertakings owned by the Company and its associated companies.

INSTITUTIONS AND SOCIETIES.

FARADAY SOCIETY.—At the meeting of the Society on May 31st the following nominations for the offices and Council (1910-11), to be elected at the annual general meeting on July 12th, were announced:—*President:* Mr. James Swinburne, F.R.S. *Vice-Presidents:* Messrs. A. C. Claudet, S. Z. de Ferranti (President I.E.E.), R. T. Glazebrook, F.R.S., F. W. Harbord, Lord Rayleigh, O.M., F.R.S., Ernest Solvay, Prof. James Walker, F.R.S. *Treasurer:* Dr. F. Mollwo Perkin. *Council:* Messrs. E. J. Bevan, Bertram Blount, W. R. Cooper, Dr. J. A. Harker, F.R.S., Prof. A. K. Huntington, Dr. T. Martin Lowry, Robert L. Mond, W. Murray Morrison, H. K. Picard, Dr. G. Senter.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Mr. Dugald C. Jackson has been elected as president of the Institute for the ensuing year.

INSTITUTION OF ELECTRICAL ENGINEERS.—On Monday, June 20th, the Institution offices will be transferred from Victoria-street to the new home on the Embankment. All communications after June 23rd should be addressed to the Institution at Victoria Embankment, London, W.C. The new telephone number is Gerrard 764. The library will be closed until Sept. 1st, for reclassification; and the common room will not be ready for use before the opening of the new session.

IRON AND STEEL INSTITUTE.—As previously announced, the autumn meeting of the Iron and Steel Institute will be held at Buxton, on Monday, Tuesday, Wednesday, Thursday and Friday, Sept. 26th to 30th. An influential reception committee has been formed, with the Duke of Devonshire as chairman, Sir Alfred S. Haslam as vice-chairman, and Major A. Brown as hon. sec. A good selection of Papers will be read and discussed, and visits to various works have been arranged.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 17th (to-day).

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

10 a.m. Annual General Meeting in the Rankine Hall of the Institute of Engineers and Shipbuilders, Glasgow.

1 p.m. Luncheon, Grosvenor Restaurant.

TUESDAY, June 21st.

FARADAY SOCIETY.

8 p.m. Meeting in the Rooms of the Chemical Society, Burlington House, Piccadilly, W. Papers on (1) "Studies in the Electro-metallurgy of Ferro-Alloys and Steel," by Mr. P. Girod. (2) "The Failure of the Light Engineering Alloys, particularly the Aluminium Alloys," by Mr. E. F. Law. Exhibit of some new types of mercury vapour lamps by Dr. F. Mollwo Perkin.

WEDNESDAY, June 22nd.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Meeting at Great George-street, Westminster. Lecture on "Recent Developments of Telegraphy and Telephony," by Sir John Gavey, C.B. James Forrest Lecture.

The Corps of Electrical Engineers (London Division).

Officer Commanding, Col. R. E. Crompton, C.B.

The following orders have been issued for the current week:—

Monday, June 20th, "A" Company.—Technical drill 7 to 9:30 p.m.; rating examination for those who have been warned.

Tuesday, June 21st, "B" Company.—Recruits infantry drill 6:30 to 7:30 p.m., technical drill 7:30 to 9:30 p.m. Any N.C.O. or man who has not yet performed his qualifying drills is reminded that they should be performed before Camp.

Wednesday, June 22nd.—Gymnasium 6:30 to 9:30 p.m.

Thursday, June 23rd, "C" Company.—Examination for ratings for all N.C.O.s and men who have been warned.

Friday, June 24th, "D" Company.—Examination for ratings for all N.C.O.s and men who have been warned.

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ELECTRIC CABLES.*

ELECTROLYSIS.

BY F. FERNIE.

(*Continued from p. 283.*)

Summary.—The author first considers the general phenomena of electrolysis as observed in the neighbourhood of electrical networks. He then discusses in more detail the corrosion of lead-covered cables and armoured cables, and the effectiveness of earthing. Another cause of deterioration is electric osmose, which causes an accumulation of moisture at the negative conductor if there is any flow of current through the insulation. Finally, the causes of faults and measures for preventing them are considered. Faults may be classified into those of manufacture, those caused during laying, and those developed after the cables are laid. The last class is due to a number of causes, such as mechanical injuries, electrolysis and electric osmose, chemical action, overloading and decentralisation, high temperature, abnormal pressures and static discharges. Another cause of trouble is the accumulation of gas in manholes, causing explosions. The various ways in which gas may accumulate are considered and the remedies to be applied.

Causes of Faults; Measures for Preventing Them.

Speaking generally, cables used for alternating currents do not develop nearly so many faults as those used for continuous currents, and this in spite of the much higher pressures employed. Also, on a three-wire system, with earthed neutral, the negative cables break down sooner and to a greater extent than the positive cables. Moisture is to be avoided as much as possible, particularly on an earthed system and with leadless cables, and experience shows that it is much better for cables to be entirely submerged rather than merely wet. This is perhaps because the minute traces of chemicals that get deposited on the outside of the cable (as we think through electrolysis) rapidly diffuse away if there is any quantity of water present. Earthenware pipes, concrete, or brickwork tend to prevent diffusion, and thus cause an accumulation of salts on the surface of the cable. If it were practical, we believe it would be a good thing occasionally to flush out ducts containing leadless cables with clean water. Thus, in testing samples of vulcanised bitumen cables, with the insulation intentionally pared down to hasten the action, we have found the insulation to stand for long periods with 460 volts if the sample be immersed in a large volume of a neutral salt solution; but if it be put in a porous pot and packed in tightly with soil it will break down in a comparatively short time in the same solution.

Wishing to test samples of pitch and bitumen for use on a "solid" system, we installed bare conductors in stoneware troughs and filled in the troughing with the different samples, and connected the conductor to the negative pole of a three-wire system. In order to make the test as severe as possible, we wrapped another bare wire tightly round the outside of the troughing and connected this to the neutral pole, and then buried the whole arrangement. Under these conditions none of the samples would break down, we think because the soil was altogether short-circuited; by earthing the neutral a few feet away from the troughing we were able to break down some of the samples.

Leadless cables, particularly when in iron pipes, often break down close to the edge of the pipe. This is perhaps due to the fact that the protective action of the iron pipe, which is to make the path of any leakage current partly metallic, is impaired, and a current may flow through the insulation along wet tapes or braiding to the earth, its path being electrolytic. Similarly, cables are sometimes found to be faulty at definite equal distances spaced along the cable, these distances corresponding to the joints in the earthenware pipes, which if of cement provide a better earth for the cable than the body of the pipe. Negative faults always collect an akaline liquid round them, and it should be the custom of the mains foreman to test any trickle of water running down a duct into a draw box with pole-finding paper for alkalinity, its presence always indicating a faulty negative cable in the duct.

Faults on the positive and neutral wire (which is nearly always *above* earth potential) are generally acid, much drier and with the conductor corroded. The great object of the designer of joint boxes and other fittings for underground use is to exclude moisture, and faults caused by the ingress of water into joints, &c., should be regarded as due to faulty workmanship or material, and not as primarily due to water. No kind of fibrous substance, however well impregnated, can be regarded as waterproof.

There is one kind of fault the cause of which is difficult to classify; where bitumen cables are bent at all sharply the insulation will crack and open in time. Now service cables often have a nearly right-angled bend in them, and we have known many bitumen service cables to fail at this point.

Faults on underground mains may be roughly divided into three classes:—

1. Faults of manufacture.
2. Faults caused during laying.
3. Faults caused after the cables are laid.

A fault may be either an "earth," a "short-circuit" or a discontinuity. With single cables it is almost impossible to get a short-circuit unaccompanied by an "earth," and with concentric or multi-core cables it is also very rare. Positive and neutral leadless cables are sometimes corroded asunder by electrolytic action, and may be clear of "earth," but this has always been caused by an "earth" originally. Multicore pilot cables sometimes develop a discontinuity without an earth, this being generally caused by a short-circuit which has cleared itself.

The faults coming under the first class are exceedingly rare, probably less than 0·1 per cent. of all those occurring on a low-tension network. Cables used for extra high-tension currents may possibly give a larger percentage. Proper testing of the cables will eliminate practically all danger due to manufacturing defects.

Perhaps 30 per cent. of all faults might be included in class 2, their chief cause being rough and careless handling of the cables. Negligent workmen will get sharp bends and kinks in a cable, will stretch the lead, drag the cable over sharp edges and rough surfaces, and in other ways lay up a store of future trouble. Badly aligned and inherently bad ducts and troughs, badly designed joint boxes and carelessly made joints are also responsible for faults caused whilst the cables are being laid. In very cold weather special care has to be taken in all the operations of handling and laying cables. The general remedy for this class of fault is, of course, efficient supervision. Really reliable foremen and gangers are difficult to get, and should be treasured when found. Faults of the second class may not, and generally do not, develop for some months, or possibly years after the cable is laid, and when they do manifest themselves the defect from which they originated is difficult to recognise. Thus the foreman responsible for laying the cable escapes all blame, and it is on account of the absence of any immediate result from improperly handling cables that it is so difficult to impress him with the necessity of using them tenderly.

Faults in class three may be caused by

(*a*) Mechanical injuries.
(*b*) Electrolysis and electric osmose.
(*c*) Chemical action.
(*d*) Overloading and decentralisation.
(*e*) Excess of temperature.
(*f*) Abnormal pressures, surges, lightning.
(*g*) Static discharges.

(*a*) Faults in this category are most generally caused by workmen engaged in excavating the streets, for underground works, electrical or otherwise. Occasionally an iron spike used for supporting a barricade round some operation will be driven into buried cables. A particularly crude method used by gas engineers for finding leaks is responsible for some severe faults. This consists in driving a heavy steel bar a foot or two into the road bed on the supposed line of the gas main, and then applying the usual tests for the presence of gas. Unfor-

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tunately, the point of the bar may unwittingly perforate an electric cable.

Cables laid under concrete (as installed for wood setts) are very liable to injury if the concrete has ever to be broken up for installing other works, because wedges and steel bars are driven through it at random. Subsidence of the ground which is particularly common with cables laid in mines and mining districts, comes under this heading. This may cause joints to be pulled asunder or severance of the cable. In one instance, where cables were laid solid in troughing, the ground fell away from the troughs and carried them with it, leaving the cable taut, with the protecting bricks and a considerable weight of earth above it, which in the end cut through the insulation. The laying of ducts or troughs may also indirectly cause subsidence owing to their acting as drains for water.

Attacks by rodents also come into this class. We have found nests of young rats in manholes, but recorded instances of damage from this cause are very rare. An inspector, under the direction of the mains department and provided with a copy of all permits given for street openings of any kind, will largely obviate faults due to mechanical injuries.

(*b*) *Electrolysis and Electric Osmose.*

Electrolytic damage is often underrated. It is discussed in relation to lead-covered cables in another part of this book. Although the term is generally applied to lead-covered cables, the slow deterioration of leadless cables possibly also is a kindred effect. Electric osmose is also discussed elsewhere.

(*c*) *Chemical Action.*

This is a relatively infrequent cause of trouble. Vulcanised bitumen is rapidly attacked by free alkalies, as discussed elsewhere. Coal gas in the soil attacks and softens bitumen, and we have seen the bitumen filling of "solid" laid cables attacked in this way. Callender-Weber bituminous casings are sometimes corroded in a similar manner with holes eaten right through the wall of the casing. The slow deterioration of rubber in dry places, and its more rapid destruction by condensed water, may be included under this heading, although vulcanised rubber with no electrical pressure on it, retains its elasticity better in a damp box underground than in a dry one.

Lead is not attacked by absolutely pure water, but oxygen dissolved in water causes lead to be corroded, forming a film of lead oxide (or dioxide) on its surface, which absorbs Co_2 from the air and forms an insoluble carbonate of lead. This permits more lead oxide to come into solution, and the process is thus cumulative. Nitrates, nitrites, chlorides and ammonia all increase the corrosion of lead, but hard water containing calcium and magnesium carbonates almost entirely prevents any corrosion. Lead buried in chalk remains particularly bright and clean.

The above kind of corrosion is, of course, generally very slow and as a rule negligible, but we have seen instances where there was a good deal of condensation on bare lead-covered cables suspended in the air, with probably a lot of Co_2 present, in which the lead was thickly coated with a white salt (carbonate) in a few weeks. Ducts should be kept dry, and in particular free from sewage contamination; and lead should be carefully protected in the neighbourhood of stables, farmyards and urinals. Stable manure and artificial garden fertilisers are liable to corrode lead, and this is a point to notice when laying in service cables through gardens. Important information as to durability may often be had from the experience with lead water pipes. PbO is a powerful base, and will combine with the weakest acids; lead in a finely divided state is extremely sensitive towards oxygen. Red lead in contact with lead in a moist place seems to cause rapid corrosion. It is probably the presence of organic acids in some pit waters that causes them to corrode lead. If in contact with wet wood (oak in particular) lead is sometimes badly attacked, due to the presence of some organic acid (acetic or tannic) produced from its decomposition. This is again a cumulative process and results in the formation of lead carbonate, a very little acid being used over and over again. The action is in some degree similar to the Dutch method of preparing white lead. It is fairly rapid, and we have seen lead sheathings corroded three parts through in a year or so. It is possible that the braiding used on lead-covered cables may itself rot in course of time if continually wet, and produce organic acids similar to those from wood. We have seen bad cases of cone-shaped pitting on cables used for alternating currents which may have been caused in this way. With reference to this speces of corrosive action, a mere film of moisture produces more marked effects than a large volume of water.

Wooden saddles impregnated with wood creosote, used for "solid" laid cables, have caused corrosion of the lead, and trouble was at one time experienced with telephone cables due to the use of creosoted wood conduits. Where conduits of this type are still used, oil of coal tar is better for impregnation than wood creosote, as it contains no acetic acid. With telephone cables, lead sheaths containing 3 per cent. of tin were found to be far less corroded than those of pure lead.

The salt glaze on earthenware casings is sometimes stated to have a chemical action on lead, but this lacks confirmation, and is very improbable. Cement and plasters are also often stated to attack lead, but this corrosion is in nearly every case due to electrolysis. Ashes badly corrode the steel armouring of cables, but do not appear to attack the lead, at any rate until all the armouring has disappeared. Care should be taken that ashes are not filled in round buried cables, and to safeguard them it is best to use troughing in "made up" ground.

(*d*) *Overloading and Decentralisation.*

This source of faults is most frequent with vulcanised bitumen and allied cables. Lead-covered paper cables of sections up to 0·5 sq. in. may be run at a current-density of 1,200 amperes per square inch for long periods without danger. Vulcanised bitumen cables, of course, vary considerably in kind, but probably 800 amperes per square inch is the maximum safe current-density for this size. Smaller sections may be run at a relatively higher current-density, for whilst the heat generated in a 0·2 sq. in. cable is twice that in a 0·1 sq. in. cable for similar current densities, the heat dissipating surface of the former is less than 1·5 times that of the latter.

Rubber insulation deteriorates more rapidly when heated up by overloads than when carrying normal currents. Vulcanised bitumen softens when heated, and the conductor tends to become decentralised. This statement is often made and nearly as often contradicted. We believe the effect takes place far more readily with some makes than with others, and not to so great an extent with the more modern cables as with the earlier ones. Some examples of decentralisation have been discussed earlier, and also the general question of the heating of underground cables.

(*e*) *Effect of Temperature.*

This is an infrequent cause of faults. Cables laid and jointed in warm weather may contract and break their joints during cold weather. This is, of course, very unlikely to happen when they are in constant use, owing to the heat produced in them by the load current. At week-ends, however, they may be so free from load that they will assume the temperature of the soil, and if this is low they may suffer severe strain, thereby causing distortion of the box fittings and bringing them into contact with earthed boxes and bonds. Some cases have been recorded of long feeders failing in this way. That there is a considerable strain may be seen by cutting a heavy feeder cable in cold weather, when the two cut ends will sometimes spring apart as far as 18 in. On the other hand, cables laid "solid" in cold weather must expand a little when they are used, and, being held everywhere rigid, must tend to break some of the joints of the troughing in which they are laid; this effect is, however, insignificant, the expansion of a cable 1 mile long being about 1 in. per degree centigrade. Rubber and bitumen cables rapidly deteriorate when laid in proximity to baker's ovens, and they should be avoided as much as possible when laying cables, although this is sometimes difficult.

(*f*) *Abnormal Pressures.*

Pressure rises may be caused in many different ways: by any disturbance on the circuit, abrupt change of load or poten-

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tial, by resonance, or by lightning phenomena. A lead-covered paper-insulated cable is hardly ever broken down by high-pressure rises occurring in practice, the failure generally taking place at joints or other fittings, transformers, &c. A momentary concentration of potential often takes place on the end turns of transformer or motor windings when switched into circuit. Even on 2,000 volt circuits we have found that when transformers fail it is nearly always due to a short-circuit on the high-tension winding, and not a breakdown to earth. At least one British firm put extra insulation on the end turns of all their transformers. On high-tension circuits, and particularly where the line is overhead and subject to lightning disturbances, a choking coil is often connected in the line to act as a buffer to receive the shock of any wave of potential.

Some oscillographs illustrating the rise in pressure produced when switching on a cable, obtained by Mr. Duddell from the County of London Supply Co.'s system, are shown in the *Proc.* of the I.E.E.* When switching on 9 miles of rubber cable on open circuit at 2,000 volts, using brass contacts in air, a rise of 2·25 times the root mean square value of the generator volts was obtained. Switching on the cable with loaded transformers is said by Mr. Duddell to reduce the pressure rise, but with a 400 kw. transformer on *open* circuit, connected at the far end of the cable, a rise in pressure of 2·7 times the root mean square generator volts was obtained under the same conditions as above. It is improbable that very quick rises of pressure, maintained for very short periods such as the above, will do any damage, but they may be prevented by charging up a cable through a resistance, or by putting the machine on at a low pressure and raising it gradually by means of the exciting current.

A rise in pressure when switching off an inductive circuit may be prevented if the current is alternating by breaking the circuit under oil, which has the effect of breaking the current at or near the instant when it reverses. The rise in pressure on breaking a current depends on the rate of change of current di/dt; hence continuous currents should not be broken under oil, but to reduce the pressure rise the arc should be drawn out as long as possible. A condenser connected across a switch or fuse will tend to break the arc immediately, because the condenser behaves (until charged) as a momentary short-circuit to the arc; lead-covered cables, intercepted by a fuse, may act as condensers in this way. On some of the long transmission lines in America it is found to be easier to work with high voltages than with relatively lower pressures, because the current being less with the higher pressures the effect of breaking it is not so disastrous. On these long lines, short-circuits or other disturbances may set up violent oscillations or surges in the line.

Resonance effects are unlikely to occur with commercial frequencies (25 or 50 periods) except on very long lines or with a large number of feeders supplied in parallel; the frequency of any oscillation set up in the circuit depends inversely on the square root of the product of capacity and inductance, and thus the larger this product is the lower will be the applied frequency which will produce resonance. Mr. Sayers† quotes an instance of resonance troubles occurring on 100 miles of high-tension mains. The cables used to fail in a wholesale way, always during the hours of light load, when the frequency of supply was reduced to about 65, the normal frequency being 83. Mr. Sayers found by calculation that resonance was probable at frequencies from 60-65. He raised the light load frequency to above 70 and the wholesale cable failures ceased. Mr. Patchell has also given the results of some interesting calculations on this point in connection with the Charing Cross Company's Bow (London) works.‡

Lightning phenomena are not often manifested on wholly underground systems, but are often a great source of trouble on these when associated with overhead systems. We have, however, seen several case of lightning charging underground mains. Cables used for a town supply come to the surface in a consumer's premises, and the whole system may get charged if a building is directly struck by lightning, but it is more probable that an electrostatic charge is induced by a heavily charged cloud immediately above. A conductor inside a conducting vessel is screened from all electrostatic influences, hence lead-covered or armoured cables, or any class buried fairly deeply in good conducting soil, are completely screened from induction by a cloud, but it would appear possible that non-lead-covered cables laid in insulating ducts above cellars with very little covering but the dry pavement flagstones, and also bare copper strip strained in culverts, also with very little covering, and that nearly insulating, might be electrostatically charged. The subject is of great interest, but its occurrence too rare to discuss fully here.*

(*g*) *Static Discharges.*

Rubber cables have been known to fail when carrying high pressures when they are near some earthed metal. This is attributed to a kind of brush discharge which oxidises the rubber and destroys its insulating properties in course of time.

Practically all the causes mentioned above as the origin of faults must operate equally on all the three cables of a three-wire system, yet with leadless cables the negative cables develop at least 90 per cent. of all the faults; with lead-covered cables the proportion is more equal between the positive and negative mains, and this is probably because the electric osmotic effect is largely eliminated.

Third wire faults are very rare if the third wire is always kept anchored down at earth potential; they chiefly develop in the immediate neighbourhood of positive or negative faults. The following table is due to Mr. C. E. Phelps, and gives the number of faults from all causes on the high and low tension and telephone cables in Baltimore during the seven years ending December, 1906, the total length of cable in operation being about 290 miles.

Nature of damage.		No. of faults.		Percentage of whole.
Defective cable		3	.....	2·0
Damage during installation		24	.....	16·0
Mechanical injuries	Damage by picks, bars, &c.	58	.....	55·0
	Floods	2	.....	
	Gas explosions	2	.....	
	Rats	5	.....	
	Workman in manholes	13	.....	
Electrolytic action		31	.....	20·0
Cables above ground		2	.....	1·5
Unknown		8	.....	5·5

This table exhibits generally the number of faults to be expected in a modern city from external and mechanical causes. It is no criterion of the number and importance of faults that are consequent on electrical defects, such as electric osmosis on three-wire systems. Half the mechanical faults occurred during two years when many street improvements were carried out after a fire, so that the percentage shown in the above table s not an exact guide for ordinary practice.

(*To be concluded.*)

Telephony from Ship to Shore.—According to the "Electrical Review and Western Electrician" the steamer "Theodore Roosevelt," which is to take the members of the Chicago Association of Commerce on a tour round the cities of the Great Lakes in June, will be in direct telephonic communication with Chicago during its entire trip. While at sea, wireless telegraphy will enable them to send and receive messages, and the Chicago Telephone Co. will install a portable telephone outfit for use on the boat. The Company has arranged with the telephone companies of the various cities to be visited by the Chicago delegation to have wires laid to the docks at which the "Theodore Roosevelt" will land. As soon as the boat is docked attachments will be made with the apparatus set up on the boat, so that those on board may call up their Chicago offices from their quarters on the steamer.

* Vol. XXXVI., pp. 139, 140.
† *Proc.* I.E.E., Vol. XXXVI., p. 129.
‡ *Proc.* I.E.E., Vol. XXXVI., p. 101.

* For an account and discussion on "Lightning Arresters" *see* Peck, *Proc.* I.E.E., Vol. XL., p. 498.

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FIFTEENTH ANNUAL CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

It is five years since the members of the I.M.E.A. had an opportunity of visiting Glasgow in connection with the Annual Convention, the occasion then being the meeting held in Edinburgh under the presidency of Mr. F. A. Newington. At that time the delegates paid a complimentary visit to Glasgow, almost as a matter of course, and were entertained by the Corporation, who are the keen rivals of their municipal brethren in the Athens of the North. Now, in 1910, the position was reversed. The Convention proceedings centred in Glasgow, and a day trip to Edinburgh formed one of the principal attractions of the programme. Progress in central station plant design and maintenance has been most marked during the time that has elapsed, and delegates to the Edinburgh Convention of 1905 who were impressed with the massive proportions of the Pinkston tramway units were keener this year upon live steam and exhaust turbines. The electricity departments of both Glasgow and Edinburgh have closely followed the developments of this class of prime mover, and each now has interesting examples of both patterns in use. In the Glasgow tramway power house at Pinkston, near the huge reciprocating engines round which much controversy raged when they were installed, a 3,000 kw. high-pressure steam turbine has been running for some time. Its diminutive proportions compared with the reciprocators are very striking.

For the convenience of members from London and the South of England who are attending the Convention, the Electrical Press (Ltd.) arranged for four special saloons to be attached to the 2 o'clock train from Euston on Monday. Some 80 members and guests availed themselves of this facility, which was greatly appreciated, the more so, since a whist drive served to pass the time very pleasantly. The consolation prizes in the drive were by no means the least valuable, consisting of a 12 months' subscription to THE ELECTRICIAN, "Electrical Industries" and "Electrics," the "Electrical Review," the "Electrical Times" and the "Referee." Music and stories also formed part of the programme, so that we need scarcely say that the long journey was shorn of all its tedium.

Among the engineers who are attending the Convention may be mentioned: Messrs. H. P. Acland, N. Appelbee, F. Ayton, G. G. Bell, H. Bell, J. A. Bell, H. C. Bishop, A. S. Blackman, T. W. Bloxam, H. R. Burnett, J. H. Cawthra, R. A. Chattock, J. Christie, S. Clegg, T. D. Clothier, A. Clough, H. H. Couzens, A. C. Cramb, J. Dalrymple, A. A. Day, C. S. Davidson, J. E. Edgecome, A. Ellis, R. F. Ferguson, S. Z. de Ferranti, E. E. Hoadley, E. M. Hollingsworth, W. W. Lackie, C. W. Mallins, A. B. Mountain, H. D. Munro, F. A. Newington, E. G. Okell, S. L. Pearce, P. J. Pringle, H. Faraday Proctor, C. A. L. Prasmann, W. M. Rogerson, T. Roles, M. Ruddle, A. H. Seabrook, C. E. C. Shawfield, D. A. Starr, H. M. Taylor, G. Tough, C. Turnbull, W. A. Vignoles, S. J. Watson, G. Wilkinson and C. H. Wordingham. There is also a large attendance of representatives of electricity committees; prominent among whom are Alderman G. Pearson, of Bristol, Alderman Sinclair, of Swanesa, Alderman J. P. Smith, of Barrow-in-Furness, and Councillor Willock, of Glasgow.

Tuesday, June 14th.

The Rankine Hall of the Institute of Engineers and Shipbuilders was well filled when the Hon. A. McInnes Shaw, Lord Provost of Glasgow, rose to give an official welcome to the delegates. As is usual on such occasions, the municipal "glad hand" was extended to the accompaniment of the permitted indulgence in electrical reminiscence. The speaker recalled his particular association with the early days of the electrical industry, and concluded with the well-worn phrase, long since deprived of its irritation, that "electricity was still in its infancy"; and this despite the rapid and important strides made in the last five years.

Mr. W. W. Lackie then read his Presidential Address, of which the following is an abstract:—

PRESIDENTIAL ADDRESS.

BY W. W. LACKIE.

After referring to the present position of the Association, which now numbers 416 members, and was being increasingly recognised as an important factor in the electrical world, the author passed on to general questions affecting electricity supply. There has been much progress since the Association met in Glasgow in 1901, under the chairmanship of Mr. Chamen, as is well illustrated by the following figures:—In Glasgow in 1901 electrical energy cost, including interest, depreciation and sinking fund, 2·96d. per unit as against 1·73d. to-day. Excluding the standing charges, the works costs then were 1·41d. per unit as against 0·562d. per unit to-day. The larger electrical undertakings throughout the Kingdom show similar evidence of development.

Very important work has been done by your council during the past year. Last August the Electric Lighting Acts Amendments Bill received the council's careful consideration, and the amendments made upon the Bill embodied in the Act now passed are practically all in accordance with the expressions of opinions received from the representatives of the municipalities interested. To the Scottish municipalities it was particularly gratifying that an amendment was accepted at the last moment protecting both authorised private companies and authorised municipal undertakings from unfair and unreasonable competition on the part of unauthorised companies.

In connection with the clause of the same Bill regarding the raising of capital by municipalities for the purpose of wiring consumers' premises, and the hiring-out of motors, &c., it is known to you that this clause was dropped out entirely. If the clause authorising the work in consumers' premises to be done "through a contractor only" had been passed, it would have been contrary to the existing Electric Lighting Acts and Orders, and undoubtedly would have been found quite unworkable. I do not know if the mover for the addition of the words "through a contractor only" realised that all municipalities would require, if these words became law, to engage a contractor to erect the main fuses and switches, and connect, disconnect, remove and repair all meters.

It has been alleged that the electrical industry has suffered through municipalities obtaining powers to raise money for electrical purposes. This, I am certain, is a fallacy. Municipalities have done much to advance our industry. In many burghs they undertook the supply of electrical energy at a time when no company would have ventured to do so. Further, they borrow money at a low rate of interest, the benefit of which is directly reaped by the public in a cheapened supply of energy; and nothing is, or can be, better for the whole industry than such a supply. It leads to more than an equivalent amount of plant being installed in consumers' premises, and the supply of such plant is, as a rule, left to private enterprise. Some kind of protection should therefore be extended to those municipalities who, after having acted as pioneers, now find their areas surrounded or invaded by private supply companies. These power companies can, as a rule, select their consumers, and this leads to unfair comparison in the same district between the rates of charge made by the municipality and those made by the private company. The supply authority, whether private or municipal, should therefore be protected. In like manner I am also averse to a municipal concern harassing a company in this way.

The question of depreciation and its relation to sinking fund is one that still remains undecided. Since the rate of sinking fund has been so seriously increased, any undertaking having a rate of not less than 3½ per cent. and a reserve fund equal to one-tenth of its capital is surely quite sound financially. As to what is depreciation, and whether it is dependent on efficiency and obsolescence, I should say in reference to these questions that:—

1. Depreciation of value is met by the sums set aside for sinking fund, if such sinking fund be properly calculated upon the probable life of the plant.

2. Decreased efficiency should be met by depreciation if the ordinary maintenance chargeable to revenue is not sufficient to keep the plant in its first state of efficiency.

3. Obsolescence does not mean, nor does it involve, depreciation. It is not true depreciation, but it is quite possible that a prudent

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authority, owning works, might look to the advantage which would be gained by installing present-day plant, and so getting greater efficiency than would be obtained from antiquated plant. Such an authority would annually lay aside a sum for this purpose and might be found dispensing with old plant in favour of something more up-to-date, even although the latter might not have reached the end of its usefulness. Such a course, however, is not compulsory under the Electric Lighting Acts. It is not legal to create a deficit by setting aside a sum either in name of depreciation or of reserve fund. Only such sums as are profits are available for this purpose. Allow me to point out that the Court of Session in 1880 held that the deduction for wear and tear to be made under the section of the Act above referred to is deduction for diminished value as a means of earning income, and not as a saleable subject, and that inasmuch as the plant in question was undiminished in value for the purpose of earning income, no deduction from income tax charge could be made beyond repairs already allowed for.

In the machinery for the generation and distribution of energy, no very great change has taken place. There has been a good deal of serious depression, which was emphasised by the advent of the metal filament lamp, but we all believe that the metal filament lamp will do for the supply of electricity for lighting purposes what the incandescent mantle has done for gas lighting, and more also; but the immediate effect has been to cause many stations to cease putting down additional plant for a year at least. It has not been so necessary for increased lighting connections to be obtained as was at first thought, owing to the growth of the power load.

Much could be said in favour of the supply authority providing the consumers with lamps. Frequently bad lighting is found to be entirely due to defective lamps. In premises which are rented, whether for business or dwelling in, the rule now is that the proprietor in the first instance provides lamps, but there is no definite arrangement for these lamps being either of the most efficient type or renewable at stated periods. It is not uncommon for a tenant to rent premises where the lamps are of an older type and dim with age; this has naturally a prejudicial effect on electricity for lighting purposes. Even if the ingoing tenant, for his own satisfaction, bears the expense of new lamps, it is too much to expect that on his departure he should leave the good lamps he has put in, in place of the old ones he found installed at the time of entry; and cases have come to my knowledge where the outgoing tenants have substituted old defective lamps on the eve of their removal. It seems to me that in the end it would be for the best welfare, not only of the supply undertaking, but of the wiring contractors, if the lamps (which, after all, are the means of transforming electrical energy into light) were left to the supply authority, either to be supplied and the price included in the charge per unit, or sold direct to the consumer by the supply authority. If the former method were adopted, one lamp might be given for every 100 or 200 units used, and if the latter, the price would be, at most, net cost.

Very great improvements in heating and cooking appliances have been effected, and more extensive use of electricity is daily being made for these purposes.

Rapid growth of supply has brought to the front the question of rates of charge to special classes of consumers. For example, consumers with large and small demands; and extra long hour consumers. This is a question which is bristling with difficulties, but it is only by flogging at it that we can come to anything like a solution, and every time that an individual engineer boldly tackles the subject of special charges as regards small, large or long hour consumers he is helping those who find themselves faced with similar difficulties. A flat rate per unit is what is wanted by most people, and it appears to me that it may be possible to adopt this. Any flat rate adopted must be based on the maximum demand system, or, in other words, on the load factor of each consumer, and, where classification is possible, on the average load factor of any one class. For instance, in Glasgow we have a maximum demand system for both lighting and power. We might begin to charge flat rates to-morrow, but these rates would be the same as the average rate paid by each consumer during the previous year on the maximum demand system. The maximum demand would still be taken during the year and the average rate worked out. This would mean that we should have flat rates for different consumers or for various kinds of consumer, ranging from 3½d. per unit to ½d. per unit, decreasing from the former to the latter by tenths or even hundredths of a penny; but each rate would be the result of fair and just computation. A rating committee might be appointed, and sit once or twice a year to hear and settle cases in dispute. It is quite conceivable that such a method might lead to increased consumption of energy; for do we not find that consumers paying 3½d. per unit for the first 730 hours' use of the maximum demand and ¾d. thereafter, or an average price of, say, 2d. per unit, forget about the units they have got at the ¾d. rate and grudge the price of energy when the time comes to revert to the 3½d. rate? It is quite likely that many such consumers would regard a flat rate of 2d. as a distinct boon, and would not exercise the rigid economy which is often practised in connection with 3½d. rate. The rating committee might be appealed to, in cases of dispute, to settle the rate of any new consumers making a large demand.

One should be careful of accepting statements such as "20 H.P. for 1d." per hour, or passing criticisms on supplies of electrical energy at prices varying from 8d. to ¼d. per Board of Trade unit. The real cost is the total charge per horse-power per annum, including all material, labour, depreciation and interest on capital. The rate per unit is not a reliable criterion as to whether the supply is cheap or dear. Strange to say, it is the consumer who is paying, say, 3½d. per unit who complains that he is being overcharged to make up the deficit caused by the consumer who is paying only ¾d. Of course, it is the reverse that is true. The time may be approaching when, instead of charging a rate per unit we will charge so much per 10 units; this would enable us to make fractional reductions smaller than the minimum possible reduction of ¼d. per unit with the present method of charge. For instance, our rates in Glasgow vary from 3½d. to ¾d.; this would work out at 2s. 11d. per 10 units for light, and 7½d. per 10 units for power.

Where a fixed rate of, say £4 or £5 per kilowatt per annum is charged plus a low rate of ¼d. or ½d. per unit, the fixed rate can be reduced, but when the fixed rate system was tried 10 years ago in Glasgow by Mr. Chamen, we had serious complaints from lighting consumers because of their bills being as heavy in summer as in winter. Many of these consumers used practically no light in summer, and yet they received a substantial bill, say, for July or for August.

I cannot now do more than refer to the knotty question of specially low rates to users of a large amount of energy for an exceptional number of hours in the year; two remarks, however, perhaps ought to be made. It has been suggested that the municipal electricity supply undertaking should, in certain circumstances, give power supplies to large industrial concerns even at a loss, for the sake of the secondary profit that may accrue through the employment thus provided. I think this is not sound reasoning. The first duty of the supply undertaking is to see that all classes of consumers pay their due share of the standing charges on the capital expenditure necessary to provide plant to supply them. Another remark I wish to make is: it seems to me that it would be to our common advantage if those who have a number of large lighting or power users connected to their mains came to some agreement as to the basis upon which the rates of charge to such consumers should be founded. I think you will agree that the present lack of uniformity in our methods of charging is a fruitful source of trouble. Without properly understanding the question of electricity charges a consumer will quote one supply authority against another, whereas the local charge may not be exorbitant after all.

Alderman J. P. SMITH proposed a vote of thanks to the President for his address, and pointed out that it was becoming increasingly difficult for a president to incorporate new and interesting matter into the address. On this account, Mr. Lackie's effort would be the more appreciated for its choice of interesting subjects and the lucidity of their presentation.

Mr. C. H. WORDINGHAM seconded the vote of thanks, and recalled his early connection with the Association as one of its presidents. He particularly appreciated the onerous position of the President, involving, as it does, the occupation of much time, the exercise of tact and need for considerable self-sacrifice.

Mr. LACKIE then called on Messrs. A. C. Cramb (Croydon) and H. Collings Bishop (Newport) to read their respective Papers on "Commercial Progress." Each author gave a summary of his Paper and thus plenty of time was available for discussion. The Papers are reproduced elsewhere.

DISCUSSION.

Mr. A. H. SEABROOK (Marylebone) opened the discussion, and remarked that as he was mainly in accord with the Papers he would offer only constructive criticism thereon. His own sales installation department showed a profit of 40 to 50 per cent. on the prime cost of apparatus sold; consequently the local contractor could not complain of price cutting. Hire purchase, he thought, should be based on a two years basis unless best guarantees were forthcoming from the consumer. Twenty-five per cent. down and balance in two years, he thought, a necessity and not an alternative as suggested by the authors. The hire of arc lamps was a useful scheme in that it bound the consumers permanently to the undertaking. Mimeographed circular letters were comparatively worthless, sepa-

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ately typed and signed letters being worth the time and money expended n them. The hire purchase of motors was to be commended because a change in horse-power, either larger or smaller, was needed it was a simple matter. The Lord Provost had referred to electricity as being in its infancy. Certainly this remark could be justly said of "business getting" in electricity supply. In Marylebone the services amounted to less than 40 per cent. of the premises in the area when he took over the undertaking. The question of canvassers was best settled by paying a man a small salary and a good commission. From his experience, a man worked more and frequented tea shops less on this system than when he received a higher salary and smaller commission. The bonus should be varied according to the class of supply obtained. He thought that Prof. Fleming's recent remarks at the Royal Institution, comparing electricity and gas for cooking and heating purposes, should be reprinted and distributed widely by electricity undertakings.

Alderman J. W. CROWTHER (Sheffield) gave a few facts as to business getting in Sheffield. Exhibitions, held annually for preference, were, he thought, more productive than a permanent show-room, and for this reason, they did not run a show-room in the central part of the city. Their two exhibitions in 1906 and 1909 had brought on a large number of electric furnaces for which a charge of 0·6d. per unit for energy was made. Small exhibitions of domestic applications were more effective than the more expensive large exhibitions. The bonus system for canvassers he thought mischievous, and press advertising had proved very disappointing. Regarding gas competition he considered this as likely to be more severe, and in Sheffield the price of gas was likely to fall as low as 11d. per 1,000 cubic ft.

Mr. C. H. WORDINGHAM felt that the day of the superior engineer and the appellant consumer were gone. Vigorous efforts to secure custom were now required. Mr. Cramb had rather overdone the specialisation of his suggested canvassing staff, and he pictured three experts of light, heat and power respectively presenting themselves to a hairdresser for his lamp, motor and curling-iron business. He did not approve of "funny" advertisements. People wanted facts. A leaf might be taken from the book of the gas interests by the production and publication of press articles which had an educative value to the lay newspaper reader. Facts might be driven home in this way. Electrical engineers were not as wily as their gas rivals in these matters. He felt that the contractor was the best friend of the station man, but was not quite fairly treated. His preserves should not be unduly encroached upon. On the other hand, it was necessary for the station engineer to act in an advisory capacity with consumers, and they should keep this well in view. Or the engineer should see that consumers were advised by genuine consultants, not by contractors. The small salaried canvasser he did not agree with. The words "good man, good salary and trust him," should be written in letters of gold in the committee room of every municipal electricity undertaking.

Mr. W. A. VIGNOLES (Grimsby) said that a reasonable commission should be paid to a canvasser, but that he should not naturally receive more than the engineer himself. The commercial department suggested in Mr. Cramb's Paper could only be organised in a large undertaking. The salaries of £2,000 which would have to be paid would only be merited on an annual turnover of some £100,000. In a small station most of the specialised duties would have to be undertaken by one or two men. In canvassing work his own men made a dead set for certain trades, and gradually brought each round to the service. The Joint Publicity Committee in London was doing good work, but something more was wanted. In newspaper advertising only indirect results were to be looked for. His idea was a scheme of national advertising, which would enable the supply undertakings of the country as a whole to benefit from educational advertisements in the great dailies. Such advertisements had a powerful educative influence, and were bound to bring results in time. He would like to see the American scheme of placing some 2,000 electric irons in a town for a short period, two or three weeks, say, tried in this country. There was good business to be got by bringing apparatus to the consumer for trial purposes. It was well to work in with the borough surveyor who had plans of new buildings deposited for his approval.

Councillor D. LIVINGSTONE (Hull) generally approved of the ideas in the Papers, and pointed to Hull as a model town in electricity business-getting methods. He thought their show-room was quite the best thing of its kind.

Mr. F. AYTON (Ipswich) detailed his publicity experience, which dated back over six years. As proof of the value of a canvassing department he pointed to a 25 per cent. increase in business last year. The canvasser should be paid a small salary and sufficient commission to secure the best results. He raised a loud laugh in making the startling suggestion that lady canvassers be brought into service to impress the value of domestic electrical apparatus upon housewives. To approach these dear ladies with male canvassers, or to bring the subject of curling irons, coffee percolators, &c., to "darling hubbies" by the same parties, was indiscreet. The sale of these necessary domestic appliances should be entrusted to ladies, and he was seriously thinking of training a number of fair damsels for the purpose. His own department had a turnover of £3,043, excluding £500 free wiring, on a total staff expenditure of £300, divided between an installation expert, foreman, canvasser and office boy. This represented 1¾ per cent. of the total revenue and 10 per cent. of the department revenue. There was no cutting of prices against contractors, and he found that 28½ per cent. profit could be obtained on apparatus sold. Their motto was "best work, best material and one price" for installation work. The cost per lamp point worked out at 8s. 9d., including fuse boards, and the price charged was 13s. 6d. Metal lamps were installed wherever possible. He always worked in with house agents to keep in touch with removals and new tenants. Much custom was obtained by being on the ground before the gas people. Press advertisements were not profitable, but tramcar advertising could always be recommended. It was always wise to keep the consumer, actual and prospective, posted up to date with the latest electrical contrivances. This paid in the long run, and was not a costly thing to accomplish.

Mr. MARK RUDDLE (Dublin) considered that business getting methods were very desirable and necessary, but that many undertakings were handicapped because they had no powers to do wiring. Concerted action on the part of the Association was necessary to give many of the provincial undertakings these powers, and so to remove a serious disability in the matter of securing new customers and keeping old ones.

Mr. E. E. HOADLEY (Maidstone) also referred to the necessity for wiring powers being conferred on those undertakings which at present laboured without them. He considered that the accounts of consumers should be paid to men who could say a few words on technical subjects to the customer, and thereby interest him in the further uses of electrical energy. He heartily approved of lady canvassers as a solution of the problem of domestic electricity extension. A show-room should, he thought, be filled with interesting pieces of apparatus and not be a mere warehouse of art metal work. More work ought to be done with electric signs, and particularly electric facia boards which were largely used on the Continent. With these latter the tradesmen could get day and night advertising with the same sign.

Mr. F. M. LONG (Norwich) pointed out the advantages of the Norwich system of charging (a percentage on the property assessment and 1d. per unit) in securing customers for bedroom radiators and other apparatus which came on during non-peak hours. They had 4,600 consumers in Norwich (population 111,000), and among them were many small consumers. These were charged on a maintenance basis of 1s. per lamp installed and 1s. per lamp per quarter, and with metal lamps this proved quite satisfactory. Some 1,000 metal lamps were in use in this way, and renewals were less than he had anticipated. Gas competition was very keen. To meet the charge of 35s. per gas lantern per annum made for shop lighting, including cost of gas, he charged 2d. per unit and £5 per pair of flame lamps used per annum. This had proved successful, and some 400 arcs were installed on this basis; also 125 lanterns with clusters of metal lamps.

Mr. A. C. CRAMB, in reply, remarked that the greater part of the criticism was constructive and could be easily met. His tables and data re staff duties and salaries were intended to be elastic. They should be fitted in with the size of station dealt with. He maintained, however, that in power installations it was better to have a man who made a study of industrial motor drives, as he could bring in the large consumer. What Mr. Wordingham had called the "Ally Sloper" funny advertisement was not to be altogether despised. Facts undiluted could not be forced upon the consumer. They had to be suitably clothed to be more readily acceptable. The gas articles were good enough, but could be improved upon considerably. National advertising schemes were being considered by the London Joint Publicity Committee and something would shortly be done. The contractor had not much of his sympathy because for years the field was his and he did nothing to cultivate it. There were good and bad contractors, and most were unenterprising. He instanced the recent spell of sultry weather, when his men were taking fans round under their arms selling to consumers, and not a single contractor's man was canvassing. Some scheme was required which would settle whether the contractor or the station should have the trade discount of 25 per cent. on apparatus sold and work done. He complained of the injustice of the British Parliament in discriminating between one undertaking and another in the matter of wiring powers. Croydon was immediately outside the Greater London area, and excluded from privileges which were enjoyed immediately across the boundary.

Mr. COLLINGS BISHOP, in reply, said that the terms for hire purchase given in the Paper were based on a high price for motors, but these prices were now tending to fall, so that the average rate would go up. Gas competition was not, in his opinion, relatively as great now as in the past. He agreed that the contractor needed to be dealt with diplomatically. He should not be thrown over, but as a rule he did not go far enough. He was too fond of pushing purely lighting business, and disregarded the importance of auxiliary apparatus. His experience of tramcar advertising was that it was so popular in Newport that he could seldom get a vacant space for the electricity department announcements. The small consumer problem might, he thought, be tackled on a fixed price per lamp basis where a row of houses was concerned. A pair of cables was run along under the roof and tappings taken to each house below. Any number of lamps might be installed, but two only could be used at a time, a current limiter being introduced as a check on the consumer. The scheme was not yet in operation, but would be shortly.

After a hearty vote of thanks had been passed to Messrs. Cramb and Collings Bishop the bulk of the party adjourned to the City Chambers, where they were the guests of the Corporation at luncheon. The toast list at this function was commendably short. After the loyal toasts there were those of the Association and the Corporation of Glasgow. The first was proposed by the Chairman, the Hon. A. McInnes Shaw, the Lord Provost, and responded to by Mr. W. W. Lackie, who referred to the growth of the Association and also the progress of the Corporation electricity department. The latter he

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regarded as contributing to the remarkably low death rate in Glasgow, the distribution and use of electrical energy having an undoubted beneficial influence on the health of the community. Ald. W. Bruce (Sunderland) proposed the second toast, which was replied to by the Lord Provost.

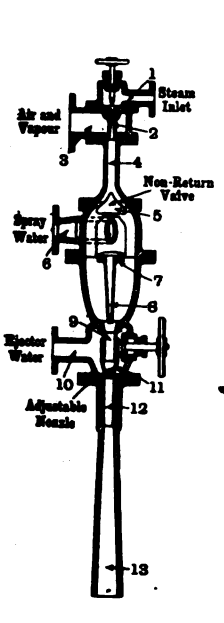
Tuesday's proceedings concluded with a reception and conversazione at the City Chambers by the Lord Provost, Magistrates and Town Council of Glasgow.

Edinburgh, Wednesday, June 15th.

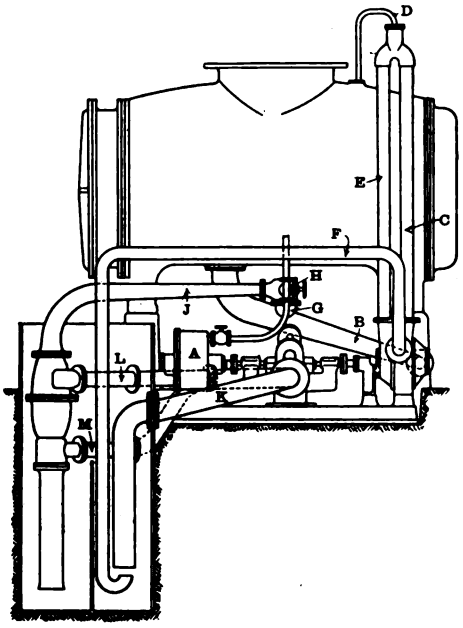
The whole of Wednesday was reserved for a visit to Edinburgh, where Papers were read in the morning and the afternoon was spent at various works in the district. The members left Glasgow at an early hour and assembled in the Free Gardeners' Hall, Edinburgh, for the reading and discussion of two Papers, one on "Exhaust Steam Turbines and Condensing Plant," by Mr. F. A. Newington (Edinburgh), and the other "Mixed Pressure Turbines," by Mr. Ashton Bremner (Burslem). The latter Paper was read by title in the absence of the author.

DISCUSSION.

Mr. I. V. Robinson (Richardsons, Westgarth & Co.), in opening the discussion, emphasised the importance of a high vacuum in the running of an exhaust turbine, and proceeded to describe an interesting kinetic air pump which his firm had developed. One of these pumps had been in operation for some eight months and was able to maintain a steady



Diagrammatic Section of Kinetic Air Ejector.



General Arrangement of Kinetic Air Pump.

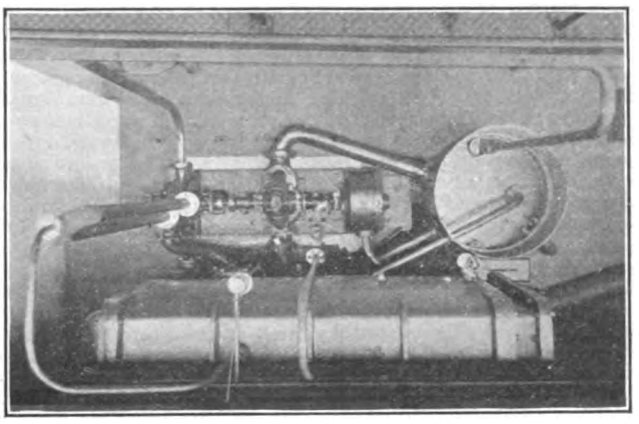
1 Steam inlet. 2 Steam nozzle. 3 Air and vapour from condenser. 4 Steam jet, air and vapour combining tube. 5 Non-return valve. 6 Spray water inlet. 7 Spray water holes. 8 Spray water driver. 9 Spray water combining tube. 10 Water jet inlet. 11 Water jet adjustable nozzle. 12 Water jet combining tube. 13 Main discharge to tank.

A Curtiss turbine driving kinetic air and heat and pressure pumps.

Condensed Water.—B Heat pump suction. C Heat pump discharge. D Equilibrium pipe to condenser. E Pressure pump suction. F Pressure pump discharge to tank.

Air from Condenser.—G Steam jet air suction. H Steam jet. J Steam jet discharge to water ejector. K Kinetic pump suction from tank. L Kinetic pump discharge to spray. M Kinetic pump discharge to jet.

vacuum of 29 in. on a 750 kw. turbo plant. The air and vapour were drawn from the condenser under the action of a steam jet, and, together with the steam, were met by a water spray, which condensed the added steam of the jet. The ejector water was then encountered and the combined flow delivered to the discharge pipe. [The adjoining diagram shows a sectional arrangement and assembly plan of the kinetic pump. A close examination of these drawings, which are fully lettered, will make the action of the pump quite clear. A further illustration shows a view taken from above of one of these pumps placed in an engine-room basement, beside the condenser barrel.] The complete arrangement, Mr. Robinson explained, included a circulating pump for the spray and ejector water and a two-stage centrifugal pump. With the latter the first stage is connected to the condenser from which the condensed steam water, over and above the air and vapour which are removed by the steam jet, is withdrawn and delivered against a static head of 8 ft. into a pipe, the top of which is connected to the condenser barrel. The connection ensures that the first stage of the pump (known as the head and pressure pump) shall discharge only against this head. Further, a positive head is thus secured for the suction side of the suction stage of the same pump. This second stage discharges the condensed steam water to the sump surrounding the ejector whence the boiler feed is drawn. [In the drawing the two pumps are shown driven by a small Curtiss turbine.] The pump dealing with the water spray and jet keeps this water constantly circulating from the sump. The advantage of the arrangement was that the latent heat in the steam jet was not given up to the circulating water, as in the case of a vacuum augmentor, but to the hot well, which was raised to a temperature 10 deg. or 15 deg. above the temperature corresponding to the vacuum. The apparatus ran with



View from above of Richardson's Westgarths Kinetic Air Pump.

the minimum of attention, being entirely rotary with ring-oiled bearings, there was but a single pumping unit, and the space occupied was extremely small.

Mr. C. H. Wordingham remarked that there appeared to be a sudden passion for exhaust turbines among station engineers, many of whom had evidently only just discovered that condensing was possible. The use of sewage water for circulating purposes was most interesting, but he inquired whether corrosion troubles had been experienced in the condenser tubes and also if the health of the employés was affected. Small plants were necessary at first in certain stations in spite of all that critics might say. He asked for details of the current density at which Mr. Newington worked the carbon brushes on his turbo-generators and also what coupling he used between turbine and dynamo.

Mr. S. Z. de Ferranti (President I.E.E.), who was loudly applauded on rising, said that the Papers would help to impress upon station engineers the value of their exhaust steam. In considering the introduction of exhaust turbines he thought the use of a specially designed machine, as distinguished from one manufactured under competitive conditions, should be carefully weighed. So many important factors contributed to the result aimed at that the question merited more than ordinary deliberation. Unless this was done, less value would be obtained from the exhaust steam. The whole problem was, he thought, somewhat involved, and the exhaust turbine appeared to be something of a makeshift at present. He had considered the use of exhaust turbines in a number of the large stations in this country and had obtained some fascinating figures of economy. The position might be looked at in the light of a proposition whereby manufacturers would contract to deal with some particular station and undertake to improve the operating efficiency, even if it involved scrapping the present plant and putting in entirely up-to-date machinery. That would be rather a drastic measure, and could not be looked for at present, though some development might make it necessary at any time.

Mr. C. E. C. Shawfield (Wolverhampton) congratulated Mr. Newington on his successful application of the sewage water for purposes of condensing. He inclined, however, to the belief that exhaust turbines were of doubtful utility, and that reciprocating plant was better scrapped and steam turbines put in. Capital would certainly be saved. Mr. Newington obtained 2,700 kw. from his two units at a capital outlay of £9,650, which included condensers and switchboard, but not pipes, strainers and cost of breaking into sewer. A 3,000 kw. live steam turbine could, he thought, be obtained for about £8,500. The average figure of 22·2 lb. of steam per kilowatt-hour seemed a high figure, but no doubt included stand-by losses. Probably a nearer figure was 19 lb., and, compared with this, a high-pressure turbine on the same vacuum would do 17 lb., and only half the size of condensing plant would be needed with less circulating water. In his own station, where three 500 kw. reciprocating engines were initially installed, he found that it was more economical to put in a 2,000 kw. high-pressure turbine as the extension plant, and not an exhaust turbine.

Mr. T. W. Bloxam (Belfast) had similar exhaust turbo units running in Belfast, but said that he was principally concerned with commutation troubles. The carbon brushes at first used overheated the commutator when the tension of the springs holding the brushes against commutator was increased. The commutator would also expand under the increased temperature. A ventilated commutator with flexible end straps and several other modifications was, however, being fitted by the makers, and he hoped would give better results. He was not sure if these direct-current turbo-generators should be self-exciting or separately excited. The circulating water in Belfast contained a quantity of rubbish which

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blocked the strainer in the intake pipes, but he found it possible to free the strainers by pumping back through the pipes about twice a week, the particular pump, of course, being out of service at the time.

Mr. R. BIRKETT (Southend) considered that enough attention was not paid to load factor in this question of exhaust turbines. In a station like his own, with a 16 per cent. load factor, he would probably not have exhaust steam, except during an hour or two daily, which would warrant the running of such a turbine at all. He obtained very good results with his reciprocating plant, averaging 23 lb. of steam per kw.-hour the year round. He employed successfully an air condenser of the Ledward type, which saved £900 per annum in water alone over the previous circulating water and cooling tower arrangement. It would also deal with twice as much steam and cost less to run than the fans on the old cooling towers.

Mr. S. L. PEARCE (Manchester) thought that before any engineer committed himself to exhaust turbines he should have a clear idea of the principles under which such turbines operated. The turbines required to be designed to get the greatest possible amount of work out of the steam. The importance of a good vacuum must be kept in mind, as without it exhaust turbines were quite out of the question. An increase of the vacuum from 27 in. to 28 in. represented an increase of 20 per cent. in the heat units utilised. But high vacuum was not always easy to obtain, and the capital cost of condensing plant and pipework often detracted from the value of the results. Mr. Newington's statement in the Paper, that exhaust turbines might be generally recommended for the extension plant in reciprocating stations, needed to be accepted with caution, as it was by no means proved. Some interesting figures had been obtained by Mr. Stott (U.S.A.) in connection with the installation of exhaust turbines at the Interborough Rapid Transit power house. A 5,000 kw. exhaust turbine was there installed in connection with the 7,500 kw. Manhattan engine type units. These resembled the engines installed in the L.C.C. tramways Greenwich power house, but he (Mr. Pearce) thought that the Manhattan engines were not in themselves economical, consequently the favourable figures shown by Mr. Stott were not reliable. He referred members to Mr. Stott's Paper for details. He had considered the use of exhaust turbines at Manchester for the Stuart-street station extensions, but came to the conclusion that they were not needed, because a saving of only ¼ lb. to ½ lb. of steam could be shown. He was accordingly extending with live steam turbines.

Mr. FARADAY PROCTOR (Bristol) suggested an alternative to Mr. Ferranti's proposal to instal new turbines and scrap the reciprocating engines. He thought that the turbines might go in, but the reciprocating plant be retained as a stand-by. It was not a matter of the capital cost of the new plant, but of the charges on the buildings and foundations of the old plant.

Councillor LIVINGSTONE (Hull) inquired whether there was any shortage of the sewage water for circulating purposes during very dry weather.

Mr. F. W. PURSE (Watford) thought that the figure of 33 per cent. saving given in the Paper was misleading, in that it was not based on the capital charges. In his own case his committee might gather that the particular figure given would apply to any station which installed exhaust steam turbines.

Mr. R. H. CAMPION (Dewsbury) thought that something should be said in favour of the mixed pressure turbine. He was able to obtain 360 kw. from his exhaust steam, and could also run the turbine on live steam. The radial commutator had done much to solve the problem of commutation and also in the provision of efficient ventilation of commutators.

Mr. F. A. NEWINGTON, in reply, said that there had been no trouble through corrosion in the condenser, nor any difficulty in the matter of nuisance or ill-health of the staff. The scraping arrangements were not yet perfect, but would be improved later. Figures re the current density on the carbon brushes he would have to communicate to the "Proceedings." He thought that the high-pressure turbine showed up well on paper, but anything could be proved on paper. As to the scrapping of plant, he personally would not feel inclined to go to his committee and suggest the wiping out of some 8,000 kw. of reciprocating units. Mr. Shawfield had in his criticism forgotten the boilers. Regarding excitation, in their own case the separate exciter had been recommended by the makers and they had accepted it. He could not say if self-excitation was better. He still held to the opinion that there were many stations with reciprocating engines of the Willans type which could profitably introduce exhaust turbines as extensions. The commutation problem had proved somewhat vexatious, but they had been able to run satisfactorily for some time now. In dry weather the sewer water was kept up by the greater number of baths used, and further the load was always lighter.

Mr. W. W. Lackie proposed a hearty vote of thanks to Mr. Newington for his Paper, and the party afterwards adjourned to the Music Hall, George-street, where they were entertained to luncheon by the Corporation of Edinburgh. The Lord Provost presided and officially welcomed the Association to Edinburgh. The speakers at the luncheon were Judge Stephenson, convener of the Electricity Committee, Edinburgh; Alderman Pearson (Bristol); Mr. W. W. Lackie, and the Lord Provost.

The afternoon was spent in visits to Messrs. Bruce Peebles' works, the McDonald-road Electricity Works and the Marine Gardens, the latter being thrown open to the members of the Association by the management.

LATEST FROM GLASGOW.

BY TELEGRAPH FROM OUR OWN CORRESPONDENTS.

Glasgow, Thursday, June 16th.

The meeting this morning was again in the Rankine Hall of the Institute of Engineers and Shipbuilders. Mr. W. W. LACKIE, in opening the meeting, explained that the morning's proceedings were somewhat of an experiment, since no Papers were being read, but, instead, an opportunity was afforded to members to discuss two matters of vital importance in central station operation and expansion—namely, (1) "Advantages of Continuous Records of Costs and of Steam Consumption," and (2) "Cheapening of the Cost of Mains and Services."

ADVANTAGES OF CONTINUOUS RECORDS OF COSTS AND OF STEAM CONSUMPTION.

Mr. G. WILKINSON (Harrogate), in opening the discussion on Records of Costs and Steam Consumption, said that at Harrogate the steam costs were made up by the switchboard attendant nightly, and were posted in weeks and had great influence in keeping the costs at a low figure. He thought that air leakage into flues was a frequent source of loss; and by using a special cement which had an affinity for metal and brickwork, a large factory station had saved £500 per year. The efficiency of an economiser could be much increased by keeping the inlet water at a low temperature. Experiments with a 280-tube Green's economiser, dealing with 1,300 gallons of water per hour, reducing the temperature of the inlet water to 94°F. showed an increased efficiency of 26 per cent., representing a saving at the coal heap of 4·4 per cent. To reduce sweating, a pipe might be led from outlet of economiser to the suction side of the pump. Condensation in the steam pipes was a great source of loss. Water often accumulated at certain points and blew over intermittently into the engines and turbines. At low loads, condensation losses might equal 2 to 4 per cent. With turbines the steam trap water should be returned direct to the boiler and not drained into the sump. Ferranti-Hopkinson valves, if used horizontally, sometimes caused water to collect at each side in the contracted portions. At Harrogate trouble from this cause had been avoided by draining the water between the valves. He instanced Harrogate as an example of the value of keeping records. In spite of a 5 per cent. drop in load and 4 per cent. increase in the cost of coal they had reduced the cost per unit generated by 10½ per cent.

Mr. C. E. C. SHAWFIELD (Wolverhampton) remarked that it was most important to keep continuous station records. He asked for apparatus to record hourly the total number of pounds of coal per unit generated. This item varied enormously during the day. His own tests were somewhat paradoxical, as he found on night shift that an increased production of units caused a reduction in the coal consumed. The whole of the condensed water should preferably be recorded on a single instrument, instead of on separate recorders on each engine. The make-up feed water should also be separately recorded to indicate the loss in the condenser. His experience with CO_2 recorders showed that these were not altogether reliable. He thought that tests made with portable Orsat apparatus were more accurate.

Mr. F. E. AYTON (Ipswich) thought that the efficiency of other parts of the system required greater attention than the station, and instanced consumers' meters. He agreed that CO_2 recorders needed continual attention. He used the Krell type, but dust in the sampling tubes was a source of trouble, particularly at rubber joints. Air leakage also might cause errors. He thought that the repairs to recording instruments would become costly after some years. The principal value of the CO_2 recorder was to indicate air leakage. He recommended glazed bricks or a mixed tar and pitch coating for the flues and brickwork. He found that cement made a grand firebrick, and that Portland cement for flues and settings gave permanent results. Sand cement generally cracked. In regard to scrapers for economisers, an improvement was wanted. He thought the use of steel tubes in the Horseferry-road station was an advance, as the surface was smoother. The heavy coal consumption on night load enabled street lighting to be done at a low cost.

Mr. C. H. WORDINGHAM thought that central station engineers were becoming meter maniacs with too many records. It was better to make careful tests at longer intervals, and to aim at the greatest possible simplicity. It was better to return the heat in steam trap water to the boilers than to measure condensation losses.

Mr. F. A. NEWINGTON (Edinburgh) had tried to reduce the amount of moisture in coal by tests from which reductions in contract price were made; but he found a difficulty in working such an arrangement. Alternative prices for coal with 10 per cent. or indefinite amount of moisture showed a difference of 3d. per ton, and pointed to the fact that it was not worth pressing for. He thought coal merchants knew more about coal than station engineers. He considered that bomb calorimeter tests and hourly records of coal consumption were of little value.

Mr. MARK RUDDLE (Dublin) thought that keeping detailed records in large stations was impracticable, and the time of the staff was better spent in inspecting and checking the plant. He considered that the only important test was the calorific value of the fuel.

Our report of the proceedings at Glasgow yesterday (Thursday) is concluded on p. 405.

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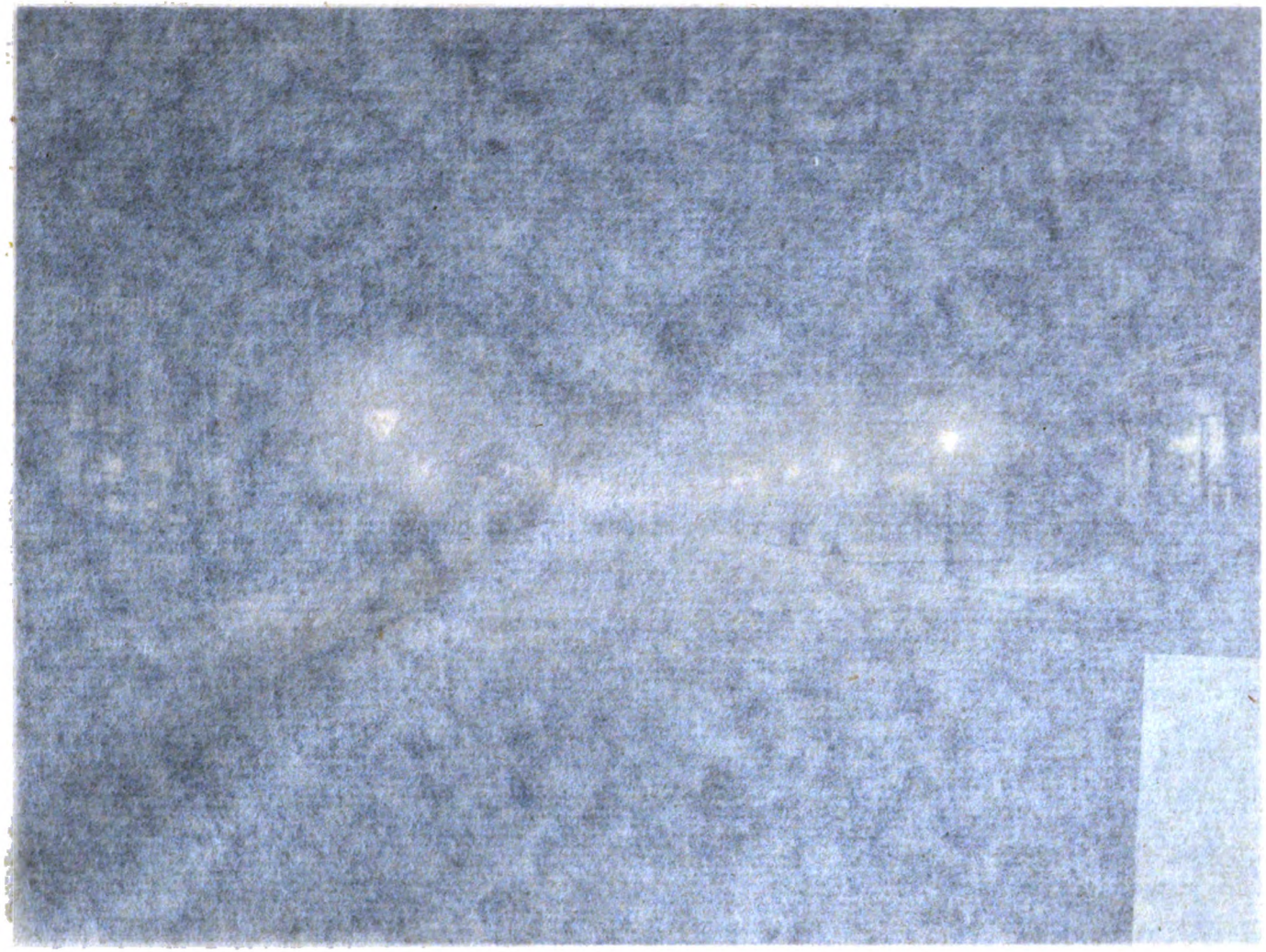
"OSRAM" STREET LIGHTING.

A Souvenir of the I.M.I.A. Convention Glasgow, 1910.



...EEN STREET, GLASGOW
Illuminated with "OSRAM" ...

Branches:
Manchester, Glasgow, Birmingham, Newcastle, Cardiff, Dublin, Belfast, &c.

1910.

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blocked the strainer in the int[illegible] the strainers by pumping ba[illegible] particular pump, of course

Mr. R. BIRKETT (Sou[illegible] paid to load factor ir[illegible] like his own, with a[illegible] exhaust steam, e[illegible] the running of [illegible] his reciproca[illegible] round. H[illegible] which sa[illegible] water [illegible] muc[illegible]

[illegible]OM GLASGOW.

[illegible] OUR OWN CORRESPONDENTS.

Glasgow, Thursday, June 16th.

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[illegible] OF CONTINUOUS RECORDS OF COSTS AND OF STEAM CONSUMPTION.

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"OSRAM" STREET LIGHTING.

A Souvenir of the I.M.E.A. Convention. Glasgow, 1910.

QUEEN STREET, GLASGOW
(Illuminated with "OSRAM" Lamps).

The General Electric Co., Ltd.
Head Office:
67, Queen Victoria Street, London, E.C.

Branches:
Manchester, Glasgow, Birmingham, Newcastle, Cardiff, Dublin, Belfast, &c.

Printed and Published by George Tucker at the Editorial, Printing and Publishing Offices, 1, 2 & 3, Salisbury Court, in the City of London. Friday, June 17th, 1910.

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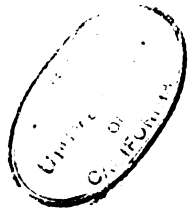

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PAPERS READ AT THE CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

We give below abstracts of the four Papers which were read this week at the Convention of the Incorporated Municipal Electrical Association. The first two Papers, namely, those by Mr. A. C. Cramb and Mr. H. Collings Bishop, which deal with commercial progress, were read at Glasgow on Tuesday last; whilst the Paper on "Exhaust Steam Turbines and Condensing Plant," by Mr. F. A. Newington, and that on "Mixed Pressure Turbines," by Mr. A. Bremner, were read at the meeting at Edinburgh on Wednesday. An account of the discussion which followed the reading of these Papers will be found on an earlier page.

COMMERCIAL ADVANCEMENT OF ELECTRIC SUPPLY.*

BY A. C. CRAMB.
(Chief Electrical Engineer, Croydon.)

Summary.—The author urges the necessity of a vigorous campaign for developing the use of electrical apparatus, and indicates on general lines how this campaign should be organised.

In the past comparatively little attention has been bestowed upon the commercial development of electric supply, and more particularly does this refer to undertakings owned by municipalities. The enormous reduction in revenue brought about by metal filament lamps, however, has made this a vital question. The state of affairs in this country as contrasted with that in America is well illustrated by the following extract from some articles written by an American engineer as a result of a careful investigation of electric supply in this country: "This condition is almost universal in Great Britain—aggressive work by the gas interests and procrastinating somnolence on the part of the electric departments." Few who have given this matter careful consideration will be inclined to disagree seriously with this criticism.

Electric supply is as much a competitive business as any other, whether in the domain of lighting, power, heating or in almost all the numerous uses to which its suitability has been demonstrated. This being so, a proper expenditure on business getting is essential if development is to be satisfactory. Of primary importance is a thorough scheme of organisation of the commercial side of the business, modified to suit the conditions of each particular undertaking.

In undertakings of any appreciable size the duties of general management will occupy so much of the engineer-manager's time as to render it necessary to have a competent sales assistant, working immediately under his direction to control this portion of the business. This appointment is an important one, and the salary should be such as to obtain a good energetic engineer with sound commercial experience and with good organising capacity. At the moment there is a lack of suitable men, but many engineers with natural aptitude for business getting would soon become fully competent to carry out this work if many posts with a sufficiently remunerative salary were offered. The business-getting men must know their business, have faith in their wares, be courteous, of even temper, active, tenacious, reliable, and withal close students of human nature.

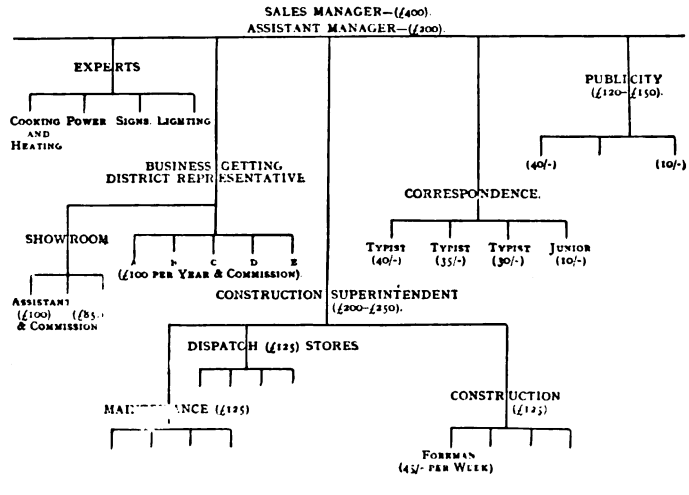
The organisation of the staff on the commercial side depends considerably on the policy of any particular undertaking. A large number of undertakings at the present time work under very restricted powers. What is legal in one area is called illegal in the next, which is the acme of absurdity. The public who have been educated up by the gas companies to expect to be able to buy, hire and hire-purchase almost everything in connection with gas supply, naturally and rightly expect the same of electrical supply. Every manager of electric works can testify that gas companies are able to hold and extend their business on a scale which would be impossible were the relative positions on an equality.

Gas companies generally supply under the condition that increases in dividend are co-dependent on a reduction in price to the public. Rather than reduce the price of gas, however, gas companies use large sums of money that should go to the public in reduced price for gas, in fitting up houses free, or nearly so, and in doing a great deal of work for the public with a view to keeping out the electric supply, which generally has not such powers.

In the case of undertakings in which the business is confined to the sale of electrical energy, the sales staff should consist of (in undertakings above a certain size) a sales manager (£150–£300), district representatives (£78–£104 and commission, or £120–£180), an advertising assistant (£100–£120), specialists each in power, lighting and signs, and heating and cooking (£120–£250), a show room attendant (£100–£150) and a clerk (£80). It is advisable to pay the manager a fixed salary. District representatives are generally, however, paid a salary with commission. The salary should vary from 30s. to 40s. with commission of 3½d. per 35 watt lamp, 2s. 6d. per brake horse-power in motors, and pro rata for heating and cooking apparatus. Some managers, however, prefer to pay a fixed salary, as there is otherwise, they think, a tendency to overload a consumer. It is advisable to divide the area of supply into districts, allocating a man to each district. Each man should make an average of 30 calls per day. A record should be kept of the number of calls per order for each man—in one case this works out at nine.

The advertising assistant's salary is sufficient, because literature and advertisements can be arranged through the joint publicity committee. The expenditure for commercial development under these conditions should be in the neighbourhood of 2 to 3 per cent. of the annual revenue, and should be charged to joint working costs.

When sales and installation departments are carried on, the staff engaged would be a much larger one; the expenditure on sales, installation, hire, &c., should be covered by profits on this work, but the remaining expenditure, including publicity, should be charged



to working expenses, as in the former case. The above diagram shows a suggested arrangement for such a staff in the case of a large town.

The construction department will be divided into two branches, maintenance and construction. Maintenance will control hire and hire-purchase of arc lamps, motors, heating and cooking apparatus, in addition to maintenance contracts, which have proved of great value in retaining consumers. Construction will be responsible for all new work. The salaries set against the different positions are a general guide, but can be taken as about fair. The bonus should be paid on net sales, disconnections being debited.

Hire and Hire-purchase.—For hire a gross profit rental of 30 per cent. should be paid, made up as follows:—Redemption of capital, 15 per cent.; interest, 5 per cent.; repairs and maintenance, 5 per cent.; contingencies and other charges, 5 per cent. The hirer must pay for any breakdowns not due to fair wear and tear and fire insurance. The rental to include inspection and maintenance other than above. For hire-purchase (two to five years) the list price of the motor, and a further 15 per cent., should be taken and divided into equal parts. Alternatively, 25 per cent. of cost paid in advance and the remainder in eight quarterly instalments is a good plan if it can be arranged.

Arc lamps are hired at inclusive prices, and in one case the charge is £8. 4s. per annum up to 800 hours use per annum, payments to be made in advance, 2½d. per lamp per hour being charged for excess use. M.F. fittings should give good results on the same principle.

Electric vacuum cleaners, for hire, including delivery, at a rental of 7s. 6d. to 10s. per day, should have a fair demand. Cooking and heating apparatus must be hired at liberal rates to cover depreciation.

* Abstract

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Show Rooms.—It has been proved by actual experience, and will be conceded, that a central position in a good business thoroughfare must be selected. Having secured a position, it is advisable to arrange the frontage in an attractive manner, and as much as possible should be devoted to window space, in such a way as to make an attractive show of electrical apparatus to passers-by. It is important that the premises should be kept clean and bright. Every effort should be made to get as many people as possible to call. The collection of accounts should be made from these premises, consumers having to walk through the show rooms to reach the cashier, so that existing consumers can be kept in close touch with new ideas and new apparatus, and the benefits of such demonstrated to them. Undertakings not availing themselves of this opportunity are undoubtedly losing many opportunities of increasing business. Complaints can also be much more easily and effectively dealt with in this manner.

If the premises are sufficiently extensive, it is advisable to fit up certain small rooms to demonstrate under normal conditions the varied uses of electricity in the household, and, in fact, every opportunity should be taken so to arrange the electrical apparatus that its operation can be demonstrated in such a way as to carry conviction as to the advantages of its adoption. All articles should be clearly marked with the list price and the cost of current per hour, and good illustrations of the many applications of electricity should be hung from the walls.

The show rooms should be in charge of a qualified man, able to explain accurately and convincingly all the good points of the apparatus, and to give information on all matters appertaining to electric supply without worrying the visitor.

The outside of the premises should be well lighted by night; an illuminated facia helps to make the premises attractive, and will lead to orders for similar business. A large sign projecting at right angles from the building, so arranged that the wording can be changed, will be found to be a great advantage.

Exhibitions.—Exhibitions at intervals have proved to give very satisfactory results in increased business when well arranged and run on business lines, and are popular with the public. The out-of-pocket expenses should not exceed £50 to £100, according to the size of the town. In large towns a booth to give demonstrations is useful in large stores, bazaars, &c.

Advertisements.—A good business catching system of advertisements is essential to back up the canvassing staff and to carry on the large work of educating the public to things electrical, which is so necessary. This should be done by (*a*) Eye-catching advertisements in the local press, backed up by chatty paragraphs on new apparatus or work carried out. Church magazines are also useful for domestic applications. (*b*) Posters on hoardings which should be full of human interest and of artistic merit. (*c*) Showcards distributed in contractors' windows. (*d*) Artistic calendars distributed to tradesmen. (*e*) Tramcar advertisements. (*f*) Illuminated signs &c., perhaps, the most effective of all if properly thought out.

Circular Letters.—These and pamphlets dealing with the various applications of electricity, got up in an attractive manner, should be regularly circulated amongst the householders. A fair expenditure for advertising and publicity literature should be in a medium size undertaking 0·3 to 0·5 per cent. of revenue.

A joint publicity committee, representing company and municipal electric supply interests, and controlled by the manager, has recently been formed, and it should, in time, have a very material influence in developing the electric supply throughout the country. The committee will issue posters, pamphlets, and carry on all the work necessary for the purpose of commercial development of electric supply, and should be supported by every undertaking in the country. This committee may, at a later date, act as a registry for the commercial staffs of the undertakings.

A good office system is necessary in connection with the business-getting department. A card system can be made good and efficient use of. A record of all premises should be kept arranged in street numbers alphabetically (a suggested form for this purpose is given by the author), and the cards in the order of the street numbers. The back of the card contains a record of the date of calls, canvasser's initials and the result of such calls. It is further advisable to keep separate files of business premises, power users, &c., so that these consumers can be dealt with on special lines.

A scheme which in practice has worked well is to give a registered number to each premises and have separate dockets for same; all correspondence is filed therein, giving a complete record of all information respecting each particular installation.

Canvassers should be provided with a book of data likely to be useful to them, and each day they should submit a report on calls made. These particulars, after inspection by the sales manager, should then be entered up on the card by the show-room attendant, or in large undertakings by the clerical staff. Each man should have a diary, in which he should enter up at the proper dates any calls it is advisable to make in the future. A close watch must be kept on new premises being erected, and it is important to obtain early notice of premises let.

Treatment of consumers should receive careful attention. Complaints should be received in a sympathetic manner, and the confidence of the consumer obtained by courteous treatment. Such a course often leads to recommendation and increase in business. A list of unused services should also be kept, and these should receive occasional calls.

Heating and cooking is a branch of the business which in the past has not made much progress. Certain small lines, however, such as electric irons, should be good revenue-earning articles, and should be vigorously pushed. These should be placed on 14 to 30 days' trial, and 60 to 80 per cent. should be sold. An electric iron should produce a revenue of 15s. to 25s. per annum. Electric cooking is retarded more by the initial cost of the apparatus than by the cost of current, and a progressive scheme of hiring out is necessary.

Attempts at a more active business development of the supply undertaking have been accompanied by hostility from the contractors. There are two alternatives for the future, either co-operative arrangements between the contractors and the supply authority, or a vigorously conducted sales department by the latter. The author is of opinion that the sales department would bring a more rapid increase of business, and must be the final solution of the problem, as already clearly proved by the experience of the gas companies; but the former scheme being properly supported might produce useful results. The difficulty of attempting co-operation, however, seems mainly to be due to trade jealousy amongst the various contractors in any particular district.

THE COMMERCIAL PROGRESS OF ELECTRICITY UNDERTAKINGS.*

BY H. COLLINGS BISHOP,
(Chief Electrical Engineer, Newport, Mon.)

Summary.—The author describes the commercial development of the Newport electric supply undertaking during the past three years, discussing installation work, arc lamp hire, hire purchase schemes, charges, gas competition, free or assisted wiring, &c.

The past three or four years have seen the development of the commercial side of electrical undertakings to a far greater extent than at any previous time. Engineers have recognised that they must pay as much attention to that side of the business as they have done in the past to the engineering side, so that at the present moment electrical engineers have practically double duties to perform.

In the undertaking managed by the author the progress made in the past three years is, in his opinion, satisfactory, but still open to many improvements, chief amongst which may be mentioned the question of show rooms. At the present time no town need suffer from the want of advertising matter, as plenty can be obtained free from the various manufacturers if one is prepared to push their goods, and there is more than one company in existence which is prepared to supply any amount of literature in return for the coin of the realm. As to whether advertising matter so obtained is suitable must depend to a great extent on local conditions. Personally the author does not consider it altogether advisable to depend on matter made up in London as a suitable means of advertising, say, the Newport undertaking, a hundred and fifty miles away; and he is of opinion that the correct way to deal with the problem is to make up your own advertising matter to suit your special requirements, even though the standard of literary art may not be up to that of the expert.

The author has spent a good many years in America, but has not returned with the American idea of advertising, which necessitates dumping a postcard or letter on your breakfast plate every day until, from sheer exhaustion, you succumb and give an order. In Newport the sending of numerous letters, postcards, &c., was tried for some time but the results were not nearly so good as dealing individually with prospective consumers, and using your judgment when to give them a rest. Circularising specialities is another matter and can very well be done in the first instance by circular, to be followed by a call showing the article you want to introduce. When that article is likely to be suitable, such, for instance, as an iron, it should be left for a week's free trial. Nine times out of ten this will result in a sale. The essence of successful advertising is good judgment.

* Abstract.

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Canvassing is the most important of all the departments connected with the commercial development of electrical undertakings. Payment by commission should not, in the author's opinion, be indulged in. His advice is, given a good man, pay him a proper salary and trust him. If a commission is necessary to make him look after your interests get rid of him, he is no good to you.

Two or three years ago the Newport Corporation appointed a combined canvasser and illuminating engineer, and the appointment has been an unqualified success, not only in the way of obtaining new consumers but in satisfying those who grumble. He has also been able to cover practically the whole of his salary by the casual sale, during his rounds, of lamps, irons, radiators, &c. The appointment has undoubtedly resulted in more contented consumers, less grumbling, and increased business, and the author would strongly advise those undertakings which have not launched out in this department to do so at once.

The mode of procedure in Newport has been as follows:—The canvasser works directly with the consumer or prospective consumer and reports daily to the chief the result of the previous day's work, and generally discusses the work in hand. By this means there is a minimum of delay in giving the prospective customer a definite reply, the canvasser becomes daily more acquainted with the policy of his chief, and is gradually able to deal more quickly with customers, and when the necessity arises of taking the responsibility of giving a decision on a matter at the moment, he is able to settle without feeling that he has taken any risk of disapproval. There is no doubt that a customer likes the man who has called upon him to be able to give a decisive reply without having to wait whilst the matter is referred to the office, and the close co-operation between the chief and the canvasser enables this to be done. Another important point when dealing with prospective consumers is to guage the correct time for the manager to step in and see the new consumer. This refers rather to the smaller jobs, the experience of the author being that in the larger jobs he has to do a great deal of the negotiating himself.

Installation Work.—There is no doubt that, were the field free, the electrical undertakings are in an excellent position for dealing with all the necessary installation work for their own consumers, and a good percentage of electricity users prefer that all repair and installation work should be carried out by the undertaking. Newport, which possesses full powers for dealing with all work connected with the undertaking, has so far rested content with carrying out such work as has been directly thrust in its way and in carrying out work under the hire or hire purchase systems. The general run of work has been left to the contractor. The number of consumers who now send direct to the electricity department is, however, growing rapidly, showing that they really prefer the work being carried out by the supply authority.

One is often asked, What is to become of the contractor? The author's reply would be that the properly trained and conscientious contractor has little to fear, but the man who becomes an expert in a night must, in the interest of the whole industry, go. A great deal of harm is being done by these men, and also by some of the large plumbers and ironmongers, who often put on an inexperienced man as electrical foreman and leave the whole department to him.

Motive Power.—In the author's case he has yet to find the consumer who discards electric power once he has started, except due to failure in business or other like cause. The ease of starting, and the knowledge that the power is always available for use are strong arguments in deciding people to change over from older methods of motive power to the more modern one. It is, however, necessary to run the hire department upon business lines. Ten per cent. to cover interest and all other charges, based upon the cost price, is bound to end in a loss to the department. Neither does the author consider it at all necessary to make the hire rate very low in order to obtain consumers. In Newport there has been no difficulty in obtaining 20 per cent. return on the cost price (the rates obtained in Newport for the hire of various sizes of motors are given in the Paper).

Arc Lamp Hire.—This is a department that has not been started by a great number of undertakings, nevertheless it is one that has many points worthy of consideration. There are two chief reasons that deter consumers from installing arc lamps, viz., first cost and the bother of trimming and cleaning. The author has found it most successful to undertake both duties, and in Newport there are at the present time 283 arc lamps on hire from the Corporation. The whole of these lamps are maintained by the Corporation for an inclusive fee per hour (in use) for current and carbons. In addition, there are 55 lamps owned by consumers, but maintained by the Corporation at a given sum per annum. There is no doubt that lamps so maintained give better results than when trimmed by the consumer.

The rates charged in Newport are as follows:—One 360 watt alternating lamp, 2d. per hour; one 400 watt alternating lamp with metal core (yellow) carbons, 2½d. per hour.

The rates charged for the hire of the lamps are as follows:—One alternating lamp and transformer, £2. 8s. per annum; two alternating current lamps, £4. 3s. per annum; four direct current lamps, £6. 18s. per annum.

Hire Purchase.—In this department we deal with almost any kind of apparatus that a consumer may require, both for lighting, heating, and power, and we vary the payments from one year to five years as may be required. The business done has been fairly good, without unduly pushing it; that is to say, if we think a consumer is prepared to buy outright we leave him to the contractor, but when we know it means deferred payments then we push the scheme for all it is worth. The author has found this scheme popular, even amongst those who are able to pay outright, for the reason that they like to have the maintenance in the hands of the Corporation.

Inspection.—In 1906 the author mentioned the question of inspection, and was criticised by one member as advocating red tape. The author abominates red tape of any sort and keeps all agreements, applications, &c., down to the smallest point, and for the same reason the published regulations are as short as possible. But he is still of opinion that some form of inspection is required, and the chief point to consider is, who is the right authority to undertake it? It used to be said that this should be done by the municipal authority, but now that so many corporations undertake installation work themselves it is questionable if they are the right ones to do inspection of work that may be done by a competitor.

Charges for Energy.—It will be agreed to, by some at least, that a general flat rate, although simple, is not satisfactory because it does not afford that flexibility that is necessary. The maximum demand system has been found wanting by many, and the town that has four pages of varying charges is laughed at by many engineers and grumbled at by the poor consumer, who does not know which to adopt. At the same time the author ventures to say that there must be a reasonable number of varying charges to permit him to satisfy the most difficult prospective consumers that it will pay them to adopt electricity. The rates in force in Newport are given in the Paper.

Gas Competition.—The author ventures to say that this does not exist to nearly the same extent that it did a few years ago. It is now strenuous fighting on the part of our rivals to prevent consumers migrating to a really healthy illuminant. Where competition really does exist is with the small consumer, who, at the present time, uses gas, oil or candles. Here there is a great field for activity. The competition in street lighting is dead. The advent of the flame arc for main streets and the high candle-power metal lamp for side street lighting has put that necessary finishing touch of superiority which makes it most difficult to raise arguments in favour of any other form of illuminant. One is able now successfully to attack that stronghold of the gas company—heating, and the gradual increased consumption in heating units that is being made each year is bound to tell in time.

Free or Assisted Wiring.—Many schemes have been tried for inducing small consumers to take electric light by offering to wire premises free or for a small rental, but there are not many cases where it has been a success. A better plan, in the opinion of the author, is to put forward the prepayment meter; and in Newport considerable success has been obtained in this line, some 50 to 60 meters having been installed during the past seven or eight months. This, however, does not overcome the difficulty of obtaining the very small consumer whose demand does not exceed two or three lights. Prepayment meters in these cases are no good because the revenue allowed in the charge made is not sufficient to make a sufficient return on the cost of the meter, and the author now puts forward for consideration a scheme for the inclusive rental of wiring and energy.

Briefly the scheme is as follows:—To charge a weekly rental for current and hire of fittings; to use a cheap form of surface wiring; a variable weekly rental according to the time of the year; an arrangement by which all rooms can be wired and a varying rate charged according to the number of lamps it is desired to have power to light up at the same time; a locking holder to minimise the theft of lamps; a scale of weekly rents for the varying conditions that may arise.

The charges shown on the scale are based upon the following rates: Charge for energy, 4½d. per unit; capital cost for wiring (without lamps), 10s. per point; capital cost for each service, 20s.; capital cost of the instrument to prevent the use of more lights at a time than are paid for, 15s.; collection charges, 1d. per house per week; annual allowance per lamp for renewals, 2s.

The average number of burning hours per annum has been based on

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the following:—One point installed, 1,000 hours per annum; two points installed and two lights permitted at a time, 1,300 hours per annum; and so on up to six lights installed and six permitted, 2,000 hours per annum. A chart is also given in the Paper showing how the weekly charges work out on these figures, taking 35 watt lamps. Thus with one light at a time permitted, the weekly charge in winter would be 7d., and in summer 4d. With two lights at a time permitted, and two points wired, the weekly costs would be 8d. and 6d. respectively. With two lights permitted and four points wired, 9d. and 7d. respectively; and so on, until with six lights permitted and six points wired the charges would work out at 12d. and 10d. for winter and summer respectively.

The author next considers the case of 100 consumers divided under these various headings, and shows that the total annual revenue from these 100 consumers would be £184. 0s. 10d.; whilst the cost per annum works out as follows:—

5,330 units at 0·75d.	£16	13	1
Interest and repayment on installation costs	26	5	0
Interest and repayments on services	7	10	0
Interest and repayments on the proportion of plant and mains required (basis maximum demand 5·6 kw.)	21	0	0
Collection expenses	21	13	4
Lamps	16	0	0
Limiting apparatus and terminal costs	15	0	0
Total	£124	1	5

This would leave a net profit of £59. 19s. 5d. Allowing 20 per cent. in extra units for waste, the net profit is reduced to £56. Since drawing out the above scheme the author has come across an article on the proposals of the Fixed Price Light Co.; and, curiously enough, it appears that he has hit upon a very similar scheme that it is the intention of that Company to carry out, with the following differences. The author's scheme provides for the collection of accounts, the supply of lamp renewals, a limiting device, &c., whilst the Company do not collect accounts, supply lamps, or apparently use a limiting device. The price proposed by the Company, viz., 2½d. in the summer and 3½d. in the winter, appears to the author to be too low when dealing with lamps up to, say, two in number. When that number is exceeded the two schemes appear to agree fairly well in price.

In conclusion, the author gives a list of the business obtained during the past three years, which he attributes to the results of commercial activity:—New consumers obtained, 710; equivalent in 30 watt lamps, 74,800; total revenue from sales and wiring (mostly hire purchase), £8,101; total number of arc lamps let out on hire, 283; total horse-power of motors connected to the mains, three years ago, 1,080, at the present time, 2,450; total number of private arcs maintained by the Corporation on consumer's behalf, 338. Annual receipts for motors on hire, £328; annual receipts for the hire of arc lamps, £461; annual receipts on hire purchase account, £1,047; annual receipts for the maintenance of arc lamps, £380; total capital involved, £8,800.

EXHAUST STEAM TURBINES AND CONDENSING PLANT AT McDONALD ROAD STATION.

BY F. A. NEWINGTON.
(Chief Electrical Engineer, Edinburgh).

Summary.—A description is here given of the exhaust steam turbines and condensing plant recently installed at Edinburgh. The most interesting feature is the use of sewage for condensing purposes. The capital cost of the installation and the reduction in the costs per unit generated are tabulated.

The plant described in this Paper consists of exhaust steam turbines connected to direct-current dynamos and condensing apparatus. When McDonald-road Station was designed the intention was to use towers for cooling the circulating water for condensation, but this scheme had to be given up, as it was thought the towers would be unsightly and might cause a nuisance from the steam issuing from the tops of the towers condensing and falling to the ground in the form of rain. Several other methods of getting a sufficient supply of water from a distance were considered, but were found to be prohibitive on account of the cost.

In 1907, the Water of Leith main sewer, which crosses under McDonald-road about 180 yards from the generating station, was brought to our notice, and on investigation, it was found that an average flow of about 750,000 gallons per hour could be obtained. It was therefore decided to utilise the sewer for condensing, and to extend the generating plant by means of exhaust steam turbines.

The sewer is 6 ft. 6 in. inside in diameter, and 22 ft. below the level of the road. A shaft, 26 ft. in diameter, formed of cast iron segments bolted together, was sunk down until the top of the sewer was reached, and a ring of brickwork, of the same diameter as the cast iron shaft, was continued downwards for about another 9 ft., that is, to the bottom of the sewer. The sinking of the cast-iron shaft did not give rise to any difficulties, but the building of the lower brick ring was more troublesome, as during this part of the work there was a great deal of rain, and trouble was caused by the ground slipping in. This ring was built in sections, each a few feet wide. The chief difficulty arose in providing temporary means for carrying the water while the brickwork of the old sewer was being removed. The method adopted was as follows: The top part of the brickwork for about one-third of the circumference was removed; an iron trough formed out of an old Lancashire boiler cut in two longitudinally was then inserted into the brick sewer, the ends projecting 3 ft. or 4 ft. beyond the shaft, both up and down stream, the joints between the sewer and the ends of the trough being made as watertight as possible. The remainder of the sewer inside the shaft was next demolished, the floor of the shaft completed and the temporary trough removed. On account of the heavy rainfall at the time, the sewer was more or less in flood, which increased the difficulties.

Four suction pipes, each 18 in. in diameter, and one discharge pipe, 26 in. in diameter, are laid from the shaft to the station. Straining screens are fixed in the shaft just in front of the suction pit. The end of the discharge pipe in the sewer is water-sealed, so that a syphon action is maintained. Four 14 in. motor-driven centrifugal circulating pumps, each with a capacity of 182,400 gallons per hour, are placed in the basement of the boiler house, each pump having a separate suction pipe from the shaft. The pumps deliver into a common pipe 26 in. in diameter, to which is connected a Bailey & Jackson rotary strainer. From this the circulating water passes through the four condensers back through the rotary strainer, and then is returned to the sewer. The centrifugal pumps are 16 ft. above the average level of the water in the sewer, and the highest point of the pipe system is 30 ft. above the pumps or 46 ft. above the sewer water level, but on account of the pipes forming a closed system, the average head against which the pumps work is 15 lb., that is, 8 lb. suction head and 7 lb. delivery head. As there is a very considerable quantity of air in the water, two air-extracting pumps have been provided: one extracts the air on the suction side of the pumps, the other the air on the delivery side. By this means the syphon action is maintained, and the pressure at the highest point of the pipe system averages about 20 in. of vacuum.

Four surface condensers of the Contraflo type are used, each having a cooling surface of 3,750 sq. ft. The air pumps are of the Edwards type with three throw cranks. The feed water force pump is also driven off the same shaft. At first the air pumps were intended to work on the dry system, but as there was some difficulty in getting the force pumps to work properly, one line of each air pump was altered so that it now delivers the condensed steam to the force pump, the other two lines working dry. Each condenser and air pump will deal with 45,600 lb. of steam per hour with the circulating water entering the condenser at 60°F., and leaving at 90°F., with a guaranteed vacuum of 28 in. with the barometer at 30 in. The ratio of the weight of circulating water to condensed steam being 40 to 1. The air pumps are driven by motors geared through Reynolds chains.

At first the idea of using sewage for condensing does not sound very promising, but at Edinburgh it has proved thoroughly successful. The quantity of water is not as large as one would wish, but is sufficient for a maximum output of about 10,000 kw. Unfortunately about 5 p.m., that is, at the time of the top load in winter, the flow is considerably reduced in consequence of paper works and other industries stopping for the day. The chief troubles are efficient straining and getting rid of the air in the water. The straining arrangements in the shaft consist of three iron grids each 5 ft. high and 3 ft. 6 in. wide, with vertical bars spaced $\frac{3}{8}$ in. apart. These are kept clean by scrapers automatically worked by a small motor. This arrangement answers fairly well, but a certain amount of scraping by hand is necessary at the time of top load. Probably it will be possible to devise some more efficient method of cleaning the grids, and so do away with hand labour. Further straining is done by the Bailey & Jackson rotary strainer which is placed between the pumps and the condensers. This consists of a cast-iron wheel, 9 ft. in diameter, and 12 in. wide with 12 spokes. Between the spokes are fitted grids formed of brass strips built up very much in the form of honeycomb—that is, full of small holes—and about 4 in. deep, the holes being about 0·12 sq. in. in area. The wheel is surrounded by a cast-iron casing which is divided vertically into two portions, which form the delivery and discharge chambers. The vertical partition is wide enough to cover the space between two adjacent spokes of the wheel. The casing has four pipes connected to it, inlet and outlet pipes on the

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delivery side, and the same on the discharge side. The water enters the strainer by the inlet pipe on the delivery side, passes through half of the grids in the wheel and deposits on them everything that will not pass through the holes. It then leaves by the outlet pipe on the delivery side. After passing through the condensers it re-enters the strainer by the inelt pipe on the discharge side, passes through the other half of the grids, but in an opposite direction, and finally leaves the strainer by the outlet pipe on the discharge side. The wheel is rotated slowly and the discharge water washes off from the grids everything that has been deposited on them on the delivery side, and carries it back to the sewer. The idea of the discharge water cleansing the grids is extremely ingenious. The leakage of water from the inlet chamber to the outlet chamber is considerable. It has only been possible to measure this with one pump in use, the quantity being from 10 per cent. to 12 per cent. of the total. Probably this amount will not be very much increased with four pumps running, but with a limited quantity of water this is rather serious. It also means larger pumps and motors and a larger quantity of electricity used for pumping.

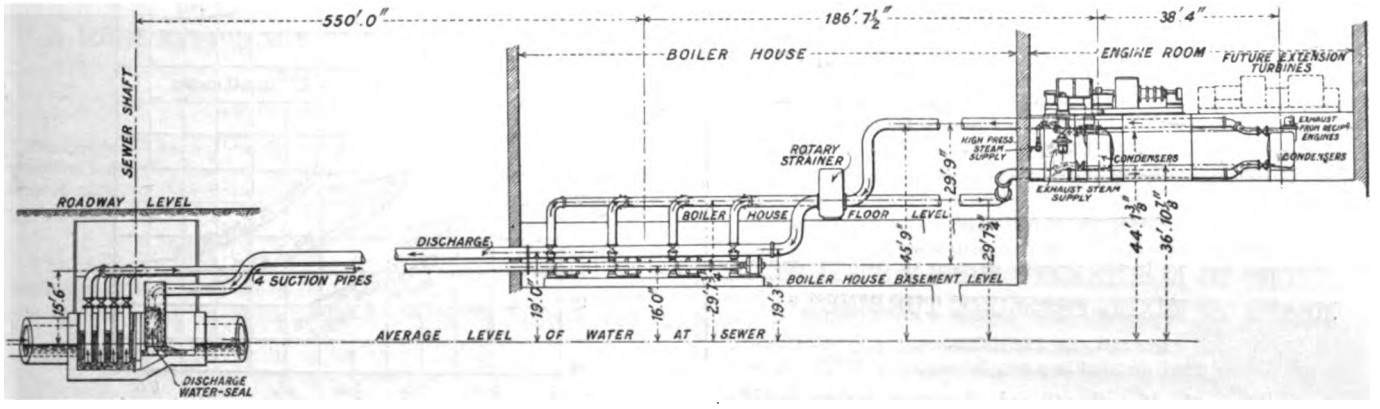
The temperature of the water in the sewer averages about 60°F. in the winter and 70°F. in the summer. As we are prohibited from returning the water to the sewer above 90°F., the range of temperature for condensation is small, and so the quantity of circulating water required per pound of steam condensed is large.

At present only two exhaust steam turbo-generators have been installed, but there is sufficient steam from the reciprocating engines for two more exhaust turbines, and these will be added as soon as the increase in output requires them. The turbines are of the Rateau type running at 1,250 revs. per min. The guaranteed output of each set is 1,200 kw., about 2,200 amperes and 560 volts, with 45,600 lb. of steam per hour at a pressure at the inlet to the turbine not exceeding 14·7 lb. per square inch absolute, and at the exhaust 1·3 lb. absolute, say, 27¼ in. vacuum.

two other condensers. As previously mentioned, two other exhaust steam turbines will be installed over these condensers when required. Automatic atmospheric valves are placed in the exhaust pipes between the reciprocating engines and the turbines. The conditions under which these valves have to work are very severe. They are balanced to open at about 3 lb. above atmospheric pressure, so they are always nearly in equilibrium, consequently they are very apt to chatter and so damage the faces. The valves first supplied were quite unsuitable. Those now in use, however, are working very well, the improvement being due to very strong construction, careful fitting of all moving parts to prevent all backlash, and the use of a special dash pot which admits air freely on the upward movement of the valve, but by means of a non-return valve, only allows it to escape very slowly when the valve is closing.

Oil separators of the Blake type are placed in the exhaust pipes between the reciprocating engines and the turbines which extract the greater part of the oil. The feed water is further treated by the Davis Perrett electrical process for freeing it from oil. The water from the air pump discharge passes into wooden tanks in which are a number of iron plates spaced about 2 in. apart. A current of electricity is passed through these tanks with the object of precipitating finely divided oxide of iron. The small globules of oil adhere to the oxide of iron, and so are easily separated from the water. The treated oily water then passes into filters containing gravel and sand which retain the oil. Automatic arrangements are provided for flushing the filters to clean the sand. The quantity of electricity used in the filter is 1 unit for every 1,000 gallons of water treated. The makers guarantee that the filtered water will not contain more than $\frac{1}{10}$ grain of oil per gallon. This is such a minute quantity that it is not easy to measure, but after 12 months' steaming the boilers show hardly a trace of oil.

The diagram shows the general arrangement of the shaft, pipework, condensers, turbines and other plant.



DIAGRAMMATIC ARRANGEMENT OF CONDENSING PLANT AT THE ELECTRICITY SUPPLY STATION, McDONALD-ROAD, EDINBURGH.

This output is easily obtained in everyday work. This means that the exhaust steam from two of the 780 kw. reciprocating sets is sufficient to give an output of 1,200 kw. from one of the turbo-generators. Live steam is connected to each turbine through a reducing valve in case the supply of exhaust steam at any time should not be sufficient. These machines will give 25 per cent. overload for a short period. The rotor of each turbine has 11 wheels with 265 blades on each wheel. The clearance between moving and stationary parts is considerable, and there has not been any indication of stripping. Besides the usual governor there is an emergency governor which comes into action if the speed exceeds 10 per cent. of the ordinary running speed, and also acts if the pressure of the lubricating oil falls.

The dynamos were built by Brown, Boveri & Co. They are four-pole machines, and are separately excited by a small dynamo at the end of the shaft. Copper brushes are in use on one machine. The commutator of the other machine has been altered to give increased ventilation, and carbon brushes are fitted. There was some little trouble at first with commutation, but this has been overcome, and both machines are now running well, especially the one fitted with carbon brushes. This commutator keeps very cool, being only 42°F. above the temperature of the air after a six hours' full load run. Each commutator has 100 bars giving a pressure of about 22 volts per bar. At first there was a considerable amount of vibration on these machines, but this was caused by the turbine and dynamo shafts not being quite in line, and by the type of flexible coupling employed. Since one machine has been accurately lined and another type of coupling fitted, the vibration on this has entirely ceased.

The exhaust steam pipes are arranged so that the steam from the reciprocating sets can pass either to the exhaust turbines or direct to

There is not the least difficulty in running the turbo-generators in parallel with the other dynamos. The old dynamos are shunt wound, and the turbo-generators compound wound. The whole regulation is done by the switchboard attendant by means of the shunt resistances. The only point to be careful about is to see that steam is not escaping past the atmospheric valves, which would mean waste. In order to prevent this, indicators have been fitted just above the atmospheric valves, and directly any steam passes the valve an electric circuit is closed which rings a bell on the switchboard. The switchboard attendant then puts more load on to the turbine, and so reduces the pressure of the steam in the exhaust pipe.

Cost of Plant.—The condensing plant is sufficient to deal with the steam from reciprocating and exhaust turbines of 11,000 kw. The capital cost was as follows:—

	£	Per kw. £
Sewer shaft with four 18 in. suction and one 26 in. discharge pipe in roadway	5,600	0·5
Circulating water exhaust steam pipework inside the station and oil-extracting plant	6,000	0·5
Rotary water strainer	2,000	0·2
Four condensers circulating and air pumps	11,000	1·0
	£24,600	2·2
Two 1,200 kw. turbo generators with switchboard	£13,800	5·7

The economy caused by the exhaust steam turbines and condensing plant is shown by the following figures, which are for similar periods in 1908 when only reciprocating engines were used without condensation, and in 1910 with exhaust steam turbines and condensation. In 1908 the price of coal was considerably lower—10d. a ton—than in

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1910, but for the purpose of comparison the 1910 price has been taken for both periods. In the costs per unit generated for the 1910 figures, the units used by the condensing plant have been deducted. As only three of the boilers are fitted with superheaters the amount of superheat is quite small :—

	1908.	1910.
Duration of test	3 weeks	3 weeks
Date	Jan. 16th to Feb. 6th	Jan. 20th to Feb. 9th
Units generated	715,491	888,644
Units used by condensing plant	—	43,045=4·8%
	715,491	845,599
Load factor	22·8%	25·1%
Plant factor	89·6%	76·9%
Lb. of water per unit generated	39.0 lb.	22·2 lb.
Lb. of water evaporated per lb. of coal	6·67 lb.	6·6 lb.
Lb. of coal per unit generated	5·85 lb.	3·9 lb.
Maximum output	6,227 kw.	7,021 kw.

Costs per Unit Generated.			Saving.
Fuel	0·251d.	0·167d.	33·4%
Oils and stores	0·009d.	0·004d.	50·0%
Water	0·027d.	0·006d.	78·0%
Salaries and wages	0·054d.	0·047d.	—
Repairs (estimated)	0·057d.	0·057d.	—
	0·398d.	0·281d.	30·0%

At present at the time of top load in the winter months three or four reciprocating engines are exhausting direct to the condensers, so the economy will be increased when the other two turbines are installed.

Some engineers seem to think that exhaust steam turbines are only a passing fashion and will disappear in a few years, but in stations with existing reciprocating engines, either exhaust steam or mixed pressure turbines seem the most suitable for extensions, as the combination of reciprocating engine and turbine is as economical as high-pressure turbines, and obviates all necessity of scrapping the old sets until these are worn out. As shown by the figures above giving the capital costs, the price of the sewer shaft and pipework in the roadway comes to £0·5 per kw. This is considerably less than cooling towers would have cost. In places where a river or other sufficient supply of water is not available for condensation, a main sewer, if near the generating station, is well worth consideration.

EXTENSIONS TO ELECTRICITY SUPPLY STATIONS BY MEANS OF MIXED PRESSURE TURBINES.*

BY ASHTON BREMNER.
(Chief Electrical Engineer, Burslem.)

Summary.—The author describes the mixed pressure turbine installed at Burslem, and gives particulars of the saving in works costs thereby obtained. He also mentions the saving obtained in other installations of mixed pressure turbines, which latter he considers are an economical method of extending existing supply stations.

One of the chief reasons why many stations are financial failures is because they are overweighted by capital charges. Burslem is situated in an industrial area where, for the most part, only motors of small power are required and steam for heating and drying is a necessity. Here, if electricity is to compete at all with other motive powers, the scale of charges must be very low indeed ; consequently more than ordinary care was taken that the plant at first installed was suitable to the probable demand and easily extended.

Starting in 1905 with one 100 kw. and one 200 kw. Howden-Dick, Kerr sets, a similar set of 350 kw. capacity was installed in 1907. Further extensions becoming necessary, the writer early in 1908 advised that a 600 kw. Belliss-Siemens mixed pressure turbo-generator be installed, the plant being so designed that it could be used either as auxiliary power on exhaust steam or as stand-by plant on live steam. This type of plant seemed to offer the best solution of the problem because, as the original sets were run non-condensing the whole of the exhaust steam could be utilised in the turbine to produce additional power without increasing the cost of coal and water. A study of the entropy diagram will show that the turbine develops approximately the same power as the sets which supply it with steam.

The general lay-out of the mixed pressure turbine at Burslem is shown in a diagram accompanying the Paper. The reciprocating set can be run either non-condensing, condensing or in connection with the turbine, or the turbine can be run as a separate unit.

* Abstract.

The results of the official test of the turbine carried out at the makers' works are as follows, the plant running at 1,850 revs. per min. :—

No. of H.P. nozzles open.	Kw.	Steam per kw.-hr.	—	Vacuum, inches.
		lb.		
0	610	24·6	Live steam	27·27
1	607	24·5	,,	27·27
2	607	25·3	,,	27·27
3	607	25·8	,,	27·27
0	310	32·0	,,	27·33
0	762	24·6	,,	26·65
0	580	38·8	Low-pressure steam	26·21
0	418	39·9	,, ,,	26·77
0	321	48·6	,, ,,	27·33
0	300	46·2	,, ,,	26·9
		Total steam		
0	No load	2,650	Live steam	28·0
0	with	2,910	,,	27·0
0	excita-	3,080	,,	26·12
0	tion	4,500	Low pressure	27·5

Fig. 1 gives the result of tests of the steam consumption per kilowatt-hour under different conditions and varying loads. As a guide to the power obtainable from the exhaust steam of reciprocating engines the following figures given by a firm of turbine builders may

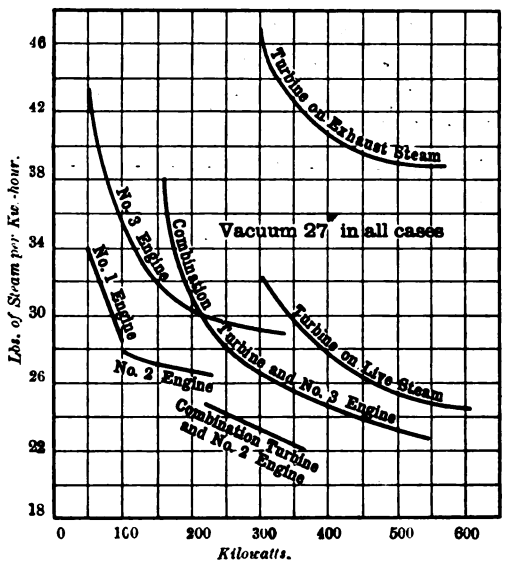

Fig. 1.

be mentioned. With a 500 kw. compound engine working non-condensing on saturated steam, 375 kw. additional power can be obtained from the turbine ; or, if superheated steam is being used, the power obtainable is 320 kw., in each case less, say, 5 per cent. required to

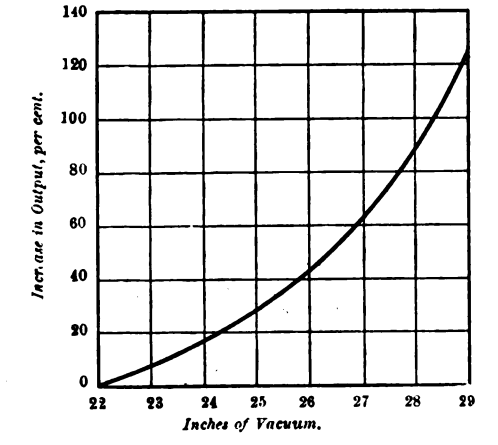

Fig. 2.

drive the condensing plant. The author also gives the results of the working economies of the power house plant of a large engine builder's works. The figures show a saving per kilowatt-hour, by using a mixed pressure turbine, compared with the engine alone, of

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18·45 per cent. on a one hour's test (steam consumption 17·7 lb. and 21·7 lb. respectively), and 26 per cent. (fuel consumption 3·93 lb. and 5·31 lb. per kilowatt-hour respectively) on a test extending over three months under average station conditions. The power house was equipped with one 300 kw. and one 400 kw. triple-expansion engine running with a steam pressure of 160 lb. and vacuum of 26 in., the steam being superheated from 50°F. to 150°F. At the beginning of 1908 an exhaust pressure turbine was installed which, running on the exhaust of one of the engines, was able to cope with the maximum load of the station and at the same time to give economical running on lighter loads. The fuel is slack of poor calorific value.

A turbine of the Westinghouse-Parsons type of 368 kw. capacity installed at the Gloucester Railway Carriage & Wagon Co.'s works is fitted with high and low-pressure steam chests, the latter capable of dealing with 9,000 lb. of exhaust steam per hour, and from which 210 kw. is obtained, the rest of the load being carried on high-pressure steam. In this turbine the governing is effected by giving the low-pressure governor valve a lead over the high pressure, so that the full quantity of exhaust steam is always used before high-pressure steam is admitted.

After giving a brief description of the Belliss-Morcom mixed pressure turbine installed at Burslem, the following figures of works costs per unit generated are tabulated to show the gain (32 per cent.) due to installing the turbine. The calorific value of the coal = 12,700 B.Th.U. per pound, and its cost per ton 7s. 3d. into bunkers.

	Reciprocating sets only. April, 1909.	Combination of turbine and reciprocating sets. April, 1910.
Coal	0·244 l.	0·184d.
Water	0·071d.	0·028d.
	0 315d.	0·212d.

Fig. 2 shows the increase in output from exhaust turbine with increased vacuum.

A HIGH EFFICIENCY REFLECTOR FOR STREET LIGHTING.*

BY CLAYTON H. SHARP.

Summary.—The author describes a new form of reflector, specially adapted for street lighting by incandescent lamps and designed to give a more uniform illumination. The results of tests on typical installations are given.

The problem of the satisfactory illumination of public streets and highways is one which we shall always have with us. The extent of the streets requiring illumination is practically limitless and the

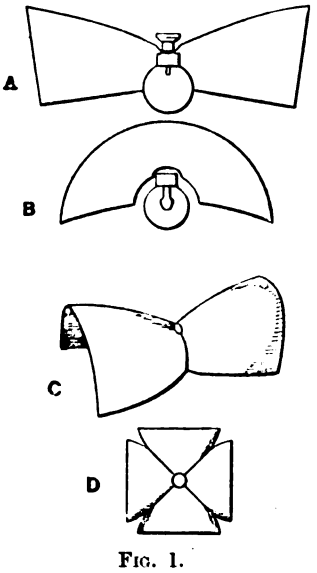

Fig. 1.

demand for more light is unceasing. In view of this undoubted demand for higher degrees of illumination and for continuous extensions of lighting systems to streets now unlighted, the most important question which arises is that of economy. An economical street lighting system can be realised in any particular case by the selection of such illuminants as shall be most economical, by the proper location of these illuminants, and finally by the most effective utilisation of the luminous flux available.

Great progress has been made in the last 10 or 12 years in the production of economical illuminants for street lighting. The introduction of high-pressure mantle burners, of tungsten lamps and of flaming arc lamps has been of great importance to the art of economical street illumination. In many respects the most significant and important advance has been in the production of the tungsten lamp, the advent of which opens up a field in street lighting which was formerly entirely inaccessible to the electric supply company and which has enormous possibilities.

In the production of devices aiding in the proper distribution of luminous flux for the economical lighting of streets, relatively little progress has been made. In interior illumination, this is not so. Within the last few years the greatest attention has been given to the question of proper shades and reflectors so that to-day almost any requirement can be met by appliances actually on the market. The problem of the design of reflectors and globes for street lighting is

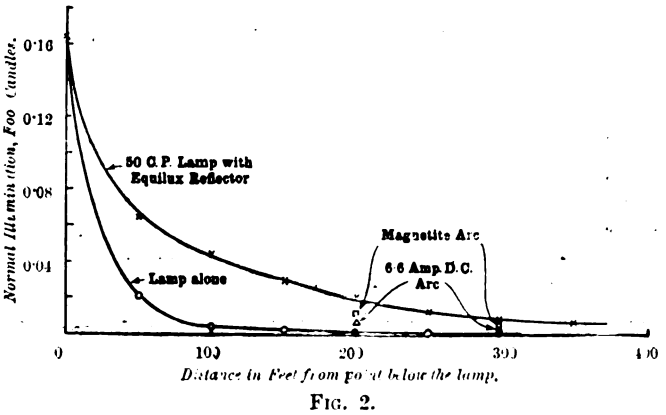

Fig. 2.

quite different from that of interior illumination, although this difference has seldom been recognised. For the illumination of interiors, it is desirable that a certain flux of light reach the ceiling of the room. The ceiling must be illuminated, and sends back a proportion of such flux to participate in the useful illumination of the room. In the case of street illumination, all flux leaving the fixture above the horizontal plane is absolutely wasted. Therefore, a street lighting reflector should direct as nearly as possible all luminous flux in directions below the horizontal. Furthermore, in interior illumination, the distribution of flux about the vertical axis of the lamp with its reflector, may usually, without detriment to efficiency, be symmetrical. In the illumination of streets, the case is quite different. The crosswise dimension of a street may be taken as of negligible importance as compared with the lengthwise dimension. Therefore, if the distribution of flux be symmetrical, an undue proportion of the flux is directed towards the sides of the street. The distribution must be unsymmetrical, a far greater proportion of flux being directed lengthwise of the street than crosswise of the street.

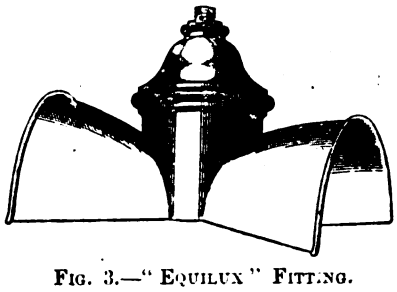

Fig. 3.—"Equilux" Fitting.

The requirement of street illumination is that the roadway and objects in the same shall be illuminated to a degree which shall at every point exceed a certain minimum value. What results from the ordinary arrangement of lamp alone or lamp with symmetrical reflector is that, in the vicinity of the lamp, the street is excellently illuminated, but this illumination falls off rapidly with the distance, so that at a point midway between lamps it has a relatively very low value. At the same time each lamp distributes crosswise of the street as much light as lengthwise, and only a small proportion of this light is effective in lighting the street itself, the major part being wasted on the roadside. Thus the ordinary system of street illumination is very inefficient from two causes, first in that only a small percentage of the total luminous flux is incident on the surface to be

* Abstract of a Paper read before the New York Section of the Illuminating Engineering Society.

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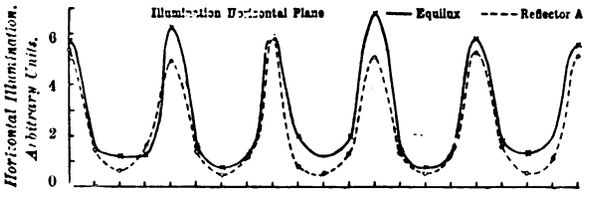
illuminated, and second in that the distribution of the flux so incident is such that the illumination in the immediate vicinity of the lamps is unduly high, while midway between lamps the minimum illumination, which is by far the most important factor to be considered, is far too low.

The reflector and lighting fixture here described represent the results of an endeavour to obviate these disadvantages of the ordinary system of street lighting, and thereby to obtain a more economical and more uniform illumination. The problem was to collect the luminous flux ordinarily wasted in the upper hemisphere and toward the sides of the street and to re-direct that flux so that it would be incident on those parts of the street where it was most needed—namely, in the region midway between the lamps. This result should be accomplished without interfering with the natural illumination on the street surface from the lamp directly, so that in case the device became inoperative or operated badly, as by the accumulation of dirt, the illumination would at least not be any worse than if the device were absent entirely.

It is clear that stray light could be collected and redirected so as to illuminate the regions midway between lamps by the use of a parabolic mirror with the lamp at the focus. But this arrangement

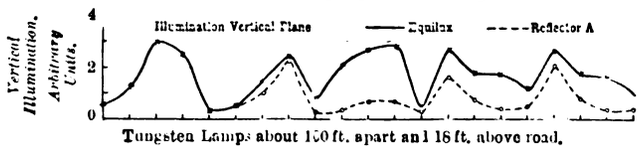


Tungsten Lamps about 100 ft. apart and 18 ft. above road.

FIG. 4.

would cut off the necessary light near the lamp-post and hence would be impracticable. This difficulty could be met by cutting away the lower portion of the reflector. But this arrangement is not yet all that is desired because it directs the light in only one direction instead of two directions 180 deg. apart as required. This condition may also be met if the parabolic reflector is cut through vertically in the focal plane and a similar reflector also with its lower half cut away is placed back to back with the first. This results in a structure which does not obstruct the natural illumination of regions near the lamp and which by redirecting light otherwise wasted builds up the illumination in the dark parts of the street. A cross-sectional view of such a reflector is given in Fig. 1 A. It will be seen that the semi-paraboloids are inclined to each other so that the two reflected beams will fall on the street surface at the required distance from the lamp-post. Fig. 1 B shows an end view of the reflector and lamp, and Fig. 1 C gives a perspective view of the exterior.

An objection may be made to this arrangement on the grounds that a parabolic mirror throws a nearly parallel beam of light. Consequently the effect of the proposed arrangement would be to



Tungsten Lamps about 150 ft. apart and 16 ft. above road.

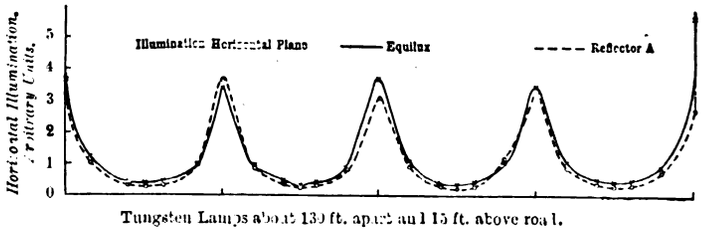
FIG. 5.

illuminate only a small area of the street by the rays coming from the mirror; that is, at a point midway between the lamps there would be a little bright patch which would amount to nothing as far as the general illumination goes, while the surrounding portions of the street would be left in darkness as before. This objection would be a very valid one provided we had a very small source of light in the focus of the mirror. Then the effect would be that of a searchlight beam. What we actually have in practice with the tungsten lamp is quite an extended source. The result of this is that the beam of light is a divergent one, and at the distance where it is effective it covers a considerable area. The angle of divergence of a beam of this character is equal to the angle which is subtended at the mirror by the source of light. It is found in practice that this angle is sufficient to cause reflected rays to cover all the area of the street surface which is required.

The idea which is developed above of using two semi-parabolic mirrors pointing in opposite directions may evidently be extended to include three or four or more. For example, at the intersection of streets, a reflector would be used which has the form shown in Fig. 1 D. It is clear that this reflector would not be so effective in any one direction as is the two-direction reflector, because the luminous flux is divided by four rather than by two. Still the gain resulting from the use of this reflector would undoubtedly be very considerable. The most effective form being the two-reflector form, and there being less waste light with such reflectors as are commonly in use in the case of lamps placed at the intersection of two streets than there is in the case of lamps placed in the middle of a block, the two-direction reflector is the one which has been given the chief attention up to the present time.

The first reflector which I had made was constructed of zinc. The zinc was spun into the form of a paraboloid of revolution cut through the focal plane. This paraboloid was afterwards cut in two lengthwise and the halves were mounted in the way shown in Fig. 1. The interior of the paraboloid was brightly burnished and made a very good reflecting surface. In the proper position in this reflector a 50 c.p. Gem lamp was mounted, and the fixture was raised to a height of approximately 15 ft. above the street. The normal illumination produced at different distances by the reflector was then measured by a portable photometer and was compared with the illumination which would have been produced by the lamp alone. The latter illumination, however, was, excepting quite close to the lamp-post, too small to be measured with any degree of accuracy. This test was carried on in a quiet residence street which was very badly illuminated by series incandescent lamps placed some 300 ft. apart. The normal illumination values obtained in this test are given in Fig. 2. Points are also plotted to show the standard values adopted for the magnetite arc and for the 6·6 ampere direct-current enclosed arc, as adopted by the National Electric Light Association. It will be seen that both of these values are considerably exceeded by the 50 c.p. incandescent lamp with reflector.

The results of this test were so encouraging that the work was taken up of developing a commercial form of street lighting fixture embodying this reflector. In this part of the work, I have enjoyed the invaluable co-operation of Mr. S. G. Rhodes, engineer of the street lighting department of the New York Edison Co., and of his assistants. To the efforts of Mr. Rhodes is largely due the successful form in which the lighting fixture now is found. The typical form



Tungsten Lamps about 130 ft. apart and 15 ft. above road.

FIG. 6.

of this fixture for incandescent lamps, which is patented, is shown in Fig. 3. To this fixture I have given the name "Equilux," which is descriptive of its purpose.

In the fixtures so far made the reflectors have been enamelled white on the interior. This enamel finish has the great advantage of being permanent and easy to clean. It has not, however, the very high reflecting power of a planished metal reflector, and consequently is considerably less efficient in increasing the illumination. The planished metal reflector is open to the objection that the light from it is very intense and that the glare is somewhat blinding. This is simply another way of saying that it is delivering a very powerful beam of light and that it is very efficient in doing the work for which it is intended. Any device whereby the glare is diminished at the same time diminishes the efficiency. The white enamelled reflector gives less glare; it also gives less powerful directed beams, although the total light from it is probably nearly as great. It is necessary, therefore, in choosing reflectors of this kind to weigh the advantages of lack of glare and ease of maintenance of the white enamelled reflector against the very high efficiency of the polished metal type.

The results of illumination tests made by the Electrical Testing Laboratories on two installations of these reflectors are given in Figs. 4 to 7. In the case of the first installation (Figs. 4 and 5) there were five "Equilux" reflectors with series tungsten lamps, and on the same street five reflectors of the flat round type with flutings, such as are often used, the lamps being similar. The spacing of the poles was about 100 ft. and the height of the lamps from the ground about 18 ft. In the second installation (Figs. 6 and 7), practically a country road, the spacing of the poles was 130 ft. and the height of the lamps from the ground 15 ft. With this installation, also, illumination tests were made under comparable conditions using the "Equilux" reflector and a standard round reflector. It will be seen that the "Equilux" reflector was effective in increasing the illumination in those parts of the street where it is naturally deficient, and that the percentage increase was quite a notable one in those regions.

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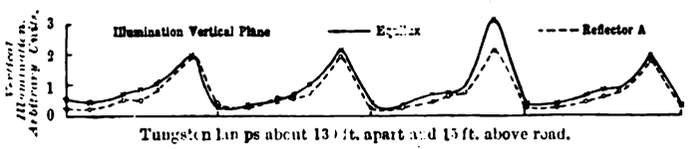
An unexpected result was that the illumination directly below each lamp was also somewhat higher, indicating the large amount of diffused reflection from the white enamelled surface. This diffused reflection is a cause of a loss of efficiency of the "Equilux" reflector as far as its own particular function is concerned of increasing the illumination midway between the lamps. It is upon this feature, however, that the absence of glare from the reflector depends. The second installation tested showed a result which was considerably inferior to that of the first installation. The reason for this deficiency was to be found in the character of the enamel on the "Equilux" reflectors, and being simply an incident of the manufacture, should not be taken as detracting from the possibilities of the type. Even with the inferior enamel the increase in illumination in the regions where the light is most needed amounted to something like 50 per cent. It is safe to say that with the "Equilux" reflector a substantial gain of 100 per cent. in the effective illumination can be obtained with the enamel type; whereas with the polished metal type, there should be no difficulty in increasing the effective illumination 200 or 300 per cent.



Tungsten lamps about 13 ft. apart and 15 ft. above road.

FIG. 7.

The polished metal type is of particular applicability to the illumination of country highways where for reasons of economy it is necessary that lights be placed at very considerable distances from each other. By the use of the polished metal "Equilux" reflector and such incandescent lamps as are ordinarily used for the purpose at the present time, a very acceptable highway illumination can be obtained with but 10 lamps to the mile. As has been said, the glare from this polished metal reflector is objectionable. However, it should be distinctly understood that this glare is not as great as is the glare from an arc lamp with clear globe, whereas the illumination produced with an 80 watt tungsten lamp with a polished metal reflector is at least comparable with that obtained with the ordinary type of arc lamp consuming four of five times the energy. Moreover, where trees do not interfere too greatly, tungsten lamps with polished "Equilux" reflectors can be mounted at such an elevation above the road surface that the light does not fall too directly into

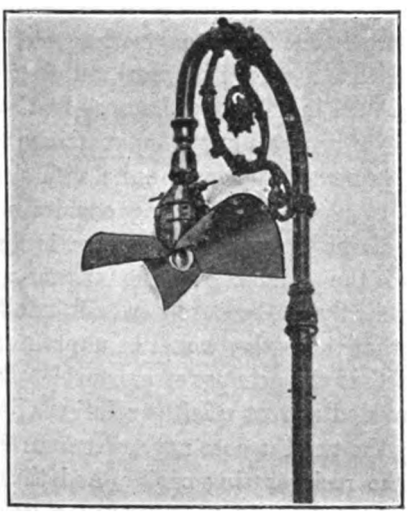


FIG. 8.—SUGGESTED STREET LIGHTING FITTING.

the eyes of pedestrians. This would require simply a reflector with a greater angle between the two halves.

A number of street lighting fixtures for incandescent lamps in which the reflector has been incorporated are illustrated in the Paper. One form is shown in Fig. 8 herewith. The appearance of these fixtures is undoubtedly somewhat odd, but the author says that one soon grows accustomed to their strangeness and they are by no means displeasing. The applicability of this type of reflector to other illuminants should also not be lost sight of. It can be applied to mantle burners and to arc lamps, though probably the effectiveness of it in the case of these sources of light would not be so great as in the case of incandescent lamps. There are also other fields of application outside of street lighting—for example, long corridors, as in a hotel.

FARADAY SOCIETY.

At the meeting held on May 31st, in the rooms of the Chemical Society, Burlington House, Mr. W. M. Morrison in the chair, Mr. J. W. HINCHLEY read a Paper entitled

"Some Practical Experience of the Sherardising Process."

The sherardising process (a method of dry galvanising in which iron or steel articles are coated with zinc by being heated in closed receptacles with zinc dust) is of great interest on account of the fact that no adequate scientific explanation has appeared. It was discovered by Mr. Sherard Cowper-Coles about eight years ago, and has been worked commercially for the past seven years. The general theory given by the inventor that the zinc vaporises from the zinc dust and is condensed on the particles is in complete antagonism with the commercial practice of the process. The successful conduct of the process depends mainly on the percentage of metallic zinc in the zinc dust being kept at a suitable figure, while the limits of temperature and time required are comparatively wide. The best mixture of zinc dust for jobbing work contains about 18 per cent. of metallic zinc.

Sherardising begins at a temperature just above that required to produce a film of magnetic oxide of iron on the article. In all cases the deposit of zinc contains iron, and the conclusion is drawn that the interaction of the film of magnetic oxide of iron and the zinc dust determines the deposition of zinc. No deposit can be obtained from the vapour of zinc at any sherardising temperature—*i.e.*, at any temperature below the melting point of zinc. At temperatures higher than this the deposit is not in any way comparable with a sherardised coating, and is useless. At 250°C., a temperature usually not much exceeded in best work, the vapour tension of zinc is not likely to be greater than that of mercury at 0°C.—*i.e.*, $\frac{1}{2000}$ mm. mercury—a pressure quite incapable of depositing 1 oz. of zinc per square foot of surface in less than an hour.

The process is essentially a contact process; a film of magnetic oxide of iron is first formed and then reduced to metallic iron by contact with the metallic zinc in the zinc dust, forming a film of solid solution of iron in zinc as closely adherent to the iron as the original magnetic oxide film. If the amount of metallic zinc in the zinc dust be insufficient, a black film of reduced iron is formed. The deposit resists corrosive agents much better than pure zinc on account of the P.D. between it and metallic iron being less than between pure zinc and iron. As a protective agent against atmospheric corrosion the deposit is most remarkable. After the slight yellowish powder which is first formed has been washed off by the rain the surface gradually becomes black and practically permanent. Chain blocks treated by the process have been in use in the open air for seven years, and are now free from rust and, apart from the result of daily wear, as good as new. In England a dearth of enterprise on the part of manufacturers has led to the existence of jobbing factories only. In America many firms making specialities have adopted the process in their own factories, and the daily output is greater there than the quarterly output in England.

The following Papers were also read: "Thermic Reactions in Vacuo," by Mr. F. E. Weston and Mr. H. R. Ellis; "Relations between Critical Temperature, Boiling-point and Thermal Expansion of Phosphorus Pentachloride," by Mr. E. B. R. Prideaux; and "Note on the Composition of Eutectic Mixtures," by Dr. Cecil H. Desch.

Mr. C. V. Biggs and Mr. W. Pollard Digby also exhibited and gave a short demonstration of: (1) Apparatus for the Rapid Determination of the Resistance of Liquids; (2) Apparatus for the Determination of the Specific Resistance of Oil. The former apparatus consists of a megger furnished with a scale reading reciprocal megohms, used in conjunction with a glass U-tube to contain the liquid under examination. Polarisation is minimised by the use of annular platinum electrodes and by having the tube very long compared with its sectional area, the voltage employed being about 250. A reading is obtained in a few seconds. The apparatus is particularly suitable for checking the purity of the water supply for boilers, for controlling the softening of hard water and for similar engineering purposes, as well as for scientific investigations.

The apparatus for measuring the resistance of oil consists of two parallel metal discs of 100 sq. cm. area, insulated from one another. These are separated by a micrometer head to a distance of about 100 mils, immersed in the oil, and then connected to a megger and a reading taken. The mean specific resistance is calculated as the mean of a series of readings.

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With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fiftieth issue of the Supplement will be published (Gratis) with the number of "THE ELECTRICIAN" for June 24.

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THE PROGRESS OF THE EXHAUST STEAM TURBINE.

In the race for a profitable existence the keynote of the electricity undertaking is "efficiency"—the obtaining of more and more energy from a given amount of coal. The problem is largely one for the engine designer, though it must be admitted that a very great deal still depends upon the methods pursued in the boiler house. In the engine room the chief line of progress but a few years ago was the use of high steam pressures and large units with a certain superheat. But even with condensing engines a considerable proportion of the energy in the steam is finally rejected unused into the condenser. The expansion cannot be carried sufficiently far, because it would entail cylinders of such a size that the outlay would be unprofitable.

It is here that the exhaust steam turbine has stepped in and has provided a most efficient solution of the difficulty. Fortunately the turbine does not suffer from the same limitations as the reciprocating engine, and thus there is no difficulty in dealing with a large volume of low temperature steam, and recovering valuable work from a waste product. Instead of pressure upon a piston we deal with the momentum of the steam, and this is a quantity that depends very much less upon the pressure of delivery. Thus the exhaust steam turbine becomes not merely commercially practicable, but quite efficient.

Some prominence was given to the subject last year by Sir ALEXANDER KENNEDY in a report in which he recommended the use of exhaust steam turbines for the Dewar-place generating station of the Edinburgh electricity undertaking. This station was working non-condensing, and the

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output per annum was 7,500,000 units. The average cost of generation for the whole undertaking with an output of 17,600,000 units was 1·18d. per unit. By running the station condensing and putting in exhaust steam turbines it was estimated that a further output of 3,500,000 units per annum would be obtained at a cost of 0·45d. per unit. Thus a saving of £10,000 per annum appeared to be possible.

Further attention is now drawn to the subject by Mr. F. A. NEWINGTON'S Paper read at the Convention of the Incorporated Municipal Electrical Association, in which details are given of the results obtained at the McDonald-road station of the Edinburgh Corporation. Here again the station was formerly non-condensing, and it was intended to erect cooling towers for the condensing water; but this idea was given up as it was thought that such towers would be unsightly and might cause a nuisance. Condensing water has now been obtained from the main sewer, and a very interesting installation is the result. Needless to say sewage does not provide an ideal water for condensing purposes, and more than usual precautions have had to be adopted in order to free the water from refuse. In addition to this novel method of condensing, two exhaust steam turbines, each of 1,200 kw., have been installed. It is found that the exhaust steam from two of the existing 780 kw. sets is sufficient for one of the 1,200 kw. turbo-generator sets. For a period of three weeks, with a small amount of superheat, it was found that in 1908 the water used per unit generated amounted to 39 lb. and the coal per unit generated to 5·85 lb.; whereas in 1910, under the new conditions, the number of pounds of water per unit generated fell to 22·2 and the pounds of coal per unit generated to 3·9. The number of pounds of water evaporated per pound of coal was roughly the same in both cases, and the load factor had risen from 22·8 per cent. in 1908 to 25·1 per cent. in 1910. A saving of 33·4 per cent. is thereby shown in the cost of fuel per unit, 50 per cent. in oil and stores and 78 per cent. in water. These results must be considered as extremely satisfactory. We do not doubt that they will serve to direct further attention to the subject, and they by no means tend to the idea that the exhaust steam turbine is a passing fashion.

THE EFFECT OF VACUUM ON THE ECONOMY OF STEAM TURBINES.

BY R. M. NEILSON.

Summary.—The author deals with the important question of the effect of variation in the terminal pressure on the economy of steam turbines, and, from a consideration of the available heat energy in steam and the constructional requirements in steam turbines, explains why the efficiency of a turbine is affected as it is by change in the terminal pressure. A curve is given from which the effect of such changes on the steam consumption of any turbine may be estimated.

It is well known that the steam consumption of a steam turbine for a given output is reduced by raising the vacuum—*i.e.*, by a reduction in the terminal pressure. This reduction in steam consumption is not, as a rule, due to a better utilisation of the available energy in the steam but to the fact that the available energy increases very rapidly at low pressures.

A steam turbine has many efficiencies—thermal efficiency, overall efficiency, efficiency ratio, &c. It is not necessary to define these efficiencies on the present occasion.* It is to be remarked, however, that no efficiency, as commonly expressed, is of such a nature that the vacuum which makes that efficiency a maximum for any turbine is necessarily the most economical vacuum to employ for that turbine. The ascertaining of the most economical terminal pressure for any turbine involves a consideration of many things, including initial cost of turbine, steam generating plant and condensing plant, depreciation, interest, &c. The subject was dealt with in a Paper read recently by the writer before the Institution of Electrical Engineers,† and will not be treated of here, but it may be remarked—and, in fact, is obvious—that one of the most important considerations in determining the most economical terminal pressure is the reduction in the steam consumption of the turbine with decrease in terminal pressure. Now considerable divergence exists between the results recorded by different experimenters of tests of turbines of different types and powers, so that it is difficult to know what variation in steam consumption to allow for any given variation in terminal pressure. There is no doubt, in the writer's opinion, that in tests of steam turbines, terminal pressures are often inaccurately measured or wrongly expressed, inaccuracies being, in many cases, unavoidable with the vacuum gauges at the experimenters' disposal. The inaccuracies may be small and yet, if they occur at a low

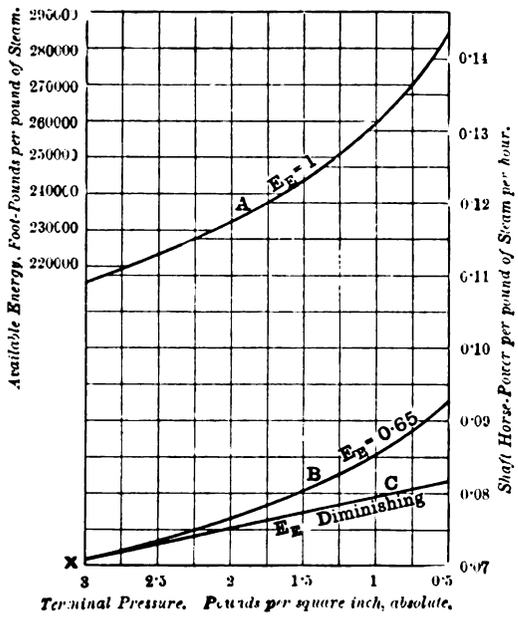

FIG. 1.

pressure, they may cause a very appreciable error in the estimation of the reduction in steam consumption for a given small reduction in terminal pressure.

Curve A in Fig. 1 represents, to the left-hand scale, the available energy given up by saturated steam expanded isentropically from an initial pressure of 200 lb. per square inch, absolute, to a terminal pressure indicated by the abscissæ. It will be noted that, as the terminal pressure falls, the available energy rises at an increasing rate—*i.e.*, every tenth of a pound fall in terminal pressure increases the available energy by a greater increment than the preceding tenth.

If the whole of the available energy of the steam supplied to a turbine were converted into shaft horse-power—*i.e.*, if the effective efficiency were 100 per cent.—curve A would represent, to the right-hand scale, the shaft horse-power per pound of steam.

Such a result is, of course, never obtained. The effective efficiency varies, depending to a certain extent on the type and design of the turbine and to a large extent on the full-load power of the machine and on the fraction of this power at which the machine is being run. What is noteworthy about a tur-

* The several efficiencies are defined in chapter V. in the fourth edition of the writer's book "The Steam Turbine." (Longmans & Co.)

† "Proceedings" Inst. of Elec. Engineers, January, 1910.

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bine is that the effective efficiency does not vary greatly as the terminal pressure is altered; the turbine, within certain limits, converts nearly the same proportion of the available energy into useful work whatever be the terminal pressure. It is only when very low terminal pressures are reached that there is any rapid falling off in the effective efficiency.

If the effective efficiency of the turbine were constant for all terminal pressures, the shaft horse-power per pound of steam would be represented by a curve of the nature of curve B, Fig. 1; and, in fact, this curve represents the shaft horse-power per pound of steam for a constant effective efficiency of 65 per cent., the initial steam pressure being, as before, 200 lb. per square inch, absolute.

In practice, however, the effective efficiency falls off after the terminal pressure reaches a certain value depending on the type and design of the turbine. The volume of a pound of steam is very great at low pressures. For example, at a pressure of ½ lb. per square inch absolute, the volume is 633 cubic ft. To do the same justice to the steam at the lowest as at an intermediate pressure would involve, in some types of turbine, excessive dimensions, and a compromise has to be struck. Moreover, decrease in terminal pressure by increasing the available energy would necessitate an increase in the speed of rotation to obtain the same bucket efficiency, and the speed is usually controlled independently of the terminal pressure. A falling-off in effective efficiency at low terminal pressures is therefore to be expected, and such a falling-off always occurs in practice, although the point of commencement and the extent of the falling-off vary with different turbines.

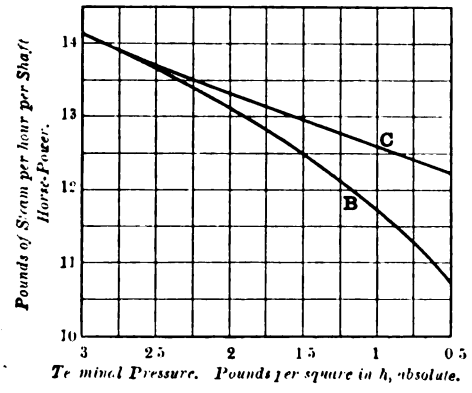

FIG. 2.

To get a good idea of what this falling-off amounts to, suppose that the effective efficiency remains constant with fall in terminal pressure till the latter reaches 3 lb. per square inch, and that thereafter, instead of following the curve B, Fig. 1, the straight line C is taken, which is a tangent to B at the point X, where the terminal pressure is 3 lb. per square inch. We are thus supposing that every decrement of terminal pressure below 3 lb. involves a constant (instead of an increasing) increment of shaft horse-power. Such a result would only occur in a turbine ill-suited for high vacua. For condensing turbines which have an effective efficiency of 65 per cent. with an initial pressure of 200 lb. and a terminal pressure of 3 lb., curves B and C may be considered as the limits within which lie all actual results obtained with lower terminal pressures.

Fig. 2 has been prepared from Fig. 1, and represents the consumption of steam per shaft-horse power, the curves B and C corresponding respectively to the similarly lettered curves in Fig. 1.

Fig. 3 has been prepared from Fig. 2, and shows the percentage reduction in steam consumption with reduction in terminal pressure. The curves have been lettered as before, and it will be seen that, whereas B (Fig. 3) rises with reduction in terminal pressure, C falls. Care must be taken not to misunderstand the reason of the fall in curve C. There is no increase in steam consumption with reduction in terminal pressure, but there is a diminution in the rate at which the reduction takes place. If C, Fig. 2, had been a straight line (instead of slightly convex downwards) C, Fig. 3, would have been horizontal.

It has already been stated that, when in actual practice the shaft horse-power curve passes through the point X in Fig. 1, it will always lie between curve B and curve C. It follows that in Fig. 3 likewise the corresponding practical curve must lie between curves B and C. Curves B and C in Fig. 1 are so close together that all test-obtained curves passing through X appear to be in fair agreement. When the results are set out in Fig. 3, however, great divergence appears. Fig. 3 is very useful in testing the accuracy of the measurements taken during tests; an unnatural curve in Fig. 3 will often be strong evidence of inaccuracy.

The writer has graphed the results, as published, of many steam turbine tests on a diagram of the same nature as Fig. 3. There were obvious inaccuracies in some of the results given. Other results which gave natural curves may, of course, also have contained inaccuracies, but, as many tests by different persons were taken, the mean result should be of use. This mean result is expressed by the curve D in Fig. 3, which, it is hoped, will be of service when it is desired to estimate the effect of change of terminal pressure on the steam consumption of any turbine and when no results, or insufficient results, are available from which a curve for the particular machine can be drawn.

The reason why curve D does not pass through the inter-

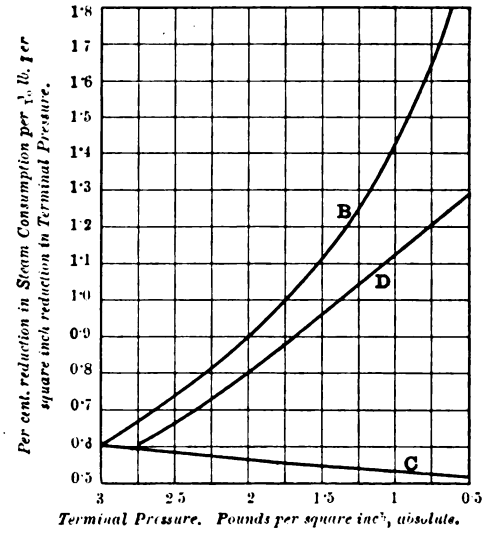

FIG. 3.

section of curves B and C is because the several turbines tested had different effective efficiencies at 3 lb. terminal pressure, the mean effective efficiency at this pressure being apparently less than 65 per cent.

As an example of the use of the curve, suppose that with a terminal pressure of 2·2 lb. the steam consumption of a turbine is 19 lb. per kilowatt-hour, and it is desired to know the steam consumption with a terminal pressure of 1 lb. Between 2·2 lb. and 1 lb. pressure the mean percentage reduction in steam consumption is 0·935 per cent. per ½ lb. reduction in pressure, and there are 12 tenths between 1 and 2·2. The total estimated reduction in steam consumption is, therefore, $12 \times 0{\cdot}935 \times \frac{19}{100} = 2{\cdot}13$ lb., and the actual estimated steam consumption with a terminal pressure of 1 lb. is, therefore, 16·87 lb. per kilowatt-hour.

The curve will, it is submitted, be found to give fairly accurate results for moderate power or high power steam turbines rotating at speeds usual in the driving of electric generators and supplied with dry saturated steam at pressures between 150 lb. and 200 lb. per square inch above atmosphere. The curve is not applicable to exhaust steam turbines, and may not be reliable if applied to machines under, say, 750 kw., or to machines in which highly superheated steam is employed. Moderate superheat, however, although greatly affecting the steam consumption, does not greatly affect the curve.

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PHYSICAL SOCIETY.

At the meeting held on May 27th, at the Imperial College of Science, Prof. H. L. CALLENDAR, F.R.S., president, in the chair, a Paper

"On an Oscillation Detector actuated Solely by Resistance-temperature Variations"

was read by Dr. W. H. ECCLES. The experiments described in this Paper are offered as additional support for the author's hypothesis of the mode of action of certain types of electrical oscillation detectors. This hypothesis suggests that in detectors constituted of a loose contact the energy of the oscillatory current through the contact is transformed into heat at the contact and warms the matter there sufficiently to change its electrical resistance and, consequently, the steady current through the indicating instrument. The principal deductions from this hypothesis were worked out and were illustrated by experiments on iron-oxide coherers in a Paper read before the Physical Society on March 11th last. The present experiments are on a detector of the so-called "crystal rectifier" type, from which, however, the possibility of thermoelectric effects have been eliminated. This detector consists merely of a loose contact between two pieces of galena—a substance which, according to the author's theory, ought, by virtue of its large negative coefficient of change of resistance with temperature, to be a very efficient detector of electrical vibrations. The experimental curves obtained from a galena-galena detector are: the steady current curve, the sensitiveness curve and the power curve. The first has steadily applied E.M.F. as abscissæ, and current through the detector circuit as ordinates. It proves to be a curve which in general rises slowly at first, then quickly, and then slowly again; but if the circuit be arranged to have but little resistance other than that at the contact, the curve may possess a negative gradient at the point of inflection. The chief difficulty met in obtaining these steady-current curves arose from the slow movements of heat through the mass of the crystals—which have, of course, small thermal conductivity. This difficulty was overcome, and the true character of the curves brought to light, by allowing a proper time-interval for thermal equilibrium to be established before each galvanometer reading was taken. The sensitiveness curve has the E.M.F. applied to the detector as abscissæ, and the power passed to the indicating instrument as ordinates, the intensity of the electrical vibrations being of fixed amount. It is a curve which rises to a maximum near the point of greatest slope of the former curve, and thereafter descends slowly. The power curve has the power supplied to the detector in the form of electrical oscillations as abscissæ, with the power passed by the detector to the indicating instrument as ordinates, the steady E.M.F. applied to the detector being the best value. This curve is a straight line. The properties of this "crystal rectifier" are, therefore, just such as are logically deducible from the fundamental fact that the contact possesses a negative resistance temperature coefficient.

Mr. W. DUDDELL said the author was making progress with his thermal theory of coherers. He pointed out that in the experiments described considerable time was taken in determining the part of the steady current curve with negative characteristic, whereas in practice the changes were very rapid.

Prof. C. H. LEES remarked that Dr. Eccles had introduced simplicity into a very difficult subject. He agreed with the remarks of Mr. Duddell, and suggested using very minute points and surfaces so that less time would be occupied in securing thermal equilibrium. The working conditions would thus be more nearly reproduced.

The AUTHOR, in his reply to the remarks of Mr. Duddell and Prof. Lees, explained that in order to get a correct notion of the character of the steady current curves the curves should be drawn either very quickly or very slowly—that is to say, either adiabatically or isothermally. The former was really the curve required for strict quantitative correlation with the experimental facts of the behaviour of the detector towards high-frequency electrical oscillations. The isothermal curves actually obtained were the same in character as the adiabatic ones, to a sufficiently close approximation. If the masses of the crystals were reduced, as Prof. Lees suggested, in order to reduce the heat losses from the contact, then the metal leads to which the crystals were soldered might be brought near enough to the contact to make the heat losses larger, not smaller. The chief advantage of making the crystals smaller accrued from the reduction of that idle portion of the electrical resistance of the detector which underwent no temperature change of the kind desired. The author practically accomplished this already by copper-plating the crystals all over, soldering into place and then baring the small area of crystal required for the contact.

Mr. A. EAGLE exhibited a

"Resonance Transformer."

The transformer is practically a Rowland's coil. The capacity shunted across the secondary is so chosen that resonance is obtained with the alternating current supplied to the primary. The condition for this is $\left(L-\frac{M}{N}\right)Cp^2=1$, where L and N are the self-inductions of the secondary and primary respectively, M is the mutual induction between them, C is the capacity, and p is 2π times the frequency. In this way large condensers may be charged to a high potential very economically. Such a transformer forms a non-inductive load. Besides the great saving in current there is also a saving in energy due to the fact that the current from the secondary has not the tendency to flow through the spark-gap in the form of an arc discharge as in the general case. 110 watts have sufficed to run a spark with a condenser of $\frac{1}{10}$ mfd. capacity at a potential of 8,500 volts (R.M.S.).

The chief advantage of the resonance transformer lies in the character of the sparks. The voltage rises according to the law

$$V=V_m(1-e^{-kt})\sin pt,$$

where $1/k$, the time constant, is over 1 second. Hence, if V_s is the sparking potential, sparks will follow each other at intervals of $\frac{1}{k}\log_e\frac{V_m}{V_m-V_s}$. The interval can be varied within wide limits by varying V_m by altering the choking coil in the primary circuit. A succession of clear and distinct discharges is thus obtained instead of an indifferential stream of sparks with more or less of an arc discharge superposed on them.

A Paper entitled

"The Limitations of the Weston Cell as a Standard of E.M.F."

was read by Mr. S. W. J. SMITH. In this Paper the recent experiments of Mr. F. E. Smith on cadmium amalgams are discussed from the point of view of the modern theory of alloys. Theory and experiment alike suggest that there is no range at any temperature over which the E.M.F. of a Weston cell is absolutely independent of the percentage of Cd in the amalgam. Even if the materials are quite pure, the existence of surface energy must cause some variation. Within the range over which the E.M.F. is usually taken as constant the E.M.F. appears to rise, very slowly, with increase in the cadmium content. The rate varies, but is never more than a few millionths of a volt for 1 per cent. Cd. From the data it seems possible also to discover the precise way in which the use of the richer two-phase amalgams may lead to variability of the E.M.F. of the Weston cell. The interpretation advocated is that the irregularities are due to electrolytic skin effects arising out of want of uniformity of composition of the surface grains. The probable reason why the temperature coefficient of E.M.F. of a Weston cell, always small, actually vanishes near 0°C. is indicated. An outline of the way in which the phase rule can be used to exhibit the nature of the incomplete equilibrium of the Weston cell is also given.

Mr. RAYNER referred to hysteresis effects, which he said were a source of serious trouble when working with Weston cells. He gave details of the behaviour of a particular cell during a period in which the temperature of the cell was raised from 14°C. to 25°C. for three days, and asked the author if he could explain the observed variations of the E.M.F. on the theory he had advanced.

The AUTHOR, in reply to Mr. Rayner, said that, while he was not prepared (without further information) to give a fixed opinion concerning the behaviour of particular cells, he thought he had shown how to find the exact causes of any peculiarities for which pure amalgams might be responsible. The utility of the theory he had described lay in the fact that it should be possible, by means of it, to discover what the effect on the amalgam of any particular thermal treatment would be. His object had been to discuss one cause of some of the variations of the Weston cell, and to indicate a theoretical limit to the accuracy obtainable.

TEST OF 2,500 B.H.P. STEAM ENGINE.

On Friday last, at the invitation of Messrs. W. H. Allen, Son & Co., of Bedford, we had an opportunity of seeing one of the largest high-speed vertical engines which they have yet built running at their works. The engine has been constructed to the specification of Mr. Harper, chief engineer to the Corporation of Melbourne, and will be installed in the Melbourne electricity works by the side of three 1,000 B.H.P. engines, which are also of Messrs. Allen's make. The new unit will develop 2,500 B H.P., and is coupled to a 1,500 kw. direct current generator, which will supply energy for lighting and power in conjunction with the existing plant. The engine is a fine piece of constructional work, and follows the lines of Messrs. Allen's standard practice in high-speed engine designs. On the occasion of our visit both the engine and generator were seen running on three-quarter load. The illustration shows a general view of the complete unit as erected on the test plate for the official trials, which had been carried out on the previous day.

The engine is of the triple-expansion type, the cylinders being 22 in., 34 in. and 55 in. diameter respectively, and the stroke 26 in. The

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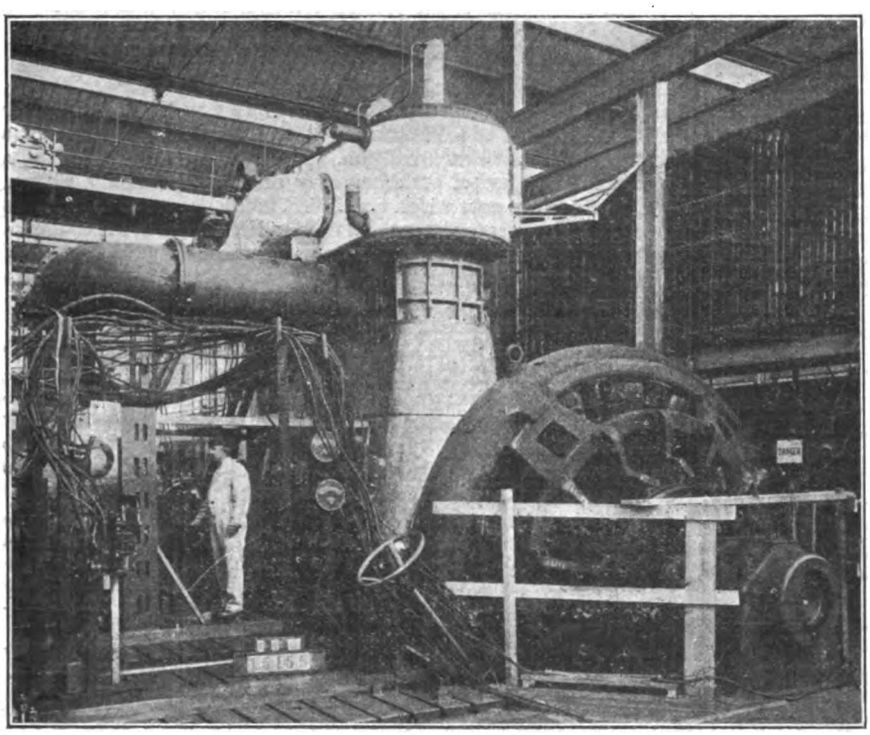
working steam pressure is 160 lb. per square inch. The cylinders are not steam jacketed, but plainly lagged; the engine is designed to work on 160° F. superheat.

Piston valves are fitted throughout the engine, and the heavy reciprocating parts are steam balanced. The upper ends of the L.P. and I.P. pistons have guide rods fitted, and these pass through stuffing boxes in the cylinder covers. Relief valves are fitted to all the cylinders. The main bearings, top and bottom ends, eccentric straps and guides are lubricated by oil under 15 lb. pressure per sq. in. Two oscillating valveless pumps positively driven from one of the eccentrics maintain this oil pressure. The pumps are directly connected to a distributing box which extends the length of the crank chamber, inside and immediately below the guides. From this box the pipe connections are neatly taken to the various feed points. Two relief valves are fixed on the distribution box. The oil supply is taken from a tank which extends under the entire length of the bedplate. Included in the oil supply system is a large and efficient oil strainer, which is fixed at the governor end of the bedplate.

The governor is of the centrifugal type, and is placed vertically, being driven by bevel gearing from the crankshaft. The governor rod is carried directly up the engine to the throttle, which is of the tandem piston type. From full load to no load the variation is 3 per cent. at settled speed. The normal speed of the engine is 225 revs. per min.



2,500 B.H.P. ALLEN-G.E.C. SET ON TEST PLATE.

Immediately at the back of the engine is a standard pattern Allen condenser having a cooling surface of 2,240 sq. ft., and capable of dealing with 28,000 lb. of steam per hour when supplied with 1,400 gallons of circulating water per minute. The condenser barrel is so arranged as to ensure the efficient disposition of the cooling surface, and the uniform distribution of the steam to be condensed over the whole of the cooling surface, thus reducing to a minimum the quantity of cooling water required for condensation. The circulating water enters at the bottom of the condenser, circulates several times the length of the tubes, and leaves at the highest point, thus obtaining the maximum effect from the cooling water. The steam to be condensed enters the distributing chamber at the top of the condenser, whence it circulates transversely through the various nests of tubes, the vapour and water of condensation being withdrawn from the bottom of the condenser by the air pumps. The steam thus flows in a contrary direction to the circulating water on the "counter-current" principle.

The three-throw 12 in. by 10 in. air pumps are also of Messrs. Allen's make, and are direct coupled to a 12 H.P. direct-current motor, which runs at 145 revs. per min. At the other end of the air pump shaft is a 5 in. by 9 in. plunger pump, which is used to force the condensed water up to the level of the boiler feed tank, whence it is delivered to the boilers by the ordinary feed pumps.

Between the engine and generator is a 7 ton flywheel, 8 ft. diameter. The generator shaft is bolted directly to the flywheel boss without the intervention of a bearing, the flywheel and armature being hung between two bearings. The generator is an interpole machine, and has a capacity of 1,500 kw., with an overload of 20 per cent. for three hours, and was constructed by Messrs. The General Electric Co., of Witton, Birmingham.

CORRESPONDENCE.

HOPKINSON TESTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The method of analysis of the results of the Hopkinson test used by Dr. Drysdale, though not seen in any of the text books, is fairly well known. It is undoubtedly most successful, and is capable of yielding figures for the efficiency of dynamos with greater accuracy than is required for commercial testing purposes.

With reference, however, to the difference in the efficiency between motor and generator action, as shown in Fig. 2 of his Paper, the error introduced by improper allotment of the iron losses cannot amount to more than $\frac{1}{10}$th of 1 per cent. in the efficiency. The difference shown by the curves is, however, a real one and is an inherent feature of the efficiency curves of any machine as will be seen by what follows.

For any given output the armature current of a generator can be divided into useful current and exciting current, while that of a motor consists of useful or power current and "losses" current. The "losses" current when motoring will generally be greater than the exciting current, when generating for the same output, thus the motor armature current and C^2R loss will be slightly higher than those of the generator.

In this particular case we have, at 10 kw. output:—

Exciting current	2·5	amperes.
"Losses" current .	8·2	,,
Useful current	95	,,

The ratio of the C^2R loss in this machine when working as a generator to that of the same when operating as a motor will, therefore, be as $97{\cdot}5^2 : 103{\cdot}2^2$, or as $1 : 1{\cdot}13$. At 10 kw. output the C^2R loss is about 7 per cent., so that the difference in efficiency would be about 8 per cent. This practically agrees with the difference of about 1 per cent. between the curves.—I am, &c.,

East London College, June 7. JOHN F. FORREST.

We have submitted the above letter to Dr. C. V. Drysdale, from whom we have received the following reply:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am much obliged to Mr. Forrest for his letter and am glad to hear that the method of dealing with the observations advocated in my article has already found favour, although it had not come to my notice. But it has always been a matter of surprise to me that so important and widely used method as the Hopkinson test has had so incomplete a theory; and the method I proposed is so obvious that I can quite believe that it must have occurred to many. It is to be hoped that this discussion will result in a more complete treatment in text books.

Coming, however, to the point which Mr. Forrest raises, I am afraid that the difference between the generator and motor curves cannot be dismissed as lightly as he does. His remarks about the armature copper losses are correct in principle, and would account for a difference in efficiency between

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UNIVERSITY OF CALIFORNIA

a machine running as generator and as motor, under the same conditions of magnetisation, speed and output. But I am at a loss to account for his assumption that the error introduced by wrong apportionment of the iron losses cannot account for more than $\frac{1}{20}$th per cent. in the efficiency. As a matter of fact, we have made exhaustive tests upon the losses of these machines, and the two exciting currents correspond to core inductions of 8,500 and 7,000 in the generator and motor respectively, and a difference in the iron losses of 120 watts or 1·2 per cent. of the output. Further, I did not speak of iron losses but of "fixed" losses, which include excitation, accounting for an additional difference of 40-50 watts, thus making a total difference in these "fixed" losses of about 160 watts, which is nearly double the difference in the armature C^2R loss referred to by Mr. Forrest.

I hope to publish these other tests shortly, and will defer further discussion of this subject till then. In the meantime the approximate method seems good enough for most purposes.—I am, &c.,

Reigate, June 14. CHARLES V. DRYSDALE.

FISCAL POLICY AND THE ELECTRICAL INDUSTRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: When you reported the first instalment of the manufacturers' debate you expressed a doubt whether the disputants were properly equipped for such a discussion in point of economical knowledge. May one, who has at any rate been a life-long student of economics, venture to think that your doubt has been largely justified? Political economy must be not only a science, but a very difficult science, exceptionally requiring special study, since so many able men seem unable to grasp its simplest principles. I even venture to think that the opinion of the man in the street on the future of radium would be about as valuable as that of the average manufacturer, uncorrected by special study, on a problem in political economy. The debate frequently illustrated this.

You yourself, sir, ask why this should be the only country in the world for which Free Trade is good. May I say, with all respect, that economists doubt, or even deny, the fact? The most that any economist of repute has ever said is (with Mill) that Protection may be good for infant industries—the trouble, however, being that, when the infants have become adults, you cannot get rid of the Protection. If you ask the question in another form—Why is it that we alone have had Free Trade?—the answer is simple; we are the only nation that *could* have it. We were first in the field and occupied the ground so effectually that other nations could not, unprotected, compete with us, even in their own markets. To them Protection was a necessity and Free Trade an impossibility.

The tactics of the Tariff Reform speakers in the debate seem to have been to set aside statements, however good their authority, that did not agree with their conclusion, and to evolve out of consciousness others that did. This led to some monstrous assertions. One speaker informed the meeting that 90 per cent. of our tramway material came from America! My friend, Mr. Anderson, is accountable for two monstrosities. Discarding the Board of Trade figures of unemployment as applying only to trades unions, he evolved the statement that, outside the unions, unemployment was "appalling," forgetting, I think, that just as the Tariff Reform imagination is held in check by the Board of Trade figures with regard to skilled employment, so it is, or should be, held in check by the pauperism tables as regards unskilled. Any "appalling" unemployment must be reflected in the column headed "Adult, able-bodied" paupers, and none is. He then repeats the statement that Sir H. Campbell-Bannerman did not make—if I may be allowed a "bull"—that 12 millions of our people are on the "verge of starvation." Our proportion in Birmingham would give us about 150,000 persons weak and fainting from want of food—a conclusion too nonsensical for words. When an able man quotes (or thinks he quotes) with approval such a manifest absurdity, one can judge how much thought he has given to the subject. It is clear that he and others have never tried simply to think out and ascertain the truth, but merely have looked round for arguments—any are good enough—to support a conclusion they have determined shall be true, happen what will; a state of mind fatal to scientific inquiry. Mr. Hirst actually thanked his friends for the "fervour" with which they had supported him. That is just it. I could not ask for a better epithet for the Tariff Reformer than "fervid." But fervour is not supposed to be favourable to dispassionate inquiry.

I now come to sins of omission. I think I shall not be misrepresenting these speakers if I say that underlying all their argument is the idea that profits, satisfactory to manufacturers, form an essential element in national prosperity. That is a mistake. So long as profits are just sufficient to keep manufacturers from shutting up shop, that is all that is necessary. National prosperity is measured by one thing and one thing only—the total production of wealth. And of that I know only two measures, the statistics of employment and the import of raw materials. Incidentally, I observe that both are at the present time in a strikingly satisfactory state, and are still improving. This by the way. The immediate point is that no Tariff Reform speaker tried—no Tariff Reformer has ever tried—to show just how Protection tends to increase total production and employment; bearing in mind, of course, that we do not produce gold and silver, and have nothing but goods made at home wherewith to pay for goods bought from abroad. I challenge Mr. Hirst to free himself from generalities and show the *modus operandi*; how precisely it comes about that Protection increases total production. This is the fundamental point; nothing else really matters.

It is the easiest thing in the world to exhibit the opposite tendency—how Protection tends to *diminish* employment and the production of wealth, as thus: Protection, if it protects, raises prices. (I decline to argue with anyone who is capable of denying this.) Prices being raised, the purchasing power of the community is reduced; our people cannot buy so much; demand, and with it production, falls off, and with production, employment. I think I am tolerably conversant with the literature, and I venture to say that no Tariff Reformer has succeeded in showing—has ever fairly and squarely attempted to show—any tendency of Tariff Reform calculated to counteract this. He may simply assert it with Mr. Chamberlain; but a child in economics can refute him. He should show the steps.

If Protection cannot increase total production, or even reduces it, but can and does increase the profits of manufacturers, clearly its total result is merely to affect distribution. The manufacturer gets more of the wealth produced by the nation, and other people less. I know he will "hold it villainy to have it thus set down," and will recoil from it on paper. Will he recoil from it in practice? I wonder. He may or may not be fully conscious of the fact, but that is what he is really driving at. He may or may not succeed in deluding himself with the idea that what will be good for him will also be good for other people; but, if he really believes it, he *is* deluded. At any rate I, for one, after much searching, have never found any argument that will hold water for a moment enabling me to share his belief.

I would if I could. My partner (Mr. Arthur Chamberlain) and I would be richer men if we had Protection. As he once said, "Give us Protection and we employers will show you a thing or two in the way of rings and trusts that will astonish you." In this controversy we have consistently argued, he and I, against our own interests. How many Tariff Reformers can say as much?—I am, &c.

Birmingham, June 14. GEORGE HOOKHAM.

EFFICIENCY OF SHORT SPARK METHODS OF GENERATING ELECTRICAL OSCILLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Galletti's letter in your last issue contains two propositions. In the first he implies that a low efficiency of transference of energy from the primary to the secondary

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circuit of a generating set is necessarily associated with a small change in the resistance of the spark-gap in the primary circuit, when the secondary circuit is put in and out of action. This is obvious for efficiencies as low as the ones mentioned by Mr. Galletti, but these are not under discussion.

The second proposition refers to higher efficiencies. Quoting an experiment in which the aerial current and the primary current were both doubled when the power supplied was quadrupled, your correspondent shows *by equating the efficiencies before and after doubling the current across the gap* that the resistance of the spark-gap must have remained unaltered by doubling the current. To equate the efficiencies begs the whole question.

That a change of resistance of the gap probably does take place can be deduced in an interesting manner by combining our absolute measurement of the efficiency with Mr. Galletti's experimental fact that $i_1 = 2i_2$, where i_1 and i_2 were the primary currents when the secondary circuit was in action and out of action on a certain occasion.

The efficiency as determined from our calorimetrical measurements was 49 per cent., and using this figure and the expression for the efficiency given in our last letter we get :—

$$\frac{K_1 i_1^2 - K_2 i_2^2}{K_1 i_1^2} = 0{\cdot}49,$$

where K_1 and K_2 represent the unknown resistances of the gap when the currents i_1 and i_2 are flowing. This gives $K_2 = 1{\cdot}96K_1$, which is in accordance with our previous suggestion that the resistance of the gap may be halved when the current flowing through it is doubled.—We are, &c.,

W. H. Eccles.
A. J. Makower.

South Western Polytechnic, London, S.W., June 14.

LARGE "WITTON" GENERATOR FOR MELBOURNE

As mentioned on another page of this issue, we had the opportunity last week of inspecting a large electric generating plant which is being shipped to Australia for installation in the Melbourne electricity works. The following particulars of the generator, which has been supplied by the General Electric Co. and is direct coupled to an Allen engine, will doubtless prove of interest.

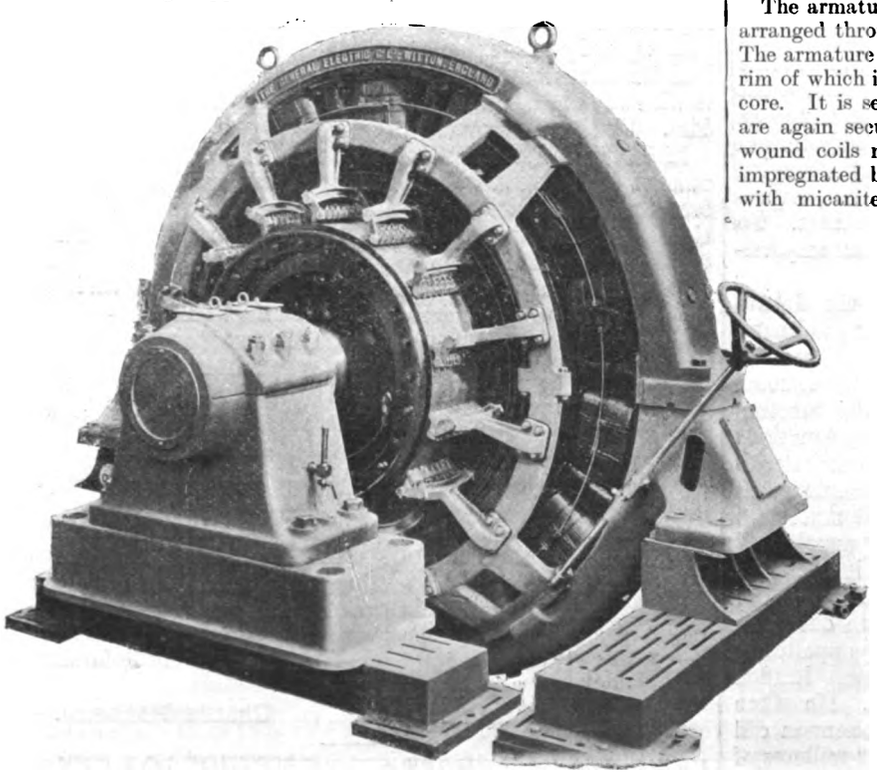

Fig. 1.—General View of 1,500 kw. "Witton" Generator for Melbourne.
(The General Electric Co.)

It consists of a 1,500 kw. shunt-wound continuous-current dynamo fitted with commutating poles, and has been designed to give full load either at a pressure of 480 volts and a speed of 225 revs. per min., or at 530 volts and 235 revs. per min. The magnet frame is made of cast iron and is split horizontally, thus permitting of easy inspection for cleaning the armature or changing the field coils. The main poles are built up of stampings and are fixed to the frame by means of strong steel bolts, whilst the pole tips are shaped in such a way as to give the best field for commutation with a fixed position of the brushes. The shunt windings of the field magnets consist of bobbins wound on spools of special insulating material and are taped all over and impregnated. Any spool can be removed and replaced without affecting any other part of the machine. The commutating poles are placed between the main poles and are made of cast steel, wound with bare copper strip. They are excited by the main current of the machine.

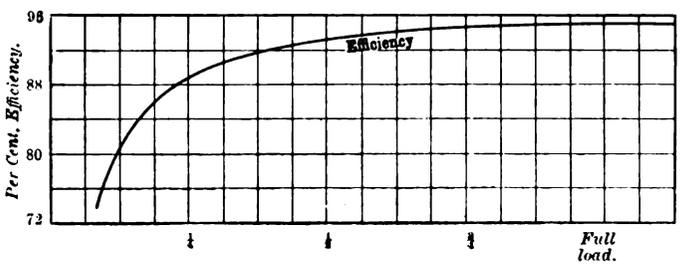

Fig. 2.—Curve showing Efficiency of 1,500 kw. "Witton" D.C. Generator.

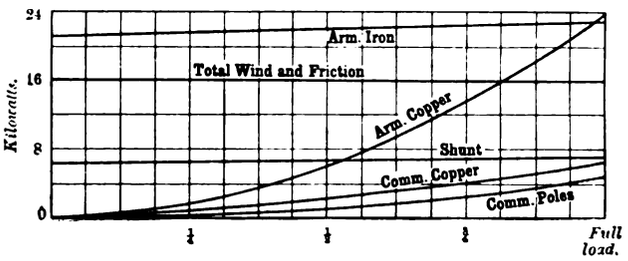

Fig. 3.—Curves showing Losses.

The armature is of the drum type, ample ventilating ducts being arranged through the core and between the core and end-plates. The armature spider is a massive casting in the form of a wheel, the rim of which is formed by the assembled stampings of the armature core. It is securely fastened between two strong end-plates which are again secured to the spider. The winding consists of former wound coils made up of copper strip, each coil being taped and impregnated before being inserted in the slots. The slots are lined with micanite tubes closed up by means of maple wedges. The binding of the armature consists of steel bands locked by means of strong steel cotters.

The commutator is built up of hard-drawn copper bars, insulated with mica, and erected on a heavy cast-iron ring bolted to an extension of the armature spider. The commutator thus becomes independent of the shaft, and can be erected in one piece with the armature. The lugs connecting the commutator bars to the winding are of ample section and are kept as wide as possible, so as to ensure efficient ventilation of the commutator surface. A set of equalising connections is also provided to ensure perfectly equal distribution of the current in the various parts of the windings and of the commutator.

The brushes are of carbon, and on each spindle there are several small brushes, each having its own brush-holder, this system being found to be the most satisfactory when dealing with large currents and many poles. The brush-holders are of gun-metal and of the "sliding-box" type, the moving part being connected to the block and the spindle by means of flexible copper leads, so that but little current is carried through the sliding contact; and the shape of the carbons is such that there is no alteration or shifting of the contact surface peripherally due to wear of the carbons. As will be noticed from the view of the generator given in Fig. 1, each spindle carrying one row of brush-holders is supported at both ends by a strong arm insulated from the rocker ring, and is constructed so that it can be adjusted peripherally independently

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of the others, thereby securing accurate spacing of the brushes. Every alternate arm is connected with copper collecting rings which run round the rocker, and from these rings the current is taken away to the terminals by means of large cables, sufficient flexibility being allowed for rocking the ring and adjusting the brushes whenever required. The rocking ring is supported by the field frame of the machine, whilst the collecting rings are so placed that they are mechanically protected from accidental contact. It is interesting to notice that the terminals of the machine are placed at the bottom of the yoke, inside the pit, which enables the cables to be taken directly to the switchboard through cement troughs laid in the ground.

The generator was specified to give an efficiency of 95 per cent. at full load, 94·2 per cent. at three-quarter load, 92·5 per cent. at half load, and 85·5 per cent. at quarter load. It will be seen from Fig. 2 that these results were obtained on test.

Fig. 3 is interesting as showing the various losses in the generator, which had to run sparklessly up to 20 per cent. overload and to take this overload continuously for two hours without injurious heating; whilst the temperature rise after a six hours' run on full load did not exceed 70°F. on any part of the machine.

FIFTEENTH ANNUAL CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

(*Concluded from page 388.*)

Mr. LEA (Lea Recorder Co.) said that his water recorder had been developed as the result of experience with South African mining plant, in the running of which details of cost were required. He considered that much of the money spent in CO_2 recorders was well spent, and the cost was proportionately small. He was of opinion that the running of plant should be taught in technical schools.

Mr. R. ROWLAND (Stretford) thought that the draught should be regulated by the main dampers. He considered that CO_2 recorders were a good investment. He had reduced his coal consumption considerably.

CHEAPENING THE COST OF MAINS AND SERVICES.

Mr. S. J. WATSON (Bury) opened the discussion on Mains, in the absence of Mr. S. E. Fedden (Sheffield) owing to illness. He stated that although the cost of generating plant had much decreased, that of mains was practically the same as 10 or 15 years ago. Many cables were now 20 per cent. more costly than in 1902. Again, it was impossible much to reduce the cost of excavating and making good. Also, as the mechanical protection varied with the insulation, it was only possible to economise on the conductor and insulation. In comparison with a low-tension cable at 8s. per yard, of which sum the insulation cost 3s. 5d., a similar high-tension three-core cable cost 9s. 4d. per yard, or 16 per cent. extra cost for 10 times the capacity. Therefore, three-phase distribution should be more considered. He thought that the Board of Trade regulation re pressure variation might be relaxed, owing to the use of metal lamps, with considerable advantage as regards mains. He regarded aluminium as impracticable for underground cables owing to the increased diameter necessary, but it was advantageous for overhead construction. An aluminium overhead line at Bury one mile long had been erected at one-third to one-quarter the cost of an underground main. Mechanical joints were used, and a satisfactory job had resulted. He suggested the use of three-phase (three-wire) current at 400 volts and house transformers at low pressure.

Mr. F. E. AYTON (Ipswich) said he had used solid and armoured services with little difference in cost. Six yards of 7/20 laid solid cost £1. 19s. 9d. and with armoured twin cable £2. 4s. 5d. The cost, therefore, was not much affected by the service cable, and a new type of cable was not so important as cheaper service fittings and meter.

Mr. B. SANKEY (Whitehaven) gave figures for 10 yards of 7/16 cable as £2. 16s., or with fittings £3. 6s. 7d.

Mr. W. G. PICKVANCE (Wrexham) said he used lead-covered or bitumen cable in troughing, and the average service cost £2. 5s. He thought it best to protect the cable with bitumen.

Mr. J. H. BOLAM (Weymouth) thought the density factor more important than the load factor in many cases, and the cost of mains and the density of the area to be the controlling factors. He thought services should be not less than 7/18 for mechanical reasons.

Mr. F. C. RAPHAEL suggested that services should be laid with mains to reduce cost.

Mr. W. W. LACKIE (Glasgow) gave detailed figures. The average cost of 60 services during the last two months was £4. 6s. 6d., as compared with nearly £7 a short time ago. The reduction was due to specialisation.

Mr. W. A. VIGNOLES (Grimsby) thought that smaller distributors were now possible owing to the advent of metal lamps, and he had laid 3,700 yards of 7/16 three-core cable at 1s. 8d. per yard. Labour was not a fixed quantity; it varied from 3s. 6d. to 9d. per yard, making it desirable to lay long lengths at one time in the case of cheap cables. He considered that transformers for rows of houses were not always possible. He supplied houses in pairs, and had reduced the service cost per house to 30s. He had supplied 14 semi-detached cottages by means of looping at a cost of 30s. per cottage.

At the close of the meeting, members adjourned to the Grosvenor Hotel, where luncheon was served. This afternoon the St. Andrew's Cross power station of the Glasgow Electricity Department, the Coplawhill works of the Tramways Department, and the electricity works of the Govan Corporation were visited; whilst some members went further afield and inspected the power station of the Clyde Valley Electric Power Co. at Yoker, the Partick electricity supply station, the shipbuilding works of Messrs. Beardmore at Dalmuir, and the works of Messrs. Babcock & Wilcox at Renfrew.

This evening the annual dinner of the Association is being held at the Windsor Hotel and is very well attended.

CONGRESS OF THE TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

This congress was opened on Thursday last week at 10:30 a.m. in the Imperial Hotel, Dublin. In the unavoidable absence of the Hon. Arther Stanley, M.P. (Chairman of the Association), the chair was occupied by Mr. James Devonshire. A Paper on "THE DUBLIN UNITED TRAMWAYS," by Mr. R. S. Tresilian, secretary of the Company, was taken as read. This was followed by a Paper

"BRAKESHOE STANDARDISATION,"

by Mr. J. A. Panton.

Prof. ERNEST WILSON, in a written communication, gave the following figures, obtained in the Siemens Electrical Engineering Laboratory, King's College, London, from tests made with a Peacock geared brake spindle. The effective length of handle was 10¾ in.; gear ratio, 14 to 34; diameter of drum on which the chain was finally wound, 2½ in.; links of chain (flat) 2¼ in. maximum length, 1¼ in. maximum width; diameter of iron, approximately, ¼ in. When lying on the 2½ in. drum the chain added about ¼ in. to the radius; the leverage as between handle and chain was therefore 14·9, neglecting friction.

The following were some figures obtained for the relation between the pull on the chain and the pull on the handle, and the calculated results:—

Pull on 10¾ in. handle in pounds.	Pull on chain in pounds.		Difference as a percentage of calculated pull.
	Observed. (approx.)	Calculated, neglecting friction.	
10	125	149	16
20	265	299	11
30	380	447	15
50	625	745	16
70	830	1,045	20
100	1,170	1,490	21·5
120	1,380	1,790	23

Before the shoes were reached there was the additional pull due to the brake rigging. Mr. Panton had given figures relating to Ackley and Peacock geared brake spindles, but omitted certain details, and also did not state if the figures were the result of a test or calculation. This was important. Further, he did not state if the pull obtained was at the chain, or if the pull due to the rigging was included. The makers of the Peacock brake usually recommended for light cars the use of a handle not exceeding 10½ in. in length. It was probable that a 10¾ in. handle was more generally suitable for the majority of cars in use in this country than were the handles 12 in. and 14 in. long. In conclusion, it seemed very desirable in geared brakes of the Ackley and Peacock types, that the shape of the drum should be such that whilst the chain was passing from the large to the small part the change in leverage should be gradual.

Mr. J. R. SALTER (South Lancashire Tramways Co.) pointed out that the number of car-miles run with a given brake block was a very doubtful criterion, since the wear of the block unit obviously depend upon the track, the frequency of the stops and the handling of the brakes. He proceeded to give the opinion of his assistant, Mr. Edwards, upon the Paper. Mr. Edwards agreed as to the desirability of standardisation, but thought that the author had put the cost of brake renewals too high at 10 per cent. of car maintenance: 2·2 per cent. would be nearer the mark, or 0·012d. per car-mile. The author had also put the scrap weight unduly high and the scrap value too low. He preferred a composite block to a cast-iron block; the former cost more but wore so much longer as more than to compensate for extra cost. Under identical conditions he had found 4,000 car-miles for cast-iron blocks and 9,000 car miles for composite blocks.

Mr. F. E. SAUNDERS (Maidstone) agreed that car-mileage of brakes depended on the track and that 10 per cent. of car maintenance was too high a figure for brake block renewals. He thought the figure of £10 per ton for brake blocks too high, and gave £5 for cast iron and £8 for chilled blocks as reasonable figures.

Mr. R. J. HOWLEY agreed as to the desirability of standardisation, which had been done to a certain extent in America. The object of the designer should be to reduce the amount of scrap. He had been experi-

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menting with a brake shoe, renewable and reversible, and pointed out that in considering the metal to be used it was important not to neglect the convenience of passengers and to provide for a smooth retardation of the car. He preferred good grey cast iron to chilled blocks.

Mr. A. A. BLACKBURN (Belfast) wished to know if the figures had been taken from the Liverpool overhead lines; if so, they were no data for city lines. He agreed with former speakers as to different wear on different lines, and instanced a line of track along a sandy seafront where the wear of certain seasons was quite abnormal; £10 per ton was entirely too high a price for brake blocks. As to the absence of flanges in the type advocated by the author, he did not think there was much in it, as it was the track and not the brakes which wore the flanges.

Mr. MCCULLOUGH (Liverpool) advocated composite blocks, since they produced fewer flats. It was quite possible to manufacture brake blocks to give any desired result. Brake troubles were due to variation in the power applied and a desirable improvement was to limit this variation.

Mr. PANTON (in reply) defended the 10 per cent. of car maintenance as a figure for brake renewals as accepted American practice. He said the partially chilled brake blocks would cost £10 per ton, but it was worth paying; and he admitted that cast-iron brake blocks could be got for £5, but doubted whether it was worth while to use them. As to the form experimented on by Mr. Howley—so long as the wearing part could be fitted and reversed it would fulfil its purpose.

The Paper

"TRAMWAY ECONOMICS"

(of which an abstract was given in our last issue) was read in a condensed form by the author, Mr. J. R. Salter.

Mr. C. W. MALLINS (Liverpool), in a written contribution, corrected the statement in the paper that the report of the year 1908 on the Liverpool tramways was by Mr. Bellamy, and claimed that it was by him (Mr. Mallins). He argued at length against the appointment of engineers as managers, claiming that the duties required quite other than engineering training. He thought a service should not be increased or diminished without a very careful analysis of the figures, and gave an example from his system where a reduction of service gave an increased profit.

Mr. S. SELLON thought the Paper one of the most valuable ever presented to a tramway congress. On the question of engineer managers, he pointed out that Mr. Mallins spoke from the experience of a large city, able to pay highly both engineer and manager. This was not possible in small undertakings. He also alluded to the impossibility of comparing the efficiency of working of different lines unless one knew the exact conditions of each. It was now generally agreed that the comparison of gross expenses with gross receipts was not of much value. So long as a man knew that he was getting every penny of net earnings he need concern himself little about the proportion of gross receipts to gross expenditure. As to the common misconception as to the impossibility of making a reasonable profit on a line with small receipts—a small 7 mile line known to him, capitalised at £10,000 per mile and earning only £2,000 per route mile, paid 6 per cent. on the preference shares, 6 per cent. on its ordinary shares, and put by a fair amount for depreciation. In this connection he complimented the Dublin United Tramway Co. on their financial success with very low earnings (9d.) per car-mile; and this in spite of the fact that the mileage per head of population was greater than in richer cities. He believed that railless traction would take the place of motor 'buses, especially in the matter of testing volume of traffic at small expense. The Mercedes system was the best, in his opinion.

Mr. H. E. BLAIN (West Ham) especially appreciated the value of the "Density Factor" in the author's Paper.

Mr. E. HATTON (Newcastle-on-Tyne), alluding to the strictures of Mr. Mallins on the engineer manager, gave it as his opinion that the Liverpool figures showed that if the manager were an engineer or had control of the engineer it would be better for Liverpool.

Mr. W. CLOUGH (Bury) thought that Mr. Salter's Paper gave tramway managers valuable material for thought; but he took exception to the part dealing with car-mileage receipts and expenses, and thought that the author had mixed up certain standing charges with running expenses. The really important matter in any given case was to know the critical point at which increased earnings just equalled increased cost, *i.e.*, where no increased profit was possible. Commenting on the Heywood case, he laid it down as essential that there should be one authority empowered to settle the through fares in cases of running powers, and that if should not be left in the power of one authority along the route to raise the fare on its portion and nullify the whole agreement; in particular he objected to clause 9.

Mr. R. J. HOWLEY noticed that the "Density Factor" was simply earnings per mile of route, divided by a constant and given a fancy name. His idea of standing charges was that they were a fixed quantity with no reference whatever to car mileage. The really importan question was whether with increased car mileage, in any given case, the net revenue was increased. He advocated a system of discount tickets available during the slack hours. As to the size of cars, he preferred big cars, in spite of extra consumption of power during slack hours, principally because of saving in wages. In the matter of running power, he believed there was only one fair way—each party to get fares in its own district.

Mr. R. W. CRAMP (Birmingham) thought there was this at any rate in the Heywood agreement that it had put on the statute book an Act giving power to a small authority to run into a larger one to the advantage of both. He advocated a central tramway board.

Mr. SALTER (in reply) said that the report of 1904 (not 1908) by Mr. Bellamy was the one alluded to. As to Mr. Mallins' contention that engineers were not suitable managers, he pointed out that certain systems were so large and profitable that they could afford the luxury of great independent departments without much affecting the financial results. Smaller concerns could not afford this. Buxton, for instance, could not be run so economically unless by an engineer. Non-engineer managers succeeded not because they were not engineers, but in spite of that fact. Such would succeed anywhere, and were not worth £1,000 a year. Dealing with Mr. Clough's contention as to running and standing charges, he held that Mr. Clough's contention, if true, helped him (Mr. Salter), because if the standing charges were increased this increased the necessity for extra car-mileage. He admitted that running charges were not proportional to car-mileage, but took them as those charges which occurred only when the lines were run and ceased if they were shut down.

A Paper on "RAILLESS TRACTION," by Mr. Harry England was next summarised by the chairman.

Mr. A. H. POTT (Metropolitan Electric Tramways) represented the only company which had yet experimented with a trolley 'bus in England. He appreciated the system as a pioneer or feeder system for existing trams and so workable on same system throughout. The Mercedes system praised by Mr. Sellon was—from this point of view—the least suitable of any. He thought the figures given for the trolley 'bus system were much more favourable than were possible in practice. A trailer car could be used; the saving in depôts could not be realised—corrugated iron sheds were not used for tramcars, why should they be used for 'busses. Wooden poles were not used for tramways: why should they be used for motor 'buses? It was unfair comparison to credit the motor 'bus with all sorts of cheap devices not used in tramway practice. The figures given for repairs and maintenance were much too low. He accepted the motor 'bus as available for pioneering, and believed they would have to pay towards road maintenance.

Alderman IVEY thought that if their use brought to a head the unfairness of the present position of the motor 'bus in competition with the tramway, in that the former paid nothing for the use of the road, their advent would be of service.

Mr. SELLON alluded to the Paper as damning the tramways in favour of an experiment.

The Paper "SHOULD THE ACT OF 1870 BE REVISED" was taken as read, and led to no discussion.

E.M.F. ELECTRIC FANS.

A line of fans very suitable for domestic and office use has been placed on the market by the E.M.F., Ltd., and various details of these, both technical and commercial, are contained in a catalogue

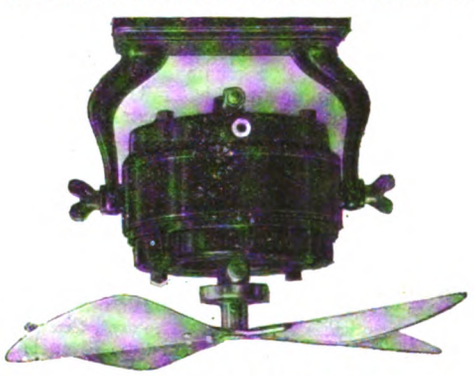

FIG. 1.—"E.M.F." CEILING FAN.

recently issued by them. We commend this catalogue to the attention of all those who intend to purchase this useful equipment.

All the fans are thoroughly well made and are the outcome of considerable experience in this class of work. It is claimed that the material used is of the very best, while the motors run noiselessly and have a high efficiency. It may be mentioned that all the single-phase and three-phase fans are fitted with induction motors, so that there are no brushes or commutators to give trouble, while the bearings are of the adjustable type and are arranged so that the wear can be taken up. A great number of experiments have lately been carried out on the question of the most suitable shape of blade used in fan work, and it is, therefore, interesting to note that the E.M.F. Co. have taken advantage of the figures thereby obtained, and have accordingly arranged their blades to give the greatest displacement of air obtainable.

Turning to the fans themselves, it may be well first to draw attention to a piece of apparatus which should find an exceedingly wide application. It consists of a special combination apparatus, which has been designed to allow one fan to do the work of table, bracket and ceiling fans. To do this the fan motor, fan and carrying trunnion are fixed by means of bayonet slots in a special base, and can be clamped

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in that position by means of a milled nut. It is, therefore, possible, by arranging these base blades round the room in various positions, to use the same fan either as a ceiling, bracket or desk fan, while, of course, it can be taken from room to room as required.

What may be called the domestic type of fans made by the E.M.F. Co. are supplied in three sizes 10, 12 and 16 in. in diameter, and taking 26, 55 and 90 watts respectively. They can be supplied on a solid base with a swivel and trunnion, or on a bracket, and also in connection with the special equipment mentioned above. The motors are designed for pressures between 50 and 120 and also 200 to 240 volts when continuous current is employed, and from 70 to 130 and 150 to 220 volts when alternating current is used.

A more serious type of fan is that shown in Fig. 1. This has been specially designed for tropical climates, and is arranged for fixing on the ceiling. The example shown is of the alternating-current type, and is fitted with four brass blades. This is the standard with alternating-current motors, but on continuous-current motors either wood or aluminium blades can be used. These fans are made in various sizes from 24 in. to 60 in.

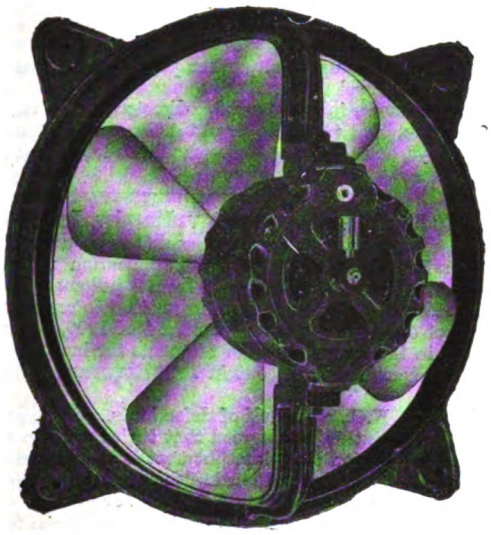

Fig. 2.—"E M.F." Porteole Fan.

Another very useful type of fan made by this Company is the port-hole fan shown in Fig. 2. These fans are fitted with motors of a semi-enclosed type, and can be designed to run either on continuous or alternating current. They are made in three sizes, having diameters of 10, 12 and 16 in. respectively. The E.M.F. Co. are also making a speciality of small motors similar to those used in fan work, capable of being applied to such applications as grinding and polishing machinery.

LEGAL INTELLIGENCE.

Attorney-General v. Leicester Corporation.

Mr. Justice Neville commenced the hearing of this action on Monday.

Mr. Felix Cassell, K.C., for the Attorney-General, said he sued as the relation of Mr. Utly, a ratepayer at Leicester, to obtain a declaration that defendants were not entitled to carry on the business of electrical contractors, and he also claimed a declaration that defendants could not expend their funds for that purpose, and an injunction to restrain them from so doing. Defendant Corporation obtained in 1890 a provisional electric lighting order which authorised them to supply electrical energy within the municipal area. Defendants did not obtain any express power to enable them to supply fittings, motors, &c., and the point at issue was whether, if there was no such express power, the Corporation was authorised to carry on such work as being incidental to the undertaking of electricity supply. Defendants contended that, apart from their special statutory powers they, as a Corporation at common law, had powers apart from their statute. Even if that were so he did not think that would very materially affect the plaintiff's case. There was an issue of fact and also an issue of law to be tried. Plaintiff's case was that defendants carried on nothing more nor less than an electrical contractor's business. In 1894 they opened show-rooms where they had offered for sale every kind of appliance in connection with the use of electricity. His contention was that the undertaking which defendants were authorised to carry on was the supply of electrical energy, and that they were expressly debarred from going beyond the business of supply and undertaking the supply of fittings, wiring materials, &c., used in the consumption of electricity. He submitted that defendants' power stopped when they had supplied electricity to the premises of consumers. As soon as the consumer turned on the switch defendants' power ceased. Defendants had power to do anything which was incidental to the business of supply, such as the purchase of coal, putting up a generating station, &c., but the power must be limited to that which was incidental to such a business. Up to a certain point they had admissions from defendants, admissions which, he submitted, were enough for his purpose, but he should call evidence which would carry the case far beyond those admissions. He contended that the whole of the things mentioned in the statement of claim were illegal and *ultra vires*. Evidence would be given to prove that at the show-rooms defendants supplied lamps and other things to anyone who chose to walk in and ask for them. One man who was not a resident in the borough walked in, asked for a lamp and bought one. Another thing he especially complained of was the supply of electric bells. In any event those things could not be said to be incidental to defendants' business. In another case defendants supplied a dynamo for an independent installation, and those things could not be incidental to the supply of electrical energy. Defendants were carrying on that business at a considerable loss. His submission was that the Corporation had not got power to set up such a competing business and use the rates for carrying it on, rates which were paid by the very people they were competing with.

Mr. Justice Neville said that it appeared to him that there were two questions before the Court. First of all could the Corporation do these things, and secondly, if they could, could they pay for them?

Mr. Cassell said that was so, so far as exercising any powers under the Electric Lighting Acts was concerned, but it seemed that defendants raised something beyond. Supposing that, apart from any statute, defendants had a general right to carry on business then he (counsel) contended that they could only throw on the local rate the expenses incurred under the Act, and they had no power to pay for anything that was not authorised by the Act.

Mr. Danckwerts, K.C., for defendants, said he was not going to rely upon anything that was outside the statutes.

Mr. Cassell submitted that the words "necessary and incidental" as used in the 1882 Act meant necessary and incidental to the supply of electric current. He relied on the absence in the Act of any such provision as was found in the Gas Works Clauses Act of 1871. Sec. 38 of that Act contained a right to supply fittings that were the property of the consumer, but the fittings and meters were the property of the supplier. In the Electric Acts a clear distinction was drawn between the user and supplier. The Electric Act contained words that clearly showed that if the fittings of the consumer were of such a character that the electricity was being wasted that suppliers could refuse a supply, but could not go on the premises of the consumer and control the fittings. They had no control over the fittings on the premises, and the statute did not give them power to put in their own fittings.

The first witness, Mr. Taylor, said his house was wired by the Corporation. The installation included the supply of a hat rail, mahogany blocks, lamps, bell-push, shades, &c. For his garden and stable he paid rates to the Corporation, but for the house he paid rates to the parish of Oadby. There were no electric fittings except in the house, though the electric cable ran through the garden.

Mr. Robert T. Smith, who had made an inspection of defendants' works, gave a number of instances of the Corporation supplying fittings. They had supplied the workhouse infirmary, which was outside their area. They not only supplied bells but also the chemicals for them.

Mr. Danckwerts said his clients claimed the right to supply everything connected with electricity.

Witness, continuing, said he saw nothing to indicate that only persons using the energy would be supplied with fittings. The electrical and gas departments were in separate rooms, but he did not admit that there was no entrance to the electrical department without going through the gas department.

Mr. R. I. Crowford also gave evidence to similar effect.

Mr. Waters, electrical contractor, said that the contractor's business carried on by defendants was a distinct business, and was well known in the trade.

Mr. L. G. Tate explained the usual method of giving supply and the connecting up of the supply cables at consumers' terminals. The trade of wiring or putting in an installation was a separate business, he said, from that of the supply of electricity.

In cross-examination witness said that the Electrical Contractors' Association did not guarantee its members against the costs of actions. There was an arrangement between the members themselves for guaranteeing against loss. He did not know anything about a guarantee with reference to the costs of this particular action. Electricity supply undertakers were, by Act of Parliament, bound to keep a consistent pressure within certain limits.

Mr. W. R. Rawlings also gave evidence as to the wiring of consumers' premises. He said the terminals were usually reckoned to be at the main cutout, and then the supply could be cut off by the withdrawal of the tubes. Installation work was regarded as perfectly distinct from the business of supply.

Mr. Danckwerts, for the defence, said that from 1898 to the present time the course adopted by the Corporation had been the same, and was entirely consistent with the resolution they passed on May 9 that year and the letter that they then wrote. That letter clearly expressed the intention of the Corporation only to do wiring and only to sell apparatus and fittings to such premises as were taking or were going to take their supply of electricity from the Corporation. That was what they had done according to the evidence, and that was what they claimed they had a right to do. For 12 years the Corporation had adopted that attitude,

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and when he drew attention to the Acts of Parliament and the authorities the Court would find they authorised the taking of that attitude. He relied upon the doctrine that had been stated in various ways in the numerous authorities that a company formed for the purpose of supply had power to do everything incidental and necessary to such supply. The Acts employed compendious language, but he hoped to show that the compendious language did cover a supply right up to the point at which the gas or electricity, as the case might be, was consumed. It must continue right up to the point of consumption, because until it got there the supply was not complete. If the supply was not complete until you got to the point of consumption then everything that was used for getting to the place of consumption was part of the supply. Whether you called it an electric line apparatus or fittings did not matter. Sec. 10 of the Act of 1882 gave power to do all such things as were necessary for the supply, and to enter into contracts for the purpose, why, therefore, should the Corporation not be entitled to enter into contracts to supply fittings, which were certainly incidental and necessary to the supply, because they were necessary to enable the consumer to utilise the supply. Until one got the light or heat or whatever it was that was required the supply was not complete. He contended that it had been proved definitely that everything the Corporation had supplied had been supplied in connection with their supply of electrical energy. He did not contend that they had any right to supply telephone wires or anything of that sort, nor was he going to contend that they had any right to supply electricity outside the borough in a general way. He should contend, however, that the Court would not interfere by way of injunction in the exercise of its discretion, that they had not got the proper parties before the Court to enable it to grant an injunction, and that the Act of 1909 contained provisions that enabled a Corporation to supply outside their area with the sanction of the Board of Trade. The Board of Trade had been approached by Leicester Corporation, and while they declined to make a general order authorising a supply outside the area they said they would consider any specific instance.

Mr. CASSELL pointed out that he was not asking for any injunction in respect of supply, but only in respect of fittings.

Mr. DANCKWERTS said then he need not pursue the matter further. He submitted that all the evidence given as to the supply of fittings were instances where they were supplied to people who were taking a supply within the borough area, and it was thought they were required in connection with that supply.

Mr. JAMES SWINBURNE said that the electric supply made a complete circuit and was always under pressure, and the pressure must be kept steady within a small margin. He explained the methods of measuring electric current and the method by which it passed through the meter. Any leakage up to the meter would be the concern of the supply company, and any leakage beyond the concern of the consumer.

For the defence, Mr. J. J. P. BARKER, manager of the Corporation's electric fittings department, said that the Corporation's showrooms were separated from the stores by a yard, and if anyone asked for an electric lamp or anything of that sort it would have to be fetched from the stores. Wiring had been done by the Corporation for people who did not take their supply from them, but it was a long time ago and it was done very seldom. The Corporation had done bell wiring, but that was usually when they were called in to repair wires, and while doing the other wiring they did the bell wiring as well. They were not now doing bell wiring, and if they were asked about bell wiring they referred the applicant to a contractor. He had never put in any telephones or telephone wires, but the work in connection with the Corporation's telephones and wires in their own buildings was done by the Corporation's own men. In his opinion, it was important that premises should be securely wired, and that the fittings should be perfect. He had known instances of the wiring being imperfect on the premises of persons who took current from the Corporation. The Corporation always tested the wires before they were used, whether the wiring was done by themselves or not. Failures often occurred on Saturday afternoons and holidays, when, he assumed, most business premises would be closed and when, therefore, it would be essential to apply to the Corporation.

In cross-examination, he said that so far as he knew it was not the custom to ask their customers to make any declaration. Customers just asked for what they wanted and did not say what they wanted it for. The showrooms had ordinary shop windows in which were displayed water heaters, cooking utensils, &c. The Corporation had put in fittings for one firm to the value of over £500, who were not consumers of their supply. That occurred 15 years ago, but the firm had not taken a supply of energy from the Corporation. The Corporation men never went on premises of people not taking a supply from the Corporation mains unless specially authorised to do so by Mr. A. Colson, their late manager. When usual business premises were closed it was necessary to call upon the Corporation in the event of failure, and he did not know that there were electrical contractors always ready to do the necessary work.

The case for the defence having concluded, Mr. CASSEL, in replying on the whole case, submitted that the Electric Lighting Act of 1909, which had only recently come in force, was absolutely destructive of the position taken up by the Corporation. It extended the rights under the old Acts, and if the arguments for the defence were well founded no extension would have been necessary. It was argued that under the old Gas Acts supply terminated at the burners, or point of consumption, but the Gas Acts and Electric Lighting Acts in that respect were quite distinct. The Gas Acts provided for a supply of fittings, but the Electric Lighting Acts did not refer to electric fittings at all. The word supply was used both in the Electric Lighting Acts and in the Gas Acts. In the Gas Acts no doubt it meant supply up to the point of combustion, but in the Electric Lighting Acts it was expressly defined as being a supply up to the consumers' premises. In the Gas Acts there was power to charge for various things, but in the Electric Lighting Acts there was only power to charge for the supply and for meters. Even assuming that the Corporation were entitled to do wiring on premises which they supplied with current, counsel submitted they were not entitled to extend their undertaking to the sale of the numerous articles they were supplying.

His LORDSHIP thought that they might be considered as things incidental to the supply.

Mr. CASSELL submitted that such a sale was merely keeping a shop.

At the conclusion of the arguments his lordship said he would consider his decision.

Affairs of an Electric 'Bus Co.

On Friday last before Mr. Justice Swinfen Eady, the action of the Reorganisation Control Synd. (Ltd.) v. the International Motor Traffic Synd. (Ltd.) and the Brighton, Hove & Preston Omnibus Co. (Ltd.) was mentioned on a motion for an injunction to restrain defendants from parting with or disposing of eight electric omnibuses or parts of same.

Mr. WARD COLDRIDGE said the International Co. had already parted with the 'buses to the Brighton Co., and therefore he asked for no relief against the first named defendants.

Mr. ASHTON CROSS, for the Brighton Co. undertook that the omnibuses should not be delivered up to any other persons than plaintiffs without giving them seven days' notice.

All the parties consenting, his Lordship directed, with a view to a speedy trial of the action, that plaintiffs should deliver the statement of claim within seven days, and that the defence should be lodged within ten days thereafter.

"Z" Electric Lamp Mfg. Co. (Ltd.) v. Marples, Leach & Co. (Ltd.)

This case came before the Court of Appeal (Lords Justices Farwell and Kennedy) on Saturday on defendants' application to allow further evidence on the hearing of their appeal from a judgment of Mr. Justice Parker on plaintiffs' claim, and for an injunction to restrain the alleged infringement of Johnson's patent No. 21,654 of 1906, which related to improvements in the manufacture of filaments for incandescent electric lamps. The judgment was set out in THE ELECTRICIAN for March 11 (p. 905).

Mr. T. TERRELL, K.C., on behalf of defendants, said he and Mr. A. J. Walter, K.C., for plaintiffs, had agreed that their lordships should make no order upon the motion that day, but that it should stand over until the hearing of the appeal, when their lordships would be in a position to know whether further evidence should be heard or not.

Their lordships decided accordingly.

Donnersmarckhutte Oberschlesische Eisen & Kohlenwerke A.G. v. Electric Construction Co. (Ltd.)

In the Court of Appeal (Lords Justices Farwell and Kennedy) on Saturday, Mr. J. A. Walter, K.C., moved on behalf of plaintiffs, who are appealing from the decision of Mr. Justice Parker (reported in THE ELECTRICIAN for March 4, p. 846) that the notice of appeal which was delivered on May 31 might be declared a proper notice, or alternatively plaintiffs asked that if the notice of appeal was held to be bad, the time might be extended.

Lord Justice FARWELL said that he found the notice of appeal was two days out of time, and asked Mr. Bousfield, K.C. (for defendants) whether he opposed the application.

Mr. BOUSFIELD said he saw no reason to anticipate that the judgment of Mr. Justice Parker would be reversed.

Lord Justice FARWELL said the Court would extend the time as asked, the costs of the motion to be costs in the appeal.

Price Bros. v. Cuban Telephone Co. and Others.

This action, in which plaintiffs seek to restrain Messrs. Chaplin, Milne, Grenfell & Co. from parting with and the Telephone Co. from receiving sums that had come to their hands in respect of 5 per cent. first mortgage bonds of the Telephone Co., was mentioned to Mr. Justice Parker again on Friday last.

Mr. TOMLIN (for Messrs. Chaplin, Milne, Grenfell & Co.) said that as soon as the undertaking was given the previous week his clients sent out a circular letter to persons interested whose address they knew stating the terms of the undertaking, and he was quite prepared to give a similar undertaking in all the actions until trial.

Mr. H. E. WRIGHT (for the Telephone Co.) said that he had no objection to the undertakings being given if the costs of the motions were reserved, but he desired to protest against this multiplication of motions, which he submitted ought never to have been brought.

His LORDSHIP said all he could do was to accept the undertaking in the actions now before him, and reserve the costs of the motion. He intimated his view that no further motions ought to be made.

Tungsten Lamp Patent Litigation —In reference to the litigation as to the Tungsten lamp patents we have received the following communication from Messrs. G. M. Boddy & Co.: "We are writing to request you to invite anyone attacked to put themselves at once into communication with our solicitor, Mr. Jonathan E. Harris, 95, Leadenhall-street, E.C., who is defending the action on our behalf with the approval of the Messrs. Philips Metallic Glow Lamp Works (Ltd.)."

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Watertube Boiler Litigation.

We have received a communication from Messrs. Edwin Danks & Co. (Oldbury) (Ltd.) in reference to the action brought by Messrs. Babcock & Wilcox (Ltd.) against the Water Tube Boiler & Engineering Co. (Ltd.) and E. Danks & Co. (Oldbury) (Ltd.) and reported on p. 365 of our last issue. As the proceedings were sufficiently reported in our last issue, and as we have been informed that fresh actions by Messrs. Babcock & Wilcox are pending against the defendants, we consider it undesirable to refer to the matter further at this stage.

PARLIAMENTARY INTELLIGENCE.

LONDON COUNTY COUNCIL (TRAMWAYS AND IMPROVEMENTS) BILL.

A Select Committee of the House of Commons, presided over by Mr. A. W. Soames, commenced the consideration of this Bill on Thursday last.

Mr. ERSKINE POLLOCK, K.C., said the proposed expenditure was £931,335, and the works included a double line of tramway from Brixton to Herne Hill, via Effra-road and Dulwich-road, and a line from Effra-road, along Water-lane to Norwood-road. Owners and occupiers of premises in Effra-road opposed the scheme.

Mr. A. L. C. FELL, chief officer of the L.C.C. tramways, said the line would be of advantage to the public, as it would afford alternative facilities for getting from Norwood to Victoria.

Mr. Pollock dealt with the proposed extension of the tramway in Tooley-street from the present terminus to a point near London Bridge.

Mr. M. Fitzmaurice, chief engineer to the L.C.C., said the Deptford line would be worked electrically in a few months, and the proposed continuation would cost £5,500.

London Electric Supply Bill.—This Bill was read a second time in the House of Commons on Wednesday.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the position of secretary in the Birmingham Corporation electric supply department. Applicants should have had a sound commercial training in some large mercantile or manufacturing concern, and a certain amount of technical knowledge in connection with electricity supply is also required. Salary £600 per annum. Applications to the city electrical engineer, Mr. R. A. Chattock, M.I.E.E., 14, Dale End, Birmingham, by July 1. See also an advertisement.

Applications are invited for the vacant position of assistant lecturer and demonstrator in the physics department of the Technical School, Sunderland. Salary £150 per annum. Applications to the secretary to the Education Department, Mr. T. W. Bryers, 15, John-street, Sunderland, by Tuesday, June 21. See also an advertisement.

A first-class electrical engineer is wanted, with experience in the design of c.-c. machinery. See advertisement.

An electrical engineer is required for an electricity undertaking at Kandy (Ceylon). Commencing salary £350, with furnished bungalow. Five years' agreement, free passage out and home. See an advertisement.

A chief electrical engineer is wanted for an electric power station in the Federated Malay States. See an advertisement.

The governors of the Technical Institute, Loughborough, invite applications for the position of lecturer in engineering subjects. Preference will be given to candidates further qualified to teach mathematics or science. Commencing salary £120 per annum. Particulars from the director of education, Mr. W. A. Brockington, M.A., 33, Bowling Green-street, Leicester.

The Council of the University of Manitoba, Winnipeg, Canada require a lecturer in electrical engineering. Salary $1,500 a year. Applications to the Registrar by June 25.

Professors of engineering, chemistry and mathematics and physics are required for Queensland University. Salary, in each case, £900. Applications to Agent-General for Queensland, London, by Aug. 31.

Watford Council require an assistant electrical engineer. Salary £120, rising to £170. Forms from the Electrical Engineer.

A junior shift engineer is required in Wednesbury Corporation's electricity department. Commencing wages 30s. per week.

At Wednesday's meeting of the Electricity committee of the new county borough of Stoke-on-Trent the appointment of an electrical engineer to take charge of the several electricity undertakings in the federated borough was considered. Applications were received from the managers of the four works formerly carried on by the Councils of Hanley, Burslem, Stoke and Longton—viz., Messrs. C. H. Yeaman (Hanley), A. Bremner (Burslem), P. J. S. Tiddeman (Stoke), and W. Langford (Longton). The committee decided to recommend Mr. Yeaman for the appointment, the final voting being between Mr. Yeaman and Mr. Tiddeman.

Mr. Frank E. Frampton was recently appointed engineer and manager of Paignton Electric Light and Power Co.

Mr. F. H. Hummel, M.Sc., A.M.Inst.C.E., lecturer in civil engineering at Brimingham University, has been appointed professor of civil engineering in Queen's University, Belfast.

Mr. W. H. Hemer, of the Birmingham Technical School, has been appointed teacher of engineering at the Durban Technical Institute.

Accrington.—Haslingden Corporation are considering the terms submitted by Accrington for the supply of electric current to Haslingden on a seven years' agreement.

Acton.—At the meeting of the Council last Friday it was decided, by 12 votes to 10, to hand over the Council's electricity undertaking to the Metropolitan Electric Supply Co., subject to a satisfactory agreement being arrived at. A committee has been appointed to negotiate the terms. It is suggested that the company shall take possession under a 37 years' lease, and pay the Council's loan charges.

Aldershot.—An inquiry will shortly be held into the Council's application for sanction to borrow £2,000 for extensions of the electricity undertaking.

Bexhill.—The assessment of the electricity works has been reduced on appeal from £2,000 to £1,600.

Bournemouth.—The Council are considering the question of the appointment of an electrical inspector.

Dover.—The electric supply mains are to be extended to Alkham.

Ealing.—The electrical engineer (Mr. J. D. Knight) has been empowered to give a free supply of current to local tradesmen for exhibiting electrical appliances at the Suburban Home Exhibition in September.

East Ham.—As Wanstead Council decline to allow East Ham to supply electricity (under sec. 6 of the Electric Lighting Act, 1909) to premises belonging to West Ham Guardians within Wanstead district, East Ham Council will ask the Board of Trade to make an order for the supply being given to the premises.

Electric Power in South Africa.—A recent issue of the "South African Mining Journal" states that Messrs. Harper Bros. & Co. are considering a proposal for the erection of a new power station in the Kroonstad coal mine district, near Klerksdorp, and the transmission of electrical energy to Kimberley, Koffyfontein, Jagersfontein, Bloemfontein and Kroonstad, for supplying power for mining, pumping, tramways, lighting and general power purposes. Messrs. Harper Bros. are reported to be satisfied that such a power station would enable Kroonstad to effect a saving of at least 25 per cent. upon the present cost of generating power.

Fire.—On Saturday afternoon last a fire occurred at the Rosyth Naval Base which destroyed the electric power house.

Fire Alarms.—The leading fire insurance offices announce that discounts up to 10 per cent. are allowed in most cases on fire insurances where approved fire alarms are installed in accordance with the rules of the fire office, and there is also a notification made that shops occupied by furniture dealers, haberdashers, drapers, makers of and dealers in mantles and upholsterers, which are rated at over 5s. per cent., are now allowed 5 per cent. discount if these shops are lighted (even with the exception of the living rooms) wholly by the electric light. These considerable discounts allowed by the insurance offices should prove a useful weapon with which to tackle the gas interests in all large cities and towns.

Fulham (London).—Alterations to sub-stations to meet the requirements of the regulations under the Factory and Workshop Act, 1901, are to be carried out at a cost of £823.

Gillingham.—The Council have applied for sanction to a loan of £3,500 for mains extensions, services, &c.

Goole.—Mr. J. W. Speight has intimated to the Council that he proposes to apply for a provisional electric lighting order.

Hendon.—At the expiration of the contract with the Gas Light & Coke Co. in September next, 27 lamps are to be excluded from the new contract which Kingsbury Council desire should be lighted by electricity. Hendon Council will supply current and maintain these lamps at the rate of £3 per lamp per annum.

Hereford.—An inquiry was held last week into the application of the Council for sanction to borrow £3,000 for extensions of the electricity undertaking.

It was stated that £1,500 of the loan was required for mains and the balance for services. The total capital expended was £47,425 and the mount sanctioned £46,338.

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The Inspector (Mr. H. Ross Hooper) suggested that an overdraft of £425. 11s. 10d. should be paid out of revenue. There were certain items in the capital account for which the L.G. Board did not sanction loans, and he would point that out to the Board. The cost of the provisional order and miscellaneous items amounted to £383. 18s. 9d. Deducting that from the overdraft of £425. 11s. 10d., the balance was £41. 12s. 3d.

The Town Clerk said the Inspector's suggestion had come rather as a shock, because previous expenses in that connection had been allowed.

The Inspector said the difficulty had been that in the past they had pooled all their loans, and it was never intended that they should pool their loans. He suggested that the amount of the loan asked for should be increased, and if the Council liked to forward a resolution asking for an additional £500 it could be sanctioned without further inquiry.

Hornsey.—Stroud Green school is to be wired.

Huddersfield.—Linthwaite Council have accepted the Corporation's offer of £4,000 for their tramways, subject to the Corporation taking over the contracts entered into by the Council and laying a double line from Pinfold to Slaithwaite.

London County Council Tramways.—It is stated that the opening of the line from Woolwich to Eltham is postponed, owing to delay in delivery of a portion of the equipment.

To meet the objection of the Admiralty to the usual earth return, which, it was urged, might have interfered with instruments at Greenwich Observatory, the expedient of equipping each car with two trolley poles through one of which the return current is transmitted to a return wire, has been adopted on this section of the tramways.

The line from Streatham, via Mitcham-lane, to Tooting is expected to be opened in about six weeks.

At the meeting of the Council on Tuesday the Highways committee recommended that three months' notice be given to the Metropolitan Electric Tramways (Ltd.) requiring them to sell to the L.C.C. their tramway in the Seven Sisters-road, between Blackstock-road and Green Lanes (Manor House section).

Market Harborough.—The Council have applied for an extension of time for carrying out their provisional order.

Melbourne (Derbyshire).—The Council are in negotiation with the Melbourne & District Electric Light & Power Co. in regard to street lighting.

National Electrical Manufacturers' Association.—The next committee meeting will be held at Balfour House, Finsbury-pavement, London, E.C., on the 21st inst., at 2:30 p.m.

Newport (Mon.).—An inquiry was held last week into the application of the Corporation for sanction to borrow £31,255 for extensions of the electricity undertaking.

The town clerk (Mr. A. A. Newman) stated that the demand for current was increasing at such a rate that it was necessary to carry out extensions. Mr. C. P. Sparks, who had been consulted by the Corporation, had recommended certain things, including the installation of new plant, and that there should be a centralisation of the generating plant at the present power station in Corporation-road. The loan was required for machinery for the power station in Corporation-road, machinery in substitution for the old plant at Llanarth-street, for cables to convey current from the Corporation-road station to Llanarth-street, and to distribute current from Llanarth-street to various parts of the town, and for the supply of sub-station plant to reduce the voltage.

The engineer and manager (Mr. H. Collings Bishop) said it was the intention to ultimately make the Llanarth-street works a sub-station. They had had an inquiry for a supply of 1,460 H.P. from one consumer.

On the resumption of the inquiry on Saturday some evidence in opposition was given on behalf of the Ratepayers' Association.

The Inspector said he had no intention of tying the town up too tightly, but it was necessary to be careful about the expenditure, because it was obvious that the undertaking was over-capitalised.

The Town Clerk said he could not admit that there had been any reckless expenditure.

Mr. H. Collings Bishop: Not for many years. And it was due in the past to a large extent because there were two systems.

Obituary.—The death took place on June 3 of Mr. Frank Wright, consulting engineer. Deceased was the inventor of a "penny in the slot" gas meter and (jointly with Mr. W. Mackie) of a glass-blowing machine. In the early days of electric lighting Mr. Wright was assistant to Mr. G. Lane-Fox.

Oswestry.—The Watch committee have been instructed to reconsider the tenders for public lighting, especially as the local electric lighting company has offered to light 44 lamps at 7s. 6d. per lamp per annum less than the gas company.

Patent Legislation.—A Patents Bill will shortly be brought up for consideration in the Second Chamber of the States General of the Netherlands.

Under the bill patents can be granted for new or improved inventions, the person first sending in an application being considered to be the inventor, and applicants must be resident in Holland or establish their domicile at the address of a proxy in the Netherlands. The application is to be published in a "Gazette" issued by the Industrial Property Office, and during the following six months the specification, &c., may be examined by the public and opposition entered. At the end of this time the Patent Council shall decide whether the patent shall be granted. Three months are allowed for appeal. After three years from the granting of the patent, the Patent Council may grant compulsory licences in the interest of the Netherlands, her colonies or possessions, compensation being paid to the patentee by the persons receiving the licenses. A patent is to be granted for 15 years, but the Patent Council may repeal a patent if within five years from the date on which it was granted the patentee (or a holder of a license granted by him) has not a bona fide establishment for working the patent in the Netherlands or her colonies. A patent can be expropriated if public interests so require.

The British Consul at Bangkok, Siam (Mr. W. N. Dunn), says there is no Siamese patent law, but holders of British patentees may exhibit copies of their patents at H.M. Consular establishments in Siam, or publish a notice in the "Bangkok Times," the "Siam Observer," or the "Bangkok Daily Mail" of the ownership of a patent, and sec. 59 of the Siam Order in Council, 1906, provides that "any act which, if done in the United Kingdom or in a British possession, would be an offence against the then existing British Patent Acts, or any statute amending or substituted for them, shall, if done by a British subject in Siam, be punishable as a grave offence against the Order in Council."

Personal.—Col. R. E. Crompton, R.E., has been appointed consulting engineer to the Road Board, and Mr. Rees Jeffreys secretary.

Public Electric Lighting in Hammersmith.—In a recent communication to the "Daily News" the chairman of the Hammersmith Electric Lighting committee (Mr. Arthur R. Cracknell) states that his committee has lately converted all lamps in streets where low-tension mains are laid from gas to electricity, with the highest and best results, both from efficiency and cost.

The electricity undertaking has taken over the street lamps at the price per post the borough was paying for gas, and in place of the ordinary gas mantle light are giving 100 watt Osram lamps. This light, being far better than gas lighting, has given the highest satisfaction to the inhabitants. "I have no hesitation in stating (Mr. Cracknell proceeds) that public lighting by electricity, when supplied on a proper basis, at a reasonable price, is far cheaper and better than gas."

St. Anne's-on-the-Sea.—An unopposed inquiry was held last week into the Council's application for sanction to borrow £3,000 for extensions at the electricity works, including an economiser and a new chimney shaft.

Spain.—The Spanish Public Works Department have granted concessions to the Sociedad Anonima Tranvia de Cadiz á San Fernando y Carraca for the construction of an electric tramway from Cadiz to San Fernando and Carraca, and to the Sociedad Nueva Montana for the construction of an electric tramway in the vicinity of Santander.

An application has been lodged on behalf of the Compañia Madrileña de Urbanización (Madrid) for a concession for the construction and working of a combined steam and electric tramway in the vicinity of Madrid.

Stretford.—Mains are to be extended to supply current to 140 houses and some shops of Mr. H. M. Emery in Old Trafford.

Sunderland.—At the last meeting of the Corporation the chairman of the Electricity and Lighting committee, Ald. Bruce, referred to the new agreement with Messrs. Laings.

During the period when the company was in liquidation temporary arrangements were made with the liquidator. An agreement had now been drawn up to be in force for 15 years.

With regard to the annual report, Ald. Bruce said their engineer (Mr. A. Blackman) deserved every commendation for the way in which he had grappled with the serious problem since he came to the town. It was very creditable that he had been able to place Sunderland in a very favourable position as regarded works cost. They were now bracketed third with Bradford on the list of towns having the lowest works cost. With regard to total cost they stood sixth on the list.

Swansea.—Messrs. Vivian & Sons, who now take current from the Corporation to the extent of about £1,680 per annum, notify that they propose to put down their own plant.

Sweden.—H.M. Minister at Stockholm reports that both Chambers of the Swedish Legislature have agreed to the Government's proposals to establish an electric power station at the Porjus waterfall and to convert to electric traction the State frontier railway in the north of Sweden. These schemes, with the construction of a railway from Porjus to Mount Gellwara, are estimated to cost 21,500,000 kroner (£1,194,500).

Walsall.—Extensions of the Birchills tramway depot are to be made at a cost of £2,000.

West Ham.—The Council have recently entered into a number of agreements for supply of current, including Messrs. J. Knight (Ltd.), the Anglo-Continental Guano Co., Savill Bros. (for Taplow's bottling stores) and the New Oil Refining Process (Ltd.).

Whitwood.—The Council have entered into an agreement with the Yorkshire Electric Power Co. for the supply of electricity in bulk.

Wireless Telegraphy—It has been announced from Liverpool that the experiment which was recently made by one of the principal fishing trawler-owning companies of Hull to utilise wireless tele-

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graphy on their steam trawlers has not proved successful and has been abandoned.

Wireless Telephony.—In a short note in our last issue, page 368, we referred to Mr. Raymond Phillips' "wireless controlled airship" as having been constructed at New Passage, near Bristol. We are informed by Mr. Phillips that this is an error, as his airship was designed and constructed by him at his private residence in Liverpool.

Woolwich.—The Council have consented to West Ham Corporation supplying electricity to the Port of London Authority in North Woolwich on payment of £40 per annum.

Workhouse Lighting.—Portsmouth Guardians have decided to extend the workhouse infirmary, and the new wards will be lighted electrically.

Power plant is to be installed at the Bedford workhouse laundry.

Atcham (Salop) Guardians are considering the question of adopting electric lighting at the workhouse.

York.—The Board of Trade inspection of the two final sections of the municipal tramways took place on Friday. The lines were then opened for traffic.

Electrical Contractors' Association.—The annual dinner of this association took place at Edinburgh on Monday, the retiring president (Mr. Wm. Finlay) in the chair.

Mr. J. D. GIBSON proposed "The Electrical Contractors' Association." He said he appreciated the value of an association like that. It could do nothing but good, not only in promoting the good feeling which they all wished to prevail in all their respective lines of business, but in establishing and maintaining the highest possible standard of work, which, he was sure they would agree with him, was best for the man who paid, for the man who saw the work through, and for the contractor.

Mr. G. HARLAND BOWDEN (president), in responding, said the association had an ambitious programme. Some of the schemes suggested at their meeting that day were far-reaching, and if carried through would have important effects. He referred to the proposal to consider the desirability of bringing into line every industry connected with the electrical industry. The association was considerably stronger than a year ago.

The annual general meeting of the association was held in the afternoon, Mr. W. R. Rawlings (London) presiding.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Bury (Lancs.)—The accounts of the electricity supply department for the year ended March last show capital expenditure £117,053 (increase £23,460). The total amount raised by loans is £119,372, of which £19,586 has been extinguished. The sinking and reserve funds are £5,814 and £10,355 respectively.

The year's revenue was £18,600 (against £16,733 in 1908-9); total working expenses £8,269 (against £7,742); interest absorbed £3,003 (£2,709) and sinking fund £3,759 (£3,368); total costs, including capital charges, being £15,031 (£13,819) and net profit £3,569 (£2,914). Working expenses were 0·51d. (0·57d.) per unit, and total costs (including capital charges) 0·92d. (1·03d.); but, in consequence of average revenue being reduced to 1·14d. per unit (against 1·25d.) the net profit was the same as last year (0·22d. per unit). £1,000 (£1,500) has been allocated to relief of rates and £2,569 (£1,414) to reserve. 4,048,373 units were generated; 1,771,718 (1,623,603) supplied to tramways and 2,077,624 (1,536,943) to private consumers. The total maximum demand was 2,065 kw. (1,695 kw.) and the load factor 21·6 (21·6). There are 565 consumers with 107,313 equivalent 8 c.p. lamps connected, increases of 27 and 16,565 during the year, compared with 28 and 15,098 in previous year. The increase of motors connected was 39 (479½ H.P.), making a total of 314 (2,506 H.P.).

The total capital expenditure of the tramways department is £281,146, in addition to capital spent on tramways leased and worked by the Corporation. The year's revenue was £59,820 and total working expenses £36,294 (=5·868d., against 5·833d. per car-mile), and the net profit was £2,636. Total revenue per car-mile was 9·14d., working expenses were 5·868d., and the average fare per passenger was 1·16d. 12,333,902 (11,632,126) passengers were carried and 1,566,768 (1,513,580) car-miles run.

Croydon.—The total revenue of the tramways department for the year ended March 31 was £84,847, including £83,030 from traffic receipts.

The working came to £63,034, leaving gross profit £21,763. After crediting £909 for bank interest and paying £8,084 for interest, £7,371 for sinking fund and £211 for income tax, there was a net profit of £7,006. 18,705,604 passengers were carried (against 16,262,290) and the car-miles run 2,253,710 (against 1,945,645).

Huddersfield.—The accounts of the tramways department for the year ended March 31 show total receipts of £90,829, including £87,420 traffic revenue.

Working expenses were £47,467 (including £21,912 traffic expenses, £7,512 for power, £13,915 for general repairs and maintenance and £4,128 general expenses), and the gross profit was £43,362. After paying interest and sinking fund charges, placing £12,250 to reserve and applying £2,062 to relief of rates, the balance (£6,807) was carried forward. 17,925,058 passengers were carried and 2,027,077 car-miles (including 9,588 coal truck-miles) run. 4,516,750 units of electrical energy (1·44 per car-mile) were consumed; and the percentage of working expenses to receipts was 52·26. The capital expended is £408,325. 12s. 10d.

Keighley.—The accounts of the tramways department of the Corporation for the year ended March 31 show total revenue of £9,249, the traffic receipts amounting to £8,994.

Working expenses were £5,724; interest absorbed £1,081 and sinking fund £1,696, leaving net profit £747. 2,125,800 passengers were carried, and 225,347 car-miles run. 270,889 units of electrical energy (1·2 units per car-mile) were consumed; the average total revenue per car-mile was 9·85d. and the total expenses (including power) 6·09d. The capital expended is £46,112, an increase of £31 during the year.

Lincoln.—The accounts of the electricity supply and tramways undertakings for the year ended March 31 were approved by the Council last week.

The year's income of the electricity department was £12,777, and included £7,989 from the sale of current for public and private lighting, £3,826 from power supply and £880 from the tramways department. The total working expenses were £6,284, and the gross profit was £6,493. Dividends and interest on stock came to £2,045, and the annual instalment paid to the consolidated loans fund was £1,945, and the deficit for the year on the tramways was £43. 15s., leaving £2,459 to be transferred to reserve. 1,642,424 units were sold, against 1,718,612, the decrease being due to a drop in the demand (122,741 units) by Messrs. Clayton & Shuttleworth. Notwithstanding the increased use of metal filament lamps there was a considerable advance in the demand for private lighting. The equivalent of 5,481 8 c.p. lamps was connected during the year (against 4,438 8 c.p.), bringing the total connections to 74,253 8 c.p. The total works costs were 0·918d. per unit sold (against 0·899d.) and the total costs (including interest and sinking fund) 1·501d. (against 1·454d.).

The traffic revenue of the tramways department was £6,309, and the total income £6,429. The working expenses were £3,901, and after providing for redemption and interest there was a net deficit of £43. 15s. There was an increase from £731 to £918 (1·12d. to 1·40d. per car-mile) in the expenses of repairs and maintenance, and from £1,370 to £1,478 (2·10d. to 2·26d.) in traffic expenses. The power and management and general expenses showed slight decreases.

Loughborough.—The receipts of the electricity department for the year ended March 31 were £3,300, against £3,285.

Income from the sale of current was £2,862, against £2,329. Total expenditure was £2,447, against £2,738, and the balance was £854, against £547. Interest required £1,467, sinking fund instalment £834 and renewals fund £10, total £2,311. There are 336 consumers (including 34 "free" wired installations and 26 power consumers on hire-purchase system) connected to the mains, representing the equivalent of 26,653 8 c.p. lamps, against 21,804 8 c.p. There are 90 motors, against 69 of an aggregate of 480 B.H.P. against 381½ B.H.P. The works costs were 1·361d. per unit sold, against 1·852d. The capital expended is £32,136, an increase of £232.

Nottingham.—The traffic receipts of the tramways department for the year ended March 31 was £152,495, the total income being £154,936.

Working expenses were £98,163, leaving a gross profit of £56,773. Interest absorbed £16,540, sinking fund £6,930, and instalment for repayment of loans £11,004, leaving a net profit of £22,298, of which £20,550 was devoted to relief of rates and the balance (£1,748) carried to reserve. Capital expended is £613,864, an increase of £232. 34,647,238 passengers were carried and 3,340,549 car-miles run.

Warrington.—The accounts of the electricity department for the year ended March last show capital expenditure £98,269 (increase £3,068).

The year's revenue was £16,818 (against £15,400 in previous year), generation and distribution costs were £9,231 (£9,318), gross profit £7,587 (£6,740), and net profit £1,691 (£943). Maximum load was 1,625 kw. (1,220 kw.), and the number of equivalent 8 c.p. lamps (exclusive of traction load) connected at the end of the year was 106,143 (87,232). Units sold (exclusive of traction) were 2,243,822 (2,064,552). Current supplied for lighting increased by 54,248 units, although many metal filament lamps were substituted for carbon lamps during the year.

Weymouth.—The income of the electricity department for the year ended March 31 was £6,184, and included £4,240 from the sale of current and £1,907 from public lighting.

Working expenses were £2,823, leaving a gross profit of £3,361 to meet interest (£1,760), sinking fund (£1,695), and bank interest (£19.10s.). The net deficit was £113, against a profit of £102 in 1908-9. The total units sold were 392,319. There are 400 consumers, with the equivalent of 28,778 33-watt lamps connected, and the maximum load was 353 kw.

The engineer and manager (Mr. J. H. Bolam) states that the small decrease in revenue (£107) is due to the increasing use of metal filament lamps and to depressed trade. The total working costs were 1·44d. per unit sold, the coal costs were 0·45d. per unit (against 0·6d.), and the total costs were 2·13d. per unit. The prospects for the current year are better.

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Worcester.—The accounts of the electricity department for the year ended March 31 were presented to the Council last week. The total revenue was £15,764, including £10,738 net from the sale of current.

Working expenses were £6,996, leaving a gross profit of £8,768. After paying interest and sinking fund (£10,169) there was a net deficiency of £1,401. This result is mainly attributed to the loss of revenue from lighting (£1,170) due to the extended use of metal filament lamps. There was an increased revenue from power users of £428 and of £66 from street lighting, while there was a reduction of £634 in costs of production. During the past year 35 new consumers (representing 4,109 30-watt lamps) were connected (bringing the totals to 882 consumers and 76,032 30-watt lamps), against 52 (9,939 30-watt lamps) in 1908-9. The year's output at Powick water-power works was 371,011 units against 497,289. 1,379,056 units were generated at Hylton-road, against 1,304,962. The total costs per unit sold were 0·966d. (against 1·011d.). The total capital expenditure is £146,947, an increase of £1,537.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding **that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.**

TENDERS INVITED.

HAMMERSMITH (London) Council invite tenders for supply of l.t. service cable and air-cooled transformer. Specification, forms of tender, &c., from the borough electrical engineer, Mr. G. Gilbert Bell, electricity works, 85, Fulham Palace-road, W. Tenders to the town clerk, Mr. H. Thompson, Town Hall, Hammersmith, W., by 4 p.m. June 22. See also an advertisement.

SHANGHAI Municipal Council invite tenders for supply and delivery (c.i.f. Shanghai) of two 940 k.v.a. two to three-phase step-up transformers, e.h.t. switchgear, e.h.t. underground mains and feeder pillars. Specifications, &c., from Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, S.W., to whom tenders before noon July 5. See also an advertisement.

Tenders are invited by July 6 for the supply of cordless switchboards to the Postmaster-General's Department in SOUTH AUSTRALIA. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to July 27 for supply of a pneumatic tube service to the Postmaster-General's Department at ADELAIDE (S. Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See an advertisement.

Tenders are invited up to Aug. 2 for the supply and delivery of 1,820 private letter box fronts to the Postmaster-General's Department in the States of VICTORIA, QUEENSLAND, SOUTH AUSTRALIA and WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

BELFAST Harbour Commissioners are prepared to receive tenders for the construction, delivery and erection in their electric light station, Abercorn Basin, Belfast, of a direct-coupled steam engine and dynamo, with all requisite accessories. Specifications and form of tender, &c., from the harbour engineer, Mr. W. Redfern Kelly, M.Inst.C.E. Tenders to the secretary, Mr. W. A. Currie, Harbour Offices, Belfast, by June 22.

The Electricity committee of the County Borough of NEWPORT (Mon.) invite tenders for the supply and erection of l.t., h.t. and e.h.t. switchboards. Specifications, &c., from the borough electrical engineer and tramway managers, Mr. H. Collings Bishop, M.I.E.E. Tenders to the Town Clerk, Town Hall, Newport, Mon., by Monday, June 27.

CROMPTON Council want tenders by 10 a.m. June 30 for supply of dynamos and other electrical equipment, including motors, wiring, lamps, &c., for lighting new and present buildings at New Hey sewage works. Specifications from Messrs. J. P. Wilkinson & Son, 301, Cathedral-street, Manchester.

LONDON County Council require tenders by 11 a.m. July 5 for supply of 250 electric tramcar bodies and 250 electrical equipments for conduit and overhead systems. Specifications, &c., from the Clerk.

LONDON County Council want tenders by 11 a.m. June 28 for supply of petrol or electrically-driven fire escape vans. Specifications, &c., from the Clerk.

BIRMINGHAM Corporation want tenders by June 30 for 12 months' supply of stores for their electricity department, including electrical accessories, ironmongery, &c. Particulars from the City Electrical Engineer.

RAWTENSTALL Corporation want tenders by July 1 for permanent way construction and supply of steel poles, overhead equipment, cables, conduits, &c., for a tramway. Specification from the Borough Engineer.

BATLEY Council require tenders by noon June 28 for supply of a battery of accumulators, an automatic reversible traction booster and a battery charging booster. Specifications from Borough Electrical Engineer.

STOCKPORT Electricity and Tramways committees require tenders by noon June 22 for supply of carbon brushes, overhead line material, tubing, ironmongery, oils, &c. Forms of tender from Borough Electrical Engineer.

MANCHESTER Electricity committee want tenders by 10 a.m. June 22 for meters, service cables, motors and starters. Forms of tender from Mr. F. E. Hughes, Town Hall, Manchester.

MANCHESTER Electricity committee also require tenders by June 24 for supply and erection of two 125 k.v.a. three-phase static transformers and h.t. and l.t. switchgear. Specifications, &c., from Mr. F. E. Hughes, Town Hall, Manchester.

TONBRIDGE Council want tenders by July 1 for supply of a Lancashire boiler, economiser extension and pipework. Specification from Mr. M. P. Plunkett, Electricity Works, Tonbridge.

Tenders are required by June 28 for supply of electric light and power plant and wiring at the County Asylum, Knowle, FAREHAM. Specification from the County Surveyor, The Castle, Winchester.

EALING Corporation require tenders by noon July 4 for supply and erection of surface condensing plant, &c., at the electricity works. Specification, &c., from Town Hall, Ealing.

DUNMANWAY (Ireland) Rural Council require tenders by 11 a.m. June 21 for lighting the town by 33 electric, acetylene or oil gas lamps for 10 or 15 years.

NOTTINGHAM Tramways committee want tenders by July 4 for supply of 400 tons of steel rails. Specification, &c., from the City Engineer.

CLACTON-ON-SEA Council require tenders by noon June 22 for supply of 440 yds. 7/18 v.b. armoured twin-service cable.

Tenders are invited for supply of 36,000 incandescent electric lamps to the City of MELBOURNE. Specifications, forms of tender, &c., from the agents for the City Council (Messrs. McIlwraith, McEacharn & Co. Proprietary, Ltd.), Billiter-square Buildings, London, E.C., to whom tenders by noon July 1.

Tenders are invited up to July 19 for supply and delivery of 4,200 telephone sets (as per schedule No. 231) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, BRISBANE (Queensland), will receive tenders until noon June 22 for supply of copper wire and accessories, covered wire, iron wire, insulators, ironwork and sal ammoniac and zinc for batteries. Local representation is necessary.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representa-

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tion is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The ITALIAN MINISTRY OF MARINE require tenders by 11 a.m. June 30 for the supply of electric lamps and lamp-holders to the arsenals at Spezia, Naples, Venice and Taranto. Upset price 150,000 lire (£6,000). Deposit of 15,000 lire (£600) required to qualify tenders. Only firms on the Government list are generally allowed to tender. Specification may be seen at 73, Basinghall-street, London, E.C.

The Commissione Consultative dei Tranvia Elettrici Municipali, 49, Piazzi SS. Apostoli 49, ROME, want tenders for supply of 50,000 metres (31 miles) of tri-phase cable, 30,000 insulators (4,000 to withstand 30,000 volts), supplies for generating and transformer stations, alternators, transformers, water turbines, 138 miles of copper wire and reinforced concrete standards and iron standards.

The Société Nationale des Chemins de fer Vicinaux, BRUSSELS, want tenders by July 20 for underground cables, and by July 27 for the equipment of a transformer station.

The Austrian State Railways Administration, VIENNA, require tenders by June 27 for equipment of an electric power station at Simmering.

The Ministerio de Fomento, MADRID, will receive tenders until July 30 for the construction of an electric (or steam) strategic railway from Requena to Alcaráz, via Casas Ibáñez and Albacete. The contract is open to Spanish firms only.

The Ministerio de Obras Publicas, SANTIAGO (Chili), will receive tenders until July 15 for the substitution of electric for steam traction on the first section of the Chilian State Railways—from Valparaiso to Santiago and Los Andes.

TENDERS RECEIVED AND ACCEPTED.

West Ham Council received the following tenders for additional plant for the eelctricity works:—

Watertube Boiler, Superheater, Stoker, &c.

Babcock & Wilcox (*accepted*)	**£1,575**
Edwin Danks & Co.	1,052
Clarke, Chapman & Co.	£1,174 & 1.235
Stirling Boiler Co.	1,650

Condensing Plant.

British Westinghouse Co. (*accepted*)	**£1.835.** £2,050 & £1,897
Willans & Robinson	£2,900 & 2,300
Mirrlees-Watson Co.	2,690
Richardsons, Westgarth & Co.	2,200
Worthington Pump Co. (Ltd.)	2,114
W. H. Allen, Son & Co.	1,863

Coventry electricity committee have received the following tenders:—

One 2,500 kw. Turbo-alternator.—British Thomson-Houston Co. (*accepted*), A.E.G. Electric Co., Belliss & Morcom, British Westinghouse Co., Brush Co., Dick, Kerr & Co., General Electric Co., J. Howden & Co., Lahmeyer Elec. Co., J. Musgrave & Sons, C. A. Parsons & Co., Richardsons, Westgarth & Co., Willans & Robinson.

Four Watertube Boilers.—Babcock & Wilcox (*accepted*), Clarke, Chapman & Co., E. Danks & Co., Richardsons, Westgarth & Co.

Two Fuel Economisers.—E. Green & Sons (*accepted*), E. Danks & Co., Goodbrand & Co., Arthur Lowcock (Ltd.).

The following tenders for plant in connection with the electric light and power installation of Edmonton Union have been accepted by the Guardians:—

For electric motors and accessories for laundry equipment, Messrs. G. Harland, Bowden & Co., £240 (with E.C.C. motors); for electric lift motors and fan, Messrs. R. Waygood & Co., £293.

The consulting engineers were Messrs. May & Hawes.

Liverpool Overhead Railway Co. have let contracts for annual stores to the following:—

F. W. Cotterill (Ltd.), bolts and nuts; General Electric Co., electrical fittings and insulating tapes; Manufacturers Agency Co., files, packing and screws; W. & F. Walker, boiler fluid; Burnyeat & Dalzell, general stores; Hellewell & Co., indiarubber, &c.; A. & R. Brown, iron and steel; M. Wilson, ironmongery; C. C. Wakefield & Co., oil and grease; Neale & Co., timber; A. A. Leech, waste and sponge cloths.

Whitehead & Co. A.-G. (Fiume) have secured, after keen competition, the order for the building of a second submarine boat of the Whitehead type for the Dutch Government. This boat will be of the same type as the one ordered from the firm 10 months ago for the Dutch Navy, and will also be built by the "Schelde" shipyard at Flushing.

Poplar (London) Council have accepted the following tenders:—

Westminster Engineering Co., re-winding one stator and fixing new end supports, £170; Bruce Peebles & Co., re-winding stator in solid copper, in place of flexible, re-assemble core, ventilate castings and fix new end supports, &c., £300.

London County Council Education committee have accepted the tender of Johnson & Phillips (at £286) for wiring the Amberley-road school, Paddington; and that of E. Lawrence & Sons (at £346) for wiring the Fairclough-street school, St. George-in-the-East.

Southampton Council have accepted the following tenders:—

Electric Construction Co., motor-alternator; Dick, Kerr & Co., steam generator (Cole, Marchent engine) and surface condensing plant, £8,131; Babcock & Wilcox, water-tube boiler, £1,590.

Whitehaven Council have accepted the following tenders:—

Whipp & Bourne, main switchboard; Stout & Son, pipework; Vulcan Engineering Co., economiser; Callender's Co., cable; and Vaughan & Co., boiler-house runway.

Sunderland Corporation have accepted the following tenders:—

British Westinghouse Co., static transformer for sub-station at Messrs. Doxford's; W. T. Henley's Co., 220 yds. of service cable.

The tender of Johnson & Phillips has been accepted for the wiring of two blocks at the Withington workhouse, West Didsbury, Manchester.

Llandudno Council have placed a contract with the Chloride Electrical Storage Co. for re-plating their storage battery at the electricity works.

Newport (Mon.) Council have accepted the tender of the General Electric Co. for a 60 kw. motor generator, two 400 kw. generators and a booster, at £3,047.

Burnley Council have placed orders with the United Electric Car Co. for two tramcar bodies at £292. 5s. and with Dick, Kerr & Co. for electrical equipment at £264. 8s. 6d. per car.

Clacton-on-Sea Council have accepted the tender of Johnson & Phillips for service boxes, joint box compound, cut-outs and meter boards, and that of Engelbert & Co. for oils.

Croydon Council have accepted the tender of Johnson & Phillips for wiring the hospital extensions at £349.

Stretford Council have accepted the tender of E. Heaton & Sons for a boiler at £1,050.

Walsall Council have accepted the tender of F. & J. Wootton (at £1,150) for erecting a sub-station in Darwall-street.

Faversham Council have accepted the tender of Remark (Ltd.) for forced lubrication of gas engine at the electricity works at £90.

Bradford Corporation have accepted the tender of Thornton & Crebbin for tramway castings at £299. 7s. 6d.

Commonwealth Tenders.—The following tenders have been accepted by the Australian Postmaster-General's Department:—

Victoria.—E. Duckett & Sons, bolts and nuts, £402. 15s.; Danks & Son, 1,000 iron poles and fittings, £875.

N.S.W.—Australian Wireless (Sydney), wireless telegraph stations at Sydney and Fremantle, of 1,250 nautical miles range, £4.150 per station; J. Paton & Co., material for Edgecliff telephone exchange, £125. 6s.

Queensland.—Lawrence & Hanson, 20 miles v.i.r. wire (No. 18 gauge), £195.

Dundee Works committee have accepted the tender of T. C. Keay for wiring St. Paul's (South) Parish Church.

BUSINESS NOTICES

Mr. H. M. Sayers notifies that, as he has accepted a foreign engagement, the business carried on by him at 39, Victoria-street, S.W., has been transferred to his eldest son (Mr. Wm. Higley Sayers), who will carry it on in his own name and on his own account. Matters of account relating to Mr. H. M. Sayers' practice will be dealt with by Mr. A. G. Sayers, C.A. (Messrs. Sayers & Wesson), 19, Hanover-square, W.

We are informed that it has been arranged that Mr. R. B. Slacke, who, as a director of the Key Engineering Co., is known to many of our readers as one of the pioneers of the large gas engine movement in this country, is to join the staff of Messrs. Galloways (Ltd.), who are now manufacturing the Ehrhardt & Sehmer gas engine at their works at Manchester. The Key Engineering Co. will continue to act as agents for the Ehrhardt & Sehmer gas engine and will be prepared, as hitherto, to quote alternatively for these engines made at either the English or German works.

Herr F. W. Busch, of Lüdenscheid, Germany, asks us to state that Mr. A. Brauckmann has ceased to represent him and that he has appointed Mr. E. C. Seear, 16 and 17, Devonshire-square, E.C., his sole agent for the United Kingdom.

Walter O. Rooper and John C. G. McFerran, electrical and consulting engineers, 26, Victoria-street, London, S.W., and Stafford, have dissolved partnership. Debts by Mr. Rooper.

Sale by Auction.—Messrs. Fuller, Horsey, Sons & Cassell have been instructed to sell by auction at H.M. Dockyard, Portsmouth, on

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July 18 and following days, at 11 a.m., some old and surplus stores, including quantities of scrap brass, old tubes and other scrap metal, scrap steel and iron, lead, old wire rope, electric cable, electric fans, various electrical gear and stores, lathes, engines, &c. May be viewed three days prior to and on morning of sale, and catalogues (6d. each) may be obtained at the Dockyard or of the Auctioneers, 11, Billiter-square, London, E.C. Further particulars are given in an advertisement.

Plant for Sale.—Messrs. Hazell, Watson & Viney advertise for sale some modern electric generating plant, including three Browett-Lindley high-speed engines direct-coupled to Johnson-Lundell generators of 120 kw. each.

Some second-hand electric motors are advertised for sale in another column.

Motor Wanted.—An advertiser in the Midlands requires an electric motor 150 B.H.P., d.c., 250 volts.

Premises to Let.—Messrs. Jubber & Co., 61, Great Portland-street, London, W., have premises in Charing Cross-road to let, suitable for show rooms for electric light fittings, &c.

Patent Development.—The proprietor of patent No. 13,891/1907, for "Apparatus for treating liquids electrolytically," desires to enter into arrangements for exploiting and working the same in this country. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

"A.E.G. Zeitung."—The current number of the "A.E.G. Zeitung" is full of interest. The first article deals with hydro-electric plant, and is the fourth of a series by Mr. Gaze. Other illustrated articles deal with the power station at Havana, the measurement of electric currents, and new applications of electricity.

"Installation News."—The June issue contains some notes on the Holophane system of illumination and on fans and small motors. The article on "Points affecting Conduit Systems" is continued, and there is an interesting article on "Distribution Boards."

Publicity Committee's Literature.—We have called attention on former occasions to examples of the Electric Supply Publicity committee's literature issued in furtherance of the scheme to bring prominently before the public the advantages which electricity offers over gas and other means of lighting, power and heating. The committee are continually issuing illustrated posters, pamphlets, leaflets, &c., many of which have been most effective. We have now received from Mr. H. B. Renwick, secretary of the committee organising the London district, a set of illustrated cards and folded leaflets, which are topical and useful reminders of the facilities of electricity supply in the home, the shop, the workroom, the restaurant, &c., during the hot weather, and we illustrate the frontispiece of one of these leaflets entitled "Electricity and Pure Air," which deals with the ventilation of stuffy places by different types of fans which are neatly illustrated. There is no doubt that this literature, along with other methods adopted for bringing the claims of electricity before the public, will make possible consumers into actual consumers by graphically showing them the means at their command for increasing comfort and improving health. The size of the different items of printed matter, which the trade can obtain through the committee from the offices at Moorgate-court, Moorgate-place, E.C., will be found very useful, and their general circulation must prove advantageous to the industry.

Intensive Illumination.—The inset which will be found in the current issue of THE ELECTRICIAN between pages 388 and 389 is a significant example of the brilliancy of the illumination of public thoroughfares which can be obtained from the latest development of the electric incandescent lamp. There are moments in all industrial developments when the "striking example" is the most effective object lesson, and we think it will be admitted that this is the case in the illustration of the lighting of Queen-street, Glasgow, which the inset is designed to bring to our readers' attention. The General Electric Co., on whose behalf the photo has been taken, with a view of showing graphically the effect of the use of Osram lamps in street lighting, claim this to be one of the finest examples of night photography yet obtained. There are 30 lamps installed in Queen-street, Glasgow, on 23 posts. These consist of 16 100-watt and 14 55-watt lamps. The voltage at Glasgow is 260. The installation was started on April 1, and we are informed that the lamps have burned for 365 hours with the best possible results.

CATALOGUES, &c.

FUSIBLE CUTOUTS.—The British Thomson-Houston Co., of Rugby, are issuing a circular giving illustrated particulars and prices of their fusible cut-outs and fuses.

MOTOR STARTERS.—From Mr. Geo. Ellison, of Birmingham, we have received a copy of sheet No. 181, which deals with the face plate type of "Star-Delta" starters for three-phase squirrel-cage motors.

LIFT AND HOIST TRAVEL METER.—Messrs. Marryat & Place issue a leaflet dealing with a lift and hoist travelling meter made by them, designed to show on a scale each time the lift goes up or down. It should prove a useful check on the energy consumption of the lift.

BANKRUPTCIES, LIQUIDATIONS, &c.

John A. F. Milton, electrician, lately trading at 18, High-street, Crewe, has been adjudicated bankrupt. First meeting of creditors June 23 at the O.R.'s, King-street, Newcastle, Staffs., and the public examination on July 22 at the Petty Sessional Court House, Crewe.

A receiving order has been made against John A. F. Milton, electrician, 258, Hungerford-road (lately trading at 18, High-street), Crewe.

John P. L. Donlevy, consulting electrician, 123, Tulse-hill, London, S.W., has been adjudicated bankrupt.

A first and final dividend of 4½d. is payable at 28, King-street, Cheapside, London, E.C., to creditors of Joseph G. S. Cunnington (separate estate), electrical engineer and contractor, formerly trading with Harry P. Allison, as Laing, Wharton & Cunnington, at 7, Gt. Newport-street, London, W.C.

A first and final dividend of 5s. 9d. will be payable on June 25 at 2, Offa-street, Hereford, to creditors of Robt. E. Walker, electrical engineer, &c., 16, Widemarsh, and Eigne-road, Hereford.

The Typewriting Telegraph Corpn. (Ltd.) is being wound up voluntarily. Mr. C. S. Beale, 72, Bishopsgate-street Within, London, E.C., is liquidator.

A meeting will be held at 28, Baldwin-street, Bristol, on July 12 to receive an account of the winding up of the Unity Motor Electrical & General Engineering Co. (Ltd.)

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

April 7, 1910.

8,371 BOOTH & BOOTH. Installations of electric incandescent lamps connected in series.
8,375 TUCKER. Electrical switches.
8,380 BURKITT. Arc lamps.
8,409 SIEMENS BROS. DYNAMO WORKS & PARKER. Ventilation of dynamo-electric machines.*
8,410 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Armature windings for dynamo-electric machines.
8,411 SIEMENS SCHUCKERT WERKE G.M.B.H. Electric searchlights. (Addition to No. 12,556/08. Date applied for, 8/4/09.)*†
8,418 LUNDBERG, LUNDBERG & LUNDBERG. Electric switches.*
8,444 WILKINSON. Conduits and conduit fittings for electric wiring.
8,450 HATFIELD. Electrical maximum demand indicators and like apparatus.

April 8, 1910.

8,460 SYKES & SUGDEN, & SUGDEN. Double-break electric switches.
8,507 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Searchlights or projectors.*
8,510 HARRISON. Arc lamps.
8,513 HEBDEN. Electric lamp and process for manufacturing same.
8,551 SIEMENS BROS. & CO. & HIRD. Telephone switchboards.*
8,556 CATTORI. Systems of electric power distribution.
8,559 LEMMENS. Charging electric accumulators and/or maintaining them in a charged condition.

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April 9, 1910.

8,621 Allgemeine Elektricitats Ges. Control of alternating electric current induction motors. (Date applied for, 10/4/09.)*†

April 11, 1910.

8,698 Pordes. Electric lamps.
8,711 Petersson. Electric resistance furnaces. (Addition to No. 6,035/10.)*
8,730 Temple. Counting the evolutions of revolving parts by the employment of an electric current.

April 12, 1910.

8,810 Elementbau G.m.b.H. & Lessing. Galvanic batteries. (Addition to No. 23,622/04.)*
8,828 Barnes. Switches.
8,831 Jellinek & Tovaros. Suspension of trolley wires. (Date applied for, 19/7/09.)*†
8,858 Rawlings. Earthing device for electric switches.*
8,862 Samaia. Actuating conduit traps and car ploughs for electric conduit tramways.*

April 13, 1910.

8,922 Chamberlain & Hookham & Sprague. Prepayment electricity meters. (Addition to No. 3,250/10.)*
8,927 Rouse. Switch plug.
8,943 Pearson. Electric switches.
8,977 Davis & Siebe, Gorman & Co. Electrical plug connections.
8,984 B.T.-H. Co. & Gray. Electric incandescent lamps.
8,988 Criggal & British Vitrite Works. Process of manufacture of bases for electric lamps.

April 14, 1910.

8,996 Anson, Henderson & Newlands. Galvanic batteries.
9,046 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H., Germany.) Polyphase electric compensated series motor.*
9,071 Nash & Western Electric Co. Covers for electric magnetic relays. (Date applied for, 11/1/10. Comprised in application No. 752, dated 11/1/10.)
9,076 Siemens & Co. Electrodes for electric arc lamps. (Date applied for, 14/5/09.)*†
9,082 Cowper-Coles. Electro-deposition of iron.
9,094 Politz. Protecting tubes and vessels from galvanic or electric currents. (Date applied for, 22/4/09.)*
9,097 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*
9,101 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Means for starting and controlling electric motors.*
9,103 Booker, Ogilvy-Webb & Reinecke. Arc lamps.

April 15, 1910.

9,153 Trier. Electric switches, cut-outs and the like.
9,164 Snow & Radley. Electrical signalling apparatus.*
9,171 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric Motors.*
9,176 Newlands & Parkinson. Preparation to be employed in making electrolyte for primary batteries. (Addition to No. 11,926/09.)*
9,182 Anchor Cable Co. Fireproofed electric cables, acid-proofed electric cables and the like.
9,191 Booker & Webb. Arc lamps.
9,199 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Controlling electric motors.*
9,208 Cowper-Coles. Electro-deposition of iron.
9,209 Allgemeine Elektricitats-Ges. Arc lamps. (Date applied for, 22/4/09.)*†

April 16, 1910.

9,222 Missotten. Varying the power of an explosion motor combined with an electric machine.*
9,225 Westminster Engineering Co. & Way. Arc lamps of the projector type.
9,250 Weber. Mercury-carbon filament incandescent lamp. (Date applied for, 9/10/09.)*†
9,276 & 9,278 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*
9,304 Heather. Controlling the starting and retarding of induction motors.

SPECIFICATIONS PUBLISHED.

1903 Specifications.

27,858 Tanner & Claremont. Distribution of electric energy and cables therefor. (Post-dated 8/4/09.)

1909 Specifications.

5,891 Rawlings, Handcock & Dykes. Fixings for making attachments to walls or ceilings for electrical conductors.
6,008 Fessenden. Producing indications by received electromagnetic waves.
8,620 Stevenson & Williams. Rapid "make and break" electrical switch movements.
8,692 Rose. Mechanism in quick make and quick break electrical switches.
8,979 B.T.-H. Co., Wedmore & Whitcher. Electric distribution systems.
9,318 Horvath. Electric incandescent metal or other filament lamps.
9,338 Felten & Guilleaume-Lahmeyerwerke Akt.-Ges. Control of electric motors. (Date applied for, 30/11/08.)
10,288 Rawlings. Electric candle lamp.
10,793 Schwerin. Production of electric currents. (Date applied for, 7/5/08.)
11,413 Pinson. Electric current distributors.
11,954 Hatry. Electric fuse carriers.
15,147 Cockshott. Trolley heads of electric tramcars.
16,476 Alldays & Onions Pneumatic Engineering Co. & Joselin. Electrically-driven centrifugal fans.
17,368 Gottschalk. Telephone transmitters.
19,209 B.T.-H. Co. (G.E. Co., U.S.) Enclosed electric fuse indicators.
19,826 Lundsteen & Aktieselskabet International Elektrisk Trappeautomat. Electric switches.
20,055 B.T.-H. Co. (G.E. Co., U.S.) Regulation of load equalisers for electric supply systems.
21,540 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke Ges.) Polyphase commutator dynamo-electric machines.
24,190 Miller. Illuminated electric signs.
24,769 Waterhouse. Ceiling roses for electric lamps.
25,118 Imray. (Soc. of Chemical Industry in Basle.) Processes and apparatus for continuous electrolysis of aqueous solutions.
25,132 Morse. Electric switches.
25,551 Jakobsen & Jensen. Electric switches. (Date applied for, 11/8/09.)
26,006 Jaeger. Incandescent electric lamps.
26,466 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Rectifiers for high-tension alternating electric current.
26,907 Kohler. Current collector for electrically-propelled vehicles. (Date applied for, 4/10/09. Addition to No. 26,347/09.)
27,221 Accumulatoren-Fabrik Akt.-Ges. Electric storage battery plates. (Date applied for, 11/2/09.)
27,252 Blathy. Rotating field magnets for turbo-generators.
27,641 Brush Electrical Engineering Co. & Porter. End connections of the rotor and stator bars of dynamo-electric machines.
27,972 Hay. Electric furnaces. (Date applied for, 19/6/09.)
29,088 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke Ges.) Rotary converter dynamo-electric machines.
29,592 Lundberg, Lundberg & Lundberg. Plug and socket connections.
29,719 Kelvin & James White, Chetwynd & Clark. Magnetic compasses. (Date applied for, 19/8/09.)
30,049 Bosch. Sparking plugs for internal combustion engines. (Date applied for 25/8/09.)
30,176 Allmanna Svenska Elektriska Aktiebolaget. Revolving magnets for dynamo-electric machines. (Date applied for, 12/7/09.)

1910 Specifications.

65 Stille. Relays for telephone or other weak current apparatus. (Date applied for, 12/1/09.)
457 Marshall. Electric hoists.
748 Heimann & Schaffer. Working arc lamps in series with incandescent lamps. (Date applied for, 13/1/09.)
999 Siemens & Halske Akt.-Ges. Connections of telephone apparatus. (Date applied for, 10/2/09.)
1,009 Franz Clouth Rheinische Gummiwaren Fabrik. Insulators for high-tension electricity conductors. (Date applied for, 29/9/09.)
1,087 Soc. Anon. Ateliers Jaspar & Meller. Automatic electromagnetic regulators. (Date applied for, 15/1/09.)
1,292 Siemens Schuckertwerke Ges. Commutators of dynamo-electric machines. (Date applied for, 6/2/09.)
1,404 Siemens Bros. Dynamo Works & Kloss. (Siemens-Schuckertwerke Ges.) Cooling the windings of the rotors of dynamo-electric machinery. (Addition to No. 1,679/09.)
1,707 Boult. (Maxwell.) Telephone transmitters.
2,031 B.T.-H. Co. & D'Arcy. Bearings for the spindles of electric measuring instruments.
2,608 Siemens & Halske Akt.-Ges. Telephone exchanges. (Date applied for, 12/2/09.)
2,814 Schulz. Unipolar turbo-dynamos. (Date applied for, 4/4/09.)
4,171 Westinghouse Electric Co. Electromagnetic brakes. (Date applied for 3/3/09.)
5,044 B.T.-H. Co. (G.E. Co., U.S.) Control of alternating-current electric motors. (Date applied for, 24/3/09.)

COMPANIES' MEETINGS AND REPORTS.

ARON ELECTRICITY METER (LTD.)—The directors' report for the year ended March 31 states that the net profit, after providing for general charges and depreciation, was £21,117. 17s. 3d., making, with £6,549.8s.1d brought forward, a total available profit of £27,667. 5s. 4d. The directors distributed in December last a dividend of 3 per cent. on the preference shares, absorbing £3,746. 17s. 6d., leaving £23,920. 7s. 10d. to be disposed of. The directors recommend payment of a further 9 per cent. on the preference shares, representing 3 per cent. the remainder of arrears and the full 6 per cent. dividend for the past financial year, amounting altogether to £11,240. 12s. 10d., and a transfer to reserve towards goodwill and patents of £6,000, leaving a balance of £6,679. 15s., out of which it is proposed to appropriate £1,326. 3s. 10d. to pay off arrears of management commission and directors' fees, and to carry forward £5,353. 11s. 2d. By the distribution of this year's profits as proposed, the preference shareholders will have received, apart from their yearly dividend, the residue of the arrears due to them. The board hope that the ordinary shareholders may in the near future participate in the distribution of dividends. The past year's trading has been most satisfactory, the sales having exceeded those of any previous year. The increased demand for the company's products has employed the factories to the full. The taximeter business is progressing satisfactorily in England, Belgium and Austria, though it has not yet contributed to the profits. The transfer books and register of members will be closed from 20th inst. to July 2 inclusive.

BIRMINGHAM & MIDLAND TRAMWAYS (LTD.)—At the meeting on Monday Mr. C. S. B. Hilton said, in regard to the new system of fares which they hoped would improve their revenue, they had not yet had sufficient experience of its working to arrive at any conclusion. There was, however, a very satisfactory improvement in the sale of electricity for power and light. The total number of units sold showed an increase of 38 per cent., the revenue showed an increase of 23 per cent. and the balance of revenue over expenses an increase of 32 per cent. That improvement was being well maintained during the present year, and they had been obliged to order additional plant. They were also interested in the Shropshire Power Co. and in the developments of the very large area of the company, and they looked for a very considerable improvement in revenue when the Shropshire Co. had been able to develop their area.

BRITISH ELECTRIC TRACTION CO. (LTD.)—The directors' report for the year ended March 31 states that the £3,000 5 per cent. perpetual debenture stock and £53,206. 4½ per cent. second debenture stock of the company were purchased in the open market; the issued debenture stocks have been reduced by those amounts, and the difference of £16,383.11s.3d. between the purchase price and the nominal value has been transferred to reserve. The amount of reserve at March 31 was £618,581. 17s. 3d., and this figure will be further increased by £15,000 proposed to be transferred to reserve out of the profits of last year. In addition, reserves amounting to £58,752. 2s. 3d. have been made from time to time out of profits against loss and depreciation of specific assets. The various associated companies have created depreciation and reserve funds of their own, which amounted at Dec. 31, 1909, to £1,175,997. Investments and undertakings stand at £4,997,845. 17s. 4d., and consist of shares and debentures in associated tramway, electricity supply, manufacturing and other companies, Consols and sundry securities and undertakings. The expenditure on and in connection with the new building in Kingsway amounts to £42,036. 18s. 4d. It has been arranged to grant a lease of this building to the British Electrical Federation for 21 years. Expenditure on Acts of Parliament, &c., has increased, and now stands at £26,783. 16s. 3d. It is being written down annually by 20 per cent.

The net profit, after reserving £12,500 against depreciation of undertakings worked by the company, buildings and freehold land, doubtful debts and expenditure on undertakings not proceeded with, and after transferring to reserve the profit of £10,397. 18s. 10d. on sales of investments, is £130,564. 5s., added to £20,203. 10s. 10d. brought forward, making £150,767. 15s. 10d. After deducting interest on the 5 per cent. perpetual debenture stock and the 4½ per cent. second debenture stock for the year (£97,484. 15s. 4d.) there remains £53,283. 0s. 6d., out of which it is proposed to pay a dividend of 3s. per share on the preference shares, amounting to £24,215. 11s., and to transfer £15,000 to reserve, leaving £14,067. 9s. 6d., which the directors propose should be carried forward.

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This dividend will bring the payment of the full dividend on the 6 per cent. cumulative preference shares to June 30, 1908, and the reserve will be increased from £618,581. 17s. 3d. to £633,581. 17s. 3d. The yield for the past year on the total investments and undertakings standing in the books at £4,997,845 was 2·63 per cent., compared with 2·5 per cent. for the preceding year on £5,037,095.

For some years past the directors have made every effort by increasing fares, eliminating unremunerative services and by similar means to increase the profits of the tramway undertakings, and they have been successful in arresting the steady decline in the receipts per passenger. The directors have during the past year given much time and attention to the examination of various schemes for increasing the net profit on the working of tramways, keeping in view the importance of not increasing the fares to an extent likely to deter traffic. As a result the "Fair Fare" system has been devised, and many of the federated companies have adopted the system. The directors state that during the past few months there has been a marked improvement in the traffic receipts on the tramway undertakings, but there has not yet been sufficient experience of the system to enable them to say definitely to what extent the improvement is the result of its adoption or is due to better weather conditions and improved trade.

The various lighting undertakings in which the company is interested show steady improvement, but owing to the introduction of metal filament lamps the advance in net profits has to some extent been checked. The electrical manufacturing industry is still in a very unsatisfactory condition, and the accounts of the Brush Electrical Engineering Co. for the past year show a loss. With regard to the other branches of the company's operations and particularly the development of new electrical enterprises, the directors feel that opportunities for promoting new tramway and lighting undertakings in this country with a prospect of reasonable profit are rare.

Having regard to the general position of the company the policy by which the directors are guided may be stated as follows: To meet depreciation, the associated companies have made various reserves which amount to £1,175,997; moreover the B.E.T. Co. itself has a reserve of £633,581. 17s. 3d., which is also available to meet depreciation. The increase of these reserves is a matter to which the attention of the directors is constantly given, and while they recognise that the depreciation of assets which has occurred may be in excess of the existing reserves, they consider that it would be incorrect under the existing conditions to make any valuation based upon the present market quotations of the company's own shares and debenture stocks, which in the opinion of the directors show an unduly exaggerated depreciation. They propose for the immediate future to deal with the depreciation as and when its amount is ascertained, and so long as such depreciation continues to transfer to reserve any profits or losses (other than accrued dividends or interest) made by realisation of present investments. The accounts for the year are made up on this principle. They recommend also an annual addition to reserve out of net profits. With regard to the management of the associated companies, an efficient organisation for the administration and working of the various undertakings has been established by means of the British Electrical Federation, and the results show that, compared with other enterprises of a similar kind, the associated undertakings are being economically worked.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—The net revenue of the company for the year ended May 31, after deduction of expenses, amount to £209,117. 17s. 11d., making, with £27,305. 5s. brought forward, £236,423. 2s. 11d. From this there has been distributed £131,085. 9s. in interim dividends, leaving an available balance of £105,337. 13s. 11d. The directors now recommend payment of the following final dividends—viz., 3s. per share (less tax) on the preference shares, making 6 per cent. for the year (less tax), and 5s. 9d. per share net on the ordinary shares, making 5⅞ per cent. net for the year. These dividends absorb £77,656. 8s. 11d. and leave £27,681. 5s. to be carried forward.

R. WAYGOOD & CO. (LTD.)—The profits earned during the year ended March 31 (including £3,159. 10s. 8d. brought forward) amounted to £23,755. 8s. 6d. After paying directors' fees, &c. (£2,800), preference dividend (£8,100), placing £1,000 to reserve, writing £1,090. 3s. off experimental work, and paying interim dividend on ordinary shares (£3,375), the balance was £7,390. 5s. 6d. A further ordinary dividend is declared at the rate of 7 per cent. (making 6 per cent. for the year) (£4,725), leaving £2,665. 5s. 6d. to be carried forward.

NEW COMPANIES, STATUTORY RETURNS MORTGAGES AND CHARGES.

NEW COMPANIES.

LEAKE-SUMNER GUN FIRE CONTROL SYND. (LTD.) (110,104.)—Reg. June 9, capital £1,500 in £1 shares, to carry on the business of engineers, manufacturers of and dealers in apparatus used in connection with electric signalling, &c., and to acquire from H. C. Leake and O. Sumner and turn to account certain inventions relating to gun fire control and improvements therein, &c. Private company. Reg. office, 39, Victoria-street, London, S.W.

TELEGRAPH CONDENSER (LTD.) (110,048.)—Reg. June 7, capital £5,000 in £1 shares, to take over the business of the Telegraph Condenser Co. and to carry on the business of manufacturers of and dealers in electrical apparatus, &c. Private company. First directors, J. A. L. Dearlove and S. G. Brown. Reg. office, The Factory, Vauxhall-street, London, S.E.

STATUTORY RETURNS.

ELECTROPHONE (LTD.)—In return to March 31 capital is £15,000 in 10s. shares. All shares taken up. 10s. per share called up on 7 and 1s. per share on 7,027. £354. 12s. paid, leaving 5s. in arrears. £12,239. 15s. considered as paid, being 10s. per share on 22,966 and 5s. per share on 7,027. Mortgages and charges, nil.

S. H. HEYWOOD & CO. (LTD.)—Return to March 30 gives capital as £12,000 in £1 shares. 8,007 shares taken up. £7 paid. £8,000 considered as paid. Mortgages and charges, nil.

HOWARD ASPHALT TROUGHING CO. (LTD.)—According to return to April 13 capital is £20,000 in £1 shares (1,000 deferred). 5,007 ordinary and 1,000 deferred shares taken up. £1,007 paid. £2,000 considered as paid. Mortgages and charges, nil.

MORTGAGES AND CHARGES.

ALUMINIUM CORPN. (LTD.)—Trust deed, dated May 18, 1910, to secure £50,000 debenture stock. Property charged, lands and premises in Caerhun, Dolgarrog Abbey, Dolgarrog, Llanrhychwyn, Trefriw and Maenan, rights and privileges, &c. Trustees, London General Investment Trust.

ELECTRIC BATTERIES & CARBONS (LTD.)—Debenture, dated April 25, 1910, to secure £1,000, charged on the company's undertaking and property, present and future, including uncalled capital. Holder, R. G. Orr.

FILAMENTS (LTD.)—Issue on June 1 of £80 debentures, part of a series of which particulars have already been filed.

HINDHEAD & DISTRICT ELECTRIC LIGHT CO. (LTD.)—Issue on May 13 of £1,050 debentures, part of a series of which particulars have already been filed.

RECEIVERSHIP.

SUNDERLAND DISTRICT ELECTRIC TRAMWAYS (LTD.)—A notice of the appointment of C. Eves, of Capel House, New Broad-street, E.C., as receiver and manager, by order of Court dated June 2, 1910, has been filed.

CITY NOTES.

MEMORANDA (June 16).—**Bank rate 3 per cent.** (since June 9, 1910). **Price of silver,** 24⅝d. per oz. Consols 81⅞—82⅛ for money and **for account. Consols Pay Day, July 1; Stock and Shares Continuation Days,** June 27 and July 12; **Ticket Days,** June 28 and July 13; **Pay Days,** June 29 and July 4; **Mining Shares Carry Over Day,** June 24.

PRICES OF METALS (London).—*Copper*, **cash,** 54½; **three months.** 55⅛. *Lead*, **English,** 12¾—13⅛; **foreign,** 12⅝—12¾. *Spelter*, 21⅞—22⅛. *Tin*, **English,** 146½—148½; **foreign cash,** 147½; **three months,** 148¾. *Iron*, **Cleveland, cash,** 49/-, **three months,** 49/10½.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The units delivered to consumers during the four weeks ended April 29 were 780,512, compared with 573,738 units for the corresponding four weeks of 1909.

CANADIAN GENERAL ELECTRIC CO. (LTD.)—The directors have declared a dividend of 1¾ per cent. on the common stock for the quarter to 30th inst.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The transfer books and registers of holders of the 5 per cent. first and 4½ per cent. second debenture stock of this company will be closed from 17th to 30th inst. inclusive.

COMPANIES STRUCK OFF THE REGISTER.—It is notified that the following were struck off the Register of Joint Stock Companies on June 10:—

Beeston Accumulator Synd., Birmingham Electrobus Co., British & Foreign Light Railway Synd., Electric Canal Haulage Co., Electric Mercantile Agency, International Telegraphic Appliances, Lancashire & Yorkshire Electrobus Co., Liverpool Electrobus Co., Manchester Electrobus Co., Nottingham Electrobus Co., Nottingham Gas & Electric Fittings Co., Provincial Electrobus Co., Richardson Electrical Co., Scottish Electrobus Co., Tramways Development Co.

INDIA-RUBBER, GUTTA PERCHA & TELEGRAPH WORKS CO. (LTD.)—The directors have declared an interim dividend of 5s. per share (2½ per cent.), tax free, on the ordinary shares.

NOTTING HILL ELECTRIC LIGHTING CO. (LTD.)—The directors have declared a dividend of 3 per cent., plus a bonus of 1½ per cent. (together 9s. per share), less tax, on the ordinary and preference shares.

PROVINCIAL TRAMWAYS CO. (LTD.)—The directors have declared an interim dividend of 8d. per share upon the ordinary shares on account of the financial year ending Sept. 30.

UNITED ELECTRIC TRAMWAYS OF MONTEVIDEO (LTD.)—Mr. G. A. Touche, who presided at the meeting on Wednesday, said that the period under review was the first complete year of working by electric traction, and the results had been up to expectations. The dividend which had been declared on the ordinary shares was equal to 6 per cent. for the year.

VERITY'S (LTD.)—The directors have declared a dividend at the rate of 5 per cent. on the ordinary shares for the half-year, making 5 per cent. for the year.

VICTORIA FALLS & TRANSVAAL POWER CO. (LTD.)—Mr. H. L. Cripps has joined the Board of this company.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	June 3	213	— 13	22	4,781	+ 82
Anglo-Argentine	,, 10	44,684	+ 6,998	23	1,016,469	+110,935
Ayr Corporation	,, 11	317	+ 23	4	1,124	+ 1
Baker St. & Waterloo Ry.	,, 11	3,150	— 140	23	78,540	+ 1,650
Barnsley	,, 3	158	— 62	22	3,759	+ 90
Barrow	,, 3	248	— 57	22	5,260	+ 617
Bath Electric Trams, Ltd.	,, 8	813	+ 65	23	17,225	+ 1,254
Birmingham Corporation	,, 11	6,605	+ 598	10	69,315	+ 110
Birmingham & Midland	May 27	795	— 47	21	17,421	+ 651
Blackburn Corporation	June 8	1,038	+ 40	‡11	11,618	— 936
Blackpool and Fleetwood	,, 11	555	— 243	..	..	..
Bolton Corporation	,, 12	2,520	+ 111	11	24,530	— 1,151
Bombay	May 13	2,762	+ 205	19	52,504	+ 3,695
Bournemouth Corporation	June 8	1,663	+ 34	10	16,187	— 883
Bradford Corporation	,, 11	5,157	+ 394	11	52,112	— 131
Brighton Corporation	,, 12	969	+ 77	§10	9,418	— 607
Bristol Trams & Carriage	,, 11	5,964	+ 728	23	129,837	+ 12,362
Burnley Corporation	,, 11	1,275	+ 48	23	29,183	+ 670
Burton Corporation	,, 12	271	+ 27	10	2,742	— 33
Bury Corporation	,, 12	1,236	— 102	§10	12,315	— 675
Calcutta Tramways Co.	,, 11	₹49,654	+ ₹1,834	23	₹1,188,800	+ ₹40,172
Camborne-Redruth	,, 11	112	— 43	23	2,766	— 113
Cardiff Corporation	,, 10	2,182	— 409	10	20,295	— 471
Cavehill	,, 3	81	— 24	22	1,736	+ 155
Central London Railway	,, 11	5,940	+ 79	23	129,897	+ 2,394
Charing C., Euston & H'stead	,, 11	3,590	— 205	23	88,395	— 945
Chatham & Dist. Lt. Rys.	,, 9	906	+ 108	23	18,304	+ 778
City & South London Rly.	,, 12	3,101	— 101	23	74,647	— 294
City of Birmingham	,, 3	2,772	— 681	22	62,480	+ 2,700
Colchester Corporation	..	..	..	..	..	..
Cork Electric Trams Co.	,, 9	567	+ 70	23	10,625	+ 1,687
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	,, 3	422	— 5	22	8,986	+ 954
Dover Corporation	..	..	..	..	..	..
Dublin & Lucan Railway	,, 10	146	— 12	23	2,877	+ 17
Dublin United	,, 10	5,491	+ 82	23	120,196	+ 3,613
Dudley-Stourbridge	,, 3	794	— 593	22	16,263	— 625
Dundee Corporation	,, 8	1,216	+ 1	§3	4,180	+ 11
East Ham Council	,, 11	1,058	+ 142	¶10	10,643	+ 70
Exeter Corporation	,, 10	324	+ 23	10	3,175	— 685
Gateshead & Dist. Trams	,, 3	954	— 164	22	21,023	— 472
Glasgow Corporation	,, 11	18,987	+ 1,270	2	30,807	+ 3,161
Glossop Trams	,, 11	119	— 12	23	2,570	— 140
Gloucester Corpn.	..	..	..	..	..	..
Gravesend-Northfleet	,, 3	201	— 110	22	4,255	+ 67
Great Northern & City Rly.	,, 11	1,345	— 21	23	34,017	— 436
Gt. Northern, Piccadilly, &c.	,, 11	5,525	— 415	23	138,565	+ 5,330
Greenock & Port Glasgow	,, 3	669	+ 81	22	12,530	+ 1,746
Hartlepool Tramways	,, 3	237	— 85	22	4,767	+ 137
Hastings Elec. Trams Co.	,, 9	1,006	+ 48	23	19,675	+ 306
Hong Kong	,, 11	$9,462	+ $1,653	23	$199,192	+ $19,167
Huddersfield Corpn.	,, 10	1,755	+ 131	10	18,016	+ 660
Hull Corporation	,, 11	2,678	+ 355	10	27,411	+ 1,373
Ilford District Council	,, 11	540	+ 96	10	5,437	+ 134
Ilkeston District Council	,, 8	122	+ 8	10	1,241	— 85
Ipswich Corporation	,, 11	443	+ 67	10	4,025	+ 43
Isle of Thanet Co.	,, 11	650	+ 72	¶35	12,378	+ 125
Jarrow	,, 3	111	— 48	22	2,518	+ 106
Keighley Corporation	,, 9	175	+ 18	10	1,745	+ 16
Kidderminster & District	,, 3	90	— 138	22	2,072	+ 32
Kilmarnock Corporation	,, 11	148	+ 6	4	586	— 11
Lanarkshire Trams Co.	,, 9	1,436	+ 159	23	31,184	+ 3,419
Lancashire United	,, 8	1,284	— 169	23	28,985	+ 72
*Leamington	,, 3	159	— 120	22	3,278	— 135
Leeds Corporation	,, 11	7,115	+ 418	10	72,127	+ 2,146
Leicester Corporation	,, 11	2,387	+ 386	..	..	..
Leith Corporation	,, 11	640	+ 35	4	2,436	+ 14
Lincoln Corporation	,, 11	122	— 7	11	1,379	— 2
Liverpool Corporation	,, 4	11,123	— 363	22	238,695	+ 6,377
Liverpool Overhead Rly.	,, 12	1,441	+ 95	24	32,139	+ 691
Llandudno&ColwynBayRy.	,, 3	214	— 355	§25	4,339	+ 121
*London County Council	..	..	..	..	..	..
London United	,, 11	6,797	+ 1,138	23	139,081	+ 8,366
Lowestoft	,, 11	172	+ 8	37	5,534	+ 261
Maidstone Corporation	,, 11	171	+ 5	10	1,701	— 228
Manchester Corporation	,, 11	15,820	+ 1,103	10	157,756	+ 1,173
Mersey Railway	,, 11	2,223	+ 14	23	46,691	+ 1,126
Merthyr	,, 3	131	— 114	22	4,316	— 214
Metropolitan Dist. Railway	,, 11	10,947	+ 215	23	250,746	+ 23,639
Metropolitan Elec. Trams	,, 3	7,630	— 930	22	156,013	+ 28,450
Middleton	,, 3	295	— 173	22	6,511	— 490
Nelson Corporation	,, 11	152	+ 12	§10	1,468	— 28
Newcastle-on-Tyne Corp.	,, 11	3,911	+ 258	¶10	39,095	— 1,716
Newport (Mon.)	,, 11	705	+ 65	11	7,483	+ 179
Northampton Corporation	,, 10	495	+ 50	§10	4,964	— 114
Oldham, Ashton & Hyde	,, 3	514	— 137	22	11,849	— 131
Oldham Corporation	..	..	..	..	..	..
Perth (N.B.) Corporation	,, 8	170	— 3	§3	575	+ 12
Perth (W.A.) Elec. Trams	,, 10	1,447	+ 57	23	35,880	+ 2,693
Peterborough	,, 3	103	— 73	22	2,305	— 40
Portsmouth Corporation	,, 11	2,107	— 48	10	19,902	— 1,452
Potteries	,, 3	1,677	— 350	22	37,998	— 641
Preston Corporation	,, 8	698	+ 25	10	7,224	— 388
Rotherham Corporation	,, 9	605	+ 55	10	6,133	— 79
Rothesay	,, 3	195	+ 20	22	1,937	+ 25
Salford Corporation	,, 13	4,995	+ 534	†10	49,021	— 477
Sheerness	,, 3	50	— 23	22	959	— 35
Sheffield Corporation	,, 12	6,084	+ 620	¶11	67,462	+ 3,520
Singapore Trams	,, 11	$9,687	+ $360	23	$228,098	+ $5,125
South Metropolitan	,, 3	949	— 270	22	17,101	+ 874
South Staffs	,, 3	787	— 387	22	17,970	— 160
Southend Corporation	,, 8	572	+ 121	10	4,925	+ 289
Southport Tramways	,, 3	227	— 211	22	5,796	+ 213
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 11	741	— 23	¶10	7,216	— 1,071
Sunderland Corporation	,, 12	1,282	+ 101	11	11,576	— 541
Sunderland District	,, 8	389	— 42	32	12,846	— 1,469
Swansea Trams	,, 3	1,058	— 344	22	22,262	+ 2,315
Swindon Corporation	,, 8	146	+ 17	..	..	..
Taunton	,, 3	40	— 14	22	883	+ 99
Tynemouth and District	,, 3	223	— 224	22	3,877	+ 266
Tyneside Trams Co.	,, 8	432	+ 10	23	9,055	— 318
Wallasey District Council	,, 11	978	+ 77	§10	9,345	— 481
Walsall Corporation	,, 11	500	+ 40	23	12,226	+ 608
Warrington Corporation	,, 2	382	— 19	9	3,412	+ 31
West Ham Corporation	,, 2	2,415	— 567	9	21,946	+ 49
Weston-super-Mare	,, 3	109	— 272	22	1,437	— 93
Wolverhampton Co.	,, 3	386	— 344	22	9,049	+ 62
Wolverhampton Corpn.	,, 8	866	+ 159	10	8,955	+ 1,552
Worcester	,, 3	276	— 144	22	5,620	+ 59
Wrexham	,, 3	35	— 43	22	2,078	+ 9
Yorkshire W.R. Trams	,, 12	1,264	+ 70	24	29,456	..
Yorkshire Woollen District	,, 3	949	— 262	22	21,045	+ 1,847

These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	NAME.	Price Wed., June 15	Rate per cent. Yielded.	Dividend Due.	Business Week to June 15 High- est.	Business Week to June 15 Low- est.
		Electricity Supply.		£ s. d.			
10	6/0	Boarnemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9½	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 15 0	Feb, Aug	..	..
10	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
St.	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼—7½	6 9 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7 —7½	4 13 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	98 —101	3 19 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾—4¼	6 1 0	Feb, Aug	3⅛	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 17 6	Feb., Aug	4⅛	4⅛
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	95½—97½	4 2 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101⅛—103½	4 7 0	..	102	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅞—4⅜	5 3 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3¾—4⅛	5 9 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11⅛—11⅞	5 19 0	Feb, Aug	1⅛	1⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 —103	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2⅜—3½	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7½—8	6 0 0	Feb, Aug	7⅛	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¼—11⅛	5 5 0	Mar, Sept	11⅛	10⅛
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	105 —108	4 3 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	98 —101	4 9 0	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4⅜	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	6¾—7⅛	5 10 6	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5¾—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94½—96½	4 3 6	..	..	..
St.	4%	Kensington & Knghtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	96 —99	4 1 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅛—2	4 10 0	Mar, Sept	1⅛	..
5	3/0	Do. 6 per Cent. Pref.	4¼—5½	5 14 0	Mar, Sept	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	3¼—4	5 9 0	April, Oct	3⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¼—4⅞	4 12 6	Jan, July	4⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	85⅛	84
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	97 —99	4 11 0	June, Dec	..	..
5	4/0	Newcastle Elec. Supply Ord.	4¼—4⅜	4 7 6	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾—4⅞	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	102⅛	101⅛
100	5%	North Metro. Elec. Power Sup. 5 Morts.	99 —101	4 19 0	..	100⅛	99⅛
10	9/0	Notting Hill Electric Ord.	11⅛—12⅛	5 17 6	March	..	..
5	4/6	Oxford Electric Ord.	6¾—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅛—8½	5 9 6	Feb, Aug	8⅛	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7⅛	4 15 0	Feb, Aug	7	6⅞
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	85 —88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1⅛—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3⅛	6 11 0	April	..	..
St.	5%	Do. 5 % 1st Mort. Stock (red.)	101 —104	4 16 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—¼	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	⅛—1⅛	6 4 6	Feb, Aug	1⅛	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	⅛—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8⅛—8½	5 14 6	Mar, Sept	8⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	5⅛	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97	96½
1	..	Bath Elec. Trams Pref. Ord.	⅛—¼	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—¼	6 13 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock	83 —86	5 5 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	5½—6	10 0 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7¼—8	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅞—1⅛	..	June, Dec	1⅛	1⅛
10	..	Do. 6 per Cent. Cum. Pref.	3 —3½	8 11 0	Feb, Aug	3⅛	2⅞
St.	5%	Do. 5 Cent. Perpetual Debs.	89 —93	5 7 6	April, Oct	90⅛	87½
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 —73	6 3 0	May, Nov	69⅛	68⅛
St.	3%	Central London Ordinary Stock	69 —71	4 4 6	Feb, Aug	70	69⅛
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	88	..
St.	2%	Do. Deferred Stock	53 —55	3 12 0	Feb.	53⅛	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	95 —97	4 2 6	Jan, July	96⅛	96
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	32⅛—33⅛	3 12 6	Feb, Aug	33⅛	32⅛
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	93 —100	4 0 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8⅛	7 1 0	..	8⅛	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 —97	4 2 6	Jan, July	96⅛	96
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	63 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅜—1⅛	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	63 —65	5 18 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅜—1 ⅛	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—89½	5 13 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2½	..	Jan, July	2⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 —71	5 12 0	Jan, July	68⅛	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅞—1⅛	..	..	..	..
1	..	Do. Deferred	⅛—¼	..	April	⅛	⅛
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—¼	5 0 9	Feb, Aug	⅛	⅛
St.	4½%	Do. 4½ per Cent. Deb. Stock	93 —101	4 19 0	Jan, July	..	..
St.	1%	Metropolitan Railway Consolidated	41⅛—41⅞	2 8 3	Feb, Aug	42⅛	41⅛
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	66⅛	..
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90⅛	89⅛
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87⅛	86⅛
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	..	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shre	Last Dividend	NAME.	Price Wed. June 15	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to June 15 High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	91 —93	3 15 0	Jan, July	92½	91½
St.	..	Metropolitan District Railway Ord.....	22⅞—23⅛	..	Feb, Aug	25⅜	22⅛
St.	..	Do. Extension Pref. (5 per Cent.).....	69 —71	..	Feb, Aug	..	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	72⅛	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	75⅛	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.....	102 —104	3 17 0	Mar, Sept	103½	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	142 —144	4 3 3	Jan, July	143⅛	..
St.	4%	Do. 4 per Cent. Ditto.....	96 —98	4 1 0	Jan, July	..	..
1	4½	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅛—¼	6 14 0	Feb, Aug	⅜	⅛
St.	4½%	Do. 4½ per Cent, Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	7½	†S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—¼	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	68 —72	5 11 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	57 —61	8 4 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoupo	37 —39	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds.....	100½—101½	4 18 6	..	101¼	100½
..	4½%	Do. 4½% Bonds with coup. 5	89 —91	4 19 0	..	90	89½
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	98 —100	4 0 0	..	99	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	¼—½	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	79 —82	5 10 0	Jan, July	75	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101½—103½	4 7 6	..	..	..
1	..	Aron Electricity Meter Ord.....	⅜—⅝	..	..	..	..
1	7½d.	Do. 6% Cum. Pf.	¾—1	6 5 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.....	5⅛—5⅜	5 15 9	April, Oct	5⅛	5⅜
1	0/7½	Do Pref.....	1⅛—1⅜	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7	7 3 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.....	5½—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	103 —106	4 5 0	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.....	⅞—1	..	Feb, Aug	⅞	⅞
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	98½—100½	5 19 6	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	59 —62	3 4 6	Jan, July	..	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	25 —29	15 10 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9½—10½	6 8 0	Jan, July	9¾	9½
5	2/6	Do. 5 per Cent. Cum. Pref.....	5 —5⅛	4 13 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	102½—104½	4 6 0	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.....	2⅛—2⅜	5 7 6	May, Nov	2⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	106 —109	4 3 6	Feb, Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	⅜—½	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	⅜—½	7 0 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	⅜—½	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	⅜—½	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	88 —91	5 10 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¼—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	¼—1⅛	5 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	¾—1½	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United (" A " Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅛—¼	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—1⅝	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)..	74 —77	5 16 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅛—¼	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1⅛—1⅜	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	61 —66	6 1 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7½—8½	6 1 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅞—12⅜	6 6 6	Feb, Aug	12⅜	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5⅜	4 3 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	103½—105½	4 5 6	Mar, Sept	15⅛	15
10	15/0	India Rubber, Gut. Per., &c., Works....	14½—15½	6 9 0	Feb, Aug	..	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10⅛—10⅝	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	..	..
1	..	National Elec. Construction Co.	⅛—¼	..	April ..	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	No.	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—¼	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	30/0	Telegraph Construction & Maintenance..	33 —35	6 0 9	Mar, July	..	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100½—102½	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 11 0	..	2⅛	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1⅜	4 0 0	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	108 —111	4 10 0	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	101 —103	3 7 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	103½—105½	4 15 6	..	..	..
10	8%	J. G. White & Co. 6% Cum. Pref	10½—11½	6 19 0	..	..	..
1	..	Willans & Robinson Ord.....	⅛—¼	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1½—1⅝	10 13 6	Apr, Oct	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3⅝	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100½—102½	4 17 6	June, Dec	..	..
St.	15/0	Anglo-American	69 —71	5 2 8	F,My,Ag,N	70	66
St.	30/0	Do. Preferred	112 —114	5 5 6	F,My,Ag,N	114⅛	104
St.	25/0	Do. Deferred	29½—30½	4 6 0	F,My,Ag,N	30¼	27⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	86 —88	4 10 9	Jn,Ap,Jy,O	87⅛	86½
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	8⅞	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 12 6	Feb, Aug	16¼	..
5	2/0	Direct Spanish Ord.....	3⅛—3⅜	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	7⅞—8⅛	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable.....	15½—15⅝	5 8 0	Ja,Ap,Jy,O	15⅝	11⅛
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.).	100 —102	4 18 0	June, Dec	..	..
St.	65/0	Eastern Ordinary	133 —136	5 3 6	Ja,My,Jy,O	135	133½
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	85 —87	4 0 6	Ja,My,Jy,O	85⅜	85½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	101 —103	3 17 6	May, Nov	102⅛	..
St.	6/6	Eastern Extension	12⅝—13½	5 7 6	Ja, Ap, Jy, O	12⅝	12½
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	9½—10½	3 18 6	May, Nov	..	..
10	26/0	E.N (of Copenhagen), with Coupon 79 ..	30¼—31¾	5 13 6	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt.Db.(red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	†Mackay Companies Common	87 —89	5 12 0	Ja,Ap,Jy,O	..	..
100	4%	†Do. Preference	76 —78	5 2 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛—⅜	..	April	..	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	97 —99	3 19 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 12 9	May	⅛	..
100	4%	Do. 4 per Cent. Debs.....	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	⅜—½	..	May, Nov	8½	..
10	6/0	Do. 6 per Cent. 1st Pref.	8¼—9½	6 11 3	May, Nov	..	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.....	100½—102½	4 17 6	Jan, July	..	..
100	3/0	Western Telegraph.....	13⅜—14⅛	4 18 0	Mr,Jn,O,D	14	13¾
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	101 —103	3 17 6	June, Dec	..	..
	1%	Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	..	..	..

Shre	Last Dividend	NAME.	Price Wed., June 15	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to June 15 High-est.	Low-est.
		Telephones.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	138 —140	5 14 6	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan. July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	102 —104	3 16 6	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
5	3/0	Chili Telephone	7½—8⅛	4 15 9	August ..	..	..
1	0/7½	Monte Video Telephone Ord.....	¾—1	7 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅞—1	5 13 9	May, Nov	..	..
St.	6%	National Co. Pref. Stock	104½—105	5 14 6	Feb, Aug	105½	104½
St.	6%	Do. Def. Stock	124 —126	4 15 0	Feb, Aug	125	124½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 10 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 10 6	Feb, Aug	10 1/16	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref....	5⅛—5⅜	4 11 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)....	97 —99	3 11 6	June, Dec	97⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 —102	3 18 0	Jan, July	100½	100
..	4½%	New York Telephone Co. 30 yr. Bnds.....	97½—98½	4 11 6	..	98⅛	97⅝
..	..	Oriental	1 1/16—1 1/8	4 15 0	April, Oct	1 1/16	1 1/32
1	0/7½	Do 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock.....	88 —90	4 9 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	100½—102½	4 8 6	Jan, July	..	..
5	3/0	United River Plate.....	7½—7¾	5 9 0	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 1/16—5 3/16	4 12 3	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan. July	103½	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2⅞—3⅛	8 18 0	Jan, July	..	..
10	2/0	Globe Telegraph & Trust	10⅜—10⅞	5 5 9	Sp,DcMrJu	10⅝	10 1/16
10	3/0	Do. 6 per Cent. Pref.	13 —13⅜	4 8 9	Sp,DcMrJu	13⅜	..
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
..	..	Anglo-Argentine 5% Cum. 1st Pref.	4 1/16—4 1/8	5 3 9	April, Oct	4 1/16	4⅛
..	..	Do. 5% Cum. 2nd Pref.....	4 1/16—4 3/16	5 9 6	Jan, July	4⅛	..
..	..	Do. 4% Deb. Stock	90 —91⅛	4 7 6	June, Dec	91½	90½
St.	4%	Do. 4½% Deb. Stock	96 —99	4 13 0	..	97⅛	96½
St.	4½%	Auckland Elec. Trams. 5% Deb. (red.)....	10 —107	4 13 6	Jan, July	..	..
St.	5%	Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	..	..
St.	4%	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 13 9	May, Nov	..	..
5	4½	Do. 4½ per Cent. Db. Prov. Certs.....	101 —104	4 6 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	142 —147	5 9 0	Mar, Sept	145	144½
St.	6%	Do. Pref. Ord. Stock	123 —127	4 13 6	May, Nov	125½	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock.....	109½—112½	4 9 0	Jan, July	111⅛	..
St.	4%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
St.	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	104 —105	3 19 0	..	104½	104⅛
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	100⅛	99½
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	96 —99	6 1 0	Feb, Aug	97½	97½
..	..	Calcutta Tramways (1 to 137,610).....	4¼—4⅜	4 4 3	Mar, Sept	4¼	..
..	2/6	Do. 5 per Cent. Cum. Pref.	4⅜—5	5 0 0	Jan, July	4⅜	4⅛
5	4½	Do. 4½% 1st Deb. Stock (red).....	98 —101	4 9 0	Jan, July	..	..
..	..	Cape Electric Tram Shares	½—¾	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 9 6	F,My,A,N	..	..
..	..	Do. 4 per Cent. Deb. Stock.....	99 —102	3 18 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	95 —98	5 2 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	78 —81	6 3 6	June, Dec	..	..
..	..	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	96½—99½	5 0 6	Feb, Aug	98	..
..	..	Kalgoorlie Elec. Trams Sh.	⅜—½	..	..	..	..
1	5%	†Do. 5 per Cent. "A" Deb. Stock.....	92 —96	5 3 6	Jan, July	96½	..
..	..	†Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	76½	..
5	5%	Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
100	5%	Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
100	5%	Manaos Trams and Lt. Co. 5% Debs.	88½—90	..	..	89¼	..
100	$1½	Manila Elec. Ry. $1,000 Gold Bonds.....	95 —97	5 2 6	Feb, Aug	..	..
100	5%	Mexico Trams Co. Com. St.	127½—129½	4 18 6	..	99¼	98½
100	$2½	Do. Gen. Con. 1st Mort. 5% Gold Bds.	98½—99½	5 0 9	..	101⅛	100⅜
..	5%	Do. 6% 50 yr. Mort. Bds.....	101 —102	5 18 0	..	..	..
..	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	101	..
1	0/6	Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	..	..
100	$1	Perth Elec. Trams Ord.	⅜—½	5 14 0	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅜—5⅞	5 2 6	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	101 —103	4 17 6	..	96⅛	95⅞
1	$1	Rio Janeiro Tram, Lt. & P. Co.....	95 —97	4 2 6	..	97⅜	96⅛
100	$2½	Do. 30 yr. Gold Bnds.	98½—99½	4 0 3	..	83¼	88
100	5%	Do. 50 yr. Mt. Bnds	87½—88½	5 13 0	..	..	..
10	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	148½—150½	6 14 0	..	149½	..
100	5%	Do. 5 per Cent. 1st Mt. $500 Db.	102½—104½	4 15 0	June, Dec	103⅛	103
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	102	100
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5⅜—5⅝	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.....	10½—11	5 9 0	..	11	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red).....	95 —97	4 12 6	Jan, July	97	96
..	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock..	96 —98	4 18 0	..	..	..
St.	4%	Calcutta Elec. Supply Ord.	6⅜—7⅛	5 12 6	April, Oct	6⅜	..
100	5%	Canadian Gen. Elec. Co. Com. St.....	108 —112	6 6 0	..	110	108½
St.	4%	Do. 7% Cm. Pf. Stock	119 —122	5 14 6	..	121½	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	98 —102	4 18 0	Jan, July	..	..
10	5/0	Elect. Development Co. of Ontario.....	86 —89	5 12 0	..	88	85½
100	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	..	..
5	5/0	Indian Elec. Sup. & Trac. Co.	1⅜—1⅝	..	..	..	..
20	4/0	Kalgoorlie Elec. Power & Ltg. Ord.	1/16—1/8	..	..	..	..
100	4½%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	8⅝—8¾	5 14 6	..	..	..
St.	65/0	Mexican Lt. & Power Co. Com. St.	80 —92	4 17 6	..	81	..
100	5%	Do. 7% Cum. Pref. St.	103 —105	6 13 6	..	104½	..
25	52/6	Do. 5% 1st Mort. Gold Bnds.	91½—92½	5 8 0	..	93	91½
100	5%	Montreal Lt. Ht. & Power Co. Cap. St.	133 —137	4 18 0	F,My,A,N	..	..
100	4%	River Plate Electricity Co. Ord.	2 1/16—2 3/16	5 12 9	April	2 1/16	..
1	..	Do. 6 per Cent. non-Cum. Pref.	1 1/16—1 1/8	5 2 0	May	1 3/32	..
100	4%	Do. 5 per Cent. Deb. Stock	103 —105	4 15 6	Jan, July	..	..
2½	1/3	Rosario Ele . Co. Ord.	8½—9	..	..	..	..
100	4%	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
10	..	Do 2nd Pref.	8⅛—8⅝	6 14 6	..	..	..
10	6/0	Shawinigan, Water& Power Co.Ca	101½—103½	4 7 0	..	104½	..
10	9/0	Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	108½	108⅛
100	5%	Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102½	101½
100	3/0	†Toronto Power Co. 4½% Db. St.	100 —102	4 8 6	..	102	..
St.	4%	Victoria Falls Power Co. Pref.(1 to 808,000)	½—⅝	5 6 6	Jan, July	..	..
	1%	Do. (803,081 to 1,700,000)	½—⅝	..	..	..	..

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,675. [No. 11. Vol. LXV.] FRIDAY, JUNE 24, 1910. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Municipal Trading.

THE judgment delivered on Monday by Mr. Justice NEVILLE, in the action brought by the Attorney-General against Leicester Corporation, deals with a question of considerable importance to municipal electricity supply undertakers. The point at issue was whether a municipal corporation working under a Provisional Electric Lighting Order granted under the Electric Lighting Acts of 1882 and 1888, could undertake ordinary wiring work in addition to the supply of electrical energy. The subject has been frequently discussed by borough electrical engineers, wiring contractors and others interested in the business of electricity supply, and, although there was some doubt on the point, the opinion was generally held that a municipal corporation could not engage in work of the character referred to without special statutory powers. So general was this opinion that very many Corporations obtained powers to wire premises (in some cases only through contractors), to let motors and fittings on hire, and to do other things necessary for the development of modern electricity supply departments. On the other hand, there were some who contended that the wording of certain sections of the Electric Lighting Act of 1882 was sufficiently wide to enable municipal undertakers to do wiring work; in particular they relied on sec. 10, which authorises undertakers subject to certain conditions, for the purpose of supplying electricity ". . . . to do all such acts and things as may be necessary and incidental to such supply." The electrical engineer of the Leicester electricity undertaking (the late Mr. A. COLSON) was one of those who were of this opinion, and accordingly he established a wiring and fittings department in connection with the municipal electricity undertaking. The wiring contractors resented this, and ultimately brought an action against the Corporation, through a local contractor, for a declaration that wiring work could not be undertaken without special statutory authority; and as Leicester Corporation were not so authorised, an injunction was asked to restrain them from carrying on such work.

FROM the judgment, which is given elsewhere in this issue, our readers will see that the contractors' contention was upheld, as the Judge laid down that the business of electricity supply is distinct from electric wiring and fitting, and that the latter can only be executed by a municipal corporation when they are specially authorised to do so. On the facts of this particular case we think, and always have thought, that the principle laid down in the judgment is sound law; but whether it is for the good of the electrical industry is another matter. In some cases adequate progress is difficult unless the supply authority also carries out wiring, and in recent years the importance of being able to sell or let out on hire apparatus for electric heating and cooking has become very apparent. Indeed, in our opinion, this latter development is much more important than wiring, as the average contractor cannot afford to run a hiring or hire-purchase department. Undoubtedly, where possible, it is far better to work in harmony with the local contractors, competition being resorted to merely as a last resource; but it would be well if the contractors themselves would bear in mind the importance of real co-operation, which would be better for all concerned than war to the knife.

The "G.B." System at Lincoln.

WHILST surface contact systems generally are somewhat under a cloud, the "G.B." system at Lincoln and the Lorain system at Wolverhampton continue to give satisfaction, judging by the reports of the tramway managers in those towns. In the case of Lincoln, the tramway accounts for the year ended March 31, 1910, show a deficit of £44 after payment of all capital charges, com-

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pared with £98 a year ago. It is satisfactory to notice that the traffic receipts have increased, without any curtailment of the service, from 9·2d. per car-mile last year to 9·6d. per car-mile on the present occasion. On the other hand, the working expenses have increased by £252, and now stand at 5·95d. per car-mile. Repairs and maintenance account for £187 of this increase, the cost of repairing cars having advanced from £522 to £697. It must be explained, however, that £62 of this latter sum represents spares, which have now been "written off" in the books. The cost of maintaining the "G.B." equipment amounted to £140. This, however, includes £28 for special improvements and the upkeep of feeders, so that the amount to be directly charged against the "G.B." equipment is £112, as compared with the "G.B." Company's guaranteed figure of £90 per annum. Mr. STANLEY CLEGG, the tramway manager, points out that for the four complete years of operation the cost only averages £69 per annum. On the present occasion the bulk of the expenditure has been incurred in renewal of stud heads and carbons. The life of these parts was estimated at five years, and the fact that this period is drawing to a close has accounted for an increased number of live studs—the number is not stated in the annual report of the engineer and manager—but as these studs are stated to be in no way a danger to the public it was not thought necessary to undertake a general re-carboning of the track. As the Lincoln undertaking is the smallest municipal tramway in operation, it is, of course, difficult to compare the above items of cost with those in larger undertakings, but attention may be drawn to the fact that the cost of repairs and maintenance, on the car-mile basis, is less at Wolverhampton, whilst the power consumption is greater, the average number of units per car-mile at Lincoln being 1·075, as against about 1½ units at Wolverhampton. This difference, however, may be largely accounted for by the different running conditions as regards speed and weight of the cars and the absence of gradients.

Exhaust Steam Turbines.

DURING the discussion on exhaust steam turbines at the Glasgow Convention of the Incorporated Municipal Electrical Association, several speakers were evidently doubtful as to the real value of such turbines when used for the purpose of extensions. In all probability it is in stations using an old type of plant—namely, generators that have been in use for some time and are somewhat inefficient for an increased output—that the advantages of the exhaust steam turbine are the most apparent. There are many cases in which the engineer desires to lay down fresh plant to meet an increasing load, but wishes to do so at a minimum of cost. In such cases the exhaust steam turbine will appeal strongly to those in charge, as it involves no increase in the boilers or condensing plant. Two other alternatives are generally open to the engineer. The first is to put in a high-pressure steam turbine to cope with the additional load, but in such cases more boilers and condensing plant will be required. The other alternative is that which was advocated more particularly by Mr. FERRANTI, namely, to scrap the old plant completely and to put in high-pressure steam turbines instead. This sounds a drastic course to adopt. It is, no doubt, one that would appeal to our American friends, and would probably be adopted by them without hesitation. We do not doubt that in the long run such a course might be the best to adopt, but we are inclined to think that, in municipal work at least, the engineer would find it difficult to induce his committee to accept such a recommendation; and in any case there would be much difficulty with the Local Government Board in obtaining permission for the necessary loans, for the loans on the old plant would generally not have been completely paid off, and the "scrapping" would lead to loans outstanding without corresponding assets. We do not suggest that the advantages shown for the exhaust steam turbine in the Papers read before the Incorporated Municipal Electrical Association would always be obtained, as the stations concerned were previously worked non-condensing, and the advantages of condensing, in a more or less marked degree, are obtainable with any type of steam plant. Nevertheless, the exhaust steam turbine in itself shows very decided advantages, though no general law should be laid down, and each case should be considered on its merits.

Electric Traction in Germany.—It is officially announced by the Prussian State Railways Administration that plans are being prepared for the electrification of the main lines between Magdeburg, Zerbst, Leipsic and Halle, especially the Dessau-Bitterfeld section. A large central power house is to be erected at the village of Muldenstein, near Bitterfeld, the selection of this locality being due to the large quantities of cheap coal available in the district. Alternating-current electric locomotives are to be used, employing current at 10,000 volts. Dessau and Bitterfeld will be the first sub-stations.

London County Council Tramways.—In view of the objection of the Greenwich Observatory authorities to the use of the ordinary trolley construction with rail return for the Council's tramways from Beresford-square, Woolwich, to Eltham, which pass near the Observatory, the lines are being equipped with positive and negative overhead conductors. Each car used on this route, about 2½ miles long, will, therefore, be provided with two trolley poles; and in order to allow these cars to run on other sections of the Council's track, a throw-over switch is provided for connecting the negative terminals of the motors, either to the rails or to the second wire as required. The positive and negative wires are spaced about 3 ft. 6 in. apart.

Fire Alarm.—A recent issue of the "Electrical World" states that a U.S.A. patent was recently granted to Mr. E. Lamoureux, of Montreal, for a fire alarm in which the thermal element consists of a row of compound expansion bars mounted to slide upon parallel rods. These expansion bars are of the double type, in which a stiff metal bar has riveted to its extremities two slightly longer strips of a different metal which has a larger thermal expansion coefficient. The resulting structure resembles a carriage spring in external shape, and due to the unequal expansion of its parts, varies its dimensions with the temperature. By setting a number of these bars side by side quite an appreciable movement can be obtained with a change in temperature. The expansion bar at one end of the row is fixed; that at the other will carry a hook or trigger which can be set to release a spring, thereby closing an alarm circuit when the temperature exceeds the predetermined value.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repairs.
Assab—Perim	July 8, 1909 ...	—
Malta—Tripoli.....	April 20, 1910 ...	—
Suakim—Jedda	May 6, 1910 ...	June 18, 1910
Madagascar—Reunion.....	May 12, 1910 ...	—
Reunion—Mauritius	May 20, 1910 ...	—
Lattaquie—Talura	May 26, 1910 ...	—

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Report of the Electrical Inspector of Factories.—In his annual report, which has just been issued, Mr. G. Scott Ram mentions that only 90 out of 447 accidents in electricity works during the past year were due to electrical causes. The number of electrical accidents in factories and workshops was 257, a slight increase over the number recorded last year. A full abstract of the report will be given in our next issue.

Mono-rail in Alaska.—The "Mining World" states that the Brennan gyroscope mono-rail car is to be tried in Alaska. The scheme proposed provides for the construction of 1,000 miles of mono-rail track from the Matanuska coal fields towards Fairbanks, and the cost of construction is estimated to be about one-seventh that for a light two-rail track. If the system proves a success, it will become an important factor in making possible the opening up of mining regions only accessible with difficulty.

Wear of Steel Trolley Wire.—The "Electric Railway Journal" mentions that a recent examination of the No. 0000 grooved steel trolley wire of the New York, New Haven & Hartford Railroad, which has been in service over the main locomotive terminal track in the Stamford yard for 20 months, showed that the lower lobe of the wire was reduced in thickness by 14 per cent., or approximately one-seventh of the allowable wear. A total of 85,000 locomotive movements had been made under this wire, or four times the number of movements made under main track wires in the same period. A pantograph trolley is used. At this rate of wear a steel trolley wire over main track with the present density of traffic should last 44 years. The sample of wire examined was coated with a thin layer of grease from the pantograph collector pans and soot from the steam locomotive exhaust. When this coating was removed by wiping with waste, the surface of the wire was found to be bright and smooth, with no signs of corrosion.

Oxford University.—The new electrical laboratory presented by the Drapers' Company to Oxford University was opened on Tuesday last. Mr. Fletcher, on behalf of the Company, made the presentation. Lord Curzon, Chancellor of the University, acknowledging the gift on behalf of the University. In his speech Lord Curzon called attention to what the opening of the electrical laboratory meant to the cause of scientific research in the University. He believed that before the year 1900, when the Wykeham Chair of Physics was founded, electricity and magnetism were practically untaught in the University, notwithstanding that electricity had made most astonishing strides in recent years, and had such a future before it that its study was indispensable in an institution like their own. When they said they needed an electrical laboratory, what they meant was that Oxford needed it, not merely for examination purposes, but also to enable them to keep in touch with the most modern scientific discovery by the pursuit of independent research with the aid of the most recent appliances; and to provide similar opportunities for outside people.

City and Guilds of London Institute.—The annual report of the Council of this Institute shows that the total number of students attending diploma and special courses at the Central Technical College was 469 in the session 1908-9, compared with 438 in 1907-8, and is the highest number yet recorded. Of this total, 113 students were attending the electrical engineering course, being the same number of students as last year; whilst 227 students took the civil and mechanical engineering courses. The total number of students receiving instruction in electrical engineering, however, was 318, as against 302 in the previous year. At the close of the session in July the diploma of associate was awarded to 98 matriculated third year students, whilst 42 students of the college obtained their degree of B.Sc. (Engineering) in the University of London, 37 in honours and 5 pass. As regards the Finsbury Technical College, it is mentioned that the electrical department continues to be affected, in common with other technical colleges, by the depressed state of the electrical industries of the country; and that the rush of young men to qualify for a career in this particular branch of engineering in earlier years has probably affected the remuneration generally obtainable in the industry, and has thus diverted students to other branches of engineering, and possibly to other occupations. This probably explains the decrease to 67 in the number of day students attending the electrical engineering course at this college, as against 76 last year and 110 in 1902-3. At the close of the session 24 certificates were awarded to electrical engineering students. The evening department of the college was attended by 291 students, as against 298 in the preceding session, 91 entering the electrical department, of which number only 13 took the complete course, the remainder (78) taking single classes. The corresponding figures for the session 1907-8 were 19 and 125 respectively.

Cost of Services.—At the Convention of the Incorporated Municipal Electrical Association at Glasgow last week much interesting information was given in regard to the cost of services. Some of this will be found in last week's issue of THE ELECTRICIAN, but there are certain details which could not be transmitted telegraphically, and therefore we think it well to return to the subject briefly. The following are detailed costs in Glasgow given by Mr. W. W. Lackie, being the average of 60 services.

	£	s.	d.
Jointers' time	0	17	0
Wireman	0	6	5
Mason's time	0	6	11
Joiner's time	0	0	3
Watchman	0	0	3
Branch box	0	9	6
Fuse boxes	0	13	0
Cable	0	19	0
Compound	0	2	6
Mason's material	0	0	8½
Jointers' material	0	0	2½
Sundries	0	10	9
	£4	6	6

A short time ago the cost was about £7 per service, but this has been reduced by specialising so that each part of the work is done by a man well qualified for the purpose. Mr. F. E. Ayton, of Ipswich, gave the following figures for 2-wire services:—

	6 yds.	10 yds.
7/20 solid; two singles	£1 19 9	£2 9 5
7/18 „ „	2 0 11	2 11 0
7/20 armoured; twin	2 4 5	2 12 0
7/18 „ „	2 6 4	2 14 11

The greater cost of the armoured service is due to the cost of the service box, which will be reduced at Ipswich in due course.

Rail Corrugation.—In a pamphlet issued a year or two ago Mr. J. H. Briggs, of Leeds, endeavoured to show that the conditions which cause the effect known as chattering on tramways were to be found in the throat action of a wheel on a tramrail. The author has recently investigated the conditions for chattering, and has published his conclusions in a pamphlet entitled "Corrugation: On the Origin of Vibration in Tram Rails." He shows that chattering is possible where corrugation frequently occurs, and that chattering is impossible under certain conditions, under which corrugation does not occur. Details of experiments to corroborate this are given. All instances of chattering are the result of friction between two surfaces. This friction in the case of tramways may be caused, in the opinion of the author, by braking, accelerating, and difference in length of inner and outer rails, and that between flange and rail as a result of side thrust. As regards throat friction, when curves of large radius begin to corrugate, the throat alone of the leading outer wheel is taking the side pressure. Thus, in the case of this wheel, in passing from a level straight rail to a curve there will be a gradual change from little or no pressure at the throat through light, then heavier, throat pressure to heavy pressure on the side of the flange. The throat or flange side of the leading outer wheel can only be in contact with the rail at a position in advance of a vertical radius of the wheel. The motion of the wheel at this place is of necessity downwards. This downward motion, in conjunction with the above mentioned lateral pressure—when these are effective in the throat—only results in the friction which the author suggests breaks into chattering. We may mention that Mr. Briggs will be pleased to present copies of his pamphlet to applicants. His address is "Strathlea," Claremont Drive, Headingley, Leeds.

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Electricity Supply in Boston, U.S.A.—The annual report of the Commissioner of Wires, Mr. J. E. Cole, of Boston, for the year ended January 31, 1910, has just been published and contains a large amount of data of interest in connection with recent electrical progress in that city. Mr. Cole emphasises the value of underground conduit construction as demonstrated in the blizzard of last Christmas. No fire has occurred during the year on account of wiring approved by the department. During the year, about 2,500 of the Gilbert type of enclosed arc lamps have been replaced in Boston by magnetite lamps and flame arcs for street service, and 1,200 new lamp poles suitable for the new lamps have replaced the poles formerly in service. Tungsten lamps have to some degree replaced gasoline lamps, necessitating a considerable part of the increase in new pole settings during the year, 536 in all. There are now 1,635,644 ft. of conduit installed in Boston, 10,376,795 ft. of single duct, 13,401,059 ft. of cable, 7,457 manholes, 16,886 services, 599,709 ft. of Edison three-wire tube, and 628 Edison distribution boxes. About 50 per cent. more of the above construction was installed in 1909 than in 1908. The size of cable varies from 600 pair telephone services to 2,000,000 circ. mil feeders for railway operation. The Edison Electric Illuminating Co. installed 731 underground services during the year, and put down 294,623 ft. of cable in 18,956 ft. of conduit. The Boston Elevated Railway Co. installed 24,194 ft. of conduit and 94,635 ft. of cable, and the New England Telephone & Telegraph Co. installed 111,015 ft. of cable in 13,100 ft. of conduit. In the past 15 years over 59,000,000 ft. of wire, or about 11,000 miles, have been removed from overhead service in Boston. The isolated plant capacity in Boston decreased slightly in 1909, the total kilowatt rating of the generators being 25,370 in January, 1910, compared with 25,702 kw. in 1909. The capacity of electric motors operated by isolated plants dropped from 14,986 H.P. in 1909 to 14,642 H.P. in 1910. The number of isolated plants increased from 319 to 322. The total rating of electric motors in Boston on January 31, 1910, was estimated at 331,763 H.P., including 271,449 H.P. in motors operating street and elevated cars.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. E. B. Brown contributes an article on "An Accurate Electrical Method of Measuring Speeds of Rotation," the discharge from a condenser being used for this purpose.

In an article on Electric Cables, Mr. F. Fernie deals with the subject of explosions in conduits and street boxes.

Last Wednesday evening Sir John Gavey, C.B., delivered the James Forrest lecture before the Institution of Civil Engineers, taking "Recent Developments in Telegraphy and Telephony" as his subject.

The convention of the Incorporated Municipal Electrical Association at Glasgow terminated last Friday with the annual general meeting, when Mr. J. Christie (of Brighton) was elected president.

The Board of Trade have refused the application of the Lancashire Electric Power Co. for a provisional order to enable them to supply electrical energy for power in Radcliffe. The Council possess electricity supply works.

The Turkish Government are inviting tenders for a concession for constructing, equipping and working electric tramways at Salonica.

Mr. G. A. Bruce is to report upon the practicability of adopting the railless trolley system on a section of light railway at Lowestoft.

An inquiry was held at Norwich on Tuesday into the application of the Corporation for permission to borrow £17,783 for their electricity undertaking.

An inquiry was held last week into the application of Pembroke (co. Dublin) Urban Council for sanction to a loan of £8,000 for electric lighting extensions.

The estimates of the London County Council tramways for the current year are abstracted in another column.

Llandudno Council have decided, after two years' experience of incandescent gas lighting on the promenade, to revert to electric arc lamps.

Legal.—On Monday Mr. Justice Neville delivered judgment in the action brought by the Attorney-General against Leicester Corporation, and granted an injunction restraining the Corporation from carrying on wiring work, &c.

Companies' Meetings, &c.—The directors' report of J. G. White & Co. for the year ended Feb. 28th states that the Company is engaged in carrying out several important contracts in South America and elsewhere, and that the prospects of the Company are very good.

In the report of the Marconi Wireless Telegraph Co. for the period to December 31st last, particulars are given of the progress of the Company's trans-Atlantic service and of the position of several of the auxiliary companies.

INSTITUTIONS AND SOCIETIES.

INSTITUTE OF METALS.—This Institute has just published the third half-yearly volume of its "Proceedings," a book of 360 + xi. pages. The frontispiece is an excellent portrait of the President of the Institute, Sir Gerard Muntz, Bart. The major portion of the journal consists of a series of Papers read at the annual general meeting in January last. Valuable as these Papers were when they were read, their utility is now vastly increased as a result of written communications received since the Papers were read. The useful series of abstracts of Papers relating to the non-ferrous metals and the industries connected therewith, which was commenced in the second volume of the journal has been continued and amplified in the volume under notice, and there are also 48 pages devoted to abstracts on such subjects as ores and minerals, extraction of metals, electrometallurgy, properties of metals and alloys, analysis, testing and temperature measurement, statistics and bibliography. In view of the fact that the Institute is about to become an incorporated institution, the concluding section of the journal is appropriately devoted to the new memorandum and articles of association; there also appears a list of members of the Institute, which, compared with the list contained in the first volume of the journal published just a year ago, serves to show the extremely rapid strides that are being made by this, the youngest, and one of the most vigorous, of our scientific institutions.

JUNIOR INSTITUTION OF ENGINEERS.—Arrangements are being made for the summer meeting of this Institution to take place at Dublin and Belfast from July 16th to 23rd. The programme opens with a reception at Trinity College, Dublin, by the Provost and professors of engineering, and an inspection of the engineering school, &c. A visit will be paid in the afternoon to the power house of the Dublin United Tramways Co., and in the evening the Institution of Civil Engineers of Ireland will entertain the members and ladies accompanying them. On Monday morning, July 18th, Messrs. Guinness's brewery is to be visited, and in the afternoon, by invitation of the Main Drainage Improvements Committee of the Dublin Corporation, there will be a steamer excursion into Dublin Bay for inspection of the outfall works, &c. The next day will be occupied by an excursion by rail and jaunting cars for a visit to the Corporation's new reservoir under course of construction at Roundwood, Mr. J. G. O'Sullivan, the City Engineer, acting as guide. In the evening the party are to be guests of the Engineering and Scientific Association of Ireland. Wednesday morning will be left free, and in the afternoon the party proceed to Belfast, visiting on the following morning the Belfast Ropeworks at Conneswater. The Lord Mayor of Belfast, the Right Hon. Robert J. M'Mordie, M.A., will afterwards receive the members at the City Hall and entertain them to luncheon. Friday is to be devoted to an inspection of the shipbuilding and engineering works of Messrs. Harland & Wolff, by whom the visitors have been invited to luncheon, Lord Pirrie presiding. At these works will be seen in process of building the two White Star liners "Olympic" and "Titanic," each 850 ft. long and of a gross tonnage of 45,000 tons. The Institution's summer dinner takes place in the evening, at which it is hoped that the President, Engineer Vice-Admiral Oram, C.B., Engineer-in-Chief of the Fleet, will be in the chair. Saturday is left for an excursion to Portrush and the Giant's Causeway, as the concluding item of the programme.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 24th (to-day).

PHYSICAL SOCIETY.

3 p.m. Visit to the National Physical Laboratory. A series of demonstrations will be given of work in progress in the laboratory.

TUESDAY, June 28th.

INSTITUTION OF ELECTRICAL ENGINEERS.

9 p.m. Conversazione at the Natural History Museum, South Kensington.

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THE ARRANGEMENT OF EXPERIMENTAL ELECTRICAL CIRCUITS FOR LABORATORIES.*

BY W. P. STEINTHAL, M.SC.

Summary.—The author discusses the special requirements, as regards supply and distribution of electrical power, of an experimental laboratory—physical, chemical and electrical. The source of power, arrangement of circuits, and switch and plug boards are described.

The question of the equipment of laboratories for experimental work as regards the distribution of electric current first came to my notice some 10 years ago, when Prof. A. Schuster commissioned me to prepare a scheme for the new physical laboratories about to be built for the Manchester University. At that time there was no physical laboratory in this country in which any elaborate system of distribution had been adopted. It was therefore considered advisable to see what was being done on the Continent, and for that purpose the then recently completed Electrotechnical Institute in Darmstadt was selected for a visit of inspection. From the observations made at this institution, together with valuable advice and suggestions from Prof. Schuster, a scheme of electric distribution was evolved for the Manchester laboratories, and the installations that have been erected in recent years, and of which I propose to give short descriptions later, are the outcome of the experience gained at Manchester.

In arranging a distribution scheme for laboratory work we have to consider the special requirement of a laboratory in which the chief objects to be attained are: (1) To supply a source of current that will give a steady pressure; (2) to provide a centre of distribution such that various voltages can be made available on different circuits simultaneously; (3) to arrange a network of circuits that shall be as inexpensive as possible in first cost, that will lend itself easily to alterations or additions, and that will maintain a high insulation resistance.

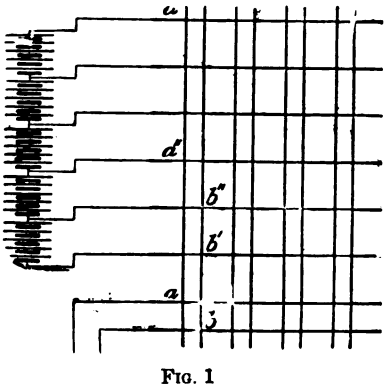

FIG. 1

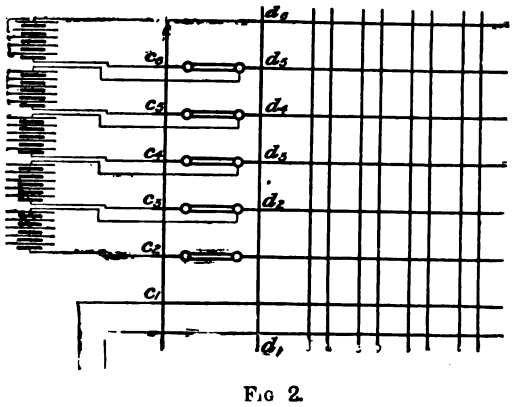

FIG 2.

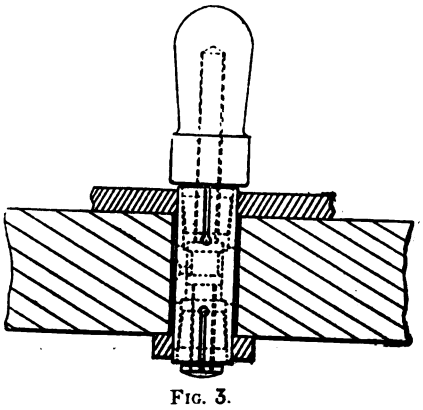

FIG. 3.

It would then appear to be most convenient to split the generator into two and instal either a dynamo at, say, 110 volts and a small booster at 50 volts (assuming that 140 is the charging voltage for the whole battery), or two similar dynamos giving 70 volts each. In the former case the two machines would be used separately or in series, and would each be driven by a motor; or, again, two converters of the type referred to above would be installed. In the latter case the two machines can be mounted on one bedplate with the motor in the centre, all three machines driving on one shaft. The generators can be used separately, in series or in parallel. The second arrangement is on the whole the more convenient of the two, because we get the additional advantage of having a set eminently suitable for running lecture table arc lamps and also providing a heavy current by paralleling the two machines. Of course, a machine giving 110 volts is almost as useful as one giving 70 volts for arc lamp work. The choice will then depend on the requirements, and, generally speaking, the first alternative is the more convenient for a physical laboratory and the second for a chemical laboratory where heavier currents are as a rule required. Next comes the provision for alternating current. Here, again, two cases arise. Firstly, where the supply is continuous current, it will be found convenient to instal a motor-generator and possibly to arrange the dynamo with slip-rings, so as to make provision for one, two or three-phase current. Secondly, where the supply is alternating, it will be merely a question of providing a suitable transformer for the requirements of the laboratory. In physical laboratories a single-phase alternating current is all that is required in the majority of cases, and the demand for current is not likely to exceed 25 amperes. But the chemical laboratory will require much heavier currents for furnace work. I believe that for certain types of furnace an alternating current is found to be most suitable and the current required may be anything up to 2,000 amperes. The heaviest currents will be used at comparatively low voltages, ranging from 26 to 50 volts. The question arises as to the best type of generator to instal for furnace work. I am inclined to follow the practice in America, and have a single-phase machine with the armature divided into four exactly similar sections, so wound that the four sections can be coupled up in series or in parallel. In the machine that I have selected each section has an output of 350 amperes at 25 volts, so that we get from the machine either 1,400 amperes at 25 volts, 700 amperes at 50 volts or 350 amperes at 100 volts. The voltages may be further varied within certain limits by varying the excitation of the fields. In cases where an alternating current is available, a transformer can be used on similar lines.

Source of Current.—For laboratory purposes a battery of accumulators is essential as furnishing the only means of providing absolutely steady currents. It may be said that any standard make of secondary battery will suffice, provided that the plate selected will allow of a high rate of discharge if required. The question then arises as to the best arrangement for charging the cells. Leaving out of account the cases where the laboratory has its own generating plant, we will consider the question of a supply from public mains. In the majority of cases we may take the voltage available to be between the limits of 200 and 250. As a general rule, the battery will consist of from 30 to 55 cells, which means that the maximum voltage required will be 140. There are then two alternatives, either to charge direct from the mains through a suitable rheostat or to instal a motor-generator. As you cannot expect to obtain a greater combined efficiency than 70 per cent. from a motor-generator of comparatively small size, it will be noted that the losses will be the same in both cases if the supply is at 200 volts, and will be in favour of the motor-generator set when the supply voltage exceeds that amount. As an alternative to an ordinary motor-generator we have now available a direct-current motor-converter. I am informed by the makers that for a machine of 12 kw. output, converting direct current from 200 to 140 volts, an efficiency of nearly 90 per cent. can be guaranteed. We have, however, more important considerations to take into account than percentage efficiency. We have to take into account that the cells will be unevenly discharged, as explained later, and that we have, therefore, to provide means for obtaining low voltages down to, say, 15 or 20 volts.

Distribution.—Here the most important requirements is to arrange a method of delivering current at any desired voltage to any of the laboratory circuits, and to ensure that the arrangement can be easily manipulated without loss of time from a convenient centre. The voltages may vary from, say, 4 up to 110, but except for certain electrolytic experiments it is probably most convenient to arrange the source of current so as to vary the voltage in multiples of 10. This being the case, we divide the battery into groups of five cells and arrange our distribution board so that these groups of cells can be connected up in series to give the necessary voltage. We then have to design the distribution board so that the groups of cells can be discharged on to any of the circuits as required. The actual type of board that I am in the habit of using for this purpose is described later, but I may here say that it is convenient to combine with the actual panels for distribution a special charging panel and also a panel to afford a simple means of connecting the groups of cells in parallel for obtaining large currents in those cases where such an arrangement is necessary, which will be more particularly the case in chemical laboratories.

Circuits.—Now as regards the circuits themselves, what type of conductor is the most suitable to employ? The choice lies between

* Abstract of an original communication to the Institution of Electrical Engineers, accepted by the council for publication in the "Journal."

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insulated conductors and bare conductors, and I propose to show that the use of the latter is far more satisfactory from every point of view. The advantages chiefly lie in the cost of material and erection, and in the facilities afforded for making alterations and additions, such as tapping off extra terminal positions. Suppose we consider the necessary conductor required to carry 25 amperes. If we use an insulated conductor we should naturally work to the rules of this institution, and the size of conductor for this current would be 7/16. Now in the case of a bare conductor we can work at a much higher current density, and we have merely to consider what limits of heating in the conductor we can allow and the corresponding drop in pressure at the end of the line. Some years ago, in order to arrive at a satisfactory current density to be used for bare conductors, so as to allow of reduction of weight to a minimum and still not to risk any undue heating, a series of experiments were made, and the following formula was finally decided upon to be used for laboratory circuits: $C^2 = 15\ D^3$, where C is the current in amperes and D the diameter in millimetres. This formula gives us 22·7 amperes for a No. 10 S.W.G. wire. The drop in voltage per 100 ft. double run is therefore, in this case, nearly 2·9 volts. It may be of interest to add that a No. 10 bare copper wire will rise 18°F. from 75°F. in a room when carrying 26 amperes. Whereas to produce the same rise in the open air on a calm day in summer 42 amperes are required (*see* "Modern Electric Practice," Vol. III., p. 79).

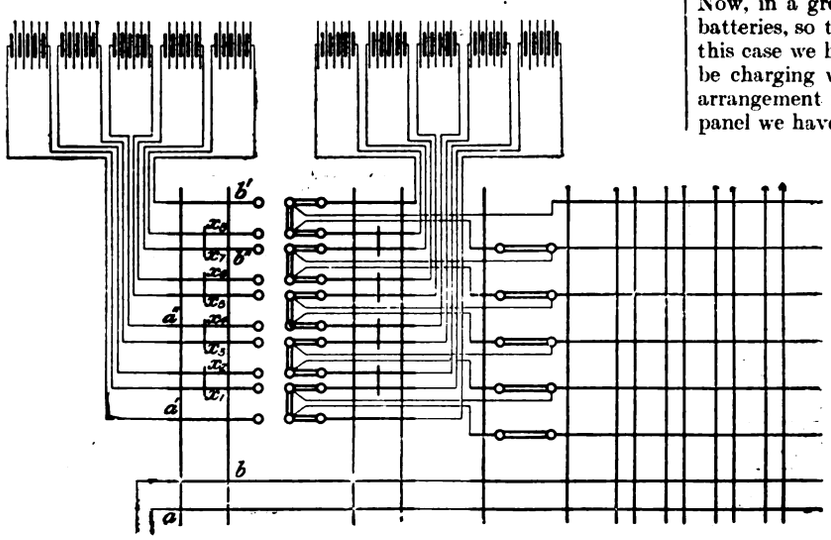

FIG. 1.

Now we see from the above that we have to compare a bare No. 10 copper wire with a 7/16 cable as regards cost, the price of the former, taking copper at 9d. per lb., being about 12s. per 110 yds., and of the latter about £5 per 110 yds. Again, in erection it is not at all objectionable to run your bare conductors overhead, spanning from point to point to obtain the shortest runs. It will, I think, be admitted that this is hardly feasible with insulated cables of 7/16 and above. So that in addition to the saving on the conductor, we shall most probably use a smaller length of bare conductor for any particular circuit. The great point in using bare conductor is to have a really first-class insulator, and if the conductors are carefully erected, you can rely on obtaining a very high insulation resistance in a dry building. As an illustration, in a laboratory that has been recently equipped, an insulation resistance of over 100 megohms has been obtained on each individual circuit, which is satisfactory, taking into account that the conductor will, on the average, be carried on at least a dozen insulators, and possibly pass through several walls.

Take, first, the simplest case, where we desire to distribute currents from a battery of, say, 30 cells, giving steps of 10 volts. We divide the battery into groups of cells, in this case six groups of five cells each. Therefore, by placing one or more groups in series we get 10, 20, 30, 40, 50 and 60 volts available. Now, if we have a panel with seven 'bus bars connected, as shown in Fig. 1, to the cells, by connecting the ends of any circuit to two of these 'bus bars we place on that circuit the voltage corresponding to the position of those bars. Instead of using switches, the most convenient arrangement is to have a series of horizontal and vertical bars drilled at each intersection and fitted with plugs to make contact between a horizontal and vertical bar. Fig. 1 shows diagrammatically such a board fed by five groups of cells and distributing to four circuits. Here we see an arrangement by which we can distribute current from the cells to any of four circuits at voltages varying from 10 to 50 in 10-volt steps.

It is, however, convenient to be able to charge the cells without having to disconnect the plugboard. For this purpose we then add two more horizontal bars, which bars are connected to the dynamo through the usual apparatus, such as automatic cut-out, ammeter, &c. It will be seen (Fig. 1) that by inserting plugs at *a*, *a'* and *b*, *b'*, we can charge the whole battery or we can pick out a single group to charge by inserting plugs at *a*, *a''* and *b*, *b''*. It will be noticed that with this arrangement we can also place current direct from the ynamdo on to any of the circuits.

The next arrangement is to have means available for connecting up the group of cells in parallel for use on a special circuit. This is effected by the device shown in Fig. 2. Here we have a pair of leads brought from each group of cells to the plugboard instead of connecting all the groups together in series at the battery. We split the horizontal bars in two pieces and interpose a single-pole switch between the two portions. It will be noticed that so long as all the switches are closed we have all the groups in series as before, and for using the four circuits we proceed in the same way as in Fig. 1. If, however, we wish to have the groups in parallel on to the special circuit, we simply open all the switches and insert plugs at points marked C_1 to C_6 and D_1 to D_6. As far as connections for charging are concerned, we use these same plug positions. Thus, to charge the whole battery, we keep all the switches closed and plug at C_1, C_2, D_1, D_6; or, supposing we desire to charge the third group from the top, we open the second and third switches and plug at C_1, C_4, D_1, D_4. Now, in a great many cases it is convenient to have two separate batteries, so that one battery is always available for discharge. In this case we have to devise an arrangement so that one battery can be charging whilst the other is discharging, and vice versa. This arrangement is effected as shown in Fig. 4. Here on the charging panel we have two identical sets of bars and plugs on each side of a vertical row of double-pole change-over switches. The centre short bars are so arranged that when all their plugs are inserted we have the corresponding cells all in series. The object of these short centre bars is to enable a single group or number of groups to be selected for individual charging. By means of the change-over switches in the centre it is possible to connect either battery to the distributing panel, and the complete arrangement enables the one battery, or any part thereof, to be charged simultaneously with the discharge of the other or any part of it.

As regards the connection of circuits to the plugboards, I have adopted two different methods. In the first, two series of 'bus bars are used, arranged at right angles to one another on either side of an insulating slab. What may be called the feeding 'bus bars are placed horizontally at the back, and the distributing 'bus bars are placed vertically on the front. A hole is drilled through both bars and the slab at each intersection, and a plug can then be inserted where desired to connect the front and back bars together. The circuit wires are connected through fuses to the ends of the vertical 'bus bars. These plugs have presented some little difficulty. It is of great importance that the contact should be electrically and mechanically sound, and that the contact between back and front bars should be made expeditiously. The first two objects can be attained with a plug having a screw connection at one end and a cone at the other, but this is expensive. It means, firstly, an expensive plug, and it necessitates tapping the holes in the back bars and providing the front bars with coned seatings. You may be able to rely upon the screwed contact, but the cone and its seating are liable to wear and finally to become unsatisfactory. The next type of plug, consisting simply of a brass sleeve split at each end, does away with the objection of having tapped holes and coned seatings, thereby saving expense. The plug itself is also reasonable in cost, and is, further, quick in manipulation, but though fairly reliable as regards contact, it is not entirely so. Both these types of plugs are in use, but the final type of plug, which I now use exclusively, is most reliable and inexpensive. This type is shown in Fig. 3. You will notice that it consists of a brass sleeve internally tapered towards each end. Through the centre runs a spindle, on which work two coned pieces of brass on a right and left-handed thread. The spindle is rigidly connected to the handle, which, when rotated, causes the two cones to move inwards, thereby pressing the ends of the sleeve, which are split to allow of expansion outwards. The rotation of the handle after the plug has been placed in position in the holes causes the plug to expand inside the holes. With this plug only parallel holes are required, and the contact obtained is electrically and mechanically perfect.

As to the second method of connecting the circuits to the boards, its advantages lie chiefly in a saving of cost in manufacture of the boards. In this method the vertical 'bus bars are entirely dispensed with, and the horizontal bars are placed on the front of the slab.

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The circuits themselves are brought down to a fuse panel, Figs. 5 and 6, and flexible cords are brought from the underside of the fuses over a system of pulleys and counterweights to appropriate positions on the front of the slab, so that the plug connected to the flexible can be connected to the 'bus bars as required. The plug in this case has only to make a single contact, and is constructed on the same principle as the double-contact plug, but with a single internal cone working on the spindle. The saving in cost of this type of board is effected through the saving of the circuit 'bus bars, and the saving in drilling of the slab, the latter being a considerable item. The saving here indicated more than compensates for the cost of the pulleys and counterweight gear. The chief difficulty with this design arose in connection with the flexibles. Great difficulty was experienced in obtaining a flexible conductor to carry up to 50 amperes sufficiently flexible to run nicely over a 3 in. pulley. Several makers in this country were tried without success, but a flexible conductor was finally obtained in Germany consisting of 3,081 strands of No. 48 S.W.G. The conductor is not insulated, but merely covered with a braiding of soft cotton, as it was decided to trust to the pulleys for insulation. This decision has been justified, as on the circuits, as mentioned earlier in this Paper, an insulation resistance of over 100 megohms has been obtained, including the flexibles themselves, which will be roughly 2½ yds. long from fuse to plug. The pulleys are made of lignum vitæ with brass bushes working on a steel shaft.

I propose now to describe one or two arrangements which have been adopted for special purposes in connection with distribution of current. In the first place, it may be of interest to describe a device designed to prevent plugs being inserted into wrong holes on distributing panels. Supposing we take the case of a distributing panel for eight circuits, that means we have 16 'bus bars, and in this particular case we arrange that the vertical circuit bars shall be at the back and the horizontal feeding 'bus bars on the front. We desire to ensure that one plug only can be inserted in any horizontal bar at the same time. For this purpose we have an ebonite guard bar fitted between the 'bus bar and the slab, and free to slide backwards and forwards parallel to its length. There are the same number of holes in the ebonite bar as there are in the horizontal brass bar, but the holes are so spaced that when one hole in the ebonite bar corresponds with a hole in the brass bar, and so allows a plug to go through both, all the other holes are out of adjustment. The spacing of the holes is found as follows: Suppose we space the holes in the brass bar at 1⅞ in. centres. We have 16 holes, so that the total distance between the two extreme holes is 15 in. by 1⅞ in.; if we take sixteen-fifteenths of this length, and divide the result by 15, we get as the result 2 in., which will be the spacing for the holes in the ebonite bar. And it will be found that this spacing satisfies the condition required.

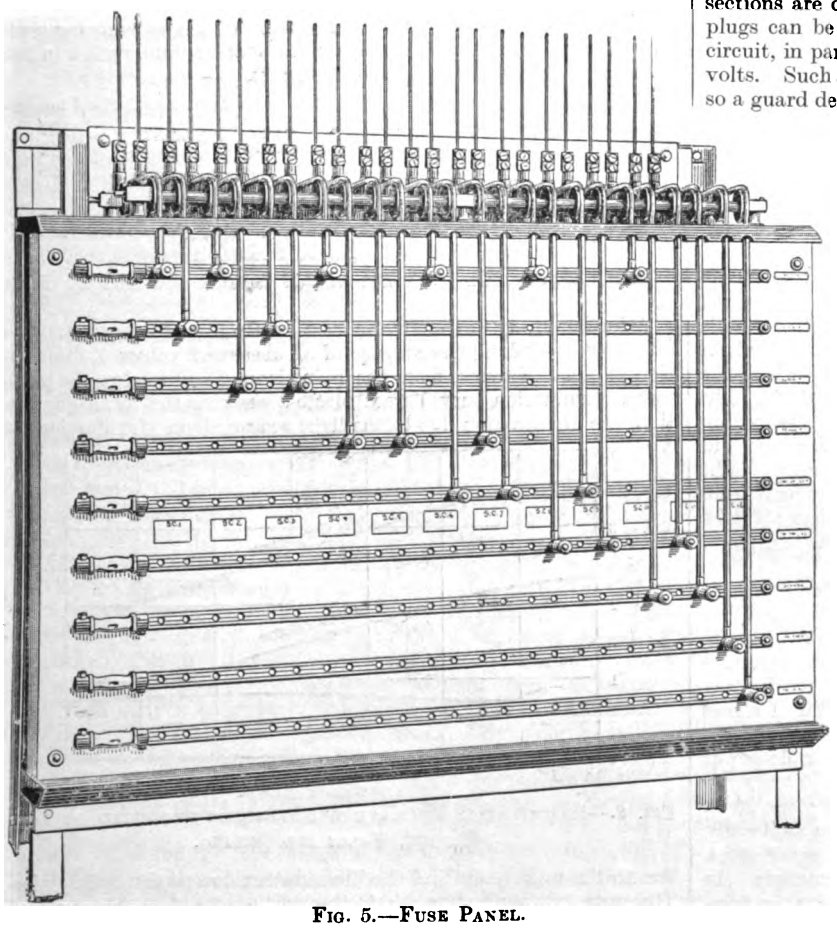

Fig. 5.—Fuse Panel.

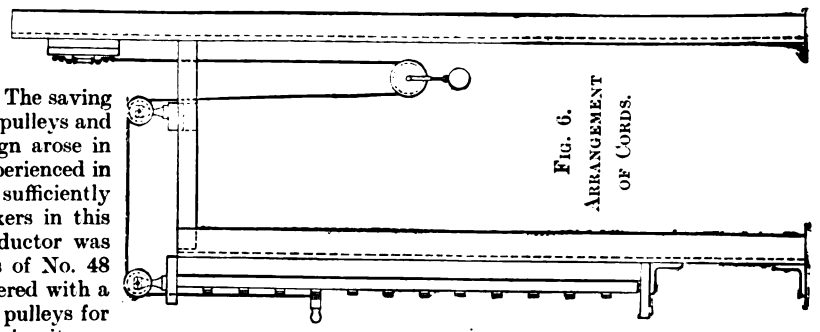

Fig. 6. Arrangement of Cords.

The second special application of plugs that I propose to describe is an arrangement for high-tension work to prevent accidental contact with 'bus bars carrying a high-tension current. We have a plugboard arranged to place four sections of a transformer secondary in series or in parallel. Assume the transformer primary to be fed by a single-phase alternating current at 100 volts, and that the secondary is split into four equal sections, each giving 250 volts. These four sections are connected to a board, and by means of double-contact plugs can be arranged in series to give 1,000 volts to the external circuit, in parallel to give 250 volts, or in multiple series to give 500 volts. Such an arrangement might be a source of danger to students, so a guard device is necessary to prevent accidental contact with the 'bus bars. In the first place, a sheet of plate glass, perforated with the necessary holes to allow of the insertion of plugs in the proper positions to obtain the required voltage, is fitted on the front of the board. The double-contact plugs are fitted with elongated handles in which are cut circular grooves. An ebonite bar, pivoted at both ends, and therefore free to move about an axis parallel to its length, is provided at proper intervals with slots, which engage with the grooves in the plug handles. One end of the ebonite bar is connected by means of a link with the handle of a double-pole switch, which is placed into the primary circuit of the transformer, and is so set that when the switch is closed all the plugs are locked by the ebonite bar, and can only be moved after opening the switch. Thus, when the 'bus bars are alive, the plugs can neither be inserted nor withdrawn.

Generally speaking, it is obvious that a combination of plugs and switches can be arranged to meet almost any desired purpose, and I should like to point out the very great convenience arising from these arrangements in laboratory work. There is a great saving of time and trouble in being able to set your connections in a simple way by means of these plugboards, instead of having to work with loose wires and cables.

Terminals for connecting Apparatus to the Circuits.—In designing the general scheme for a laboratory we have to consider the requirements of three classes of students: Elementary, advanced and research. The requirements for elementary students are for most purposes met by small portable batteries. But it is convenient to have circuits available for use from the central distribution system as well. The current required by each student will be small and the voltage low. The most convenient arrangement is probably to feed the elementary laboratory with a couple of 50-ampere circuits, and arrange a series of tappings off the circuits, whose number will depend on the number of students working together in one class. In the case of more advanced students it is best to set apart a number of circuits for their exclusive use, feed these on to a separate plugboard, and wire the necessary number of terminal positions off this plugboard, arranging so that not more than two students are working off the same circuit simultaneously. For research work it is advisable that each terminal position should be an entirely independent circuit, so as to ensure absolutely steady currents and avoid any risk of the circuit being interfered with by another experiment.

The capacity of the various circuits must depend upon circumstances in each particular case, but, generally speaking, physical

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laboratory circuits are best arranged for 20 and 50 amperes, and those in chemical laboratories for 50 and 100 amperes.

Special Conductors.—In certain rooms of a physical laboratory it is necessary to eliminate all possible magnetic effects from the circuits. This can be attained either by crossing the conductors at short intervals or by changing from bare conductors to insulated concentric cables. For furnace and other heavy current circuits copper strip may be conveniently used, fitted on iron brackets with the usual pattern of 'bus bar insulator. A current-density of 2,000 amperes per square inch may be used, as a drop in pressure is not material, and these circuits are usually very short. For the lecture tables it is best to bring the bare copper as close to the table as may be convenient, and then finally connect up to the terminals on the tables with insulated conductor.

The author finally gives brief particulars and diagrams of connections of three recent laboratory equipments, in which the foregoing principles have been embodied.

ILLUMINATION TESTS.*

BY CLAYTON H. SHARP AND PRESTON S. MILLAR.

Summary.—Particulars are here given of the results of tests on a particular installation to ascertain the light flux derived from the light source, ceiling and walls respectively. Tests were also made to ascertain the reflecting efficiency of the ceiling and walls, and to determine the intrinsic brilliancy.

Most illumination tests have been made with some specific purpose in view and hence have not included some of the elements without which a study of an illumination installation cannot be said to be complete. It is the purpose in this Paper to present the results of certain illumination measurements which have been made chiefly with three objects in view:—first, to illustrate tests which can be made and methods which may be employed in the study of the illumination of an interior; second, to illustrate methods of discussion of results; and third, to illustrate the degree of accuracy which it is practicable to attain in work carried out with ordinary field equipment.

Test Conditions.

The tests were conducted in a room 12 ft. 7 in. long, 12 ft. 2 in. wide and 9 ft. 10 in. high. The ceiling was covered with white cloth. The walls were grayish white, and the windows were covered with manila paper. There were provided for the ceiling and walls black cloth coverings, which reflected practically no light and which could be removed readily. A screen was constructed by which the test-plate of the photometer could be shielded from all direct light from the light source, while a minimum of light from the ceiling and walls was obscured. A second screen was of such shape and dimensions as to shield the plate from all direct light from the light source and from the ceiling, while obscuring a minimum of light from the walls. A third box-like screen was so designed that all light reflected from the walls directly could be screened from the test-plate, while a minimum of ceiling light was obstructed.

The light source consisted of a single 250 watt bowl-frosted, metallised filament lamp, supplied at the watts necessary to produce its rated candle-power and equipped with a satin finish prismatic bowl reflector, mounted in a form A holder. This unit was mounted upon a drop cord from a centre outlet on the ceiling, the bottom edge of the reflector being 9 ft. 4 in. above the floor. Fig. 1 shows the curve of the distribution of light about the lamp and reflector used in these tests. The values given are apparent candle-power as observed at a distance of 10 ft. from the light source.

Studies were made of the illumination on a horizontal plane 36 in. above the floor (the "table plane"), and on the ceiling and walls. The horizontal plane was divided into 25 rectangles of equal areas. A test station was located in the centre of each such rectangle. In some of the tests upon the ceiling, corresponding test-station measurements were followed. In other tests, stations were located in the centres of large rectangles, both upon the ceiling and upon the walls. At each test-station, three to five settings were made by one observer.

Illumination on Table Plane.—It was desired to determine by direct measurement, not only the total flux on the horizontal plane with the room in its normal condition, but also the proportion of such flux which was contributed by the light source directly, by the ceiling and by the walls, respectively. Thus, with the walls and ceiling covered with black cloth, the illumination on the table plane was that due to the lamp alone: with the walls black and the ceiling white, the illumination was due to the lamp directly and to the light of the lamp reflected from the ceiling: with the direct rays of the lamp screened from the test-plate, the illumination measured was that due to the light of the lamp reflected from the ceiling, plus the light of the lamp reflected from the walls, plus the light of the walls reflected from the ceiling, plus the light of the ceiling reflected from the walls. In all tests, the light reflected from the brown linoleum-covered floor, from objects on the floor and from the wainscoting, below the 36 in. plane, has been ignored.

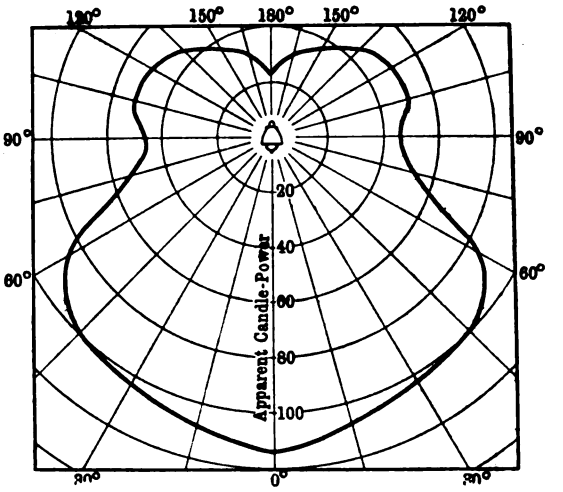

Fig. 1.—Light Distribution in Vertical Plane from 250 watt Gem Lamp with E13 Reflector.

The results may be summarised as follows, the value being given in lumens (obtained by multiplying the average illumination in foot candles by the area of the plane, 153 sq. ft.):—

Component flux from	Total lumens.
Light source direct	191
Ceiling alone	42
Walls, via ceiling	26
Walls alone*	86
Ceiling, via walls	35
Total	380

This checks against a value of 373 lumens obtained by direct test.

A further study of the illumination on the test-plane can be made as follows:—Taking the average of all measured values of illumination at equal distances from the point immediately below the lamp, mean illumination curves were plotted, showing the total illumination, the illumination due to the light source alone, the illumination due to the walls alone and the illumination due to the ceiling alone. The curve of illumination due to the light source alone is not strictly comparable with that derived from the distribution curve, since the latter was measured at a distance of 10 ft. from the light source, whereas the distances involved in the measurements in the room, varied from 6·67 ft. to 9·67 ft. Nevertheless the comparison is an interesting one. These curves are shown in Fig. 2. In comparing point by point the measured total illumination intensity with the sum of the components, the differences were found to average less than 2 per cent., the maximum individual variation being 5·4 per cent.

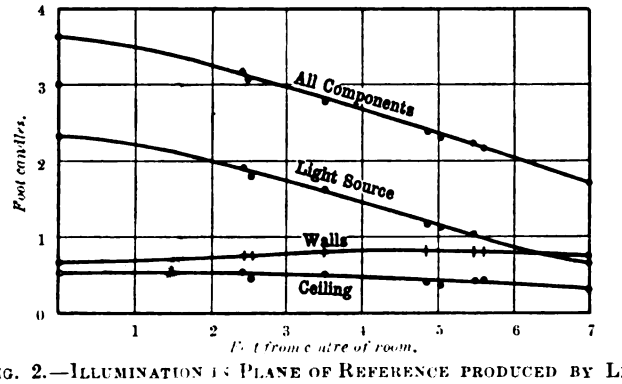

Fig. 2.—Illumination in Plane of Reference produced by Light Source, Walls and Ceiling.

Illumination of Ceiling and Walls.—In studying the illumination of ceiling and walls, photometric procedure was followed, which can be employed satisfactorily only with some form of illumination photometer, of which the illuminated surface or test-plate may, when

* Abstract of a Paper read before the New York Section of the American Illuminating Engineering Society.

* This value includes light reflected from wall to wall prior to being reflected from a wall to the plane of reference.

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required, be located at a considerable distance from the photometer itself. The accuracy of the results obtained will depend, of course, in great measure upon the precision capabilities of the photometer used, the extent to which the photometer complies with the theoretical requirements, and upon the skill and experience of the observer. In the tests here described a detached test-plate was located on the ceiling or wall in the position and at the angle desired. The photometer was removed from the test-plate a sufficient distance to minimise obstructions of light due either to the instrument or to the body of the observer. The test-plate in this instance consisted of a circular sheet of de-polished milk glass, 100 sq. in. in area with an opaque backing. This detached test-plate was viewed normally through the photometer in all cases. While not a perfect diffusing surface, it followed the cosine law with substantial accuracy through an angle of 60 deg. from the normal, and therefore served all practical purposes in these tests. It is not to be expected that the results with the detached test-plate will be as accurate as with the plane of reference previously considered, in which the test-plate was attached to the photometer.

Analysis of Ceiling Illumination (data refer to flux incident upon entire ceiling area).

	Lumens.
Direct from light source	183
Ceiling light reflected by walls back to ceiling	20
Wall light reflected to ceiling	77
Total flux on ceiling	280

Analysis of Wall Illumination (data refer to flux incident upon entire wall area.)

	Lumens.
Direct from light source	382
Ceiling—first reflection	116
Walls—first reflection	104
Ceiling via walls+walls via ceiling	70
Total flux on walls	672

Among the values determined for the illumination on the table plane, ceiling and walls, there is for each the flux of light incident from the light source direct, all indirectly reflected light being eliminated. The sum of the values of such components upon each plane is comparable with the total flux of light produced by the light source, as computed from the curve of light distribution. Such a comparison is as follows :—

	Lumens.
Direct light incident upon ceiling	183
" " " " walls	382
" " " " reference plane	191
Total	756
Total flux computed from distribution curve (Fig. 1)	779

This check of the illumination tests shows accord within 3 per cent. It is an excellent demonstration of the validity of the methods employed, and of the substantial accuracy of the results.

Ceiling as a Reflecting Surface.—From the data in the tables it is possible to compute the reflecting efficiency of the ceiling under the conditions which prevailed. From the following figures it will be noted that 63 per cent. of all light falling upon the ceiling from the walls is reflected by the ceiling, while the corresponding value for the light incident upon the ceiling from the light source alone is 86 per cent. This difference is probably due to the fact that the ceiling receives the bulk of the light from the light source at angles of very high incidence, under which condition it would naturally display a most favourable reflection coefficient. Moreover, the cloth of which the ceiling was composed allowed less light to pass through its interstices at high angles ; hence reflected a larger percentage.

A corresponding study of the walls as reflecting surfaces is also given.

The low value for the percentage of light reflected by the walls on the test-plane and ceiling seems reasonable, if we remember that a very large proportion of the reflected flux travels from wall to wall and is finally absorbed. The components of this flux falling upon the test-plane and upon the ceiling may reasonably be expected to be rather small ; in fact, a simple comparison of the areas involved would indicate that the test-plane and ceiling would receive a smaller percentage of the light reflected from the walls than do the walls themselves.

Specific Intensity or Intrinsic Brilliancy.—In view of the great importance of this element in illumination installations, it was decided to make such determinations upon the walls and ceiling. Time did not permit of an exhaustive study, but the determinations were made for the ceiling when it received the total direct and indirect light flux, and again when the walls were covered with black cloth ; also for the walls when they received the total direct and indirect light flux.

Ceiling as a Reflecting Surface.

First reflections only.	Lumens.	Reflecting efficiency of ceiling.
Incident upon ceiling from light source	183	
Reflected to table plane	42	
Reflected to walls	116	
Total reflected from ceiling	158	86%
Multiple reflections only, first reflections excluded.		
Incident upon ceiling from all sources except light source	97	
Reflected to table plane	26	
Reflected to walls	35	
Total reflected from ceiling	61	63%
All first and multiple reflections included.		
Incident upon ceiling, from light source	183	
" " " from walls	97	
Total	280	
Reflected from ceiling to table plane, 1st reflection from light source alone	42	
Reflection of light from walls, via ceiling	26	
Total	68	
Reflected from ceiling to walls, first reflection from light source alone	116	
Reflection from walls, via ceiling to walls.	35	
Total	151	
Total reflection from ceiling	219	78%

Walls as Reflecting Surfaces.

First reflections only.	Lumens.	Reflecting efficiency of walls.
Incident upon walls from light source	382	
Reflected to table plane	86	
Reflected to ceiling	77	
Total reflected from walls	163	43%
Multiple reflections only, first reflection excluded.		
Incident upon walls	290	
Reflected to table plane	35	
Reflected to ceiling	20	
Total reflected from walls	55	19%
All first and multiple reflections included.		
Incident upon walls	672	
Reflected to table plane	121	
Reflected to ceiling	97	
Total flux reflected	218	32%

The detached test-plate previously referred to was calibrated as a standard of specific intensity by producing upon it illumination of high intensity, determining the intensity, and determining the illumination which the detached test-plate produced under those conditions at a stated distance. For example, in the standardisation test an illumination of 58·8 ft.-candles was produced upon the test-plate, and it was found that under this condition the test-plate produced a normal illumination of 0·393 ft.-candle at a distance of 5 ft. along a line perpendicular to its surface. This yielded a specific intensity of 0·0982 c.p. per square inch for the test-plate as illuminated, which corresponds to a specific intensity of 0·002 c.p. per square inch per foot-candle of illumination. After the illumina- intensity had been measured by means of the detached test-plate, the test-plate was removed, while the photometer remained in position, and repeated observations yielded the specific intensity of the ceiling or walls as compared with that of the test-plate. Some of the determinations made by this method are as follows :—

Specific Intensity or Intrinsic Brilliancy of Ceiling and Walls.

		Specific intensity (in c.p. per sq. in.) Mean for surface.	Min. measured.	Max. measured.
Conditions.	Surface.			
Nothing obscured...	Ceiling	0·0032	0·0014	0·0037
Walls black	Ceiling	0·0016	0·0005	0·0061
Nothing obscured...	Walls	0·0031	0·0023	0·0047

The value given for the mean specific intensity of the ceiling, 0·0032 candle per square inch, may be roughly checked by the use of the following equation : $F = \pi i$, where F is the average flux per square in. of the ceiling ; or in other words, the total flux divided by the area of the ceiling in square in., and i is the specific intensity required. The value so derived for the mean specific intensity will be larger than the value obtained by measurement, because it is based on the assumption that the surface of the ceiling is a perfectly diffusing surface, which it was not. The mean value for the first test of the ceiling, computed according to this equation, is 0·0949 candles per square in.

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BRAKE SHOE STANDARDISATION.*

BY J. A. PANTON.

Summary.—Attention is first called to the large amount of waste in connection with brake heads and blocks. The author then discusses the properties of the various types of brake blocks, and finally suggests a standard design which, he claims, will show a saving of over 100 per cent. in material.

The question of brake shoes and their wear, consistent with economy, safety and efficiency, is of greater importance than appears at first sight, and has up to the present time failed to receive due consideration. When you consider that the outlay on brake blocks is 10 per cent. of the car maintenance, it will be recognised as a very important factor in economy, and it is here suggested that as much attention be given to the scrap heap as to the brake block itself. At the present time some 40 to 60 per cent. of the material received is returned to the scrap heap partly worn; not worn out, but worn to such an extent that their consignment to the scrap heap is a wise precaution against accident. With heavy equipment and high-speed brake application, it is found that a soft cast-iron shoe in cooling after a hard and heavy application takes a sharper curve on the face than on the wheel, and this shoe, when re-applied at the next application, unless thick, will crack and break off.

A few years ago blocks were frequently made in one solid piece, so that the brake block itself could be attached direct to the truck lever. This method increased the weight of that portion of the block that goes into scrap, and it also required more time and labour in changing. The chief reason for the brake block being made in this manner was probably because of the limited space between the wheels. The lengthening of the wheel base a few inches has removed this difficulty, and the brake shoe has been generally adopted.

The original weight of brake blocks is found to vary between 20 lb. and 36 lb. Where space is not limited, it would seemingly be good practice to use the heavier blocks, which would remove the necessity for frequent changing. The figures given for discarded blocks of the above weights vary from 15 lb. to 24 lb., and correspondingly lower figures when steel backs are used.

In general it might be said that the weight at which blocks are discarded could with advantage be given considerably more attention than is customary. The scrap heap offers convincing evidence of this. Blocks are frequently found worn thin at one end, while the other end has barely been in contact with the wheel, and it is safe to say that not more than two-thirds of the available material is usually worn away. The fault usually lies in the length and adjustment of the hangers and design of brake shoe used, which does not permit of these being worn out, even if they could. The reason of this waste material is not far to seek, as the present plain cast-iron brake shoe has many disadvantages, apart from lack of inherent strength against breakage.

Plain Cast Iron.—This material is approved by many on the grounds that it is cheaper to wear out the brake shoes than the wheels, also to the fact that the frictional properties are comparatively uniform and high under all conditions of service. It will probably surprise many to know that wheels wear quicker without brake shoes than with them. Brake shoes assist in preserving the wheel camber. Although effective and efficient, they unfortunately show two very distinct objections and disadvantages for general use—namely, rapid wearing qualities and lack of strength against breakage.

The action of cast-iron shoes upon steel and chilled-iron wheels has been explained on the theory that the surface of a cast-iron shoe is characterised by sharp projections of a crystalline nature, and that these crystals under wear become readily detached and break along the cleavage faces, continually furnishing angular crystalline particles to grind between the shoe and wheel. The face of the chilled wheel is a series of minute elevations and depressions, and when pressed together the two surfaces interlock and mesh with the particles ground off from the shoes, so that there is a continuous grinding and rolling action, and consequent high friction and heavy wear on blocks. The steel tyre is not so hard as the chilled wheel, and possesses an element of ductility, so that projections on its face tend to flow or bend away from the brake shoe, to become compact and polished over, affording less resistance, and permitting a sliding rather than a grinding action between the two surfaces, and consequent wear of both wheel and block, producing excessive heat, which in turn causes a corresponding fall in retardation. With the harder qualities of cast iron it is possible to have considerable difference in wear with equal retarding effects.

Part-chilled Blocks.—With partially-chilled blocks there is less wear and a more even coefficient of friction throughout the process of retardation; any slight heating is dissipated in the chill, which to some minor extent assists retardation without rapid wear, and protects the intermediate soft iron which produces the necessary friction between the surface chills, thereby occupying a very useful intermediate position in braking efficiency and durability. The one great drawback at present about partly face-chilled blocks is that the chill does not penetrate more than ¾ in. into the body of the block; hence, when the block is only one-third worn, we arrive at very soft iron with rapid wear and increased coefficient of friction, resulting in chattering and erratic stops as the speed is being reduced, owing to various brake-shoe coefficients. Hence the necessity of chilling from the back as well as from the front in staggered positions, so that the retarding properties may correspond equally throughout the wear; therefore brake shoes should be purchased from manufacturers who specialise in this class of work.

Composite Brake Shoes.—The composite shoes of various grades of hard and soft iron and steel inserts give better results on steel tyres, but tend to tear the tyre by reason of hard spots forming on the inserts that fuse and roll between the shoe and wheel, preventing bearing on the entire wearing surface of the wheel.

All-Face Chill Blocks.—Some five years ago, in this country, a part-chilled block or chill of any description was utterly condemned; to-day we find a great many in use even to the extent of an all-face chill block. The author cannot go this far unless under great caution, as the all-face chill block is only suitable where very soft wheel tyres are in use. The present-day tramway and railway managers are in favour of very hard and high quality steel-tyred or chilled-iron wheels, and by the use of hard-face chill brake blocks on such wheels no reasonable friction is obtained, as the two surfaces immediately get highly polished, forming what is known as an all-chill glaze, which in turn, under the best dry conditions, involves a very low coefficient of friction and unnecessary heavy wheel pressure, resulting in undue heating, with its attendant drawbacks (in wet weather). It is with a block of this class (in wet weather), when a car is about to descend an incline, that the worst possible conditions may be obtained. The block is saturated with water, therefore the temperature of the wheels and blocks will be low. The coefficient will not be sufficient in the first few seconds to generate the heat required to evaporate the film of water between the blocks and wheels, with the result that racing may occur.

White Iron Blocks.—The above results with all-face chill blocks apply equally to hard white-iron blocks, with a greater tendency of this type of block when heated being liable to crack and break off, the nature of the material being very short in the grain and without ductility. Hence their early removal from service when only part of the material has been worn off. In the same way the glaze is here recognised by the squealing effect obtained when the car is coming to rest. Cracks in all-chilled or white-iron brake shoes result in total fracture unless precaution is taken to hold the parts together regardless of cracks. Brake-shoe manufacturers have resorted to the steel plate reinforcement at the back of the shoe, which is so designed as to anchor the cast-iron body firmly to the back. The brake shoe to meet to-day's requirements should have a steel back, and is a success, regardless of the facts that the extra durability for wear in the brake shoe required by many officials necessitates the use of a grade of iron which does crack under conditions of modern service. Hard cast iron is a metal which appears to have a lower rate of heat conductivity than soft cast iron.

End-chilled Blocks.—Another type of casting has the block ends chilled, and presents decided wearing qualities as well as decided tearing qualities, the outer edges presenting sharp cutting faces to the wheel tread, so that in reality the wheel tyre suffers more than the brake shoe.

The various types of shoes described above group themselves into three distinct classes with respect to braking results. The first class covers the soft-iron shoe, which is the most efficient though least desirable, on account of rapid wear. The second class embraces the part chill and composite shoes with hard and soft inserts, which occupy a useful and intermediate position in braking efficiency and durability. The third class includes heavily chilled and white-iron shoes, which are the least effective in braking, though most durable.

Suggested Improvements.—Having described the various results obtained from the blocks now in use, the author is still under the impression that a better brake block can be so manufactured to suit individual and local circumstances that it can be depended upon to control cars either in case of emergency or in making service stops, and to have pronounced retardation by reason of friction between block and wheel, so that the maximum braking effect can be attained. Secondly, the selection of brake shoes of the size, shape and metal best adapted for their service in stopping the car promptly, and with the least possible pressure, and at the same time preserving and conserving as much as possible the size of the wheel and its original contour of flange and tread.

* Abstract of a Paper read before the Tramways and Light Railways Association at the Dublin Congress. A brief account of the discussion in connection with this Paper was given in our last issue.

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UNIVERSITY OF CALIFORNIA

Hitherto the chief improvements in tramway brakes have been effected by the introduction of various forms of track brakes, but it seems to me that the track brake can at its best only be regarded as supplementary to the wheel brake when properly understood. The Brake committees have reported very fully on track brakes without giving much attention to the actual wheel brake shoe with varying conditions and materials in contact, and the desired foot-pounds of work done by that material for a given amount of wear has still to be ascertained. Hence the wheel brake has been made responsible in connection with many runaway cars. The importance of determining the effect of the shoe upon the wheel becomes apparent when one considers the possibility of a shoe showing a high resistance to wear, which may, in fact, be protected at the expense of wear upon the wheels. It is suggested that a specification should be framed on these lines, covering frictional qualities of brake shoes, provided that shoes when tested shall give results as follows: Upon a chilled wheel in effecting stops from a speed of 35 miles per hour a mean coefficient of friction of not less than 22 per cent., when the brake-shoe pressure is 2,800 lb., and a steel-tyred wheel in effecting a stop from a speed of 60 miles per hour a mean coefficient of friction of not less than 18 per cent., when the brake-shoe pressure is 2,800 lb., or an average of 20 per cent. for all purposes; that the rise in the value of the coefficient of friction at the end of a stop shall be within such limits; that the value of the coefficient of friction for a point 15 ft. from the end of the stop shall not exceed the mean coefficient of friction by more than 7 per cent. The general conclusion is that commercial brake shoes at present as a rule meet this standard as to mean coefficient of friction during a stop, but they fail in most cases as to the increase of coefficient of friction at a point 15 ft. from the end of the stop. The author is of the opinion that while a high coefficient of friction is in the abstract a desirable characteristic to be possessed by a brake shoe, operating conditions make uniformity of action

Suggested Standard Brake Head and Shoe.

desirable for the purpose of securing uniformity both in time and intensity of its action, in order that the surging of trains and trailing cars may be prevented. Many interests would be served if manufacturers, in submitting shoes for test, would give a statement covering wearing qualities as well as a statement covering coefficient of friction. It is also possible that if a satisfactory test could be formulated, specifications covering wearing qualities might be framed. In order to arrive at this, the author submits in the Paper a test sheet which he suggests should be sent out, and the information secured carefully collated by an engineering committee, together with other material upon this subject, to form the basis of a report on brake-shoe standardisation.

Brake-shoe Heads.—Improvements have been made in the past by separating the head from the shoe, accomplishing a saving in first cost and scrap weight, but the practice still remains expensive on account of lack of interchangeability. It would, therefore, seem important that we consider this question with a view to having all brake heads made strictly in accordance with the present contours or dimensions, to ensure more satisfactory service and avoid the difficulties which have been experienced in fitting the brake shoe. The shape of the brake head may be allowed to vary in accordance with the truck design, provided always that they fit the standard shoe. Within the last two years steel-back brake shoes have been introduced; heavy and high-speed equipments demand a shoe of this type, which practically doubles the life of the shoe, with less strain on the brake head. The best argument in favour of steel-back shoes is that they can be worn down very thin without danger of breaking and causing derailment of the car. A similar remark also applies to the present cast-iron key lug, which breaks in service very frequently, thereby accounting for brake failures and accidents. Improvements have been attempted in this direction by casting in steel bands reinforced and supported by the cast metal of the shoe, a practice which developed blow holes on account of the fusing of the metals, and separation of the lug from the casting while in service. It would, therefore, seem desirable in designing a standard that particular attention should be given to avoid these defects; that the iron lug should be sufficiently strong without other supports and well protected during the process of casting.

Standardisation.—Attempts recently made to obtain definite figures regarding the wear of brake shoes disclose the fact that close records of this important feature are not kept in a great many car shops. It may be argued that there is no need for such figures. On the other hand, it is reasonable to presume that the more definite the information that can be secured in car-shed practice about such a considerable item of expense as brake shoes the greater is the probability of reducing expenses. The number of stops and the weight of cars differ so widely on different systems that widely varying brake-shoe mileages are obtained. Difference in operating conditions is also largely responsible for the wide difference in brake-shoe mileage obtained; therefore our present method of cost per 1,000 car-miles is obviously wrong. Braking pressures must vary directly with the weight of the car. Brake-shoe wear will vary directly as the braking pressure and work accomplished, and, therefore, it is not considered as important for purposes of comparison to know the cost per 1,000 car-miles or ton-miles as it is to know the "percentage of metal worn." The standard brake shoe should be one-third the diameter of the wheel tyre (within reasonable limits) or applicable to any wheel from 30 in. to 33 in.

The pressure applied to the brake shoe on tramways at present varies according to the weight of the car. But the total brake pressure applied should not exceed 75 per cent. of the total weight of an empty car. With the latest type of "Peacock" and "Ackley" geared brake spindle a common standard of brake pressure applied by the motorman could be arrived at for all weights of tramway cars between 8 and 15 tons.

Whatever may be the pressure arrived at, the results clearly distinguish between the slow-wearing and the rapid-wearing shoe. All shoes wear more rapidly on a steel-tyred wheel than on a cast-iron wheel. In general terms it may be said that for the absorption of a given amount of work the wear on brake shoes upon the steel-tyred wheel is twice as rapid as upon a cast-iron wheel. A standard shoe should, therefore, develop for each pound of metal worn away 350,000,000 ft.-lb. of work in contact with a cast-iron wheel and 200,000,000 ft.-lb. of work in contact with a steel-tyred wheel. A standard specification framed along these lines would form a basis for comparative tests on brake-shoe wear, regardless of any and all conditions of running, and would in all probability reject 50 per cent. of inferior wearing material now offered for service. This would involve no extra expense to the manufacturers, as some manufacturers have for many years given practical attention to these requirements, and can fully demonstrate that it is entirely practicable to do so.

Standardisation does not mean standard material, but does mean standard design, for all classes of material to suit the different conditions and attain the standard coefficient of friction and wear herein described. Now that through running of cars is an established fact, standard design is essential in case of failure necessitating interchange of wearing parts.

In the standard brake head and brake shoe submitted (*see* illustration herewith) it will be noticed that the plan contemplates keying the contacts at the centre lug of the brake head, while the ends of the brake head fit close to the full length and width of the brake shoe back, that function being a great support to the shoe. The raised recess at each side of the iron lug, in conjunction with the end abutments, is merely to keep the shoe in vertical alignment, and should fit the holder and lug so snugly as to prevent any upward or downward movement of the shoe, the centre lug transmitting the load directly to the beam by virtue of the usual wedge-shaped key. In practice a great deal of play is often found at this point, which is very objectionable, as it allows the shoe to chatter up and down with the rotation of the wheels. Also many brake heads are found which bear at the ends and lack contact in the centre, causing the shoe to break at the centre when worn. Many brake heads will not allow the brake-shoe key to be properly driven into place.

On a large proportion of electrical equipments we see that the brake head is carried over the flange portion of the brake shoe. This means that whenever a brake shoe is worn through the flange (and that is generally what happens in the effort to obtain longer life out of the shoe), the brake head is worn. If another shoe is applied to that head it will not fit, and consequently does not do its proportion of braking work; the brake head is therefore scrapped after a short life. The proposed standard brake head shown has been so designed that however much the block may be worn the brake head cannot be injured.

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On examination of the proposed standard shoe it will be noticed that quite a little unnecessary metal has been removed from the flange and back of shoe. The author believes that better results in braking would be secured if all the braking were done on the tread of the wheel instead of the flange, for the following reasons: (1) The effect of using a flanged brake shoe is that the sand and grease, which is carried up by the wheel, collects at the root of the flange, causing unequal wear and hard braking. (2) The brake shoe crowds into the throat of the wheel tread (causing sharp flanges) in the endeavour to get on to the larger diameter of the flange, with the tendency to climb and tip the block up at one end, causing chattering. (3) When the wheel flanges are chipped, the flange catches the shoe suddenly, causing the brakes to buck. By omitting the flange portion of the shoe these difficulties would be obviated, and there would be fewer flats on wheels; or that sufficient flange only be left to steady the brake shoe, and made with a deeper opening, so that it will guide the shoe without braking on the flange. By removing the waste material from the back of the shoe and the intervening air spaces, we would get ½ in. more wearing material on the body of the shoe in slightly less space than by adopting the old practice. The proposed standard shoe may, with all safety, be worn down to the steel back, while the old style has to be removed when half worn to prevent the wheel flange from wearing out the brake head.

——	Wt. of head.	Wt. of shoe.	Cost of shoe.	Thickness of shoe.	Metal worn away.	Cost of metal worn.	Metal scrapped.
Old practice	14¼ lb.	22 lb.	1/10½	1⅝ in.	8 lb.	8d.	14 lb.
Standard practice...	19¼ lb.	19¼ lb.	1/8	2¼ in.	17 lb.	1/5¼	2¼ lb.

The above figures show comparative details and indicate a saving of over 100 per cent. in material. A brake shoe of this type has a particularly fine opportunity to effect a large saving by its application, other than those which will bring immediate benefits of a financial sort. We would have less weight purchased, less weight scrapped, less material handled and a better service, with less cost all round.

AN ACCURATE ELECTRICAL METHOD OF MEASURING SPEEDS OF ROTATION.

BY E. B. BROWN, B.SC.

The measurement of speeds of rotation by means of a condenser was suggested by Maxwell's historical determination of the absolute capacity of a condenser, and has been carried out in different ways by various experimenters. The following modification of the method in which a special type of differential galvanometer is used will, the author belives, prove very convenient, and is of sufficient importance to merit publication. It is capable of a high order of accuracy and its convenience is such that in many cases it will meet a long felt want in the electrical testing room.

By means of a rotating commutator a condenser is alternately charged by a battery, and discharged through one coil of a differential galvanometer. The steady deflection which would exist due to the rapid succession of discharges, is opposed and prevented by a steady current from the same battery passing through the second coil of the differential galvanometer. This steady current is adjusted by variable resistance in series until the galvanometer is restored to its zero position.

The ratio of the steady current to the mean value of the pulsating current will be a constant for the instrument, but the steady current is equal to the P.D. of the battery terminals divided by the total resistance exterior to the battery, while the mean value of the pulsating current is equal to the product of the P.D. of the battery terminals, the capacity of the condenser and the number of discharges per second.

If the capacity of the condenser may be regarded as constant, the reciprocal of the total resistance in the steady current circuit must be proportional to the speed of rotation when the galvanometer shows no deflection, the battery P.D. being eliminated.

The speed for rotation may then be calculated by dividing a constant by the resistance in circuit.

In order to test the value of the method the author made a series of experiments determining the speed independently by an electric recording chronograph, and calculating the capacity of the condenser at different frequencies of charge and discharge. The following results were obtained from experiments on the 0·5 section of a divided microfarad mica condenser :—

Frequency determined by chronograph.	Capacity, microfarads.	Temperature.
26·969	0·49402	16·5°C.
23·375	0·49502	16
18·901	0.49530	16·5
18·904	0·49526	23
15·853	0·49613	16·5
9·6376	0·49648	23

Battery used, one Leclanché cell.

Examination of the above table shows that over a wide range of frequency from 9·6 to 27 discharges per second, the capacity varies only about 0·4 per cent. In using the apparatus to measure speeds this variation of capacity may be allowed for by constructing a graph between the reciprocal of the speed and the added resistance. This graph will be very nearly a straight line, since the capacity is nearly constant, so that only a few observations are necessary to construct it.

The two observations at a frequency of 18·9 were taken on days when the temperature was different by 6·5 deg., but as the table shows, the same value of the capacity (within limits of experimental error) was obtained at both temperatures. This is important because it shows that the change of capacity with temperature is small.

A brief description of the apparatus employed and the method of experiment may be of interest.

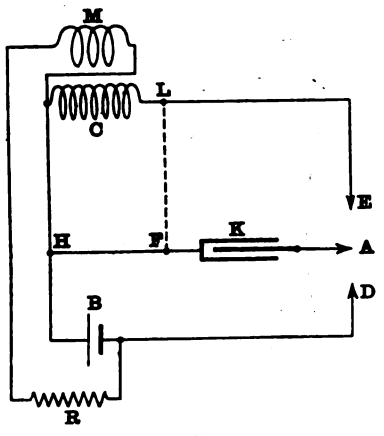

DIAGRAM OF CONNECTIONS.

The special feature of the galvanometer employed is the large ratio between the number of turns in the two windings. This enables series resistances of moderate value to be used instead of the very large and expensive resistances which would be necessary with an ordinary differential galvanometer.

This galvanometer was constructed from an ordinary reflecting D'Arsonval galvanometer by adding an extra winding of a single layer over the ordinary winding. This extra winding carries the steady current, and is wound of manganin, so that its resistance does not vary much with temperature. Both windings have a common junction to the upper suspension of the moving coil, the steady current passing out through the lower suspension, while the condenser currents flow through an extra spiral of very thin copper strip. The ratio between the currents in the two coils when equilibrium is obtained was experimentally found to be 40·708.

The commutator consists of a brass tube rotated on its axis by a shunt motor driven by storage cells, a carbon rheostat in the armature circuit giving a fine speed adjustment. At one end of the brass tube a little more than half the circumference is cut away, so that the remaining part alternately makes contact with one or other of two copper gauze brushes mounted on an ebonite block.

The connections are made in one or other of two ways as shown in the accompanying diagram.

In this diagram the two coils of the differential galvanometer are represented by M and C, and the commutator by the arrow heads D, A and E. Of these A, attached to one terminal of the condenser K, alternately makes contact with D and E, charging and discharging the condenser. B is the battery and R the

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series resistance. If F be connected to H the condenser discharges pass through the coil C, but if F be disconnected from H and connected to L, the charging currents pass through C. Both methods of connection give the same value of the capacity within the limits of errors of observation. All the values given in the table were obtained with charging currents passing through C. Details of a typical observation are as follows :—

Temperature of air, 16·5 deg.	
Corrected value of R	3002·1 ohms.
Resistance of M	121·2 „
Total res.	3123·3 „

During a run of 10 minutes the galvanometer spot was kept on the zero by the fine speed adjustment. The chronograph sheet showed that the greatest variation of speed from the mean was 1 part in 3,800, and the mean time of 1,000 discharges was 63·08 seconds.

$$\text{Capacity} = \frac{0{\cdot}06308 \times 10^6}{3123{\cdot}3 \times 40{\cdot}708} = 0{\cdot}49613 \text{ mfd.}$$

The above experiments show that corresponding to every value of the speed there is a definite value of the series resistance which will bring the galvanometer to zero. As far as the adjustment is concerned the battery E.M.F. is immaterial, except that increasing it increases the sensitiveness of the arrangement.

When the apparatus is used for measuring speeds of rotation, and if great accuracy be desired, a calibration curve is easily constructed which takes account of variations of capacity with frequency; from this curve the speed of rotation corresponding to the value of the added resistance can be taken. For most purposes, however, since the capacity of the condenser is practically constant over a wide range of frequency, it will be sufficiently accurate to obtain the speed directly by dividing an easily determined constant by the total resistance in series.

ELECTRICITY IN COAL MINES.

At a meeting of the Mining Institute of Scotland, held on the 11th inst., at Dunfermline, two Papers of particular interest to electrical and mining engineers were read and discussed. The first Paper was by Mr. F. Onslow, and dealt with

"Some Considerations Affecting the Installation of Power at Collieries."

The author observed that much controversy was raging just now as to the relative advantages of the three-phase and direct-current systems for colliery work. Each system, however, possessed inherent advantages, and the problem was to select in each case the one better suited to that particular colliery. For all practical purposes each system was equally dangerous, or perhaps it was better to say equally safe, if properly installed under conditions suitable for the system selected. It was in the interests of all concerned that no time should be wasted in what might be termed "hair-splitting" as to which system was academically the safer. Apart altogether from the question as to which system should be adopted in a new colliery, where that best suited to the conditions could be selected, the present position of existing installations had to be considered. In certain parts of England and Wales some advantage might conceivably be gained by converting some of the existing direct-current systems for alternating current. In Scotland, however, the conditions were different, and attention ought rather to be concentrated upon the question of rendering existing installations safer. No doubt much could be accomplished in this direction, as many of the plants were at least from 10 to 15 years old, and desirable modifications would not only afford greater safety in working, but probably result in increased economy. Speaking generally, then, all such installations should be seriously tackled and brought up to date.

As an instance of how simply accidents might occur, he gave the following particulars, which recently came under his notice. The installation was on the direct-current system, and a serious accident nearly resulted from the live wire coming into contact with some supporting iron H-girders. Current was generated at the colliery, and two separate cables carried down the shaft to a distribution board just at the bottom. The roof at this point was supported by H-girders, and the slings supporting the cables (which were of the ordinary vulcanised class) were not long enough, with the result that the cables were held in contact with the girders. The distribution board was in a cast-iron case, which was connected to an earth-wire attached to a plate sunk in the shaft sump. It was while engaged in carrying out some alterations to the iron joists that a workman experienced a shock. Iron supports are extensively used in Scottish mines, and several accidents resembling the above, although unhappily attended by more serious results, have recently taken place owing to their becoming electrified.

The possibility of electric shock was always present, no matter what system was employed. For all practical purposes the danger was independent of voltage, as the lowest practical had been shown to be fatal. The possibility of shock could be comparatively easily eliminated in all generators, motors, and other plant by earthing, with the exception of coal cutters, which were more difficult to deal with. The greatest danger of shock, however, was from the cables, including main, distribution and trailing cables. This danger was particularly prominent in Scottish mines owing to the wet and low seams. The arrangement of the cable system was necessarily a matter which must depend upon local conditions, the principal points to provide against being shock, fire and undue deterioration. Armoured and unarmoured cables both possessed advantages, and the type best suited to the conditions might be selected. But, whichever type was adopted, great care in the installation thereof, with constant supervision afterwards, was the essential and only safe manner of dealing with cables, if fatal accidents were to be avoided. One of the main objections raised to direct-current plant was upon the score of sparking. The improvements in the design of this plant had resulted in practically sparkless commutation, even under severe overload conditions, but it could not be disputed that the danger of ignition of gas or coal-dust from this cause still existed. However, this danger was also present with alternating-current slip-ring motors, and also in a modified degree with those of the squirrel-cage or short-circuited type. Generally speaking, overload and other devices which had been proved to be reliable might be recommended, but before new devices were applied they ought to be thoroughly experimented with under practical working conditions.

The author suggested that it would be better to equip one colliery for a complete trial by experts, rather than to have partial installations in many pits. To earth or not to earth was at present a great question, and there were many advocates both for and against. If earthing were attempted it must be carried out effectively and, generally speaking, two main earth-plates should be employed, one on the surface, and one below ground in the shaft-sump or other suitable position. These two plates should be connected together by a main wire, which should run the full extent of the installation, and all electric apparatus and metallic work should be connected to it by wires of requisite section. The alternative of a number of local earth-plates was sometimes preferred, but the difficulty in this system was to obtain a good earth, so that the main wire would appear to offer on the whole the best solution.

Where winding plants of comparatively small capacity and speed were to be operated, both systems might be regarded as equally applicable, although the better torque of a direct-current motor was rather an advantage. When larger plants, requiring greater speed and more rapid acceleration and retardation were concerned, a direct-current winding motor was almost, if not quite, a necessity, although one or two schemes had been more or less perfected to allow the direct use of alternating current, but the scope of these was limited. In dealing with large winding plants an equalising system was usually necessary to reduce the demands upon the generating station or supply mains. Generally some system of mechanical storage of energy was necessary, although in the early days on the Continent accumulators were utilised. These were not then entirely successful, but reversible boosters had since been developed, and might result in a battery scheme being not impracticable, notwithstanding its high capital expenditure. A feature of such a scheme was the stand-by it afforded for week-ends, and in case of failure of the generating plant or supply mains.

Fans and pumps required motors to run them (1) at a low or medium constant speed; (2) at a high constant speed; and (3) at variable speeds. In the first case direct or alternating current motors were equally suitable. As regards the second case, alternating-current motors could be more economically constructed for high speeds, and no commutation troubles were involved, if squirrel-cage machines were employed. Frequently high speed was not possible with alternating current owing to the low frequency of the power company's supply. When variable speeds were necessary, direct current was usually preferable, as the speed variation properties of alternating-current machines could not be compared with those of direct-current. From a working point of view, direct-current coal cutters were superior to those operated by alternating current, but the latter type had proved itself quite reliable and satisfactory.

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There was another possibility with regard to coal-cutting machines, as by the use of compressed air these might be operated from an electrically-driven compressor. Such a combination offered many possible advantages, especially where a number of cutters were employed in a small area, as these could all be supplied from one compressor, thus securing the advantage of compressed-air cutters, and the economy of electrical transmission.

DISCUSSION.

Mr. MUIR (Bowhill) said, with reference to the generation of electricity in connection with exhaust steam, that they had such a provision at Bowhill, and they found it a very valuable acquisition indeed to the colliery. Its value was all the more marked in connection with the winding engines. He thought there was considerable room for improvement on the gas engine, and while he believed there was likewise a necessity for improvement in the steam engine, he thought the latest combination with exhaust steam turbines would be very successful indeed. His own experience in connection with the distribution of power had been entirely with the three-phase system, and he homologated the view that had been expressed by Mr. Robert Nelson, H.M. Electrical Inspector of Mines, in his recent valuable Paper "Electricity in Mines." He had no doubt whatever that an installation, properly installed, of the three-phase system, and armoured continuously throughout, would make for safety. He believed, in regard to thin seams, that it was a great consideration whether one would not adopt continuous current in consequence of the difference in height required for the three-phase motor. He was confident, however, that electrical engineers would themselves soon overcome that objection. One difficulty in taking power from power companies was the fear that sometimes their power might not be suitable for everything in connection with a colliery. Both in the alternating and continuous-current systems there was usually a considerable amount of trouble with the switches. That was one thing in which unquestionably there was a good deal of wear and tear, and any person who could invent a switch that would be satisfactory for all conditions about a pit would be conferring a very great boon indeed on colliery owners. One of the most important things in connection with alternating current was a proper controller, and his own opinion in that matter was that the controller ought to be on the water-tight principle.

Mr. SAM MAVOR (Glasgow) said that in the past the discussions on Papers such as this had been left largely to electrical people who were personally interested in one or other of the systems. He had the feeling, however, that it would be much more useful if colliery managers who had experience of the systems would enter into the discussions.

The PRESIDENT (Mr. Robert M'Laren) said he fully endorsed that observation, and so as to furnish time for consideration of the Paper he proposed to adjourn the discussion until the next meeting.

The second Paper, which was entitled

"POWER PRODUCTION AT COLLIERIES, WITH SPECIAL REFERENCE TO GAS POWER AND ELECTRICAL CENTRALISATION,"

was jointly contributed by Messrs. R. Crawford and H. Moores. The authors at the outset pointed out that the growing need for economy made the subject of power cost one to which the colliery manager must devote attention with a view to generating and transmitting this power in such a manner as would ensure the highest possible efficiency. Of late years the adoption of electricity as a secondary power for pumping, ventilation, haulage, coal-cutting, &c., had greatly increased the efficiency of mining power plant by displacing small steam units, thereby considerably reducing colliery consumption. Much good work had also been done by the introduction of low and mixed-pressure turbines, so arranged as to utilise the large amount of exhaust steam from the winding engines, and to a less extent from haulage and other engines about the colliery. Examples of this kind, the authors mentioned, were not wanting in Fife, and mention might be made, say, of the Fife Coal Co., which had six mixed-pressure turbines at work, of a total capacity of 5,800 H.P.

Whilst a good deal of attention had been devoted to electrical centralisation of power at large collieries by means of exhaust steam turbines, it was found that much higher economies could be obtained by converting the fuel into gas for the purpose of driving gas-engine electrical generating sets, from which energy would be transmitted at high-tension to the machinery at outlying pits. It was undoubtedly in this direction that colliery managers must look for the highest possible economies.

The following was an estimate for a proposed 5,000 kw. gas-driven central electrical generating station for a colliery. Assuming coal of an average quality of 13,000 B.Th.U. per lb. and a gas-producer efficiency of 75 per cent., each pound of coal gasified would yield 9,750 B.Th.U. available in the engine cylinder. A large engine would work on three-quarter load on a consumption of about 8,000 B.Th.U. per brake-horse-power-hour, and there was at least one case on record of an engine having performed a continuous non-stop run of over two years on a consumption of only 7,892 B.Th.U. per brake-horse-power. In the present instance, however, the writers took the consumption as 9,350 B.Th.U. in order to cover all contingencies, such as ultimate loss of compression due to piston wear, &c. With a dynamo efficiency of 90 per cent., this was equivalent to 1·42 lb. per kilowatt-hour at the switchboard. The capital outlay involved in a gas-power station of 5,000 kw., comprising Mond gas-plants with ammonia recovery apparatus, multi-cylinder gas engines of, say, 1,000 kw. each, direct-coupled generators, buildings, foundations, &c., was approximately £17 per kilowatt, or a total of £85,000. Such a plant, working on a load factor of 60 per cent., which could easily be obtained in most collieries, and exceeded in the case of wet pits with heavy pumping—would generate 21,600,000 units per annum. The coal consumption for 21,600,000 units at 1·42 lb. per unit would be 13,692 tons per annum, costing £1,369. On this basis the cost of production was found to be 0·20d. per unit at the switchboard, from which the bye-product revenue must be deducted. Assuming a yield of 95 lb. of sulphate per ton of coal gasified, the recovery would be 585 tons per annum. This represented, at £11. 10s. per ton, a sum of £6,727, while the yield of tar might be expected to realise a further £384. On deducting these amounts from the gross cost, the net cost of electricity would be found to work out at the very low rate of 0·12d. per unit. This would be still further reduced to 0·11d. per unit if screen refuse were used instead of duff. There did not as yet appear to be any reliable data available regarding the total inclusive cost of power from a combined colliery installation of non-condensing piston engines and turbines, but the writers believed that the figure mentioned above, namely, 0·12d. per unit, represented a clear gain of not less than £19,898 per annum on an outlay of £85,000. With refuse shale as fuel, the gain would be correspondingly greater.

In conclusion, the authors contended that a gas-driven central electrical power station for a group of collieries was the ideal arrangement, where circumstances admitted of the outlay which such a scheme involved. There appeared to be no doubt that many such would spring into existence during the next few years with a view to using to the best advantage the heat possibilities of the coal consumed.

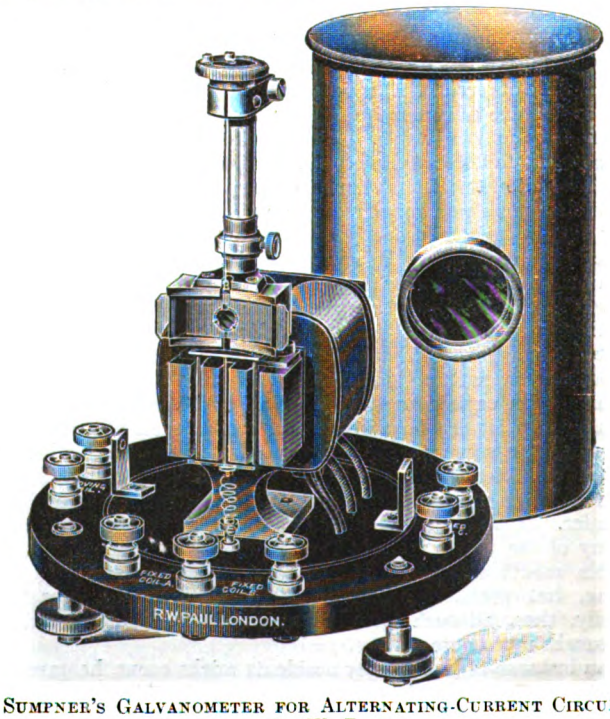
This Paper is to be discussed at the next meeting of the Institute.

PHYSICAL SOCIETY.

At the meeting held on June 10th, Prof. H. L. CALLENDAR, F.R.S., President, in the Chair, a Paper on

"A Galvanometer for Alternate-Current Circuits,"

by Dr. W. E. SUMPNER and Mr. W. C. S. PHILLIPS, was read by Dr. Sumpner. Tests of effects due to change of current, such as induction



SUMPNER'S GALVANOMETER FOR ALTERNATING-CURRENT CIRCUITS, BY R. W. PAUL.

phenomena, are often hard to carry out because the ballistic galvanometer is not sensitive enough. Alternate current tests are still less satisfactory owing to special difficulties. The vibration galvanometer overcomes only a few of these difficulties. It must be adjusted to resonance for the best effects, and its indications vary with current frequency. The sensitiveness of ballistic galvanometer tests can be

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greatly increased by the use of some form of mechanical commutator by means of which a crude form of alternate current is produced. A better method would be to generate the current in the usual way if a suitable instrument existed. The galvanometer here described is the result of an attempt to construct a measuring instrument by means of which inductances and capacities can be compared by bridge methods as accurately as it is possible to compare resistances. The instrument (which is illustrated herewith) is like a moving coil galvanometer in almost every respect, except that its field is due to a specially constructed electromagnet excited by an alternating voltage. This voltage V is applied to a winding of m turns of the electromagnet, and the core flux N is such that $V = rA + m\dot{N}$, where r is the resistance of winding and A the current traversing it. The coil and electromagnet are so designed that for currents of the frequencies used the value of rA is negligible in comparison with V. The rate of change of N will therefore be at each instant a measure of V, whatever the permeability or hysteresis of the core. The instrument has a laminated electromagnet formed of stampings of two kinds—a rectangular portion with two straight limbs forming the core of the electromagnet, and a specially shaped stamping between the poles. The moving coil of 50 turns swings in a narrow gap separating the stampings, in much the same way as in a permanent magnet instrument. On the limbs of the magnet are windings of 200, 2,000 and 4,000 turns. The iron will not be too strongly magnetised if the winding used contains 20 turns per volt on 50 ~ circuits, but the instrument is so sensitive that such excitation will only be needed for exceptional tests.

If a voltage, V, be applied to one of the field coils of m turns, and if the same, or another, field winding of n turns be joined up, through a condenser of K microfarads, to the moving coil, the torque acting on this moving coil will be a measure of $Kn(V/m)^2$; *i.e.*, the deflection is proportional to the square of the voltage. By suitably choosing K, m and n, the voltmeter may be used over a large number of ranges. Thus with the instrument shown a deflection of 200 mm. on a scale at 1 metre distance can be obtained either for 200 volts or for 20 millivolts. The deflection is independent of frequency and wave-form if the field winding to which the voltage is applied has a resistance negligible in comparison with its impedance. Thus with $m = 4{,}000$ and $n = 200$ it was found that the value of V^2 required to give a certain deflection was independent of frequency between 50 ~ and 100 ~ but at 25 ~ it was 6½ per cent. less than 50 ~. At any fixed frequency the deflection will always measure KV^2. The instrument may be used with great advantage to compare inductances and capacities by the ordinary bridge methods, the working conditions being (i.) the alternating voltage V applied to the field coil of the instrument must also cause the current in the bridge conductors, (ii.) the alternate current in the bridge must be made in phase with the voltage V by the use of suitable non-inductive resistances, (iii.) the moving coil must be placed directly across the bridge.

The balance can be adjusted with ease to 1 part in 10,000 when the voltages set up in the coils or condensers are of the order of 1 volt. When a balance of great precision is needed, the minute E.M.F., e, induced in the moving coil by the alternating field of the magnet tends to cause a small deflection disturbing the balance. When the moving coil circuit is non-inductive, the current due to e will be in phase with e and in quadrature with the flux so that the corresponding deflection will be negligible. But in all cases any effect due to e can be accurately eliminated by working to a false zero. As illustrations of the behaviour of the instrument, the results of tests are given on the measurement of the mutual induction of coils, the comparison of capacities, and the measurement of specific inductive capacity.

Mr. A. CAMPBELL expressed his admiration of the galvanometer and in particular of the ingenious method of connecting it with a condenser when voltage is to be measured. He remarked that the instrument was very similar in construction and use to that used by earlier experimenters. Stroud and Oates ("Phil. Mag.," 1903) described such a galvanometer and showed how sensitive it was for testing condensers by Anderson's method and for other purposes; and Terry ("Phys. Review," 1905) used a similar one for accurate comparisons of condensers. Abraham ("Comptes Rendus," April, 1906) described another in which the false zero was got rid of by a compensating arrangement. With regard to vibration galvanometers, there was no difficulty in keeping them in tune on any reasonably steady alternating circuit. In the bridge methods illustrated in the Paper, a double adjustment was necessary when a vibration galvanometer was used, and in general an evaluation of effective resistance or leakage resistance could be made simultaneously with the measurement of inductance or capacity. He asked the authors if this double adjustment could be entirely dispensed with when the quadrature galvanometer was used. It would be interesting also to know how the instrument would work with non-sinusoidal wave-forms in a case where the balance depended on the frequency.

Mr. W. DUDDELL asked if the authors could supply more numerical data so that the instrument could be compared with other galvanometers of similar design. He pointed out that the tests were simplified owing to a double adjustment being unnecessary.

Mr. IRWIN thought that with small modifications the instrument would be useful for tests other than those described in the Paper. It might, for example, be used in determining the resistance of electrolytes. He pointed out that errors might arise due to a small amount of magnetic material in the moving coil.

Dr. SUMPNER stated, in reply to Mr. Campbell and Mr. Duddell, that the object of the special shape of pole piece was to increase the impedance of the exciting coil. Electromagnet galvanometers were not new, but the special mode of controlling the magnetic flux by the applied voltage was novel. The behaviour of the instrument was a direct consequence of this device. The vibration galvanometer responded to a voltage irrespective of its phase, and hence in some tests troublesome double adjustments were needed. This was not the case with the new instrument in regard to any of the tests described in the Paper. The current taken by the instrument could easily be calculated from data given in the Paper. In reply to Mr. Irwin, the author said that the small deflection due to magnetic impurities in the moving coil could be eliminated in all balance tests by using a false zero method. In deflectional methods the effect could be rendered negligible by reducing the voltage exciting the field, and using a moving coil current of correspondingly increased strength.

Mr. PHILLIPS stated that the present Paper was preliminary to a more detailed account of the work which had been done with the instrument. In reply to Mr. Irwin, he stated that it was proposed to make use of the instrument to measure the specific inductive capacity of materials and the resistance of electrolytes.

Mr. A. E. GARRETT read a Paper entitled

"Positive Electrification due to Heating Aluminium Phosphate."

In 1904 Dr. R. S. Willows and the author communicated to this society the results of some experiments on the halogen compounds of zinc, in which it was shown that those compounds when heated ionised the air around so that both positively and negatively electrified bodies gradually lost their charge. Work in this direction was continued, and the results obtained showed that a large number of inorganic compounds possess properties of a like nature to the above. In 1907 Sir J. J. Thomson found that chlorides, phosphates and nitrates give off an excess of positive ions when heated, and he incidentally discovered that aluminium phosphate was most active in this direction. As many of the substances previously examined are known to be unstable (and hence the ionisation produced may be the result of chemical change), while aluminium phosphate, on the other hand, is a most stable substance, it was thought that an investigation of the ion producing properties of that compound would be of interest. The apparatus was arranged so that the salt could be heated to the desired temperature (900°—1,300° C.) on a strip of platinum foil. The pressure could be reduced as required. For most of the experiments a sensitive galvanometer was used as recording instrument. With the usual distance between the electrodes (0·5 cm.) it was found that a difference of potential of 60 volts was sufficient to obtain a saturation current with the positive ions. The way in which the current varied with the time when the saturation voltage was applied was first investigated. For the first half-hour the current was somewhat irregular. This was found to be due to the water present in the salt. The current for the first hour or two appears to be largely influenced by the surrounding gas. Neglecting the preliminary effects due to water, the decay of the current with the time can be represented by a curve having the general formula $A(e^{-\lambda_1 t} - e^{-\lambda_2 t}) + B(1 - e^{-\lambda t})$. The current finally obtained depends almost entirely upon the salt itself. After five or six hours' heating, no further change takes place in the current obtained under fixed conditions of temperature and pressure. A temporary increase, however, can be brought about by moistening the salt, and also by passing a discharge from an induction coil through the tube for about ½ minute. When the salt is insulated and heated for some time, an extraordinarily large current passes when the field is first put on. This effect increases with the time up to about 10 minutes, after which any longer insulation causes no increase of the initial current. With the salt in the final steady state the conditions were suitable for experiments on temperature and pressure effects. It was found that for every temperature tried there was a certain pressure at which the current obtained was a maximum, and the higher the temperature the lower was this pressure. The currents obtained with constant pressure and variable temperature indicate that the relationship between the rate of production of positive ions and the absolute temperature can be represented by the Richardson formula $a\theta^{\frac{1}{2}} e^{-\frac{Q}{2\theta}}$. By using a quadrant electrometer in place of the galvanometer, it was found at pressures of 0·01 mm. that some positive ions are ejected with a velocity of the order 10 cm. per second; and other experiments showed that the ions at very low pressures and acted upon by small electrostatic fields moved with great velocity, so it was thought that this substance could be made use of as a means for rectifying alternate currents. It was found that it could be so used. The values of l/m obtained by Thomson's cycloid method indicate that the smallest of the positive

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ions present possess a mass comparable with that of the hydrogen atom. Many of the results obtained, in particular (*a*) those with varying pressures and constant temperatures, (*b*) those at atmospheric pressure in which after removal of all free ions by a field sufficient to produce a saturation current, a current of equal values for ions of both signs was found at an electrode placed behind that on which the saturation voltage acted, and (*c*) the loss of charge of a Faraday cylinder when screened from the action of free ions, indicate that one of the products due to heating aluminium phosphate is in the form of neutral pairs or doublets which afterwards split up into negative and positive ions.

AN IMPROVEMENT IN SINGLE-PHASE ALTERNATORS.*

BY PROF. C. PICHELMAYER.

Summary.—Means are described whereby the dangerous pressures, induced in the rotors of single-phase alternators by the inverse rotary field, can be avoided and the factor of safety of working of these machines made equal to that of polyphase machines.

In various single-phase installations which have been erected during recent years, it has been noticed that the exciting windings of large single-phase generators—and more especially of turbo-driven sets—have frequently broken down, due, it has been suggested, to high pressures being induced in them. Since these breakdowns have always necessitated the unit in question being shut down, it will be seen that they seriously disturb the working of the system. The origin of this trouble, therefore, was rapidly investigated and prevented.

Below an arrangement is described which fulfils this object completely, and was the subject of an Austrian patent (11/12/08), which, however, was abandoned in the meantime on account of difficulties appearing in its practical application. The arrangement consists in having a cylindrical rotor for the

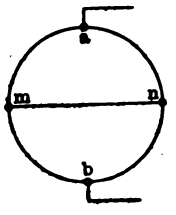

Fig. 1.

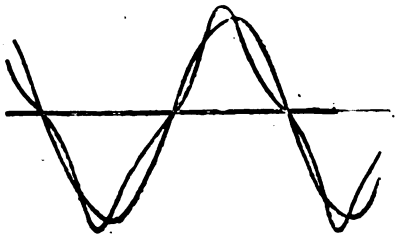

Fig. 2.

magnet wheel of single-phase generators, the rotor being provided with an ordinary continuous-current winding. The terminals are connected as usual to two diametrically opposite points, *a* and *b*, in a bi-polar arrangement (*see* Fig. 1), whilst two other points, *m* and *n*, 90 deg. from *a* and *b*, are electrically connected to one another. This cross-connection has no effect on the exciting circuit, being joined to two equi-potential points, but forms a very good damping circuit in conjunction with the exciting winding. The action of the two-phase damper will be at once clear when the armature reaction of the generator is explained by means of the theory of two oppositely rotating fields, which can be used here with advantage. (*See* article by H. Brühn, "Betrachtungen über die in der Erregungswicklung von Einphasengeneratoren induzierten Spannungen," "Zeit. für Elec. und Masch.," January 3, 1909. An abstract of this article appeared in The Electrician, Vol. LXIII., p. 20.) If we split up the pulsating stationary field, produced by the single-phase current in the stator, into two oppositely rotating fields, each of half the magnitude of the stator field, then the rotary field revolving with the rotor—being relatively at rest to the latter—will have the same effect as the armature flux of an ordinary polyphase machine. This component, therefore, will not induce E.M.F.s of any great magnitude in the exciting winding. On the other hand, the inversely rotating field can induce considerable pressures in the rotor winding. With the same number of turns in stator and rotor and similarly disposed windings, this pressure produced by the inverse field in the rotor winding will—owing to its relative velocity being twice that of the main field—be twice as great as the reactance pressure induced in the stator-winding by the component revolving with the main field—thus it may reach 50 to 60 per cent. of the terminal pressure. Now the latter pressure will be about 40 to 50 times the exciter pressure with the same number of turns in stator and rotor, so that the pressure induced in the rotor winding may become 20 to 30 times the exciting pressure, which, of course, is by no means safe. This happens with normal working at normal load where the reactance pressure of the armature is 25 to 30 per cent. of the terminal pressure, as assumed in the above example. In case of short-circuit, this pressure will become much more dangerous.

The inverse field not only produces these dangerous pressures, but also distorts the current and pressure waves of the generator, for this field exerts a strong reaction on the exciting circuit and induces in the latter a current of double the frequency of the stator current. This in its turn reacts on the stator winding and produces a third harmonic current, as is well known from the theory of armature reaction.

Now the inverse field is only partly damped by the exciting circuit along *ab*. When, however, *m* and *n* are short-circuited practically a complete damping of this component takes place. This can be well illustrated by means of the oscillograph—the curves of pressure and current being strongly distorted when the cross-connection is open, but quite good when the latter is closed.

Experimental Results.—The experimental machine consisted of a single-phase stator and a continuous-current armature of

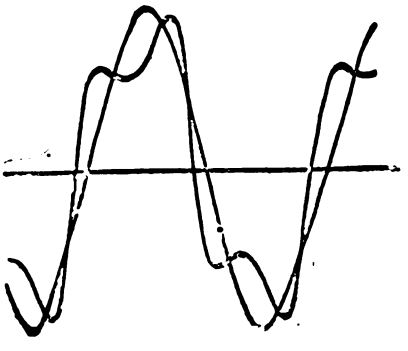

Fig. 3.

3·5 kw. output. The air-gap was 3·5 mm. There were four slip-rings connected to the points *a*, *b*, *m* and *n* respectively (Fig. 1). Most of the tests were taken with a stator current of 28 amperes, whilst the rotor was excited with 36 amperes at 22 volts. The number of turns in series on stator and rotor were 112 and 204 respectively, so that the ratio of the stator to the rotor ampere-turns was $\frac{112\times 28}{204\times 36}=\frac{1}{2\cdot 34}$. When the cross-circuit *mn* was open the pressure across these points was 80 volts with 28 amperes in the stator, and this pressure was found to be practically proportional to the stator current. On closing the cross—or damping—circuit *mn* a considerable compounding effect was observed, which at full load reached about 5 per cent. Under these conditions also the short-circuit characteristic was 15 per cent. higher than with the cross-circuit open—*i.e.*, normal.

Amongst the oscillograms taken, Fig. 2 shows the pressure curves on non-inductive load with and without the cross-connection (note the distorting effect when no damping is present). Fig. 3 shows similar curves for inductive load. The cross-circuit pressure and current were also shown to be of twice the frequency of the main current.

It was thus proved that the introduction of the damping circuit led to three useful results: (1) Compounding effect, (2) prevention of excessive pressure in the exciting winding, (3) suppression of higher harmonics in the terminal pressure wave.

* Abstract of an article in the "Electrotechnische Zeitschrift."

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Since, moreover, the whole exciting winding is used as a damper it will be seen that the loss thus created is very small. For example, if A_s denotes the ampere-turns per pole-pitch in stator, then at full load the ampere-turns of exciting winding will be 3A to 4A_s, whilst the ampere-turns damped are practically $\frac{1}{2}A_s$. Hence the loss due to the damping current in the exciting winding will be only $\frac{1}{36}$ to $\frac{1}{64}$ of the excitation loss, which can be neglected.

With regard to the adoption of this device, it has to be pointed out that the continuous-current winding is not always desirable for turbo-rotors, though for slow-speed machines the same difficulties do not occur. The arrangement can also be used in converters to keep down pulsations in the resultant field, in which case the exciting winding is made up of a continuous-current winding with cross-connection.

The same effects as above, though connected with greater losses, can be produced by a Hutin-Leblanc damping winding. Preferable to this, however, is a complete squirrel-cage winding spread over the whole rotor. This is the means adopted on the generators of the New York, New Haven & Hartford single-phase railway to prevent the dangerous rotor pressures. Such improvements as the above make the single-phase generator practically equal to the polyphase, and the author is of the opinion that the single-phase output of a given type fitted with either the damping arrangement or short-circuited winding is equal to the polyphase output of the same machine.

A GRAPHITE CATHODE DISH.*

BY J. W. TURRENTINE.

Summary.—Simple graphite electrodes are described, which are designed for use in the place of platinum as insoluble electrodes in electrochemical experiments. An account is given of preliminary experiments with a graphite dish intended to supplant in some forms of electrochemical analysis the Classen platinum dish. The dish is recommended for electrochemical separations and for analyses where great accuracy is not required.

In conducting a laboratory course in applied electrochemistry, one devoted largely to that phase of electrochemistry which has to do with solutions and the electrolysis of solutions, the need has been experienced for some good material which could be substituted for platinum in the construction of insoluble electrodes. In the Cornell laboratories, for ordinary work, graphite has been substituted. Trouble was experienced with this material on account of the fact that it was porous and absorbed the solutions in which it was used, and, therefore, could not be cleaned readily. This prevented its use in experiments where impurities might interfere with the desired reaction. Also, at high current densities the graphite electrodes showed a tendency to disintegrate and to fill the solution with clouds of finely divided graphite powder. This was due, possibly, to the discharge within its pores and beneath its surface of gases which forced off the surface particles. A further objection was found in the graphite's propensity for rubbing off and smutting.

After experimentation to determine a means of preventing the absorption of solutions by the graphite, it was found that if the graphite electrodes were treated while hot with molten paraffin, in amounts which are readily absorbed by them, the surface of the graphite acts as though it were greased, and is not wetted by aqueous solutions. Because of surface tension phenomena, the pores are not entered by the solutions. The treatment with paraffin furthermore reduces to a minimum the inclination of the graphite to rub off, so that it is rendered quite clean, and it may be handled freely without smutting.

In the laboratory of Wesleyan University we are now using graphite electrodes made from Acheson sheet graphite of 0·5 cm. thickness. The sheet is cut into pieces which are 15 cm. by 2·5 cm. in dimensions. One end is copper plated, and a copper wire about 20 cm. long is twisted around this end and is soldered in place to the copper plate. To protect the exposed metal at this point from fumes, the end of the electrode is covered with a light coating of varnish. The graphite is then paraffined while hot.

We were thus enabled to supplant very satisfactorily by the use of paraffined graphite the platinum sheet electrodes heretofore used in ordinary experiments in laboratory work. In electrochemical analysis, however, and separations, expediency still demanded the use of the Classen platinum dish. The use of a graphite dish as a substitute for the platinum dish need not be confined to pedagogic electrochemistry, but should also find an extended use in commercial laboratories.

Encouraged by the success of the paraffined graphite electrodes, a graphite dish was prepared from a 4 in. cylindrical stick of Acheson graphite. This dish was turned out on a lathe. Graphite was chosen as the material of which to construct the dish, because in it we have a substance which is at once a good conductor of the electric current, is cheap, is light in weight and is non-attackable by solutions. The porosity of the graphite may prove to be the greatest obstacle in the way of the dish becoming a success when employed in the most accurate analysis. The degree of porosity is expressed numerically as the quotient obtained by dividing the difference between the real and apparent specific gravities by the real specific gravity. The apparent specific gravity is that obtained when interstices of the graphite are kept free of the liquid in which the determination is being made. This is accomplished by coating the sample lightly with shellac. The real specific gravity is found after the air has been removed from the pores of the sample by greatly reducing the pressure over the immersing liquid. When the suction is released the evacuated pores become filled. The average of several determinations gives the porosity of graphite at about 0·25. Such a degree of porosity would seem to make this substance an impossible one of which to construct a dish designed for such purposes as is this one. The paraffin, however, is very effective in preventing the absorption of solutions into the pores. That the latter are not entirely filled by the paraffin is shown by the fact that alcohol is able to penetrate the paraffined graphite fairly readily. It is highly probable that while aqueous solutions do not enter the interstices, aqueous vapor does and condenses there to a certain extent; so it may be necessary eventually to fill these entirely with paraffin by the evacuation method used in the specific gravity determination.

The purity of graphite is high, and therefore it is improbable that any contamination of solutions can possibly result from its use. The experimental dish was prepared for use by first burnishing on a revolving steel-wire buffer, which served to remove all dust and gave the surface a somewhat polished appearance. The graphite still rubbed off on the fingers, but to a much lessened extent; after treating with paraffin it no longer rubbed off at all.

The dish was warmed in a hot-air bath to a temperature of about 110 deg., and, while still hot, molten paraffin was applied with a brush until it was no longer absorbed readily, but remained visible on the surface. The dish was then returned to the oven, several sheets of filter paper were placed under it and the bath was maintained at the temperature of 110 deg. for several hours. In this way the excess of paraffin was drawn off, by gravity and capillary action, into the filter paper. After this treatment the surface of the graphite appeared quite dry. The dish was then reburnished.

The preliminary experiments conducted with this dish gave such very promising results that two other dishes were obtained. These are much lighter in weight, weighing, respectively, 38 and 32 grams after having been paraffined. Their capacity is 200 c.c. In dimensions they are 9·5 cm. in diameter across the top and are 5 cm. deep.

The method was adopted of drying, after washing with distilled water, by holding the dishes by means of crucible tongs directly over the smokeless flame of a Bunsen burner, moving them around during the drying so that the heating would be uniform, and then cooling in a desiccator. This extremely crude method was justified by its rapidity and surprisingly satisfactory results.

A number of determinations of efficiency were then made by electrolysing an acidified solution of copper sulphate contained in a graphite dish in series with a copper coulometer filled with a portion of the same solution. Copper anodes were employed in both cells and a copper cathode in the coulometer. A current of 0·1—0·16 amperes was passed and the electrolysis was continued for about one hour in each run. The results were generally good, but an occasional result failed signally to agree with the theoretical value. As a check on the method, a Classen dish, containing a similar solution and copper anode, was also placed in the circuit; this cell was worked in series with the other two. The results, as a whole, were hardly as good as those obtained with the graphite dish, and, like those, an occasional one was bad.

The results obtained for the graphite dish are for the most part lower than those obtained with the platinum dish. It appears that there is perhaps some loss in the weight of the dish itself in drying, which causes the low results. Therefore, the method of drying directly over the flame will be abandoned and, instead, the dishes will be washed thoroughly with distilled water and then dried rapidly in a stream of warm dry air.

* Abstract of a Paper read before the American Electrochemical Society.

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CONTINUOUS RECORDS.

As to the advantage of records in electricity supply there can be very little doubt, though there may be some question as to the extent to which they should be adopted. Much wisdom was shown (possibly unintentionally) when it was decided that electrical undertakings working under Provisional Orders should be required to make public the detailed costs at which electrical energy was generated. This resulted in the publication of a great deal of useful information, and we do not doubt that the general accessibility of these data has stimulated a certain competition between central station engineers, and has led to the highest possible efficiency. Probably this course has led to the very low costs which are general in this country, and which place us at an advantage over many countries abroad in regard to electricity supply.

Annual records, however, are not all that is required, as the interval is too long for many purposes. At the recent meeting of the Incorporated Municipal Electrical Association, Mr. GEORGE WILKINSON, of Harrogate, advocated continuous records of costs and of steam consumption. The opinions, however, of those present seemed to be somewhat divided. For example, Mr. C. H. WORDINGHAM thought that central station engineers were becoming meter maniacs, with an unnecessary profusion of records, and that careful tests at longer intervals were more important than daily tests, which could not be nearly so accurate. Mr.

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Mark Ruddle, of Dublin, also thought that the keeping of detailed records in large stations was impracticable, owing to the time involved in their preparation, and that the time of the staff was better spent in inspecting the plant and seeing that it was in proper working order.

Although records are easy, and give the desired result with a minimum of trouble when it is a question of electrical measurements, the mechanical engineer finds himself in a much less happy position when he attempts a continuous record of the performance in the boiler house. To ascertain the total quantity of coal and of steam over a long period is a simple matter, but what it is really desirable to know is the rate of usage rather than the total usage, although the latter is also highly necessary as affording a more reliable figure in the long run. The total does not, however, show how the working varies from day to day. Unfortunately, to obtain a continuous record of the rate of using coal is far from easy. The capacity of the boiler produces a difficulty at once, and leads to the likelihood of introducing serious errors over short periods, even as regards the water. It is almost impossible to ensure the standard quantity of water in a bank of boilers at the end of each days's run, and, therefore, the measurement of the steam in some form or other seems preferable to the measurement of feed water. Coal consumption in particular is a difficult matter to handle from the point of view of continuous records, and it looks as if some indirect method of attack should be adopted. In the case of hand firing, extreme regularity cannot be expected. With mechanical stoking the outlook would seem more hopeful, but at best it would appear that the determination of coal, as coal, must depend upon the measurement of a quantity over a more or less long interval of time, which is not what is desired. It is the difference between the voltameter and the ammeter.

On the particular question of the desirability of continuous records, we do not think there can be any question that they are really desirable if the cost of their production is not too high. Probably very few engineers have an exact idea how the cost of production varies at night on low loads, as compared with production in the daytime. Mr. C. E. C. Shawfield, of Wolverhampton, mentioned that he had obtained results showing that an increased production of units at night caused a reduction in the coal consumption, but he did not care to put forward this result without some hesitation. Evidently, if electrical energy is produced so uneconomically at night by many stations, the addition of a street lighting load may cause practically no difference in coal consumption, and should enable street lighting to be effected at times of light load at an extremely low cost. We do not suppose that such a doctrine, as enunciated by Mr. F. E. Ayton, of Ipswich, will meet with approval from our gas friends, and they may attempt to show that it is wholly illogical. There is, however, nothing illogical in it if the facts are as suggested by Mr. Shawfield. It is in questions of this kind that continuous records would prove of very great utility; and so long as the true perspective of the subject is not lost sight of we think that much will be gained by cultivating this aspect of electrical generation.

ELECTRIC CABLES.*

ELECTROLYSIS.

BY F. FERNIE.

(*Concluded from p. 383.*)

Summary.—The author first considers the general phenomena of electrolysis as observed in the neighbourhood of electrical networks. He then discusses in more detail the corrosion of lead-covered cables and armoured cables, and the effectiveness of earthing. Another cause of deterioration is electric osmose, which causes an accumulation of moisture at the negative conductor if there is any flow of current through the insulation. Finally, the causes of faults and measures for preventing them are considered. Faults may be classified into those of manufacture, those caused during laying, and those developed after the cables are laid. The last class is due to a number of causes, such as mechanical injuries, electrolysis and electric osmose, chemical action, overloading and decentralisation, high temperature, abnormal pressures and static discharges. Another cause of trouble is the accumulation of gas in manholes, causing explosions. The various ways in which gas may accumulate are considered and the remedies to be applied.

Manhole Explosions.

Manhole explosions are caused when an accumulation of inflammable gas is ignited by an arc on a faulty cable, or by sparking generally. It is possible that gas may be exploded by the hydrogen which takes fire when sodium or potassium combine with water. It is well known that metallic sodium and potassium are deposited on a faulty negative cable by the electrolysis of the soil. The presence of these metals in a duct or manhole therefore implies a leaky cable or fitting, and hence this form of ignition is really only a special case of the general one quoted above. It is conceivable that a spark might be produced in a manhole by some stray current from an outside source, or from a fault current from somewhere else on the network, travelling along the lead of a cable. When a cable is used for high potential alternating currents the lead may spark to earth if it is not earthed properly, or if a bond has been melted or broken; this is a consequence of the condenser action of the cable.

The gas in the manhole may be the result of leakage from a faulty gas main, or it may be an inflammable gas generated by the decomposition of a cable dielectric or covering through heating, or it may be an accumulation of marsh gas, CH_4, the miner's "fire damp." The latter is always a product of the decomposition of vegetable matter in soil, and hence may easily be present in underground ducts; it may also come from drains and sewers. The spontaneous combustion of phosphoretted hydrogen in air may be sufficient to ignite accumulation of other gases. PH_3 may be formed by the action of lime on animal phosphates existing in road refuse. Coal gas is only explosive when mixed with air in certain proportions, the limits being 5 to 25 per cent. of coal gas. About 10 per cent. coal gas gives the most explosive mixture.

The gas given off by vulcanised bitumen, or the bitumen round a "solid" laid cable, is probably a mixture of several hydrocarbons. The resin in a paper-insulated cable may also give off some explosive gas, such as olefiant gas (C_2H_4), but probably not to a sufficient extent in practice to cause an explosion, as a fault on a paper-insulated cable is generally very local, and only a small portion of the paper insulation is destroyed. Marsh gas mixed with about 10 times its volume of air forms a powerfully explosive mixture.

Bare copper strip in culverts has earned a bad reputation for explosions. The gas in this case must come from an outside source—*i.e.*, it must be coal gas or some gas generated from decomposing matter in the soil. This is the most likely case for the firing to be caused by sodium or potassium, as accumulations of alkali salts often appear in concrete culverts on the insulators; these metals when combining with water might also generate sufficient hydrogen to form an explosive mixture. If an arc is formed between two adjacent strips of copper of opposite polarity in a culvert it may travel along the copper for a considerable distance, travelling in such a direction as

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to increase the area of the circuit of which it forms a part. Such an arc may then fire gas in a manhole some distance from the point where the arc was formed. Its path may be traced by the little beads of copper formed on the strip. Such an arc may be prevented from going far by inserting dividing fillets of slate between the strips of opposite polarity in the straining boxes.

Vulcanised bitumen cables drawn into earthenware ducts are probably the most frequent cause of explosions, and this is because this class of duct is the very worst for such cables, and hence faults are more frequent with this combination than with others, and where faults are frequent there is naturally a great probability of explosion. Also a vulcanised bitumen cable is likely to generate inflammable gases in greater bulk, and at a greater rate, when overheated than other types of cables. Some disastrous explosions have occurred in Manchester, within the last few years, which have been mostly attributed to the volatilisation of the bitumen surrounding the cables and the formation of an explosive mixture.

In a report by Mr. J. A. Bell to the gas and electric lighting committee of the Aberdeen Corporation,* on the culvert explosions in that city, it is stated that the mere sudden expansion of air, caused by a short-circuit will blow up manhole covers. "Those experiments tended to show that the explosions were in many cases brought about by the sudden heating and consequent expansion of the air in the manhole or culvert." On the other hand, violent short-circuits have occurred in manholes and culverts that have *not* blown up any covers, but as direct experiment has proved its possibility, the fear of its occurrence can never be entirely absent. Very curious things happen sometimes in connection with explosions

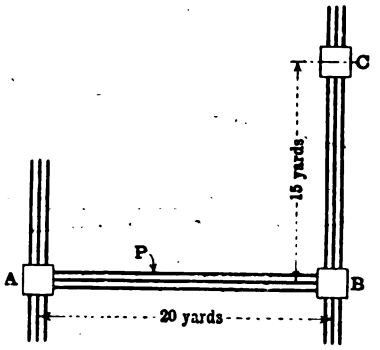

FIG. 1.

in mains. Cases have occurred where starting at some fault, a series of some twenty manhole covers have been blown up, one after another along a whole street. The ducts and manholes in these circumstances were probably all full of a fairly strong (over 15 per cent.) mixture of coal gas and air, and this burned back through the ducts causing an explosion in each manhole. Often the most unexpected cover will blow up. Referring to Fig. 1, A, B and C represent three manhole covers connected by ducts as shown; a steel wedge was driven into a cable at P, causing a bad "earth." The manhole at B was open at the time, A and C were both caulked down and air-tight. The cover of A was light compared to that of C which was exceptionally heavy. Before A could be opened, C cover was blown up at least 20 ft., although nothing was wrong with the cables in C. After A was opened, and the fault disconnected, some gas continued burning at the mouth of the ducts, leading from B in A. It was burning with a blue flame and came in gusts, with a roaring noise, very like a large blow lamp. The faulty cable was lead covered, and paper insulated, and about 2 in. of it only were burned away. This explosion may have been caused by marsh gas, and probably the large earth current travelling on the lead of the cable produced a spark in box C. The boxes were carefully caulked down afterwards, but no trace of coal gas accumulating could be found after some weeks. It is said, however, that coal gas percolating through soil, may lose its characteristic odour. Stoneware conduits with square holes are sometimes shattered by an explosion if it takes place wholly or partly in ducts. Occasionally they will be cleanly divided as if cut with a chisel (*see* Fig. 2); this has been found to occur on 10 or more consecutive casings each 2 ft. long. As regards remedies, ventilation may be used to prevent the slow accumulation of gases, and also to minimise the effect of the explosion, but will not be an *absolute* safeguard if the gas is there and a spark occurs.

The best and easiest method of ventilation is to use ventilated box covers. Such covers must tend to promote a circulation of air along the ducts, since heavily loaded cables will heat up the air in them more than where the load is light; hence the circulation of air will be, in general, from the outskirts of a network towards the central, most heavily loaded parts. Fig. 3 is a sketch of a portion of such a ventilated water-tight

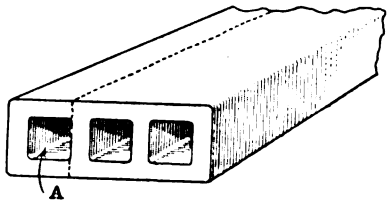

FIG. 2.—EARTHENWARE THREE-WAY DUCT.
Dotted line shows course of fracture caused by explosion in duct A.

box. The cover and frame are of cast iron, the cover being filled with concrete, and hinged, so that in the event of an explosion, the danger is very much minimised, the cover flapping open and then shutting down again. Such a cover requires no caulking; the drain pipe may be led to the gutter, or be built round with broken stones. Box covers have also been chained down to minimise the effect of an explosion; even should the chain break it is unlikely that the cover will rise high enough to *fall* on a passer-by, which is the worst danger. A brick built box, lined with cement is both cheaper and handier than a cast-iron box. There is no difficulty in making it water-tight. When it is remembered that manholes

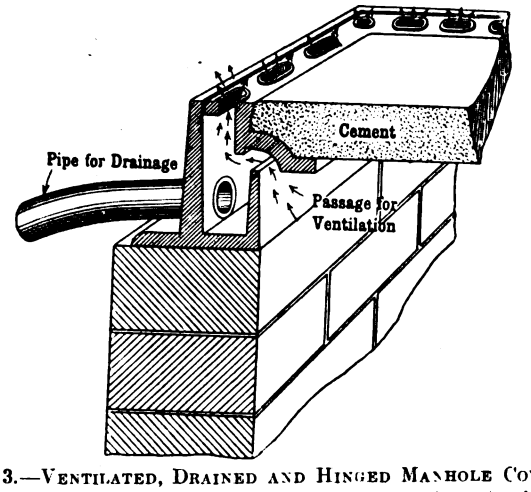

FIG. 3.—VENTILATED, DRAINED AND HINGED MANHOLE COVER.
The outlet of the drain is covered with broken stones. The cover bears at each corner. Hinges not shown.

have frequently to be built in between and amongst pipes, and with ducts coming in at all sorts of different levels, the superior adaptability of the brick box will be evident. With a cast iron manhole, it is sometimes necessary to find the place where it is possible to put it, rather than to put it in the best possible place.

Railway Electrification in Sweden.—"The Times Engineering Supplement" states that a proposal has been adopted by the Swedish Government for the electrification of the State Frontier Railway in the north of Sweden, the power to be derived from the Porjus waterfall, near Gellivare. This fall is believed to be capable of yielding 50,000 H.P.—about 16,000 H.P. in excess of the requirements when the railway is working under normal conditions. An electric generating station is to be erected at Porjus, and a railway is to be constructed from that point to Mount Gellivare. The cost of this work, including the electrification of the Frontier railway, is estimated at £1,194,500

* THE ELECTRICIAN, August 23, 1907.

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THE SENSITIVENESS OF SYNCHRONISING APPARATUS.*

BY J. TEICHMÜLLER.

With single-phase alternators there are two methods of synchronising, viz., by so coupling them to the lamp that it either burns brightly or not at all. With three-phase machines there are still

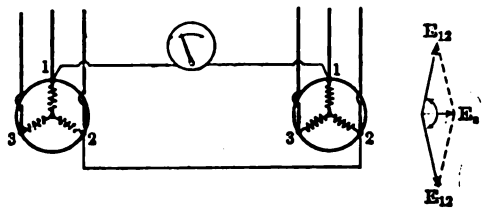

FIG. 1.—($\alpha = 180°$)

two other methods. The four systems of connections are shown in Figs. 1 to 4. The two first can be used either for single-phase or three-phase machines, the instruments being supposed to be voltmeters. Let us suppose the alternators to be in phase when the voltages in the synchronising circuits differ by the angle α, which

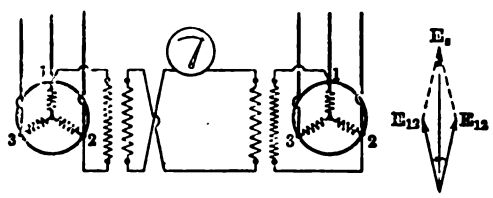

FIG. 2.—($\alpha = 0°$).

may be called the angle of synchronisation. Its value in the various cases is as follows, viz., in Fig. 1, $\alpha = 180°$, in Fig. 2, $\alpha = 0°$; in Fig. 3, $\alpha = 120°$; and in Fig. 4, $\alpha = 60°$. The vector diagrams are given in all cases, though in Figs. 1 and 2 the angle α differs slightly from its proper value, in order to show the result more clearly.

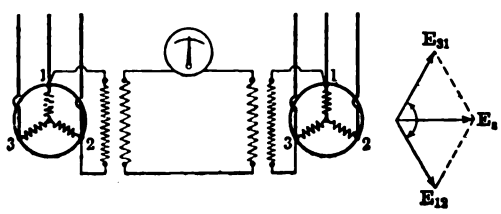

FIG. 3.—($\alpha = 120°$).

Voltage transformers are assumed in all cases to be connected to the voltmeter.

The question now arises as to which of these methods is the most sensitive, and it is necessary on many grounds to have a clear conception of the different cases, as this has a bearing not only on the method of synchronising, but also on the type of instrument to be supplied on the switchboard.

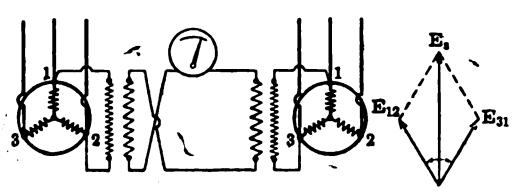

FIG. 4.—($\alpha = 60°$).

The voltmeter shows the algebraic sum of the machine voltages, each of which may be supposed to be E, the sum being E_s.

Therefore $$E_s = 2E \cos \frac{\alpha}{2}.$$

The sensitiveness of the method is given by the equation

$$\frac{dE_s}{d\alpha} = E \sin \frac{\alpha}{2},$$

the negative sign being omitted as unessential. The precise value of this last quantity is not so much the point as the extent to which it is indicated on the voltmeter. It is, therefore, necessary to consider the connection between the deflection on the voltmeter and the voltage. Let us assume that x being the deflection, the connection can be expressed as follows, viz.,

$$x = cE_s^n = 2^n \cdot c \cdot E^n \cos^n \frac{\alpha}{2}. \quad \ldots\ldots\ldots\ldots \quad (1)$$

The value of n depends on the instrument under consideration, and in order to compare the instruments on a convenient and common basis, we must suppose that the deflection in all cases is the same for the maximum voltage that can occur. This is, of course, 2E, and we have therefore $c = \frac{A}{(2E)^n}$ or $x = A \cdot \cos^n \frac{\alpha}{2}$, if A is the maximum deflection. The sensitiveness of the indication becomes

$$\frac{dx}{d\alpha} = \frac{n}{2} A \sin \frac{\alpha}{2} \cdot \left(\cos \frac{\alpha}{2}\right)^{n-1}. \quad \ldots\ldots\ldots \quad (2)$$

The expressions given in eq ations (1) and (2) are plotted in Fig. 5 for values of n between $\frac{1}{2}$ an i 6. These curves must now be examined.

The deflections have in all cases their maximum values corresponding to the zero value of α, and at this point a horizontal line through A is a tangent to all the curves. The sensitiveness at this point is in all cases a minimum. The deflections decrease with increasing values of α, falling more quickly with the higher values of n. For $\alpha = 180°$, the deflections are in all cases zero, but they approach this value in characteristically different fashion. At this point the sensitiveness is infinite for all values of n less than unity; it is zero for all values of n greater than unity; for the value 1 it has a certain finite value. Voltmeters, for which the value of n is greater than unity (and this includes probably every instrument on the market), are on strictly theoretical grounds unsuitable for the values

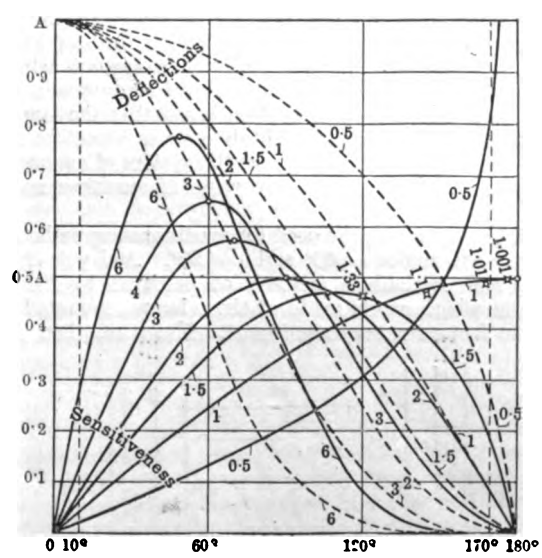

FIG. 5.—CURVES SHOWING THE CONNECTION BETWEEN THE DEFLECTION OF THE VOLTMETER AND THE SENSITIVENESS IN THE FOUR POSSIBLE METHODS OF CONNECTION.

$\alpha = 0°$ and $\alpha = 180°$. Practical difficulties would indeed be felt, if it were only ɪ ossible to switch the alternators in parallel exactly at the instan, hen there was a precise similarity of phase. But this is not so. We must find out the rates at which they tend to approach their limiting values at these points; in other words, we must study the shape of the curve of sensitiveness at these points. For the value $n = 2$, there is no difference in the choice between $\alpha = 0°$ and $\alpha = 180°$; for higher values of n the differences are most marked in the neighbourhood of $\alpha = 0°$; for lower values, $\alpha = 180°$ is to be preferred.

There are scarcely any instruments on the market for which n is equal to 1, and absolutely none for which n is less than 1. This leads us to see whether it is not possible to connect up so that there is a difference of voltage in the synchronising circuits at the instant when there is a similarity of phase in the machines themselves, in so far as their relations to the 'bus-bars are concerned. With polyphase current there are two such methods, as shown in Figs. 3 and 4. Indeed, when sensitiveness is a matter of importance, these methods are always to be preferred. For values of n greater than 2, the method in which $\alpha = 60°$ is to be preferred; for values between 1 and 2, it is preferable to connect up so that $\alpha = 60°$. It is only for $n = 1$ that it is well to consider the case of $\alpha = 180°$, but even then it is only very slightly higher than for $\alpha = 120°$. It is also necessary to bear in mind that in the cases of $\alpha = 60°$ and $\alpha = 180°$ the voltage shown on the synchronising voltmeter depends on the 'bus-bar voltage, which is liable to vary with the time of day; and it may therefore be advisable to have two scales, the one showing the 'bus-

*Abstract of an article in the "Elektrotechnische Zeitschrift," March 17, 1910.

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bar voltages, to which the synchronising voltages, shown on the other, correspond.

We are now, therefore, in a position either to choose the type of instrument which suits a certain system or to choose the system best adapted for use with a given instrument. Doubtless the value of n might vary over the range of any particular instrument, but such variation would not be likely to affect the point of the argument. It might also be of interest to attempt to devise a method for use with single-phase machines by which a difference of phase in the synchronising circuits might coincide in point of time with a similarity of phase in the machines themselves; and a device of this kind, which could doubtless easily be contrived, would be of special importance in cases in which the machines were automatically connected to the bus-bars.

The curves for $n=4$ and $n=6$ are also shown, because they affect the use of lamps as indicating devices, for in the neighbourhood

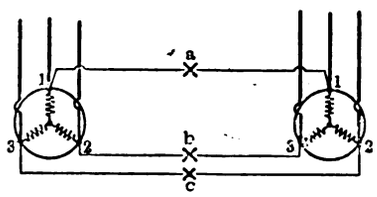

Fig. 6.—First Method of Connection on Michalke's System.

of its working voltage the illumination of the tungsten lamp varies as the 3·6th power of the voltage, and the carbon lamp as the sixth power. It, therefore, is evident that carbon lamps are more sensitive for the purpose. But it is noticeable that for $\alpha=0$ the sensitiveness is, as before, a minimum. It is therefore not astonishing that lamps give no very decided indication of an approach to similarity of phase. The objection is often heard that the lamps tend to dazzle the attendant, so that slight differences cannot be noticed, but this is probably not the case, and the system of connections is more likely to be the cause of any want of sensitiveness in the method.

Lamps obviously cannot be used for synchronising without other apparatus for the angles $\alpha=60°$ and $\alpha=120°$. And yet, if used in connection with Michalke's method, as patented by Siemens & Schuckert, in which use is made of three lamps, mounted on the board, these facts are very significant. There are then the two

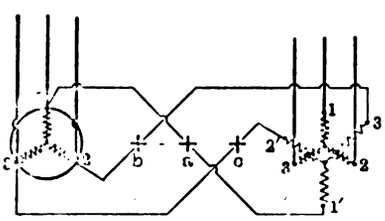

Fig. 7.—Second Method of Connection on Michalke's System.

methods, shown in Figs. 6 and 7, which are possible. The angles between the voltages are as follows, viz., in Fig. 6, for the lamp a, $\alpha=180°$; for b, $\alpha=60°$; and for c, $\alpha=60°$. In Fig. 7, for lamp a, $\alpha=0°$; for lamps b and c, $\alpha=120°$. As far as lamp a is concerned, it gives no light in Fig. 6, and shines brightly in Fig. 7. In both cases, at the moment of synchronisation, lamps b and c burn equally brightly; on either side of this point their lights are unequal. If we compare the two methods with reference to the sensibility of the lamps, Fig. 7 has the advantage in that a shines brightly, but Fig. 6 is better in so far as b and c are concerned, since we have already found that the sensitiveness is greater for $\alpha=60°$ than for $=120°$. It must, of course, be allowed that the candle-power of the lamps only varies with the 3·6th or 6th power respectively, when they are supplied with their working voltage. At 60° and 120° its value is, of course, lower, but this does not seriously affect the point of the argument.

Music by Telephone.—The "Electrical World" states that the telephone company at Wilmington have equipped a department with phonographs and keep a complete line of records. When a subscriber wants music he asks for the music operator and selects from the catalogue, supplied to all subscribers, the record he desires to hear. The result is as good as though the phonograph itself were transported to the receiving end of the line. The charges are 1½d. for regular records and 3½d. for those by operatic stars.

RECENT DEVELOPMENTS IN TELEGRAPHY AND TELEPHONY.*

BY SIR JOHN GAVEY, C.B.

We may select the ordinary Morse circuit as our starting point. With the simple form of this circuit the speed of working is limited by the skill of the operator, and rarely exceeds 30 words a minute. For many years this simple form of apparatus or its equivalents served the requirements of most countries, but as the telegraph service grew and the traffic rendered it imperative to erect long lines directly connecting distant cities, the problem of obtaining a greater revenue from the large capital expenditure involved became pressing, and progress was made broadly on three distinct lines of development. In the first, means were designed for the transmission of several messages simultaneously over the same conductor; in the second, by the use of suitable mechanical and electrical devices, the actual speed of transmission was raised in overhead wires to 10 or 12 times that possible by manual operating, and, finally, type printing and writing systems were invented with varying degrees of success.

Simultaneous Transmission.—In the duplex system, which admits of the simultaneous transmission of two messages in opposite directions over the same wire, at each end of the circuit is a differential receiver which comprises two equally-balanced electromagnetic coils, one of which is connected at its further end to the line wire and the other to an artificial line, which, in its electrical resistance and capacity, is as nearly as possible the equivalent of the actual line. The two inner ends of the magnet coils are connected together, so that when a current is sent from the point of junction it divides equally between the actual and the artificial lines, and the magnetic effect of one coil being neutralised by the magnetic effect of the other, the signals originating at either end pass through the home apparatus without affecting it. At the far end, however, the current passes through one coil alone of the receiving apparatus and the signal is recorded. When both keys are depressed simultaneously, if the batteries are so connected that they aid each other, then the current which circulates through the line wire and through both of the magnet coils connected thereto is doubled; but as the current which circulates through the magnet coils at each station connected to the respective artificial lines is unaltered a signal is recorded, because the balance at either end is destroyed by the action of the other operator.

The transition from duplex to quadruplex working—viz., the sending of four messages simultaneously over one wire—involved but a step. A single-current key is connected to a powerful battery which is intended to work a non-polarised magnet, but the connections are led through a reversing key, which latter is designed to actuate a polarised magnet. When the single-current key is depressed the powerful current that circulates through the apparatus actuates the non-polarised relay at the far end, leaving the polarised relay unmoved. When the reversing key alone is depressed, a weak current circulates which actuates the polarised magnet, but is too weak to act on the non-polarised instrument. If both are depressed simultaneously the powerful current from the single-current key is reversed by the depression of the double-current key, and both instruments at the far end are affected. The receiving apparatus at each end is arranged differentially, as in the duplex system, so that the outgoing currents have no effect on either of the receivers at the home end. This arrangement admits of four operators sending four messages simultaneously over one wire.

Another method, based on entirely different principles, which in theory admits of sending as many as 12 simultaneous messages in one direction, or double that number if duplexed, depends on the superposition of musical vibrations on a telegraphic circuit at one end of a line. To effect this result a number of electrically-driven tuning forks, arranged to vibrate at different frequencies, are connected through telegraphic keys to a line wire, so that on depressing any one key a series of electrical vibrations, of the frequency of its companion tuning fork are sent through the line. At the far end the receivers are of a type that will respond to musical vibrations only, and each receiver is constructed or adjusted to respond to the vibrations of one of the distant tuning forks alone and to no others. This system originated in America, but it has been developed and improved by Mercardier, in France, where it is said to have given good results recently. In the modern apparatus the receivers consist of so-called mono-telephones, each of which is so made and adjusted as to respond to only one frequency.

A method of multiplex telegraphy, based on entirely different principles, is the following: A large number of insulated metallic segments are arranged in a circle at each end of the line and divided

* Abstract of the "James Forrest" Lecture, delivered on Wednesday evening before the Institution of Civil Engineers

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into groups, say, of eight each. No. 1 of the first group is metallically connected with No. 1 of all the other groups, and, through the transmitting key, with No. 1 instrument, No. 2 with No. 2 series of contacts and instruments, and so on. Centrally-pivoted arms, provided with metallic brushes which ride over the segments, are joined one to each extremity of the line wire, and it is obvious that if both these arms, starting simultaneously from No. 1, revolve at precisely the same speed, then each segment with its instrument at one end is for a brief period placed in connection with its corresponding segment of the instrument at the distant end. If the sending key of No. 1 instrument is depressed, a brief current is transmitted to its corresponding instrument when the revolving arm reaches No. 1 contact of any group, to be repeated when the arm reaches No. 1 of the next group, and so on throughout the series. Instead, therefore, of a dot being represented by a single current of continuous duration, it is replaced by three or four shorter impulses spread over the same period of time, and a dash by three times the number of impulses. By this means it is possible, under favourable conditions, to transmit eight messages simultaneously over one wire. This system, invented by Delaney, was developed to some extent in this country, but owing to various causes it has recently been abandoned. It is, however, referred to here as the principle of revolving commutators is in use in other forms of apparatus to be dealt with later. The second method of increasing the output of telegraphic wires is the automatic or machine-transmitting instrument, which is typified by the Wheatstone apparatus adopted and perfected by the Post Office in Great Britain. In all instruments of this character a long paper ribbon is perforated by a suitable machine in an arbitrary manner, and the transmitting and receiving apparatus is so designed as to transcribe these perforations at the distant end into Morse signals, into similar perforations, into type printed messages, or even into written characters.

There are three rows of perforations in the tape, or slip, of the Wheatstone system. The centre row is continuous, as it is used for drawing the slip through the transmitter at the speed at which the latter is running, the upper and lower holes cause the transmitting key to send electrical signals, dots when these rows are vertical, dashes when diagonal. The actual apparatus which effects this object is comparatively simple. Two small vertical plungers, to which an up-and-down motion is imparted by the clockwork of the apparatus, are pivoted to two bent levers connected by horizontal rods with a small vertical transmitting key, which in one position sends a positive and in the other a negative current to line. When no slip is in the machine, the plungers as they rise and fall move the key to and fro and send reversals, which are received as dots at the far end. When the slip is inserted, if the plungers meet a series of vertical perforations they pass through at each movement and dots are still transmitted, but if they meet diagonal perforations the movements of the plungers are arrested by the unperforated portion of the paper slip, and the transmitting key is not drawn back until one of the plungers enters the lower diagonal hole of the slip, and withdraws the key from its sending position, thus recording a dash.

This Wheatstone system has been very fully developed in the United Kingdom. It is capable of dealing with traffic at a maximum rate of 450 words per minute, and it is invaluable for the transmission of news. Thus, in the central office in London, items of news may have to be transmitted to 50 or more towns simultaneously. Circuits are made up for news transmission, each providing for a number of towns, some of the circuits being of a permanent character and some formed temporarily to meet special requirements. As many as eight Wheatstone slips can be punched simultaneously in one operation, and each length of slip is run through the necessary transmitters at the highest speed considered judicious.

For ordinary public message traffic, on lines of moderate length, where each individual message is short, the Wheatstone has certain disadvantages—namely, the initial delay in perforating the slip, its distribution, and finally the re-distribution of the received slip amongst the writing telegarphists; for it is obvious that at the high speed at which Wheatstone is worked several operators are required at each end of the line to keep pace with the apparatus. In practice in this country, for circuits of moderate length, it is generally considered preferable to provide direct Morse apparatus worked simplex, duplex or quadruplex as circumstances may dictate.

With overhead lines the limit of speed in automatic working is that imposed by the receiving apparatus, which, owing to its self-induction, obstructs the reception of Morse signals at a higher speed than that named. This difficulty has been overcome by substituting a chemical for an electromagnet receiver. In this form the current at the received end passes through a long paper ribbon saturated with a solution which is decomposed by a positive current. The Morse signals appear in blue lines on the received slip. It is said that with this method a maximum speed of 1,000 to 1,200 words is possible under favourable conditions, but the difficulty in working at such high speeds, where characters are received in Morse code, and have to be transcribed manually, is the division and distribution of the slips amongst the large number of writers necessary to keep abreast of the work, the precautions needed to avoid loss of messages, the injurious effect of brief contacts caused by workmen which result in the loss of several words, and last, but not least, the difficulty and delay in obtaining repetitions where errors, false signals or missing words render this necessary.

All the foregoing methods increase the carrying capacity of the wires; in other words, they reduce the capital expenditure per message, but none of these increase the output per operator, nor do they diminish the working cost in the instrument room; in fact, with high-speed automatic transmission this cost may be higher than with other methods described. The initial preparation of the transmitting slip will always, of course, be necessary in all automatic systems; but inventors have turned their attention to increasing the speed and reducing the cost of transcription at the received end, in the case of manual as well as automatic sending, by the substitution of typing apparatus worked mechanically or electrically for the manual transcription. One of the earliest of such instruments, which has met with permanent success, and by means of which a very large proportion of the work in Europe, and nearly the whole of the trans-Continental work, is dealt with, is the well-known Hughes type-printing instrument. This consists of a disc, on the periphery of which are embossed the letters of the alphabet, numbers and other signals that have to be transmitted; a piano-like keyboard and a horizontal plate with a series of slots arranged in a circle. Enclosed in each of these slots, and connected with one of the sending keys, is a movable plunger, which is raised when the key is depressed, but which normally lies flush with the surface of the plate. An arm carried on a vertical shaft in the centre of the plate is caused to revolve above it by the motive power which drives the instrument, and when a key is depressed this arm is arrested momentarily by the protruding plunger, and a current is sent to the distant station. The printing disc and the revolving arms at both sending and receiving stations move in unison, this being effected mainly by the action of a governor, any slight want of coincidence being corrected mechanically each time a letter is printed.

The Hughes method of transmission has many advantages. It provides a clearly-typed message for delivery instead of a written one, it removes a possible source of error in transcription, and it increases the speed of working as compared with Morse by about 25 per cent. It can be duplexed, and it is used by the Post Office on all its Continental wires. It has, however, the disadvantage that a considerable interval of time elapses between the transmission of two consecutive signals, owing to the revolving arm having to traverse all the intervening letters. Baudot has obviated this waste of time by adopting the multiple system of telegraphy. He entirely abandons the Hughes method of transmission, and forms an arbitrary signal code, in which, by means of five consecutive currents, some plus some minus, in combination, he represents each letter of the alphabet, figures or other signals. By his method he can provide four or six channels simultaneously on one wire, each being worked manually. The translation of these arbitrary code signals into printed letters is effected in the following very ingenious manner: At each receiving instrument two discs, firmly fastened together, have on their peripheries a series of serrations, corresponding with the arbitrary code, which, in certain defined positions, represent the various letters of the alphabet. Riding on the periphery of one of them are five levers termed selectors, each of these levers being so pivoted as to be susceptible of a slight to-and-fro movement on its axle, and also of a transverse movement in the line of the axle. When all the electromagnets have their armatures raised the selectors rest on the inner disc, but if a certain number of the armatures are depressed, then, through the action of intermediate levers, the corresponding selectors are shifted to the second disc. As the two discs revolve together the combined selectors at some point drop simultaneously, and for a brief interval, into the series of serrations which correspond with the letter code signalled from the far end, and this movement and the rapid jerk out of the serrations as the discs revolve cause the letter to be printed from a type wheel which revolves at the same speed as the discs. The uniform revolution of the contact arms, the coded discs and the type wheels is maintained by a clever adaptation of governors and brakes, partly electrical, partly mechanical. The Baudot system admits of the transmission of a much larger number of messages over each wire than the Hughes. It is also more flexible, inasmuch as the various channels it provides can be divided amongst an equal number of towns. It is largely used in France and has been introduced into this country.

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Murray has devised a system which has undergone lengthy trials both at home and abroad. His slip has one row of perforations which gears into the moving mechanism of the transmitter, and below this a second series of perforations which represent his artificial signalling code, which is of the Baudot type. The transmitting and receiving apparatus are arranged to run synchronously. When the vertical plunger of the transmitter passes through a perforation a positive current is sent over the circuit, and when the plunger is stopped by the paper a negative current circulates. The result at the receiving apparatus is that an exact counterpart of the transmitted slip with its perforations is reproduced, and this perforated slip is passed through and actuates an automatic typewriter which prints the message. The typing machine is fitted with five horizontal plungers, which are prolongations of an equal number of slotted combs, to which in action a to-and-fro motion is imparted. The perforated slip acts on the principle of the Jacquard loom, and when at a given moment a series of perforations appear the corresponding plungers move forward and the remainder are arrested by the unperforated part of the paper. The slotted combs are at the moment so grouped that the one letter indicated by the code is actuated by the controlling motive power, and it is accordingly printed, and the combs restored to their normal position ready for the next letter. The message is typed in page form.

Creed has worked in the same direction, but he uses the ordinary Wheatstone alphabet and Wheatstone transmitter. At the receiving end a perforated Wheatstone slip is reproduced by a punching machine, which, controlled by the reverse currents from the transmitter, and, using compressed air as a motive power, perforates the received slip at considerable speed. This slip is then passed through an automatic typewriter adapted to work with the Wheatstone alphabet, which types the message on a long slip, to be gummed on the telegraph form. In both these cases the received slip can be inserted in a second automatic transmitter and the message sent on to another town—an advantage in the transmission of news. Both these systems are in use in the British Post Office.

(To be concluded.)

FIFTEENTH ANNUAL CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

(Concluded from page 405.)

The annual dinner of the Association was held on Thursday, June 16th, at the Windsor Hotel, with Mr. W. W. Lackie, the retiring President, in the chair. The proceedings were of more than usual interest, and the function was very well attended. The speeches were of the usual complimentary order, and the praises of the Association were duly sung by the conveners of the electricity committees of Glasgow and Govan. Mr. John Christie (Brighton) proposed the toast of the City of Glasgow and referred to the contemplated extension of the electricity undertaking by the erection of a monster power house on the banks of the Clyde. Sir John Ure Primrose made the speech of the evening, and was particularly happy in his reminiscences of the early days of the electrical industry. He reminded present-time central station men, and particularly those in charge of great undertakings like Glasgow, of their indebtedness to Mr. Ferranti for his pioneer work at Deptford. These remarks aroused great applause for the new I.E.E. President, who, through some evident official oversight, was seated among the guests below the top table. In response to subsequent persistent calls for a speech, Mr. Ferranti acknowledged the ovation, with his usual modesty, by expressing his thanks in a few simple words.

The proceedings of the 1910 Convention were brought to a close on Friday by the business meeting which was held in the Rankine Hall of the Institute of Engineers and Shipbuilders. There was a good attendance, and the election of President, Officers and new Members of Council was at once proceeded with.

The following is a full list :—

President : J. Christie (Brighton).
Vice-Presidents : G. Wilkinson (Harrogate), C. E. C. Shawfield (Wolverhampton).
Past-Presidents : H. Talbot (Nottingham), S. L. Pearce (Manchester), W. W. Lackie (Glasgow).
Council : A. C. Cramb (Croydon), J. H. Rider (L.C.C.), C. Furness (Blackpool), R. A. Chattock (Birmingham), F. M. Long (Norwich), T. P. Wilmshurst (Derby), A. H. Seabrook (Marylebone), S. J. Watson (Bury), Alderman Sinclair (Swansea), Alderman J. P. Smith (Barrow-in-Furness), Alderman Bruce (Sunderland), Alderman West (Coventry), Bailie Willock (Glasgow), Councillor German (Brighton).
Hon. Solicitor : Alderman G. Pearson (Bristol).
Hon. Treasurer : J. E. Edgcome (Kingston-upon-Thames).
Hon. Secretary : H. Faraday Proctor (Bristol).
Secretary : C. McArthur Butler.

Mr. Lackie announced that the Council had also elected Mr. C. H. Wordingham to be an honorary member.

The fifteenth annual report of the Council was then read, and is given below in abstract.

ANNUAL REPORT OF THE COUNCIL.

The membership of the Association now stands at 416, made up as follows: Committees (members), 170; chief electrical engineers (members), 191; honorary members, 3; chief assistants (associate members), 11; assistants (associates), 41. After allowing for deaths, resignations, removals and lapses due to members leaving municipal employ, there is an increase of 26 on last year's total.

The revenue account shows decreased expenditure under nearly every heading and an increased revenue. The Convention receipts balanced the outgoings. The net result is a surplus for the year of £93. 10s. 1d., or more than double that of last year. The balance-sheet shows a margin of assets over liabilities of £485.

Standard Specifications.—The Sub-committee on Physical Standards of the Engineering Standards Committee, upon which the Association is represented, have in hand at the present moment a standard specification for bayonet socket electric lamp-holders. This specification is already printed in draft, and its issue may be expected in due course. The Sub-committee also engaged, in co-operation with the manufacturers, in preparing a specification for metal filament lamps. The completion and issue of this specification is, however, likely to occupy some considerable time.

Charges for Current Supplied for Traction Purposes from Combined Undertakings.—The Council have been approached by the Municipal Tramways Association with a view to a joint committee being formed to discuss the question of standardising the method of charging for current supplied for traction purposes from combined undertakings. A committee of the Council subsequently met a committee of the Municipal Tramways Association, and at this conference a small sub-committee was appointed, consisting of Messrs. McElroy and Spencer, representing the Municipal Tramways Association, and Messrs. S. L. Pearce and T. Roles representing the I.M.E.A. A proposal has been drawn up by the I.M.E.A. representatives, outlining a suggested method of arriving at a correct traction charge, and will be considered in due course by the tramway representatives.

Electric Lighting Act, 1909.—The vexed question of a clause enabling local authorities generally to provide electrical fittings, &c., was unfortunately thrown out of the bill, although great efforts were made to get this clause retained. Considerable criticism was offered by the technical Press as to the action of the Association in permitting its views to be made public in connection with this matter. To avoid doing so would, however, have necessitated excluding these very critics—namely, the technical Press—from the Association meeting, which would, of course, have been most unfortunate, and even had that been done the Association views would have been explained in detail to so many members of Parliament that they must have, sooner or later, become more or less public property.

A clause has been inserted in the Act protecting authorised undertakers from encroachment by unauthorised undertakers. This clause does not, however, go quite as far as was desired, although it is of considerable assistance.

Income Tax and Depreciation.—The Council have given very careful consideration to this question, but at present are unable to make any definite recommendations. It is felt generally that there is far too wide a divergence between the lives of assets, as allowed by the two Government departments—viz., the Inland Revenue department for the purposes of assessment, and the Local Government Board for the purposes of loan periods. As indicated in the circular letter addressed to the members on March 4th, one of the largest cities in the kingdom was about to be penalised under the question of assessment of its mains. Immediately the attention of the Inland Revenue authorities was drawn to this letter, however, the question was re-opened and the allowance will probably be made. Of about 76 returns received, it is found that there are 18 undertakings where the income tax, although payable, has not yet been paid, and eight of these undertakings are resisting the terms offered by the Inland Revenue department.

Economic Wiring.—A sub-committee have been in negotiation with a sub-committee of the Cable Makers' Association, and a

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specification for a class of conductor which it is considered would satisfactorily meet the requirements of the fire insurance authorities has been drawn up. This should enable installations of this class to be carried out in an efficient manner at a minimum of cost.

Travelling Studentship.—The Council again expresses its regret at the lack of interest shown by the associates in regard to the scholarship of £10 offered annually for the best Paper on some approved subject. This year again no entries were received, and the award has only been made twice in four years.

The discussion on the report was mainly confined to the subject of municipal wiring powers. Mr. Mark Ruddle (Dublin) asked that a special effort should be made to extend the power of supplying fittings, wires, &c., to all the municipal undertakings connected with the Association. A concerted effort on the part of those municipalities which enjoyed such powers with those undertakings which did not yet possess them would doubtless bring about the desired result. Mr. F. W. Purse (Watford) seconded this proposal, and Mr. A. C. Cramb (Croydon) spoke in support of it. Mr. Cramb referred to the difficulty of working amicably with contractors, and stated that one of their principal grievances was the question of the discount on goods sold by the electricity department. Alderman Pearson (Bristol) commented upon the exclusion of the wiring clause from the Electric Lighting Bill of 1909, and said that had they allowed the clause to stand their position would have been worse than before. He was of the opinion that even if a special Bill were promoted by those municipalities at present without powers, such a Bill could not be got through the House of Lords at the present time. Mr. J. E. Edgcome (Kingston-on-Thames) remarked that the Association of itself had no powers to promote a Bill, but that if the necessary funds were forthcoming from the interested municipalities, the Association would then be able to proceed. Responding to a request from Mr. A. Blackman (Sunderland) as to the cost of the Bill, Alderman Pearson replied that it was largely a matter of the opposition encountered. The House of Commons procedure might cost very little, but if the Electrical Contractors' Association fought them, both in the Commons and in the Lords, the cost might run into upwards of £500. Mr. T. D. Clothier (Bootle) thought that the Bootle Corporation would withdraw its support from the Association if a strong action was taken in this matter. They were keenly opposed to the extention of municipal trading along these lines. Mr. W. G. Pickvance (Wrexham) expressed surprise at this suggestion. His experience at Wrexham was that it was next to impossible to co-operate with contractors, and on this account he had kept his wiring department going. The discussion concluded by a resolution that subscriptions be invited from all municipalities, whether members of the Association or not, towards a fund in support of a Bill which would extend wiring powers to all municipalities.

A further discussion then took place on the subject of a satisfactory information bureau, but as there appeared to be a conflict of opinion amongst the participants, Mr. Lackie stated that the matter would receive the careful attention of the Council.

Replying to a suggestion made by Mr. W. G. Pickvance that the Council be enlarged so as to include representatives of the smallest stations, Mr. Lackie said that a special meeting of the Association could be called to discuss the matter if Mr. Pickvance could secure the co-operation of ten other members. Mr. C. Turnbull asked that the Council would appoint special committees to consider certain problems, which were of the utmost interest to certain of the members. He cited as a typical subject the supply of electric power by municipalities to tramway companies. Mr. F. W. Purse (Watford) complained of a difficulty in giving a supply outside his area, such as was sanctioned under the Electric Lighting Act, 1909. Before approaching the Board of Trade on the matter of laying mains, the permission of the County Council, who are usually the road authority, had to be obtained. The Hertfordshire County Council had required a deposit of £100 from him before he could obtain this permission. Alderman Pearson pointed out that a licence by letter for supply outside a borough could be obtained under the Act of 1909, and that if the County Authority was inclined to be unreasonable, their consent could be dispensed with by the Board of Trade. On the suggestion of Mr. A. C. Cramb, that two members be deputed to represent the Association on the Joint Publicity Committee, Mr. J. Christie (Brighton) and Mr. F. Ayton (Ipswich) were appointed. Mr. Lackie said that the Council was endeavouring to legalise the Wiring Clause, the Standby Clause and the question of delegates' expenses in connection with the Convention.

The proceedings were brought to a close by the passing of a hearty vote of thanks to Mr. W. W. Lackie and the Corporations of Glasgow and Edinburgh for their hospitality to the members of the Association during their visits to the respective cities.

On Friday afternoon many of the engineers and their wives took advantage of the fine weather to enjoy a steamer trip down the Clyde to Rothesay, and round the Kyles of Bute.

Erratum.—We regret that in our last issue Mr. F. E. Ayton was not quite correctly reported in regard to cement for settings and flues. The cement recommended is made of ground firebrick mixed with Portland cement.

CORRESPONDENCE.

FISCAL POLICY AND THE ELECTRICAL INDUSTRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Hookham's letter in your last week's issue, I should like to give a few points showing that our free imports of manufactured goods and food were not in any way the cause of our national prosperity in the years up to 1880.

There are many points requiring explanation, by reason of the political cry, as to the advantages of free imports. Landowners had considerable political power in those days, and the desire of many residents in towns was to minimise their influence, and this Free Trade cry was so continually used that it was accepted as an article of faith by many, and the whole nation was prospering so greatly—including the landlords—that no one took the trouble to repudiate it.

The cause of our national prosperity was our civil and mechanical engineering development, assisted by other features, such as the discovery of gold in California, U.S.A., in 1847 and in Australia in 1851, which much increased the world's trade.

People constantly refer to the "hungry forties" as an argument against Protection. During this period there was a great deal of disorganisation throughout the kingdom owing to the great development of new cotton, woollen and other machinery, and consequent upon this development a young girl could do the work which formerly required two or three men. The Chartist riots and the burning of machinery was provoked by loss of work and wages, many men going back to the land; but by 1850 these riots had passed away and great development in mechanical machinery, combined with cheap coal found in the neighbourhood, enabled us entirely to control the world's supply of these manufactured goods. No country in the world had any mechanical knowledge or suitable coal, and even with wages at 4s. a month, workers could not compete against us. The railway development in foreign countries also enabled us to send these goods inland and increase our cotton and woollen manufactured exports in those places where it was very difficult to deliver articles of commerce.

Free Traders argue that distress during this period was due to high prices, although the proofs are clear that a temporary check on employment was caused by these inventions in machinery, which a few years later developed in a marvellous manner our trade with the world and greatly helped to start our national prosperity. A glance at "Whitaker's Almanac" for some years back will convince any observer that there was very little difference in the price of corn before and after Free Trade, and meat, vegetables and eggs, &c., were far cheaper than they are now. People do not recognise the difficulties of conveying goods and foodstuffs in those early days prior to

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1846. People born in 1860 or 1865 would now be 50 or 45 years old; the earliest age at which they would begin to consider any question would be 18 years—in 1878 or 1883—and none of them can realise the difficulty which traders and others had to contend with in importing foodstuffs and bulky produce from abroad.

Here are some of the difficulties :—

1. *Navigation.*—Sailing ships of small tonnage only (about 500 tons), hardly any docks available, bad harbours and rivers dangerous, bad navigation charts and instruments, few and bad lighthouses, many more wrecks in proportion owing to sailing only, long voyages, high insurance charges, long periods of waiting for cargo in the different ports (sometimes months, when the interest on the unemployed ship's capital was lost), all tended to make the cost of imported corn and goods almost prohibitive.

2. *Inland Communication.*—In the early part of the period referred to, railway carriage of goods was unknown. Prior to 1846, when railway construction commenced, we being the pioneers of this important movement, travelling by road was very difficult. One ton of stuff carried 100 miles cost £3. Rivers and canals, confined to certain parts, were the easiest means of conveyance; but in 1845 and 1846, 272 Acts for the construction of railways were passed in this country.

3. *Various Difficulties.*—In the days referred to we had no telegraph, telephone, electricity or cheap postage, newspapers scarce and difficult to be got, consequently no reliable commercial intelligence. To compare the period before the Corn Law repeal with the enormous advantages we now possess is unreasonable.

On p. 442 of "Whitaker's Almanac" for 1905, readers will see that the average price of corn was but little lower for 16 years after the repeal of the Corn Laws came into operation, in January, 1849, than for the 16 years before, clearly showing that the cost of transport had more to do with the question than anything else. Our own improvements in agriculture, such as drainage, guano and other manures, and machinery, all helped to reduce cost and increase quantities, and agricultural land from 1850 to 1880 almost doubled in value. Almost every inch was cultivated, and much employment found, owing to the fact that the expense of carrying corn to this country from Chicago was 60s. per ton more in 1860 than it now is, our agriculturists having higher protection on corn in those days than any foreign country at the present day with a duty; so that railways abroad and steamships, invented and made by ourselves, have practically, under "Free Trade," destroyed our own agricultural industry.

In Meyer's "Encyclopædia," published in Germany in 1849, there appears an article on Great Britain. [We regret that pressure on our space does not permit us to reproduce the extract sent by our correspondent, which states that Great Britain outshines all other countries in every branch of human activity, that agriculture and cattle raising are extraordinarily prosperous, that England and Scotland are the workshops of the world and swamp the whole earth with produce, that the position of Great Britain makes a large export to foreign countries absolutely necessary, and that rapid decay would result if foreign markets were closed against her.] This clear explanation from Germany is correct on every point, and ought to convince readers as to the cause of our national prosperity.

The special advantage of our national prosperity was unquestionably due to the coal and iron lying near the sea, causing it to be shipped abroad at the cheapest rates, preventing all foreign competition, owing to its low price. Also, having the world's markets in our hands assisted mechanical and civil engineering development at home as soon as railways and steamship building commenced. For 30 years we made railways, steamships, engines and machinery for every country in the world, and charged our own prices. As an illustration of how mechanical work came naturally to this country: America up to the sixties had developed a good building trade in wooden sailing ships. Having large quantities of suitable wood available adjoining their lakes and rivers, they could build at very reasonable prices, but upon the development of iron-built steam ships the business came naturally to this country and continued here for some years. The railway development in foreign countries assisted greatly the increased export of cotton and woollen manufactures all over the world. With corn but little cheaper for 16 years after the repeal of the Corn Laws than for the 16 years previous to that repeal, how can it be argued that our prosperity was due to so-called Free Trade? When we first allowed free manufactured imports, two of our workers' industries were promptly almost destroyed—the silk trade and the watch trade. And why? A ton of these valuable goods sent over cost but little more for transport than a ton of corn. If it cost £3 a ton it would amount to a trifle when divided over the watches and silk, but it would represent 12s. per quarter extra cost on the corn. The loss of these two industries was not at that time severely felt, except in certain towns, for we were so busy manufacturing machinery, &c., for the whole world that we did not feel the loss. People did not find much difficulty in obtaining employment in other directions in those days, as many markets were open to us on payment of comparatively small import duties.

Free Traders now argue that, because during 1850 and 1880 many people transferred their labour to other works and trades, they can do so now, when the foreigners, whose countries have been opened up with railways, coal and iron mines and means of quick transport, are flooding our markets with their manufactured goods and trying to supply our colonies also, and taking nothing from us on equal terms. Free Traders say tariffs on foreign-made goods benefit the few at the expense of the many, whereas it is contrary to fact. Workers are by far the larger number of our population, and how can the worker benefit by the importation of electrical machinery, motor cars, watches, silks, pianos, jewellery, &c.? Manufactured imports amounted in 1908 to 120 millions sterling net after deducting re-exports (*see* "Whitaker's Almanac" for 1910, p. 471).

A British electrician who can start a factory abroad has special advantages. He has a connection on the home market, say 10,000 customers, supplied at home free of duty, and he may work up another 10,000 foreign customers where he establishes his business. We know that 20,000 people can be supplied at a cheaper rate than 10,000 people; so that he is really better off by moving abroad, as he cannot supply the foreign 10,000 customers from home, except at prohibitive prices, owing to the duty put on by foreigners.

Now, suppose these goods are delivered rather cheaper than they can be made at home. After a few years the home trade dies out. The foreigner will then command the market and raise his price. Ultimately we shall be worse off than before, besides losing employment for a large number of people.

As regards the electrical trade, it was undoubtedly severely handicapped by the Legislature in its early days, electricians having no home market to supply for several years. There seems, moreover, little doubt that countries able to use water power for electrical and other manufactures will be able to compete against coal, provided the water storage can be effected at small cost and lower wages taken than in this country.

In concluding these notes, I should like to quote the opinion of the late President McKinley, (U.S.A.): "The people of no nation in history has ever permanently prospered under a policy which sacrificed its home industries to build up and develop the resources and give employment to the labour of foreign states."

The enormous emigration of our working men as compared with Germany shows clearly that we are giving our workmen's wages to the foreigner, in order that we may obtain cheap goods.—I am, &c.,

Ealing, June 21. BENNETT FITCH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of June 17th you publish a letter on the above subject from Mr. George Hookham. I differ wholly from his conclusions, but I cannot fail to admire the clear and definite way in which he states his case. Particularly do I

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appreciate his nut-shell paragraph in which he proves that Protection may diminish employment. I am a Tariff Reformer because I believe that there is at present a terrible quantity of unemployment in this country, and because it seems to me that protective duties cannot fail to act as a remedial measure. I do not claim that they would necessarily effect a complete cure.

In the above-mentioned nut-shell paragraph Mr. Hookham's arguments are these :—

1. Protection, if it protects, raises prices.
2. Purchasing power is therefore reduced.
3. Demand and production fall off.
4. Down goes employment. (Q.E.D.)

Mr. Hookham has overlooked a few important modifying agencies, but we will not stop to press that point. His little syllogism may work out just as he says, *but* he omits to state where the employment goes down. If we can gain employment for a thousand Britishers by putting twelve hundred Patagonians (or others) out of work, then I fear it is our duty to push aside our altruistic instincts and help our own country in the great international struggle.

An effective 5 per cent. duty cannot raise the price of the goods as much as 5 per cent., so the consumption can hardly fall below 96 per cent. of its Free Trade value. If, however, it has the effect that instead of importing half of what we need we make three-quarters ourselves the net result is this :—

Under Free Trade 50 British-made articles.
Under Protection 72 British-made articles.

To my limited understanding that looks like a gain to the country, in spite of the total reduction of output.

It is always a little risky to dogmatise about the motives and mental processes of one's neighbours. The picture drawn by Mr. Hookham of the "stubborn fervour" of the Tariff Reformer bears a marvellous resemblance to my secret idea of the Free Trader. We are all in need of Burns' "giftie." I would fain say more, but that business reasons forbid my writing over my own name, and compel me reluctantly to sign myself

London, June 20 MUDRETZ.

ELECTRIC STEERING GEAR FOR SHIPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In my article on the above subject, which appeared in your Marine issue, I omitted to mention my indebtedness to the Siemens-Schuckert Co., of Berlin, who were kind enough to send me some information regarding the progress which is being made on the Continent in this direction. This Company are interesting themselves more, perhaps, than any other firm in Germany, and anticipate important developments in the near future.—I am, &c.,

London, E.C., June 20. A. P. CHALKLEY.

ISLES THIMBLE WORKS.

From the remotest antiquity some form of protection has been used for the fingers when sewing. In the earliest times fish bones were used as needles, and a leather shield was all that was required to protect the finger, but the introduction of bronze and steel needles made a metallic protection necessary. Curious bell-shaped contrivances used for the purpose have been found in the tombs of the Egyptians and the excavations at Pompeii.

The modern thimble is the result of many centuries of development, and in the Isles Thimble Works, Birmingham, thousands of these indispensable little articles, made of nickel silver, steel, aluminium and celluloid are turned out weekly. This old-established firm, like others, has felt the effects of foreign competition, and recently was forced by the keenness of this competition to realise the possibilities of the electric drive. The firm decided to throw out the gas engine plant, and to equip electrically the whole of their works. The contract was placed in the hands of the British Westinghouse Electric & Mfg. Co., with the happiest results, as not only have the power costs been considerably reduced, but the great convenience of the electric drive has been fully realised.

It is quite interesting to follow the thimble through the varous stages of manufacture. The different metals used for making the various thimbles are taken from the warehouse to the punching department, where blanks are cut out from the thin sheets of metal. These blanks are then taken to the machine shop, where they are formed roughly into shape by passing them through two sets of dies. This shop is driven by a 7 H.P. Westinghouse shunt-wound motor, running at 830 revs. per min., which operates the lathes, presses, and small grating machines from a shafting running the whole length of the building.

The rough thimbles are next taken to the raising department, where they are put into hand-operated presses and given the correct shape; and from there to the finishing departments, of which there are two. One, which is operated by a 4 H.P. Westinghouse shunt-wound motor, is used for finishing off steel thimbles, and the other, operated by a similar motor, for those made of aluminium. In this department, the thimbles are grated, machined inside and on the edges, and then sent to the annealing department. The next operation is carried out in the dipping shop, where they are cleaned in an acid solution, and then, should they require silvering, they are passed to the silvering vat; before being put into which, however, they are dried in a rotating barrel, containing sawdust. From here they pass to the polishing room, which is operated by a 1½ H.P. Westinghouse motor, and to the inspection and store rooms.

The manufacture of celluloid thimbles is a distinct branch of the business, and is carried out in a separate building. These thimbles are made from solid celluloid rods of about ½ in. diameter, which are first cut into lengths of about ⅞ in., and then heated with hot water for a few minutes, being afterwards taken and moulded into shape and size in a small press.

These rough thimbles are then put into the drying chamber, for from 10 to 15 days, and when they are sufficiently hard, taken to the finishing department where they are machined inside and finished in small lathes. In this department, celluloid finger shields are also made in thousands every week. The power necessary for operating this department is small, and a 3 H.P. Westinghouse motor is ample for the work.

The firm manufacture a number of thimbles lined with celluloid, and their most recent patent is for ventilated thimbles, for which many inventions have been tried, but which they now claim to have solved in a practical manner. They do not confine themselves only to the manufacture of thimbles, but also make fancy boxes for enclosing them, and cardboard boxes. The guillotine marking and cornering machines are driven from a shafting running the length of the building and operated by a 5 H.P. Westinghouse motor placed on the floor.

L.C.C. TRAMWAY ESTIMATES.

On Tuesday the Highways committee submitted a summary of the estimated results of the working of the tramways for 1910-11.

The surplus on the electric lines was estimated at £934,180, and the deficiency on the horse lines £22,170, giving a net surplus of £912,010, making, with £27,233 for interest, rents, &c., £939,243. The debt charges are £662,266, income tax and sundry items £32,845, giving a net surplus of £244,132, of which £125,989 will be devoted to renewals fund and £118,143 placed to general reserve.

The committee state that the results for 1909-10 are such as to enable the full amount for renewals to be transferred in respect of that year, and also an amount to cover all shortage in the fund under the basis of provision for renewals settled by the Council on June 23, 1908. The estimates submitted are dependent upon certain dates being observed in regard to the opening of further electric lines, the progress of which is somewhat uncertain. The total expenditure on capital account for tramways up to March 31 amounted to £10,710,000, and it is estimated that £2,800,000 further will be required to complete the work of electrification and the construction of authorised lines, making a total capital outlay of about £13,500,000. The amount of £2,800,000 includes £850,000 in respect of the reconstruction of existing lines and £420,000 in respect of the construction of authorised lines as well as sums in respect of cars, car-sheds, sub-stations and certain other general items. The estimated total capital outlay of £13,500,000 is £1,150,000 more than the estimate made two years ago, the increase being due to new tramways authorised by Parliament in 1908 and 1909, the purchase of further tramway undertakings, the reconstruction of certain horse tramways on the conduit system instead of on the surface contact system, the increased amount chargeable to the tramways account in respect of street improvements, the extension of the central car repair depot, the provision of additional spare cars and additional car-shed accommodation, &c. The estimates provide for expenditure on tramways in 1910-11 of £1,500,000. If the expenditure reaches this estimate, there will remain to be expended after the end of the present year only about £1,300,000. In view of the heavy cost of widenings involved and the altered traffic conditions, it may be necessary to abandon parts of the remaining horse lines which are not of importance, and some allowance has been made for this in arriving at the total figure for capital expenditure of £13,500,000. The authorised new lines not yet constructed are small, and depend partly upon arrangements to be made with tramway authorities outside the county. The

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£13,500,000 does not include anything in respect of the proposed new tramways for which powers are being sought in the present session of Parliament. Other schemes of tramways extension are under consideration which, if sanctioned, will in due course involve further considerable outlay.

The estimates for 1910-11 are based upon an estimated car-mileage of 45,356,000, and from the latest information available it appears that the annual car-mileage in 1913 may reach 52,414,000. On the basis of a surplus on working of 5d. a car-mile the committee estimate the probable result in 1913 will be somewhat as follows—Surplus on working, £1,091,958. Debt charges (interest £372,000 and repayment of loans £432,000) £804,000, less £650 in respect of Harrow-road tramways, which will be paid by the Metropolitan Electric Tramways (Ltd.), or £797,500 net, plus income tax £16,000, or a total of £813,500, leaving a surplus of £278,458, less renewals (¾d. per car-mile) £145,594, or an available surplus of £132,864. These figures must be regarded as a rough forecast only. The lines already electrified include the best paying portion of the system, and those which still remain as horse lines include a considerable proportion which, although of advantage as part of the general tramway system, have never been regarded as in themselves remunerative. Their electrification will involve large expenditure for street widenings. Moreover, several of the extensions now in hand although needed for the convenience of the public are not likely to prove remunerative at the outset. In addition a considerable amount remains to be expended for the completion of the central car repair depot, and although this centralisation of work will no doubt tend to keep down the cost of repairs, the expenditure involves heavy debt charges which will fall upon the existing revenue of the undertaking.

PARLIAMENTARY INTELLIGENCE.

L.C.C. GENERAL POWERS BILL.

This week the Local Legislation Committee of the House of Commons has been considering this Bill, which seeks to amend the Public Health (London) Act, 1891, with a view to the more effective abatement of the smoke nuisance. Sir F. Layland-Barratt was in the chair. The clauses dealing with the matter were opposed by West Ham Corporation, the L. & N.W., Central London, and Underground Electric Railways Co. of London, the Gas Light & Coke Co. and the South Metropolitan Gas Co., the London Chamber of Commerce and the Port of London Authority.

Mr. FitzGerald, K.C., said that at present proceedings for a smoke nuisance could be taken under the Act of 1891 only if the smoke issuing from a chimney in sufficient quantities to create a nuisance was "black." Two years ago a summons in the case of the Lot's-road station was dismissed because the smoke complained of was dark brown or dark grey. It was proposed to amend the Act by omitting the word "black," and thus bringing the law in London in line with that of Scotland. Hitherto Crown factories and workshops had been exempt from proceedings for creating a smoke nuisance, but it was now proposed to bring them within the scope of the Act. The Crown works most complained of were the Arsenal, the Dockyard, and the Small Arms Factory at Woolwich. The Treasury and the Home Office objected, and it would be for the Committee to decide whether those objections justified a continuance of the present immunity. It was also proposed to empower the County Council to take proceedings where a nuisance was created on the borders of but outside the county, by which people living within the county were affected.

Mr. C. C. Hutchinson, who appeared for some electric lighting companies and the London Chamber of Commerce, argued that there was no real smoke nuisance from factories and works in London, and that such nuisance as there was resulted from the burning annually of 5,000,000 tons of bituminous coal in household grates.

Dr. H. A. Des Voeux said that they were doing well under the present law in abating the smoke nuisance, but they were not doing sufficiently well. The Smoke Abatement Society had done their best to stir up the County Council to further action, but this was not the society's Bill.

On Wednesday Mr. Chas. H. Merz gave evidence on behalf of the Underground Electric Railways Co. of London. He objected to the omission from the Bill of the word "black," on the ground that too much power would be placed in the hands of permanent officials of the local authority, and that a great hardship would be imposed upon owners of factories and workshops. Large interests ought to have definite protection, so that local authorities could not be unreasonable. The omission of the word "black" would also interfere with the construction of large generating stations, which, in the aggregate, did a good deal towards reducing the amount of smoke.

Mr. Balfour Browne, K.C. (on behalf of the Underground Railways Co. and other petitioners) said he desired to insert in the Bill certain words which would exempt from penalty those undertakings which, having the best practical installations and using them in the best practical manner, could not prevent on certain occasions the emission of smoke which might be a nuisance.

Mr. Lloyd, K.C. (for the Central London Railway), also opposed the provisions of the Bill; and Mr. Evan Parry, gave evidence against it on behalf of the company.

It was pointed out that a statutory company was at present subject to the law in regard to smoke nuisance; and, on the suggestion of Mr. Fitzgerald, K.C., a sub-clause, which brought statutory companies within the scope of the Bill, was struck out.

Mr. Balfour Browne, K.C., for the Gas Light & Coke and South Metropolitan Gas Companies, said that if the law were altered in such a way as to make the emission of smoke, other than black, a matter of punishment, gas companies could not possibly carry on their undertakings. Therefore, he asked that the companies should have either the protection of the existing Act, which said "black" smoke, or an exemption clause inserted in the Bill.

Other evidence having been given in opposition to the Bill, the Committee adjourned.

L.C.C. TRAMWAYS AND IMPROVEMENTS BILL.

A Select Committee of the House of Commons (presided over by Mr. Soames) has been considering this bill during the past week.

Mr. A. L. C. Fell, chief officer of L.C.C. tramways, described the advantages of extending the Tooley-street line to Duke-street, London Bridge. The line from Greenwich to the proposed terminus would be 1⅛ miles shorter than the existing Old Kent-road route to Southwark Bridge. The extension would bring the tramway into direct communication with the railway stations at London Bridge, and would enhance the value of the line and its connections. His estimate of the net surplus (after allowing for capital charges) on the working of the extension was £143 a year.

The scheme was opposed by Hay's Wharf (Ltd.) and others on account of interference with the provision trade, &c.

The Committee found the preamble of the bill proved insofar as it related to the Tooley-street extension, upon the County Council undertaking to include in a bill next session certain road alterations to meet suggestions made by the police.

A clause was agreed to under which the proposed extension along Dulwich-road would not be opened for traffic until the entrance to Brockwell Park had been set back and the thoroughfare there widened in accordance with a marked plan. Lambeth Council had agreed to contribute £500 towards the cost, on the completion of the work.

On Wednesday the Chairman said the Committee had visited Dulwich-road, Herne Hill, and they strongly objected to the proposal to carry a line along that road 2½ ft. from the kerb. They suggested that either the boundary of Brockwell Park should be set back or the line should be single for a short distance.

The matter was deferred to allow the committee of the Council to consider the propriety of widening the road by taking in a strip of the park.

Mr. Pollock next described the proposals for tramway extension and reconstruction and street improvements in North London. The most important of these was a line from New North-road along the western end of Baring-street and along a new street to be constructed on the northern side of the Regent's Canal, and then along the eastern end of Baring-street to Southgate-road. The horse tramway up the narrow thoroughfare, Bridport-place, would be got rid of. Various reconstructions were proposed, and throughout the conduit system of traction would be adopted. The reconstructions included the St. Paul's-road, Islington, to City-road line, and the Green-lanes to Southgate-road line.

Mr. W. F. Dewey, town clerk of Islington, and the Borough Engineer gave evidence as to the interference with footways in the borough for tramway purposes, and they objected that the scheme would not allow sufficient width for the safety of pedestrians.

The Committee adjourned.

LONDON UNITED TRAMWAYS BILL.

This bill, which came before a Committee of the House of Lords on Wednesday, proposes to extend for one year from August next the time for the electrification of a tramway over Kew Bridge, which connects the Richmond and Kew system with the Hammersmith system of the London United Tramways (Ltd.), and to allow the use of overhead wires, subject to the sanction of Richmond Corporation. Middlesex County Council opposed on the ground that the use of the trolley system would be detrimental to the strength and appearance of Kew Bridge, and they claimed the right to decide what system should be adopted.

The Committee allowed the bill to proceed, and refused to insert the clause asked for by the Middlesex Council.

YORKSHIRE ELECTRIC POWER BILL.

This bill came as an unopposed bill before Mr. A. Emmott, Chairman of Committees, in the House of Commons on the 16th inst.

It was explained that the company was incorporated in 1901, and authorised to supply electricity in bulk over a large area of Yorkshire. The company had raised a considerable proportion of its £2,000,000 capital by ordinary shares, and it was proposed to give power to divide the capital into classes of shares, to be charged on new portions of their undertaking.

Mr. A. Lupton, chairman of the company, explained that the capital issued was £266,000 of ordinary stock, the whole of which was paid. They wanted further capital to meet increasing demands for power from manufacturers.

Mr. W. B. Woodhouse, the company's engineer, gave evidence as to clause 6, which would allow the company to subscribe for or hold shares or stock in any undertaking to which they were proposing to give a supply of energy.

The Committee considered that the provision would make the company a money-lending corporation, and restricted the lending to electrical undertakings authorised by Parliament.

The bill was then ordered to be reported to the House.

Post Office Telephone Service.—In the House of Commons on Tuesday Mr. Sherwell asked the Postmaster-General why the average cost per P.O. telephone station construction was £22 to £23 more per station than the National Telephone Co.'s average (as stated by the company's chairman.

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In reply, Mr. SAMUEL said the chairman of the company had overlooked the fact that the P.O. expenditure included about £1,000,000 expended in providing plant for the use of the company, although he had previously mentioned the rent paid by the company for part of that plant. That sum should, therefore, have been added to the company's expenditure, raising the average cost by about £2 a station. A corresponding deduction would reduce the P.O. expenditure by about £11. 10s. per station. Moreover, expenditure on land and buildings seemed to have been excluded from the company's cost per station, and included in the cost attributed to the Post Office system; while part of the Post Office expenditure was for plant to replace the company's overhead wires and cables, and some of their older exchanges after their system was taken over by the Post Office at the end of 1911. Further, about 65 per cent. of the Post Office stations were in London, where a very costly underground system had been provided.

LEGAL INTELLIGENCE.

The Attorney-General v. Leicester Corporation.

On Monday Mr. Justice NEVILLE delivered his reserved judgment in this case. His lordship said that defendants were the undertakers under the Electric Lighting Act, 1882 (and a provisional order granted thereunder) for the supply of electrical energy within the borough. They claimed the right to supply wires and fittings (including bells and motors) used for the consumption of such energy to persons taking energy from them under their order. They based that claim solely on the statutory powers vested in them under the Electric Lighting Acts and order. Their title to do these things, which admittedly had been done, was the main and important issue between the parties. Plaintiff alleged that, in addition to the acts which they claimed a right to do, defendants had supplied fittings to persons in respect of buildings within the borough who do not take energy from them, and in connection with buildings, and also to persons resident outside the borough. In the view of the case which he took that was not important, and he could dispose of the matter at once by saying that in his opinion plaintiff proved his allegations.

To come to the more important question, the extent of defendants' statutory power, he thought it unnecessary to consider the nature of the fittings and apparatus supplied by defendants to consumers. By sec. 18 of the Electric Lighting Act, 1882, the consumer had the right to use the electricity supplied for all purposes without interference by the undertakers. If, therefore, defendants were entitled to supply lamps to the consumers for lighting it seemed to him they must be equally entitled to supply apparatus for the use of the electricity in any other way. Defendants contended that their acts were justified as being part of the supply within the meaning of the Act (and order thereunder), or as being reasonably necessary or incidental to such supply. Sec. 10 of the Act of 1882 authorises undertakers to generally do all such acts and things for supplying electricity as may be necessary and incidental to such supply. The Act, having expressly given powers to do all such acts and things as may be necessary and incidental to the particular power to supply it seemed to him difficult to imply any further powers to do what was reasonably incidental to the power to supply. It might well be, however, that the words should be read as necessary or incidental to such supply, in which case the general powers expressly given would be identical with the general powers which would have been inferred had the Act been silent with regard to them. That consideration seemed to him, however, unimportant, for if the right to supply energy did not itself include the right to wire and fit the premises supplied, he thought the right could not be claimed as incidental. If there were a distinction between supply and use, so far as the undertakers were concerned, the acts done were clearly referable to the use, and not to the supply. He might say that, in his opinion, the Court was in no way concerned with the consideration of the desirability or undesirability of the powers claimed being vested in defendants; that was for the Legislature alone. Further, he thought it immaterial whether defendants had made a profit or a loss by the business. If it was ultra vires it was not the less so because it was commercially successful. Nor could the most brilliant success enlarge the powers of defendants. An analogy between the Acts relating to gas and electricity had been insisted upon as indicating the intention of the Legislature to bestow upon the undertakers under the latter powers with regard to the supply of electrical fittings and apparatus similar to those bestowed by the former with regard to pipes, burners, meters and lamps. In fact, however, secs. 13 and 14 of 10 and 11 Vic., chap. 15, gave express power in the case of gas, and there was no corresponding section in the Act of 1882; while sec. 18 of the latter Act expressly negatived the right of undertakers to prescribe any lamp or interfere with the use of electricity in contradistinction to the right to prescribe the burner given to the undertakers by sec. 18 of the Gas Act. He thought, therefore, that the analogy failed. He also thought that there was nothing in the sections of the Act of 1847 inconsistent with the construction of "supply" in the Act of 1882 contended for by plaintiff, namely, that it meant the supply of energy to the consumer at his terminal. Sec. 18, already referred to, plainly discriminated between supply of electricity and its use, and gave the undertakers no authority with regard to the latter. When they turned to the provisional order the interpretation, in his opinion, became still plainer. "Consumer's terminals" was stated to mean "the ends of the electric lines situate upon any consumer's premises and belonging to him at which the supply of energy is delivered from the service line." The undertakers had power to charge for supply of energy and for meters and fittings, but for furnishing and laying lines they had no power to charge, except in special cases, by clause 21 of the provisional order. However, they were bound to give a supply of energy on demand, and if the wiring of the house and provision of fittings was part of the supply, they would be compellable to do it without remuneration, and he thought there was force in plaintiff's argument that that could not have been intended by the Legislature. In his opinion "supply" within the meaning of the Act and order was completed at the consumer's terminals. The "installation of electricity" and provision of fittings was, in his opinion, a separate business incidental to the use, but not to the supply, of energy. He thought that defendants had misinterpreted their powers and had been carrying on a business in excess of them. In his opinion the Act of 1909 did not throw light upon the meaning of "supply" in the Act of 1882, sec. 16 not having, in his opinion, reference to any power given by the Act of 1882. He thought plaintiff was entitled to the declaration asked for in para. 1 of the claim and to an injunction in the same terms. Defendants must pay the costs of the action.

Mr. DANCKWERTS said his clients would like to consider whether they would carry the matter further. He asked for the suspension of the injunction.

Mr. Justice NEVILLE: Certainly, if notice of appeal is given within reasonable time—within three weeks, and duly prosecuted.

Mr. DANCKWERTS: I take it the injunction will be general.

Mr. Justice NEVILLE: I think the injunction ought to go in the form asked under the Act, because there were those minor matters, but he did not think it mattered much.

"Z" Electric Lamp Mfg. Co. (Ltd.) v. Marples, Leach & Co. (Ltd.)

On Saturday in the Court of Appeal (the Master of the Rolls and Lords Justices Farwell and Kennedy) plaintiffs asked for an order for the security of costs of the appeal which defendants had entered from the judgment of Mr. Justice Parker, which granted an injunction to restrain defendants from infringing plaintiffs' patent for improvements in the manufacture of filaments for incandescent electric lamps.

Mr. WALTER, K.C., for plaintiffs, stated that defendant company was in liquidation, and it had been agreed that security should be found for the costs of the appeal in £200 within 10 days.

Mr. THOS. T. TERRELL, K.C., for defendants, pointed out that his clients had paid the taxed costs in the Court below.

Their lordships assented to the arrangement.

Overhead Telephone Wires.

Last week Judge Harington delivered his reserved judgment (at the Croydon County Court) in the dispute between Croydon Corporation and the Postmaster-General in regard to the erection of overhead telephone wires in 17 roads in Croydon and Norbury. In the course of his judgment, his Honour remarked that the Postmaster-General declined to accede to the request of the Corporation to put the wires underground on the ground of expenditure, the difference in the cost for the roads in question working out at £726. 17s. 7d. The Postmaster-General had already spent £65,000 on underground wires in the district, and only £1,800 on overhead. It seemed to him that telephonic communication was quite as important and necessary as telegraphic. The Corporation said the poles and wires would have the effect of lowering the letting value and depreciating the selling value of house property in the roads concerned; that they would be a source of danger in times of storm and tempest, and that they would be obstructions to the traffic. He did not think much weight could be seriously attached to the objection as to danger, which was very small indeed. Neither was there any substance in the objection that the humming noise disturbed the domestic peace and comfort, while the objection that they would increase the danger to the traffic was somewhat far fetched. There was no evidence to support it, and the same objection might apply to trees which were planted on the footpath.

The evidence as to the depreciation of property was unconvincing. House property had depreciated in the Croydon district during the last 10 years, but there was no evidence to show that the result of the late Judge Russell's award, in a similar arbitration, had depreciated the property in the roads affected. The objection that the poles would be a disfigurement was really the fundamental one which induced the Corporation to refuse their consent to the proposed works. He did not attach any great weight to those objections, and although the Corporation had canvassed all the roads, less than 50 per cent. of the residents had objected. The result of his award must be in favour of the Postmaster-General in every case, subject to conditions 1, 2, 3 and 4 in the award of 1907. As to condition 2, he thought that 30 wires should be substituted for 36, and in each case the poles and wires should be fitted with appliances to prevent the humming noise caused by vibration.

Jones v. National Telephone Co.

In the City of London Court on Friday plaintiff (Mrs. E. Jones), owner of a freehold house in South Lambeth, claimed an injunction and £5 damages against the National Telephone Co. for attaching "a telephone appliance" to her chimney stack.

Mr. GOODMAN, for plaintiff, said that plaintiff let the house to one Nicholls, who had a telephone put on without plaintiff's knowledge. He left, and then the company persuaded his successor to sign a wayleave, although he did not want the telephone, and, later on, they sent him a

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crossed cheque for 1s. for a year's rent. The freeholder objected, and wanted the telephone attachment removed, as the roof was being damaged.

Mr. GAINE, for the company, said he had never heard that a tenant could not permit a telephone to be fixed or remain on his premises.

Judge RENTOUL, K.C., thought a tenant could have a telephone put on without the landlord's approval.

Mr. GOODMAN: No Parliament would give any telephone company such a right as is contended for without the freeholder's leave. The company had paid a guinea into Court, with a denial of liability.

Mr. GAINE urged that that was amply sufficient to recompense plaintiff. Her reversionary interest had not been damaged; hence she had not suffered. The tenant could give the company six months' notice to remove the telephonic attachment.

Judge RENTOUL suggested a compromise, and the parties agreed that the telephone should be removed within a month, no costs on either side.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Governors of Robert Gordon's Technical College (Aberdeen) are about to appoint an engineer graduate of distinction as head of the engineering department of the college. Salary £500 per annum. Applications to the principal (Mr. Chas. Stewart, M.A.), by July 16. See also an advertisement.

The governors of the Technical Institute, Loughborough, invite applications for the position of lecturer in engineering subjects. Commencing salary £120 per annum. Particulars from the Principal, to whom applications should be sent by July 3. See also an advertisement.

A first-class electrical engineer is wanted, with experience in the design of c.-c. machinery. See advertisement.

A competent selling electrical engineer is wanted at once for India. See an advertisement.

Two or three first-class draughtsmen and two or three juniors are required for works in London. See an advertisement.

An instructor in engineering subjects is required at the Victoria Institute Science and Technical Schools, Worcester. Salary £150. Applications to Mr. Thos. Duckworth, Victoria Institute, Worcester, by June 29.

Applications are invited for the position of secretary in the Birmingham Corporation electric supply department. Applicants should have had a sound commercial training in some large mercantile or manufacturing concern, and a certain amount of technical knowledge in connection with electricity supply is also required. Salary £600 per annum. Applications to the city electrical engineer, Mr. R. A. Chattock, M.I.E.E., 14, Dale End, Birmingham, by July 1.

Mr. Harry Webber, assistant electrical engineer at Sunderland, has been appointed borough electrical engineer at Keighley, at a commencing salary of £250 per annum. There were 123 applications.

Mr. C. E. C. Shawfield, borough electrical engineer and general manager of the electricity works at Wolverhampton, has been retained as consulting engineer of the tramways department, and Mr. H. Vickers has been appointed tramway engineer and chief assistant to the general manager at £200 per annum.

Mr. J. Hayward Home has resigned his position as engineer and manager of the Berwick-on-Tweed electricity works in order to take up the position of managing director of the Kenyon Ironworks Co. (Ltd.), Manchester.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

Heriot-Watt College (Edinburgh).—This college provides theoretical and practical training for mechanical, electrical and mining engineers, technical chemists, brewers, &c., and printers and publishers. The training for engineers consists of three years in the college and a three years' apprenticeship on the "Sandwich" system in a local engineering works. The course in mining extends over two years, and the training is also recognised by the University of London for the B.Sc. degree in mining. Complete courses of instruction, extending over four years, are provided for students studying for the fellowship of the Institute of Chemistry, &c. An entrance bursary of £25 will be offered for competition on Sept. 27 and 28 next. Particulars of fees, &c., may be obtained from the principal, Mr. A. P. Laurie, M.A., D.Sc.

Education Bequests.—The late Prof. Jas. Campbell Brown, of Liverpool University, left estate valued at £43,101. 19s. 5d., with net personalty £42,740. 2s. 1d.

He bequeathed £25,000 to £28,000 for a professorship at the University of Liverpool (or, alternatively, at the University of Manchester); £1,500 for an advanced chemical scholarship at Liverpool; and from £5,000 to £8,000 for an entrance scholarship for chemistry in Liverpool University.

Aldershot.—An unopposed inquiry was held last week into the Council's application for sanction to borrow £1,500 for electric supply mains, services, &c.

In the course of the inquiry the inspector (Mr. H. ROSS HOOPER) raised the question of the pooling of loans, and in reply

The clerk (Mr. W. E. FOSTER) said that the pooling of loans had taken place because the business had been all the time increasing, and the necessary money required by the department had not been to hand.

The INSPECTOR: You will have to start perfectly clear. You must pass a resolution that the expenditure on each loan must be spent separately, and there must be no more pooling of loans. He noticed that during the eight years the Council had conducted the undertaking it had not cost the ratepayers anything. He did not think they need allow the fact of their having a small balance on the wrong side to trouble them to any great extent, because, after all, that was not so important as that they should carry on the undertaking in a financially sound way, and that they should have no trouble or difficulty with their capital.

Argentina.—The "Financial Times" states that the first section of the extended system of the Buenos Ayres Port and City Tramway Co.'s electric tramways in the Avellaneda district will be opened at an early date, and the whole of the new track (over 13 miles) should be in operation before the end of this year. There has already been a great increase in this company's traffic receipts, chiefly due to the fact that a contract under which coal and general freight is carried for the Cia Alemana Transatlantica de Electricidad has come into force.

Battersea (London).—The electrical engineer (Mr. F. A. Bond) has reported on the experiment made by him in the use of carbon brushes in place of wire gauze brushes for the turbine generator sets.

Mr. Bond states that by adopting carbon brushes the machines are more reliable and efficient, and the Electricity committee have decided that the necessary works be carried out for providing and adapting the gear for carbon brushes to the remaining turbine generator sets at a cost of £85. 10s.

Application has been made to the L.C.C. for a loan of £18,900 for extensions of mains, &c.

Bundoran (Ireland).—Messrs. John Myles & Co. are erecting an electricity supply station in this town.

Canadian Railway Electrification.—It is stated that the Canadian Pacific Railway Co. propose to electrify their terminals at Montreal.

Cardiff.—At the meeting of the Tramways committee last week the borough electrical engineer (Mr. Arthur Ellis) suggested the adoption of the rail-less trolley system to serve outlying districts, such as Whitchurch, Llandaff, &c. The system, he said, would act as a feeler for a future extension of the tramways of the city. The matter was referred to the Parliamentary committee.

The late Ald. P. W. Carey's long service as chairman of the Electrical and Tramways committee was referred to by Mr. J. W. Courtis and Ald. Illtyd Thomas, and a vote of condolence was passed with Mrs. Carey. Mr. Courtis mentioned that Ald. Carey was appointed chairman of the committee in 1899. Mr. J. W. Courtis (deputy-chairman) was unanimously elected chairman to succeed Ald. Carey, and Mr. H. C. Vivian was elected vice-chairman.

Devonport.—The Electric Power committee again recommend that the net profit on the past year's working of the electricity department be placed to reserve, and also that the salary of the borough electrical engineer (Mr. J. W. Spark) be increased from £300 to £350 per annum by two annual increments of £25 each.

Electrical Engineer's Bravery.—On the 15th inst. the Royal Humane Society awarded a silver medal to Mr. George R. Drummond, electrical engineer to the Maharajah of Bikaner, Rajputana,

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India, for his gallantry in saving one man and attempting to save two others who were rendered unconscious in a well 320 ft. deep. Three times Mr. Drummond went down, each time bringing up a man, and he himself then collapsed, but recovered later.

Fleetwood (Lancs.).—The electrical engineer (Mr. W. H. Miller) has been instructed to prepare estimates of the cost of lighting the whole of the streets by electricity.

Freshwater (Isle of Wight).—At the last meeting of the Parish Council Mr. Parker urged the members to take steps to improve the place by adopting electric lighting, &c. He suggested that the engines at the pumping station might be utilised in the generation of electrical energy. A motion to consider the matter was carried.

Greenock.—On Tuesday the Corporation adopted a recommendation of the Electricity committee to increase by £50 per annum the salary of the burgh electrical engineer (Mr. J. A. Robertson).

In moving the adoption of the recommendation, the convener (Councillor BAILEY) said it was only just to Mr. Robertson to mention that he did not ask for an increase. Neither did he make it a pretext for an increase that he had applied for the position of borough electrical engineer at Salford. Mr. Robertson had intended, after the end of the financial year, applying for an increase of salary, but at present he had made no such request. He referred to the ever-increasing amount of work Mr. Robertson had on hand, and argued that at the present time it would not be in the best interests of the Corporation and of the ratepayers if Mr. Robertson's services were lost to the community. An increase of £50 would be a very small price to pay for retaining Mr. Robertson's services, and he understood that if the Corporation approved of the recommendation Mr. Robertson would withdraw his Salford application.

Hampstead (London).—The receipts of the electricity undertaking for the year ended March 31 were £60,270, against £62,879 in 1908-9.

The Electricity committee reported last week that they had had under consideration the question of carrying out a further portion of the works recommended by Sir Alex. Kennedy, and they recommended that further plant be installed at the station at a cost of £6,600 (condensers £3,100 and cooling towers £3,500). The recommendation was agreed to.

Hindley.—The Council have applied for an extension of time for carrying out their provisional electric lighting order.

Inquest.—An inquest was held on Tuesday into the death of Wm. H. Brown, who was killed at the Powell Duffryn Colliery on 17th inst.

Evidence was given that deceased went to remove some oil boxes near the switchboard when his hand came in contact with the plunger, and he received a shock. The voltage of the current was 1,750. The removal of the boxes without switching off the current was contrary to the Home Office Regulations. Deceased had not been instructed to remove them.

Mr. LLOYD (the electrician), in answer to Mr. Carey, inspector of mines, said deceased had an oil can in his hand at the time of his death, and was probably going to attend to the boxes. A verdict of death by misadventure was returned.

Leeds.—The Tramways committee have entered into a contract for the conveyance of between 20,000 and 30,000 tons of sand and gravel for the new beds at Headingley. The waggons will be equipped with the standard motors and braking equipment of the department.

Leicester.—The Gas and Electric Lighting committee have decided to advertise for an engineer and manager of the gas works in succession to the late Mr. A. Colson, and the electricity supply department will be placed under separate and independent management.

Llandudno.—The Council have decided, after two years' experience of incandescent gas lamps on the Promenade, to remove the temporary gas standards and to restore the electric arc lamps. Tests are to be made to determine whether ordinary arc or yellow flame lamps should be adopted.

Lowestoft.—The general manager of the tramways department (Mr. G. A. Bruce) has been asked to report upon the practicability of adopting the railless trolley system on the Kessingland light railway.

Machinery Users' Association.—At the annual meeting last week the president (Sir Wm. Holland), in moving the adoption of the report, congratulated the Association on its continued success in the work which it undertook to do. As to legislation, he was glad to say that none had been passed in the last year which affected them as machinery users, except, perhaps, the Finance Act. The report mentioned the way in which machinery users were being treated by the rating authorities. In the manufacturing districts there was now, generally speaking, no reason for complaint. There were still some districts where they had difficulty. He regretted that they had not been able to obtain legislation dealing with the general question of rating, but the present state of affairs in Parliament had made it impossible for them to introduce again the Rating of Machinery Bill, and a further reason was that a more uniform system was being brought about in connection with rating.

Nelson.—The offer of Burnley Corporation to supply electricity at 2d. per unit for the tramways has been accepted by Nelson Council.

New Submarine Cable.—On the occasion of the establishment of the first submarine telegraph connection between Germany and Africa (at Monrovia, Liberia) the German Emperor telegraphed his congratulations to the Secretary of the Post Office, and to the Nordeutsche Seekabelwerke, the makers of the cable.

Norwich.—An unopposed inquiry was held on Tuesday into the application of the Corporation for sanction to borrow £17,783 for extensions of the electricity undertaking.

The TOWN CLERK (Mr. A. H. Miller) said that since the last inquiry in 1907-8 the number of consumers had increased from 4,425 to 4,692. The undertaking was acquired by the Corporation in 1903-4, when there were 3,010 consumers. The loan was required for an exhaust steam turbine with condenser, steam exhaust and water pipes, generator, switchgear, &c. (£5,000), centrifugal pump for circulating water (£200), balancer (£160), coal elevator (£150), bye-pass flue from new boiler to shaft (£70), Patersen feed water filter for dealing with 4,000 gallons per hour (£203) and mains and services (£12,000).

The electrical engineer (Mr. F. M. LONG) supplied technical details. The total capital expenditure at March 31 was £312,374, the total amount of capital sanctioned being £311,758. The net profit up to 1908-9 was £3,678.

The Inspector (Mr. H. Ross HOOPER) said he should like to draw the committee's careful attention to the question as to how far they were saving by borrowing money for services at all, and how far they were incurring additional expense by reason of capital repayment and interest.

The chairman of the Electricity committee (Mr. WILD) said he gathered that the Inspector deprecated the dispersion in rate aid of money that might be made by the undertaking.

The INSPECTOR: Your engineer would be able to give you better advice than I could; but the first principle was to be absolutely financially sound, and the next was to bring the capital down so as to be able to give the cheapest supply for the benefit of consumers.

Mr. WILD: I anticipated your answer. I asked the question really to strengthen our hands in the position we have taken up in committee. The only time we departed from our principle was last year, when £1,200 was practically wrung from us.

The INSPECTOR: It spoils your undertaking, and does little or nothing for the rates. Your engineer will know better than I do how necessary it is to build up a private reserve, especially having regard to the fact that you paid a considerable amount to the company for the undertaking.

Obituary.—The death of Mr. J. T. Mayfield recently occurred at Clacton-on-Sea. Deceased was trained as a chemist, and acted for some years as assistant to Sir Joseph Wilson Swan. After leaving Sir Joseph Wilson Swan's service he set up as a chemist, but abandoned this for electrical engineering.

Pembroke (co. Dublin).—An inquiry was held last week into the Council's application for sanction to borrow £8,000 for extensions of the electricity supply undertaking.

The electrical engineer (Mr. S. L. R. PRICE) said the proposed extensions were necessary to meet the demands of actual customers and they were also providing for additional customers. They had 763 consumers. The total revenue last year was £7,547, an increase of £614. The use of electricity for cooking and heating was increasing.

Penmaenmawr.—The Council have decided to adopt electric lighting on the promenade.

Personal.—Mr. John Newlands, C.I.E., deputy controller of the Central Telegraph Office, will succeed the present controller (Mr. Eames) when he retires at the end of this month.

Mr. Newlands, who was born at Innerleithen, Peeblesshire, in 1857, entered the telegraph service at Edinburgh, and passed through the various grades, finally being appointed controller there in 1893. From Edinburgh he was promoted to be traffic manager of telegraphs, and while occupying this position visited many towns in the United Kingdom, and he also crossed the Atlantic to visit the most important telegraph offices in Canada and the United States. In 1905 he was offered the position of deputy-controller at the Central Telegraph Office, St. Martin's-le-Grand, London, and after about two years' service in this position he was lent to the Indian Government for reorganising the traffic arrangements of the telegraph department in India. He was occupied on that mission for two years, during which time he traversed the whole of India and Burma, where he introduced many reforms. For these special services he received the decoration of C.I.E. During his stay in the East Mr. Newlands, at the request of the Colonial Office, also visited Ceylon, effecting great improvements in the telegraph system of that colony.

Presentation.—The staff and employés of Kettering electricity department have presented a barometer to the electrical engineer (Mr. W. A. Walker) on his marriage.

Radcliffe.—The Board of Trade have now given their decision, after holding a local inquiry, on the application of the Lancashire Electric Power Co. for a provisional order to supply electric current in the town for power, although the Council possess electricity supply works. The Board have decided in favour of the Council, and the company's application for an order has been refused.

The Board, however, state that, from the evidence produced at the inquiry, it appeared to them that the facilities afforded to power users in Radcliffe to obtain a supply of energy at a reasonable rate were inadequate, and, in the opinion of the Board, should be promptly extended. In the event of the company making fresh application in respect of the district at some future date, and on it being shown to the Board that the

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demand for energy for power is not being adequately met, the Board may find it necessary to arrive at a different conclusion to that now conveyed.

The new offices of the Council are to be wired.

Rawtenstall.—The Corporation have applied for sanction to a loan of £11,000 for their electricity undertaking.

Surbiton.—The Council have obtained sanction to a loan of £1,230 for services and meters.

Tramcar Design.—In order to secure additional accommodation on the lower decks of tramcars, Mr. C. W. Mallins, general manager of Liverpool Corporation tramways, has designed a new seating arrangement.

The seats are placed transversely on the lower as well as on the upper deck, thus securing the maximum accommodation. Another object secured is the alteration of the centre of gravity by making the width of the ground floor equal to that of the upper deck, thereby reducing the disagreeable side motion caused by the top-heaviness of the cars, and obtaining the maximum security. By this re-arrangement 6 additional seats are secured, 18 of the seats are transverse and 8 longitudinal. By placing the 8 seats longitudinally, 2 at each corner of the car, no interference with the sand boxes and lightning arresters is necessary. In the new car seats are provided for 64 passengers, 38 on the upper deck and 26 on the lower.

West Africa.—The "African World" states that satisfactory progress is being made with the scheme for the supply of electrical energy at Dakar, and that supply is expected to be available towards the end of this year. Electric driving will probably be adopted for pumping at the waterworks.

Wireless Telegraph Note.—It is announced that the results which have been attained from wireless telegraph stations established by the Admiralty in various parts of the kingdom have greatly exceeded anticipations, and that recently over a lengthy series of experiments in all conditions of weather the accuracy and reliability of wireless working has proved very satisfactory.

Workhouse Lighting.—Islington (London) Council are extending their electric supply mains to the workhouse of Shoreditch Guardians in Hazelville-road.

East Ashford Guardians have decided to collect information as to the electric lighting of their workhouse. The estimated cost of wiring and fitting is £350, and the annual cost £50.

Barnet Guardians propose to wire their workhouse at a cost of about £700.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Buxton.—During the year ended March 31 last 316,030 units were sold (against 316,688 in 1908-9), including 271,436 for private lighting (against 275,288).

Total revenue of the electricity department was £5,565 (4·2d. per unit), against £5,631 (4·26d.); private supply receipts were £4,875 (3·702d.), against £4,944 (3·74d.). Works costs were £1,773 (1·34d. per unit sold), against £1,950 (1·46d.); total costs were £2,702 (2·05d.), against £2,851 (2·16d.). Interest absorbed £1,120, repayment of loans £1,984, and £244 was spent on new chain-grate stokers, leaving a deficit of £485.

Croydon.—The traffic revenue of the tramways department for the year ended March 31 was £83,030, and with miscellaneous receipts and interest £85,755.

Working expenses were £63,084, leaving a gross profit of £22,672 to meet interest on capital and income tax (£8,295) and sinking fund (£7,371). The net balance (£7,006) was carried to renewals fund. 18,705,604 passengers were carried and 2,253,710 car-miles run. The average fare per passenger was 1·065d. and the working costs 0·809d. 2,896,424 units of electrical energy were used, or 1·285 per car-mile. The ratio of working expenses to total revenue was 73·28.

Dover.—The capital expenditure on the electricity undertaking at March 31 was £187,194, an increase of £605 during the past year.

The total revenue was £21,651, and included £16,484 from the sale of current by meter and £3,833 from public lighting. The total expenses were £9,545 (2·08d. per unit, against 2d.), leaving gross profit £12,106 to meet interest on loans (£7,259), other interest (£448) and sinking fund instalment (£4,626), showing a deficit of £227. Applications were received during the year for the equivalent of 2,282 30 watt lamps, and the total connections are now equal to 52,269 30 watt lamps. The output to private consumers was 549,800 units, an increase of 11,530. The estimated net profit for the current year is £1,167.

Great Yarmouth.—The total revenue of the tramways department for the year ended March 31 was £23,324.

Total working expenses were £16,734 and gross profit £6,588. Interest came to £3,959 and sinking fund to £2,648, leaving a net profit of £68. 4,364,962 passengers were carried and 663,988 car-miles run, 686,389 units of current were consumed (1·033 units per car-mile), and the percentage of working expenses to traffic revenue was 72·20. Capital expenditure is £121,241.

During the year ended March 31st the capital expended on the electricity department was £2,183, making the total £101,714.

The total revenue for the year was £20,234 (against £20,386), including £10,011 from the sale of current for private lighting and power and £9,555 from Corporation departments. The total expenditure was £11,147 and the gross profit £9,087, but depreciation on expenditure for which loans have not been granted amounted to £948, leaving an available balance of £8,139 to meet interest (£2,728), sinking fund (£4,001), income tax, discounts, &c. The net profit of £649 (against £194 in 1908-9) has been carried forward. 1,610,554 units of current were sold (646,061 to private consumers, 684,867 to the tramways department and 245,811 for public lighting), and the total maximum supply demanded was 1,142 kw. There are 189 arcs and 266 osrams for public lighting.

Leeds.—The income of the electricity department for the year ended March 31 was £99,081, including £64,474 from private lighting, £4,881 from street lighting and £29,669 from power and heating.

Gross profit was £69,586. Income tax required £1,120 and interest £28,031; redemption fund charges were £31,206 and wages of permanent men not chargeable to loan account £299, leaving a surplus profit. There are 6,026 lighting consumers (increase 394) and 1,127 power and heating consumers (increase 169), with the equivalent of 311,812 and 320,917 35-watt lamps connected (a decrease of 1,815 and an increase of 72,374 35-watt lamps respectively). There are 2,088 motors (increase 378) of 12,838 H.P. (increase 2,894 H.P.). 4,575,957 units were sold for private lighting (decrease 665,566), 937,193 for street lighting (decrease 51,592), and 6,908,014 for power and heating (increase 743,204). The units sold per 35-watt lamp (or equivalent) were 20·66 (against 22·91), the average price per unit was 1·91d. (against 2·02d.), and the revenue per 35-watt lamp was 3s. 3·55d. (3s. 10·20d.). Total working expenses were 0·59d. (against 0·67d.), and total expenses (including interest, redemption fund charges, &c.) were 1·74d. (against 1·86d.), the surplus profit being 0·17d. against 0·16d.). The capital expended during the year was £22,521, bringing the net capital to £749,265 (£47. 12s. 1d. per kilowatt installed).

Though the increase in the number of consumers for lighting was greater than for several years past, the number of 35-watt lamps installed shows a decrease, owing to the replacement of carbon by metal filament lamps, and the revenue from sales of current to private consumers for lighting shows a reduction of 12 per cent. Notwithstanding local trade depression, the sale of energy for power and heating shows a greater increase than in any previous year. The net surplus on the year's working (£8,930. 18s.) is greater than in any previous year, and has been devoted to relief of rates, making the total contributions to rates fund to date £54,797. 11s. 4d. The maximum load was 8,900 kw., against 8,220 kw.

Stockton-on-Tees.—The income of the electricity supply department for the year ended March 31 was £8,130. 10s., and included £7,835 net from the sale of current for private and public lighting.

Expenses were £4,219 and gross profit £3,911. 10s. After paying interest and providing for repayment of loans, the balance (£639. 12s. 9d.) was placed to reserve. The total capital expended is £54,271, an increase of £253 on the year. 771,255 units were sold for private lighting and 66,343 for the public lamps.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited by July 6 for the supply of cordless switchboards to the Postmaster-General's Department in SOUTH AUSTRALIA. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited for the supply to the Postmaster-General's Department, NEW SOUTH WALES, of one dust extractor electrically driven, to work on a 24-volt d.c. circuit. Tender forms, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to Aug. 2 for the supply and delivery of 1,820 private letter box fronts to the Postmaster-General's Department in the States of VICTORIA, QUEENSLAND, SOUTH AUSTRALIA and WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

CROMPTON Council want tenders by 10 a.m. June 30 for supply of dynamos and other electrical equipment, including motors, wiring, lamps, &c., for lighting new and present buildings at New Hey sewage works. Specifications from Messrs. J. P. Wilkinson & Son, 301, Cathedral-street, Manchester.

BIRMINGHAM Corporation want tenders by June 30 for 12 months' supply of stores for their electricity department, including electrical accessories, ironmongery, &c. Particulars from the City Electrical Engineer.

RAWTENSTALL Corporation want tenders by July 1 for permanent way construction and supply of steel poles, overhead equipment, cables, conduits, &c., for a tramway. Specification from the Borough Engineer.

BATLEY Council require tenders by noon June 28 for supply of a battery of accumulators, an automatic reversible traction booster and a battery charging booster. Specifications from Borough Electrical Engineer.

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LONDON County Council require tenders by 11 a.m. July 6 for electric wiring at St. Mark's-road and Haverstock Hill schools. Specifications from the Chief Engineer, Spring-gardens, S.W.

LLANDAFF and DINAS POWIS Rural Council require tenders by July 4 for e.h.t. switchgear, transformers, distributor switchboard, mains, &c., for electric lighting at Whitchurch. Forms of tender, &c., from Herbt. Lewis & Fletcher, St. Mary-street, Cardiff.

SALFORD Corporation require tenders by noon July 18 for a bore-hole pumping plant for their electricity works, Pendleton. Particulars from the Borough Electrical Engineer.

LONDON County Council require tenders by 11 a.m. July 5 for supply of 250 electric tramcar bodies and 250 electrical equipments for conduit and overhead systems. Specifications from the Clerk.

LONDON County Council also want tenders by 11 a.m. June 28 for supply of petrol or electrically-driven fire escape vans. Specifications, &c., from the Clerk.

Tenders are required by June 28 for supply of electric light and power plant and wiring at the County Asylum, Knowle, FAREHAM. Specification from the County Surveyor, The Castle, Winchester.

EALING Corporation require tenders by noon July 4 for supply and erection of surface condensing plant, &c., at the electricity works. Specification, &c., from Town Hall, Ealing.

Tenders are required for the installation of electrical plant in the vicinity of DUBLIN. Particulars from Mr. P. O'Hare, 15, Well Park-avenue, Drumcondra, on payment of 10s. 6d.

HORNSEY Council want tenders by 10 a.m. July 9 for the electric wiring and fitting of Stroud Green school. Specification, &c., from the Borough Electrical Engineer.

SHANGHAI Municipal Council invite tenders for supply and delivery (c.i.f. Shanghai) of two 940 k.v.a. two to three-phase step-up transformers, e.h.t. switchgear, e.h.t. underground mains and feeder pillars. Specifications from Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, S.W., to whom tenders before noon July 5.

Tenders are invited up to July 27 for supply of a pneumatic tube service to the Postmaster-General's Department at ADELAIDE (S. Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited for supply of 36,000 incandescent electric lamps to the City of MELBOURNE. Specifications, forms of tender, &c., from the agents for the City Council (Messrs. McIlwraith, McEacharn & Co. Proprietary, Ltd.), Billiter-square Buildings, London, E.C., to whom tenders by noon July 1.

Tenders are invited up to July 19 for supply and delivery of 4,200 telephone sets (as per schedule No. 231) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The Société Nationale des Chemins de fer Vicinaux, BRUSSELS, want tenders by July 20 for underground cables, and by July 27 for the equipment of a transformer station.

The Ministerio de Fomento, MADRID, will receive tenders until July 30 for the construction of an electric (or steam) strategic railway from Requena to Alcaráz, via Casas Ibáñez and Albacete. The contract is open to Spanish firms only.

The Ministerio de Obras Publicas, SANTIAGO (Chili), will receive tenders until July 15 for the substitution of electric for steam traction on the first section of the Chilian State Railways—from Valparaiso to Santiago and Los Andes.

The Turkish Ministry of Public Works, Constantinople, will receive tenders until July 4 for a concession for the construction and working of electric tramways at SALONICA. Deposit of £2,250 sterling required with each tender. Local representation is necessary. Specification (in French) may be seen at 73, Basinghall-street, London, E.C.

Tenders will be received at the Driftsbestyrerens Konto, Electricitetsverk, HAMAR, Norway, until noon June 29 for supply of dynamos, oil transformers, cable, 6 tons copper wire, &c. Specifications (in Norwegian) may be seen at 73, Basinghall-street, London, E.C.

The Société Nationale des Chemins de fer Vicinaux, BRUSSELS, want tenders by July 27 for the complete equipment on the overhead electric system of the Brussels-Haecht section of the light railways.

NICE (France) Municipality want tenders by July 9 for the supply and erection of an electric lift for goods.

CHATELLERAULT (France) Corporation want tenders by July 27 for supply of incandescent lamps, copper, &c.

BOURGES (France) Council want tenders by July 7 for the supply of electric cables and wires.

TENDERS RECEIVED AND ACCEPTED.

Barnes (London) Council received the following tenders for supply of 4,000 yds. triple-concentric 0·25, 0·25, 0·125 sq. in. l.t. cable (paper insulated, lead sheathed, jute served and compounded):—

Siemens Bros. & Co. (*acc.*)	£1,600	W. T. Henley's Co.	£1,720
General Electric Co.	1,865	Standard Cable Co.	1,700
Callender's Co.	1,784	Lahmeyer Electrical Co.	1,680
W. T. Glover & Co.	1,730	Electrical Co.	1,680
Johnson & Phillips	1,722	Western Electric Co.	1,648
Brit. Insulated & Helsby Cables	1,722	Union Cable Co.	1,575
		Aubert, Grenier & Co.	1,560

The following tendered for motor-generator plant required by the Newport (Mon.) Corporation, the contract being awarded to the General Electric Co. as the lowest tenderers:—

General Electric Co., British Thomson-Houston Co., Dick, Kerr & Co., Johnson & Phillips, British Westinghouse Co., Brush Co., Lahmeyer Electrical Co., Crompton & Co., Siemens Bros. Dynamo Works, Electric Construction Co., Lancashire Dynamo & Motor Co., and Bruce Peebles & Co.

Hammersmith (London) Council recently accepted the tender of Ferranti, Limited, for h.t. switchgear at £155. 2s. 6d. and l.t. switchgear at £32. 10s., but as the firm intimated that they had made an error and that their tender for h.t. switchgear should be £256. 15s., the Council permitted them to withdraw their tender, and the tender of Cowans (Limited) has been accepted for h.t. switchgear at £217, and l.t. gear at £39. 10s.

St. Anne's-on-the-Sea Council have received the following tenders for supply of a fuel economiser:—

E. Green & Sons (*accepted*), A. Lowcock (Ltd.), Carter & Sons, Clay Cross Co., Roberts Bros. and Goodbrand & Co.

Norwich Corporation have accepted the tender of Willans & Robinson for a turbo-generator, condenser, oil separator, &c., at £3,758, on condition that the contract is completed by Oct. 1, 1910.

The Metropolitan Asylums Board have placed an order with W. J. Fryer & Co. for the installation of low-voltage metal filament lamps at Tooting Bec Asylum, at a cost of £350.

West Ham Education committee have accepted the tender of Pritchetts & Gold (at £75. 4s. 7d.) for renewing the plates at the main storage battery at the Technical Institute.

Battersea (London) Council have accepted the tender of Baxter & Caunter, at £63. 3s. 6d., for the supply of two motors at the Culvert-road Depot.

Bury St. Edmund's Corporation have accepted the tender of the British Westinghouse Co. for a 200 kw. steam dynamo (Belliss engine) at £1,083.

Huddersfield Corporation have accepted the tender of J. Marsden & Son for wiring the new schools at Birkby.

Islington (London) Council have accepted the tender of the Crown Engineering Co. (at £135. 10s.) for a lathe.

Burslem Education committee have accepted the tender of E. M. Evans & Son for wiring the new central schools at £200.

Auckland Guardians have accepted the tender of the Electric Motor Co. for wiring new infirmary at £112. 16s. 6d.

Southwark Council have accepted the tender of the General Electric Co. for an 8 H.P. slow-speed motor at £33.

Cleckheaton Council have placed an order with the Lancashire Dynamo & Motor Co. for an automatic reversible booster.

Burnley.—*A Correction.*—In reference to the note in our last issue (p. 413) as to the tenders accepted by Burnley Corporation for two single-deck cars, the contract for the electrical equipment was given to the British Thomson-Houston Co., and not to Messrs. Dick, Kerr & Co., as stated.

Water-Purifying Plant.—The Seck Engineering Co. have installed one of their standard type water-softening and purifying plants at the works of the Imperial Lamp Works, Brimsdown, Middlesex, for treating the feed of a Babcock-Wilcox boiler, under an absolute guarantee of immunity from the formation of scale at a fixed working charge, which it is also guaranteed shall not be exceeded.

Government Contracts.—The following tenders have been accepted by the Government Departments:—

Admiralty.—Evered & Co., Gabriel & Co., General Electric Co., Hawkes (Ltd.), Sir James Laing & Son, W. McGeoch & Co., Player & Mitchell, and Spagnoletti (Ltd.), for electric lamps, brackets, pendants, &c.; British Insulated & Helsby Cables, Edison & Swan Co., Electric & Ordnance Accessories Co., Evered & Co., Hawkes (Ltd.), India-Rubber, Gutta-Percha &

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Telegraph Works Co., International Electric Co., Johnson & Phillips, Kelvin & James White, W. McGeoch & Co., Player & Mitchell, Reid Bros., Spagnoletti (Ltd.), Sterling Telephone & Electric Co., Walters' Elec. Mfg. Co., and A. Watson & Co., for switches, bells and other electrical fittings.

War Office.—Credenda Conduits Co., Edison & Swan Co., General Electric Co., S. Heath & Sons, Kensington Stamping Co., and Veritys Limited, for electric light fittings.

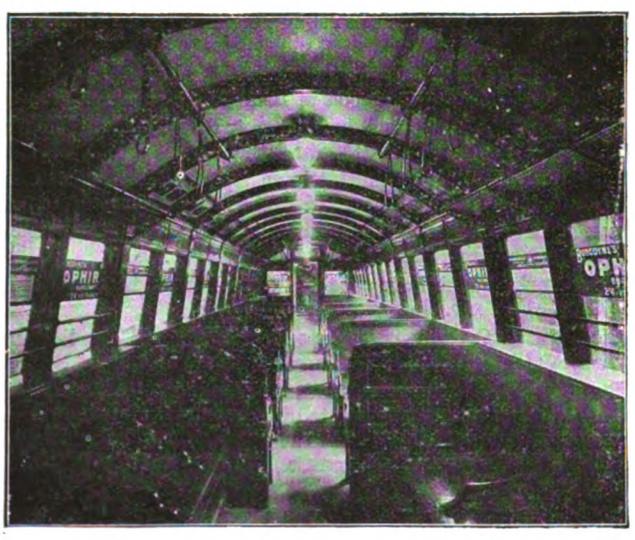
India Office.—C. & A. Musker, for electric cranes.

General Post Office.—Gell Telegraphic Appliances Synd., telegraph apparatus; British L. M. Ericsson Mfg. Co., magneto bells; Bullers (Ltd.), insulator spindles; Western Electric Co., telephones; F. Smith & Co., bronze wire; R. Johnson & Nephew, copper wire; London Electric Wire Co. & Smith's, flameproof wire; J. Gray & Son, electric lighting of Edinburgh Head Post Office; A. Maund, electric lighting of Western District Post Office, London; Western Electric Co., telephone equipment for private branch exchange lamp signalling system at Harrod's Stores; Shaddock Bros., laying and jointing iron pipes at Brighton; A. Schofield, laying and jointing iron pipes and earthenware ducts at Leeds; G. P. Trentham, laying and jointing iron pipes and erecting fire alarm pedestals at Manchester.

Sale by Auction.—Mr. W. H. Robinson will sell by auction at the Albion Hotel, Piccadilly, Manchester, on Tuesday, July 19, at 5 p.m., a plot of freehold land, containing about 5,089 sq. yds., together with substantially built premises recently occupied by Messrs. W. Brown & Sons (contractors and builders, Salford) and their subtenants. The purchaser will have the option of buying the machinery, plant and fixtures on the premises within seven days from date of sale. The land and premises are conveniently situated, and are opposite to the principal entrance of and in close proximity to the most central portion of the Manchester Ship Canal and its docks. Further particulars from the Auctioneer, Cromwell-buildings, Blackfriars-street; from Messrs. Charles Dunderdale & Co., solicitors, Marsden-street; or Messrs. March, Clayton & Pearson, 22, Bath-street, Manchester. See also an advertisement.

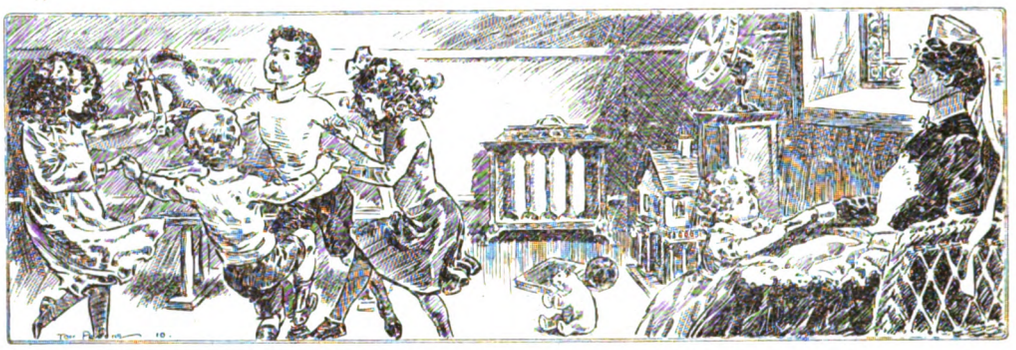
Plant for Sale.—Some second-hand electric motors are advertised for sale in another column.

Osram Lamps for Train Lighting.—The illustration herewith shows osram lamps in use for train lighting on the Waterloo & City tube railway. The general result of the lighting on this railway is undoubtedly remarkably good, and it is interesting to note that a lesser number of points per car are used than on any other of the tube railways in London. While these lines, speaking generally, arrange the lamps along the roof of the car on each side immediately above the heads of the passengers, the Waterloo & City line run their lights from the centre of the roof. 26 fittings are utilised for each four-car train, each of the larger cars taking seven 55 watt osram lamps, and the smaller cars six 55 watt osrams, each independently arranged in opalite globes, which permit of a considerable volume of light being thrown on the white enamelled roof, which by its peculiar shape acts as an efficient reflector. The lamps are burned four in series, and have now been installed a complete year. We learn that there have been very few failures, and that many of the original lamps are still in use. There is of necessity considerable vibration on this line, which does not appear to have had any adverse effect on the lamps.



TRAIN LIGHTING BY OSRAM LAMPS.

Illustrated Publicity Methods.—Last week we called attention to an illustrated poster that is being employed for publicity purposes by the Electric Supply Publicity committee, and accompanying this



ELECTRICITY PUBLICITY DESIGNS.

note are two typical illustrations of the methods adopted by the committee to advance the same interests. It will be agreed that they are very effective and display the merits of electric lighting,

ELECTRICITY PUBLICITY DESIGNS.

electric heating and ventilation by means of electric fans in a very attractive manner.

Loose Leaf Books for Engineers.—Messrs. John Walker & Co., Farringdon House, Warwick-lane, London, E.C., are placing on the market, through the book-selling and stationery trades, a series of loose leaf books for engineers, which contain a number of tables and data of service for everyday reference. The tables have been selected and prepared by Mr. Norman R. Corke, A.M.I.E.E. The loose leaf books are published in a variety of bindings and refils of the ruled paper sheets, faint ruled sheets, plain sheets or tables can be obtained.

CATALOGUES, &c.

CHLORIDE ACCUMULATORS.—The latest publication from the Chloride Electrical Storage Co. is a complete illustrated price list of all their accumulator products. Practically every type of cell manufactured by the company is tabulated, prices and full details being given of its capacity, weight and size. The range of batteries is of the fullest possible description, extending from the smallest portable accumulators to the largest heavy-weight central station cells.

ELECTRIC FANS.—The Electrical Co. are issuing a leaflet describing their 1910 season electric fans. These are of the usual porthole, wall, bracket and ceiling patterns.

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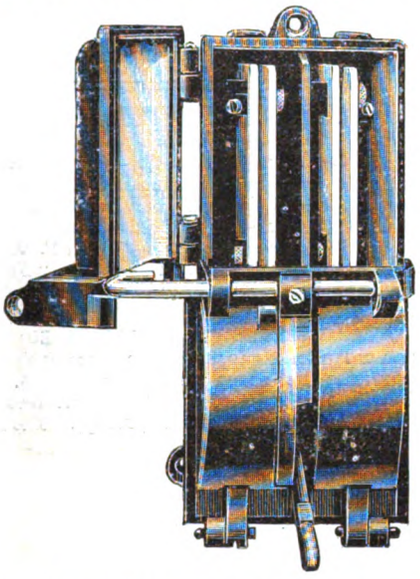
IRONCLAD SWITCHES.—Messrs. H. O. Farrell & Co., Moss Side, Manchester, send us a leaflet of their "Hof" combined ironclad switch and fuse. This is made in double-pole pattern in 20, 30, 50, 75 and 100-ampere sizes, and is suitable for pressures from 250 to



500 volts. The covers of the switch and fuse are interlocking, and the fuses cannot be inspected or removed until the switch is off. The adjoining illustration shows the general construction.

BANKRUPTCIES, LIQUIDATIONS, &c.

The examination of Wm. Chalmers, electrical engineer, 142, Bath-street, Glasgow, will take place at County-buildings, Glasgow, on June 30.

The trustees (Mr. J. H. Haley, 29, Tyrrel-street, Bradford, and Mr. R. A. Vinter, King's-arcade, Market-street, Bradford) in the bankruptcy of Arnold Roberts, electrical engineer, 21, North-parade, Bradford, have been released.

Prockter & Kenyon (Ltd.) went into voluntary liquidation on 16th inst. Mr. T. Walton, 36, Spring-gardens, Manchester, was appointed liquidator, and is also receiver for the debenture holders.

Adjudication Annulled.—The adjudication of Geo. Huntingdon, electrician (trading with Wm. Hy. Lloyd Watson as Watson & Huntingdon), 83, Battersea-rise, S.W., and Dering-street, Bond-street, W., London, has been annulled, it appearing to the Court that all the debts have been paid in full.

Winding-up Petition.—A petition for the winding-up of the North Western Electricity & Power Gas Co. was presented on June 14, and will be heard on June 29 at the Court House, Quay-street, Manchester.

Bankruptcy Petition.—A petition against Frank Sheppard, electrician, 4, Haslett-road, Kensington, London, will be heard on June 30 at Bankruptcy-buildings, Carey-street, London, W.C.

COMPANIES' MEETINGS AND REPORTS.

India Rubber, Gutta Percha & Telegraph Works Co. (Ltd.)

The half-yearly meeting was held on Tuesday, Major LEONARD DARWIN presiding.

The SECRETARY (Mr. A. P. Crouch) read the notice convening the meeting.

The CHAIRMAN said that the business of the meeting was to ask the shareholders' sanction to the payment of an interim dividend. Since he last addressed them in December the board had been passing through a time of some anxiety on account of the instability of the markets for raw material. He did not wish to refer to the rubber market at any length, as his remarks would run the risk of being misconstrued. He should limit himself to saying that while they, in common with all who were engaged in the rubber trade, were greatly inconvenienced by the uncertainty of the market, yet they welcomed the development of raw rubber production because they considered it would eventually be of good service to them. Rubber stood at a high price, gutta percha was expensive, cotton had been uncertain and copper was gradually dwindling in price. Their turnover showed a considerable advance over last year. As the turnover he referred to was that of the money received or owing to the company in trading, a certain amount of this increase was due to the advances in the selling price which they had made during the last nine months. The demand generally for the company's tyres was increasing, and they were fairly well employed in the submarine and electrical departments. In view of the increased value of the stocks the company had to hold, and an increase in the amounts outstanding in their trading accounts, as well as certain extensions, the board thought it desirable to offer for subscription the balance of the preference shares remaining unissued. The subscribers to this issue, under the terms of it, did not receive any half-yearly dividend on this occasion; their first half-yearly dividend fell due on Jan. 1, 1911. He then moved that a distribution of 5s. per share, less tax, be made to the holders of preference shares, and the payment of an interim dividend of 5s. per share, tax free, to the holders of ordinary shares.

Col. A. WESTON JARVIS seconded the resolution, which was unanimously agreed to, and the proceedings terminated.

ANGLO-PORTUGUESE TELEPHONE CO. (LTD.)—At the meeting last week the chairman (Mr. H. Allen) said that between 1904 and 1909 their gross income had increased from £25,962 to £49,489, and gross profit had grown from £10,796 to £20,767, and net profit from £8,360 to £16,571. Half a dozen years ago they were declaring a dividend of 3 per cent. on a capital of £51,000, and now, for the third year in succession, they were paying a dividend of 8 per cent. on £100,000. The event of the year had been the inspection of their telephone system in Lisbon and Oporto by Mr. Frank Gill, chief engineer of the National Telephone Co. As anticipated, Mr. Gill had not much fault to find with what they had done; nevertheless, his visit had had an excellent effect in still further increasing te efficiency and economy of their working.

BRITISH ELECTRIC TRACTION CO. (LTD.)—At the meeting on Friday last the chairman (Mr. E. Garcke) said that the net profit was but little better than in the preceding year, but the indications of improvement in the future were distinctly better. They had added £41,780 to reserve and the total reserve on March 31 last amounted to £633,000 (against £602,000 in 1909), in addition to special reserves and about £13,000 written off. As to their investments, the proportion which did not earn any return during the year was less by £342,000 than in 1909, and the return on the whole of the investments was 2·63 per cent., compared with 2½ per cent. In regard to the "fair fare" system, which consisted in dividing the routes into short sections and charging a fare according to the number of sections travelled, they had increased the facilities for travel, and by offering inducements to passengers to travel longer distances with only a proportionate increase of fare they hoped to make more money. The company was interested in nearly 400 route-miles of tramways and light railway, which served upwards of 100 different towns and districts. Since the beginning of the year the traffic receipts had shown a marked improvement. It was not possible to make a definite statement yet as to whether that improvement was entirely the result of the "fair fare" system or whether it was due to better weather conditions and improved trade.

CHADBURN'S (SHIP) TELEGRAPH CO. (LTD.)—For the year ended March 31, the balance at credit of profit and loss account was £12,614.2s.6d, less managing director's remuneration, directors' expenses and depreciation (£4,058. 12s.). With balance from last year (£1,618) the total was £10,173. 10s. 6d. Deducting the dividend at the rate of £6 per cent. per annum on the preference shares and interim dividend of £6 per cent. per annum on the ordinary stock, the balance was £4,773. 10s. 6d., out of which it is proposed to pay a dividend on the ordinary shares of £10 per cent. per annum (less tax) for the half-year ended March 31, making, with the interim dividend already paid, a dividend of £8 per cent. per annum for the 12 months, carrying forward £1,773. 10s. 6d.

DIESEL ENGINE CO. (LTD.)—Mr. G. C. Ellis stated at the meeting last week that the results of the year's working did not compare favourably with those of the previous year, but the directors were not discouraged because they saw a very considerable chance of good business in the future, the set-back being entirely due to general depression.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—The 37th annual meeting was held on Tuesday, under the presidency of the Marquis of Tweeddale, K.T., who said that the accounts would, he believed, be considered very satisfactory. It was the best report the directors had ever submitted. The receipts for the year to the end of May last, after deducting expenses, amounted to £209,117, as against £207,347 the previous year. The three usual interim quarterly dividends had already been paid to both the ordinary and preferential shareholders. These together absorbed £131,085, and the directors now recommended a final dividend of 5s. 9d. per share on the ordinary shares (making 5⅞ per cent. a year against 5¾ per cent.) and 3s. per share on the preference shares, absorbing £77,656, leaving £27,681 to be carried forward. They were, therefore, besides paying 3d. per share more as ordinary dividend, carrying nearly £400 more forward. This was mainly due to the increased dividend on the Telegraph Construction & Maintenance Co.'s shares, which had reverted to 17½ per cent. He was glad to be able to state that the value of their securities again showed a very large increase over their original cost. He then moved the adoption of the report and accounts and the payment of the dividends set out therein.

Sir JAMES PENDER, Bart., seconded the motion, which was carried unanimously. The re-election of the retiring director and auditors, and a vote of thanks to the chairman, terminated the proceedings.

GREENWOOD & BATLEY (LTD.)—After providing for interest on debentures and management expenses, making provision for doubtful debts, and writing off £2,958. 17s. 9d. in respect of final adjustment of various accounts brought forward from previous years, the profit for the year ended March 31 was £10,173. 0s. 10d., making, with £2,066. 8s. 5d. brought forward, £12,239. 9s. 3d. The directors have written off £3,000 for depreciation, and they recommend that a dividend for the year be declared at the rate of 7 per cent. per annum on the cumulative pre-

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ference share capital, absorbing £7,027. 17s. 3d., and leaving £2,211. 12s. to be carried forward. Major-General Edward Micklem has been elected chairman of the board; Mr. H. Greenwood has relinquished his position as a managing director, retaining his seat on the board; and Mr. S. T. Butler and Mr. Thos. Greenwood have been appointed managing directors.

MARCONI'S WIRELESS TELEGRAPH CO. (LTD.)—The report of the directors for the year ended Dec. 31, 1909, states that during the year the company suffered a serious set back by the disastrous fire which destroyed the Glace Bay station, in Canada, on the eve of its completion. But for this misfortune a considerable revenue should have been derived from the trans-Atlantic service. No time was lost in the reconstruction of the station, and advantage was taken of experience, and improvements which it is confidently anticipated will fully compensate in the future for the disappointment and delay. Notwithstanding the serious effect on the revenue occasioned by the fire, the profit for the past year was £11,432. 10s. 7d. Arrangements are being made which should enable the Canadian company to repay, at an early date, if not the whole, at least a large proportion, of its indebtedness (£144,279. 7s. 11d.) to the company.

Throughout the past year there was experienced a continuously and rapidly increasing demand for wireless telegraphy. A large number of contracts have been accepted by the company, but not having been completed by the end of the year no portion of the profits which should be derived therefrom figure in the accounts. A marked improvement in the business done by the associated companies has also been experienced, several of which are now commencing to show profits, and with the ever-increasing appreciation of the Marconi system the directors look with growing confidence to their large shareholding in these companies. The French and Belgian companies have declared dividends for the past year at the rates of 5 and 10 per cent. respectively. The directors recommend payment of the cumulative 7 per cent. dividend on the preference shares to June 30, 1909. The expansion of the business during the current year should enable them to make a further announcement in this direction so soon as the accounts for the first six months have been made up.

Although the report deals only with the accounts and progress of business to the end of the year 1909, the directors take the opportunity of officially informing the shareholders that the trans-Atlantic stations have been re-opened, and a regular and satisfactory service is being conducted. Other important developments of the business are in course of negotiation. In January last Mr. H. Jameson Davis resigned his directorship, and since the last meeting Mr. Godfrey C. Isaacs and Mr. Alfonso Marconi have been elected to seats on the board.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—Mr. L. B. Schlesinger, who presided at the meeting last week, said the depression in the electrical industry had been even more acute than in previous years, and finance in connection with it, particularly in this country, had been practically impossible. However, the undertakings in which the company was substantially interested were progressing. They were now engaged on the finance of a light railway scheme in England, and the progress made so far encouraged the feeling that they would be successful in completing it.

R. WAYGOOD & CO. (LTD.)—At the meeting last week the chairman (Mr. H. C. Walker) said that the past year had been beset with much anxiety for the directors in consequence of unprecedented competition and exceptionally low prices. By careful management and attention to details they had been able to maintain the dividend of 6 per cent. They had been successful in securing the most important contracts which had been let this year, including the new post office. That contract was for 12 electric lifts, some of them to raise 2 tons at a speed of 200 ft. per minute. Those were the largest electric lifts which had hitherto been made in this country to work from three-phase current, and their installation involved very special arrangements, both in design and manufacture. They were also successful in obtaining the contract for the lifts for the Royal Liver Friendly Society building in Liverpool, which was to be equipped with 15 of their high-speed electric passenger lifts, some of them working at 400 ft. per minute. The contract was awarded to them on account of economy which they were able to offer in consequence of special design, and when finished the equipment of lifts would be second to none in the United Kingdom. They had also secured the order from Messrs. Harland & Wolff to fit the new White Star liners "Olympic" and "Titanic" with 16 lifts, including eight of their special electric passenger lifts. They had now fitted over 50 ships with their lifts, quite apart from the special work done in that direction for the Admiralty, for whom they had fitted 39 electric lifts on battleships and cruisers.

J. G. WHITE & CO. (LTD.)—The directors' report for the year ended Feb. 28 states that the results of the business have been satisfactory, with a net profit on the year's trading of £64,801. 16s. 1d., the highest earned in any year since the formation of the company. The company, which is carrying out important works in Brazil, Argentina and other points abroad, has more work actually in hand and uncompleted than at any time during the past three years, and general conditions have improved so that considerable additional work is expected. The return of interest and dividends on investments during the year was equal to 6·2 per cent. on the amount of the valuation. The reserve fund having now reached £100,000, the directors consider that the "purchase of business" account should be written off, and they are therefore recommending its reduction this year by £32,975. 1s. 10d., leaving £15,000, which they hope to be able to write off next year. The directors are pleased to be able to recommend an increase of the total dividend rate on both classes of shares to 10 per cent. The balance to credit of profit and loss, after bringing in £15,480. 6s. from previous account, deducting interim dividend paid on the preferred shares on Jan. 1, and making provision for percentages due to directors and staff, is £67,879. 9s. 6d. The directors recommend payment of a dividend (tax free) at the rate of 6 per cent. per annum on the cumulative preferred shares for the half-year to Feb. 28 (£4,500), a dividend (tax free) at the rate of 6 per cent. per annum on the ordinary shares for the year (£3,000), and payment of an additional 4 per cent. (tax free) on the preferred and ordinary share capital (making 10 per cent. on all shares for the year) (£8,000), and that £32,975 be applied in reduction of "purchase of business" account, leaving £19,404. 7s. 8d. to be carried forward.

NEW COMPANIES.

FREDK. JONES & CO. (LTD.) (110,247.)—Reg. June 17, capital £15,000 in £1 shares, to carry on the business of manufacturers of silicate cotton or slag wool, fibrous plastering, building blocks and insulating materials, non-conducting covering compositions and materials, boiler disincrustants, &c., and to adopt agreements (1) with F. M. H. Jones for the acquisition of the businesses carried on by him as "Fredk. Jones & Co," and (2) with J. Christie. Private company. Reg. office, Perrin-street, Kentish Town, London, N.W.

INSTITUTION OF SIGNAL ENGINEERS (INCORPORATED) (110,158.)—Reg. June 13 as an unlimited company with a share capital of £5 in 20 shares of 5s. each. The first seven subscribers are: A. T. Blackall, R. J. Insell and C. M. Jacobs (Reading), A. M. Thompson and A. D. Michod (Crewe), W. C. Acfield and J. Sayers (Derby). The management is vested in a council.

WHITEHEAD BROS. (LTD.) (110,258.)—Reg. June 17, capital £12,000 in £1 shares, to carry on the business of engineers, founders, electricians, &c. Private company. First directors, W. Whitehead, J. Whitehead and F. Whitehead.

CITY NOTES.

MEMORANDA (June 23).—Bank rate 3 per cent. (since June 9, 1910). Price of silver, 24⅜d. per oz. Consols 82¼—82⅜ for money and for account. Consols Pay Day, July 1; Stock and Shares Continuation Days, June 27 and July 12; Ticket Days, June 28 and July 13; Pay Days, June 29 and July 14; Mining Shares Carry Over Day, June 24.

PRICES OF METALS (London).—*Copper*, cash, 51⅜; three months. 55⅛. *Lead*, English, 13—13¼; foreign, 12⅞—12⅞. *Spelter*, 22, *Tin*, English, 146¼—148⅜; foreign cash, 148; three months, 148⅞. *Iron*, Cleveland, cash, 49/1, three months, 49/11.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the four weeks ended May 27 were 786,249, compared with 693,479 units in the corresponding four weeks of 1909.

COMPANIES TO BE STRUCK OFF THE REGISTER.—The following will be struck off the Register of Joint Stock Companies, unless cause to the contrary is given before Sept. 21:—

Electric Vehicles Development Co., Foreign Chemical & Electrolytic Synd., Newark Electric Supply Co., Ozone Purification Co., Railway & Tramway Concessions Synd., Selneff Batteries, Ystradgynlais Electric Lighting Co.

EASTERN TELEGRAPH CO. (LTD.)—This company announce payment on July 15 of dividend at the rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending June 30, and a first quarterly interim dividend of 1¼ per cent. on the ordinary stock (tax free) in respect of profits for the year ending Dec. 31, 1910. The transfer books of the ordinary stock will be closed from 7th to 14th prox. inclusive.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) The directors have declared an interim dividend for the quarter ended March 31 last of 2s. 6d. per share (tax free), payable on July 15. The share register will be closed from 7th to 14th prox. inclusive.

ELECTRIC LIGHT & POWER CO. OF COCHABAMBA.—During the week Messrs. E. Erlanger & Co. invited applications for the purchase at 98 per cent. of £300,000 of six per cent. Government guaranteed bonds of this company, which is now engaged in constructing an electric railway from Cochabamba to Quillacollo (Bolivia), a distance of 15 km. (over 9 miles), and the Government have arranged with the company for the construction of a second electric railway from Quillacollo to Arani (30 km., or 18½ miles), with branches to Caraza and Vinto, and for the erection of stations for the generation and supply of electric power.

NEW YORK TELEPHONE CO.—The net earnings for 1909 were $10,571,978, and after deducting the interest charges and dividends ($5,633,329), the balance was $3,957,419, increasing the surplus brought forward to $13,591,711.

SHAWINIGAN WATER & POWER CO.—A dividend of 1 per cent. for the year ending June 30 has been declared.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed July 7 a special settling day in scrip (fully paid) for £250,000 5 per cent. debenture stock of the *Metropolitan Electric Tramways (Ltd.)* and scrip (fully paid) for £250,000 5 per cent. first mortgage debentures of the *Vera Cruz Electric Light, Power & Traction (Ltd.)*, and have granted official quotations in both cases. The committee have been asked to grant quotations to a further issue of 100,000 10 per cent. £3 preference shares and £225,000 4 per cent. mortgage debenture stock of the *British Westinghouse Electric & Mfg. Co. (Ltd.)*; $5,000,000 capital stock of the *Manila Electric Railroad & Lighting Corpn. (Ltd.)*; and $600,800 additional 5 per cent. first mortgage 20-year gold bonds and $3,000,000 common stock of the *Northern Light, Power & Coal Co.*

WINNIPEG ELECTRIC RAILWAY CO.—The directors have declared a dividend of 10 per cent. for the year ended June 30.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	June 10	224	+ 3	23	5,006	+ 85
Anglo-Argentine	,, 17	43,945	+ 4,803	24	1,060,423	+ 115,743
Ayr Corporation	,, 18	339	+ 2	5	1,464	+ 4
Baker St. & Waterloo Ry.	,, 18	3,185	— 140	24	81,725	+ 1,510
Barnsley	,, 10	168	+ 21	23	3,927	+ 110
Barrow	,, 10	292	+ 45	23	5,551	+ 662
Bath Electric Trams, Ltd.	,, 15	873	+ 112	24	18,098	+ 1,366
Birmingham Corporation	,, 18	6,712	+ 512	11	76,028	+ 623
Birmingham & Midland	,, 3	808	— 405	22	18,228	+ 246
Blackburn Corporation	,, 15	1,167	+ 27	‡12	12,785	— 904
Blackpool and Fleetwood	,, 18	629	— 2	..	..	..
Bolton Corporation	,, 19	2,465	+ 203	12	26,995	— 948
Bombay	May 20	2,652	+ 134	20	55,156	+ 3,829
Bournemouth Corporation	June 15	1,644	+ 166	11	17,831	— 718
Bradford Corporation	,, 13	5,535	+ 515	12	57,647	+ 646
Brighton Corporation	,, 19	1,012	+ 89	§11	10,431	— 518
Bristol Trams & Carriage	,, 17	5,997	+ 589	24	135,834	+ 12,951
Burnley Corporation	,, 18	1,248	+ 28	24	30,431	+ 698
Burton Corporation	,, 19	267	+ 19	11	3,009	— 14
Bury Corporation	,, 19	1,262	+ 126	§11	13,577	— 549
Calcutta Tramways Co.	,, 18	₹52,200	+ ₹2,974	24	₹1,241,000	+ ₹43,146
Camborne-Redruth	,, 18	125	— 8	24	2,891	— 121
Cardiff Corporation	,, 18	2,398	+ 219	12	25,018	— 81
Cavehill	,, 10	108	— 2	23	1,844	+ 153
Central London Railway	,, 18	5,934	+ 185	24	135,831	+ 2,579
Charing C., Euston & H'stead	,, 18	3,710	— 210	24	92,105	— 1,155
Chatham & Dist. Lt. Rys.	,, 16	906	+ 97	24	19,211	+ 876
City & South London Rly.	,, 19	2,955	— 180	24	77,603	— 474
City of Birmingham	,, 10	2,820	+ 260	23	65,299	+ 2,961
Colchester Corporation	,, 15	199	..	..	..	..
Cork Electric Trams Co.	,, 16	549	+ 35	24	11,174	+ 1,723
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	,, 10	442	+ 90	23	9,428	+ 1,045
Dover Corporation	,, 18	214	+ 16	11	2,264	— 40
Dublin & Lucan Railway	,, 17	171	+ 10	24	3,048	+ 27
Dublin United	,, 17	6,102	+ 518	24	126,298	+ 4,166
Dudley-Stourbridge	,, 10	737	— 27	23	16,999	— 653
Dundee Corporation	,, 15	1,245	+ 55	§4	5,426	+ 66
East Ham Council	,, 18	1,103	+ 90	¶11	11,751	+ 201
Exeter Corporation	,, 17	323	+ 2	11	2,503	— 683
Gateshead & Dist. Trams	,, 10	975	+ 13	23	21,998	— 459
Glasgow Corporation	,, 18	19,043	+ 1,053	3	49,851	+ 4,317
Glossop Trams	,, 13	121	+ 4	24	2,691	— 136
Gloucester Corpn.	,, 15	304	+ 19	..	..	..
Gravesend-Northfleet	,, 10	216	+ 17	23	4,471	+ 84
Great Northern & City Rly.	,, 18	1,389	+ 30	24	35,406	— 406
Gt. Northern, Piccadilly, &c.	,, 18	5,745	— 110	24	144,310	+ 5,220
Greenock & Port Glasgow	,, 10	713	+ 100	23	13,292	+ 1,846
Hartlepool Tramways	,, 10	251	+ 13	23	5,018	+ 150
Hastings Elec. Trams Co.	,, 16	960	— 17	24	20,635	+ 289
Hong Kong	,, 18	$8,731	+ $281	24	$320,540	+ $18,621
Huddersfield Corpn.	,, 18	1,821	+ 191	11	19,837	+ 851
Hull Corporation	,, 18	2,671	+ 363	11	30,082	+ 1,736
Ilford District Council	,, 18	548	+ 44	11	5,985	+ 178
Ilkeston District Council	,, 15	135	+ 11	11	1,378	— 73
Ipswich Corporation	,, 18	426	+ 34	11	4,452	+ 90
Isle of Thanet Co.	,, 18	735	+ 81	¶36	13,114	+ 206
Jarrow	,, 10	125	+ 11	23	2,643	+ 117
Keighley Corporation	,, 16	188	+ 16	11	1,934	+ 33
Kidderminster & District	,, 10	96	+ 14	23	2,169	+ 46
Kilmarnock Corporation	..	..	..	..	..	..
Lanarkshire Trams Co.	,, 16	1,475	+ 200	24	32,659	+ 3,618
Lancashire United	,, 15	1,400	+ 81	24	30,383	+ 162
*Leamington	,, 10	183	+ 40	23	3,465	— 92
Leeds Corporation	,, 18	7,418	+ 481	11	79,547	+ 2,910
Leicester Corporation	,, 18	2,491	+ 310	..	..	..
Leith Corporation	,, 18	685	+ 89	5	3,122	+ 103
Lincoln Corporation	,, 13	117	+ 5	12	1,496	+ 3
Liverpool Corporation	,, 11	11,455	+ 1,015	23	250,151	+ 7,392
Liverpool Overhead Rly.	,, 19	1,412	— 8	25	33,551	+ 683
Llandudno&ColwynBayRy.	..	..	..	..	..	..
*London County Council	,, 4	42,359	+ 2,693	¶9	389,621	+ 52,526
London United	,, 18	7,433	+ 574	24	146,514	+ 8,940
Lowestoft	,, 18	176	+ 1	38	5,761	+ 263
Maidstone Corporation	..	..	..	..	..	..
Manchester Corporation	,, 18	16,150	+ 1,194	11	173,905	+ 2,566
Mersey Railway	,, 18	2,048	+ 131	24	48,739	+ 1,257
Merthyr	,, 10	207	— 20	23	4,523	— 254
Metropolitan Dist. Railway	,, 18	11,245	+ 206	24	261,991	+ 23,845
Metropolitan Elec. Trams	,, 10	7,818	+ 2,022	23	163,861	+ 30,472
Middleton	,, 10	341	— 112	23	6,852	— 602
Nelson Corporation	,, 18	157	+ 22	§11	1,625	— 6
Newcastle-on-Tyne Corp.	,, 18	3,998	+ 295	¶11	43,093	— 1,421
Newport (Mon.)	,, 18	700	+ 61	12	8,184	+ 240
Northampton Corporation	,, 17	487	+ 12	§11	5,450	— 102
Oldham, Ashton & Hyde	,, 10	566	— 26	23	12,414	— 157
Oldham Corporation	,, 19	1,922	+ 204	12	22,994	— 1,009
Perth (N.B.) Corporation	,, 15	171	+ 23	§4	746	+ 36
Perth (W.A.) Elec. Trams	,, 17	1,438	+ 53	24	37,318	+ 2,776
Peterborough	,, 10	110	+ 7	23	2,415	— 33
Portsmouth Corporation	,, 18	2,165	— 81	11	22,063	— 1,532
Potteries	,, 10	1,689	+ 41	23	39,683	— 600
Preston Corporation	,, 15	716	+ 37	11	7,970	— 351
Rotherham Corporation	,, 16	632	+ 74	11	6,765	— 6
Rothesay	,, 10	254	— 1	23	2,241	+ 26
Salford Corporation	..	..	..	..	..	..
Sheerness	,, 10	52	— 2	23	1,011	— 37
Sheffield Corporation	,, 19	6,033	+ 520	¶12	73,492	+ 4,040
Singapore Trams	,, 18	$10,028	+ $821	21	$238,126	+ $5,946
South Metropolitan	,, 10	883	+ 140	23	17,982	+ 1,014
South Staffs	,, 10	814	+ 67	23	18,784	— 93
Southend Corporation	,, 15	615	+ 151	11	5,541	+ 440
Southport Tramways	,, 10	312	— 5	23	6,108	+ 208
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 18	776	+ 20	¶11	7,992	— 1,050
Sunderland Corporation	,, 19	1,234	+ 109	12	12,811	— 432
Sunderland District	,, 15	433	+ 1	33	13,279	— 1,468
Swansea Trams	,, 10	1,056	+ 177	23	23,328	+ 2,492
Swindon Corporation	,, 15	140	+ 20	..	..	..
Taunton	,, 10	45	+ 9	23	928	+ 109
Tynemouth and District	,, 10	271	+ 18	23	4,148	+ 284
Tyneside Trams Co.	,, 15	505	+ 75	24	9,560	— 243
Wallasey District Council	,, 18	930	— 4	§11	10,276	— 485
Walsall Corporation	,, 18	516	+ 24	24	12,741	+ 632
Warrington Corporation	,, 9	382	+ 24	10	3,794	+ 56
West Ham Corporation	,, 9	2,510	+ 369	10	24,357	+ 300
Weston-super-Mare	,, 10	155	+ 8	23	1,592	— 85
Wolverhampton Co.	,, 10	404	+ 42	23	9,453	+ 104
Wolverhampton Corpn.	,, 15	899	+ 156	11	9,854	+ 1,703
*Worcester	,, 10	334	+ 65	23	5,954	+ 123
Wrexham	,, 10	102	+ 13	23	2,181	+ 23
Yorkshire W.R. Trams	,, 19	1,236	+ 122	25	30,692	..
Yorkshire Woollen District	,, 10	1,023	+ 202	23	22,068	+ 2,049

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	NAME.	Price Wed., June 22	Rate per cent. Yielded.	Dividend Due.	Business Week to June 22 High-est.	Business Week to June 22 Low-est.
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9¾	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 15 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	102—105	4 5 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼—7¾	6 9 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7 —7½	4 13 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	98 —101	3 19 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¼—4	6 5 0	Feb, Aug	3⅛	3⅛
5	2/3	Do. 4½ per Cent. Pref.	4¼—4⅝	4 17 6	Feb., Aug	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	95½—97½	4 2 6	Jan, July	97⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101⅛—103½	4 7 0	..	102⅛	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¼—4¾	5 3 0	Jan, July	4⅛	4
5	2/6	Chelsea Electric Supply Ord.	3⅜—4½	5 9 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11½—11⅞	5 19 0	Feb, Aug	11⅛	11⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	121 —125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	100 —103	4 7 6	Jan, July	102	..
5	..	County of Durham Elec. P. D. Ord.	1¼—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¼—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7⅜—8	6 0 0	Feb, Aug	7⅛	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¼—11⅛	5 5 0	Mar, Sept	11⅛	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	105 —109	4 2 6	Jan, July	108⅛	..
St.	4½%	Do. Second Deb. Stock	99 —102	4 9 0	May, Nov	100⅛	99⅛
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4⅜	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	6¾—7¼	5 7 6	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5¾—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94⅛—96⅛	4 3 6	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 —100	4 0 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅛—2	4 10 0	Mar, Sept	⅜	..
3	3/0	Do. 6 per Cent. Pref.	4½—5½	5 14 0	Mar, Sept	..	..
5	4%	†Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	91⅛	..
5	2/6	Metropolitan Electric Sup. Ord.	3¼—4	5 9 0	April, Oct	3⅜	3⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.	4¼—4⅞	4 12 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	83 —86	4 1 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	97 —99	4 11 0	June, Dec	..	..
5	4.0	Newcastle Elec. Supply Ord.	4¼—4⅜	4 7 6	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾—4⅞	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	101 —103	4 7 6	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	100 —102	4 18 0	..	..	..
10	9/0	Notting Hill Electric Ord.	12 —13	6 0 0	March	11⅞	11⅛
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅛—8½	5 9 6	Feb, Aug	8⅛	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7⅛	4 15 0	Feb, Aug	7⅛	7⅛
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	85 —88	3 19 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1¼—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3⅛	6 11 0	April	..	..
St.	5%	Do. 5 % 1st Mort. Stock (red.)	101 —104	4 16 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—⅜	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	98⅛	..
5	2/6	Urban Electric Supply Ord.	⅛—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	7⅛—8⅛	5 12 6	Mar, Sept	8⅛	8⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	5⅛	5⅛
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.	⅛—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅛	6 12 9	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock	83 —86	5 5 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6¾—7	8 11 6	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7⅛—8	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¾ —1⅛	..	June, Dec	⅜	⅜
10	..	Do. 6 per Cent. Cum. Pref.	2¾—3⅛	8 11 0	Feb, Aug	2⅞	..
St.	5%	Do. 5 Cent. Perpetual Debs.	89 —93	5 7 6	April, Oct	93⅛	93⅛
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 —73	6 3 0	May, Nov	69⅛	69
St.	3%	Central London Ordinary Stock	67 —69	4 7 0	Feb, Aug	67⅛	..
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	50 —52	3 15 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	95 —97	4 2 6	Jan, July	95⅛	95⅛
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4½—5	5 0 0	April, Oct	4⅜	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	13%	City & South London Rly. Con. Ord.	31⅛—31⅝	3 13 6	Feb, Aug	32⅛	32⅛
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	98 —100	4 0 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	93 —97	4 2 6	Jan, July	96⅛	95⅛
5	2/0	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	63 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅝—1	4 14 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	63 —65	5 18 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅜—10⅛	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	86½—88½	5 13 0	Jan. July	88	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 —71	5 12 0	Jan, July	68	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅞—⅞	..	..	..	..
1	..	Do. Deferred	⅛—¼	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½—⅝	5 0 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	93 —101	4 19 0	Jan, July	101	..
St.	1%	Metropolitan Railway Consolidated	41½—41⅞	2 8 3	Feb, Aug	41⅞	41⅞
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	66⅛	66⅛
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	87⅛	..
St.	3½%	Do. 3½ per Cent. "A" Preference	85 —88	3 19 6	Feb, Aug	86⅛	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	92⅛	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed. June 22	Rate per cent. Yielded.	Dividend Due.	Business Week to June 22 High-est.	Business Week to June 22 Low-est.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91 —93	3 15 0	Jan, July	..	91½
St.	..	Metropolitan District Railway Ord.	22½—22¾	..	Feb, Aug	23½	21½
St.	..	Do. Extension Pref. (5 per Cent.)	68 —70	..	Feb, Aug	69	68½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	..	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	75 —77	3 18 0	Jan, July	76½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	3 17 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	102	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	142 —144	4 3 3	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto	96 —98	4 1 0	Jan, July	97½	..
1	4½d.	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—¼	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock	82 —85	5 5 3	May, Nov	..	..
1	7½d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—½	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	68 —72	5 11 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	57 —61	8 4 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoups	36 —38	..	June, Dec	37	37
..	5%	Do. 5% Prior Lien Bonds	100½—101½	4 18 6	..	101½	100¼
..	4½%	Do. 4½% Bonds with coup. 5	89 —91	4 19 0	..	89½	..
..	4%	Do. 4 per Cent 1st Power Ho. Dbs.	98 —100	4 0 0	..	99	..
..	..	Yorkshire (W.R.) Elec. Trams. Ord.	½—¾	..	March ..	..	..
..	..	Do. 6 per Cent. Cum. Pref.	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	79 —82	5 10 0	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	101½—103½	4 7 6	..	..	..
1	..	Aron Electricity Meter Ord.	⅜—⅝	..	..	⅜	⅛
1	7½d.	Do. 6% Cum. Pf.	⅜—⅝	6 5 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.	5½—5¾	5 16 6	April, Oct	5½	5½
1	0/7½	Do Pref.	1⅞—1⅞	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7	7 3 0	July, Feb	6⅞	..
5	3/0	Do. 6 per Cent. Pref.	5½—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	103 —106	4 5 0	Jan, July	103	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅞—⅞	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	98½—100½	5 19 6	..	99½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	59 —62	3 4 6	Jan, July	..	..
St.	4½%	Brush E. Eng. Co. 4½% Perp. 1st Deb. Stock	39 —44	10 4 0	Mar, Sept	60½	59
St.	4½%	Do. Perpetual 2nd Deb. Stock	25 —29	15 10 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9½—10½	6 8 0	Jan, July	9¾	9½
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 13 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	102½—104½	4 6 0	Nov, May	103	..
1	1/3	Castner-Kellner Alkali Co.	2⅛—2⅜	5 8 9	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	106 —109	4 3 6	Feb. Aug	2⅝	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
1	0/7½	Consolidated Electrical Co.	⅛—¼	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.	⅛—¼	7 0 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	⅛—¼	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	½—⅞	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	87 —90	5 11 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅛—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	1⅛—1⅜	5 0 0	Sept.	1⅛	1⅛
5	0/7½	Do. 6 per Cent. Cum. Pref.	⅛—1⅛	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	99 —102	4 8 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	65 —70	5 14 0	June, Dec	..	..
St	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	⅜—⅝	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—1¾	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	7⅛ —77	5 16 6	Jan, July	..	..
2	..	Electric Construction Co.	⅛—¼	..	Jan, July	⅛	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	10 7 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	61 —66	6 1 0	Jan, July	61½	61
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—8½	5 1 6	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	11½—12½	6 1 0	Feb, Aug	12½	12
5	2/3	Do. 4½ per Cent. Pref.	5 —5⅜	4 3 9	Feb, Aug	5⅜	5⅜
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	103½—105½	4 5 6	Mar, Sept	..	..
10	15/0	India Rubber, Gut. Per., &c., Works	14½—15½	6 9 0	Feb, Aug	..	..
10	5/0	Do. 5 per Cent. Cum. Pref.	10½—10¾	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	..	..
1	..	National Elec. Construction Co.	⅛—¼	..	April ..	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—⅜	..	May, Nov	⅜	⅜
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	80 —85	5 6 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	30/0	Telegraph Construction & Maintenance	33 —35	6 0 9	Mar, July	34½	33½
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100½—102½	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	4 11 0	..	2⅛	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference	1⅛—1½	4 0 0	..	1⅝	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108 —111	4 10 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	101 —103	3 7 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	103½	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	103½—105½	4 15 6	..	105⅛	103½
10	10%	J. G. White & Co. 6% Cum. Pref	10½—11½	8 14 0	..	..	..
1	..	Willans & Robinson Ord.	⅜—⅝	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1½—1¾	10 13 6	Apr, Oct	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Debs.	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
		Amazon Telegraph	3⅜—3⅞	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	100½—102½	4 17 6	June, Dec	..	..
St.	15/0	Anglo-American	66 —68	5 5 6	F, My, Ag, N	..	5
St.	30/0	Do. Preferred	109 —111	5 8 6	F, My, Ag, N	112½	109½
St.	25/0	Do. Deferred	27½—27⅝	4 10 6	F, My, Ag, N	29⅛	27⅜
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	86 —88	4 10 9	Jn, Ap, Jy, O	87½	86½
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 15 0	Feb, Aug	16½	..
5	2/0	Direct Spanish Ord.	3½—3⅝	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable	14½—15	5 13 0	Ja, Ap, Jy, O	15⅛	14⅛
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 18 0	June, Dec	..	..
St.	65/0	Eastern Ordinary	133 —136	5 3 6	Ja, My, Jy, O	135	133½
St.	17/6	Do. 3½ per Cent. Pref. Stock	85 —87	4 0 6	Ja, My, Jy, O	85½	85⅜
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	101 —103	3 17 6	May, Nov	102½	..
St.	6/6	Eastern Extension	12½—13½	5 7 6	Ja, Ap, Jy, O	13	12⅛
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	102½	..
25	4%	Eastern and S. Af., 4% Mauritius Sub. Debs	99½—101½	3 18 6	May, Nov	..	..
1	26/0	G. N (of Copenhagen), with Coupon 79	30½—31½	5 13 6	Jan, July	31⅛	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	†Mackay Companies Common	87 —89	5 12 0	Ja, Ap, Jy, O	..	..
100	4%	†Do. Preference	76 —78	5 2 6	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅝—¾	..	April	⅝	⅝
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	97 —99	3 19 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 12 9	May	1⅜	..
100	4%	Do. 4 per Cent. Debs.	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	⅝—¾	..	May, Nov	⅝	⅝
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9½	6 11 3	May, Nov	8½	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	100½—102½	4 17 6	Jan, July	..	..
10	3/0	Western Telegraph	13½—14½	4 18 0	Mr, Jn, O, D	14⅛	13½
St	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	June, Dec	..	..
—	1%	Western Union Telegraph, $1,000 4% Bds.	101 —104	3 16 6	..	..	..
		Telephones.					
		Amer. Telephn. & Telegh. Cap. St.	138 —140	5 14 6	..	..	140½
		Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 4 6	Jan, July	..	..
		Do. 4% Cons. Bonds 1936	103 —105	3 16 0	..	..	..
		Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
		Chili Telephone	7⅛—8⅛	4 15 9	August ..	8	8
		Monte Video Telephone Ord.	⅛—¼	7 0 0	Nov	..	..
		Do. 5 per Cent. Pref.	⅛—¼	5 13 9	May, Nov	..	..
		National Co. Pref. Stock	106 —107¼	5 11 6	Feb, Aug	107½	105½
		Do. Def. Stock	124 —126	4 15 0	Feb, Aug	125½	124½
		Do. 6 per Cent. Cum. 1st Pref.	10 —10½	5 10 6	Feb, Aug	..	..
		Do. 6 per Cent. Cum. 2nd Pref.	10 —10¼	5 10 6	Feb, Aug	..	..
		Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5⅜	4 8 6	Feb, Aug	5⅛	..
		Do. Deb. Stock 3½ per Cent. (red.)	97 —99	3 11 6	June, Dec	98½	97½
		Do. 4 per Cent. Deb. Stock (red.)	100½—102½	3 17 6	Jan, July	101	100½
		New York Telephone Co. 30 yr. Bnds.	97½—98½	4 11 6	..	99½	97½
		Oriental	1⅛—1⅜	4 15 0	April, Oct	1⅛	..
		Do 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 0	April, Oct	..	..
		Do. 4 per Cent. Red. Deb. Stock	88 —90	4 9 0	Jan, July	89½	..
		Telephone Co. of Egypt 4½% Db. Stk. (red.)	100½—102½	4 8 6	Jan, July	..	..
		United River Plate	7½—7¾	5 9 0	July	..	..
		Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 12 3	June, Dec	5⅛	..
		Do. 4½ Deb. St. Red.	103 —105	4 5 6	Jan, July	103½	..
		Financial, Investment, &c.					
		Elec. & Gen. Investment 6% Cum. Pref.	2⅞—3⅜	8 18 0	Jan, July	3	..
		Globe Telegraph & Trust	10⅜—10⅞	5 5 9	Sp, DcMr Ju	10⅞	10⅛
		Do. 6 per Cent. Pref.	13 —13½	4 8 9	Sp, DcMr Ju	13½	13
		Submarine Cables Trust (Cert.)	128 —131	4 11 6	April, Oct	128½	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4½—4⅞	5 2 6	April, Oct	4⅞	4½
		Do. 5% Cum. 2nd Pref.	4½—4⅝	5 7 6	Jan, July	4⅞	4½
		Do. 4% Deb. Stock	90 —91½	4 7 6	June, Dec	91½	90½
		Do. 4½% Deb. Stock	96 —99	4 13 0	..	97½	96½
		Auckland Elec. Trams. 5% Deb. (red.)	10⅜—107	4 13 6	Jan, July	106	..
		Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	..	..
		Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 13 9	May, Nov	5⅛	..
		Do. 4½ per Cent. Db. Prov. Certs.	101 —101¼	4 6 6	Jan, July	..	..
		British Columbia El.. Rly. Df. Ord.	142 —147	5 9 0	Mar, Sept	143	..
		Do. Pref. Ord. Stock	123 —127	4 13 6	May, Nov	125	..
		Do. 5% Cum. Perp. Pref. Stock	110 —113	4 8 3	Jan, July	112	110½
		Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
		Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
		Do. 4½% Perp. Con. Deb. St.	104 —105	3 19 0	..	104½	104½
		Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —101	4 19 0	Mar, Sept	100½	100
		Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	96 —99	6 1 0	Feb, Aug	98½	97½
		Calcutta Tramways (1 to 137,610)	4½—4⅝	4 7 6	Mar, Sept	..	..
		Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	..	..
		Do. 4½% 1st Deb. Stock (red)	98 —101	4 9 0	Jan, July	..	..
		Cape Electric Tram Shares	⅛—¼	..	..	..	..
		City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 9 6	F, My, A, N	5⅜	..
		Do. 4 per Cent. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
		Colombo Tr. & Ltg. 5% 1st Mt. Db.	95 —98	5 2 0	May, Nov	..	..
		Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	78 —81	6 3 6	June, Dec	..	..
		Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	96½—99½	5 0 6	Feb, Aug	..	..
		Kalgoorlie Elec. Trams Sh.	⅛—¼	..	..	..	..
		†Do. 5 per Cent. "A" Deb. Stock	92 —95	5 3 6	Jan, July	..	..
		†Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
		Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 0 6	July	..	..
		Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	100 —104	4 16 0	Jan, July	..	..
		Madras Elec. Trams. 5% Deb. Stk.	98 —100	5 0 0	Jan, July	..	..
		Manaos Trams and Lt. Co. 5% Debs.	88½—90	..	..	..	89½
		Manila Elec. Ry. $1,000 Gold Bonds	98 —100	5 2 0	Feb, Aug	98½	98
		Mexico Trams Co. Com. St.	127½—129½	4 18 6	..	..	..
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	98 —99	4 1 0	..	99½	99½
		Do. 6% 50 yr. Mort. Bds.	101½—102½	5 17 6	..	102½	101½
		Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	101½	..
		Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	..	..
		Perth Elec. Trams Ord.	⅜—⅝	5 14 0	May	..	..
		Do. 1st Mt. Db. Stock	101 —104	4 16 0	Jan, July	..	..
		Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅜—5⅝	5 2 6	..	..	..
		Do. 4½% 1st Mort. Deb. Stk.	101 —103	4 17 6	..	96½	95½
		Rio Janeiro Tram, Lt. & P. Co.	95 —97	4 2 6	..	99¼	99½
		Do. 30 yr. Gold Bnds.	99 —100	4 0 0	..	85	87½
		Do. 50 yr. Mt. Bnds	87 —88	5 12 6	..	..	..
		Sao Paulo Tramway, Light & Power Co. $100 Stock	149½—151½	6 13 0	..	150½	150
		Do. 5 per Cent. 1st Mt. $500 Db.	102 —104	4 16 6	June, Dec	103½	103½
		Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	101½	..
		Colonial and Foreign Electricity Supply, &c.					
		Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅜—5⅞	5 2 0	Mar, Sept	..	..
		Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 9 0	..	..	..
		Do. 4½ per Cent. Deb. Stk. (red)	95 —97	4 12 6	Jan, July	..	..
		Do. 5 per Cent. 2nd Mort. Deb. Stock	97 —99	4 19 0	..	..	..
		Calcutta Elec. Supply Ord.	6½—7	5 15 0	April, Oct	6⅞	..
		Canadian Gen. Elec. Co. Com. St.	108 —112	6 6 0	..	..	..
		Do. 7% Cm. Pf. Stock	119 —122	5 14 6	..	122	121½
		Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	98 —102	4 18 0	Jan, July	..	..
		Elect. Development Co. of Ontario	85 —88	5 12 6	..	88½	85½
		Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	89 —92	5 8 6	Jan, July	90	..
		Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
		Do. 6 per Cent. Cum. Pref.	⅞—1	8 0 0	April, Oct	..	..
		Kaministiquia Power Co. 5% Gold Bnds.	102 —104	4 16 6	..	..	..
		Madras E. S. Corp. Ord.	2⅜—3¼	..	..	..	..
		Melbourne E. S. Co. 6% Cum. Pref.	33 —38	..	..	..	..
		Do. 5% 1st Mortg. Deb. Stock	92 —94	5 6 9	..	..	..
		Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	86½—87½	5 14 6	..	87	..
		Mexican Lt. & Power Co. Com. St.	79 —81	4 18 6	..	80½	..
		Do. 7% Cum. Pref. St.	103 —105	6 13 6	..	103½	103½
		Do. 5% 1st Mort. Gold Bnds.	91½—92½	5 7 6	..	9-½	92
		Montreal Lt. Ht. & Power Co. Cap. St.	134 —133	4 17 6	F, My, A, N	135	..
		River Plate Electricity Co. Ord.	2⅛—2⅜	5 12 9	April	2⅜	..
		Do. 6 per Cent. non-Cum. Pref.	1⅛—1⅜	5 2 0	May	1⅜	..
		Do. 5 per Cent. Deb. Stock	103 —105	4 15 6	Jan, July	..	..
		Rosario Ele. Co. Ord.	8½—9	..	..	..	..
		Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
		Do 2nd Pref.	8½—8¾	6 14 6	..	..	..
		Shawinigan, Water & Power Co. Ca.	101½—103½	4 7 0	..	103½	103½
		Do. 5 per Cent. Bds.	107 —109	4 12 0	Jan, July	108½	..
		Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102½	101½
		†Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	..	..
		Victoria Falls Power Co. Pref. (1 to 808,000)	5⅛—5⅝	5 6 6	Jan, July	..	..
		Do. (803,081 to 1,700,000)	2⅛—2⅜	..	..	..	..

* Ex Dividend. † The London Stock Exchange Committee have declined to quote these

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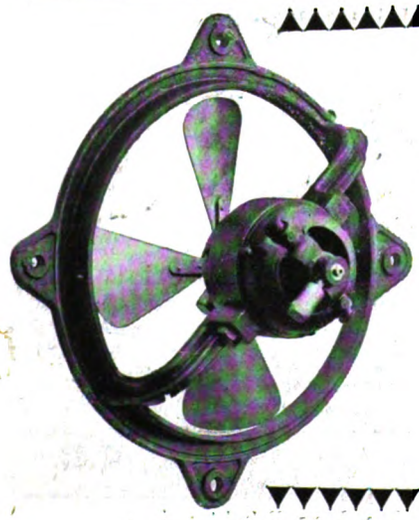
Problems of Ventilation.

THERE is yet much to be done before a satisfactory solution of the problem of ventilation is brought about The ventilation of buildings by natural and artificial methods is still something of an experiment. The process in which the air near the ceiling or roof of a building is removed by induction is not adequate for universal application. It does not provide for what, in electrical parlance, may be called "heavy overloads." When a hall is filled beyond its normal seating capacity the ventilating arrangements fail utterly at the very time when some operating reserve in them is looked for.

The value and importance of the electric motor is universally admitted as a contributory factor to the solution of this knotty problem. At a rough estimate two-thirds of the modern large public buildings are electrically ventilated, and as a rule the results achieved are highly satisfactory. But these results have only been obtained by a study of the conditions of the particular building and the application of the electrically-driven plant to the desired end.

It must not be supposed that because the electric ventilating fan is such a simple and efficient air mover there is nothing else to be done than cut a hole in the wall of a building somewhere near the roof and set the fan going to secure adequate ventilation. We are familiar with an instance of a church where something like this was once done. The edifice was electrically lighted, and the organ was blown by a motor-driven kinetic blower, so that the introduction of a ventilating fan seemed a delightfully simple matter. In construction the church was high-roofed in the nave and chancel, but rather low-roofed in proportion at the aisles. A hole was cut in the wall at the top end of one of these aisles immediately facing the Lady chapel, which was formed by an abutment on the north side of the church. Into this hole a propeller type fan was fixed, but in this position it failed to ventilate the church. After careful consideration of the matter it was apparent that the only place for the fan was in the organ loft, which was built over the south aisle near the chancel, and gave on to the body of the church through a nest of pipes in an archway immediately overlooking the choir stalls, and high up in the roof. The original hole made for the fan was bricked up and, with the fan in its new position, the ventilation of the church was all that could be desired. The fan can be speeded up so as to remove more air when the congregation is above normal in its attendance.

It is not always possible to adopt cut and try methods in dealing with the ventilation of a building, but the most satisfactory results are usually obtained when some kind of test is first applied to the initial position of the motor and fan.



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The Electric Driving of Printing Machinery.

THERE is perhaps no direction in which the electric motor so well holds its own as in the operation of printing machinery. The small space which it takes up, the ease with which it can be controlled, and the possibility of its being left in charge of comparatively unskilled labour, all mark it out for the work. In the application of the electric drive to printing machinery some interesting problems arise—problems which lead to solutions none the less interesting and ingenious. These problems fall naturally into two classes, the methods of driving and the methods of control, and as Electromotors Limited are a firm who have much experience, it will be perhaps expedient for us to give a summary of their views on both these subjects.

There are several methods in which printing machines may be driven by electric motor, namely, by coupling direct, belt driving, and spur gearing. The coupled direct arrangement is not much used in this country, as it is an expensive arrangement. The two principal methods therefore, are the spur gear drive and the belt drive. A belt-driven arrangement may be one in which the motor drives by belt on to the fast pulley of the printing machine only, or it may be provided with a broad pulley so as to drive on to the fast and loose pulley of the machine. The latter arrangement is shown in Fig. 2. In small printing works where only a few machines are used, and where it is necessary for everything to be as simple as possible this method has advantages, as when the motor is once started up the machine is operated by the striking lever in the ordinary way. Its chief disadvantages are the space taken up at the side of the machine and the fact that the motor is always running, driving the loose pulley, and using up a small amount of energy when the machine is not being run.

The belt-driven arrangement in which the machine is started and stopped by means of an electric starting switch—

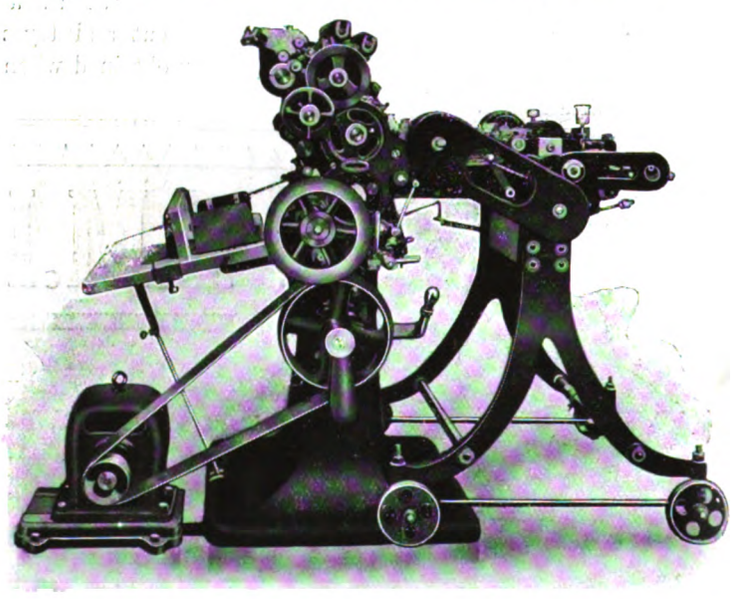

Fig. 1.—Harris Minor Press, Belt-driven by Motor.

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that is to say, the belt runs on the fast pulley of the machine only, gets over the disadvantage of running the motor continually, and so wasting a little energy, but it necessitates a more robust and better quality of starting switch than is required with the fast and loose pulley arrangement.

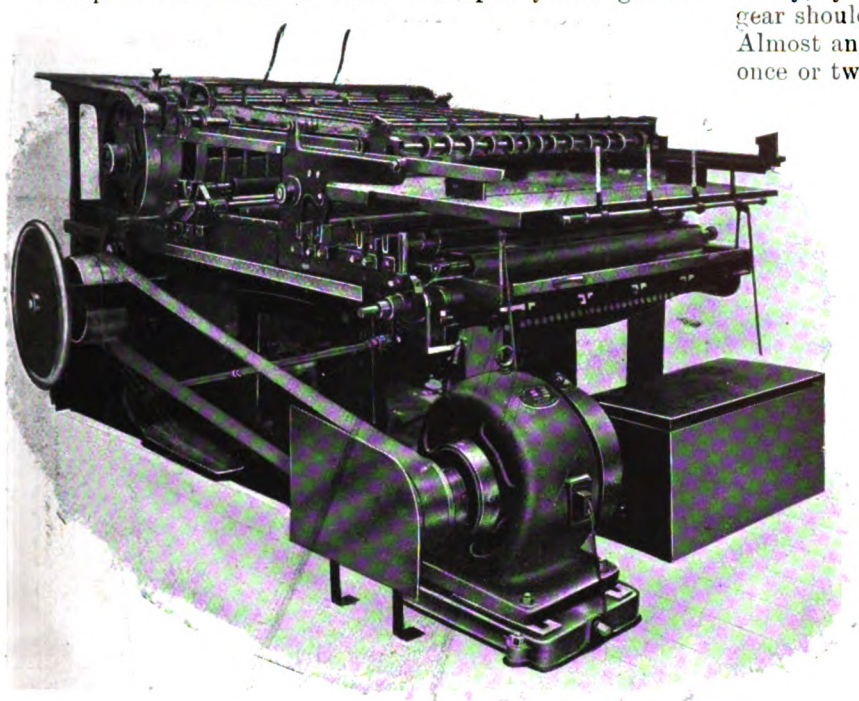

Fig. 2.—Furnival Two-revolution Press.

This is a point that is frequently overlooked by those who have not special experience in printing press equipments. Another advantage of this method is that it is possible to use larger pulleys than are usually fitted with fast and loose pulley arrangements, thus ensuring a more satisfactory drive.

Economy of space is generally an important consideration in a printing office, and accessibility to the working parts of any machine is a consideration in every works. These considerations sometimes make it necessary to fit the motor at the back of the machine, and as close up as possible. This often results in a very short length of belt.

A short drive, however can be made quite satisfactory if the arrangements are carefully designed, as is shown in Fig. 3. In this illustration it will be seen that the motor is practically close up to the litho press, the belt passing under a jockey pulley, the tension on the belt being controlled by means of an adjustable spring. With this arrangement the belt must be sufficiently flexible to bend easily in either direction. The spur-geared arrangement is an excellent method of driving and economises the space very considerably, but requires careful designing. The tooth form and ratios of gearing should be given considerable attention, and not only must the gears be properly meshed when standing, but the machine and motor must move together in unison so that they mesh together when running.

As a rule the driving arrangements receive more consideration than the switching details. Being a mechanical matter it is one which the printer can more fully enter into. When the press is started and stopped electrically, that is to say, by means of a switch, it is essential that the switchgear should be specially designed to stand the severe duty. Almost any standard switch may be used to start a motor once or twice a day, but to "inch" a machine round when 'making ready" is about as severe a duty as it is possible to imagine. When a machine operator wants to move his cylinder an inch or two, he does not pull the flywheel round if he has a switch close at hand. The result is that in printing operations the switches are used hundreds of times more frequently than with other classes of work. Obviously, the life of a switch depends not so much on the length of time it is in service, as on the number of times it is used, and as a switch on a printing press gets more use in a week than any other switch gets in a year, the depreciation is very rapid unless specially designed for the work. The motors also feel the effects of unsuitable switching apparatus, excessive strains being thrown upon them if the starting resistance is cut out too rapidly.

In all well-arranged printing machine rooms a double-pole switch is placed in a convenient position for the layer-on. This is the only switch he handles, and is less trouble to operate than the ordinary brake lever. The starting switch proper is fixed at the back of the machine, and as soon as the layer-on closes his switch the starting resistance is automatically cut out slowly, and the machine is gradually accelerated. This system removes the disadvantages referred to above, as the make and break switch can be made very strong, whilst the motor is protected against sudden shock and overloads due to improper starting. A small switch alongside the starter acts as a speed regulator which permits of 20 different speeds being obtained

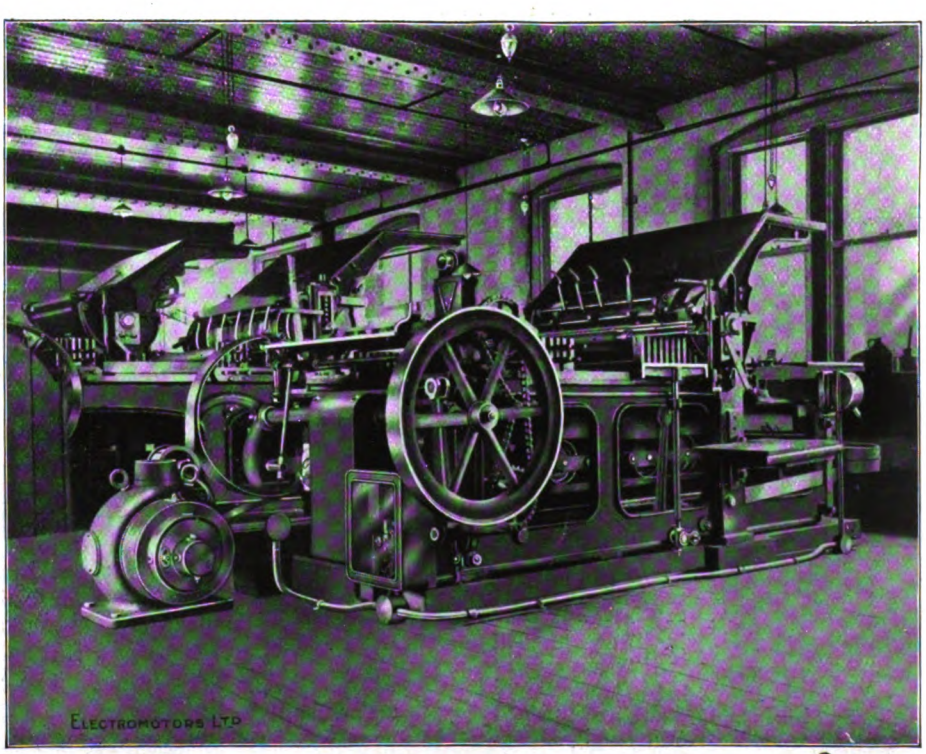

Fig. 3.—Electrically-driven Litho Press.

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in the most economical manner. The main current does not pass through this regulator, but only the magnetising current, which is a very small fraction of the total. By this means the lowest speeds are as economical as the highest The regulator is provided with a removable handle, so that the speed can be set by the overseer and cannot be altered by the layer-on. The whole thing is very compact, occupying a space of only 7 in. square by 4 in. deep. This arrangement is a little more expensive in first cost than the plain manually operated starter, but it pays in the long run.

At the recent Printing Exhibition at the Agricultural Hall, Messrs. Electromotors (Ltd.) carried out the electrical equipment of several of the stands. There were some 10 or 12 motors on Messrs. Harrild & Sons' stand, arranged with the object of demonstrating the various methods of electrically driving printing machines and the adaptability for any class of machine. There were three flat-bed presses, a demy rapid cylinder, a double-demy two-colour and a double-demy single-colour. The first of these was running at the very high speed of 3,300 impressions per hour and was driven through an ordinary belt on to fast and loose pulleys. The two-colour had a motor bolted direct to the machine frame and driving through raw

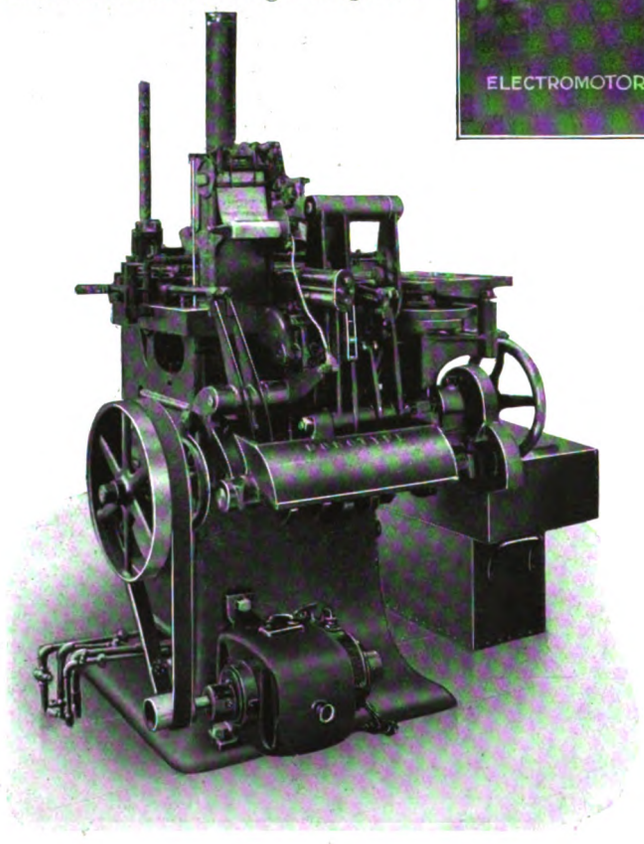

Fig. 4.—Monotype Casting Machine driven through a Short Belt by Specially Designed Motor.

hide pinion and spur gear. The starting and stopping of the machine was obtained through a small main switch within easy reach of the operator; this main switch simply controlled automatic starting gear, and it can be seen that with this system the operator wasted as little time as possible on the electrical equipment, and the control of the press was brought to perfection. Inching could be carried out with accuracy to about ¼ in.

The single-colour machine was equipped in the same way, and both these machines had small shunt regulators which enabled the motor speed to be varied 50 per cent., so that the machines may be run to the highest speed compatible

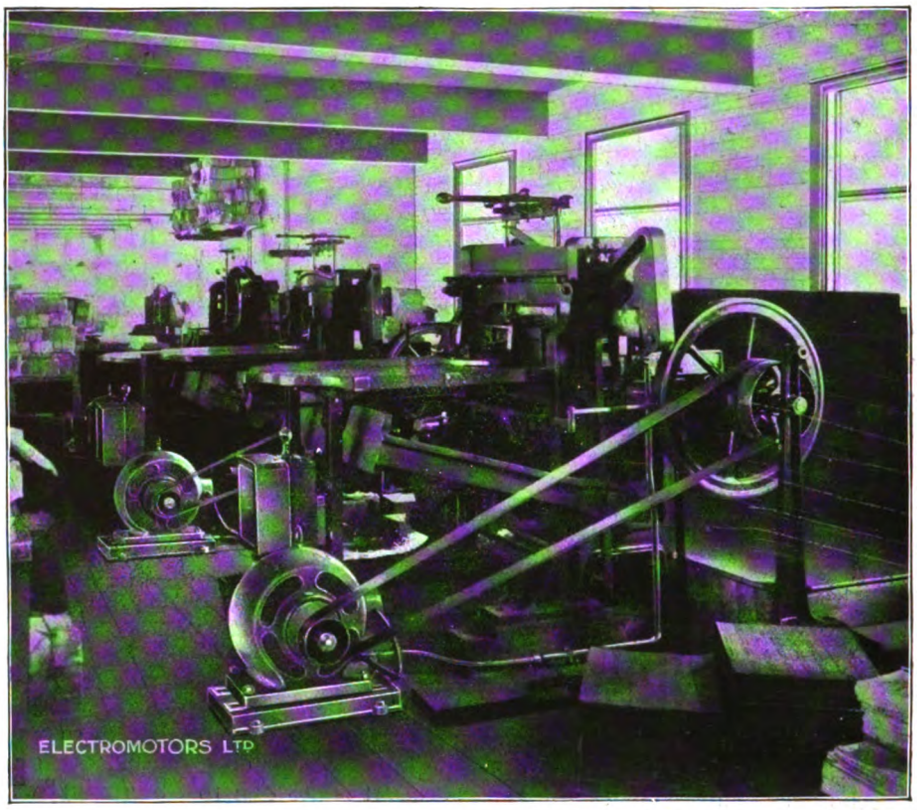

Fig. 5.—Belt-driven Printing Machinery.

with the work in hand. The other machines consisted of guillotines, saws, planers and block presses. Each one has its own individual motor and this exhibit might be looked upon as illustrating the most up-to-date electrical driving on the unit system, which was, without doubt, the most economical in running costs.

On Messrs. Crosland's stand a cutting machine operated direct by motor through fast and loose pulley, and a platen type of press, used chiefly for embossing, was motor driven, the motor being specially designed to take the heavy load which comes on at the impressions.

The drive on Messrs. Mann's stand was in contradistinction to Harrild's, as in this case a 10 H.P. motor drove on to an overhead line shaft from which the different types of litho presses and their new offset press were driven. The system has the advantage that the initial outlay is lower, but there are disadvantages to it, viz., increased running costs, no facility for obtaining variable speed except by step pulleys, and the countershaft and belting is all running if only a single press is in operation.

Messrs. Electromotors (Ltd.) also provided the equipments for the machines on Messrs. Lockett's stand. Two of their flat-bed presses were fitted with motors driving direct through gearing and bolted direct to the machine frame. The control gear on these machines was not automatic, but was of the latest type of hand operation starter which was, it is claimed, as perfect as is possible to obtain.

OSRAM·LAMPS

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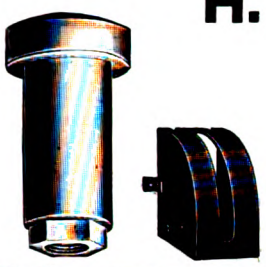


H. WEIDMANN, Rapperswil, Switzerland.

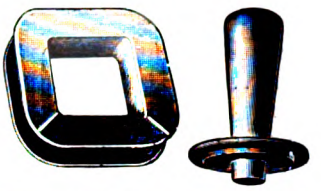
Manufacturer of Presspahn and Insulating Material.

Grand Prix : Marseilles, 1908.

PRESSPAHN in sheet, rolls and tapes. Presspahn tubes and stampings.
CORNITE, high tension Material. Handles for Switchgear and Heating Apparatus. Controller Insulation. Moulded parts of all kinds.
AMIANITE, Vulcanised Asbestos. Coil Frames. Spools for Dynamos, Motors and Transformers. Boxes, &c. Insulating Blocks, Tubes, Plates.
ASBESTOS CEMENT in Plates, Arc Shields for Controllers, &c. **MICA** and substitutes.

Insulators for Electric Furnaces, Tramways, &c.

Japanese Paper in Rolls and Tapes. Oil Varnished Linen, Silk and Paper, &c.



Insulating Material for Electrical Work. . .

PRESS-SPAHN is undoubtedly one of the most important insulating materials used in electrical engineering. Originally it was employed as a separator between the layers in the manufacture of cloth and silk, but nowadays it belongs to the most valuable materials used for insulating purposes. Its advantages are high insulating resistance, great mechanical strength and cheapness. In hot oil it will not split like costly mica and will keep for many years in temperatures of 80°C. to 100°C. The firm of H. Weidmann, Rapperswil (Switzerland), has taken an important and active share in the general introduction of press-spahn as an insulating material. This firm's product is especially prepared to meet the influences of damp air, the insulating qualities of press-spahn being largely dependent on the condition of its surface. The test results obtained in the Physikalisch-Technische Reichsanstalt, Charlottenburg, have proved that an alternating-current pressure of 3,000 volts is required to puncture a press-spahn sheet with a thickness of 0·25 mm. The size of ordinary sheets is 70 cm. by 90 cm., but other sizes are supplied on request. The thickness varies from 0·10 mm. to 15 mm., the specific gravity being about 1·25. Press-spahn is not only supplied in sheets, but also in endless rolls, the latter modification being more and more in demand ; its special, advantage is that it can be cut in any desired lengths, thereby reducing waste. These rolls of press-spahn are usually supplied in lengths of from 50 to 200 metres, according to the thickness of the material.

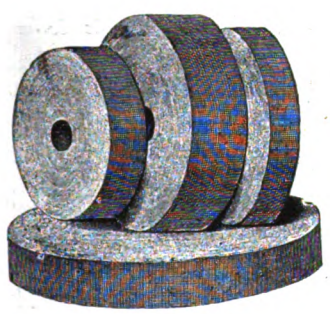


Fig. 1.

Fig. 2.

Fig. 3.

There is also an increasing demand for press-spahn in narrow strips rolled up like tape (Fig. 1). These strips are used for insulating armature slots, copper 'bus bars and strips, electric cables, &c. The width of these strips is made from 15 mm. to 500 mm., the thickness is from 0·10 mm. to 1 mm., and the length between 50 and 200 metres. Attention may also be drawn to varnished press-spahn, presspan with mica layers and oiled and paraffined press-spahn. Cheap substitutes are sometimes made under the name of press-spahn consisting of ordinary lacquered cardboard, but there is an enormous difference between the two. Lacquered cardboard may possess one advantage, and that is cheapness, but for electrical purposes it is very much inferior to press-spahn. To put on to the cardboard surface an extra layer of varnish is one way out of the difficulty, but it is such a cumbersome and expensive process that in the end the previous advantage in price is lost entirely.

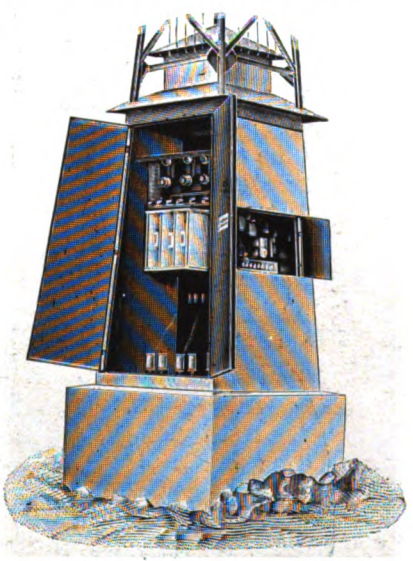


Fig. 4.

A special process has been adopted lately for making press-spahn tubes with and without asbestos and mica lining, also transformer cylinders and other insulating parts, such as slots, rings, discs and all manner of stamped articles, &c. We would finally point out that Messrs. Weidmann also manufacture all other electric insulating materials, such as mica parts, micanite in sheets and different patterns ; cornit, a high-tension material which will stand temperatures up to 300°C. and more, and which is recommended for high-tension parts (Fig. 2) ; vulcoasbestos and amianit are easily machined and formed, and are especially suitable for the construction of protective boxes and field bobbins without seams or metal corners, and made in one piece (Fig. 3) ; pyrostat, vitrit and pierrit are insulating materials for high temperatures of heat, which have been used as insulators in electric ovens.

The firm's list also includes other materials for the same class of work, such as lacquered materials and papers, Japan

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silk, tissue and felt papers, the latter in rolls and strips, insulating beads, flexible insulating tubes for meters, apparatus and lamp manufacture, asbestos cement insulation in the shape of machined bases for apparatus, screens for high-tension fuses and lightning protective devices (Fig. 4), controller partitions, insulation for electric ovens and numerous other materials for various purposes.

Pumps for Sewage Work.

AMONG the firms who have devoted themselves to the design of pumps for sewage work may be mentioned Messrs. Hathorn, Davey & Co., of Leeds. For this purpose they make pumps in two well-known types, the three-throw horizontal and the centrifugal, both of these being specially designed for use with the electric motor. A standard type of three-throw pump is shown in Fig. 1, the discharge from which is nearly constant, while the apparatus is as practically efficient at varying heads and different rates of speed. It is claimed that there is comparatively little wear under trying conditions, such as gritty or impure water, and consequently the pumps have been largely adopted in mining work. Two pumps of this type, each designed to pump 115 gallons of water per minute to a vertical height of 600 ft. have been supplied to the Waihi Gold Mining Co., in New Zealand, while another set, approximately the same size, is now being built for the Leeds Corporation water supply.

Fig. 2 shows an illustration of this firm's high efficiency centrifugal pumps, similar to those used by the Leeds Corporation. These pumps are specially adapted for use where a small portion of the district lies considerably higher than the rest; for example, a part of the Leeds area is situated at too great an elevation for the water in the high level mains to reach it. A tank was therefore elevated 50 ft. above the level of the highest reservoir, and the pump, illustrated in Fig. 2, was installed to supply it. A float in the tank starts and stops the pump, which works quite automatically and only requires the occasional service of an attendant to oil and generally overlook it. These pumps, it is claimed, are specially suitable for direct coupling to electric motors, for they are both mechanically and hydrostatically balanced and the end thrust is eliminated. They have a very high efficiency over a considerable variation of speed, capacity and lift.

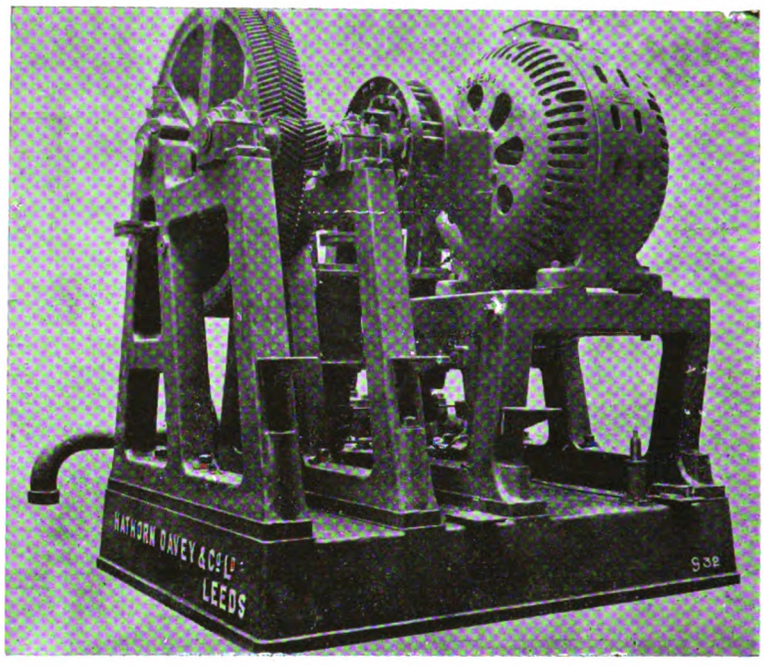

Fig. 1.—Standard Three-throw Pump (Hathorn, Davey & Co.)

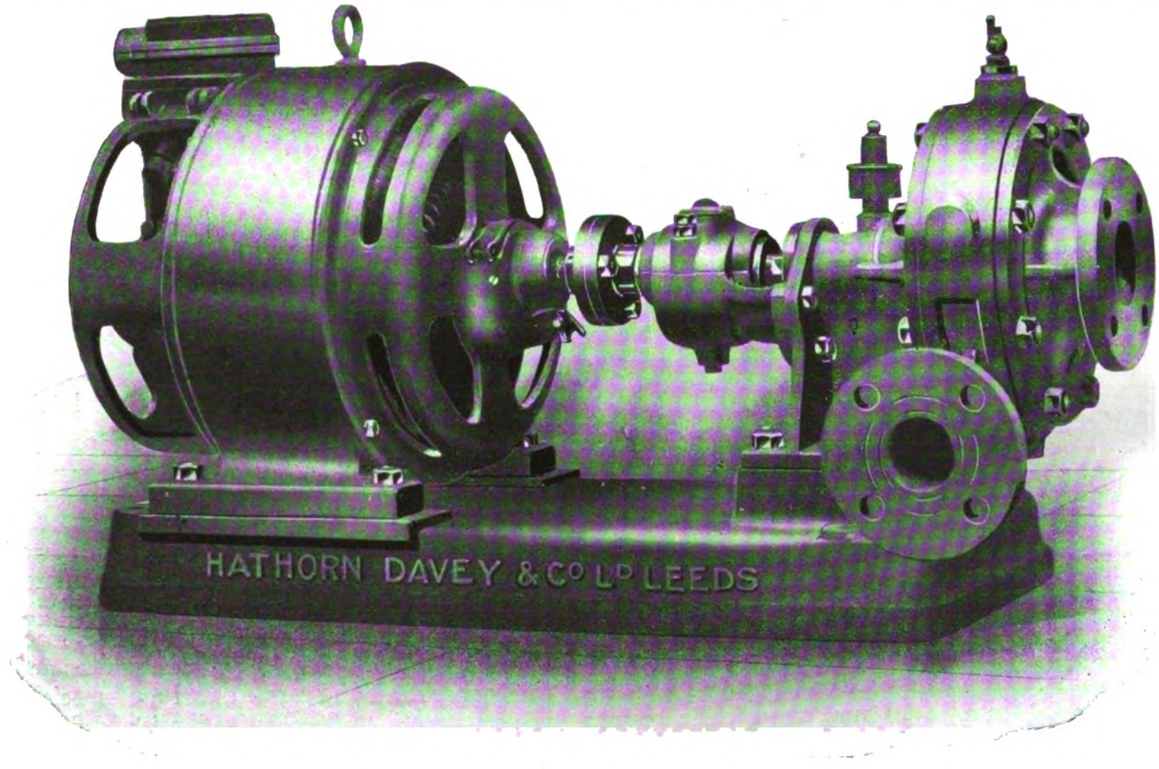

Fig. 2.—Hathorn Davey Centrifugal Pump for the Leeds Corporation.

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Electrical Progress.

IN this article we propose to call special attention to the progress which has been made during each preceding month by electrical manufacturers in their own special lines. This progress can be best gauged by reference to selections from their latest catalogues and price sheets, and we shall give short notes on the subject matter of such catalogues and lists as are sent to us, and which indicate either that new equipment has been designed or that modifications have been made in well-known apparatus.

Lighting Fittings.

LIGHTING AND HEATING FITTINGS FOR ELECTRIC VEHICLES.—In these days of Tube railways and motor cars attention must be paid to the proper design of the lighting arrangements. For in the former artificial lighting is always necessary, while in the latter the provision of a light inside the car greatly increases both its comfort and scope. A catalogue recently issued by *Messrs. Siemens Bros. Dynamo Works (Ltd.)* should, therefore, be welcome to every motor car owner. In it he will find illustrations and financial details of ceiling fittings and wall brackets, as well as more material things such as testing lamps, plug sockets and headlights. The comfort of the passenger in cold weather is not forgotten, and a very neat radiator has been designed for warming the car. With regard to price, it may be mentioned that a very good ceiling fitting can be obtained for 16s., rising to £1. 12s., while the wall brackets range about 16s. The radiator costs £1. 15s. complete.

"SUNLITE" AND "SUNLINE" REFLECTORS.—The needs of the shopkeeper who wishes to illuminate his windows in the best style should be met by a glance through a recent catalogue of the *Sun Electrical Co.* which gives details of "Sunlite" and "Sunline" reflectors. These are fitted with a heat resisting metal plate, while the lamps are carried on a swing arm allowing them to be easily get-at-able. Illustrations are also given of special fittings which have been designed for the lighting of pictures and other special positions. These reflectors are cheap, working out at 6s. 9d. per lamp length, and their use should quickly repay this small initial outlay owing to the increased light obtained.

LIGHTING ACCESSORIES.—In a pamphlet they have recently issued *Messrs. D. H. Bonnella & Son* go very fully into the question of wall sockets and plugs. These are made in a number of types and sizes in wood, porcelain, the prices ranging from 20s. to 72s. per dozen according to capacity. Combined switch and wall connections at 48s. per dozen and pressed switches at 40s. per dozen are also illustrated and described.

Motors.

MOTORS AND SWITCHGEAR.—One of the most complete motor catalogues which we remember to have seen has recently been issued by the *Electric Construction Co.* It is, in fact, a series of leaflets built up into one entity, each dealing with a particular type of motor. In this way we are taken rapidly through continuous-current motors of all sizes, through continuous-current generators, then alternating-current motors and switchgear. Finally we come to application, and here are shown the E.C.C. motor driving haulage gear. The catalogue ranges over too wide a field for us to go into it in any detail, but it will suffice to say that it should be in the hands of every electrical engineer and power user.

Electric Mine Pumping Installation for Handling Hot Water.

IN reopening the Ward shaft at Virginia City, Nev., a considerable flow of hot water was encountered, which for a time baffled the efforts of the workmen. The great depth of this shaft, 3,480 ft., and the high temperature of the water, 175 deg., made the work of pumping out the impounded quantity very difficult, but a temporary electric pumping outfit was finally successfully put into commission, and has since been supplanted by a permanent installation which easily handles the present continuous hot flow.

For emptying the mines, in the first place, a temporary motor-driven pump equipment was installed, by which compressed air-driven sinker pumps at the bottom of the shaft lifted the water to a centrifugal pump on the 2,330 ft. level. This, in turn, delivered to a vertical triplex pump on the 2,100 ft. level. The sinker pumps were supplied with compressed air from two 100 H.P. compound air compressors driven by 100 H.P. motors located on the surface. A three-stage centrifugal pump on the intermediate level was belted to a 50 H.P. induction motor, while a 100 H.P. induction motor drove a $6\frac{3}{4}$ in. by 8 in. vertical triplex pump at the uppermost pumping level.

This apparatus has since been replaced by the installation of the permanent pumping plant located in a pumping station 80 ft. long, 24 ft. wide and 20 ft. high, connected with the shaft 3,100 ft. below the surface. The permanent pumping equipment consists of a special slow-speed 800 H.P. induction motor, direct-connected to an express type duplex double-acting pump, operated at 195 revs. per min. The valves and other visible parts are of bronze, and the pump has a capacity of delivering 1,600 gallons per minute against a total head of 1,550 ft.

THE THOMSON ELECTRIC LAMP.

The Meter Reader's Lamp.

HANDSOME, DURABLE, NICKEL PLATED CASE. COMPACT, HANDY, AND PORTABLE IN SIZE.

The accumulator can easily be recharged, and will give from 4 to 6 hours' Brilliant and Continuous Light. For the past three years the THOMSON LAMP has been Used in all parts of the world, for all purposes.

WRITE FOR PARTICULARS.

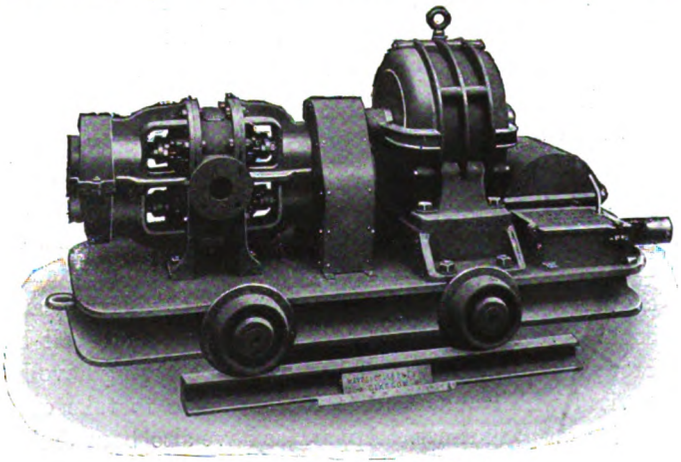
Sole Agents:
L. E. WILSON & Co.
Tel Address: "Telephony Manchester." Telephone: City 344.
20, CROSS ST., MANCHESTER.
And at 67, Stanley Street, Liverpool.

7/6

HALF SIZE.

Mavor & Coulson Pumps.

ONE of the great advantages of the electrically-driven pump is that it can be made portable with the greatest of ease. Given a source of energy supply, all is well. The combined pump and motor can be mounted on a trolley and moved over a wide radius of activity. The



Mavor & Coulson Portable Pump.

accompanying illustration shows a small electrically-driven portable drum pump manufactured by Messrs. Mavor & Coulson. They have supplied a large number of these sets for various pumps, which have proved entirely suitable for doing the work they are called upon to perform.

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THE ELECTRICIAN INDUSTRIAL SUPPLEMENT.
ISSUED MONTHLY
"THE ELECTRICIAN"
Telegraphic Address: "ELECTRICIAN NEWSPAPER LONDON" Telephone No. 940 HOLBORN.

All communications should be addressed to the Editor, "The Electrician" Industrial Supplement, 1, 2 and 3, Salisbury Court, Fleet Street, London, E.C.

Copy for Text or Advertisement pages for next issue, publishing on **July 22nd, 1910,** *should reach the above address by Tuesday,* **July 12th, 1910.**

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

The Off-Peak Load Problem.

In the early days of electricity supply, when the load was purely a lighting one, the whole design of the station depended on the amount of load which came on during the peak hours in the evening. These hours formed a small part of the total time of supply, the load itself being generally quite out of proportion to the demands on the station at other times. In fact, it was of an exceedingly peaky character. The condition imposed in this country, that the supply must be always available, made this state of things an additional disadvantage, so that stations were overburdened with capital expenditure upon which it was very hard to obtain an adequate return. At the present time, in many cases, these conditions have changed for the better. The increasing use of the electric motor has made an adequate day load possible, and in many cases the number of units supplied for power purposes exceed those supplied for lighting. But, even taking this into account, the load factor on many stations is much lower than it might be under better conditions, proper attention being paid in all cases to the necessity for a certain amount of spare plant being installed. How to improve these conditions has been the problem constantly before most station engineers in this country for some time past; fans, heating, cooking and domestic electrical apparatus, have all been brought into the arena, and systems of charging have been devised which almost force the consumer to take energy during off-peak times. Apparatus have also been designed for getting rid of the peak altogether, the Therol water heater being an example of one of the methods which have been devised for this purpose.

It is not surprising to find that in America, too, great efforts are being made towards obtaining a better off-peak load. Many American stations are not under the obligation to supply at all hours of the day, so that certain low-load losses, which are inevitable in this country, are avoided; but, on the other hand, it is not the desire of most station engineers to see their plant standing idle during a large part of the 24 hours, so that they naturally use their utmost endeavours to obtain an adequate day load, even in purely residential districts. Some interesting information on what had been done in this respect was given by Mr. H. G. Glass, of Pittsburg, in a Paper which he read a little while ago before the Iowa Electrical Association. The company to which he belongs supplies a number of large and small towns in Pennsylvania. A feature of every American city after nightfall is the electric light sign, and the company, therefore, fostered this method of advertising by supplying current for lighting these display signs at a flat rate. Metal filament lamps were used which were plainly stenciled, so that none, except those owned by the company, could be employed. Domestically an endeavour was made to obtain an introduction of electrically-driven apparatus by at first putting such things as irons and small motors on trial before actually requiring the consumers to buy them. The plant which proved most successful in this case was the flat iron, a type of apparatus by which much good was achieved in getting housewives to see the live possibilities of electrical working. The method employed was to issue a certificate for 8s. worth of energy, redeemable within 30 days of the date of issue by 8s. in cash in payment for the iron. The idea was to put the iron out on trial for 30 days and force the consumer to decide within that time whether he would cease to use the apparatus or pay the purchase price.

One of the last pieces of machinery to come under the influence of the electric motor is the sewing machine. In too many houses this is not electrically driven, and although we have never operated one ourselves, we cannot help thinking that the energy required to drive it must take the attention to a great extent from the work in hand. Mr. Glass pointed out that the plan set out above had assisted to popularise the use of sewing machine motors in his district, while electric toasters were brought to the notice of the public in much the same way. These latter apparatus, he found, gave even better revenue than irons, although their use has not become so general.

To obtain an adequate off-peak load it is self-evident that much careful canvassing must take place to induce consumers to recognise the advantages of electrical apparatus. Without wishing to decry our own country, it may be said that the American is an exceedingly good salesman, and recognises distinctly the points which must be brought before the prospective consumer. Mr. Glass has found that there are certain arguments that are very successful in bringing before the notice of the public the advantages of electrical apparatus. He advises that insistence should be placed on the small cost, the great safety and the cleanliness of electrical apparatus. That the less fire and accident risk should be pointed out, that mention should be made of the greater flexibility of the apparatus, while other points may be talked about are that there are no pipes to burst, that the operation is steady and that there is, consequently, less repair, less noise, power is always to hand, and less insurance money need be paid. There are no no-load

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Osram and Tantalum Lamps.

LARGE STOCKS AND QUICK DELIVERIES.

Always holding large stocks of both Osram and Tantalum lamps for all usual voltages and candle-powers, we can supply your requirements **satisfactorily and promptly.** If you require lamps in a hurry, you can always depend on getting them here. If the circuit conditions are abnormal or the shape and size you require something special—a 'phone message or a wire will bring you the information required.

REDUCED PRICES OF TANTALUM LAMPS.

Don't forget that these lamps are now reduced in price, and we have laid in an extra supply to meet the resulting brisk demand. If you want your Tantalum lamps in a hurry, send along here.

The SUN ELECTRICAL CO., Ltd.,

118-120, Charing Cross Road, LONDON, W.

Telegrams—"Secabilis London." Telephone—Gerrard 2291 and 2292.

losses, while better ventilation and lower temperature can be secured.

There has been a great discussion in this country lately as to whether central stations should undertake the selling or hiring of electrical apparatus. Much the same problem has apparently required to be tackled by American engineers, and, in the case of Mr. Glass's company, experience has taught them that the undertaking should at least be in a position to sell or hire motors; but whether it should actually do so depends entirely on local conditions. If the dealer handles a good type of motor and instals them at a reasonable profit, he should be assisted in his good work by the central station. But if there are cases where the central station must handle the sale of motors on account of the size of the main, terms of payment or the possibility of using the motor, it should be in a position to make the sale, and it should be able to inform the dealer that it has been done. With this point of view we agree. If the contractor can do the work he ought certainly to be allowed to do it; if he cannot, the electricity supply department must take the matter up.

Some Problems of Electric Headlights for Locomotives.

In this country we are not, as electrical engineers, excessively troubled with the problems of electric headlighting for locomotives. Our trunk lines are so hedged in, if not exactly with divinity, yet with something quite as substantial, as to be practically private rights of way that it is not necessary for the driver to see clearly whether cattle or humans have strayed on to the track. Further, the fact that the train runs on rigid rails and is subject to a complete system of signalling makes it unnecessary for the driver to see exactly where he is going.

In cases where electric lighting is used for the illumination of the trains it would certainly be advantageous to fit the locomotive headlights with, say, 16 c.p. lamps, but we protest against arc lamps being used for this purpose. These contentions are supported by some tests made recently by Prof. Benjamin, of Pendue University. In the United States the track is not so well guarded as in this country, and it is doubtless for this reason that electric searchlights have long been employed for throwing a concentrated beam along the track. Prof. Benjamin, however, finds, as might be expected, that the great intensity of the beam prevents signals and obstructions from being recognised. It may in this connection be pointed out that the driver is too near to the light for it to be of any help. The light from an approaching train was also blinding in its effect. These lights also made recognition of the signals difficult. It was found that the brilliancy of the beam from the electric headlight was so great as to produce by reflected light false signals from lanterns which had been extinguished. For example, in one test run, in which a green light had been extinguished, no light appeared up to a distance of 1,000 ft. At 600 ft. four of the 11 observers saw a green light in the extinguished lantern, which persisted for one observer up to 400 ft. The green lights suffered to an exceptional degree, but the red danger lights, fortunately, were less seriously affected. No reflections were observed when an oil headlight was used.

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"THE ELECTRICIAN" TABLES OF

No.	Supply Authority.	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit. H.P.	Max-demand Kw.	H.T. motor (if any).
1	**Aberdeen Corporation**	J. Alex. Bell	Granite quarries, eng. works, shipyards, ice factories, fish-curing and preserving wks., paper wks., woollen and jute wks.	400	220, 440 three-wire 230 2-wire	4,307 30/4/10	747	104	745 at 11.0 a.m.	...
2	**Acton Council**	J. Martin Blair	Laundries, motor works, dyeing and cleaning, printing	...	230, 460 three-wire	631 30/5/10	73	170	174	...
3	**Aston Manor Corporation**	R. Foster..	General	400 3-phse. 50 ∿	460 three-wire	4,747 31/1/10	250	500	2,300 *	220 H.P.
4	**Ayr Burgh Council**	Roland Marshall	Principally residental, building trades, laundries, small eng.-works, shipyard, carpet works, boot factory	100, 200 Single phase	250 500	472 31/5/10	129	30	...	...
5	**Barnes Urban District Council**	C. S. Davidson	Gas mantle works, sawmills, brewery, golf-club making, laundries, printers	..	210, 420 three-wire	458 31/3/10	55	20	505	...
6	**Barnsley Corporation**	E. A. Barker	Foundries, laundries, builders and joiners, linen manuf'ters, paper mill, &c.	...	230 460	685	120	30	822	...
7	**Barrow-in-Furness Corporation**	H. R. Burnett	Shipbuilding, iron, steel and engineering works	220, 440	970	150 30/9/08	50	...	...	...
8	**Bath Corporation**	Francis Teague	Engineering, cabinet-making, clothing and corset factories	110 single-phase	220, 440 three-wire	530 31/5/10	153	72	...	..
9	**Battersea Borough Council**	F. A. Bond	Soap and candle works, engineering works, millers, railway goods yards, stone yards	...	230*,460†	2,550 31/5/10	...	50	500 day load	...
10	**Belfast Corporation**	T. W. Bloxam	Shipbuilding, spinning and weaving, ropeworks, handkerchief making.	...	220, 440 three-wire	5,875 31/5/10	714	70	*	...
11	**Birkenhead Corporation**	W. Wyld	Shipbuilding and ship repairs, laundries, leather works and foundry	...	230, 460 three-wire	924 31/1/10	145	120	693*	...
12	**Birmingham Corporation**	R. A. Chattock	Metal, cycle and jewellery trades	5,000	220, 440 three-wire	20,085½ 31/3/10	2,398	350	10,060 l. & p. 5,206 tr.	5-720 H.P.
13	**Blackburn Corporation**	P. P. Wheelwright	Cotton manufacture and general industries	220	220 440	2,712 25/3/10	629	120	...	...
14	**Blackpool Corporation**	C. Furness	Joinery works, bakeries, bottling stores, laundries, cinematogrphs & entertainmts	200	500	1,200 31/3/10	171	80	...	...
15	**Bolton Corporation**	Arthur A. Day	Cotton spinning and engineering works	100, 200* 400†	230, 460	10,017¼ 31/3/10	915	150	6,441	...
16	**Bootle Corporation**	T. Dawson Clothier	Timber, engineering, dyeing, pumping, tin smelting & general	...	220, 440 three-wire	2,267 31/3/10	...	60	1,260	...
17	**Bournemouth & Poole Electricity Supply Co.**	E. Ll. Ingram	Boarding-houses and hotels	100,200,400 three-wire	250, 500 three-wire	527 6/6/10	203	25	...	...
18	**Bradford Corporation**	Thomas Roles	Textile works, dye works, mechanical and electrical engineering, miscellaneous.	230, 400 50 ∽	230 460	*9,646 8/6/10	*1,797	110	2,491	*
19	**Brighton Corporation**	J. Christie	Engineering works, breweries, sawmills, laundries, foundry, &c.	...	230, 460	2,474 28/5/10	464	100	...	...
20	**Bristol Corporation**	H. Faraday Proctor	Tobacco, cocoa, printing, leather, confectionery, cloth and brewing	105 & 210 93 ∽ S.P.; 210 & 360 50 ∽ 3-phase	250 500	10,832 25/3/10	1,201	120	2,529	None
21	**Burnley Corporation**	Jas. E. Starkie	Cotton weaving, foundries, &c.	...	220, 440	710¾ 31/3/10	241	30	529	None
22	**Burton-on-Trent Corporation**	P. J. Pringle	Breweries, timber mills, engineering works	200, 100	500 (tramways only)	940·7 21/5/10	151	45	500*	...
23	**Bury Corporation**	S. J. Watson	Textile, engineering, paper, &c.	...	220, 440	2,642 31/5/10	306	80	...	...
24	**Carn Brea, R.S.O. (Urban Electric Supply Co.)**	L. A. Hards	Mining and foundries	10,000, 440	240, 480 three-wire	1,943 31/5/10	141	30	924	None
25	**Canterbury Corporation**	C. A. Blascheck	Brewing and various	...	220, 440	395 6/6/10	96	50	411	...
26	**Cardiff Corporation**	Arthur Ellis	Ship-repairing yards, engineering works, foundries, laundries, printers, brewers, millers, cold storage, &c.	200 400	200, 400 three-wire	3,232 31/1/10	500	110	...	None
27	**Carlisle U.D.C.**	S. T. Allen	Cotton factories, tinplate printers, engineering works and railway shops (companies)	...	L. & P. 230 460, 3-wire, traction 500	760 6/6/10	253	57	L. & P. 555 traction 250	...
28	**Charing Cross, West End & City Electricity Co.**	H. W. Kingston J.M. Gatti (*Mn. D.*)	Printing	10,000	100, 200, 400, 1,000	Ex. bulk sup. 14,688, 30/4/10	...	250	...	...
29	**Chester Corporation**	S. E. Britton	Engineering, flour mills and printing	...	210, 420 three-wire	531	128	25	1,320	...
30	**Chesterfield Corporation**	R. L. Acland	Printing, brewery, furniture-making, foundries	...	240, 480 three-wire	716 31/12/08	150	30	...	...
31	**Clyde Valley Electrical Power Co.**	D. A. Starr	Steel works, rolling mills, collieries, paper mills, brickworks, foundries, shipyards, &c.	11,000 trans. to 400 for power	...	29,389 1/6/10	...	500	6,900	Several
32	**Colne Corporation**	A. G. Cooper	Weaving, spinning, loom making, foundries, fell-mongering and electric crane making	...	240, 480 three-wire	417 31/3/10	158	20	...	...
33	**Cork Electric Tramways & Lighting Co.**	H. H. Nalder	Breweries, butter factories, laundries, bacon curing, feather purifiers, printing, tanneries, milling, refrigerating, &c.	...	460	2,358 26/5/10	342	40	...	None
34	**County of Northampton Electric Power & Traction Co.**	W. J. S. Jones	Boot factories, engineering works and joineries	...	230, 460 three-wire	174	26	20	175	...
35	**Coventry Corporation**	George Tough	Cycle and motor cars, toolmaking, weaving, watchmaking	200 two-phase	...	5,828 31/3/10	601	120	3,018	...
36	**Darlington Corporation**	J. R. P. Lunn	Engineering, yarn spinning and school furniture	...	230, 460	1,757 30/11/09	199	125	867	
37	**Derby Corporation**	T. P. Wilmshurst	General engineering, foundries, motor cars, silk mills	200	460, 230 three-wire	2,720	430	230	1,100	...
38	**Derbyshire & Nottinghamshire Electric Power Co.**	A. E. Loos	Iron works, collieries, lace and hosiery works, engineering works, brickworks, &c.	440	500 550	2,759 31/5/10	...	200	708	...
39	**Dewsbury Corporation**	R. H. Campion	Woollen manufacturers, rag grinding, printing, laundries, clothing manufacturers, wool shaking, iron cutting	...	220 440	614 1/2/10	124	30	130	...
40	**Dublin Corporation**	M. Ruddle	Saw mills, factories, elevators in stores, &c.	200 S.P. 3-phse. 346	...	1,620 1/4/09	364	20	...	...

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ELECTRIC POWER SUPPLY.

No.	Method of Driving: Group. H.P.	Method of Driving: Indiv. H.P.	Rates: Per unit.	Rates: Bulk supply.	Approx. H.P. of other power displaced by electric motors.	Isolated Plants at present Operating. g=Gas. sg=Suction Gas. s=Steam.	Remarks. (Note.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
						H.P.	
1	...	...	2½d. to ⅞d. accord. to cons.	...	...	...	Two 100 H.P. motors for harbour sheerlegs shortly to be coupled.
2	...	...	1¾d. flat 2½d.&1d.M.D.	Under consid'n	..	150*g*, 220*sg*, 200*s*	Includes new scheme of electric pumping at Council's sewage works, auto. plant.
3	...	...	†2d. to ⅞d. according to load factor	On application	...	...	* All purposes except traction. † Sliding scale. .....
4	200	100	2d. to 1¼d. Load factor basis	...	400	150*g*, 50*sg*, 200*s*	
5	48	410	1½d. with dis. to 33⅓ p.c.	On application	*	55*g*, 500*s*†	* Most of our consumers are new to the dis- † Includes plant at sewage works [trict.
6	...	...	1½d.-1d. motors, 3½d. flat, lighting 7d & 1½d. D.I.*	...	...	...	* Discount 5 per cent. off lighting accounts Sliding scale for motors. [only. .....
7	...	...	3d. & 1d. M.D. 2d.–1½d. F.R.	...	...	...	
8	...	...	1¾d. to 1d.	...	...	*	* Isolated plants using gas, suction gas and steam are in operation, of which there are no particulars.
9	...	...	Flat rate 1d. ‡	Terms by arrangem't	...	...	* Under 3 H.P. † 3 H.P. and above. ‡ Or £4 per kw. per annum and ½d. per unit.
10	...	...	1½d. & 1d. M.D., accord. to cons.	On application	...	...	* Lighting and power 4,000, traction 3,300.
11	...	...	2d. for 1500 units 1½d. next 3500†	...	...	...	* Motor load only. † Exceeding 5,000 units per quarter at 1d.
12	...	...	1·35d. to 1·10d.	1d. to 0·7d.	12,600	...	.....
13	...	...	...	F'm 1½d. to0·45d.*	...	...	Total B.H.P. does not include traction. * Sliding scale according to amount taken. .....
14	...	...	3d. and 1d. M.D.	...	...	...	
15	...	...	2d. 1st 1,000, 1d. after less 10%‡	...	...	...	* Single-phase. † Three-phase. ‡ Extra discounts to large consumers.
16	...	...	2d. to 500 per qtr., 1d. after	...	1,000	1,500*g*, 80*sg*, 4,510*s*	.....
17	...	...	2½d. flat.	On application	...	...	.....
18	...	...	2d. to 1d. 2d. to ¾d.	£3 per kw.†	...	...	*These figures include the following motors owned by a consumer taking a supply of current from 3 500 kw. motor-gens. used for converting our supply current at 6,600 volts, 3-phase, 50 periods, to d. cur. at 230 and 460 volts: number of motors, 140; horse-power, 2,116. †Plus ½d. per unit, less discount.
19	...	...	1d. restricted hours, 1½d. unrestricted	...	...	...	Special terms to large users.
20	...	...	1½d. & dis.. 1¼d. and ¾d. *M.D. with discount	On application	...	800*sg*	*To avoid as far as possible the use of max. demand indicators a flat rate is usually agreed upon. Special agreements based on a fixed charge per kw. installed are also entered into.
21	2,640	..	Lighting 3½d. flat Pwr. 1¾d. 1st 39 hrs. per ½, 1d. aftr	None	...	...	.....
22	211·0	729·7	3d. & 1d. M.D also 2d.&1½d. 1d.–¾d†	...	327	75*sg*	80 per cent. of total power is on restricted hour system. 80 per cent. of total power units sold on restricted hour system. * Includes lighting. † Restricted hour.
23	About 2,246½	About 395½	1¾d., 1d. and ⅝d.	On application	1,283	About 40,000	.....
24	...	126	4d.& 1d. M.D. or 2½d. flat	On application	...	50*g*, 10*sg*	Power supply includes driving stamps, pumps and other mining machinery.
25	...	395	1½d. flat 5 p.c. dis. cash 28 days	...	...	...	Maximum demand to date (February 12, 1910), 411 kw. on feeders, includes light and power.
26	...	...	1½d. flat, 4d. & 1d. M.D.	Spl. rates to large consumers	...	...	Most of the engineering works on private property, from which Corporation are at present debarred from entry.
27	68	692	2d. flat. 1d. and 3½d. two-rate. Also Maximum Demand.	Special terms	66	...	Power supplied to tramway company, also to Council for sewage pumping.
28	...	...	3d. to ¾d.	On application	...	...	.....
29	157	374	1½d. 1st 200 units per qtr., 1d. after	Above 25,000 p.a 1d. flat rate	..	...	.....
30	...	...	1½d.—1d.	...	...	...	.....
31	...	...	On application	On application	...	...	.....
32	62	96	2½d. flat, 3d. and 1d. M.D.	On application	212	...	Several of ½ H.P. and less not included in return. Motors let out on hire.
33	1,558	800	2d, 1½d., 1¼d., 1d. sliding scale	None	500 steam 450 gas	500*g*, 200*sg*, 2,000*s*	Competing gas 2s. 8d. per 1,000 c.f. with 25% disc. when annual bill exceeds £50.
34	...	...	1½d. flat and spl. agreem'ts	...	100	...	.....
35	344 about	257 about	1½d. 2,500 units per quarter and 1d. after*	...	4,000	...	* Over 50,000 units per quarter flat rate of 1d.
36	...	...	1½d. to ¾d.: £4 kw M.D. and ½d. unit	...	...	...	.....
37	...	...	1d. for all day use	...	800	...	.....
38	...	...	1⅜d. to 0·4d.	...	...	...	.....
39	Both		2½d.(1)—1d.	Two Tramway Companies.	...	..	Maximum demand system or 1d. restricted hour.
40	Both		1¼d.	...	2,200	...	Large additions in hand.

ECKSTEIN, HEAP & CO.
SPECIALISTS IN SWITCHGEAR FOR CENTRAL STATIONS, AND INDUSTRIAL POWER . . . . . INSTALLATIONS.
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For Maintenance and Repairs of Car Motors USE . . . . "Ohmaline,"
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SIEMENS WIRES and CABLES.

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"THE ELECTRICIAN" TABLES OF

No.	Supply Authority.	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit. H.P.	Max. demand Kw.	H.T. motors (if any).
41	Dundee Town Council	H. Richardson ...	Jute mills, shipbuilding, foundry	...	400	1,950	404	65	...	...
42	East Ham Corporation	W. C. Ullmann ...	Printers and wood yard for motors, otherwise district is purely residential.	...	240, 480	Pte.463, *Stn., 43½, Feb., '10	Prvte., 127 Station, 5	40	...	...
43	Edinburgh Corporation.....	F. A. Newington.	Printing, joiners, masons, engineers, brewers	...	230, 460	10,307 15/6/10	2,430	50	...	...
44	Fulham Borough Council	Arthur J. Fuller	Engineering works, woodworking machinery, laundries, paper mill	200 two-phase above 5 H.P.	...	1,321 31/3/10	183	80	540	...
45	Frome U.D. Council.....	F. H. Merritt.....	Cloth, silk and india-rubber mills, iron foundries, engineering and motor works, breweries, mill furnishing, dairies, bacon curing, printing, furniture & cabinet mkg.	...	240, 480 three-wire	845 30/4/10	205	35	210 approx	...
46	Glasgow Corporation.....	W. W. Lackie.....	Engineering, clothing, printers, butchers and bakers	6,500	250/500 three-wire	32,746 30/4/10	4,827	250	...	...
47	Govan Council	T. C. Parsons ...	Shipbuilding and engineering ...	...	500, 250	5,550 15/5/10	...	165	1,736	...
48	Grantham Urban Electric Supply Co.	J. E. Edmundson	Brickwork, foundries, timber merchants, engineering works, blouse factory, malting	...	240, 480 three-wire	342 31/5/10	100	13½	...	...
49	Greenock Corporation	J. A. Robertson...	Shipbuilding, engineering, sugar refining	...	500	5,351 31/5/10	392	545	1,500 Appx.	...
50	Grimsby Corporation.....	W. A. Vignoles ...	Docks, timber yards, foundries and engineering works	...	230, 460 three-wire	1,090 28/5/10	167	90	1,291	...
51	Guernsey Electric Light & Power Co.	C. Lakin-Smith ...	Laundries, stoneworks and quarries, joinery works, foundry	...	210, 420	2,200	150	80	800	...
52	Hammersmith Borough Council	G. G. Bell	Engineering works, electric lamp works, small laundries, &c.	110, 220, 440 2,300 H.T.	...	4,497 31/1/10	377	500	...	3 200 2 120 2 500
53	Hanley Corporation	C. H. Yeaman ...	Brickworks, potteries, iron works, collieries, earthenware and china manufactories	Single-phase 100 ~, 100-200, 400	50*	1,101½ 31/3/10	144	60	1,251	1 60
54	Heckmondwike Council	G. H. Carter	Woollen manufacturers, rag grinders, foundry, boot and shoe, factory, coachbuilders, &c.	...	230, 460 three-wire	1,210 31/5/10	...	150	...	...
55	Hereford Corporation.....	W. T. Kerr.....	Cider making, breweries, mills (flour), farm work, joinery, refrigerating	...	220, 440	501 25/3/10	109	50	410	...
56	High Wycombe Electric Light & Power Co.	W. E. Brandreth	Chair and cabinet making, paper mills, engineering	...	420 210	563½ 31/5/10	151	30	...	...
57	Hove Electric Lighting Co.	C. B. Smith.....	Purely a residential district excepting shops	...	220	442 21/2/10	136	12	...	...
58	Huddersfield	A. B. Mountain ...	Cloth manufacturers	Three-phase One-phase	... ...	*2,539 *1,423	121 440	150 35	850 2,000	...
59	Hull Corporation Electricity Department	H. Bell.....	Oil mills, shipbuilding and engineering.	...	220, 440 three-wire	6,848 31/3/10	601 Consumers	75	4,790	...
60	Ilford Urban District Council ...	A. H. Shaw	Photographic apparatus, chemical works, paper mills	...	230, 460 three-wire	656 13/5/10	121	60	...	...
61	Islington Borough Council	Albert Gay	Bakers, brewers, builders, clothiers, coach and van builders, engineering works, confectioners, printers	Single-phase 50 ~ 100 200 and 400	...	2,321 31/1/10	472	50	3,863	...
62	Kettering Council	W. A. Walker.....	Boot and shoe and clothing factories	...	230, 460 three-wire	811½ 31/5/10	170	30	310	...
63	Kidderminster & District Electric Lighting & Traction Co.	A. Charlton.....	Carpet manufacture.....	...	460	1,010	...	26	520*	...
64	Kirkcaldy Corporation	O. F. Francis	Linoleum, engineering, furniture, malting works, linen, &c.	...	230 460	907 ...	...	130	811	...
65	Lancaster Corporation	W. A. Tester.....	Timber yards, builders' yards, foundry, linoleum works	...	230, 460	457 1/6/10	119	50	200	...
66	Leeds City Council.....	H. Dickinson	Numerous	200 400	...	13,145 31/5/10	2,115	100	5,660	...
67	Leith Council.....	A. Peden Rutherford, M.I.E.E.	Engineering and general.....	...	230, 460	3,482·3 31/5/10	436	100	723*	...
68	Liverpool	Alfred Clough ...	.....	...	230, 460	10,825 31/3/10	2,664	80	...	...
69	Lincoln Corporation	Stanley Clegg ...	Engineering works	...	230, 460 and 500	1,336½ 7/6/10	192	45	425	...
70	Loughborough Corporation	W. H. Allen	Hosiery and engineering	...	220, 440 three-wire	370 30/10/08	67	43	120, for pr. only	...
71	Luton Corporation	W. H. Cooke	Straw hat making, motor cars and lorries, hydraulic and general engineers, foundries, printing works	...	500	2,086¼ 5/5/10	330	160	948	...
72	Maidstone Corporation	E. E. Hoadley ...	Building, brewing, paper making	...	230, 460	1,437 31/5/10	186	60	...	...
73	Mansfield Corporation	E. Holcombe Hewlett	Boots, hosiery, cotton doubling, foundling, tin box, motor bodies, sand and stone quarries, coal mining	...	240, 480 500-600	270¼ 3/6/10	85	12	About 50	...
74	Metropolitan Electric Supply Co.	J. S. Highfield.....	Ordinary shops	200	200	3,936 26/4/10	1,062	60	...	...
75	Middlesbrough Corporation	H. M. Taylor.....	Iron and steel works, shipyards, joiners shop	...	220, 440 three-wire	1,694	303	50	450	...
76	Motherwell.....	S. Williams.....	Engineering and steelworks	...	230, 460	About 3,500	60	3 of 120 1 of 200	1,040	...
77	Newcastle and District Electric Lighting Co.	W. D. Hunter ...	Engineering and shipbuilding, steel and lead works, &c.	100	240, 480 three-wire	9,919 31/5/10	...	150	4,500	...
78	Nelson Corporation.....	D. Helme.....	Cotton manufacturing	...	230, 460 three-wire	310 1/4/10	72 On hire	40	...	...
79	Newport Corporation.....	H. Collings Bishop	Coal, iron, clothing, nails, brickworks, millers, ship repairs, &c.	200 A few permitted	230, 460 three-wire	2,177 31/1/10	261	100	Cannot give	None

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ELECTRIC POWER SUPPLY.—*Continued.*

No.	Method of Driving. Group H.P.	Method of Driving. Indiv. H.P.	Rates. Per unit.	Rates. Bulk supply.	Approx. H.P. of other power displaced by electric motors.	Isolated Plants at present Operating. g=Gas. sg=Suction Gas. s=Steam. H.P.	Remarks. (Note.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
41	500 approx.	1,450 approx.	2½d. downwards	On application	...	...	.....
42	...	...	2d., 1½d. & 1½d.	...	...	...	*Motors used in gen. stn. for cooling towers, artesian well, driving machinery, &c.
43	...	...	1½d. flat. ½d. Stch. R., 1d. 5hr. M.D.	...	...	...	... .
44	...	...	1d. flat	...	...	...	Power and lighting on same mains, 540 kw. day-load motors only.
45	90 approx.	740 approx.	2½d. flat; 4d. and 1d. M.D.	On application	200, also 365 private electric plant	50g, 20sg, 850s, 10 water (approx.)	.....
46	...	...	1½d. & ¾d. M.D. 1d. flat rate for restricted hours	¾d. & ½d. M.D.	...	...	.....
47	...	...	Sliding scale 2d.—¾d.	...	...	290s, 200s, 4,000s	.....
48	...	...	4d. and 1d. M.D.I. 2½d. flat.	Special rates	...	No record.	.....
49	...	...	2½d. to 1d.	1d. to 8d.	...	...	.....
50	..	...	2½d. to 1d. with dis., 1d. T.S.	...	...	...	Number and horse-power of motors does not include the docks or Admiralty supply.
51	...	...	*	To sub-stations	1,00	...	* Lighting: 7d.-3d. M.D.. 6d. flat 5½. Power 4d. and 1½d. M.D., 2d.-2½d. flat.
52	...	...	1½d. with dis. to a max. of 33⅓ p.c.	...	...	...	.....
53	...	...	3d., 1d., ⅝d. and ½d.	On application	...	...	Power load rapidly growing and especially favoured with the many small and diverse trades subsidiary to staple industries of district. *Local for magnetting.
54	...	...	2d. to 1d. Sliding scale	Special terms	...	...	A large power demand still to connect.
55	95	285½	*3d. to 1d.	...	...	20g, 160 g, 300s	* With discount on hours of running.
56	...	...	4d.—1d. M.D. system, 2½d. flat rate or on 2 rate meter	...	...	16g, 200sg	All motors are hired out by this company, and are maintained and inspected.
57	...	...	3d. one hr., 1½d. after	...	...	...	Radiators are at power rates but are not included in this return.
58	...	...	2d. and 1d. less discount	...	...	...	* January 31, 1910.
59	...	...	2d.—1d. per sliding scale*	On application	...	..	Hired motor system in operation. About 600 H.P. connected * Subject to 2½ per cent. dis., for payment within 14 days.
60	...	...	2d. & 1d. M.D. 2d. to 1d. sliding scale	...	..	...	1d. power rate for large consumers.
61	...	...	1d. flat	Nil	1,235	...	Since 31/10/09 three temporary motors = 55 H.P. have been disconnected in consequence of building contractors completing their jobs.
62	760	51¼	2d. to 1d.	On application	598	...	... .
63	...	...	1½d.	...	...	No information available	*This is a combined figure for lighting and power.
64	...	...	2½d. to ¾d. sliding scale	...	...	...	1 large engineering works, 1 large colliery, 1 large malting works received entire power supply from Corporation.
65	11	108	2½d. sliding scale to 1d.	By contract	440	200g 500s	.....
66	...	...	0·8d. to 1·75d. less 5 per cent.	...	...	...	.....
67	...	...	1½d. to 1d.	...	...	...	*For industrial purposes only.
68	...	...	*2d., 1½d., 1d.	...	...	...	* 2d. up to 3,000 per qr., 1½d. from 3,000 to 10,000 per qr. 1d. all units in excess of 10,000 per qr.
69	...	...	2½d., 2d. & 2d. & 1d. M.D	On application	...	...	.....
70	219	151	1d. flat	...	158	49g, 25sg, 492s	Two private plants, total 1,200 kw., running.
71	About 1,660	About 426	*2d., 1½d., 1d.	...	About 400	About 200g 100sg, 250s	*2d. first 1,000 per qr., 1½d. second 1,000 per qr., 1d. remainder.
72	Both		Various.....	...	650	15sg	.....
73	...	...	4d. & 1d. M.D. 1d. daylight	...	214	450s*	Town gas sold at 1/6 1,000 for power. Tramway supply 1,200 H.P. not included. * Not including collieries.
74	...	...	3d. and ¾d. M.D.	...	...	...	.....
75	...	...	2d. & 1d. M.D. Sp. on app'n.	...	1,500	...	Largest installation, shipyard, max. demand 400 kw.
76	...	...	1d. and ¾d.	...	...	...	.....
77	...	...	Max. 1½d.	According to load factor, &c	...	...	Largest consumer, Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick Works.
78	Both		*	...	...	...	* Motive power—2½d. for 1st hour per day, 1½d. every subsequent hour, less 5%.
79	About 825	1,352	2d. and 1d. acc. to quan.	On application	...	...	One dry dock being converted to electric from steam.

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For Measuring Steam Consumption.
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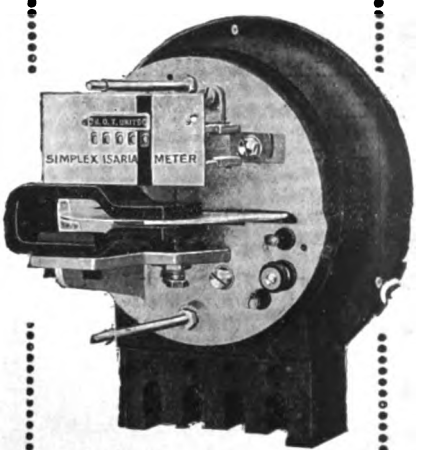

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"THE ELECTRICIAN" TABLES OF

No.	Supply Authority	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit.	Max. demand. Kw.	H.T. motors (if any).
80	Northampton Electric Light & Power Co.	G. H. Jackson ...	Boot and shoe factories, printers, motor car works and tanneries	...	210, 420 three-wire	1263 31/5/10	...	40	...	...
81	North Wales Power and Traction Co.	G. K. Paton (Chief Elec. Eng.)	Slate quarries	500 3-phase	...	3,050 31/5/10	60	200	1,000	...
82	Norwich Corporation	F. M. Long	Boot and shoe, mustard, printing, breweries	...	220, 440	2,844¼ 31/3/10	527	50	750 at station	...
83	Nottingham Corporation	H. Talbot	Lace, hosiery, tobacco, engineering, leather	...	200, 400 three-wire	4,245 18/5/10	1,053	60	...	...
84	Nuneaton Corporation	S. C. Gibson	Hat making, hosiery wool, cotton, elastic web, foundry, quarries and collieries	...	220, 440 three-wire	332½ 31/5/10	75	60	180	...
85	Partick Council	W. Sillery	Shipbuilding and engineering works	...	240, 480	2,725 15/5/10	272	60	2,033	...
86	Peterborough Corporation	J. C. Gill.....	Engineering, brickworks, railway	...	200, 400	268 31/5/10	70	20	502	...
87	Reading Electric Supply Co.....	E. Rowley Hill ...	Printers, engineers and iron founders, saw-mills	200	200, 400	1,852 31/12/09	271	65	1,236	...
88	Redditch Urban District Council	Wm. J. Ferguson	Needle trade, fishing tackle, cycle factories	200	...	775 17/11/08	97	40	...	...
89	Rochdale Corporation	C. C. Atchison ...	Textile and engineering.....	3,000 220	220, 440, 500	1,559 31/5/10	257	50	...	56 H.P.
90	Rotherham Council.....	E. Cross	Iron, steel and brass works	...	230, 460 three-wire	990 1/6/10	112	106	335	...
91	Salford Corporation	V. A. H. M'Cowen	Textile and engineering	200	220, 440 three-wire	10,861 30/4/10	1,022	300	...	...
92	Sheffield Corporation	S. E. Fedden	Steel and iron works, cutlery works, foundries, general engineering works	2,000, 400, 200	...	12,896 31/5/10	1,369	350 H.P.	6,870	One 350, 80, 120, 50 kw.
93	Shoreditch Borough Council.....	C. N. Russell	Printing, shoemaking, cabinet and furniture manufacture	...	240, 480 three-wire	4,690 31/1/10	950	...	...	...
94	Shrewsbury Corporation	C. M. Johnston ...	.....	...	210 420	198 31/3/10	85	20	381	...
95	Smithfield Markets Electric Supply Co	Edgar Dowling ... (*Chief Engineer*)	Cold storage.....	...	100 200	482 31/5/10	31	130	409	...
96	South Shields Corporation	J. H. Cawthra ...	Shipyards, docks and marine engineering works	110, 220	550	2,383 31/5/10	200	160	...	...
97	Stalybridge, Hyde, Mossley and Dunkinfield Electricity Board	Robert Blackmore	Textile, paper mill boiler works, bleach works engineering works, iron works	400 230	460 230	7,500	250	375	4,600	...
98	Stamford (Urban Electric Supply Co.	J. E. Edmundson	Brickworks, laundry, foundry, engineering works, flour mills, printing works, timber yard	..	240, 480 three-wire	491 31/5/10	100	35	...	...
99	St. Helens Corporation	E. M. Hollingsworth	Chemical, glass and bottle works, steelworks, collieries	230, 400 3-phase	230, 460 three-wire	2,045 31/5/10	266	100	400	...
100	St. Marylebone Borough Council	A. Hugh Seabrook	Printing, building, small workshops (various trades)	None	240 480	2,838 31/3/10	732	110	8,688 whole supply	None
101	Stockton-on-Tees Council	J. J. Smith.....	Shipbuilding, engineering and ironworks	...	230, 460 three-wire	1,077 31/3/10	133	50	...	...
102	Stoke-upon-Trent Corporation (Stoke Station)	P. J. S. Tiddeman	Potteries, engineering works.....	None	240, 480 three-wire	1,077½ 31/5/10	...	80	545	...
103	Sunderland Corporation	A. S. Blackman...	Shipbuilding, marine engine and boiler makers, coal mining, flour mills	5,000 220	220	11,235¾ 17/2/10	728	275	4,425	...
104	Swansea Corporation.....	C. A. L. Prusmann	Metallurgical, coal exporting &c.	220, 440 three-wire	220, 440 three-wire	2,002 31/5/10	...	60	1,122	...
105	Uxbridge and District Electric Supply Co.	A. Randall Bell...	Flour mills, printing, engineering, brickmaking	200	...	633 1/6/10	67	60	466	...
106	Wakefield Corporation	H. A. Nevill	Engineering, woollens, coal, printing, laundries, wire mills	200	...	1,378 31/3/10	183	110	1,205	...
107	Walsall Corporation	A. S. Barnard ...	Saddlery, harness, leather, clothing, iron founding, tubes, brushes and rolling mills	...	105 210	790 31/1/10	161	35	...	...
108	Warrington Corporation	F. V. L. Mathias..	Wire mills, printers, saw mills, tanneries, engineers, corn mills, gas stove manufacturers, builders, min. water mfctrs, &c	380 3-phse. 50 periods	460	5,500 3/6/10	...	215	...	...
109	West Bromwich Corporation .	W. A. Jackson ...	Spring works, steel rolls, hollow ware foundries, edge tools, tubes, school furniture, corn mills, wire nails	...	230, 460 500	1,582 31/1/10	159	110	About 500*	...
110	West Ham	H. H. Couzens ...	Chemical, engineering, flour mills, ink mills	100, 200, 400	500	7,985 kw. 31/5/10	1,037	115	...	...
111	West Hartlepool County Boro'..	H. F. Friederichs	Blast furnaces, steel wks., ship yds., engine wks., paper mill, saw-mills and joinery wks	...	230, 460 three-wire	1,965 30/5/10	225	120	550	...
112	Whitby (Yorks) District Council	L. H. King	Fishing	...	460	175	32	18	400	...
113	Whitehaven Corporation	B. Sankey	Tannery, flour mill, printing and machinery works, &c.	...	420, 210 three-wire	176¾ 31/5/10	39	20	240	...
114	Wigan Corporation	Jas. Slevin	Coal mining, cotton mills, engineering works	...	230, 460 three-wire	1,680 31/5/10	233	50	921	...
115	Windsor Electrical Installation Co.	A. E. Farrow.....	Brewing	220	220	208	76	13	75	6
116	Wolverhampton Corporation ...	C. E. C. Shawfield	Ironworks, edge tool works, corn mills, paint works, cycle and motor works, saw-mills, &c.	6,000, 400	440, 220 three-wire	5,338 31/3/10	419	100	...	...
117	Worcester Corporation.....	C. M. Shaw	Porcelain, glove, leather, flour, engineering, various, buttons, confectionery, printing, horse-hair cloth, &c., works	100, 200	230, 460 500	941 31/3/10	173	2 40's	910	...
118	York Corporation	J. W. Haine	Confectionery, printing, railway works, flour mills, brickworks	...	230, 460 three-wire	1,207¼ 31/3/10	256	35	1,035	...
119	Yorkshire Electric Power Co.	W. B. Woodhouse	Textile mills, iron works, collieries, calcium carbide factory	2,000, 400	500	13,000 14/2/10	350	140	3,400	1 100 H.P

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ELECTRIC POWER SUPPLY.—*Continued.*

No.	Method of Driving. Group. H.P.	Method of Driving. Indiv. H.P.	Rates. Per unit.	Rates. Bulk supply.	Approx. H.P. of other power displaced by electric motors	Isolated Plants at present Operating. g=Gas. sg=Suction Gas s=Steam.	Remarks. (Note.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
						H.P.	
80	About 1,000	About 263	2d. to 1d. sliding scale	On application	About 950	.....	.....
81	575	2,475	1½d.—⅞d. and under sliding scale	...	3,050	...	Slate quarry load mostly winding, pumping, air compressor and mills. Transmission at 10,000 volts three-phase, all overhead, bare wire and 20,000 volt.
82	...	...	2d. to ¾d.	...	...	...	A 150 B.H.P. motor-driving sewage pump will shortly be installed.
83	...	...	1¼d.	...	...	...	.....
84	...	220	2½d. to 1d. on sliding scale	On application	...	50*sg*, 100*s*, 20 *oil*	.....
85	...	...	1d. flat rate	...	...	...	.....
86	...	...	1½d. flat.	...	...	...	.....
87	About 1,400	300	1½d. flat	...	400	50*g*, 125*sg*	.....
88	...	...	2d. to 1d. sliding scale.	...	...	...	....
89	Practically all group driven.	...	2d. to 1d sliding scale*	On application	Steam 804 Gas 187	333*g*, 20*sg*, 190*s*	Isolated plants on present route of mains (approximate only). *Special terms for special conditions.
90	...	...	1½d. and 1d.	On application	About 1,000	...	Several large firms about to adopt electric drive.
91	...	...	*	...	...	...	* Flat rate.—1½d. first 1,000 units per qr., 1d. all in excess. Fixed charge system £1 per qr. per B.H.P. demanded and ½d. per unit consumed.
92	...	...	Lht 4d., Heat 1d., Power 2d. to ⅚d.	...	6,000	...	Great expansion of use of power supply in rolling mills and cutlery works.
93	...	...	¾d. up to 75,000 p.a., ½d. after*	...	...	...	* Plus £3 per B.H.P. demanded.
94	...	...	*3d., 2d. and 1½d.	...	...	...	* Discounts: 5 per cent. over 600 units, 10 per cent. over 1,000 units.
95	...	...	1½d. and 1d.	...	...	...	.....
96	Both		1½d. 1st 5,000 per qr. 1d. after.	...	...	...	Also traction supply.
97	...	..	2½d.—·45d.	On application	2,000	300*g*, 1,700*s*.	... .
98	...	...	2½d. flat, 4d. and 1d. M.D.	On application	...	...	.....
99	...	...	2d. and 1d. with disc'nts	...	1,000	100*sg*	.....
100	...	...	2d. and 1d. M.D.*	...	220 since Aug., 1905	703*g*, 10*sg*, 1,109*s* 160 *oil*	* Or 40s. per B.P. per annum, and 1d. per unit: also restricted hour 1d. flat rate.
101	...	...	Sliding scale 2d. down to 1½d.	On application	...	...	One works take about 250,000 units per annum, and the total amount sold per annum for power purposes amounted to 421,692 units.
102	Both		1½d. to 0·8d.	...	...	...	The potteries all require steam for heating, and this is generally the drawback to electric driving.
103	...	...	2½d. (dis. to ½d.) 2½d. & 1½d. M.D.	On application	400	...	Large flour mill converted from steam to electric driving.
104	...	...	2d. (1st hr.) & 1½d. M.D.*	...	...	...	Motor hiring scheme in operation. * 200,000 per annum and over special rates.
105	58	568	2½ to 1½ flat*	...	...	50*g*, 1,200*sg*, 500*s*	Large power users by contract at prices based on load factor. * £4 per H.P. demanded per an. and ½d. per unit.
106	...	...	2d. to 1d.	...	746½	...	.....
107	594	196	(*See* remarks)	On application	...	...	2d. up to 100, 1¾d. up to 200, 1½d. up to 500, 1¼d. over 500; 10 per cent. discount for over 10,000 per annum, 12½ per cent. discount for over 15,000 per annum.
108	...	...	·6d. to 2d. according to conditions	...	4,500	...	.....
109	About 885	About 697	1½d. to ¾d. Less 2½ % dis.	...	About 750	...	72 motors on hire = 487 H.P. Applications in hand for 225 H.P. * Motors only.
110	Partly both		1d. max.	On application	5,209 kw.	...	.....
111	100	1,755	2d.—1½d. flat with disc.	1d.—¾d.	1,650	510*g*, 230*sg*, 5,375*s*	Flat rate for less than 50,000 per annum, 2d.-1½d.; over 50,000, under 500,000, 1½d.-1d.; from 500,000 to 600,000 and over, 1d.-¾d.
112	115	60	£5 per kw. per an. at 1d. unit	...	...	...	.....
113	...	...	1½d. and 1¼d. or 2 rate, 2d. for small motors	...	67	35*g*, 20*sg*, 12*s*	.....
114	580	About 1,100	Up to 1,000 units per annum 2d., over 1,000 1d.	...	300	...	.....
115	...	...	£3 per H.P. installed per ann. and 1d. per unit	None	108	15*g*, 90*sg*, 40*s*	.....
116	...	...	1d.	Various	...	...	.....
117	688	253	2½d. & 1d. M.D. ¾d. sewerage P. 1d. & 1¾d. restricted hour	...	Over 1,000	200*g*, 450*sg* 1,860*s*	.....
118	...	...	1½ downwards	On application	...	...	.....
119	...	...	Sliding scale	...	...	...	.....

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Automatic Solenoid Starters.

AN interesting series of automatic solenoid starters have been arranged by the British Westinghouse Co. for use in connection with "floating tank" equipments, that is, when the starter is required to stop the motor when the level of water rises to a certain amount and to start it

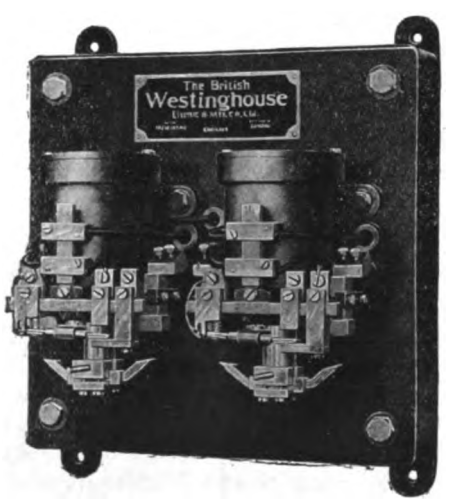

Fig. 1.—Westinghouse "El" Starter.

when the water level has fallen, and with hydraulic accumulators when it is desired to keep the motor running only as long as the accumulator is below a certain fixed level. In the latter case the float-switch is replaced by a suitable switch and air compressors. When it is desired to keep the air pressure within certain limits the float-switch is replaced by an air-governor switch. Or the same arrangement may be used for distant operation, that is, by closing the solenoid circuit by means of a small press button and so starting the motor up from a long distance and saving the cost of heavy cables between the point from which it is desired to start the motor and the motor.

The type "El" starter (Fig. 1) consists of either one, two or three solenoid operated switches, the number

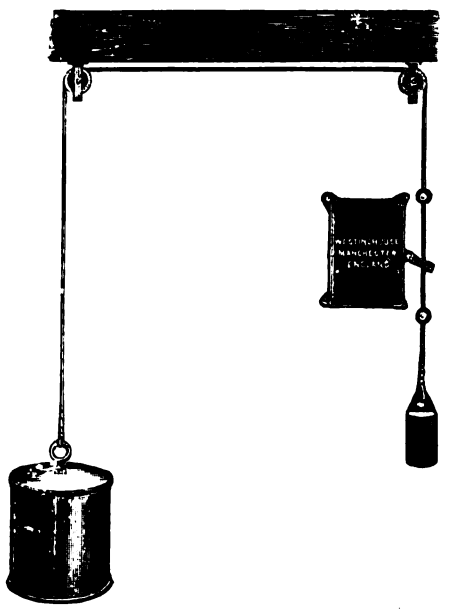

Fig. 2.—Diagram of the "El" Starter arranged for "Floating Tank" Work.

depending on the output of the motor, the coils of which are connected across the armature circuit. The main circuit of the motor is, in this case, made on the auxiliary switch. In the case of distant control with the El starter an extra solenoid switch would be required. This would be energised from the push button and would make the main circuit of the motor. The motor starts up, and as soon as its speed reaches a certain value, and therefore, of course, the E.M.F. across the coil increases to a certain amount, one of the solenoid switches will close, cutting a step of resistance out of circuit. The motor will then speed up and the voltage across the armature again increases, so cutting out another step of resistance. Another similar type of starter consists of a solenoid operated switch and a solenoid operated starter mounted on one cast-iron base. The solenoid of the starter operates a cam which, as it rises, allows the contact which cut resistance out of the armature circuit to close in the right order, so bringing the motor up to speed. This solenoid operates against an adjustable air dash-pot so that the time in which the motor starts can be regulated as desired. The auxiliary switch, that is, the float switch or air-governor switch, as the case may be, in this case makes the solenoid circuit of the main switch which closes and completes the circuit of the motor through the resistance, which in turn cuts out the armature resistance as explained above.

Both the above starters are insulated throughout with mica or porcelain, and are therefore absolutely fireproof. Being solenoid operated, they are, of course, fitted with a no-voltage release. The resistance is cut in the solenoid circuit of the switches when they have done their work, so that the energy consumed by them is cut down as low as possible. In the case of the type El equipment we would point out that only one solenoid is in circuit while the motor is running. The above starters can, when required, be fitted with sheet-iron covers.

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Thornycroft Petrol-Paraffin Engines.

THE petrol-paraffin engines made by Messrs. Thornycroft are very instructive as examples of the application of internal combustion oil or petrol motors to a variety of duties. They are widely used for marine work in connection with both the main driving on launches and for auxiliary purposes such as lighting and pumping. The powers of the engines made range from 7½ B.H.P. to 350 B.H.P., and the sets include paraffin oil as well as petrol motors. In the Thornycroft system of using paraffin oil exclusively one lamp only is employed (irrespective of the number of cylinders) for heating the vaporiser, while an arrangement whereby, after running on petrol the few minutes necessary to heat the vaporiser, paraffin may be turned on and used without a vaporiser lamp is also supplied.

The ignition in all types of Thornycroft engine is by high-tension magneto, which has, contrary to the ideas formerly held, proved more satisfactory for sea work, as it renders starting much easier, and is more reliable than low tension, and at the same time avoids the complication of carrying a duplicate ignition of coil and battery. The lubrication system has been very much improved, and is now, it is claimed, as simple and as perfect as it is possible to design. The control is also a great advance on most arrangements hitherto produced, rendering the engine, it is said, as flexible as a steam plant. Most of the enignes are capable of running under ordinary working conditions between the very wide range of 300 to 1,100 revs. per min. for the paraffin sets, or 300 to 1,300 and 1,500 revs. per min. for the petrol sets. The reversing gears are of the latest types, in which have been embodied the results of experiment and information gained during many years of service under various conditions.

An example of the Thornycroft marine engine is the single-cylinder set, with a cylinder 4½ in. diameter, and a 6 in. stroke, developing 7½ B.H.P. on paraffin oil, with reversing gear and stern gear, comprising stern tube, shafting and a three-bladed Thornycroft bronze propeller. This type of engine has proved so successful in the West Coast Scotch fishing boats that it has paid for itself as a result of the increased earnings of the boat in one season of fishing. It is a very useful engine for either small launches or for auxiliary work.

A two-cylinder set of the same cylinder dimensions, developing 15 B.H.P. on paraffin oil, with reversing and stern gear, may also be mentioned. Large numbers of this type are in use for Government departments abroad, and it makes, it is claimed, a particularly serviceable equipment for ship's boats, where a good turn of speed and ability to work continuously with the minimum of attention are essential. A four-cylinder set (M/4 type) of the same cylinder dimensions, with reversing and stern gear, is also made. This is a particularly powerful and well-designed engine of most attractive appearance, developing 30 B.H.P. on paraffin oil. Attention may also be drawn to a four-cylinder (C/4 type) 6 in. by 8 in. set, developing 47 B.H.P. on paraffin oil, with reversing and stern gear. This engine has proved to be the most efficient of the various engines which have been fitted into Scotch East Coast drifters. The consumption of fuel is very low, the possibility of breakdown is remote, the ease of handling is such that a member of the ordinary drifter crew usually has charge of its running, and its power is equivalent (judged by speed under way) to motors of considerably greater listed power. Accessibility has been given particular attention so that the connecting rods and pistons may be removed without lifting the engine. Similar sets have been in service in various types of boats abroad (several in charge of natives) for many years, and are still regularly working. They are now being fitted to a number of large private yachts as auxiliaries. The same type of engine has been largely adopted for heavy vehicle propulsion, and it was one of this type which was fitted in the War Office tractor and obtained the sole prize of £750 granted by the War Office in March of last year. The exceptionally successful running of the engine and the general success of the vehicle itself have resulted in several repeat orders for tractors from the British War Office.

A four-cylinder 4 in. by 4½ in. petrol set (P/4 type) with reversing and stern gear has been designed to meet the demand for a lighter form of engine, suitable for pleasure or racing launches. The crank-case and other similar parts are of aluminium, and lightness has been attained without, it is claimed, in the least sacrificing the reliability which is a feature of all Thornycroft engines. The cost is very moderate, and the engine has already become very popular.

As regards stationary engines these are made in the single-cylinder type, 4½ in. by 6 in., the design being based generally on those for the corresponding marine sets, as the conditions of service (a constant load for long periods at a stretch) correspond to those for marine enignes. These engines can be used in connection with dynamo for electric lighting of ships, private houses and works or for generating power for tool driving. The output of the standard sets is about 4 kw., and this may be attained constantly without trouble. The set is shown with special bedplate with extension on which the dynamo is bolted. Another application of this motor is to the driving of centrifugal pumps for salvage purposes and water supply to country houses, &c. The bedplate of this plant is generally of the same form as in the electric lighting sets. The pump is coupled direct. Sets have been supplied for abroad with generator at one end and a pump at the other, with disconnecting gear to enable one or both to be run at the same time, or for the motor to drive machine tools by belt off the flywheel.

Messrs. Thornycroft are well known in launch work, and it may be interesting to give some details of one of their latest type. The boat is of the type of which Messrs.

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Thornycroft have built large numbers. It is 30 ft. in length, built of teak throughout, and fitted with one of the two-cylinder 15 H.P. engines described above, using paraffin, and giving a speed of about 9½ miles per hour. It is capable of standing more than the ordinary amount of bad weather usually expected of such size craft, and it appears particularly suited for use all the year round off our own coasts. Such boats are in use by many of the large steamship lines as ship's boats, and also by pilot and Customs departments. The cost complete with all fittings is very moderate.

Electric Lifting Magnets.

IN recent years much has been done in the application of magnets to industrial work. Where iron of any kind has to be lifted or transported, it is obviously more economical to use a magnet to pick up the bars or scrap than an ordinary crane hook, for the arrangement is self loading and more material can be handled at a time. The holding capacity of such magnets depends largely on the materials which they have to handle, particularly, however, on the following points: The magnetic quality of the load; the temperature of the material to be lifted, which should not be above black heat; the shape of the load, and whether it consists of one solid piece or a number of small parts; and the manner in which the material to be lifted is stacked.

For general guidance it may be assumed that a magnet is capable of lifting a solid piece of steel, with machined

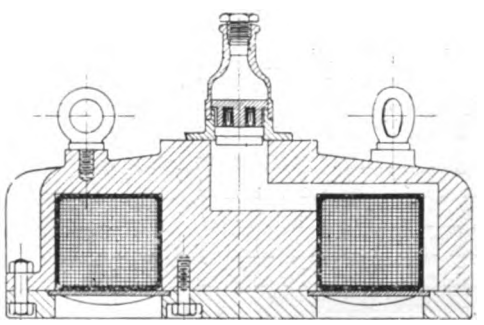

Fig. 1.—Section of Witton-Kramer Lifting Magnet.

surface, of not less diameter than the magnet itself, weighing approximately 15 times the weight of small magnets, 8 to 12 times the weight of magnets from 2 ft. to 3 ft. diameter, and five to six times the weight of magnets from 3 ft. to 5 ft. diameter. When dealing with materials such as sand-cast pig iron, or heavy scrap iron, the lifting capacity decreases considerably, depending entirely on the amount of material which is covered by the contact surface of the magnet. The larger the latter the greater the load attracted. With large diameter magnets, in addition to the first layer, further material is in some instances attracted by the centre pole, and thus a second, or even a third, layer is lifted. When handling metal plates the load depends greatly on the size of the plates, but up to six layers can be lifted, according to the thickness and the weight of each plate and the type of magnet. The quantity of loose or particularly small materials, such as punchings, stampings, drop forgings, nuts or bolts attracted by the magnet varies greatly, and is relatively small, in some cases only reaching up to about one-half the weight of the magnet. In order to increase the bulk of the material handled with each lift, a battery of two or more magnets should be used. In such cases the magnets are so suspended from a common bar or frame as to obtain the best results. This arrangement is advisable, particularly when handling long steel strips or sheets, as the overhang would possibly pull the load away from one large magnet.

Amongst other applications, magnets can be used with great advantage in connection with the iron balls or "crackers" employed for breaking up scrap castings in foundries, and attention may be drawn to the ready attachment and easy release of the ball, which can be obtained in all positions. Also, for pile-driving machines, the magnet can be used instead of the mechanical clutches usually employed, thus considerably increasing the operating speed. For submarine work, or submersion in water and other liquids, special watertight magnets are made. In fact, magnets can be applied with advantage wherever it is desired to dispense with mechanical clutches, clips, slings, chains or similar means for attaching materials to crane

Fig. 2.—Witton-Kramer Magnet Lifting Turnings.

hooks, where manual labour is too costly or unsatisfactory, and where hot plates, trays, hot castings, drop forgings and similar materials which cannot safely be touched by hand have to be transported. It has also been found, when unloading pig iron and scrap metal from railway trucks, considerable saving is effected by using magnets, as the small chips which are usually left in the truck when mechanical means are employed can be readily removed, it being only necessary to lower the magnet to within 1 in. or so of the bottom of the truck and sweep it over the surface when the remnants are gathered up.

The above-mentioned advantages and improvements are strongly emphasised by the very moderate working costs. For instance, a magnet of 24 in. diameter consumes only one-pennyworth of electricity for 25–30 lifts of one minute's duration each. A magnet of 48 in. diameter will do 8–10 lifts with one pennyworth of electricity. The maximum saving which owners can effect with a magnet such as is made by the Witton-Kramer Co. is, however, derived from

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the fact that, besides the operator of the crane and a ground man (if the latter is at all necessary), all other manual labour at present required for the loading or unloading of the material can be entirely dispensed with. A saving in some cases amounting up to £25 per month per magnet can thus be obtained. The capital outlay for the magnet is therefore soon recovered.

Lifting magnets are only constructed for direct current, and where the supply is alternating current it is necessary to supply a motor-generator set or small accumulator battery, or an independent small steam or oil-driven set, to generate direct current for the magnets. In some cases it is also advisable to instal an additional accumulator battery to work in parallel with the dynamo, so that, should the latter break down for any reason whatsoever, the accumulator takes up the load. With magnet installations it is, of course, an essential point that the electrical wiring for same is executed in all its details in the most perfect way. We have made a special study of this, and are pleased to give our clients the benefit of our experience. Under such circumstances, there is no more chance of the load dropping than of the breaking of hoist ropes or chains. In special cases, however, if desired, mechanical safety appliances can be attached to any magnet.

The Witton-Kramer Electric Tool & Hoist Co., of Witton, Birmingham, have had a wide experience of this class of work, and some of the applications of their magnets are shown in the accompanying illustrations. The general construction of this magnet is as follows: The shell is of special high permeability magnet steel, with external ribs to assist the radiation of the heat generated in the magnet coil, and to add to the strength of the casting. To the top of the shell the necessary links, or eyebolts, are fixed for attaching the suspension chains.

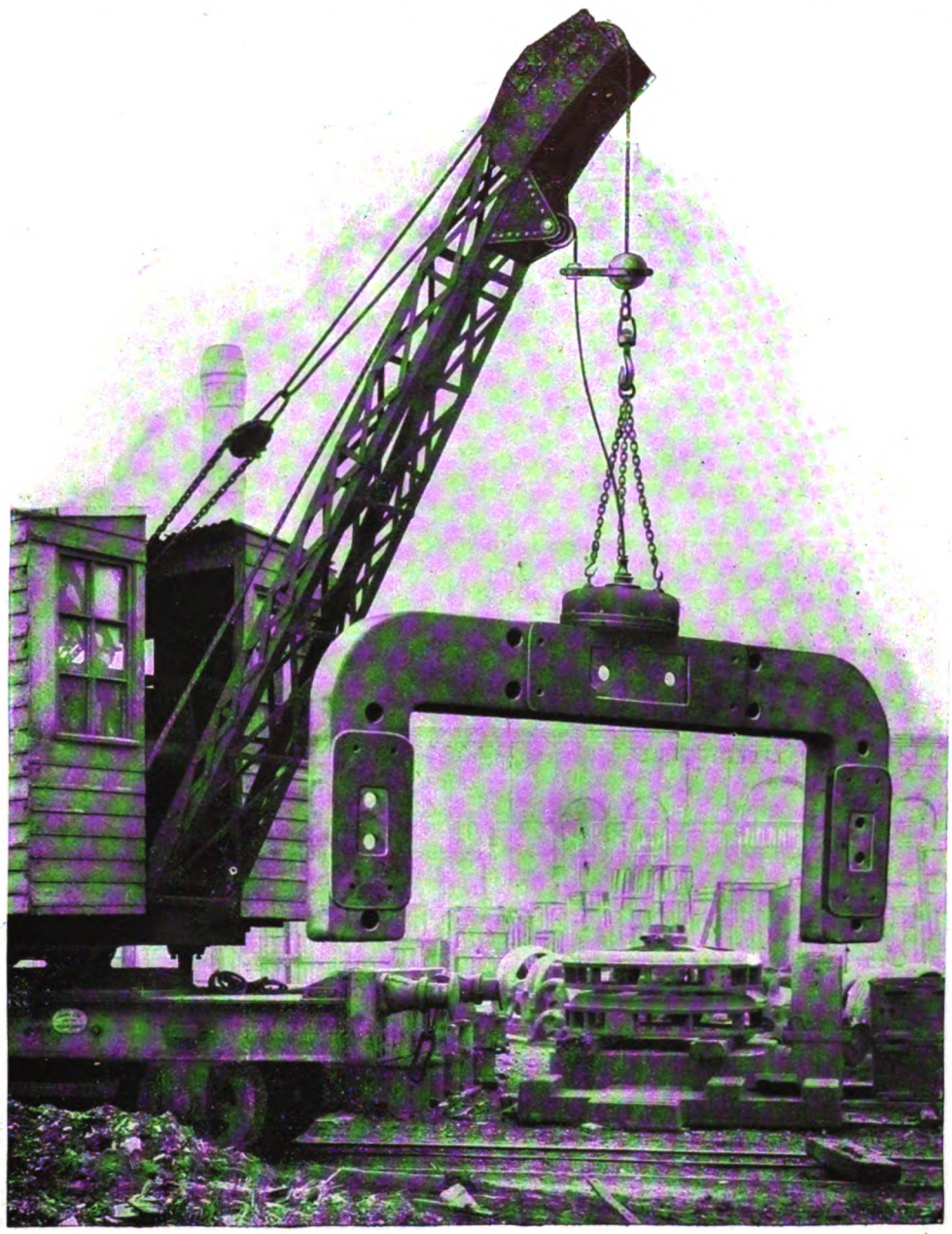

Fig. 3.—Witton-Kramer Magnet Applied to Heavy Crane Work.

The coil is wound of covered copper wire, insulated in the most up-to-date manner with the best and most suitable materials obtainable, and, when wound, undergoes the following treatment: The air and dampness unavoidably contained in the covering of the wire and the insulation in general is extracted by placing the coil into a vessel connected to a vacuum pump. Immediately the gauge glass shows that no more air or moisture is contained in the coil,

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the vacuum chamber is filled from a high-pressure tank with a boiling asphalt compound. The coils are then kept under great pressure in this liquid at a temperature of approximately 200°F. The coil is then firmly fixed in the shell and compounded in position, and by these means is made entirely waterproof and impervious to moisture.

The coil is protected by means of a coil shield of manganese steel or extra hard phosphor bronze. The coil shield is held in position by means of the inner and outer pole shoes, which are of high permeability magnet steel, and can be easily removed by loosening the bolts which hold them. In some cases the joints are soldered.

The connection to the mains is obtained by means of a special iron-clad plug and socket, with suitable locking device. The leads are usually held by means of a split washer, and the whole plug and socket is filled with compound and entirely watertight. A cap is provided which fits over the plug when same is removed from the socket to prevent short-circuiting.

The controller is of the drum type, and, in some cases, oil-immersed. Non-inductive resistances are supplied to take up the induction of the coil when breaking the circuit. The wiring necessary for operating electric lifting magnets consists of a twin cable, specially made suitable for this class of work, leading over a system of pulleys provided with a counterweight to keep cable taut. In the case of jib cranes this cable is connected to the supply in the crane cabin, but for travelling cranes it is usual to instal two more trolley wires alongside the bridge, providing special collectors to collect the current.

The method of operating a magnet crane is similar to the working of any electric crane, with the addition only of an extra controller for exciting the magnet and releasing the load.

Pearn Colliery Pumps.

AN interesting sermon on the text of the application of electrically-driven pumps to colliery work could be preached by describing Messrs. Frank Pearn & Co's. activities in this direction. This agreeable task we have not time to do in anything like detail, but must confine ourselves to the description of one of two installations.

To make a start, the set of pumps shown in Fig. 1 have been supplied by this firm to the Rand Collieries at Johannesburg. They are of the three-throw ram type, and are driven by single reduction spur gearing direct by a B.T.-H. three-phase motor of 75 B.H.P. running at 480 revs. per min. This set is capable of delivering 10,000 gallons per hour against a head of 1,050 ft. The rams are 6¼ in. diameter by 9 in. stroke, and the crank shaft makes 60·66 revs. per min. The motor shaft carries a steel spur pinion, which gears with the cast-iron spur wheel, made in halves. The teeth of the latter are accurately cut. The crank shaft is a Siemens-Martin steel forging, and is of the combined sweep and overhung pattern; it is carried in three adjustable bearings. The construction of the connecting rods and pump barrels resembles those already described. The valve boxes are three in number, a suction and delivery chamber being embodied in single castings provided with separate doors for the valves. The rams are of cast-iron, working through gun-metal neck rings and cast-iron glands. The crossheads are cast on the rams, and are fitted with steel pins firmly secured, and work in slipper guides. The whole of the pumps, crank, and motor are mounted on a common bed-plate, which contains three castings bolted together. An alleviator by-pass valve and suction air vessel complete the installation. The illustration represents one of eleven pumps supplied to the mines in the Transvaal, six being at work at the Rand Collieries, four at the Cinderella Deep and one at Van Ryn gold mines.

Two interesting pumps, recently constructed for colliery work by Messrs. Frank Pearn & Co., Ltd., Manchester, are illustrated in Fig. 2, which represents one of two sets of horizontal three-throw ram pumps supplied to the Wallsend and Hebburn Coal Co., for Hebburn Colliery, near Newcastle-on-Tyne. The pumps are driven through cotton ropes by three-phase 40 cycles, 600-volt motors, supplied by the British Westinghouse Co., and when running at 375 revs. per min. consume 210 B.T.U. The combined efficiency of the motor and pump is about 75·6 per cent. Each set of pumps is capable of delivering 630 gallons per minute against a head of 1,100 ft. The rams are 12¼ in. in diameter by 18 in. stroke, and work at the very moderate

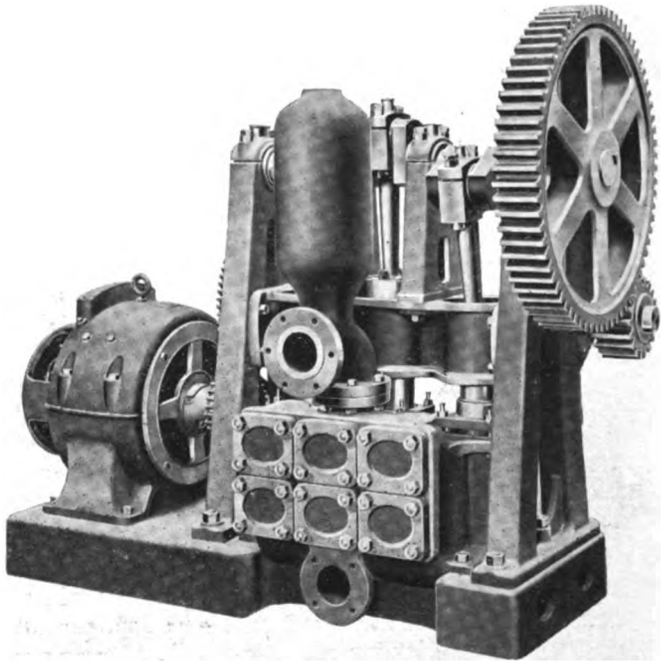

Fig. 1.—Pearn Three-throw Pump.

speed of 29 revs. per min. The advantage of slow-speed working is obvious. The minimum of attention is required, and no appreciable wear will take place for many years. The first motion shaft carries a rope pulley 13 ft. 3 in. diameter, with 13 grooves for 1¼ in. ropes, and is carried in adjustable gun-metal bearings. The crank shaft is driven from either side by means of single reduction gearing, the wheels being of cast steel, made in halves, with machine-cut teeth. The crank shaft is of forged Siemens-Martin steel of the sweep type, and is annealed after being rough turned. It is carried in four adjustable gun-metal bearings. The connecting rods are solid forgings, and have adjustable gun-metal bearings at each end. The pump barrels are similar; all flanges, as far as practicable, are fitted with bolts, no studs being used. The valve boxes for both the suction and delivery branches are all interchangeable. The rams are of solid gun-metal, and bolted to the crossheads. The stuffing boxes are fitted with loose gun-metal neck rings, and the glands are bushed with the same metal. The crossheads are of cast iron, with ample wearing surfaces, and working in slipper guides. The baseplate on which the pumps, crank, and intermediate shafts are mounted, is in three separate sections bolted

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together. The pumps are fitted with a by-pass valve, delivery and suction air vessels, and Wipperman & Lewis air chargers.

An example of a verticle type equipment is the three-throw ram pump made by Messrs. Frank Pearn & Co., and driven by electric motor through double reduction gearing. The capacity of the pump is 9,600 gallons per hour against a head of 600 ft. The rams are 6 in. diameter and the stroke is 8 in. The pump barrels, valve chamber and vacuum are all formed in one exceptionally strong casting; which has a trough cast on to collect all leakage from the glands. The rams and crossheads are of cast iron, working through gun-metal neck rings and cast-iron glands; the crossheads, which are cast to the rams, are fitted with steel pins firmly secured, the crossheads working in guides. The ram guides are of the circular type of large area, and effectively take the wear off the rams, glands and packings. The guides are truly bored to fit the rams, thus permitting the rams to be readily removed. The guides are formed in one casting, which is bolted to the standards, thus ensuring rigidity. The crank shaft is turned out of a solid forging of specially selected steel, and annealed after being rough-turned, carried in four gun-metal adjustable bearings. The connecting rods are made from solid steel forgings, fitted with adjustable gun-metal bearings at each end, the ram ends working upon steel pins.

Fig. 2 shows a three-throw ram pump specially constructed to work under the following conditions, either verticle, horizontal, or on the incline, as may be required, during sinking

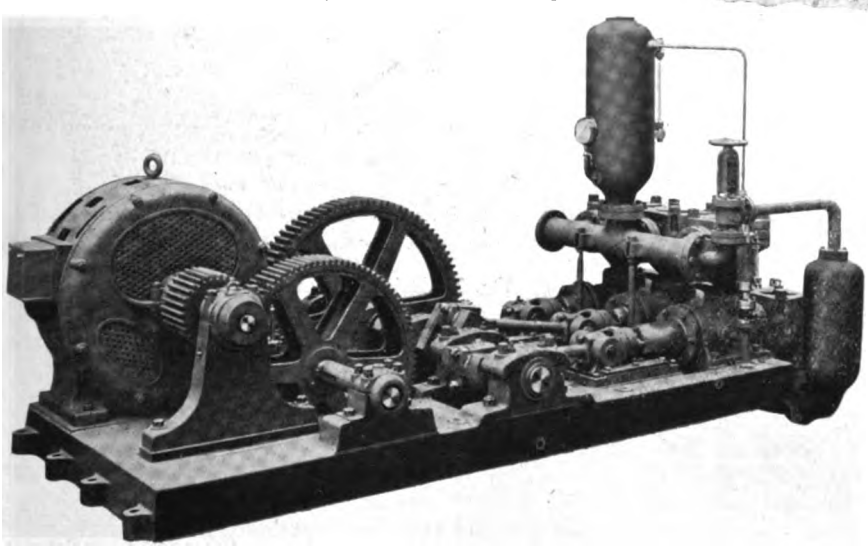


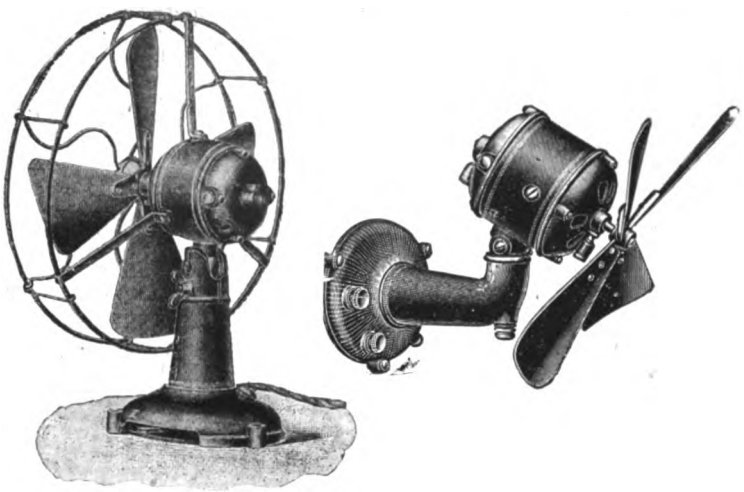
Fig. 2.—Pearn Electrically-driven Colliery Pump.

operations. This was constructed for use in the West African goldfields. The pump is capable of delivering 15,000 gallons per hour against a head of 500 ft., the rams being $8\frac{1}{2}$ in. diameter with a 15 in. stroke. The speed is 38 revs per min., the pump being driven through a train of double gears all machine cut, the motor speed being 500 revs. per min. The pump barrels are all in one casting and securely bolted to H section steel girders, these girders in the first instance being connected together by cast iron distance pieces at each end and then treated as though it was a complete casting. The pump barrels are also stayed to the main crankshaft pedestals. All cross strains are eliminated, and the strains on the girders and stays are in tension. Both the crank shaft and intermediate gear are between bearings, and not overhung.

OSRAM LAMPS

Siemens Fans.

AMONG the many specialities manufactured by Messrs. Siemens Brothers Dynamo Works (Ltd.) may be mentioned their table and bracket fans. These are made for continuous or alternating current for voltages varying from 6-220, the air displaced per minute varying from 105 to 1,050 cubic ft.



Examples of Siemens Fans.

In Fig. 1 we illustrate a 12 in. fan provided with a knee joint, speed reducing switch and wire guard, the knee joint making it suitable for use either as a table fan or, without alteration, for fixing on the wall as a bracket fan.

Larger size fans are provided with a special regulator to reduce the speed by about 33 per cent. Alternating-current fans are provided with induction motors which run silently, and these, having neither commutator, slip-rings nor brushes, can be left running for long periods without attendance. Fans for installing in damp situations are provided with special insulation.

Fig. 2 shows one of the Siemens type GMT fans with knee joint arranged as a bracket fan.

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Turbine-driven Centrifugal Boiler-feed Pump.

THE first requisite of a boiler-feed pump is the ability to give uninterrupted service while receiving little, and often unskilled, attention. The centrifugal pump, however, is free from many of the disadvantages of the reciprocating pump, and possesses several important advantages in addition. An interesting pump of this type is described in a recent issue of the "Electrical World." The impeller is of bronze and there is an absence of guide vanes. One of the chief obstacles to high head per stage in certain types of centrifugal pumps has been the leakage from the discharge, past the impeller, back to the suction chamber. In this pump this has been prevented by the use of special labyrinth packing rings instead of the plain, straight, water-packed joint commonly employed. At each joint there is one labyrinth ring attached to the impeller and another meshing with it set into a recess in the pump casting and secured in place by the act of letting the cover down upon the lower pump casing. The two labyrinths intermesh in such a way as to form a long, tortuous passage in which any leakage currents are repeatedly broken up. At the same time the water within the labyrinth is set in motion by the drag of the moving ring, creating a counter centrifugal force in opposition to the leakage.

The casing of the pump consists of two parts only: the bottom casting and the cover casting. In the bottom casting are formed the inlet and outlet passages to the piping, while both castings contain passages leading from the delivery of the first impeller to the inlet of the second, these passages being cast in the solid metal. The top, or cover casting, when raised, exposes the entire interior and all working parts of the pump, and, after removing the shaft-bearing caps, the impeller may be lifted out entire.

Balcke's Centrifugal Pumps.

THE various advantages attendant on the use of that dual combination the centrifugal pump direct-coupled to a motor, are so well known to our readers in a general sense that it is unnecessary to dilate further upon them. But we may give some examples of this general

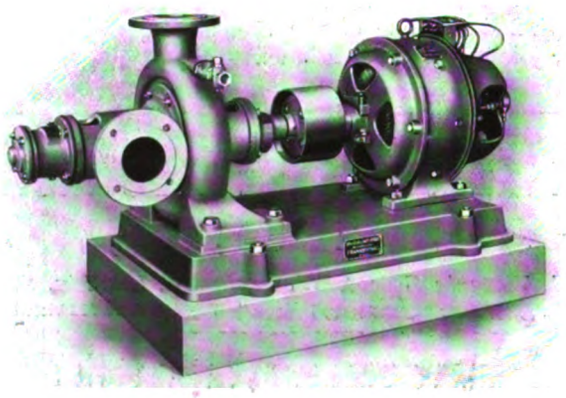

Fig. 1.—Balcke Low Lift Centrifugal Pump.

droposition, and for this purpose cannot do better than describe the low lift centrifugal pumps made by Messrs. Balcke & Co.

All these pumps are provided with guide vanes to convert the velocity when leaving the impeller to static pressure with minimum loss. The larger sizes have also a spinal casing for obtaining the most favourable flow of water.

The speeds of the standard patterns have been kept within moderate limits. For higher speeds, which may be required for coupling to a high-speed motor, a pattern with a double inlet is recommended. In these pumps the width of the impeller is increased at the same time as its diameter is reduced.

The water enters the impeller through a suction bend cast on the pump cover. From the impeller it flows at a higher speed into the guide vanes, which form part of the casing, where its velocity head is converted into pressure and ordinary pipe velocity without undue loss due to friction or whirling. The position of suction and delivery branch can, in each case, be altered to suit any piping arrangement. By most accurate workmanship, it is claimed, the water loss is reduced to a minimum, but at the same time there is no undue friction.

Accurately machined bronze rings, which are easily changed, are fitted between the impeller and the casing. End thrust is entirely prevented by a special design of the impeller. At the same time, for fixing the latter, a light thrust bearing is provided on the suction side of the pump.

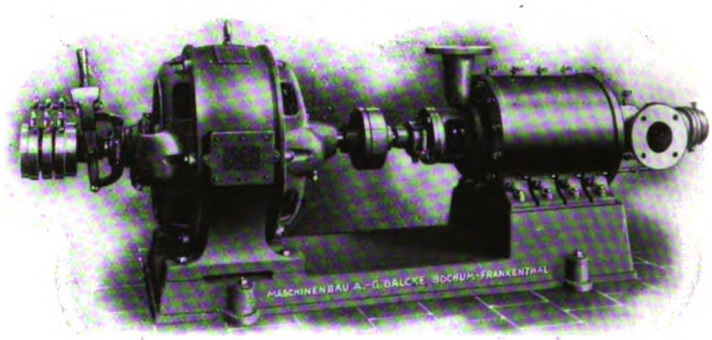

Fig. 2.—Balche Three Stage Turbine Pump.

The shaft runs in easily accessible bronze ring oiled bearings, which are entirely separate from long glands. These latter can easily be got at and are water sealed on the suction side to prevent air entering the pump.

The pumps can be driven by belt or can be coupled direct to a motor, steam engine or steam turbine.

Fig. 1 shows an example of Balcke's low lift centrifugal pump direct-coupled to a motor. These pumps are made in sizes whose lifts vary from 13 ft. to 82 ft. per minute, the capacity being between 955 and 1,240 gallons per minute. Fig. 2 shows a three stage turbine pump, also electrically driven. These pumps can be supplied for any capacity and lift, and are designed specially for use in mines or for boiler feed purposes.

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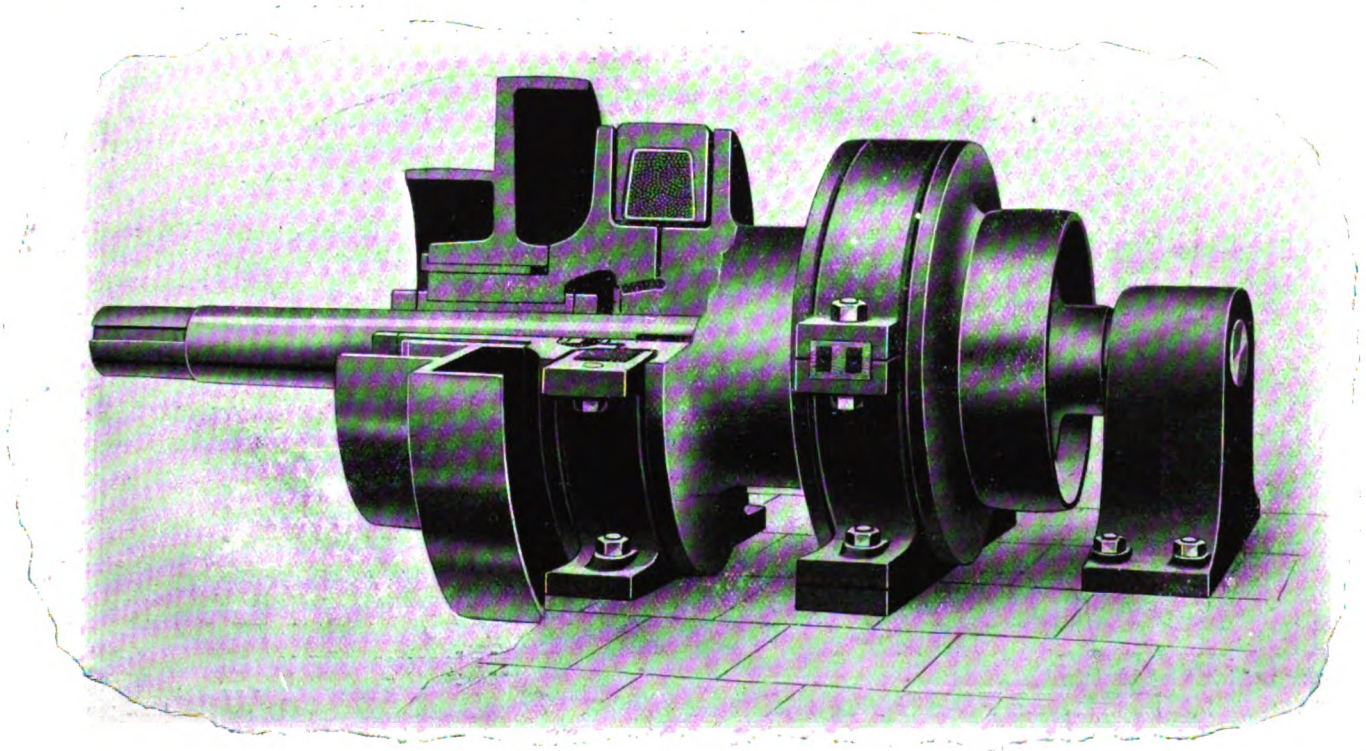
The S.M. Electro-Magnetic Drive.

AN interesting application of the electro-magnet to machine drive is that of the S.M. clutch made by Messrs. C. E. Lugard & Co., of Chester. In this system a reversing magnetic clutch is utilised instead of the shifting belt. This clutch consists of a stationary magnetic body containing a coil ; a divided armature, one part secured to the shaft, and provided with a renewable cone of hard fibre ; the other part running loose on the shaft and carrying the belt pulleys. Continuous current is supplied to the energising coil from the shop mains by wires connected to the stationary magnetic body. As soon as the circuit is closed the two parts of the armature are sucked together by magnetic attraction. The old striking gear is removed, and one of the levers is utilised to move a sliding switch, which automatically energises the clutch. The shaft carrying three belt pulleys and the quick return sleeve and pinion, is replaced by a shaft carrying a double S.M. electro-magnetic clutch fitted with pulleys. All variations in speed are obtained by pulley ratio. The electrical connections consist of a double-pole switch, non-inductive resistance, two single-pole fuses, for connection to the shop mains, and a pear switch with flexible cord for control from a distance.

As an example of the economies effected by this system we may instance the case of an old planer, 5 ft. 6 in. by 16 ft. table, only cutting at 25 ft. per minute, resting $3\frac{1}{2}$ seconds, and returning at 35 ft. per minute, which has been fitted with a magnetic drive. The speeds are now : cutting (two speeds) 28 ft. and 50 ft. per minute, return 60 ft. per minute with no appreciable rest at the end of the stroke. Heavier cuts even at 50 ft. with a reduced load on the motor can now be taken owing to the better grip of the belt. The machine gives $2\frac{1}{2}$ times its former output.

Besides the economies which can be expressed in mere figures there are other decided advantages resulting from the uses of such an apparatus. Much of the old unsatisfactory mechanical equipment is removed, and there remains instead an arrangement which is simple and easy to operate. The clutch takes up but little room and should have a wide application.



General View of the S.M. Clutch.

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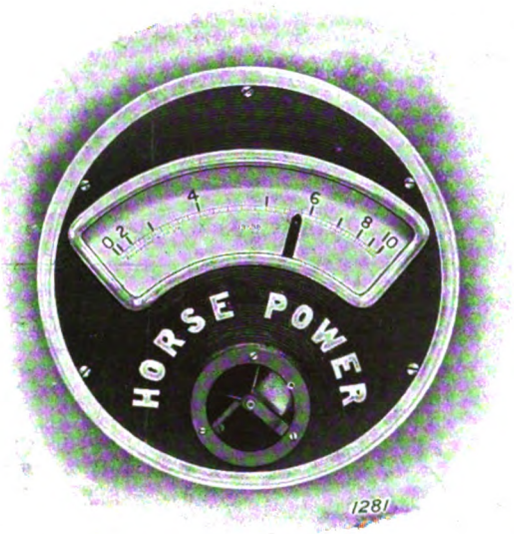

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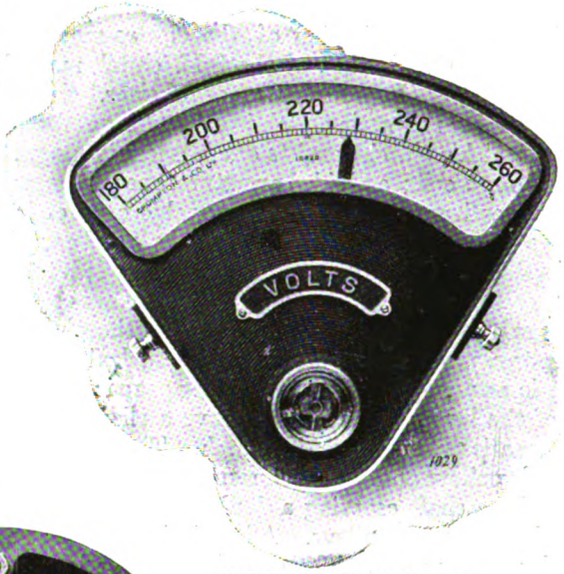

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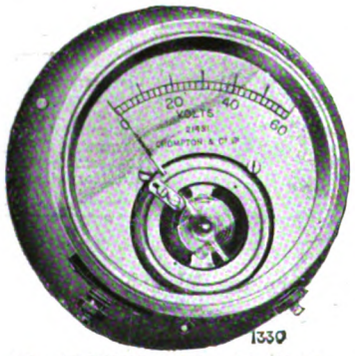

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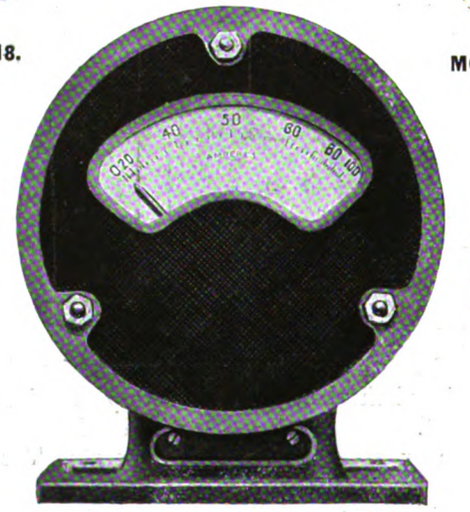

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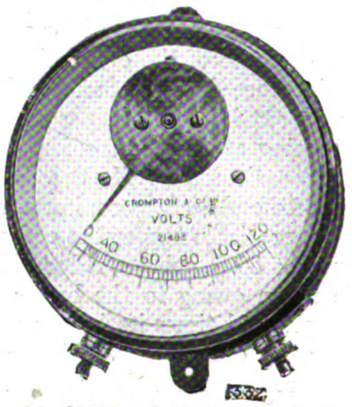

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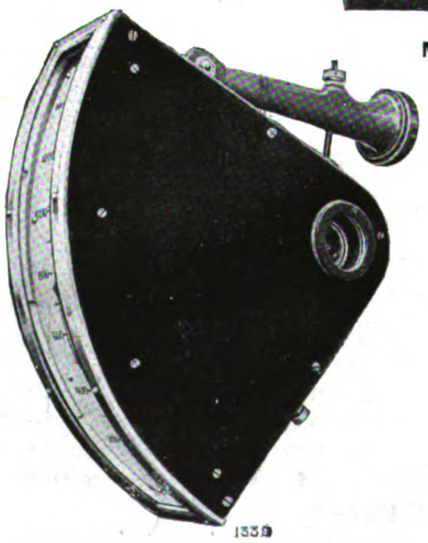

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Printed and Published by GEORGE TUCKER, at the Editorial, Printing and Publishing Offices, 1, 2 and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, JUNE 24, 1910

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,676. [No. 12. Vol. LXV.] FRIDAY, JULY 1, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

The Daimler Petrol-Electric Omnibus.

THERE are three main features in the new Daimler petrol-electric omnibus, as our readers will see from the description given in another column, namely, (1) the use of petrol and electric motors in the form of detachable units, (2) the abandonment of the usual chassis, and (3) the use of an all-steel body. So far, the chassis has been a popular form of construction in all motor vehicles, except of the lightest possible type, as any other form of construction with a wooden body renders hard wear an impossibility. The chassis takes up the main stresses in driving, and the body is thus concerned merely with supporting the load of passengers. An all-steel body, however, renders this form of construction unnecessary, as the steel can take up the stresses which would otherwise be met by the chassis, and weight can thus be saved in one direction, although it is necessarily increased somewhat by adopting this construction for the body. The result, as a whole, however, seems to be favourable to lightness.

THE usual claims of the petrol-electric system are that the change-speed gear, which is necessarily associated with the petrol motor when used by itself, is eliminated, and there is much greater flexibility in the driving. Results of this kind have been obtained by previous systems, but probably the most important distinction in the Daimler motor omnibus is that the driving units are detachable. A petrol engine with an electric motor coupled on the same shaft is mounted on each side of the omnibus, and each set drives a rear wheel by means of worm gearing. The weight of the back axle and differential is thus saved, and these driving units are so mounted that they can be removed in quite a short time. A battery of accumulators completes the essential part of the equipment, the motors acting as generators at times. The new scheme seems to be very important from the point of view of maintenance. The engine is essentially that part of the equipment which requires the greatest attention, and satisfactory running cannot be expected unless the engine is kept in thorough order. On the other hand, with the usual arrangement, if the engine is to be overhauled the omnibus as a whole must be thrown out of work, and thus capital is kept idle to a very considerable extent. By adopting the principle of detachable units, this difficulty is overcome, as the engine and motor can be overhauled at leisure under the best conditions, whilst the omnibus is performing its usual task with fresh units. Other points of novelty are the wire wheels, the wire type not having been so far adopted for heavy vehicles, and, further, the much larger diameter of the wheels. It is evident that every care has been taken to reduce the weight to a minimum; and as the larger wheels will result in much smoother running, we do not doubt that the cost of maintenance as a whole will be reduced below the usual figure. We hope that this new type of omnibus will show itself entirely satisfactory under working conditions, that it will prove to be an advance on present practice, and that it will enable the petrol-electric system to compete advantageously with the purely petrol type.

"Golden" L.C.C. Tramways.

ALTHOUGH the result of the past year's operation of the London County Council tramways scarcely justifies the above epithet, used by the "Daily Chronicle," it certainly cannot be considered unsatisfactory. Thus, the report of the Finance Committee on the tramway accounts for the

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year ended March 31st last, which report was presented to the Council on Tuesday, showed that the balance, after payment of interest and sinking fund, amounted to £192,109. This compares with £107,570 a year ago; and it is satisfactory to notice that the whole of the above sum is to be placed to the reserve fund and as a provision for renewals, notwithstanding the clamour of a certain section of the daily Press that at least some of this "profit" should be handed over to the relief of the rates. It will be remembered that Messrs. W. B. PEAT and F. W. PIXLEY, in their report some two years ago upon the accounts of the Council's tramways, stated that an adequate reserve for future renewals is an essential element in the cost of the year's trading and should be charged before the balance of net revenue is arrived at; so that, as a matter of fact, the real surplus, if any, in the present instance is quite small. In this connection it is instructive to notice the efforts made to beguile the ratepayers into the belief that a "commercial profit" of more than three-quarters of a million has been obtained.

THE work of converting the horse-operated lines proceeds apace, and the Chairman of the Highways Committee stated at the meeting on Tuesday that of the 20 miles of track which remained to be converted on March 31st last, the electrification of 14 miles is now in hand. The difference between the results achieved on the horsed tramways and on the electrically-operated routes is certainly very striking; but as has been frequently pointed out, the two cases are not at all comparable. There is no doubt, however, that although the remaining horsed routes are not likely to show after conversion such a high average revenue as 11·48d. per car-mile, their early electrification will be a decided advantage both to the tramway undertaking and to the public. It is probably partly owing to the fact that the "best paying" routes were converted at an early date that the average revenue per car-mile on the electrically-operated lines continues to decrease, the figures for the past four years being 12·23d., 11·95d., 11·81d. and 11·48d. respectively. On the other hand, in regard to the future prospects of the undertaking, it is very satisfactory to notice that the increase in receipts during the past three months will, if maintained, result in over a quarter of a million additional revenue during the present year.

The Telephone Transfer.

THE proceedings at the sixteenth annual dinner of the staff of the National Telephone Co., held on Thursday evening last week, were noteworthy. The absence of the Postmaster-General, of the Assistant Postmaster-General, and of other departmental leaders was unfortunate, as the presence of the State representatives would have given *éclat* to the occasion. Their absence did not, however, detract in any way from the harmony of the proceedings. It will be seen from our report on another page of this issue that the process of the lion lying down with the lamb is almost an accomplished fact. There is, however, a "fly in the ointment," as the chairman referred to the possible expenditure of £100,000 (presumably in litigation or arbitration) before the complete consummation of the parable. It is to be hoped, in the interests of all parties to the transfer, that this huge expenditure will be avoided, and that the negotiations which have been, and are, proceeding will be brought to an honourable and satisfactory termination. Except for this jarring note, the proceedings at the staff dinner were of a most harmonious character, and the facts and figures presented by the President of the National Company (Mr. GEORGE FRANKLIN) and by the chairman (Mr. ALBERT ANNS) showed, if any such showing were necessary, that the Company, despite the sword which hangs over it, is a virile, progressive enterprise, and promises to be a most valuable asset for the State to acquire. The outlook for the shareholders appears to be an improved one, and if the future position of the staff could be definitely settled we feel sure that the public would regard the State's latest purchase with equanimity and with hope. To the very large number of the Company's staff whose future lies in the lap of the gods, the feeling of doubt and uncertainty is becoming wearisome, and they may reasonably ask their future masters to make an end of this uncertainty by a prompt and, it may be, liberal settlement of all outstanding questions.

L.B. & S.C. Electrification.—Statements continue to be published of the decision of the London, Brighton & South Coast Railway Co. to extend the electrification of their suburban line to the Crystal Palace. The portion of the line which is to be included in the new scheme is that between Battersea, Clapham Junction and Balham to the Crystal Palace, and from Peckham Rye to the Crystal Palace, enabling the electric service of fast trains to be available from either Victoria or London Bridge and the intermediate stations to the Palace. Those who are concerned in the future of the Crystal Palace regard the Company's decision as a most important one in that interest.

Kew Observatory.—In accordance with recent arrangements the administration of the work of the Kew Observatory, in so far as it is concerned with observational and experimental work in meteorology and geophysics, is to be transferred to-day to the Meteorological Office. The administration of the observatory at Eskdale Muir is also to be associated with the Meteorological Office instead of, as heretofore, with the National Physical Laboratory. In addition to continuing as superintendent of the Central Observatory, Dr. C. Chree, F.R.S., has been appointed Assistant Director of Observatories for the Meteorological Office. The work of testing instruments now carried on at Kew will be transferred to Teddington, the well known "K.O." mark being retained by the National Physical Laboratory.

Wireless Telegraph Station at Colon.—According to the "Electrical World," there has been installed in the United States Navy wireless telegraph station at Colon a complete new wireless telegraph equipment, including antenna. The new equipment consists of the latest improved design of Fessenden apparatus. The transmitting apparatus is of the high frequency 500-cycle type, with a rotating spark gap which is attached to a 25 kw. generator. Two compressed air condensers, each operating under 250 lb. air pressure are also used. Power for operating the transmitter is received from the Isthmian Canal Commission plant at Gatun. This equipment was put into operation on March 1st last and has since operated satisfactorily.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Madagascar—Reunion	May 12, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910
Fort de France—Paramaribo	June 25, 1910
Gibraltar—Tangier	June 30, 1910

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Increasing the Speed of Telegraphic Transmission.—It is stated that by means of an invention due to Mr. Hans Knudsen the speed at which telegraph messages can be transmitted will be quadrupled. Mr. Knudsen proposes to dispense with the Morse code of signals and to employ a lettered keyboard. The message at the receiving station is to be automatically printed by a typewriting machine, thereby simplifying the operation at transmitting and receiving stations.

Personal.—On June 15th the honorary degree of doctor of science was conferred on Mr. H. F. Parshall by the Massachusetts Institute of Technology. Mr. Parshall is well known in this country, though his early engineering days were spent in his native country, the United States. From 1887 to 1898 he occupied responsible positions with the Sprague Electric Railway & Motor Co., the Edison General Electric Co. and the General Eletric Co., while he was also a lecturer in electrical engineering at the Massachusetts Institute of Technology.

Birthday Honours.—We are glad to see that some names well known in the technical world appear in this year's list of Birthday Honours, though pure science has not received as much attention as might have been expected. The following is a list of those names best known to our readers :—

Barons.—Sir WEETMAN D. PEARSON, Bart., head of S. Pearson & Son (Ltd.), railway and tramway contractors, &c. Among the many big engineering works carried out by the firm was the construction of the Great Northern & City (Tube) Railway.

Sir CHRISTOPHER FURNESS, chairman of Messrs. Richardsons, Westgarth & Co. (Ltd.), engineers and shipbuilders.

Privy Councillor.—Sir WILLIAM MATHER, chairman of Messrs. Mather & Platt (Ltd.), the well-known electrical and mechanical engineering firm. Apart from engineering, Sir William has for many years been a consistent and generous supporter of technical education.

Baronet.—ALFRED MOND, M.P., a managing director of Messrs. Brunner, Mond & Co.

Knights.—ALFRED HOPKINSON, K.C., LL.D., Vice-Chancellor and Principal of the Victoria University, Manchester.

CLARENDON HYDE, a director of the Great Northern & City Railway Co. and of S. Pearson & Son.

C.B.—RICHARD TETLEY GLAZEBROOK, Director of the National Physical Laboratory. Dr. Glazebrook is a Past-President of the Institution of Electrical Engineers, a Past President of the Physical Society, and the author of several works on optics and physics, a life of Clerk Maxwell, &c.

C.I.S.O.—ALFRED E. EAMES, retiring Comptroller of the Central Telegraph Office, G.P.O.

Street Railway Development in the United States.—Some interesting figures regarding the development in tramway mileage in the United States are given in a leaflet recently issued by the Department of Commerce and Labour. From these it appears that electricity is used as a motive power on 99 per cent. of the lines, while in 1907 the total number of miles of line, by which is meant length of first main track or road bed, was 25,547·19, compared with 16,645·34 in 1902, the per cent. increase being 53·5. The total number of miles of track, meaning the total length of all trackage, including sidings, was 34,403·56 in 1907, as against 22,576·99 in 1902, the per cent. increase amounting to 52·4. Of the total number of miles of track, those operated by electricity in 1907 numbered 34,059·69 and in 1902 21,907·59. The per cent. increase was 55·5. The track operated by animal power in 1907 was 136·11 and in 1902 259·10 miles. The per cent. decrease amounted to 47·5. The track operated by cable in 1907 was 61·71 and in 1902 240·69 miles, the per cent. decrease being 74·4. The track operated by steam in 1907 was 146·05 and in 1902 169·61 miles, a decrease of 13·9 per cent. The percentage increase in cost of construction in 1907 compared with that in 1902 was 67·8, while the number of employés increased by 57·3, and the passengers carried increased from 5,836,615,296 to 9,533,080,766. The car-mileage was 1,617,731,300 in 1907 and 1,144,430,466 in 1904. The use of electricity has made it possible to increase the size of the cars so that the number of cars in 1907 was only 16·1 per cent. greater than in 1902 ; and while in 1890 99 per cent. of the traffic was passenger, in 1902 this had fallen to 94·5 and in 1907 to 91·4 per cent.

Improvement of London's Means of Transport.—At a meeting of the London Chamber of Commerce, held on Wednesday last, Mr. A. W. Gattie read a Paper in which he described an arrangement for improving existing traffic conditions in London. He holds the view that the greater part of the present congestion is caused by the vans of the various railways and parcels agents and traders, and that these carts not only stand about for long periods, thus blocking the road, but also hardly ever carry more than half their normal load. Further, the large size and present arrangement of our goods stations prevents the produce being effectively dealt with, with the result that a large amount of time is wasted on the journey. To overcome these difficulties Mr. Gattie proposes to apply the clearing house system to railway goods traffic. He would erect one large clearing house in the Clerkenwell-road to which would be carried all goods intended for transport by rail. At this clearing house the goods would be sorted into the towns, while they would also be so arranged that they would be quite ready for despatch at the other end by a similar arrangement. This method of working would include all forms of merchandise except coal and cattle. The building has been so designed that the Clerkenwell-road would run right through its centre, while the other neighbouring main streets would be well available for bringing up the goods. Clearance, after sorting, would be by two special lines of rail connecting up the trunk railway systems north and south of the Thames. Although this idea is likely to be of interest to the electrical engineer in his public capacity, yet the point that will appeal to him most is the way in which electric power is to be used in marshalling and arranging the goods within the clearing house. The parcels are not, in fact, to be touched by hand at all, but would be distributed by cranes or conveyors to the railway trucks, which are timed to receive them at a particular point. The conveyors are fitted with electromagnetic apparatus which enables them to suck on to themselves or to thrust from themselves loads which are deposited beside them on suitable magnetic trays or tables ; and, by means of a controller, they are able to do this in a way predetermined by the operator. Neither the function of receiving nor discharging a load involves any shock or concussion. This result is achieved by the use of reciprocating roller magnets, which revolve at the same speed, one set being fixed at the station, the other set being carried by the moving platform. The switching arrangements are intricate, and it is impossible to indicate them briefly, but we hope we may be able to return to this part of the subject when it has been more fully developed. The patents are in the names of Mr. Gattie and Mr. A G. Seaman of the British Westinghouse Co.

Magnetic Separators.—At a meeting of the South African Institute of Electrical Engineers, an interesting discussion took place on the extraction of iron from ore and pulp. The presence of iron in mill pulp is undesirable from several points of view. It interferes with the cyanide tretament, as it absorbs oxygen ; it is separated together with the heavier bodies and returned over and over again to the tube mills to be reground until it is passed on to the cyanide works. The quantity of iron present in the pulp is approximately 4 lb. per ton, and as this increases the expense a simple means for its removal is desirable. The most favoured idea seems to be a magnetic separator. Mr. C. McCann described briefly the separator installed at the Premier Mine for the extraction of magnetic substances from the concentrates before going to the sorting tables. Although some 32,000 tons of ground are crushed and treated per day, the concentration methods are so good that only about 1 ton of concentrates per day, containing the whole output, needs treatment by this machine. The method of treatment is as follows : The concentrates are fed by hand into a hopper which distributes them over a slowly moving canvas belt some 4 ft. wide ; on this belt they first pass under a narrow magnet placed across the width of the belt, and along the face of this magnet runs a small canvas belt. All metallic iron particles are attracted and lifted up by this magnet and carried and thrown on one side by the small belt. They amount to about 10 per cent. by weight of the concentrates. The remainder is then carried on by the main belt, and allowed to fall between the poles of a pair of powerful magnets, where they are divided by a knife edge, the non-magnetic particles dropping straight down and the others

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being deflected. A peculiar fact in connection with the operation is that practically the whole of the above-mentioned second stream of matter consists of what are generally believed to be non-magnetic substances, and are so, in an ordinary field, such as that produced by a powerful horseshoe magnet. In samples taken on several occasions Mr. McCann was unable to detect any particle showing signs of magnetism. Chemical analysis also failed to show any general trace of iron, but traces of oxides and sulphides were found in a few samples, also a few traces of nickel, in the form of nickeliferous pyrrhotite, which is a magnetic compound. The field which produces this unusual degree of separation is an exceedingly powerful one (B=20,000 lines per square centimetre, estimated). The pole pieces are about 4 ft. to 5 ft. wide, and are wedge shaped, tapering from some 6 in. or 8 in. to a curve of about $\frac{1}{4}$ in. radius, at which part, of course, the flux is concentrated. The main energising coils are four in number, each resembling one of the field coils of a large two-pole dynamo. The current taken by these is about 40 amperes at 500 volts. Mr. McCann mentioned that the figures given as to dimensions and current were, to the best of his recollection, correct, but were subject to correction.

Submarine Power Cable.—According to the "Electrical Review and Western Electrician," the American Steel & Wire Co. recently laid what is said to be the first long-distance submarine cable for high-voltage transmission in an inland lake. The cable was laid on the bottom of Oneida Lake, New York, from a point several hundred feet east of the South Bay terminal of the Syracuse & South Bay Electric Railroad to the east shore of Frenchman's Island, a distance of more than 6,000 ft. The cable consists of three conductors No. 5 B. & S. gauge, insulated with special crown-rubber insulation to the depth of $\frac{3}{16}$ in. around each conductor, with jute laterals, and wound with two reversed saturated jute servings. It is armoured over all with No. 9 galvanised iron wires. Power will be transmitted at 6,600 volts and stepped down to 110 volts at the island, where it will be used principally for illuminating the dancing pavilion, groves and dock.

Street Railway Accidents in New York.—The Public Service Commission of the First District of New York has recently issued a comparative statement of the accidents which occurred on the street railways in the district under its jurisdiction for the month of April in the last three years. The following summary is given by the "Electric Railway Journal":—

	April, 1908	April, 1909	April, 1910
Car collisions	140	88	99
Persons and vehicles struck by cars	930	994	963
Boarding	562	563	690
Alighting	544	557	625
Contact with live conductors	36	21	26
Other accidents	2,498	1,947	1,920
Totals	4,710	4,170	4,323
Injuries:—			
Passengers	1,681	1,610	1,828
Not passengers	662	484	487
Employés	503	400	490
Totals	2,846	2,494	2,805
Serious Injuries (included in above):—			
Killed	30	28	36
Fractured skulls	24	8	9
Amputated limbs	5	3	8
Broken limbs	30	18	38
Other serious injuries	102	120	133
Totals	191	177	224

In explanation, the Commission says that the increase in the number of persons killed is accounted for partly by the fact that 2 of the deaths were from suicide, 6 from employés working on tracks, and 10 from stealing rides, falling from structures, trespassing, contact with live conductors, &c. No one was killed in collisions between cars, and only one person was killed from collisions between cars and vehicles. Nine persons were killed by being struck by cars this year, as against 12 last year.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. J. M. Fernandez contributes an article on "A New Arrangement for the 'B' side of Quadruplex Apparatus."

The latest form of Collins Wireless Telephone is described in our columns by Mr. W. Dubilier.

Mr. D. Owen contributes an article on "Short Spark Gaps."

The new exchange of the National Telewriter Co. is being opened by the Lord Mayor of London to-day. The exchange is situated in the City.

A new type of petrol-electric motor omnibus has been constructed by the Daimler Motor Co.

We conclude our account of Sir John Gavey's "James Forrest" lecture on "Recent Developments in Telegraphy and Telephony."

In presenting the Post Office estimates in the House of Commons on Thursday of last week the Postmaster-General (Mr. Herbert Samuel) gave interesting particulars of the Post Office telegraphs, telephones, wireless telegraphy, &c.

Islington (London) Borough Council have decided to increase the capacity of certain of the electricity supply mains at a cost of about £20,000 and to provide a new main switchboard at a cost of £3,000.

Leicester Corporation have decided to separate the electricity and gas departments and to place the electricity department under separate management.

Companies Meetings, &c.—The directors' report of the Rio de Janeiro Tramway, Light & Power Co. for 1909 gives particulars of the progress made in the tramway, lighting and power and telephone departments of the Company during 1909.

INSTITUTIONS AND SOCIETIES.

Royal Society.—Among the Papers read at the meeting of this Society yesterday afternoon were the following: "On the Scattering of Homogeneous β-Rays and the Number of Electrons contained in an Atom," by Mr. J. A. Crowther, and "A Determination of the Ratio of Mass to Weight for a Radio-active Substance," by Mr. L. Southerns.

Merchant Venturers' Technical College, Bristol.—The speech day of this college will be held in the Great Hall on Friday, July 22nd, when the Master of the Society of Merchant Venturers (Col. F. C. Ord, C.B.) will distribute the prizes.

Academie des Sciences.—Sir Wm. Ramsay, F.R.S., has been elected an associate member of this Society.

Institution of Electrical Engineers.—The annual conversazione was held on Tuesday evening last at the Natural History Museum, South Kensington, the guests being received by Dr. Gisbert Kapp, president, and Mrs. Kapp and the Council of the Institution. The attendance was very small compared with that in recent years, probably less than half the usual number of guests being present. A programme of music was performed in the Central Hall of the Museum by a portion of the string band of the Royal Engineers, whilst the Alexandra Ladies' Quartette gave an entertainment in the Shell Gallery.

The Association of Mining Electrical Engineers.—An interesting diversion from the usual proceedings of the Mining Electrical Engineers took place on Saturday last, June 25th. A large party of the members of the Newcastle Branch and their lady friends joined together in a picnic, visiting Ripon and Fountain's Abbey. Luncheon was served at the Unicorn Hotel, Ripon. Dr. Thornton, who was in the chair, expressed a few encouraging remarks concerning the objects and work of the association.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, July 8th.

Physical Society.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. *Agenda:* "A Thermo-electric Balance for the Absolute Measurement of Radiation," by Prof. H. L. Callendar, F.R.S.; "The Convection of Heat from a Body Cooled by a Stream of Fluid," by Dr. Alex. Russell; "On Hysteresis Loops and Lissajous' Figures, and on the Energy Wasted in a Hysteresis Loop," by Prof. S. P. Thompson, F.R.S.; and on "The Energy Relations of Certain Detectors used in Wireless Telegraphy," by Dr. W. H. Eccles.

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ANNUAL REPORT OF THE ELECTRICAL INSPECTOR OF FACTORIES.

The annual report of the Chief Inspector of Factories, Dr. B. A. Whitelegge, C.B., was issued last week, together with the various sectional reports, including that of Mr. G. Scott Ram, Electrical Inspector of Factories.

In the general report the Chief Inspector refers to the importance of the adequate lighting of workrooms. The question of standards, he says, is beset with difficulties, and, in the absence of a standard, a broad requirement of adequate lighting is only a half-measure. As regards artificial light, other considerations arise, apart from contamination of the air by all except electric light and ventilated gas burners—namely, the quality of the light and the intensity of the source from which it is radiated, that is, glare. It appears that artificial light in which the rays from the violet end of the spectrum predominate may on that account be less efficient, at all events for certain kinds of work, and that radiation from a small but intensely luminous source, such as an unshaded electric light, may be more trying to the sight, and hence less effective, than the same amount of light diffused from a larger surface. The subject as affecting industrial employment is not one which admits of settlement by a stroke of the pen, and close investigation of the conditions will be necessary. As a beginning, Mr. D. R. Wilson has been directed to inquire into the present lighting of certain classes of workrooms, beginning with underground bakehouses in London.

There is no question that this subject is important, but electrical engineers generally will be more interested in the report of Mr. Ram, of which the following is an abstract:—

The Electricity Regulations made by the Secretary of State on December 23, 1908, came into force generally on July 1, 1909, and on January 1 of this year as regards such parts of electrical stations as were constructed before July 1, 1908. The distribution of the code and the registration of the premises affected have entailed a considerable amount of work upon the staff in the various districts owing to the large number of premises concerned. During the year I made a number of special visits, at the request of occupiers, in reference to the application of the regulations on their premises, and, in accordance with instructions, prepared for publication a memorandum* explaining the effect of the regulations and the exemptions therein allowed in the several classes of works and installations to which they apply.

The reports from the staff show that those occupiers employing responsible electrical engineers appear generally to be taking steps to comply with the regulations, but that there is a good deal of difference of opinion as to what is sufficient, and adequate, and that some general guidance in interpretation, such as the Memorandum is intended to supply, is very generally desired. Many firms do not, however, employ electrical engineers, and have little idea as to the meaning of many of the rules, though in the majority of such cases the supply is taken from public mains, and the electricity supply authorities to some extent co-operate with the officers of the Department in seeing that the requirements are complied with. Mr. T. C. Taylor (Norwich) reports that the electricity supply department of a local authority in his district is prepared to give a certificate that to the best of their knowledge the installations supplied from their mains are in accordance with the requirements of the Regulations. There is no doubt that public supply electricity undertakings might do very useful work in supervising the factory installations connected to their mains in reference to the regulations, and in the increasing number of cases where they also put in the installation, it is necessary that they should carefully work to the requirements. While such a certificate would not absolve the occupier from his legal responsibilities, it would, if given only after careful inspection by a competent person fully acquainted with the requirements, afford some assurance to the non-technical occupier that his installation complies with the Regulations.

In reading the Regulations, it is often overlooked by occupiers that many of the terms used carry defined meanings. Attention is drawn to this in the Memorandum, where the Regulations are printed with the defined terms underlined. Exemption 1 (*a*) provides certain exemptions where the pressure of the system does not exceed low pressure direct or 125 volts alternating. The greater number of installations affected by this exemption will be those using direct current. Many are supplied from public mains. In connection with these a question arises in regard to a three-wire direct-current system in which the pressure between the outer conductors may exceed low pressure, but the pressure between the earthed neutral conductor and either of the outer conductors cannot exceed 250 volts; namely, whether the exemption applies to a supply taken from one side only of such a three-wire system. The conditions are precisely similar to what they would be if the supply was on a two-wire system not exceeding 250 volts having one conductor connected to earth, in which case the exemption would apply without question. In either case, the *pressure* on the premises cannot exceed 250 volts. It is explained in the Memorandum that such a supply may be regarded as of "low pressure" and within the exemption *if the neutral conductor of the three-wire system is connected to earth*, as required by the Board of Trade regulations in the case of authorised public supply. This view of the matter will, therefore, extend the benefit of the exemption to many installations which would otherwise be regarded as of medium pressure.

A similar question arises as to whether a circuit fed from an auto-transformer at a pressure of less than 125 volts may be regarded as being under the exemption, the pressure of the supply to the transformer being above the 125-volt limit. In this class of transformer the lower pressure circuit does not form a separate system, but is directly connected to the higher pressure system. If the supply system has one conductor permanently connected to earth at the sub-station or main transformer, and if the tapping from the auto-transformer is taken off the earthed side of the circuit and the arrangement is so carried out that it may be absolutely relied upon, there is no reason why the lower pressure circuit should not be considered as coming under the exemption. The condition must, however, be carefully considered, and the connections properly supervised and carried out by a competent person and subsequently verified by tests. It is necessary that there shall be no break whatever in the earthed conductor between the main supply transformer and the auto-transformer. There must be no fuse or switch therein, as the blowing of the fuse or the use of the switch would cause the whole of the lower pressure circuit at once to assume the full supply pressure above earth. Special attention should also be given to the connections of the auto-transformer that there shall be no possibility of a loose contact. If these conditions are observed so that the pressure of the circuit cannot exceed the limit allowed in the exemption for alternating pressure, 125 volts, either between conductors or between either conductor and earth, the exemption may be considered as applying, but not otherwise. The pressure between the conductors of the circuit being so low, people are apt to regard them as being necessarily free from danger as regards shock, forgetting that unless the above described precautions are carefully observed the danger is represented by the pressure of the supply to the transformer.

It is pointed out in the Memorandum that, although Exemption 1 provides exemption from a number of the regulations where the pressure is below the specified limits, the requirement of general safety is made by Regulation 1, which is not one of the exempted regulations, and that consequently where the specified regulations do not apply, it must not be assumed that there is necessarily no need of any precautions being taken even on the lines of the exempted regulations. Thus Regulation 2 calls for the protection of conductors, but it does not follow that bare conductors up to 250 volts direct or 125 volts alternating may be indiscriminately exposed on factory premises. On the contrary, Regulation 1 provides that they must be so protected as to prevent danger, but does not specify in what manner this is to be done.

During the year I have had submitted to me numerous drawings, samples and models of electrical fittings and apparatus in reference to compliance with the Regulations, often with a request that, if satisfactory, I should give a certificate or other official approval. This, of course, would be not only undesirable for many reasons, but impracticable. I have, however, done all I could to assist manufacturers and others by discussing with them any new designs or methods submitted, after fully explaining the position. A considerable amount of time has, in fact, been devoted to this work during the past year. It is an encouraging sign that some at least of the manufacturers of electrical apparatus should be contemplating new designs in view of the regulations. There is a great deal of inertia to be overcome in the changing of a pattern of any article. There are many faulty designs of switches, fuses, connectors, lamp-holders, hand lamps, &c., which continue to be reproduced. The manufacturers will go on making them so long as people are content to buy them. As, however, attention is now definitely drawn by the Regulations to questions of safety in the construction of apparatus, there is an inducement to the manufacturer to reconsider his designs, and those who are early in the field with improved patterns will no doubt reap the benefit.

One of the most striking examples showing how improved patterns may rapidly supersede old ones when once attention has been directed to the matter is that of hand lamps. In my annual report for 1905, in describing a fatal accident, I first drew attention to the dangers of hand lamps as ordinarily made, and indicated how they should be constructed in order to obviate those dangers. As a result, one firm led the way by taking the matter up and producing a lamp on the lines indicated. In a subsequent report I drew attention to their lamp and further dealt with the matter, showing photographs of lamps which had caused fatal accidents. At the present time a number of firms are making similar "safety" hand lamps for which there is a large demand not only in this country, where now the old types are practically prohibited by the regulations for use in factories, but also from foreign countries and the colonies. Signs are not wanting to indicate that similar attention is now being paid by manufacturers to other forms of apparatus to certain dangerous aspects of which I have drawn attention, and which are capable of similar improvement from a point of view of safety.

In my last year's report in describing accidents with connectors whereby the person in putting in or taking out the plug gets his hand severely burned on account of a short circuit causing arcing at the contacts or within the plug or at the flexible wires close to the plug, I described how a plug could be easily made so as to obviate these dangers, and suggested that manufacturers should give the matter consideration.

* THE ELECTRICIAN, March 4, 1910.

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The suggestion has been taken up and plugs embodying the features which I described have now been put on the market.

In former reports I have pointed out that fuse-boards are frequently constructed in such a way that the fuses cannot be renewed without danger of shock or burns to the person handling them. This matter is now covered by the Regulations, and further observations on the requirements are given in the Memorandum previously referred to. Although greater consideration is now being paid to this matter, particularly in regard to the larger fuses, improvements in distributing fuse-boards for small sub-circuits have not yet received much attention. Some fuse-boards for use with small sub-circuits, and designed to meet the objections referred to, are illustrated in the Report. In these the fuse wires are attached to contacts fixed in porcelain holders, and they are arranged in such a way that the holders can be readily handled for putting in or taking out of the fixed contacts without danger of touching any live metal, and the operator's fingers are also shielded from the arc should a fuse blow on being put in. The fixed contacts of the fuse-board are also protected by porcelain plates in such a way that they cannot be accidentally touched. These particular distribution boards were designed and put to work long before any regulations were formulated, but they nevertheless serve to illustrate a method for meeting the requirements which might be adopted with advantage by manufacturers to-day, although no doubt there is room for improvement in detail.

Plans of switchboards for new stations or extensions and for the fencing of generators, motor-generators, &c., have also been submitted, and in this connection again, although examination and approval of plans is not called for by the Regulations and cannot be demanded, I have in every case given attention to those submitted, and have in many instances been able to point out where they were at fault in reference to the Regulations, thus probably saving considerable expense in subsequent alterations. In some cases it has, however, been clear that the Regulations had not been studied carefully, if at all, by the draughtsman.

The use of electrical energy for motive power in factories continues to grow rapidly. As in former reports, I have made a comparison of the figures for the horse-power of motors, supplied with electrical energy from the mains of electricity supply undertakings at the end of the year with the corresponding figures for the previous year, taken from the returns published annually by THE ELECTRICIAN. Comparing the figures for those undertakings giving returns for both years, 465,700 H.P. has grown to 556,700 H.P., or an increase of 91,000 H.P. These figures are not complete, some undertakings not furnishing any returns, and they do not include works having their own generating stations. A moderate allowance for these brings the total increase for the year to well over 100,000 H.P., indicating how rapidly electricity is supplanting every other form of power for driving machinery in factories. Concurrently with this increase, the various electricity supply authorities are necessarily adding to the capacity of their generating stations. The additions required to cope with the increased load for motive power purposes alone would represent a generating station larger than any public supply station at present existing in the country, or quite a large number of stations of average size.

The number of accidents at electrical generating stations is set out in the following table. The number of mechanical accidents is almost identical with that of the previous year. Those due to falls form, as usual, a large proportion and include three fatalities. The total number of electrical accidents is also practically identical with that of the previous year, although somewhat fewer occurred in public stations and more in private stations. The number of fatalities is four against two only in the previous year. Of the accidents at switchboards during ordinary routine work, six appear to have been due to faulty switches, in some cases owing to the non-provision of a quick-break action. Several were due to mistakes on the part of the switchman. In four cases the field circuit of a generator was broken at the switch, with the consequent result of an arc burning the man's hand. In two cases heavy arcing occurred at the switch when synchronoising an alternator. Unprotected fuses accounted for three accidents, and four others occurred in the replacing of fuses. Two accidents occurred in operating isolating or selector switches on a high-pressure system. In one case the accident was due to a faulty arrangement of interlocking the switches, and in the other to a mistake in pulling out a switch while it was on full load. Although the switchman was using a special pole, to operate the switch, and was several feet away from it, he was severely burned about the face and hands. A mistake of this kind on a large system is always likely to involve serious injury to the person concerned, and may bring about a complete breakdown of the supply of electrical energy over a large district. In many stations no means are provided for guarding against such mistakes on the part of the switchman. Often there are a number of isolating switches in the same passage way, all exactly alike, sometimes not even distinguished by labels, and a mistake may very readily occur. There are, however, precautions which can be provided in the case of new work and which may often be applicable to existing work. Some recent switchboards have the isolating switches enclosed in cells having doors, which are interlocked with the oil switches used for breaking the circuit in such a way that the doors cannot be opened unless the oil switches are open, and also so that the latter cannot be again closed while the doors to the isolating switches are open, consequently making it impossible to operate the isolating switches under current. In other cases the isolating switches are worked by gearing from outside the cell doors, which do not therefore have to be opened, and the gearing is interlocked with the mechanism of the oil switches. These methods are generally only applicable for new work. For existing switchboards, where a positive interlocking arrangement may be impracticable, it has been suggested to provide an ammeter or current indicator on each conductor, just below the isolating switch, so as to indicate whether a current is flowing or not. Such an arrangement could generally be readily applied and would not be costly. It might also often be practicable to provide an indicator at the isolating switch, mechanically operated from the gearing of the oil switch, to show whether the latter is open or closed. It has also been suggested to provide an arrangement whereby two operations are necessary in opening an isolating switch. In the first operation the switch blade can only be pulled out of contact a very small distance, say, $\frac{1}{10}$ in., so that if a mistake has been made and current is flowing it can be immediately closed again before the arc assumes dangerous proportions. I am not aware, however, whether the method has been tried or would prove successful.

Table I.—*Accidents at Electrical Generating Stations and Sub-stations in 1909.*

Description.	Companies and local authorities giving a supply by way of trade, and electric railways.		Private stations.	
	Non-fatal.	Fatal.	Non-fatal.	Fatal.
Non-Electrical.				
At engines, pumps and generators	26	1	11	—
At boilers and steam plant	56	—	6	—
At coal handling plant	12	1	1	—
Falls	97	3	8	—
Struck by falling bodies	23	—	3	—
Miscellaneous	99	1	9	—
	313	6	38	—
Electrical.				
At switchboards, when engaged in ordinary routine work—mostly due to faulty design of apparatus, or to mistakes on the part of the switchman	16	—	8	—
Cleaning, repairing, &c., at "live" switchboards or other "live" conductors	26	4	20	—
Cleaning, repairing, or other handling of switchboards or apparatus supposed to have been made "dead":—				
Skilled persons	1	—	1	—
Unskilled persons	—	—	—	—
Adjusting brushes and cleaning or lubricating commutators	6	—	3	—
Miscellaneous	5	—	—	—
Total	54	4	32	—

Accidents to persons cleaning, repairing, or otherwise working upon or near live conductors form, as usual, the largest class, and include four fatal cases. Three of these occurred to unskilled labourers who were employed near exposed conductors at extra high pressure. Since Jan. 1st this year the employment of unskilled persons under such circumstances is forbidden under the Regulations, and such accidents, should they occur in the future, may therefore involve serious consequences to those responsible. The fourth fatality occurred to a sub-station attendant, presumably competent, but who evidently overlooked the danger of the work he was engaged upon, viz., disconnecting a transformer for removal.

Two accidents resulting in serious injuries occurred to sub-station attendants working on switches which had been made dead, but which were in close proximity to live conductors at extra high pressure not screened off. In two cases, labourers were again employed close to high-tension conductors, with which they came in contact. Thirteen accidents were due to short-circuits by men engaged in working on live switchboards at low or medium pressure. Most of these accidents appear to have been due to the want of elementary precautions.

The number of accidents set out in Table II. is slightly more than last year, but the fatalities are fewer. The accidents due to the arcing of switches, including motor starting switches, are mostly caused by defects in the switches themselves, or by faults in the circuits controlled by them, but sometimes by mistakes on the part of the operator. The injuries are burns to the hand and sometimes to the arm and face as well, and often injury to the eyes. The use of cheap switches, too small and flimsy for the work, is not unfrequently the primary cause. The accidents from arcing of fuses nearly all occur through the use of unprotected open fuses. Ten of these were on motor starting panels where the fuses were placed near the switch handle, resulting in the operator getting burnt on the hand and arm, and sometimes on the face. The accidents in the renewing of fuses were mostly due to short-circuits in replacing wire or metal strip fuses in live terminals.

Of the accidents with portable apparatus, 23 were due to burns from short-circuits, or shock, when handling the flexible wires. Frequently the flexible wires are insufficiently protected against damage, ordinary "household" flexible being used instead of "workshop" flexible, or, if the latter, it has been damaged and not repaired or renewed. Twelve

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Table II.—*Electrical Accidents in Factories, Engineering Works, &c., other than Electrical Generating Stations and Sub-stations, in* 1909.

Description.	Non-fatal.	Fatal.
Arcing of { switches	39	—
Arcing of { fuses	17	—
Arcing at fuses, when replacing fuse wires	27	—
Portable apparatus, connectors and flexible wires	45	1
Unprotected conductors, switches, terminals, fuses &c	26	6
Working on or near live { skilled persons	32	1
conductors { unskilled persons	10	—
Miscellaneous accidents in electrical manufacturing works—mostly in testing operations	30	—
Adjusting brushes and cleaning commutators	8	—
Miscellaneous	15	—
Total	249	8

Table III.—*Electrical Fatalities reported under the Factory Acts in* 1909.

No.	Month.	District.	Voltage of system.	Voltage of circuit.	System. A=Alternating, 1=Single-phase, 2=Two-phase, 3=Three-phase.
1	January	Newcastle	20,000	—	A 3.
2	February	Glasgow	500	—	A 3.
3	February	West London	2,400	—	A 1.
*4	March	Kent	400	230	A 3.
5	April	East London	430	250	A 3.
6	May	Glasgow	440	255	A 3.
7	June	West London	380	220	A 3.
8	June	Leeds	280	200	A 2.
9	July	Manchester	6,600	—	A 3.
10	August	Rochdale	10,000	—	A 3.
*11	November	Sheffield	200	—	A 3.
12	December	Glasgow	400	230	A 1.

were due to short-circuits at connectors when plugging in or out, the operator getting his hand severely burned. Three were due to shock from portable lamps, one being fatal. This occurred on a 250 volt alternating circuit.

Of the non-fatal accidents under this heading, 13 were due to unprotected wires within reach of any person employed. In some cases the wires were bare and in others they had been covered with insulating material which had become damaged owing to absence of any further protection. Seven occurred on ships under construction, in connection with temporary installations, where the wires are liable to very rough usage. Constant supervision is necessary with such installations to ensure safety. Two accidents occurred in engineering works to men who touched live conductors with bars of iron. Two were due to unprotected switches in the driving cabins of cranes. Accidents to skilled persons when working on live conductors in factories ought not to occur, as there is seldom any real need for the work to be undertaken while the conductors are live. Unskilled persons working on live conductors generally do so under instructions from others, and not on their own initiative. Persons employing unskilled labourers and others on such work assume a serious responsibility in doing so.

The accidents in electrical manufacturing works, mostly in testing operations, occur chiefly to apprentices or improvers. The average age of the persons in the 30 cases recorded is only 22 years. As I have mentioned in former reports, apprentices generally seek employment in the testing departments for the sake of the experience to be obtained, and as they have generally had some training in technical colleges, the arrangement suits the employers. Frequently, however, the supervision of the work by experienced persons is insufficient and the precautions taken are inadequate. Amongst the miscellaneous accidents, several occurred through want of efficient earthing.

In my visits during the year, I have seen further examples of dangerous plant, such as I have fully described in former reports. I found some examples of sub-stations in which bare extra high pressure conductors were exposed in the passage ways without any protection whatsoever. I have frequently observed that a generating station which is dirty is generally also one in which the plant is ill-kept and often dangerous. A high-pressure station of a local authority I found to be no exception to the rule. It is noteworthy, also, how some occupiers or engineers will provide ordinary precautions of safety only so far as their legal obligations require. In other places where I had previously visited, I found many improvements had been effected. In several high-pressure generating stations I found that open fronted cellular type switch-gear was being supplanted by other types having no conductors at high pressure accessible from the working platform.

At the public inquiry into the draft Regulations, it was urged by a considerable section of the objectors that the display of a set of instructions for dealing with persons suffering from electric shock would have the effect of retarding the use of electricity by unnecessarily frightening the persons employed. I have not found any evidence in support of this supposition. On the other hand, " danger " notices are sometimes used with the deliberate intention of frightening people in a manner which is quite unnecessary. In such cases the occupier, probably not understanding wherein danger may lie, appears to be under the impression that in providing the notices he is absolving himself from responsibility in case of accident. I do not, however, wish to convey that danger notices are not desirable or necessary under certain circumstances. In an ordinary factory installation, however, there should be no exposed conductors with which persons employed may accidentally come into contact in the course of their ordinary employment, and any switches or other apparatus which unskilled persons may have to use should be so protected that there is no danger. In electrical stations it is often desirable in switchboard passage-ways to draw attention to the presence of high-tension conductors, although only authorised persons are allowed to enter. It is, however, quite as effective and more polite to word the notice " Danger—High Tension " than to put " Sudden death " with a skull and crossbones.

An electrical process, which has been for some years in use in the United States, has been recently introduced in this country. It is for neutralising the static charge of electricity produced by friction, which causes trouble in certain processes such as paper making, printing, and in textile mills, and thereby avoiding the use of humidifiers, steam jets, and gas flames. An " inductor " is placed at some point in the machine where the charged material passes by it at a distance of from 1 in. to 3 in. An alternating electrical discharge takes place from a number of points on the inductor neutralising the charge in the material. The inductor is connected to one pole of a high-tension transformer, the other pole of which is earthed, and also connected to the framework of the machine. The inductor consists of a number of condensers to which are attached the discharge points. A highly insulated conductor passes through the centre of the inductor. Outside the insulating covering of the conductor are a number of copper bands, each with a point attached. These are enclosed in porcelain blocks having holes for the discharge points. The whole is enclosed in a steel tube slotted on one side where the porcelain blocks project. The transformer is specially designed so that it can give only a very small current, and it is claimed that for this reason there is no danger from the high voltage produced, and that in fact there is no danger to a person taking hold of both terminals of the transformer. I have not, however, seen any such practical demonstration, nor have I yet had an opportunity of witnessing any tests bearing on the safety of the apparatus, and for the present I therefore prefer to regard it as potentially dangerous and needing very carefully devised precautions against accidental shock to the persons attending machines to which it is attached.

* Fall following shock.

A NEW ARRANGEMENT FOR THE "B" SIDE OF QUADRUPLEX APPARATUS.

BY J. M. FERNANDEZ.

In quadruplex working it is known that one of the former difficulties was the breaking of the incoming signals at the non-polarised or " B " side, caused by the operation of the reversing

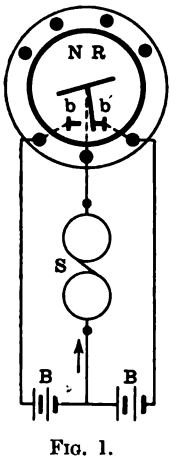

Fig. 1.

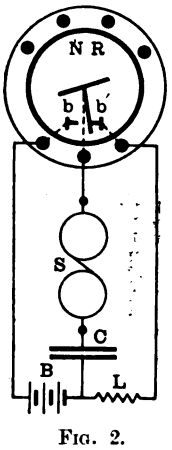

Fig. 2.

key at the distant end. To overcome this difficulty the use of the relaying sounder was generally accepted, although some telegraph engineers suggested different arrangements to avoid its use for the sake of simplicity.

Working in "decrement"—that is to say, decreasing the strength of the normal current by the operation of the B key—was one of the methods suggested; but it has the disadvantage of requiring the strongest current to be on the line during the longer periods, and has been practically abandoned.

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The author has devised a novel arrangement which meets the requirements and is very simple. Referring of Fig. 1, NR is the non-polarised seven-terminal differential relay; S a polarised sounder, neutrally adjusted, so that its lever will remain against either top; B the battery. Normally, the current flowing through b' and S in the direction of the arrow maintains the lever of the sounder against the upper top; when the relay is operated its lever comes in contact with b, and a signal is produced by the reversing of the current through S.

This signal will not be disturbed when the distant battery is reversed, though the contact at b may be broken at that time, because to release the sounder it would be necessary that the relay lever should cross the gap and make contact at b', since to affect the sounder it is necessary not only to stop the current but to reverse its direction.

Fig. 2 shows the preceding arrangement modified to obtain same results without having the current from battery B flowing all the time. The polarised sounder is then operated by the successive charges and discharges of the condenser C. Both arrangements as described will work in any line where a "decrement" quadruplex can be worked without any of its disadvantages and giving firmer signals, specially appropriate for repeating, as every dot or dash is longer in the sounder, since it lasts not only while the relay lever is against the marking contact but also during the time it takes to cross the gap.

When the KR product of the line is very high, it is necessary to delay further the release of the sounder lever, which can be obtained by inserting a self-inductance coil in the circuit to contact b'.

DUBLIN UNITED TRAMWAYS.*

BY R. S. TRESILIAN.

Summary.—The author describes the development of tramways in Dublin from the year 1867 to the present time. Brief particulars are given of the existing power station and the distribution of electrical energy.

As the Dublin United Tramways Co. was practically the pioneer in the United Kingdom of modernised electrical traction, a short sketch of the history of the Company may be interesting to members of the Association on this their first visit to Dublin. The idea of laying down rails in the public thoroughfares on which carriages with flanged wheels could run was scarcely conceived when the principle was adopted in Dublin. In May, 1867, the City of Dublin Tramways Co. obtained under the Tramways (Ireland) Act, originally intended to apply to country roads only, an Order in Council authorising the construction of a line of tramways. In 1870 a Bill was lodged in Parliament, and in the following year, 1871, became law, incorporating the Dublin Tramways Co., with a capital of £240,000, and authorising the construction of about 17 miles of tramways. The contract for the construction was in July, 1871, entered into with Messrs. Fisher & Parrish, who had previously constructed tramways in London and Liverpool, and in December, 1871, the Company purchased the rights of the City of Dublin Tramways Co. referred to above. A box rail weighing 53 lbs. to the yard, spiked to wooden longitudinal sleepers, cross tied, was used, and sett pavement was laid between the rails and for 18 in. outside each other rail at the expense of the Company, and at an immense saving to the local authorities, as previously all the streets in Dublin were laid with macadam. The cost of construction was about £3,550 per mile of single line. On February 1, 1872, the line from Stephen's Green to Terenure, about 2½ miles in length, was opened for public traffic.

The completion of other lines, authorised by the Act of 1871, quickly followed, and in August, 1874, 16 miles of route were open for traffic, and the gross profits for that year amounted to £14,907. 16s. 10d. from 5,269,546 passengers. The prosperity of this Company was so great that imitators and competitors quickly appeared, eventually leading in the closing months of 1880 to an amalgamation being effected between the companies and to a new company, the Dublin United Tramways Co. being incorporated by Act of Parliament, into whose control the whole of the lines in the city and suburbs of Dublin, except those of the Dublin Southern District Tramways Co., passed. This last mentioned Company had been incorporated by an Act of Parliament obtained in 1878, and later amalgamated with the Blackrock and Kingstown Tramways Co., which had been incorporated in 1883. After trying steam as a motive power these Companies eventually, in 1895-6, converted their lines to the overhead trolley system, a power station being erected at Balls Bridge, and they also projected a very large scheme with the avowed object of competing directly with the Dublin United Co. Negotiations between the owners of the shares of the Dublin Southern Co. and the Directors of the Dublin United Co., resulted, a little later on, in the purchase by the latter of the whole of these shares. In the same year the Dublin United Co. lodged a Bill in Parliament to obtain powers to electrify the whole of their lines, but Parliament, owing to the opposition of the Dublin Corporation, refused to give its sanction to these powers inside the city, and in consequence powers to electrify certain portions lying outside same were only obtained. In order to carry into effect the amalgamation of the undertakings, the present company, the Dublin United Tramways Co. (1896), was incorporated in 1896 under the Companies Acts and acquired all the shares of both the Dublin United and the Dublin Southern Companies and the whole working thus passed under one management.

For the purpose of following the growth of tramway traffic in Dublin and suburbs, it may be well here to state that for the half-year ended December 31, 1896, the first half-year of the consolidated working, there were 41·31 miles of track in operation, the section from Haddington-road to Dalkey only being worked by electricity and the remainder by horses; 14,865,936 passengers were carried—an average of 80,793 per day—and the receipts amounted to £91,590.

Electricity as a motive power thus having been introduced on the Dalkey line, which lay outside the city, and the directors of the Company having recognised its great efficiency in reducing working expenses and in enabling quicker and better services to be rendered, and notwithstanding that old-fashioned prejudices still stood in its way and that the former appeal to Parliament for powers to introduce it into the city had been unsuccessful, determined to equip with electricity under the powers of their Act of 1896 a portion of the Clontarf line, about two miles in length, on the North side of the bay and lying outside the city, and for this purpose erected a small generating station at Clontarf. This piece of line was converted and opened for electric traction on November 11, 1897. At the generating station referred to, plant sufficient to run about 25 cars was installed, and the overhead system of supply was adopted between the points above mentioned.

During the time the foregoing conversion and equipment were being carried out, negotiations with the various local authorities took place, and as the result of large concessions to them, in the year 1897 an Act of Parliament was obtained authorising the use of electric traction on all the lines of the Company; and the Directors having secured the services of Mr. H. F. Parshall as consulting engineer, an extensive scheme was devised with the intention of retaining the two existing power stations at Balls Bridge and Clontarf, and erecting a main station for the supply of all the lines not served by these two. A deputation from the directors, accompanied by Mr Parshall, proceeded to America in order to ascertain the most up-to-date methods, and there purchased the greater portion of the machinery and equipments needed. A fine site on Ringsend Dock was acquired, and the building of the main station was commenced in October, 1898. At the same time the laying of the conduits, which was entrusted to the National Conduit and Cable Co., was carried on, the feeder cables drawn in, and the poles and overhead lines erected. All this work was vigorously pushed on, the lines, as far as possible during the conversion, being worked by horses, whilst some were worked electrically immediately they were equipped from the old stations at Balls Bridge and Clontarf. The main power station was first operated on August 16, 1899, but the lines were not all simultaneously opened for electric traction, nor was the whole of the machinery in the station completed by that date; extensive reconstruction of the tracks had to be undertaken, the rail section used for horse traction being too light for the heavier cars and deeper flanged wheels needed for an electric system; but line after line was successively opened, and in the half-year ended June 30, 1900, horse traction was discarded, and practically the whole system worked by electric traction. The Company is now using for relaying its lines a rail weighing 105 lbs. to the yard, about double the weight of that originally used in the earlier years of its existence.

To provide rolling stock, the Company at their works at Inchicore converted most successfully a number of the old horse cars, and purchased others in America and from Messrs. G. F. Milnes & Co., but since these purchases were made, they have been constructing all the cars needed at their own works, and the present rolling stock comprises 314 cars, whilst six are at present under construction. A table in the Paper gives details of the cars and shows that they are fitted with trucks and equipments of various types.

The operation of the main station having proved most economical, and the two older stations being very disadvantageously placed both

* Abstract of a Paper read before the Tramways and Light Railways Association at Dublin.

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as to coal and water supply, it was decided that all the power required should be generated at the Ringsend main station, and to enable this to be done, modifications were made in the existing plant, and the necessary cables were laid; the Clontarf station was converted into a sub-station, with sufficient capacity to supply, not only the portions of the lines hitherto supplied by it as a generating station, but also a new line belonging to the Clontarf and Hill of Howth Tramroad Co., practically a continuation of the Clontarf line for about five miles to Howth. The Clontarf station was closed down on February 14, 1901, and at Balls Bridge on January 3, 1901, and since the latter date the main station at Ringsend has been taking care of all the lines in a most economical manner. In the half-year ended December 31, 1901, 46·34 miles were open for service, 23,816,084 passengers carried, an average of 129,380 per day, and £128,416 earned.

At the Ringsend station the two steel stacks, each 220 ft. high, have recently been lined inside with ferro-concrete in place of the original fire-brick lining, which makes them much safer and more durable. These stacks and the framework of the buildings were constructed by the Riter Conley Co., Pittsburg. There are at present 12 Babcock & Wilcox water-tube boilers erected, but provision is made for eight more. Whilst the six engines are all by the E. P. Allis Co., of Milwaukee, and are of vertical cross-compound type, yielding each about 700 B.H.P. The generators, by the General Electric Co., are keyed on the engine shafts, five being multipolar direct current, and the sixth a 2,500 volt three-phase machine with revolving field.

Since the opening of the station, one of the engines has been fitted with a three-phase alternator in addition to the original direct current generator. This was done by removing the 31 ton flywheel and erecting a flywheel alternator in place of same. In 1907, in order to meet the largely increased alternating load due to development of traffic on the coast lines, a 1,000 kw. turbo alternator was installed, the turbine being of Messrs. Willans & Robinson's manufacture under Parson's patents, the alternator being supplied by the British Westinghouse Co. A 250 kw. rotary converter, by the British Thomson-Houston Co., is also installed, as at times it is convenient to transform certain proportions of the alternating current to direct current in this station, or vice versa. There are also four negative boosters, but since the alteration in the Board of Trade rules regarding return circuits, these have been thrown out of operation. The switchboard extends on a gallery across the whole width of the engine room, and was built by the British Thomson-Houston Co.

The sub-station equipments at Blackrock, Dalkey and Clontarf are in principle alike, differing only in capacity. That at Blackrock contains three rotary converters, each 200 kw. capacity, and nine transformers of 80 kw. each, divided into two sets of three, so that should any one of the three become disabled the other two could do the necessary work. The Dalkey sub-station contains four rotary converters, of 75 kw. each, converted by Mr. Parshall from the motor generators originally in this and in the Blackrock sub-stations, and one set of three static transformers with the necessary switchboard and instruments. The Clontarf sub-station, formerly a generating station, contains one 250 kw. B.T.-H. motor generator set, the motor being of the induction type; one 250 kw. rotary converter with a set of static transformers; and two rotary converters, which were adapted from the generators in the Balls Bridge station, and altered to the designs of Mr. H. F. Parshall.

From the power station at Ringsend a most comprehensive system of conduits has been laid. They consist of cement-lined iron pipes bedded in concrete, with manholes situated at convenient intervals. The conduits pass in a specially constructed tunnel under the Canal Dock close to the power station. Both the high-tension and feeder cables are carried in these, the cables being furnished by the National Conduit & Cable Co., of America.

For the trolley wire in the centre of the system where the traffic is heavy, No. 00 Phono-electric trolley wire is employed, as this wire has been found to give very little wear even with a fast service of cars operating, and does not become crystalline and fracture, which is one of the troubles experienced with hard drawn copper after it has been erected for some time. In outlying districts the trolley wire is of hard copper, most of it of 00 B. & S. gauge; but all copper trolley wire is anchored at each suspension after it has been in service for two years, this anchoring having proved quite effective in preventing broken trolley wires from falling in the street.

Electric Power for Dredging.—According to the "Electrical Review and Western Electrician," the American Dredging Co. have contracted with the Southern California Edison Co. for electric power to be used for dredging San Francisco harbour. A minimum amount of 12,000 H.P. is to be supplied at a minimum cost of £3,000 per annum.

THE WALBROOK TELEWRITER EXCHANGE.

Although the telewriter has been more extensively used in America than in England, the credit of inaugurating the first telewriter exchange belongs to this country. This exchange, which is at present only connected to about 50 subscribers, but contains provision for connecting up a further 750, is situated in the offices of the National Telewriter Co., Bucklersbury, London, and is being officially opened to-day by the Right Hon. the Lord Mayor of London.

Since the telewriter has been employed to a limited extent for many years in this country and the United States—a description of the Ritchie telautograph, as it was then called, was given in THE ELECTRICIAN so long ago as November 16, 1900—it is rather surprising that its use has been restricted

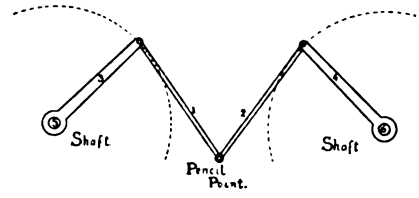

FIG. 1.

almost entirely to these two countries, the more so as the many advantages of the telewriter should appeal forcibly to certain sections of the public. As the instrument has not been prominently before our readers in recent years, it may be as well here briefly to explain the principle on which it works.

The main principle employed in the telewriter is that of producing two independent motions by the movement of the transmitting pencil, each motion causing a change of current in a circuit. At the receiving end these two varying currents produce independent motions, the resultant of which is a reproduction of the movement of the transmitting pencil.

For transforming the motion of the transmitting pencil into the rotary motion of two shafts, the arrangement diagram-

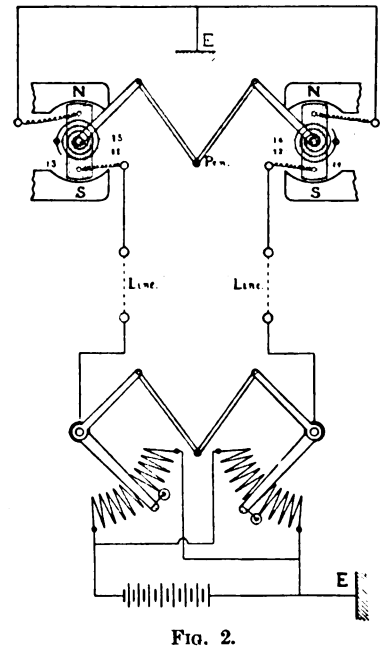

FIG. 2.

matically shown in Fig. 1 is adopted. This illustration is self-explanatory. Each of the shafts shown has rigidly attached to its lower end a lever carrying a contact roller connected to one of the two line conductors. This roller passes over the contacts of a rheostat (*see* Fig. 2), thereby varying the current flowing in the line, the earth serving as the return conductor. At the top of Fig. 2 will be noticed the receiving apparatus, the moving coils of which are controlled by springs, and take up a position in accordance with the current flowing in each circuit. By connecting the receiving pen to the shafts by a link motion

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identical with that in Fig. 1 the motion of the transmitting pencil is thereby reproduced.

The paper is fed at the same instant at the receiving and sending stations, at the latter mechanically and at the former electrically. In Fig. 3 (left-hand side), which shows an interior view of the transmitter, will be noticed a finger lever O, connected at its inner end by a rod to the paper shifter P. When the lever O is moved to and fro between its stops, the paper shifter rocks to and fro and feeds paper over the platen Q at each movement. Actuated also by the lever O is a switch which, when closed, operates a relay at the receiving end and feeds the paper forward one step. The relay R (Fig. 4) also controls a circuit which includes the field magnets W, X and the pen-lifter Y.

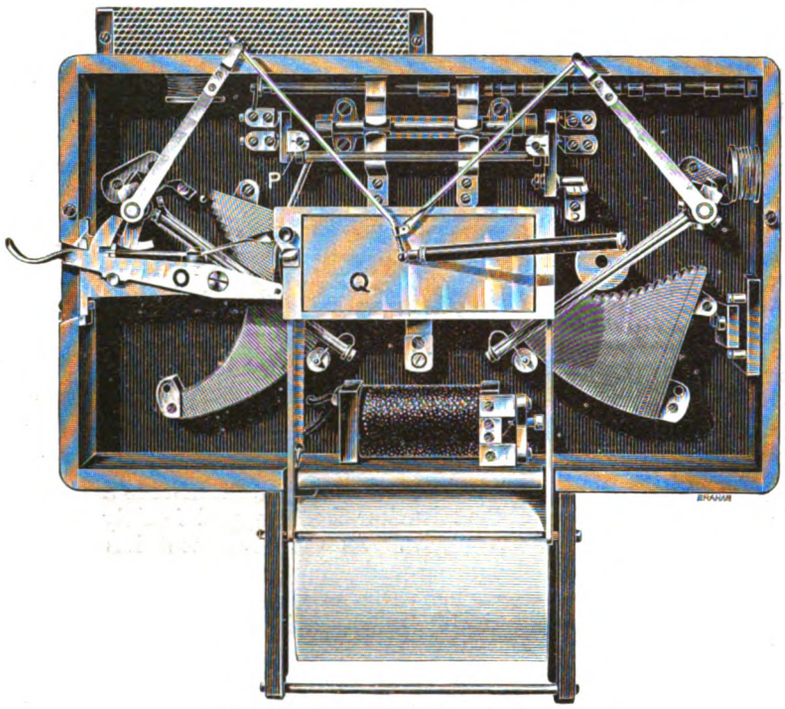

Fig. 3.—Interior View of Transmitter.

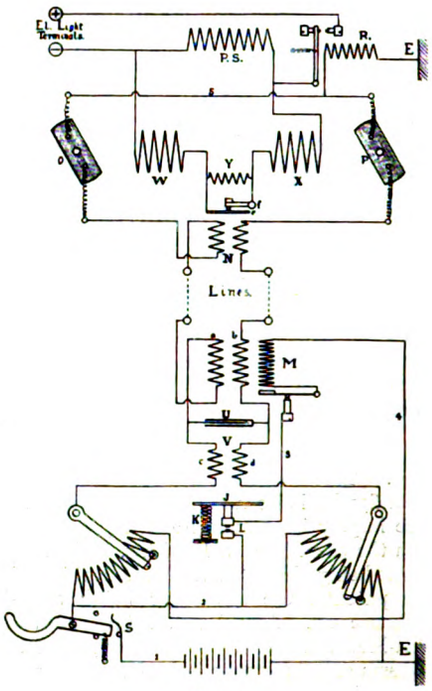

Fig. 4.

At the transmitter, movements are made both on and off the paper, and it is necessary to provide means for raising and lowering the receiving pen accordingly. This is accomplished by sending a superimposed alternating current over the lines. Referring to Fig. 4, J is the hinged platen over which the transmitter paper passes. It is held in its upward position by spring K, and is brought to its downward position by the pressure of the operator's pencil in writing. In the latter position contacts are closed at L, which completes a circuit through the break and primary winding of an induction coil, M. This coil has differential secondary windings, *a* and *b*. These are included in the line circuits, but in relatively reverse directions, so that at any given moment the induced current in one line will be in the opposite direction to that in the other; *c* and *d* are the windings of a choke coil also in the line circuits, the function of which will be referred to later. It will be seen that whenever the operator's pencil is "on" the paper the induction coil M is brought into operation, and an alternating current induced in the secondary windings is superimposed upon the writing currents passing through the lines. At the receiver this alternating current passes through the differential windings of a vibrator, N, and the moving coils O, P. The vibrator has over its core a reed, *e*, upon which rests a weighted lever, *f*, the contacts of which shunt the winding of the pen-lifter Y. When the transmitter platen is depressed, the current from the induction coil M causes the reed *e* to vibrate. This increases the resistance between the contacts of *e* and *f* to such an extent that current passes through the winding of pen-lifter Y, causes its armature to be attracted, and allows the receiving pen to rest upon the paper. When the induction coil M is inactive,

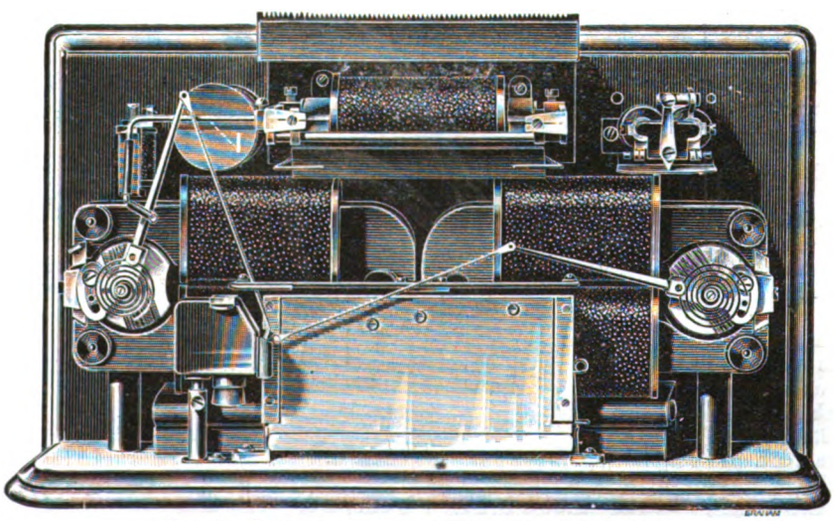

Fig. 5.—Interior View of Receiving Instrument.

Fig. 6.—Telewriter as installed on Subscribers' Premises.

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the contacts of the vibrator N are at rest, forming a shunt of such low resistance that the pen-lifter Y is inert. Under this condition, a spring moves the armature of Y forward, and thereby raises the pen from the paper. To prevent disturbance in neighbouring circuits, the alternating current is confined to the lines by means of the condenser U and choke coil V. The condenser forms a path for this current, and the inductance of V prevents it passing to earth.

The receiving pen, when not in use, is held in the ink well by the rod I (Fig. 5). It is also brought to this position every time the paper is shifted, and is thus kept fully supplied with ink. The line currents are taken from a small secondary battery, which by a switch (operated by the finger lever O, Fig. 3) is connected to and charged from the electric light supply when O is in the receiving position. When the transmitter is in use this switch disconnects the battery from the lighting supply and connects it to the rheostats. The instruments are calibrated for circuits of a fixed resistance, and the lines are made up to this with added resistance.

Fig. 6 shows a telewriter in use, whilst Fig. 7 illustrates the switchboard installed at the Walbrook exchange. This is operated in identically the same manner as an ordinary telephone board, the subscribers telling the operator the number required by means of the telephone noticed hanging at the side of the instrument in Fig. 6.

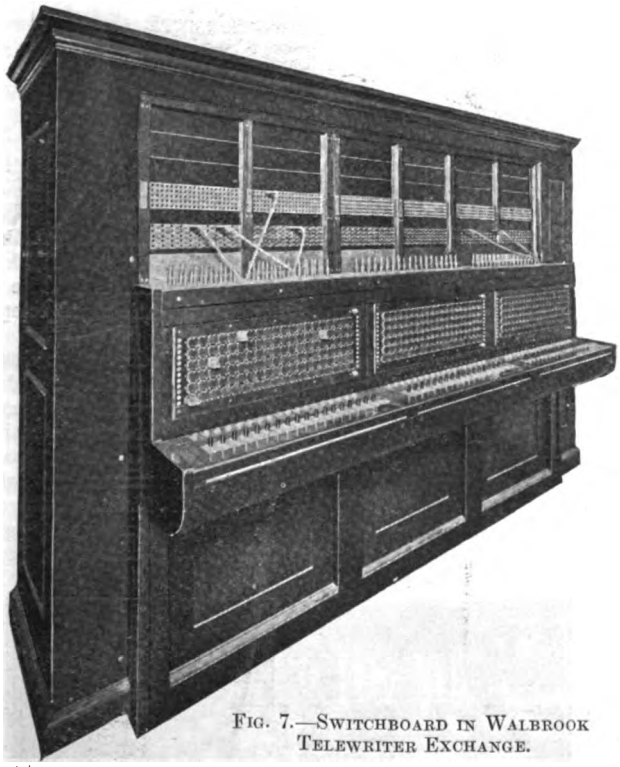


Fig. 7.—Switchboard in Walbrook Telewriter Exchange.

An important feature of the telewriter is that no attention is required at the receiving instrument, so that messages are delivered in the absence of the addressee, and are read on the latter's return. In this connection it is important to note that the first action of the transmitting instrument is to move the paper at the receiving instrument, so that a clear space is always available. It may also be mentioned that, when requested, the Post Office will arrange to forward telegrams to telewriter subscribers by means of these instruments, thus saving time in delivery. Subscribers may also send their telegrams by telewriter to the Central Telegraph Office.

As to the advantages of the telewriter, these are obvious wherever numbers and prices have to be transmitted between offices, a written record being obtained by its use; whilst a business man is able at a glance to see all those messages which have arrived during his absence, and any replies that have been given, a permanent record being thus obtained of all transactions.

We do not doubt that when the capabilities of the new exchange are widely known there will be a great accession of subscribers.

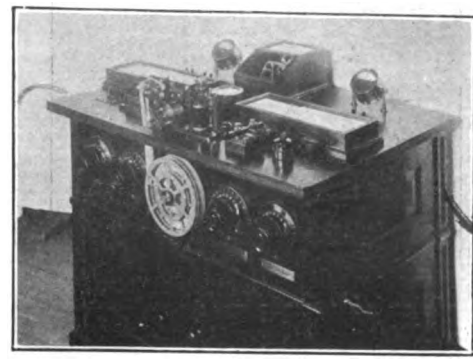
RECENT DEVELOPMENTS IN TELEGRAPHY AND TELEPHONY.*

BY SIR JOHN GAVEY, C.B.

(*Concluded from page 442.*)

Siemens & Halske, in Berlin, have devised an automatic system in which, by means of suitable apparatus, the message is printed by the receiving apparatus direct by photographic methods, an electric spark momentarily illuminating the required letter. The alphabet is stencilled on a revolving disc, and the arrangements are such that the electric spark passes only when the letter corresponding with the arbitrary signal is in the right position for printing. Figs. 1 and 2 illustrate the automatic apparatus of Messrs. Siemens & Halske.

The Western Union Telegraph Co., in America, have introduced extensively a system known as the Barclay automatic type printing



HARVARD UNIVERSITY OF CALIFORNIA

Fig. 1.—Siemens & Halske's Transmitter for High-speed Printer.

apparatus. At the sending end the code of electrical signals adopted consists of long and short intervals, either marking or spacing, representing the various letters of the alphabet. Every letter is represented by six current alternations, but the receiving apparatus is so designed that, although every current acts on an escape wheel that makes a momentary contact with certain selecting relays, only those of long duration effect any movement in the latter. There are 32 printing magnets which act as the keys of a typewriter, and cause the message to be printed direct on the receiving instrument.

Although any one of the systems described or referred to can be made to do excellent work, the actual selection of the apparatus best calculated to meet the requirements of any country depends entirely on local conditions. To what extent uniformity of practice

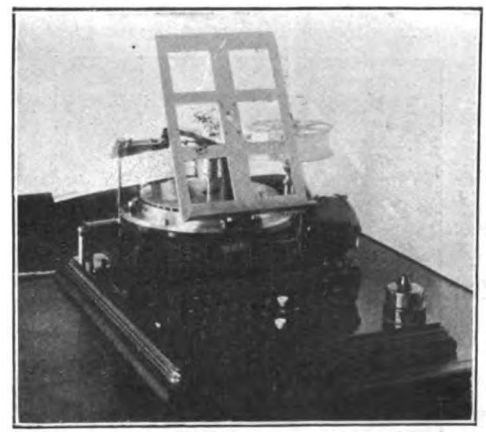


Fig. 2.—Siemens & Halske's Keyboard Perforator.

is likely to arise in the future is a doubtful question, as each country is likely to progress on the lines which have been firmly established as best adapted to its wants.

Writing telegraphs, based on the fact that two ordinates at right angles to one another can be made to describe any curve, have been designed. The telewriter is well known. At the receiving end two pivoted electromagnets, placed in a very powerful magnetic field, are deflected over arcs dependent on the strength of the current circulating at any moment. Two arms at right angles to one another are connected to the transcribing pen, one arm being pivoted to each magnet and the writer's movements are reproduced.

* Abstract of the "James Forrest" Lecture, delivered last week before the Institution of Civil Engineers.

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In the beautiful writing apparatus designed by Pollak and Virag a slip is perforated by suitable means with nine rows of holes of varying sizes. Suitable flexible brushes make contact through these holes between batteries and the line wires, and thus cause currents of different E.M.F.s and duration to circulate over the line, and to act on two telephone receivers at right angles to one another. Rays of light are reflected from one to the other and on to a photographic slip, and the written messages, which can be transmitted at 600 to 1,000 words a minute, appear developed and fixed on the sensitised paper, which emerges from the dark closet of the apparatus.

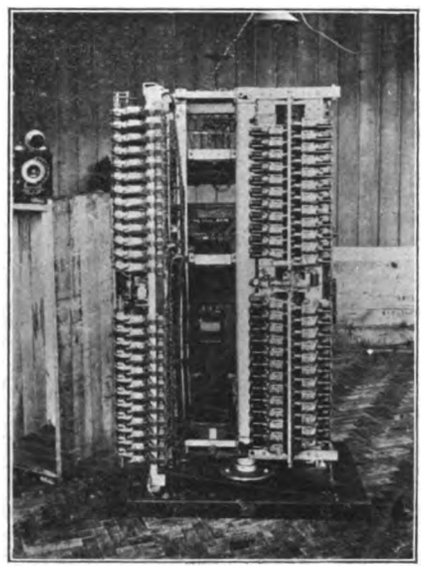

FIG. 3.—UNIT OF 100 LINE SWITCHES (HALF OPEN), AUTOMATIC EXCHANGE.

There are numerous type-printing instruments for the distribution of news, which, however, are so well known that further reference to them is unnecessary.

The effect of conductor-resistance, electrostatic capacity, self-induction and insulator-resistance (or its reciprocal leakance) was next discussed by the lecturer. Overhead wires, for many years almost exclusively used for telegraphy, and even now the only conductors that serve satisfactorily for really long-distance telephony, possess the advantages of low resistance, which can be diminished to any reasonable degree by the use of copper and by increasing the size of the conductor. Their electrostatic capacity is small, say from 0·013 to 0·014 mfd. per mile, and their self-induction is relatively great. Their use admits of attaining the maximum speed in telegraphy; and perhaps the most important limiting factor in this case

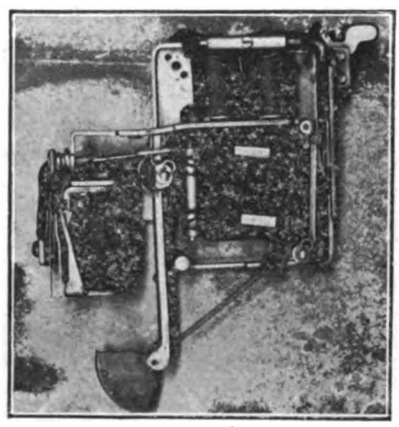

FIG. 4.—AUTOMATIC EXCHANGE LINE SWITCH.

is the self-induction of the receiving apparatus, which would be a useful factor if distributed over the line, but which tends to act as a choking coil when massed at the extremity. This self-induction in the case of the Wheatstone receiver amounts to as much as one henry, and its effect in prolonging the current, combined with that due to the capacity of the line, is neutralised to some extent by inserting a shunted condenser between the instrument and the earth.

Overhead telegraphs are subject to serious interruptions. But on the other hand, until recently, underground wires, owing to their capacity, which reached 0·3 mfd. per mile when insulated with gutta percha, and the great cost of the material, were only used in special cases where strategical or other imperative reasons rendered such a course necessary. The introduction of dry paper as an insulating material profoundly modified the situation. The electrostatic capacity of suitable paper is not very much greater than that of air, and wires wrapped with paper, cabled, thoroughly dried and enclosed in a lead sheath are not only available for long underground telegraphs, but it is not too much to say that without them the modern development of the telephone would have been wholly impossible. The Post Office has within the last few years laid 138,000 miles of paper insulated wire underground for telegraph purposes alone, and to illustrate the bearing of this material on telephone progress it may be added that, between 1900 and 1902, before a single subscriber had been secured, the Post Office laid 240,000 miles of wire underground as the first step in the development of the London system. The

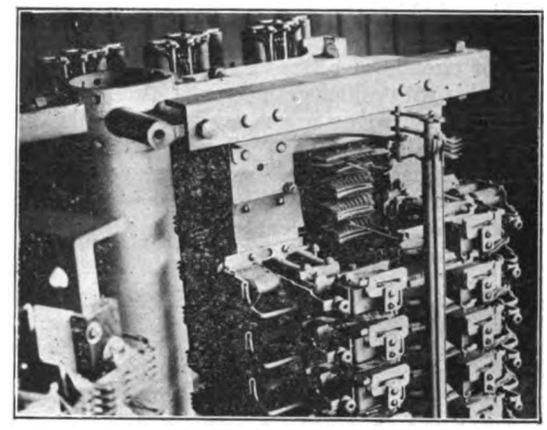

FIG. 5.—LINE SWITCHES WITH BANK OF SPRINGS, AUTOMATIC EXCHANGE.

mileage of underground wire laid by the Post Office in Great Britain for telephones is now increased to 521,000 miles. By no other known means could such a service have been provided, and these facts emphasise the connection between paper insulation and telephone development.

Submarine telegraphy is not susceptible of the many developments that have been possible with land-lines. The high electrostatic capacity, varying from 0·3 to 0·4 mfd. per mile, and the very long lengths that are necessary to connect the great continents of the world, rendering the use of any but the most delicate apparatus impossible on long cables. The receiving instruments originally invented by the late Lord Kelvin, then Sir William Thomson, are still the only apparatus available for the reception of messages on long transcontinental cables, and so far it has not been found possible

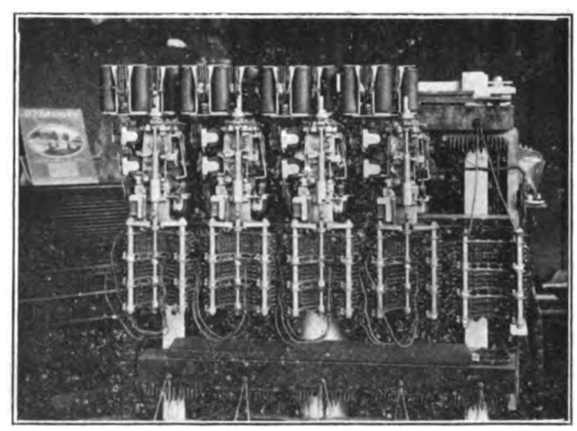

FIG. 6.—GROUP OF CONNECTORS, AUTOMATIC EXCHANGE.

materially to increase the speed of working except, of course, by increasing the dimensions and cost proportionately. Attention has been devoted to eliminating disturbing elements and perfecting the signals by the use of automatic transmission and by the use of curbing devices at the receiving end. The introduction of repeaters at intermediate points where cables land at suitable localities has recently become possible, and it may be that methods of distributed induction may ultimately be of some value.

In ordinary telegraphy when transmitting through an overhead line the frequency of the current alternations is only 180 per second

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Table *of Equivalents based on Attenuation and Empirical Formulæ respectively. Tests made with the Standard Apparatus described in the Schedule to the Agreement dated* 1905 *between the Post Office and the National Telephone Co.*

Type of line.	Constants per mile of loop. R. Ohms.	K. Mfd.	L. Henrys.	No. of miles of various types of conductors giving equal transmission to 1 mile 20 lb. cable. (Calculated from Pupin's and Campbell's formulæ)	Limiting distance based on speech limit of 43 miles standard cable. (Calculated from preceding column.)	Limiting distance based on empirical formulæ.	Limiting distance based on speech limit of 43 miles standard cable. Observed experimental values.
Underground A.S.P.C. Cable.				Miles.	Miles.		
10 lb. cable	175·54	0·07	0·001	0·61	26	25	26
20 „ „	86·0	0·055	0·001	1·0	43	43	43
40 „ „	42·0	0·056	0·001	1·47	63	66	63
70 „ „	25·0	0·063	0·001	1·83	79	72	...
100 „ „	17·0	0·058	0·001	2·45	105	91	...
150 „ „	11·7	0·065	0·001	2·95	127	113	127
200 „ „	8·75	0·07	0·001	3·5	151	150	...
Submarine Cable.							
160 lb. Cu and 300 „ G.P. per knot.....	12·9	0·12	0·00165	2·3	99	97	88
G.P. Quad.							
40 lb. Cu per mile	43·0	0·128	0·001	0·95	41	36	39
Aerial Wires.							
100 lb. Cu Open	18·0	0·00608	0·0039	8·45	363	357	...
150 „ „ „	11·9	0·00839	0·00376	11·7	503	490	473
200 „ „ „	9·0	0·00862	0·00366	14·7	632	613	626 } Means of
300 „ „ „	6·0	0·00893	0·003545	21·0	903	844	903 } several
400 „ „ „	4·5	0·00919	0·00344	26·1	1,122	1,056	1,075 } trials.
600 „ „ „	2·97	0·00958	0·00331	36·8	1,582	1,443	1,582 }
800 „ „ „	2·25	0·00987	0·00322	45·8	1,969	1,804	Not determined owing to disturbance.

for 450 words per minute, and the current has actuated the apparatus at the further end before the battery connection has ceased. Another condition, however, is introduced when a conductor is used for telephonic speech in which a maximum frequency of 1,800 to 2,000 vibrations per second has to be dealt with. In these cases the transmission from the telephone assumes complex wave-forms, and the effect of even a moderate capacity becomes far more marked than in the case of telegraphic transmission. If the capacity be

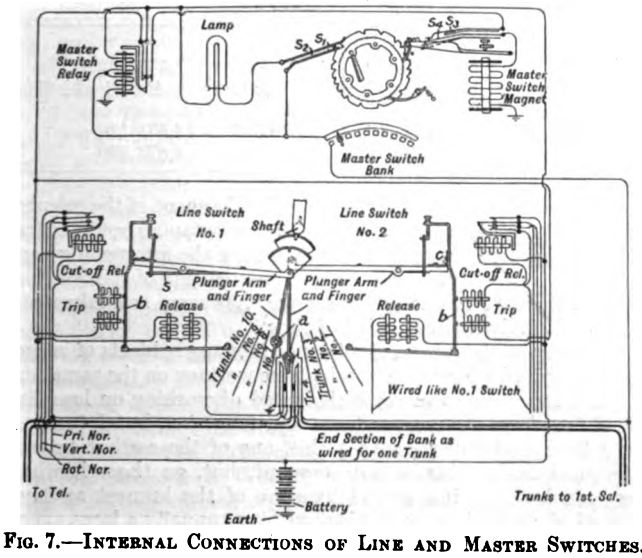

FIG. 7.—INTERNAL CONNECTIONS OF LINE AND MASTER SWITCHES.

sufficiently great and the line sufficiently long, the following wave overtakes the lagging tail of the previous one, they blend more or less together, and having lost their distinctive character they fail to impress on the receiving telephone the distinct character of the sound from which they emanate. A few years ago I had, in conjunction with the Engineer-in-Chief of the National Company, Mr. Gill, to fix certain standards of speech which had to be maintained by the two administrations working the telephone system in this country, and after a series of practical tests, which were found to accord most closely with theoretical calculations, we found the results shown in the accompanying table to represent the practical limits of ordinary commercial speech on various classes of conductor, both overhead and underground, when no special steps were taken by artificial means to overcome the deleterious effects of capacity. By endowing a circuit in which an electrical wave was in movement with sufficient self-induction to prevent the tailing and consequent distortion of the wave, the limit of speech would be materially increased, as the attenuation due to resistance alone would have to be provided for. The British Post Office has recently laid a cable with distributed inductance between England and France which will increase the range of speech about four times as compared with a similar type of unloaded cable.

The problem of connecting two subscribers' lines at an exchange is a very simple one when a small number of subscribers only are concerned. An electrical indicator of the shutter type to announce a call, flexible conductors to connect any two lines by means of plugs and spring jacks, electrical bells to call up subscribers, and the equipment is complete. The problem is a serious one, however, when, as is now the case, the number of telephone subscribers in a

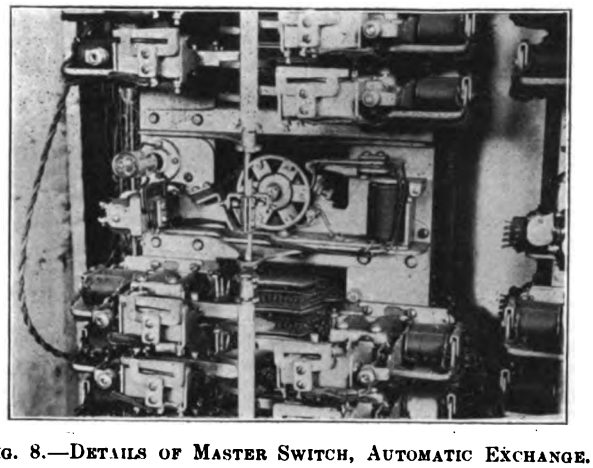

FIG. 8.—DETAILS OF MASTER SWITCH, AUTOMATIC EXCHANGE.

large city runs into five or frequently six figures, when the area covered, like that in London, amounts to 640 square miles, when it has to be served by 60 to 100 separate exchanges, between all of which intercommunication must be provided with the minimum amount of delay. Add to this the interurban communications between all the principal cities in the country, and the fact that practically the major part of the business of the 24 hours is concentrated in about 2½ hours in the morning and a similar period in the afternoon, and the difficulties to be solved become faintly apparent, even to the uninitiated.

Apart from minor improvements in the calling indicators and other details, each of which added its quota to the gradual perfection of the service, perhaps the most marked advance that was made, when exchanges grew in size, was the introduction of the so-called multiple switch. Before its introduction, each operator had the care of, say, 100 subscribers whose lines terminated in front of her. She could connect any two of these 100 directly, but as soon

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as a connection had to be made to another position a subsidiary junction line had to be brought into use and the services of another operator invoked to complete the connections. To obviate this difficulty as the number of positions and subscribers increased, the multiple switch was designed. The lines of, say, 100 subscribers are then terminated on one operator's position; but on a large panel above these local jacks the whole of the 10,000 or more lines are connected to a series of jacks within reach of the operator, and this is repeated at every operator's position, so that a line on any position can be directly connected with any of the other lines on the exchange by the operator who answers the call.

A further improvement was the "common battery system." In this, the form of manual exchange equipment now considered the most satisfactory, the shutter indicators are replaced by glow-lamps placed immediately over the jacks. When a lamp lights it indicates a call, and the operator, without doubt, hesitation or delay, forthwith inserts the answering plug into the jack. At the subscriber's office no special calling apparatus is needed. The lifting of the telephone from the hook automatically lights the lamp. The electrical energy in common battery systems is provided by accumulators at the exchange, instead of by primary batteries at each subscriber's office, and not only is the cost of the exchange infinitely small as compared with the old system of providing separate batteries for each subscriber, but the further advantage follows that the full energy is always maintained and available on every circuit, a condition almost impossible to fulfil even under the best organisation when thousands of primary cells scattered over a great city have to be looked after by linemen. Similar automatic arrangements are in use on the junction lines connecting the various exchanges necessary for the effective service of large cities.

In the period during which the ordinary telephone equipment has undergone the above modifications, inventors have turned their attention to the design and perfection of an automatic telephone in which each subscriber, by a simple method of manipulation, may, without the intervention of an operator at the exchange, obtain direct access to any other subscriber connected with the service. One of the earliest systems of this type was known as the Strowger, and by the courtesy of the Automatic Electric Co., of Chicago, the owners of the patent rights, and of the British Insulator and Helsby Co., of Prescot, the lecturer was able to illustrate the working of the system. Each subscriber's line terminates on a line switch which forms part of a group of 100 switches. This switch is connected by ten circuits, the equivalent of the plugs and cords in a manual board, with a series of selectors each accommodating 100 junction lines. According to the size of the exchange there may be two or three sets of selectors connected similarly by means of junction circuits, and finally, there is a connector, a somewhat similar instrument, which makes the connection between the two subscribers. Each telephone has a dial with finger holes and numbers. On removing the telephone from the hook the procedure is as follows: If, say, No. 4852 is wanted the caller inserts his finger in hole 4 and revolves the dial up to the limiting stop. This actuates the line switch which causes a connecting plug to enter the springs of the first disengaged junction leading to the selector group of 4000. The same action follows in sequence with 8, 5 and 2, the final movement of the connector making the connection if the required subscriber is disengaged. If he be through to another, a busy back signal (a vibratory current) is given. When the connection is made and the conversation is complete, the hanging up of the telephones restores the connections to the normal. This method has had considerable development amongst the independent telephone companies in America. Figs. 3 to 9 show various parts of the equipment.

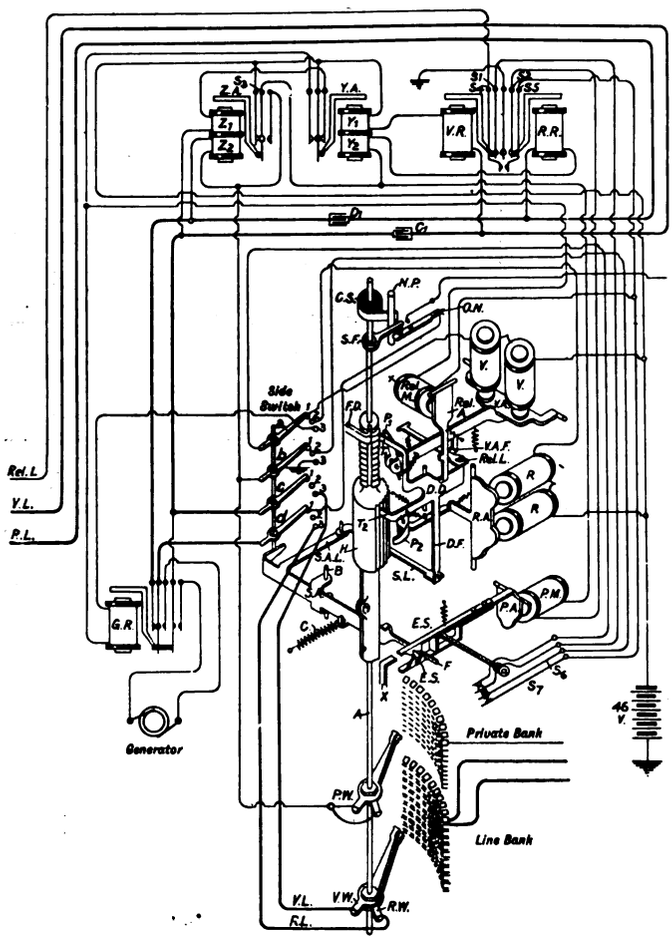

FIG. 9.—INTERNAL CONNECTIONS OF C.B. CONNECTOR

Rel.L., Release line. V.L., Vertical line. R.L., Rotary line. V.R., Vertical relay. R.R., Rotary relay. A, Shaft. H, Hub. P_1, Pawl. P_2, Pawl. V.A., Vertical armature. R.A., Rotary armature. V, Vertical magnet. R, Rotary magnet. T_1, Upper tooth. T_2, Lower tooth. D.D., Double dog. F.D., Fixed dog. P.W., Private wipers. V.W., Vertical wiper. R.W., Rotary wiper. *a*, *b*, *c*, *d*, Knife switches. S.A., Spider arm. B, Pivot. C, spring. F, Finger. E.S., Escapement springs. P.A., Private armature. X, Stop. P.M., Private magnet. Y.A., Armature. Y_1, Coil. Y_2, Coil. G.R., Ringer relay. Z.A., Armature. Z_1, Coil. Z_2, Coil. C, Condenser. D, Condenser. D.F., Finger. Rel.M., Release magnet. C.S., Coiled spring. S.F., Finger Stop. N.P., Normal post. S.A., Arm side switch. S.L., Link side switch. S.A.L., Lever side switch arm. V.A.F., Finger vertical armature. O.N., Off normal.

With giant strides, telegraphs, both land and submarine, have shown remarkable growth in the intervening period of five years, notwithstanding the keen competition of the telephone. The great increase in the latter service, however, has taken place within a relatively limited period of time.

On the subject of the future development of telegraphs and telephones, few of those acquainted with the subject would venture to dogmatise, but certain statistics I have prepared will convey to you possibilities far more pregnant than any amount of speculation. The following figures, for the years 1902 and 1907 respectively, have been gathered from authentic returns, and they embrace information from every country of importance throughout the world.

Telegraph and Telephone Statistics.—Wire Mileage.

——	1902.	1907.	Increase.
TELEGRAPHS.			
Land wires	3,659,659	5,038,981.	1,379,322
Submarine cables .	212,894	259,000	46,106 = 21·6%
TELEPHONES.			
Wire	7,467,417	19,839,537	12,372,120
Subscribers' stations	3,534,036	8,406,336	4,873,330

It will be observed that although the development of the telephone service is taking place with giant strides, telegraphs, both land and submarine, have shown remarkable growth in the intervening period of five years, notwithstanding the keen competition of the telephone. The great increase in the latter service, however, has taken place within a relatively limited period of time.

Time does not admit even of reference to many subjects of interest, such as combined telegraph and telephone working on the same wires, the use of repeaters to increase the speed of working on long lines, modern fire-alarm systems, railway signalling, &c., but I trust that what I have said will show that this, one of the earliest branches of electrical engineering, is not stagnant, but, on the other hand, is very much alive; it is served by some of the keenest and most advanced of electricians, and it is absorbing annually a large amount of capital which it is turning to good and profitable use.

Brief reference was finally made by the lecturer to wireless telegraphy, the work of Marconi, Poulsen and Lepel being specially mentioned, and a number of ship and station equipments being illustrated. By substituting a telephone transmitter for the ordinary telegraphic key, it has been found possible, the lecturer said, to transmit actual speech a distance of 30 or 40 miles, whilst the limit of wireless telegraphy may now be placed at perhaps 5,000 miles.

Rail Corrugation.—In referring last week to the interesting pamphlet on this subject which has been prepared by Mr. J. H. Briggs, the inadvertent use of the word "this" for "the" in the 13th line of our note made it appear as if friction from any cause would result in chattering, whereas Mr. Briggs in his pamphlet shows that the chattering can only arise from throat friction resulting from the downward motion of the leading outer wheel.

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ELECTRIFICATION OF THE CENTRAL ARGENTINE RAILWAY WORKSHOPS.

The Central Argentine Railway Co.'s locomotive, carriage and waggon works at Rosario de Sante Fé cover an area of 110 acres and give employment to about 3,500 men. They are equipped with every description of plant necessary for the construction and repair of railway rolling stock, and practically the whole of the rolling stock for this important railway, with the exception of the actual construction of

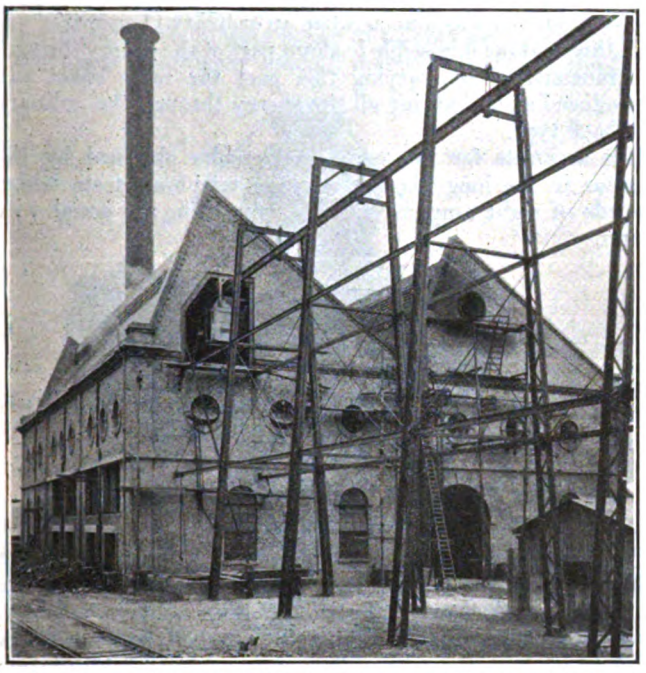

Fig. 1.—Power Station of Central Argentine Railway Workshops.

locomotives, is turned out by these works. At present about 165 locomotives, 725 passenger coaches and 6,100 waggons pass through the shops for repairs in the course of a single year, in addition to an annual output of new stock of about 60 passenger coaches, including dining and sleeping cars, and 1,500 waggons, chiefly of the covered type of from 18 to 40 tons capacity.

In 1906 important extensions were in contemplation, and it was decided to convert the whole of the works for electric driving, and also to supply, from the same central station, power and lighting to grain belts and elevators (having a frontage of about 1½ miles on the river Parana), to a sawmill situated about a mile from the shops, and to two terminal passenger stations and the extensive goods and sorting yards in Rosario. The British Westinghouse Electric & Mfg. Co. secured the contract for the plant and equipment.

The power station (Fig. 1) is situated practically at the centre of the works, and measures 116 ft. by 91 ft. 6 in. The boiler room contains four Babcock & Wilcox boilers, each having a heating surface of 5,764 sq. ft., and an evaporative capacity, when burning coal, of 20,000 lb. per hour, the steam pressure being 185 lb. per square inch. Integral superheaters, capable of superheating the steam up to 150°F. at the boiler stop valve, are fitted. Hand-fired grates were adopted with a view to burning sawmill refuse, but overhead steel coal bunkers, of a storage capacity of 200 tons, have been installed, the coal being taken direct from the waggons by a telpher. The ashes are removed from the ash cellar below the firing floor to an outside pit, whence they are picked up by a telpher.

The economiser and pump room adjacent to the boiler room contains a Green's economiser of 480 tubes arranged in two halves, with the usual by-pass flue underneath, three Hall steam-driven compound feed pumps of a capacity of 4,000 gallons per hour each, a Kennedy hot-water meter and a Rankin filter and Row's patented feed water heater. The steel chimney is of the self-supporting type, and rises to a height of 150 ft. above the base, with a diameter of 8 ft. inside the fire brick lining, this lining being carried right through to the top. A forced draught fan has been provided for increasing the draught when burning sawmill refuse. A single main with sectioning valves serves the whole of the boiler room, the engine branches being taken from this through the partition wall. The feed pumps, &c., are supplied from an auxiliary main parallel to the main header. A ring feed main is carried along the front of the boilers, each piece of apparatus in the feed system being provided with a by-pass.

The plant already installed in the engine room (Fig. 2) consists of three 500 kw. and one 200 kw. Bellis-Westinghouse sets, foundations being provided for a fourth 500 kw. unit. The engines are triple expansion, working with steam at 180 lb. pressure at the stop valve, and having a speed of 300 and 375 revs. per min. respectively. Exhaust is to atmosphere at present, but provision has been made for the addition of surface condensers should these subsequently be found desirable. The generators are three-phase 550 volts, 50 periods, and each, with its engine and separate exciter, is mounted on a combination base-plate. Motor generators, each of a capacity of 150 kw., are installed for providing direct current at 440 volts for overhead cranes and surface traversers. High-tension transmission has been adopted for power and lighting outside the works, and six single-phase 125 k.v.a. 550 to 3,300-volt step-up transformers are installed in the basement.

The switchboard galleries extend along the greater part of the length of the engine room, the low-tension and direct-current board being situated on the lower and the high-tension gear on the upper gallery. The low-tension board includes generator, low-tension feeder, direct-current feeder, transformer, load and motor-generator panels, while the high-tension board consists of six transformer and seven feeder panels. All the alternating-current switches are of the oil-break type, and those on the generator and feeder panels are provided with overload and time-limit relays. Each of the 25 feeders is provided with choking coils and lightning arresters and has also its own integrating wattmeter, so that the consumption of each department may be recorded. Isolating plugs connect the high-tension switches to the 'bus bars; the withdrawal of these plugs isolates any panel from the rest of the board. The outgoing feeders are, with one exception, carried overhead. They consist of hard-drawn stranded conductors with a weather-proof covering. A 10-ton three-motor overhead crane, also fitted with hand motion, runs the length of the engine room, and the usual auxiliary apparatus, store-rooms, offices, &c., make the station up-to-date in every respect

Group driving has been adopted in the larger portion of the fitting and turning shops, but in the sawmills and other departments, as well as for the large tools, such as wheel lathes, the individual drive is general. The motors, which are of both the squirrel-cage and the slip-ring type, range in size from 2 H.P. to 150 H.P. Up to the present about 160 motors, aggregating some 2,600 H.P., have been put to work. These figures will, we understand, be considerably increased when the extensions now in progress are completed.

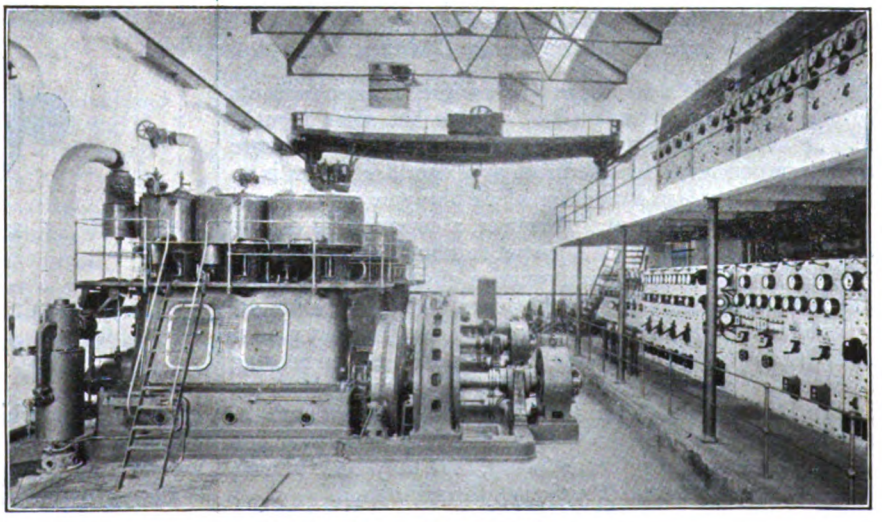

Fig. 2.—View of Engine Room.

The wiring, except in the case of the sawmills, where screwed iron barrel has been largely adopted, is by means of open insulator work. The distribution boards have one main switch with fuses on the separate motor circuits, an additional switch and fuse being mounted near each motor. The lighting circuits are supplied from 550 to 220-volt step-down transformers, an intermediate tapping being provided in the low-tension side of the latter for 110-volt arc circuits where these

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are desirable. Flame arc lamps have been installed in the majority of cases, but enclosed lamps have also been installed where they have appeared more suitable. Seven transformer sub-stations are at work, or in course of construction, at various outlying points, for the supply of light and power to the grain elevators, sawmills, stations, &c., already mentioned, and when the system is completed the power and lighting arrangements of the Central Argentine Railway at Rosario will be at least as up-to-date as those of any system in the United Kingdom.

The electrification may, we gather, be said to be an unqualified success. The cost of power has been reduced and the output of the shops has been increased. Piecework prices—which form the larger part of the wages bill—have been considerably reduced without lowering the earning capacity of the men. These results have, of course, in some cases been obtained by increased speeds.

The plant was supplied to the specification of the railway company's consulting engineers, Messrs. Livesey, Son & Henderson, and erected under the supervision of the railway company's mechanical engineer, Mr. Harry Pearse, by the British Westinghouse Electric & Mfg. Co.

A NEW WIRELESS TELEPHONE TRANSMITTER.

BY WILLIAM DUBILIER.

In almost every transmitter thus far conceived the action is produced by the variations of pressure on loose contacts, but the limit is soon reached with the ordinary transmitter in regard to the amount of energy it will carry. Many difficulties arise when large amounts of energy are utilised. In order to overcome this difficulty several attempts have been made to

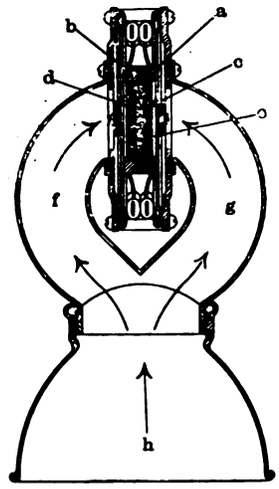

Fig. 1.—Cross-section of Collins Transmitter.

obtain a stronger effect or change by a number of loose contacts or several diaphragms being effected from the same mouthpiece. In all these cases, however, it was found that where more energy can be varied distinctness is sacrificed, that is to say, where we increase a number of diaphragms we decrease the clearness of articulation. However, a compromise can be made between the two, and if a proper combination is obtained better results can be had than when a single transmitter is used. In all these combinations, however, and in fact in almost every transmitter yet designed the contacts are generally placed behind the diaphragm, and consequently only the increasing and decreasing of pressure on the side of the diaphragm are utilised. In the solid back transmitter a large amount of energy is lost due to the vibrations of both the diaphragm and the back in synchronism, that is to say, that they both vibrate to and fro and in the same direction at the same time.

From this it can be readily reasoned that a large proportion of the vibrations or variations is wasted. Many attempts have been made to overcome this loss, utilising the vibrations of the diaphragm in both directions by constructing double acting microphones, but none of these instruments have come into general use.

Many transmitters have been constructed with several diaphragms, but all of these seem to have the drawbacks mentioned above and tend to make speech inarticulate. In the new transmitter here shown Mr. A. Frederick Collins, the well-known inventor in the field of wireless telephony, has tried to combine in an instrument large volumes of energy and variations of these volumes to such an extent as to make the transmission of speech clear and articulate. With this new transmitter the objection stated above, namely, that in a solid back type the solid back vibrates in unison with the diaphragm, thus decreasing the amplitudes of the variations, is eliminated. Further, the effect of the amplitude of the variations is increased to such an extent that in many tests the voice was received four times as loud as when an ordinary transmitter was used, thus making it possible to shunt part of the energy through the transmitter; by varying this part the same effect can be produced as by varying all the energy through the ordinary solid back type.

This accounts for the very good results obtained by the inventor in his long-distance wireless telephone tests where upwards of eight amperes have been used in the aerial wire system.

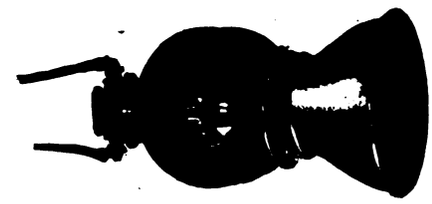

Fig. 2.—General View of Instrument.

The construction of the instrument is as follows: Referring to Fig. 1, the two diaphragms *a* and *b* oppositely disposed are rigidly held on the brass frame so that they can vibrate freely. Upon these are screwed the finely polished carbon surfaces *c* and *d*, which form the sides of the cavity containing the carbon granules shown in *e*. These granules form the loose contact between the polished carbon surfaces. To the centre of the brass frames are screwed the tubes *f* and *g* which lead around to one mouthpiece *h*. The vibrations are divided up in *f* and *g*, and act on the diaphragm in opposite directions, thus causing these diaphragms to act simultaneously against and away from each other. Thus it may be seen that instead of a single diaphragm vibrating and compressing the carbon granules we have two diaphragms operating against each other and on the same granules, producing an amplitude of variation far in

Fig. 3.—Water-cooled Type.

excess of that which can be accomplished with a single diaphragm. Fig. 2 is reproduced from a photograph of the instrument.

Many combinations of these instruments have been tried with surprisingly good results. Mr. Collins has constructed a transmitter with the granular holder cooled by a flow of water (Fig. 3), and with this arrangement it has been in constant operation for 12 minutes, allowing the high frequency current to pass through it; this current indicated 4 amperes on the meter placed in series with the aerial. During this test there were little variations in the clearness of articulation from the first to the last second, and the experiment proved that the instrument can be used for almost any reasonable length of

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time. As patents are being applied for, the details of construction of the water-cooled type cannot be given at present.

Another experiment was successfully tried with four transmitters connected in parallel and directly in series with the aerial wire system. When the Collins revolving oscillation arc (described in THE ELECTRICIAN of March 4th) was used on this system, currents as high as 15 amperes were obtained. The four transmitters connected in parallel were placed in series with the earth, and used continuously for over 15 minutes for making tests. During this time articles from various technical papers were read and recorded at the receiving end, and, when compared, there were found to be only four mistakes out of two pages of ordinary reading matter. In Fig. 4 the four

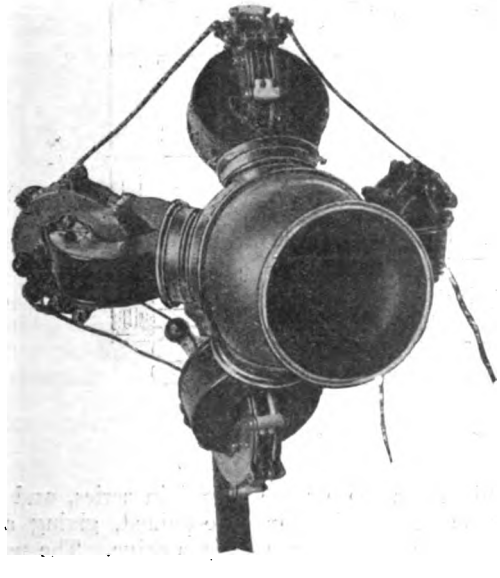

FIG. 4.—FOUR TRANSMITTERS IN PARALLEL USING A SINGLE MOUTHPIECE.

transmitters are shown with a single mouthpiece; due to the construction, this combination is equivalent to eight of the solid back transmitters.

Long distance wireless telephone tests will be made before long with this microphone, and from the results already obtained it is believed that the record for telephony will be broken, wire or wireless.

THE DAIMLER "K.L.P." PETROL ELECTRIC OMNIBUS.

An interesting type of petrol electric omnibus, embodying several novel features, has recently been developed by the Daimler Co. under the patents of Knight, Lanchester and Pieper, whence the abbreviated title "K.L.P." The principal points aimed at in the design are reduction in weight, with a minimum of unsprung parts, simplicity and accessibility of the mechanism and simplicity of control.

The novelty starts with the chassis, in that there is no chassis as ordinarily understood, the frame being formed of the bottom or well of the body. This is built up of sheet steel rolled into a deep channel section (Fig. 4) the whole width of the base of the body. At the points of load application on the springs, cross members shaped and riveted to the steel well are fitted, these adding the necessary stiffening at the points required. To obtain torsional rigidity to meet all winding and twisting strain on the frame a large rectangular steel tube is fitted in between the two sides of the steel well under the driver's seat and firmly riveted to it. This member also forms the petrol tank, and has a capacity of 25 gallons.

At each side of this sheet steel frame, and under the top horizontal webs or seat line, are fitted the power units (Fig. 2). These on the present omnibus comprise two four-cylinder. 12 H.P. (R.A.C. rating) engines of the new Daimler "silent Knight" type, the crankshafts and frames of which are extended, and on this the motors are fitted, the whole forming complete and compact self-contained units. Each motor, which is a shunt-wound six-pole machine, is nominally rated at 3 kw., but has a "give and take" capacity of three to four times this rating. The drive from each unit (Fig. 1) is taken directly from the engine and motor shaft to a worm drive fitted to each wheel through a tubular cardan-shaft, no differential gear being used.

Built up directly on the sheet-steel frame is the body, the framing of which is made entirely of sheet steel; the side posts come straight down from top to bottom, no reduction of width taking place, thus giving a base at bottom the full body width. A battery of Tudor accumulators is carried, and the motors can act as motors or generators as required. At times of light running the motors act as dynamos, and charge the battery, but when the load is heavy the battery supplies power. Reversal is effected by the motors alone, and thus the usual change speed and reversing gear is eliminated.

The road wheels are mounted on the extremities of a tubular cranked axle tree, and are driven by short live axles coupled direct to the worm wheels on the right and left-hand sides of the vehicle respectively. The axle tree is so designed that each road wheel and the worm gear by which it is operated are carried directly off the spring bracket—that is, the portion of the axle tree directly supporting the weight of vehicle.

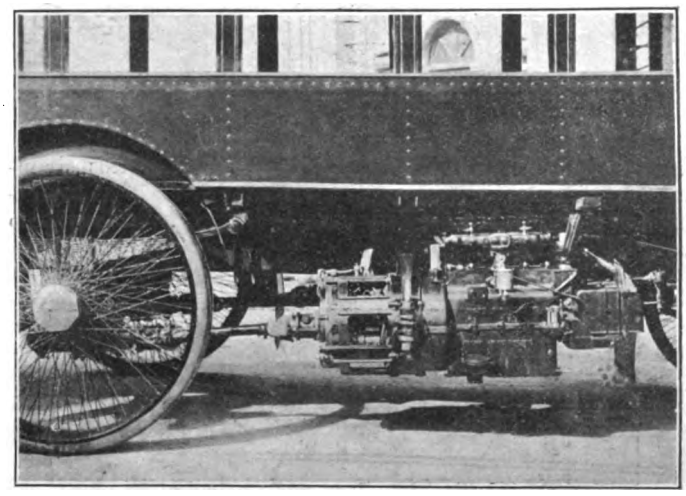

FIG. 1.—ONE OF THE PETROL ELECTRIC SETS WITH COVER REMOVED.

Between the wheel and worm casing are fixed the rear springs, and, as can be seen, this method of construction enables a maximum spring base to be used, the spring requiring to clear the wheel rims only.

In view of the fact that one of the principal objects in design has been to reduce weight to a minimum, the employment of wheels of a larger diameter than hitherto used might appear a retrograde step; but by the employment of specially designed suspension wheels it has been possible to use 40 in. diameter wheels on the front axles and 48 in. diameter wheels on the rear axles; and, besides obtaining the great advantages due to large wheel diameters, not only have the weights of the wheels been reduced, but it is stated that a much larger factor of safety has been obtained.

The unsprung weights have been reduced to a very low figure, that below the rear springs being somewhat under 10 cwt. and below front springs being about 5 cwt., as compared with weights on other makes varying from 5 to 7 cwt. on front axles and 16-23 cwt. on rear axles.

By the disposition of mechanism adopted, the height of the platform inside the body above the ground has been reduced to 27 in., this being 5 in. to 10 in. lower than the majority of existing types; also a ground clearance has been increased, being made equal to the axle clearance. This, with the large wheels employed, amounts to 15 in., against 10½ in. minimum specified in the police regulations. The power units are slung in the track of the wheels, hence their ground clearance does

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not enter into consideration; however, even here a 12 in. clearance is given.

The battery and switchboard are carried underneath the driver's seat.

Front wheel brakes are provided, and four separate methods of braking are possible:—

(1) By bringing the lever on the steering wheel to strongest field position, when the momentum of the omnibus is absorbed by charging the battery; (2) by magnetic brake operating on both cardan-shafts actuated by one foot pedal, this simultaneously de-clutching the engines; (3) by a foot lever operating the brake on front wheels; and (4) by a hand lever also actuating front wheel brakes.

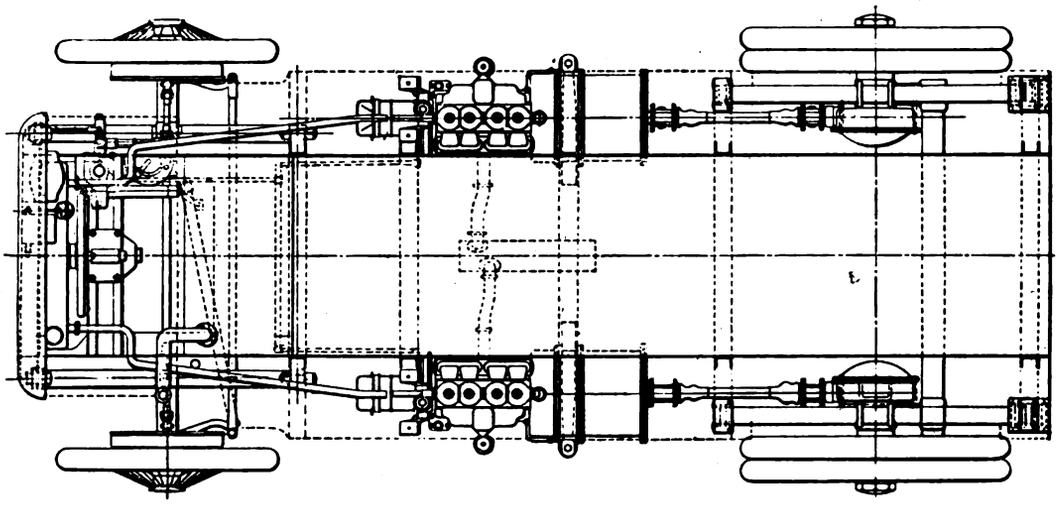

FIG. 2.—GENERAL ARRANGEMENT OF ENGINES AND DRIVING GEAR.

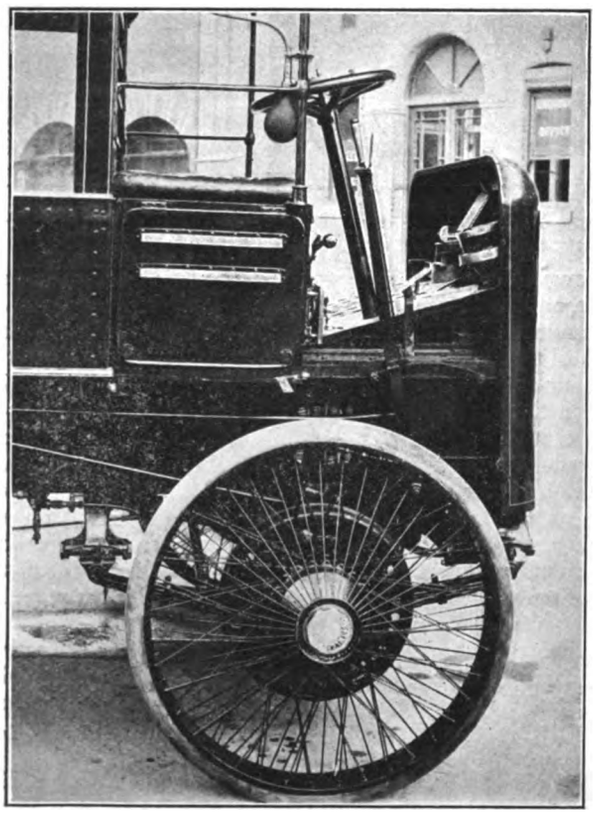

FIG. 3.—SHOWING THE CONTROL.

For the control of the omnibus there are two levers, placed on the top of the steering wheel—one connected up to the motor field controller, this lever entirely controlling the speed, which varies between 3 and 14 miles per hour; the other is connected to the two engine throttles. For running in a forward direction the two motors are in parallel with the battery; the field regulation is controlled by a common rheostat.

An automatic arrangement is provided to prevent overcharging of the battery. This consists of a solenoid device, which, when the battery voltage exceeds a certain value, acts upon the throttle levers, reducing the speed of the petrol engines. Conversely, if the voltage falls below a certain value, the speed of the petrol engine is automatically increased.

For reversing, the motors are placed in series, and so an efficient low-speed combination is obtained, giving a high torque and a perfectly balanced reverse drive. The parallel-series position is obtained by a single controller, the operating lever for which is within easy reach of the driver, but is not touched by him until change of direction is required. The magnetic brakes and clutches on both power units are in parallel with a single controller operated by a pedal.

The radiator, placed in front of the vehicle, is connected with both engines, the circulation pump serving both units in common. The pump is driven by a small ½ H.P. electric motor,

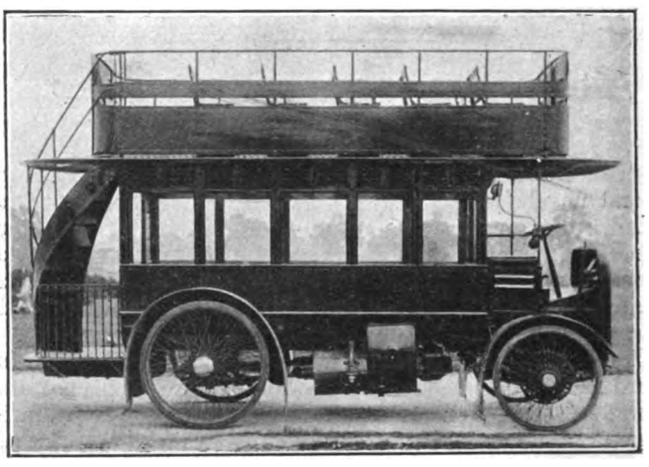

FIG. 4.—GENERAL VIEW OF DAIMLER PETROL ELECTRIC OMNIBUS.

this also driving a fan of ample capacity arranged in the customary position behind the radiator.

The total unladen weight, including 5 cwt. of accumulators, complete ready for the road, is 3 tons 9 cwt., the police regulations allowing 3 tons 10 cwt. There is seating accommodation for 34 passengers.

Fig. 2 shows the general arrangement. In Fig. 1 one of the detachable sets is shown with cover removed, whilst in Fig. 3 the simplicity of the control is apparent. A general view of the omnibus is seen in Fig. 4.

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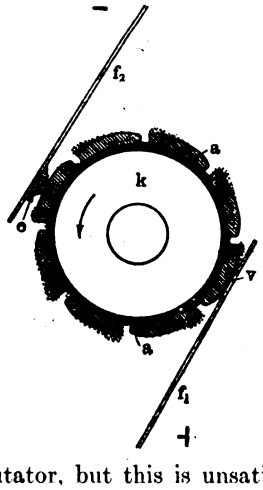
SOME NOTES ON METERS OF THE THOMSON-HOUSTON TYPE.*

BY PAUL MAY.

The Thomson-Houston meter owes its present position to the simplicity of its construction and its low price, although it must be admitted that its rivals have many good points. The more complicated types will work for six or seven years without any repairs; the Thomson-Houston meter, however, requires to be carefully examined and cleaned at least every two years, and sometimes oftener. The commutator and brush collectors usually require cleaning, but other parts are often found to need adjustment. A fresh meter is usually substituted in place of the old one, as the repairs cannot conveniently be carried out on the spot. This means finally considerable expense, as the meters often reach the repair-shop in a somewhat damaged condition. After a period of about five years, the meters are generally in such a state that they are fit for the scrap-heap. In England, the mercury meter is very popular, but the mercury requires to be kept clean. Meters are therefore usually made to consist of castings with suitable handles, so that they can be moved as required. In some cases, the Thomson meters have small openings, through which it is possible to get at the commutator and brushes. But lower prices have been quoted latterly, and these small openings seem to have been omitted from the latest designs. Some makes of meter of this type have a



replaceable commutator, but this is unsatisfactory, as a new commutator seldom runs truly. The following notes are intended to show methods by which the depreciation of meters of this type can be much reduced.

In order to start easily, the pressure of the brushes must be very light. If a commutator consists of eight sections, and makes 100 revs. per min., there will be 48,000 breaks at each brush in an hour. The small sparks that result do damage to the commutator and brushes, as shown above, magnified about 10 times. The particular meter from which the illustration was prepared had been in use about 6½ months, running 10 hours a day at three-quarters of full load. Every spark takes away a small portion of the surface of the brush f_1. These particles either fuse on the surface of the commutator or collect as small excrescences on the forward edges of the various sections. These excrescences are generally extremely hard, and are always much harder than the substance of the commutator sections and collectors, causing therefore a much increased wear. At the brush f_2 exactly the opposite process takes place, and small particles attach themselves to its surface. This has the effect of wearing away the back edges of the sections, as at *a*, which appear under the microscope at these places as rough surfaces, covered with black spots. The excrescences on the brush have, on the other hand, a spongy appearance, but in spite of this, they are none the less very hard. From this it would seem that particles are transferred from the brush f_1 to brush f_2, and a considerable number of loose metallic particles are to be found both on the brushes and on the sections of the commutator, which seems to show that the transference of the particles might be caused by friction, and not by the action of the small sparks. But, as opposed to this view, we have the fact that the excrescence always appears on the negative brush, and the pressure of the brushes, which amounts to little more than half a gramme, seems quite insufficient to cause any loss due to friction. If the commutator and brushes are rinsed with distilled water (not too great in amount), a cloudiness is formed in the water, which persists even if the water is allowed to stand for several days. With the ultra-microscope it is possible to see fine metallic particles suspended in the water, which seem to be in a state of continual motion, and reflect more or less light according to their position. Obviously this is a colloidal solution, which can be prepared, as is well known, by electrical methods. It is possible that a similar electrolytic action takes place between the brushes and the commutator sections, and the following experiment is of interest in this connection. Take a meter which shows signs of deposit on the negative brush; reverse the shunt connections, and also the connections of the series coils. The meter will continue to revolve in the same direction as before, but the polarity of the brushes is changed. It will then be found after some time that there is a complete reversal of all the processes, and the deposit will gradually transfer itself to the other brush, which was originally positive and has now become negative.

If a Thomson-Houston meter is put for some time on alternating current, deposits gradually take place both on commutator and brushes, and there is also a slight pitting. When rinsed with distilled water, there are as before signs of a colloidal solution.

As the deposit increases, so does the wear on the commutator; the brush collectors have an irregular hopping motion, and this results in increased sparking. In this state, a meter is not exactly worthless, but it registers too slowly, and errors of 15 or 20 per cent. at one-tenth full load often occur, an obvious loss to the central station. The question is what means can be taken to prevent this state of things. In the first place, the natural period of vibration of the spring-collectors should be very short. Otherwise accidental oscillations from one source or another may bring about a state of resonance, which would be accompanied by very serious sparking. It is unlikely that the period of these accidental oscillations would be very short; they would be much more likely to be long. Further, the pressure of the brushes on the commutator must be constant; the pressure should be produced by a steel spring, which takes no part in conveying the current. The pressure between two sections of the commutator ought in no case to exceed 2 volts; otherwise there is a risk of a short-circuit between the segments. The self-induction of the armature coils should be kept as low as possible. Sometimes a meter will work for a long time without sparking, whereas another similar one of the same make soon becomes useless under the same conditions. This is due to the adjusting of the spring-brushes, which is done differently by different persons. In the hope of arranging for an easy start on light load, the brushes are sometimes made to press too lightly on the commutator. In order to be independent of these chances, it has been proposed to have arrangements by which the pressure of the brushes can be directly measured; but the small amount of the pressure makes observations of this nature very uncertain, and the method has been unsuccessful. The best method is to adjust the springs carefully by hand, and it is well to leave this in the hands of one individual. With constant practice, very great skill can be obtained, and the adjustments can be very quickly made. After the springs have been adjusted, it is well to leave them one or two days in the test-room, and at the end of this time to examine them during running in complete darkness. In this way, any that show a pronounced sparking tendency can be easily detected.

Still even so, meters of the Thomson-Houston type require frequent cleaning and repairs, and it is well to see what can be done further. Some makers issue instructions to the effect that it is advisable to shift the relative positions of brushes and commutators after a certain length of time, in order to

* "Abstract of an article in the "Elektrotechnische Zeitschrift."

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obtain better rubbing surfaces; but if there is a deposit already formed on the negative brush, it will be necessary to interchange the brushes if any good effect is to be produced. If the construction admits of it, it is well from time to time to change both the shunt and the series connections, thus leaving the direction of rotation the same as before; this will considerably reduce the wear and tear. An arrangement was once used by which the collectors were gradually displaced with regard to the commutator by a clockwork motion. But this was not found to prevent the deposits on the negative collector, and meters provided with this device gave at low loads readings equally as defective as those without, and sparked just as badly. A meter with defective spring contacts and rough commutator will often read quite correctly at full load, and nearly so at half load; it is only at one-fifth of full load that serious defects are noticeable. With a certain type of meter, it has been found possible to have movable brush collectors, which can be displaced more or less by the action of an electromagnet, which carries a current proportional to the whole of the current passing through the meter. Oddly enough, this simple plan has never been applied to the Thomson type, though any slight increase in cost would be more than counterbalanced by its obvious advantages. An arrangement somewhat as follows might work. Let us suppose the spring collectors to be arranged on a small lever, pivoted at its centre, and carrying a small iron armature, that could be exposed to the action of the field set up by the series coils. The design would cause the collectors to take up a different position with regard to the commutator at full load from what they would have at light load. But this in itself would be of little advantage if deposits were allowed to collect on the negative brush, as at light loads the same errors would arise as before. This could easily be rectified by arranging that, as a result of the motion produced by the action of the series field on the suspended armature, the brushes should be, as it were, lengthened and shortened. The deposits, which are mostly thrown down at times of full load, would be formed on the brushes at such points as were more or less in contact with the commutator at such times; whereas at light loads, a different position of the brush would be brought into contact with the commutator, which would be smooth and free from deposits. Under these conditions, the readings at light loads ought to remain as accurate as when the meter was new, as the low readings at light loads are almost entirely due to the irregular friction of the uneven surfaces, which is much more noticeable when the forces tending to rotate the commutator are small.

CONGRESS OF MINING AND METALLURGY.

[FROM OUR CORRESPONDENT.]

During last week there was held at Dusseldorf, in Germany, the fifth International Congress of Mining, Metallurgy, Applied Mechanics and Practical Geology. The first assembly of the kind took place in St. Etienne, in France, in 1878, followed later by meetings at Paris in 1889 and 1900, and lastly at Liege in 1905, when exhibitions were being held at these places.

Attending the present convention there are about 1,400 participants, including about 68 Englishmen and 4 Scotchmen. Representatives from Canada, India and Australia are present, whilst members from all over Europe, Mexico and South America are also in evidence.

The conventions are now expected to be held every five years, and no congress having yet been held in England it has been decided to hold the sixth meeting of such interested associations in London in 1915, and a committee has invited the entire assembly to partake of our hospitality at that time.

The progress of electricity as an adjunct to colliery and iron and steel works equipment is emphasised in the several Papers read at the meetings, more especially with reference to metallurgy and the application of power to machine driving.

The work of the Congress was divided into the following sections: (1) Mining Section, (2) Metallurgical Section, (3) Applied Mechanics, and (4) Practical Geology. Visits were also paid to several industrial works and places of interest in the neighbourhood, whilst the evenings were spent in partaking of the hospitality of our hosts.

The only Paper presented from England was entitled "British Coal Dust Experiments," the author being Mr. W. E. Garforth. Sections I. and III. contained most matters of special interest to electrical engineers, and the proceedings of these Sections we will summarise below:—

SECTION I.

THE PRESENT POSITION OF THE MINING INDUSTRY IN FRENCH LORRAINE. By P. Nicol (Nancy).

The author, in this Paper, tells of the difficulty experienced during the initial working due to the influx of water and the methods employed successfully to overcome the difficulties experienced. He mentions that both steam and electric winding engines are used in the Briery mines, the more recently installed electric plants being preferred. Electric power plants, conceived on a large scale and mostly equipped with turbines, furnish the requisite electrical energy for the various branches of the mining operations, such as winding, operating the pumping plant for coping with existing or anticipated water, underground haulages, where these are not operated by benzine locomotives, and also for drilling purposes.

THE DEVELOPMENT OF MACHINE COAL CUTTING AND PRACTICAL UNDERCUTTING IN COAL MINING. By F. Schember (Vienna).

Reference is first made to the continued use of undercutting and picking by hand with special picks of the poll, double ended and blade types. Thereafter the author traces the original construction of coal cutting machines, which consisted of picks driven into the coal by means of mechanical gearing, as used in England, America and Germany. Subsequently the rotary and chain types of machines were introduced, which the author classifies as English, American and Continental, according to the land of their origin.

Amongst the English machines, we are familiar with the wheel machine, chain heading machine and bar machine, the bar being replaced by the pusher machine in America for percussion, undercutting and nicking, whilst on the Continent the favourite machines are the sector or Eisenbeis undercutting and nicking machine and the lever machine with lever coupling control.

The machine recommended for long wall working practice is the bar machine, manufactured by Messrs. Mavor & Coulson, of Glasgow; and for all purposes where undercutting is at all possible the author prefers the use of the Eisenbeis undercutting and nicking machine.

DEVELOPMENT OF MINING INDUSTRY IN THE MINETTE DISTRICT. By Dr. W. Kohlmann (Diedenhofen).

After describing the mining work in Germany, together with the scarcity of labour, due to the difficulty attending the settlement of workmen on the top of the Briery plateau, reference is made to the application and use of mechanical and electrical energy for auxiliary purposes, such as the drilling of shot holes and the operation of underground haulages.

Electric rotary drills of German manufacture were previously much used at these mines, but favourable results have of late been obtained in several places with the pneumatic hammer drill, though the necessity of providing compressed air plant for these drills is proving a drawback, since, unlike the case of coal mines, compressed air is not required for other purposes in Minette mining. Under such circumstances the consideration of the employment of pulsator percussion drills driven by a portable electric motor at the face, as now used in Scotland and the Midlands, might prove advantageous and economical both as regards reducing capital cost and upkeep charges.

In support of this suggestion the author states his opinion that the drill of the future is the electrically-operated hammer drill, the majority of the Minette mines having at their disposal a cheap supply of electrical power from the adjacent smelting works, and there being no difficulty to prevent the laying of electric cables in the mines. The haulage roads are wide and usually straight, so that underground haulages are throughout driven by electric locomotives and stationary motors operating endless haulages.

IMPROVEMENTS IN PUMPING PLANT. By Herr Schultz (Essen).

Distinction is drawn by the author between new sets of plunger pumps and high-pressure centrifugal pumps as driven by electric motors. An electrically-worked plunger pumping plant of German design to raise 138 gallons of water per minute against a total head of 1,443 ft., and consisting of three single action plunger pumps, is described, and particular emphasis is made to the small space—only 6 ft. 6 in. by 10 ft. 6 in. foundations—necessary for pump room accommodation.

The manner in which the efficiency of individual centrifugal pumps has increased of late is a noteworthy feature typical of engineering progress, and as an example of the economical working of high-pressure centrifugal pumps a detailed description is given in the Paper of a recently installed Sultzer pump at the Emscher-Lippe Colliery, to raise in a single stage 1,320 gallons of water against a total head equivalent to 73·4 atmospheres.

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SECTION III.

The Cheapening of Transport by Wire Rope and Electric Suspended Railways.

By Oberingenieur G. von Hanffstengel (Leipsig).

The wire rope railway presents very great economical advantages over the track railways, and the electric suspended railways, by reason of the convenience with which electric energy can be led where required, and possesses even a greater future for extended use. The combination of the wire rope railway with the electric suspended railway on the Bleichert system, as described by Herr Hanffstengel, offers the advantage that, without any surrender of adaptability the surmounting of elevations of any height is possible, thus making the system particularly suited for blast furnace charging.

The Influence of Electricity on the Development and Efficiency of Lifting Appliances in Mining and Steel Works.

By Fritz Heym Wetter (Ruhr).

Reference is made to the fact that the production of mines and metallurgical works depends on the lifting and conveying appliances in use. By reason of the characteristic of the electrical drive it is possible to operate the different motions with precision and rapidity as desired. The working expenses can be reduced by the centralisation of the generating plant, thereby making feasible the application of electricity where it was previously not sufficiently economical to do so. The author dwells on the advisability of installing electric winders, circular waggon tips, waggon tipping devices and loading bridges as means for increasing the output of material from the mines and the dispensation of manual labour by providing suitable gripping and tipping devices worked either by a driver or automatically. Where it would not pay to adopt large loading bridges, because of the amount of material to be handled, telpher lines, &c., with single travelling pulleys, are recommended. No workmen are necessary on the charging platform of blast furnaces if inclined electrically-driven hoists are installed. These transport the materials to the mouth of the furnace, and this practice is now universally adopted in Germany. Several special designs of cranes are described as suitable for different duties, and especial mention is made of the extended use of electric lifting magnets for entirely supplanting sling chains and lifting tackle, and it is emphasised that by employing a lifting magnet in handling scrap and similar materials the manual labour is almost entirely dispensed with and a large saving in wages consequently effected.

Underground Haulage. By Fr. Tillmann (Saarbruchan).

Mechanical haulage is now recognised as justifying the increased initial cost of installation. The most economically operated haulages are those fitted with electric motors supplied with either direct or alternating current. Where it is impossible to have an overhead line in the roadway or where, for any other reason, rope haulages are out of the question, electric accumulator locomotives may be employed to advantage.

Utilisation of Exhaust Steam and Mixed Pressure Turbines.

By Prof. Rateau (Paris).

In this Paper Prof. Rateau refers to the construction and use of his exhaust and mixed pressure turbines. In order to make it feasible to run mixed pressure turbines in parallel with other types it is necessary to keep the speed variations within certain limits. Prof. Rateau solves the problem by causing the speed governor to act upon the high-pressure and low-pressure inlet valves. The low-pressure valve is normally held open by a spring, whilst the high-pressure valve is kept closed at the same time. The low-pressure valve is subjected to the pressure variations of the accumulator. As soon as the available pressure falls below a certain amount the low-pressure valve closes and the high-pressure valve opens, thus enabling the high-pressure steam to replace low-pressure steam without variation of speed. Descriptions are given by the author of three plants where continuously running reciprocating steam engines are supplied with high-pressure steam and turbines make use of the low-pressure steam.

Heat Storage Tanks for the Utilisation of Exhaust Steam.

By E. Stach (Bochum).

It is proposed to extend the principle of utilising waste steam for the working of low-pressure reciprocating engines in the same manner as for exhaust steam turbines. The storage accumulator is an important part of such equipments. Mention is made of heat storage tanks, in which water is employed as the thermal substance, and steam-storage tanks for the reception and delivery of varying quantities of steam.

Electricity in Mining. By W. Phillipi (Berlin).

In the introduction to this Paper particulars are given regarding the extension of the application of electrical machinery in Germany, with special reference to the most economical generation of electrical energy. When dealing with the different applications of electricity to underground installations the advantages of electric boring machines, as compared with compressed air machines, are gone into in detail.

The advantages and disadvantages of ram pumps and high-pressure pumps are discussed in the Paper, and attention is drawn to the particular advantages of operating sinking pumps electrically. Chief attention is given to the explanation of a method of regulating the quantity of air circulated in the workings by centrifugal fans. Speed regulation is effected by transformers, the energy wasted in a rotor resistance being thereby utilised. Particulars are also given regarding the capital cost and annual charges of main shaft winding machines, the most important details in connection with safety working being mentioned, and particulars given demonstrating the reliability hitherto attained.

Only installations embodying the Ward-Leonard system of control, and particularly the electric winders of the Ilgner type are recommended, the reasons for their economical superiority being explained. The author refers to the suggested placing of winding engines in the hoisting framework.

Electricity in Metallurgical Work. By K. Maleyka (Berlin).

Owing to the special requirements of electrical machines in metallurgical practice it has been found necessary to design special machines for such use. The electric driving of auxiliary machines, trains of rolls and blowers is investigated, each case being treated by itself, in order to determine the motor most suitable for the particular duty. Electric furnaces, both of the induction and the electric arc type, have in recent years been installed in considerable numbers for the manufacture of high-grade steel.

The uniformly arranged central generating power station is advocated in order to reduce the costs of production of electrical energy to a low figure. Either continuous or alternating current can be successfully adopted for metallurgical work, and special arrangements for load compensation are generally necessary, either by means of flywheel buffer engines or accumulator batteries. The arrangement of switchgear, cable network and sub-stations are referred to, and data is given of the energy required for separate duties in blast furnaces, steel and rolling mill works.

Recent Experience with Large Gas Engine Installations.

By Prof. Langer (Aix-la-Chappelle).

Due to excessive continuous loads the first large gas engines had to contend with many difficulties. This condition has since been improved by the reduction of the mean effective piston pressure. It is important that the mixture should contain rather an excess of air, and that the constituents should be automatically regulated instead of adjusted by hand. In the case of engines without charging pumps this is rendered possible by a large pressure reduction in the mixing valve, so that as soon as the speed decreases, the excess of air in the mixture decreases, when the gas is under pressure. With two-cycle engines having charging pumps the composition of the mixture is affected by fluctuations in the gas pressure and alterations of the speed to a small extent. Breakage of cylinders is not caused by the explosion pressure, but by the reciprocal straining of the cylinder walls, or by the strains set up in the material of the combustion chamber due to difference of temperature. Careful design and casting of parts are the means to adopt for the avoidance of the former, whilst the latter will only be successfully overcome by the use of a casting material of sufficient strength with a smaller expansion under heat than cast iron, without possessing the disadvantages of cast steel.

The "Managing" of Power Engines, and in Particular of Winding and Rolling Mill Engines and Dynamos.

By Dr. H. Hoffman (Berlin).

This title has been chosen as explanatory of the control system for winding engines obtained by a special kind of brake. When ordinary braking is adopted the braking lever moves away from its central position and returns again, also it has to be moved in a great variety of ways, according as the load is great or small.

The principle of the "managing" system is that the managing and the managed movements are allowed to work together, so that when they do not synchronise a special movement is set up which influences the supply of power to the managed engine. By means of the application of the managing appliance, the steam winding engine and the three-phase current winding engine, whether fitted with induction motors or with double commutator motors, become just as reliable in working as the continuous-current winding engines with Ward-Leonard switchgear. At present the speed of the engine is kept constant on varying load either by hand or by a tension spring, which is not satisfactory when the load fluctuates very considerably. With the system described automatic governing is obtained by the installation of an auxiliary engine whereby movement is assisted or retarded as required.

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REPORT OF THE ELECTRICAL INSPECTOR OF FACTORIES.

There is always some difficulty in introducing new rules and regulations where an established industry is concerned, and we do not doubt that Mr. G. SCOTT RAM, H.M. Electrical Inspector of Factories, has found his hands somewhat full in regard to the new Electricity Regulations for Factories and Workshops adopted by the Secretary of State at the end of 1908, and which came into force generally on July 1st of last year. It is not often that such rules are entirely free from ambiguity, and, therefore, it is not surprising that Mr. RAM—as our readers will remember—issued some little time ago a memorandum on the interpretation of the Regulations. Mr. RAM's annual report, which was issued last week and is given in abstract elsewhere, contains some further information on the same subject.

Although there seems to be a general inclination on the part of electrical engineers, apart from those immediately concerned, to assist matters by seeing that there is compliance with the Regulations, there is considerable difference of opinion as to what is sufficient and adequate. In the case of occupiers employing responsible electrical engineers there is not so much difficulty, but there are many cases in which such a course is not deemed necessary. Where a supply is taken from public mains there is a good opportunity for the supply authority to come to the assis-

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tance of the layman, and in many cases this course is being followed. For example, one local authority is issuing certificates that, to the best of their knowledge, the installations supplied from their mains are in accordance with the requirements of the Regulations. This, no doubt, is a useful course to follow, and where the electricity undertakers also carry out the wiring it is only natural that they should see that the installation is in proper order. Such certificates do not absolve the occupier from his legal responsibilities, but they are at least useful as affording some assurance that the installations comply with the Regulations.

According to the Regulations there are certain exemptions when the pressure of the system does not exceed that which is known as "low-pressure direct," or 125 volts alternating. The question has arisen whether, when a supply is taken from a three-wire continuous-current system in which the pressure between the outer conductors may exceed low pressure, such exemptions apply. In the present report Mr. RAM takes the view that such circuits should be considered in the same way as ordinary two-wire circuits in which one side is earthed. If the neutral conductor of the three-wire system is earthed then the exemptions apply, but if the neutral is not earthed the installation would not so benefit.

Mr. RAM also calls attention to the fallacy of supposing that a circuit taken from an auto-transformer and giving a low pressure, such as 50 volts, is necessarily free from danger. He points out that if the transformer is supplied at 250 volts the secondary circuit may be just as dangerous as the primary circuit if certain precautions are not adopted. If, however, the primary circuit has one conductor permanently connected to earth, it is possible to arrange the secondary 50-volt circuit so that the maximum pressure above earth does not exceed 50 volts. For this to be the case, however, it is essential that the 50-volt circuit shall have one of its conductors at earth potential. In other words, the tapping must be taken off the earthed end of the transformer, and it is essential that matters should be so arranged that the earthing is carried right through. For example, it is necessary that there should be no break whatever in the earthed conductor between the auto-transformer and the main transformer. There must be no fuse or switch in this conductor, as the blowing of the fuse or the opening of the switch would cause the whole of the low-pressure circuit to assume the full supply pressure above earth.

Part of the report refers to the design of apparatus with a view to safety. We are glad to see such points taken up year by year, as by so doing Mr. RAM can render great service to the industry by pointing out to manufacturers the weak points in existing fittings as usually constructed. In this way good results have followed his criticisms on hand lamps, and we do not doubt that more good will result from his further criticisms.

We are also glad to see that the Chief Inspector of Factories is giving serious attention to the illumination of factories. As a beginning, one of the Inspectors has been directed to inquire into the present lighting of certain classes of work-rooms, starting with underground bakehouses in London. There is a very great deal to be done in this field, for we do not really know what constitutes good illumination. Possibly the Illuminating Engineering Society might assist in some way if assistance is desired, though what is first necessary is to obtain a large quantity of data and then to determine really what these data show. When we know a great deal more about the subject it will then be possible to draw up some regulations, but knowledge is the first essential.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Practical Curve Tracing. By R. HOWARD DUNCAN. (London: Longmans, Green & Co.) Pp. vi. + 137. 5s. net.

The scope of this book is such that the subject matter is introductory to the study of higher mathematics. The title chosen is not a particularly happy one, since it does not convey an accurate idea of the actual nature of the book, and, furthermore, the word *practical* is somewhat misleading. The curves considered are treated analytically and also synthetically, and lead in a natural way to the introduction of the calculus. In the earlier pages general information regarding the graphical representation of functions is given, and certain obvious facts respecting the choice of scales are stated, probably because students do not readily realise in a given case the practical degree of accuracy in plotting that is requisite for that case. Since the book is not written specially for engineering students, the example given (the load-extension curve for a steel bar under the action of a tensile load) in illustration of the extreme caution to be observed in extrapolation of a curve might have given place to a case of more interest to the general reader.

After reviewing the various factors relating to equations of the first degree, the author in the next 28 pages considers the parabolic family of curves, and concludes with an example (a bending moment diagram) of a practical case wherein his preceding results may be used. Hyperbolic, exponential and logarithmic curves are treated in the succeeding 15 pages, after which follow chapters dealing with sine curves and graphical solution of equations. In the chapter on differentiation the statement $\frac{dy}{dx} = \tan\theta$ should have had, in the heaviest type supplied by the printers, a note to the effect that the scales of "y" and of "x" must be considered in the determination of the value of $\tan\theta$. If students do not realise the necessity of noting the scales of the ordinates and abcissæ, the correctness of the tabulated results in connection with Fig. 68 will not be apparent. A little analytical work after treating of the differentiation of $y = f(x) = x^3$ would probably have been preferable to requesting the student to plot a curve for values of $n = 4{\cdot}5$ in the equation $y = x^n$, and then by drawing tangents, &c., to find $\frac{dy}{dx}$. Integration is dealt with in the concluding chapter; in illustration of its uses, four examples are worked out in detail. Logarithmic and sine tables, together with examples and answers, are appended.

In one place the author appears to tread very near to what in his preface is referred to as academic mathematics of the mental gymnastic order. Since both calculation and graphical work are in progress almost simultaneously, the subject of co-ordinate geometry, as arranged in this book, must be interesting to students; and, if the work set out be done conscientiously, much benefit must be derived from its study. The printing is well done, and the diagrams, 76 in number, are very clear as well as large in size.

Practical Testing of Electrical Machines. By L. OULTON and N. J. WILSON. (London: Whittaker & Co.) Pp. 210. 4s. 6d. net.

This small volume should prove a great boon to all engineers who have to test any class of electrical machinery, whether from the manufacturers' or the customers' point of view. In

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very clear language is set forth the various tests usually carried out on all alternating-current and continuous-current machines, as well as the objects of each test, the method of procedure, and the instruments required; and, what is really a useful feature of the book, actual test results of various machines are tabulated and the various curves, showing their performance, plotted fully out. Divided into eight chapters, the first four deal with tests on Induction Motors, Alternating-current Generators, Rotary Converters, Synchronous Motors, and Single-phase Railway Motors. The last four deal with tests on Continuous-current Machines.

The usual guarantees as to the performance of machines are incidentally mentioned, the rules of the American Institute of Electrical Engineers being usually specified. On the whole the book is so excellent as to be beyond criticism; but some of the minor details might bear slight modification. We think the division of induction motors into (1) constant-speed motors, having short-circuited rotors, and (2) variable-speed motors with wound rotors, connected to slip rings, is somewhat artificial and misleading, as there are large numbers of constant-speed motors in operation which have wound rotors solely by reason of the starting torque which is necessary.

The more common English terms might have been used in place of "running" saturation, or "locked" saturation; and we fear the reader will have considerable trouble in understanding what the author means by "total current" on pp. 6 and 7, as English books usually express current per line or per phase. Under regulation tests of continuous-current motors mention should have been made of a stability test at top speed of shunt motors having a large speed range; when these machines are fitted with auxiliary commutating poles they have a marked tendency to run away when moderate overloads are thrown on them unless special precautions are taken to prevent this.

Considering the convenient size and reasonable price, this book should prove very popular. A. N. A.

Elementary Electrical Calculations. By T. O'Connor Sloane. (London: Crosby Lockwood & Son.) Pp. x. + 304.

In reviewing a book which emanates from another country there is always the danger that sufficient notice will not be taken of the ideas held in that country, and that, in consequence, things may be decried which are in reality "standard practice." But since science and engineering are international, we need not be unduly timid on this score, but may fearlessly point out certain points which we consider are in need of considerable improvement.

To begin with, the author has attempted too much. He has, in fact, endeavoured in a "quick-lunch" way to serve up the whole of electrical engineering in just over 300 pages, and at the same time to introduce disquisitions on algebra, trigonometry and the theory of units, matters which, as we have said before, should not be included in works on engineering. The result is that in trying to be concise Mr. Sloane becomes unintelligible and even misleading. By attempting to condense matters, which can only be fully explained in several pages, into a few lines, he is likely to confuse the student, and in being epigrammatic Mr. Sloane will defeat his own ends, for nobody will know what he means.

Turning to Mr. Sloane's book in more detail, we find that the first chapter contains some peculiar notes on elementary algebra, in which we are told that "algebraic addition is the adding together of quantities, taking their signs into account," and "algebraic subtraction is done by changing the sign of the number to be subtracted and then adding the two algebraically"; which is very nice but not very clear. Mr. Sloane's descriptions of electric measurements on p. 6 may be heartily recommended as an example of the way not to do it. Coming to the chapter on "Mechanics and Physics," we find mass, as usual, defined as "any quantity of matter," though, of course, no explanation of what is meant by matter has previously been given. In the same chapter acceleration is defined as the "change of velocity per second," leading us to wonder what the change of velocity per minute is called. The same looseness of wording, with its consequent confusion, is evident throughout the book, and it is useless to multiply instances. The explanations of electrical phenomena are hard to understand, chiefly owing to their brevity, and although attempts have been made to overcome this trouble by the sandwiching of numerical examples throughout the text, these latter, in general, are of so easy a nature that they explain nothing. The same accusation may be made against the examples which are collected at the end of the book. They are practically of the same standard, a very easy one, all the way through, though here again some uncertainty is introduced into the meaning by the author's exposition.

It is an open question whether there is any field for a book such as this, even supposing it to be accurate and well thought out. For a teacher can always supply explanations of electrical phenomena and numerical examples showing their application sufficient for his purpose from his own inner consciousness, and can, further, recommend a good text book to supplement his lectures. This last adjective cannot in justice be applied to Mr. Sloane's book.

RECENT PHYSICAL RESEARCH.

SHORT SPARK GAPS.

BY D. OWEN, B.A., B.SC.

The question of the laws conditioning the passage of an electric spark when the electrodes are at very small, indeed, microscopic or ultra-microscopic, distances apart is of much interest; for example, in regard to the action of the coherer

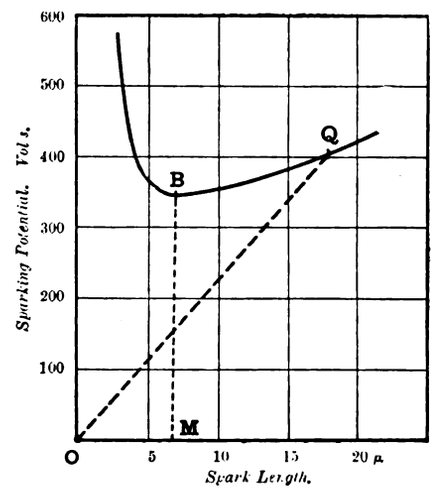

Fig. 1.—Air at Atmospheric Pressure.

detector of electric waves, or in the remarkable instrument recently devised by S. G. Brown for the relay of telephonic currents. In recent years data bearing on this subject have been steadily accumulating, which on the whole agree in pointing to certain definite conclusions.

1. It will be well before referring to this work to state the laws which hold for greater spark lengths. Where the medium in the spark-gap is a gas, the connection between sparking potential and spark length for a given pressure is of the form shown in Fig. 1, which actually represents Carr's results for air at atmospheric pressure. For sparks of appreciable length (beyond the range of Fig. 1) the curve becomes practically a straight line, and is usually represented by the equation $V = a + bd$, where a and b are constants, d the spark length. As the sparking distance is reduced, the sparking potential begins to fall off more and more slowly, until the point B of "minimum sparking potential" is reached; and beyond this, reduction in spark length necessitates increased P.D. OM is called the "critical spark length."

The minimum sparking potential is the same no matter what the pressure of the gas may be, but the critical sparking distance is inversely proportional to the pressure. For air the

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value of the minimum sparking potential is 350 volts, and the critical spark length at atmospheric pressure 6·6 μ(μ = 1 micron = $\frac{1}{1000}$mm.). Results of the same form hold for other gases, the minimum potential depending on the nature of the gas, but being completely independent of the material of the electrodes.

From the form of the curve to the left of B (Fig. 1) it would seem impossible to get a spark through the gas when the width of the spark-gap is reduced much below the critical spark length. Let us consider the action from the point of view of dielectric strength, that is, the potential gradient required to produce a discharge. This quantity is represented, for any point Q on the curve, by the slope of the line OQ. As the spark length diminishes, the dielectric strength rises, the rate of rise being very rapid to the left of B.

2. However, at an electric intensity of about 10^6 volts per centimetre the law represented in Fig. 1 ceases to hold. The mechanism of the discharge appears to alter, for at that value of the field the spark once again passes. This region of short sparking distance and intense electric field appears to have been first explored by Earhart, working in the laboratories of the University of Chicago. His first Paper, on "The Sparking Distance between Plates for Small Distances," appeared in the "Philosophical Magazine" for 1901. Further Papers by him, and by Kinsley and Hobbs, working in the same laboratory, also contributions in the same field by Almy and Shaw, have since appeared. The electrodes employed were sphere and sphere, or sphere and plane, or point and plane. In Shaw's work the distance apart of the electrodes was measured

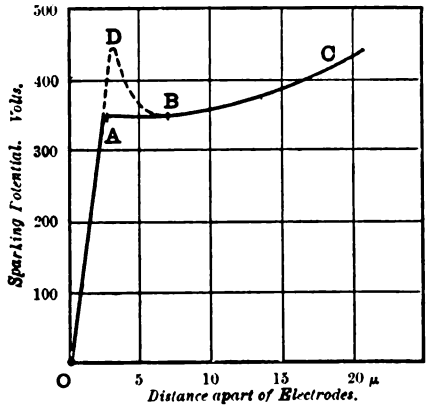

Fig. 2.—Nickel Electrodes.

with his electric micrometer, down to the extremely low limit of $\frac{1}{1000}\mu$; the other experimenters named obtained their spark lengths in terms of the wave length of sodium light, using interference fringes, by whose aid measurement to $\frac{1}{20}\mu$ is a matter of the greatest case.

Fig. 2 represents the general character of the results obtained.

From C to B the sparking potential falls with decreasing spark length down to the critical spark length, which occurs at B. From D to A the sparking potential remains constant. At A a sharp "knee" appears, and from there the curve falls in a straight line to the origin.

The dotted portion BDA represents the kind of curve that would be expected between B and A when using flat parallel electrodes. For such minute distances of separation as are here in question, however, the use of these is impracticable. As a rule at least one electrode was spherical, and in this case clearly the spark will still pass at the minimum sparking potential, not between the nearest points on each electrode, but between points at the critical sparking distance apart. Thus the horizontal portion BA is accounted for. From A to the origin the graph is a straight line, showing that the spark passes, for spark lengths below that of A, for a definite value of electric intensity, which does not depend on the width of the spark-gap.

The position of the point A might depend (1) on the nature of the gas; (2) on the pressure of the gas; and (3) on the material of the electrodes. Fig. 2 actually represents the case for air at atmospheric pressure, with nickel electrodes, the point A having as co-ordinates 2·7μ, 350 volts. Fig. 3 shows Hobbs' results for three gases. The electric field at which the knee occurs is seen to be independent of the kind of gas present. It appears to be also completely independent of the pressure of the gas (over the range of three atmospheres to 1 cm. of mercury). On the other hand, the material of the electrodes is of importance. Fig. 4 shows Hobbs' results in the case of five metals. The metals can be arranged in a series according to the slope of OA, and the results show that the heavy metals are at the head of the series. The electric intensity along OA is least for aluminium, greatest for platinum.

According to experiments by Earhart (1908), if the two electrodes are of different metals, the sparking potential gradient is determined by the metal which is the lower of the

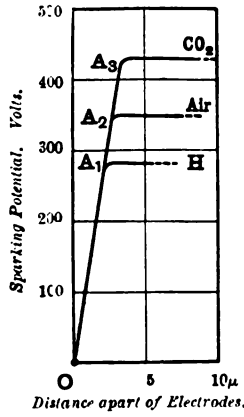

Fig. 3.—Nickel Electrodes.

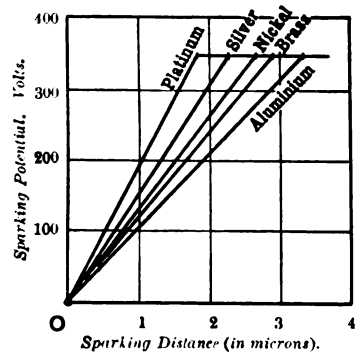

Fig. 4.—Effect of Material of Electrodes.

two in the above-mentioned series. For example, in the case of aluminium and platinum the gradient is the same as for aluminium and aluminium electrodes, and so is uninfluenced by the platinum. It is also, according to the same physicist, independent of the sign of polarity of the electrodes.

3. *Liquid Dielectrics.*—Earhart and Shaw have made experiments in which the spark passes through oil. Fig. 5 (for paraffin oil) may be taken as representative. From F to A the curve is practically a straight line. There is no horizontal portion. At A (10μ, 350 volts) a "knee" occurs. From F

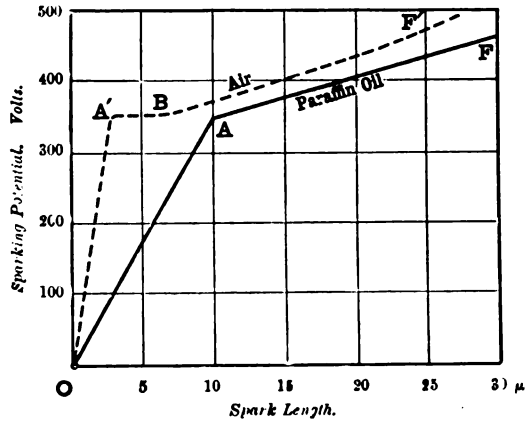

Fig. 5.—Liquid Dielectric.

to A the potential gradient at which sparking occurs has been steadily increasing. Below A the sparking potential is proportional to the spark length, that is, the sparking potential gradient is independent of distance. The dotted comparison curve is for air. The final portions, OA and OA', are similar, and suggest that the mechanism of the spark is the same in each case. It will be noted that for very short distances air has greater dielectric strength than the oil (this applies to all the oils tried), though for much larger distances the reverse is well known to be true. The cross-over point is far to the right of the limits of Fig. 5. The slope of OA depends on the oil used, though the values do not vary greatly. Earhart

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gives the potential gradient for both transformer oil and paraffin oil at 15 kilovolts per millimetre, and for olive and kerosene oils at 23 kilovolts per millimetre.

4. *Electrostatic Attraction.*—For such high electric fields as those corresponding to the region OA the pull of the electrodes on one another becomes quite appreciable. The apparatus used for the above investigations had to be designed with a view to rigidity. The phenomenon of coherence of the electrodes was found to occur throughout the region from O to A, but not for distances to the right of A. This might well suggest that movement together of the electrodes had preceded the passage of current across the gap; indeed, the experiments of Almy purport to show this to have been actually the case. There seems, however, little doubt that adequate precautions were taken, and that the foregoing results should be accepted. The phenomena of coherence remain to be investigated on their own account.

In the case of a loose contact, or where variation of distance between electrodes is actually designed to take place, as, for example, in S. G. Brown's relay, it seems as if electrostatic attraction must play an important part. Consider, for example, an air-gap between flat parallel electrodes of 1 sq. mm. area, at a distance apart corresponding to the passage of a spark with a single primary battery in circuit. According to Fig. 4, the sparking distance for 1 volt is of the order $\frac{1}{3}\mu$. The electrostatic attraction is $\frac{KF^2}{8\pi}$ per square centimetre, K denoting dielectric constant, F the electric intensity. The pull on each electrode works out as 13·5 grammes weight nearly. Assuming the stiffness of the plate, regarded as a spring, on which the movable electrode is mounted, to be such as to balance this attraction for a movement equal to 2μ, we arrive at the value 6·7 kilograms as the elastic restoring force corresponding to 1 mm. movement of this spring. Unless the stiffness of the spring considerably exceeds this value the electrostatic attraction must result in actual contact of the electrodes. Except for the fact that when the spark passes the electric field rapidly falls. In oils the pull will be of the same order of magnitude.

5. *Theory of the Short Spark.*—The mechanism of the discharge to the right of OA has been very clearly established in the case of gases, in terms of the ionisation produced in the gas by the electric field. The ions present gather sufficient impetus under the action of the field to ionise molecules with which they come into collision. These freshly generated ions proceed in their turn to produce more ions. For field intensities below a certain value only the negative ions are effective. Once that limiting value is reached, and positive ions come into play, the ionisation, and so the current in the gas, increases with enormous rapidity with further increase of field, and the spark results. Townsend has worked out this collision theory in a very complete manner in a series of Papers contributed to the "Philosophical Magazine" between 1901 and 1905.

Two explanations have been advanced to account for the phenomena of the very short spark-gap, that is, the region to the left of A in the preceding figures. Shaw supposes the presence on the electrodes of a film of moisture of thickness $0{\cdot}8\mu$. Assuming this film to possess greater dielectric strength than air, the rise in dielectric strength for distances of the order 2μ and below is accounted for. Sir J. J. Thomson has suggested an explanation based on the hypothesis of the presence in metals of freely moving electrons. These electrons have rapid to-and-fro translatory motions, just like the particles of a gas. They cannot escape from the metal because of their charge. If, however, an electric field be established, with the metal as one boundary, the metal being negatively charged, then an electron that has succeeded in escaping a little way outside the metal will be aided in its outward movement by the electric field it finds outside. Fig. 6 will make this clearer. Suppose the electron, whose charge is e, to have passed to the point P, a distance r outside the metal. The method of electric images tells us that the attraction of the metal for e is the same as if a charge e of the opposite sign were placed at P′, the same distance r on the other side of the boundary AB. The pull back on e is therefore $\frac{e^2}{(2r)^2}$, that is, the same as if it were due to an electric field of strength $\frac{e}{4r^2}$, which works out at about $2{\cdot}4\times10^6$ volts per centimetre taking $e=3{\cdot}4\times10^{-10}$ E.S., $r=10^{-7}$ cm., or 10 times the dimensions of a molecule. As will be seen from the curves of Fig. 2, &c., this is of the order of magnitude of the fields actually found for the portion OA. On this hypothesis, then, the spark for these excessively short distances is due to electrons dragged out of the metal by the electric field. The value of the field at which the spark passes might be expected on this view to depend on the material of the electrodes. If negative particles ere alone concerned, the negative electrode alone should be of importance; the effect should depend on the material of the negative, but not of the positive electrode. A discharge, too, should result even in perfect vacuum. The experiments of Hobbs (*see* Fig. 4) show that the effect does vary with different metals. Both electrodes were, in his experiments, of the same metal. Earhart's experiments, referred to above, in which electrodes of different metals were employed, are, however, in opposition to the view that negative carriers alone are concerned, for the effect is independent of the sign of the electric field in the gap.

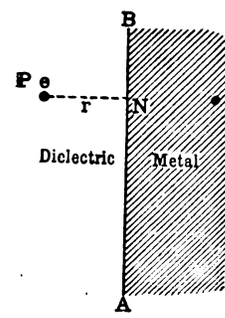

FIG. 6.

Thus far no results on the passage of the spark in the very highest vacuum have appeared.

The nature of the dielectric in the gap would be expected on this same view to be of influence, since the force of attraction on e due to the metal varies inversely as the dielectric constant outside the metal. From the numbers already quoted, it will be seen that for oils the spark occurs for fields of one-third or one-fourth the value required in air. No clear connection with dielectric constant, however, has been ascertained.

THE PROPORTIONING OF ELECTRODES FOR FURNACES.*

BY CARL HERING.

Summary.—The author describes an investigation (analytical and experimental) of the principles underlying the proper proportioning of the electrodes for electric furnaces. The author's conclusions differ very considerably from former practice.

The usual rules for proportioning electrodes for electric furnaces have been based on such factors as allowable current densities, least practicable resistance (hence shortness and large section), lowest heat conduction, the summation of losses due to the electric resistance and to the heat conduction to get the total, &c. Believing that these laws were not based on correct principles, and were therefore unsatisfactory and perhaps even misleading, and as apparently no one had made a thorough investigation of this subject based on unquestioned fundamental laws, the writer has made a careful study of the true principles underlying the proper proportioning of electrodes, based on indisputable physical laws. This analysis showed that former rules were quite incorrect and led us into entirely wrong conclusions. As the value of the annual loss of energy in such electrodes is very large, the correct proportioning is of considerable commercial importance as well as of interest to the engineer. The analytical investigation was then supplemented by an experimental one, in which the necessary physical constants and the behaviour of different electrode materials were determined. The present Paper reviews these investigations from the standpoint of the engineer who is concerned with the proper design and operation of furnaces.

Fundamental Principles.—The fundamental principle of the present analysis of the electrode problem is that the heat gradient at the hot end should be zero. This means that no heat will then traverse through the hot end, either one way or the other; hence no heat from the furnace or its products is lost through the electrode, and the

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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product can, therefore, not be "chilled" by the electrode, as has often been found to be the case with improperly proportioned electrodes. Such an electrode would act as a perfect heat insulator, better even than the walls of the furnace. This zero gradient can be obtained only by having the temperature of the hot end of the electrode equal to that of the furnace. In the present method, this is done by so proportioning the electrode that the current through it will raise the temperature of the hot end to this furnace temperature.

Although the writer's first recommendation of this fundamental principle was met with scepticism and even ridicule, it is now believed to be generally accepted as correct. The first impression—that this would consume much energy—is found to be incorrect; the explanation is briefly that as the heat near the hot end has no easy means of escape, a small amount of energy will soon produce a high temperature. Under simplifying assumptions (and perhaps under all conditions), this state of temperature equilibrium is found to be also the condition of minimum total loss of energy in the electrode.

Although this way of operating an electrode is quite contrary to that dictated by prior practice, which was based on the lowest practicable resistance, it turns out to be the most economical, even though it may involve an intentional increase of the resistance loss. Another advantage is that the whole interior of the furnace then becomes useful. It furthermore means that all the heat escaping at the cold end is then the I^2R heat. Or inversely, if all the heat escaping at the cold end is the total I^2R heat, and neither more nor less, then the temperature of the inner end will be that of the furnace, and there will be no loss of furnace heat and therefore no chilling.

It is evident that this condition can be reached regardless of how good or bad a heat conductor the electrode material is; even with such a very good heat conductor as copper. Hence, even without any further analysis, this shows the fallacy of the oft repeated and generally accepted statement that a good heat conducting electrode material necessarily chills the furnace, and is therefore objectionable. It will at once be seen that electrodes of good heat conducting materials must simply be made smaller in section than others.

There are also a number of other features in which the writer's conclusions differ very radically from former practice. The second one is in the determination of the total loss of energy in an electrode. Formerly the total loss was assumed to be the sum of that due to heat conduction alone, and that generated in the electrode itself by the current. The writer found that this also was a fallacy. The true total is the sum of the conduction heat and only half the I^2R heat, under the simplest condition of constant conductivities and no loss of heat to the walls. This has since been confirmed by others, and is now generally accepted. Under the more complicated conditions of varying conductivities, it is claimed by some to be only approximately true, but in any case it is much more nearly correct than the older method. It is easily seen why it should be so. The heat conducted from the furnace when there is no current, flows over the whole length of the electrode, hence the drop of temperature is proportional to the total flow; but the I^2R heat is generated throughout the whole length, hence is equivalent to the whole of it entering at the middle and flowing over only half the length, or to half of it flowing over the whole length. Hence, as far as the drop of temperature between the ends is concerned, only half of that corresponding to the I^2R heat must be added to that due to conduction alone.

A third point of difference, and one which is still adhered to tenaciously by some, concerns the current density. This was formerly the basis of electrode design, and is still considered so by some writers. The present investigation, however, has shown that the current density does not enter as a fundamental factor which determines the proportions. Even more than that: to base the proportions on current densities may even mislead one into using entirely incorrect proportions with unnecessarily large electrodes and losses of energy. It may have been found that when certain current densities were exceeded troubles arose, but in the writer's opinion the mistake made was in attributing them to the current densities instead of to the length. The writer's conclusions are that current densities need not be considered at all as a determining factor.

The fourth point of difference in the present method is in the resistance. The writer has found that the usual rule to make it as low as practicable is a mistake. It can be shown that the resistance for the most economical operation is not at all a matter of choice. It is determined by the conditions of the problem and is fixed by the temperature, current and material; it is different for different materials. Hence to try to make the resistances the same for different materials is improper designing.

This investigation applies to the electrode proper—that is, the part which passes through the walls, and in which the co-operation of the two heat flows is the governing feature. Any additional parts within the furnace or projecting outside the walls are not theoretically essential parts, even though they may be very necessary in practice, and they are evidently determined by entirely different conditions and considerations. Hence throughout the present Paper the proportions of the electrode, and particularly the length, refer to the essential part passing through the wall; the prolongations at either or both ends, if any, must be determined separately. When the metallic terminal surrounding the outside end is close against the wall and relatively short as compared with the part within the walls, it would probably be sufficient for most practical purposes to consider the electrode proper as ending at the middle of this terminal. And unless the cooling water is very close to the electrode, and the heat resistance between the electrode and cooling water is very low, the temperature at the virtual end of the essential part of the electrode will be higher, and perhaps considerably higher, than the cooling water; hence the drop of temperature in the electrode proper will be less. The author shows later that the hotter the outside terminal the smaller the loss in the electrode.

This shows the fifth point of difference from former views. Instead of trying to keep the outside terminals as cool as practicable, we ought to try so to design them as to let them get as hot as practicable, even to the extent of heating them with a lamp, when such heat is cheaper than electric heat. This will economise power, provided, of course, that the electric heat comes from the electrode proper and not from a poor terminal contact. The section of the electrode, however, becomes larger by raising the outside temperature.

A sixth point of difference from former practice brought out by this analysis is that, instead of tending to make electrodes large, we should, on the contrary, try to make them small, as they can then be just as efficient, and there may even be other advantages besides economy of material, terminals, &c., in doing so.

Another complete departure from former methods is in the abandoning of the conductivities of the materials as factors in calculating electrodes and electrode losses. The writer found that the desirable qualities of electrodes do not depend on either the electric or the thermal conductivity alone, but on certain relations between the two. The analysis shows that our former deep-rooted conviction that a high heat conductivity is a bad feature for an electrode is entirely wrong. The fact is that it may be a good or a bad quality, depending upon the electrical conductivity. In the writer's method of designing electrodes, both qualities have been abandoned entirely as a basis of proportioning, and they have been replaced by two new qualities which are true and correct measures of excellence of those materials when they are used for electrode purposes; moreover, they greatly simplify the calculations. Apparently the only objection to them is that they are not yet found in that form in tables of physical properties; they are, however, easily calculated from the conductivities if the latter are known.

These two new measures of electrode qualities are the "electrode voltage" and the "specific cross-section," and are constants for particular materials—that is, they are independent of the dimensions. The lower their values are the better is the material for electrodes.

Analytical Investigations.

The author, following the teachings of Lord Kelvin and Taite, considers it is best to solve such a problem first under the simplest possible conditions or premises, and afterward to consider the refinements. This made it possible to determine the fundamental relations or laws of electrodes. In this way it was found that most, and perhaps all, of the more important corrections due to the minor factors could be combined into two experimentally determined coefficients or constants. A method was then devised by the writer for determining these constants experimentally, and the results are given below. The premises of the present simplified analysis are: That the cross-section is uniform, that the two conductivities have the same values over the whole length, that the electrode is heat insulated except at its ends, also that the Thomson effect, the skin effect and other similar minor factors, are neglected. Under these premises the following relations are rigid and exact:—

Laws of Electrode Losses.—(*a*) The combined loss through the cold end of an electrode is equivalent to the sum of the loss by heat conduction alone (when there is no current) and half the I^2R loss. (*b*) This combined loss will be least when the loss by heat conduction alone is made equal to half the I^2R loss; the total loss will then be equal to the I^2R loss, and no heat will be conducted from the interior of the furnace. (*c*) This minimum loss is dependent only on the material, current and temperature, but not on the absolute dimensions; it merely fixes the relation of the cross-section to the length, but leaves a choice of either; hence (*d*) for economy of electrode material the length should be made as short as practical considerations permit. (*e*) For each material there is a definite minimum loss

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of electrode voltage which depends only on the temperature and is independent of the dimensions or the normal current for which the furnace is designed; hence (*f*) the best possible electrode efficiency for any material may be determined from the total voltage of the furnace, and this minimum voltage due to the material and the temperature, and is independent of the dimensions. (*g*) The temperatures indicated by the heat gradient of the combined flow are equal to the sums of those of the individual flows. The proof of these laws is given in a Paper by the writer on "Laws of Electrode Losses in Electric Furnaces."*

The starting point is the fundamental principle, first announced by the writer a year ago as the proper one—namely, that no heat should leave or enter the furnace through the electrode; or in other words, that the heat generated by the electrical resistance shall raise the temperature of the hot end to that of the furnace; it is shown that under the given conditions this is also the condition of least total loss.

The author here explains that it is quite correct, and greatly simplifies the calculations to represent and measure a flow of heat in terms of watts, instead of in calories per second. Heat is energy, and a rate of flow of heat per second is power, hence it is measurable in units of power, like watts. When the heat conductivity of a material is given as 10 watts for an inch cube, it simply means that with one degree Centigrade difference of temperature between two parallel sides, and perfect heat insulation on the other four, the same amount of energy will flow through as heat, say into water at the cold end, as would enter the water from a resistance in which 10 watts were being dissipated. It is recommended that in future all thermal constants pertaining to electrodes be given in terms of watts instead of calories per second. The conversion factors are: Gramme calories per second $\times 4{\cdot}18617 =$ watts, and watts $\times 0{\cdot}238882 =$ gramme calories per second.

Formulæ.—The following formulæ are in terms of actual units, and may therefore be used directly in practice. Let S = cross-section in square inches; L = length (essential length) in inches; I = current in amperes; W = watts generated electrically in the electrode; H = heat flow in watts which would flow if there were no current; h = heat flow in watts which enters the hot end from the furnace; X = heat flow in watts leaving the cold end; T = temperature drop in degrees Centigrade between the hot and cold ends; r = electrical resistivity in ohms, inch cube units; k = thermal conductivity in watt, inch cube units; e = electrode voltage; E = total voltage between the two ends, or the watts per ampere; s = specific cross-section in square inches; S′ = section in square inches per ampere per inch of length.

In general, the flow of heat in watts at the cold end is

$$X = H + W \div 2$$

and entering at the hot end $h = H - W \div 2$, in which $H = kTS \div L$ and $W = rI^2L \div S$.

The total flow out of the cold end will be a minimum when $H = W \div 2$. Representing this minimum flow by mX, then

$$mX = 2H = W = I\sqrt{2krT} = Ie\sqrt{T}.$$

This it will be seen does not contain either S or L, which means that this is the same for all dimensions; it includes the condition, however, that the ratio of the section to the length is $S \div L = I\sqrt{r \div 2kT}$, which means that either the length or the section may be made anything one desires, provided only that the ratio is equal to the above. As the length is usually fixed by other conditions, this formula is best written $S = IL\sqrt{r \div 2kT}$.

The electrode voltage is $e = \sqrt{2kr}$, and the total voltage is $E = \sqrt{2krT} = e\sqrt{T}$, both of which are seen to be independent of the dimensions or the current, the electrode voltage being even independent of everything except the properties of the material, and hence itself a physical constant.

The total voltage E being known, a convenient way is at hand of finding out whether the hot-end temperature of the electrode is that of the furnace or not, as this voltage might be measured without much difficulty during the operation of the furnace; if the measured voltage is found to be less, the electrode is chilling the furnace, if greater the electrode is getting hotter within the wall than it is in the furnace.

The electrode voltage is that physical constant which is a true measure of the loss of power in an electrode. When multiplied by the square root of the temperature drop and by the current, as shown above, it gives the minimum loss in watts which can possibly be obtained with that material for that current and temperature. Hence if its value is known it is not necessary to know the two conductivities in order to calculate this loss of power.

The quantity E is measured directly in the experimental determinations; hence it is known for each temperature and material. Substituting its value in the equation for minimum flow gives $mX = IE$. That is, the minimum loss in watts may be determined directly by multiplying this value of E by the current; hence the voltage E may be called the "watts per ampere." This shows the simplified method suggested by the writer for calculating these minimum losses. It consists in tabulating for each material the values of E for different temperatures, as obtained directly by experiment; then for any given case, in which of course the current and temperature are given, one needs merely to multiply the corresponding value of E by this current to get the result.

Returning to the formula for S, if I, L and T are made unity, that is, for 1 ampere, 1 in. and 1 degree Centigrade, the resulting cross-section (now represented by s) becomes $s = \sqrt{r/2k}$. This the writer proposes to call the "specific section," because it is a physical property of the material.

Now let S′ be another quantity, so that $S' = s \div \sqrt{T} = \sqrt{r \div 2kT}$. It will then be seen that in the same way and for the same purpose as was described above for E as compared with e, it is possible to determine by direct measurement the values of this quantity S′ for various temperatures and for each material. When these values are tabulated it again becomes an extremely simple matter to calculate the proper cross-section, because $S = ILS'$. This quantity S′ is therefore here termed the "section per ampere per inch of length." A set of values of both S′ and E is given in a table in the Paper. When S′ is not known, then $S = ILs\sqrt{T}$. It will be seen that again the two conductivities drop out and need not be known. In the absence of these tables the values of e and s should be used. If they, too, are unknown, the mean conductivities must be resorted to. If in turn these electrode means are not known, and the conductivities at the specified temperature are known, the mean values must first be determined from them. The writer calls attention to the fact, on which particular stress was laid in his first published description of his method, and which fact has been entirely ignored by the critics, that the curve of the combined losses is quite flat at its minimum point. This means that a considerable error can be made in the cross-section without affecting the power loss appreciably.

Various other relations exist between these old and new quantities which at times are of interest and use. They are easily deduced, and are therefore merely summarised here—viz., $e = I \div W\sqrt{T}$, $e = r \div s$, $s = e \div 2k$.

All the above is based on the premise that the temperature variations of the physical constants may be neglected; this so greatly simplifies the formulæ and relations that the numerous useful and interesting results given above are obtained. In the present method the values of the conductivities and other deduced factors obtained are the mean values peculiar to electrode conditions. What they really represent are the values of another, or "equivalent electrode," the conductivities and other properties of which are the same as these mean values, and are constant from end to end—that is, they are independent of the different temperatures along the electrode. Such an equivalent electrode will, as a whole, operate in exactly the same way, and hence, as far as the flows of heat at the two ends are concerned, it is theoretically identical. It differs, however, in the shape of that part of the temperature gradient which is intermediate between these two end points.

(*To be concluded.*)

* "Trans." Amer. Electrochem. Soc., Vol. XVI., p. 265.

CORRESPONDENCE.

FISCAL POLICY AND THE ELECTRICAL INDUSTRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Mr. Hookham's letter of the 14th one sees exposed, in all its nakedness, the basic error of the free importer's mind. In his last paragraph he declares that his own interests, and those of Mr. Arthur Chamberlain, are opposed to those of his country. Coming from one whose exceptional talent and life-long work has been a great benefit to his country, and the admiration of all who know him, such a statement passes my understanding. Perhaps it is because I am an "average manufacturer," and not a "life-long student of economics." Yet I believe myself able to understand the men who have done more than argue—laid down their lives for their country, thankful for the privilege, and proudly conscious of the fact that it was "in their own interests."—I am; &c.,

Middleton, Lancs., June 24. A. BRUCE ANDERSON.

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EFFICIENCY OF SHORT SPARK METHOD OF GENERATING ELECTRICAL OSCILLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Messrs. Eccles & Makower accuse me of begging the question by equating the efficiencies before and after quadrupling the power which doubled the aerial current (and also the primary current), as found by experiment.

Double the aerial current involves four times the aerial energy expenditure, on the authority of Hertz, who for his part applied Poynting's theorem to calculate radiation. If four times the power supplied produced four times the aerial energy the efficiency was unchanged; wherefore it is experiment and not my fancy which disposes of the argument advanced by my contradictors.—I am, &c.,

Lyons, June 20. R. C. GALLETTI.

We have submitted Mr. Galletti's letter to Messrs. Eccles & Makower, from whom we have received the following reply:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Accepting as an experimental truth your correspondent's statement that quadrupling the power supplied to the spark-gap doubles the oscillatory currents in the primary and secondary circuits, what follows is that if the efficiency of transference before quadrupling is the same as that after, then the resistance of the spark-gap is the same before and after; but if, on the other hand, the efficiency is not unaltered the resistance is not unaltered. This was what we indicated in our last letter.

It appears that Mr. Galletti's attack on our protracted series of direct measurements of efficiency is based on a rough indirect method of estimation carried out with apparatus whose details have not been divulged. We shall be better able to discuss Mr. Galletti's suggestions when he has made and published a substantial series of measurements and a full description of the apparatus used.—We are, &c.,

W. H. ECCLES.
A. J. MAKOWER.

South Western Polytechnic Institute, London, June 28.

COST OF ELECTRIC POWER AT NIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The remarks in the leading article in your last issue with reference to the phenomenal results tentatively put forward by Mr. Shawfield are very interesting. I have for the past three or four years been endeavouring to bring it home to electrical engineers that there are certain conditions in a night (and sometimes in a day) load when quite a considerable number of extra units could be generated at a ridiculously low price for coal charges, but I have never in my wildest dreams got quite so far as the results quoted by you. Knowing, however, the careful way in which Mr. Shawfield usually keeps his records, it seems highly probable that the coal bill due to the additional units was an exceedingly small one, and is a further justification of the use of accumulators in stations where such conditions obtain. Not that I have any doubt but that their use can be justified in the great majority of cases, but I am persuaded there will be found many cases where not only in the dead of night, but at intervals during the daytime, the charging of accumulators can be carried on at a ridiculously low cost.

The whole point of my 1908 I.M.E.A. Paper was to bring home that if the cost of the energy going into the cells was of the order of 0·1d. or 0·15d. per unit, and if the discharge was available for peak purposes when the energy was worth four to five times that amount, the inefficiency of the accumulator (which has been made so much of) becomes of correspondingly little importance. It is pleasing to know that many engineers are beginning to recognise this, and that there are occasions when the cost of the energy entering the cells can reach such low figures as those suggested.—I am, &c.,

Birmingham, June 28. A. M. TAYLOR.

ELECTRICAL PROPULSION OF SHIPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great interest the articles in your special Marine issue describing systems of electric propulsion, and more particularly what has been said regarding the adaptation of the squirrel-cage type of induction motor for propelling ships, this motor being of the utmost practical value. It appears to me that variation of speed by altering that of the turbines is not so simple or so efficient in steam consumption as where the turbine or prime mover is kept at constant speed, working within the range of its best efficiency, and at the same time the speed of the motors is varied by the frequency and voltage at their terminals. The question of efficiency of the turbine running at its most economical speed is the determining factor in favour of electric propulsion of ships, where the number of generator units can be varied as the demand for power varies, instead of having to use all these units at a low steam economy when permanently fixed on the propeller shaft, as now in use in our large turbine-propelled ships.

The cardinal and starting point for design is propeller efficiency, coupled to the most economical turbine speed—*i.e.*, the minimum of steam used, with the maximum of propelling efficiency of the boat. If a high-speed propeller could be used with advantage a still higher turbine and motor speed could be adopted, with consequent saving in weight all round.

In all transportation problems the vital economical question is the cost of fuel per ton-mile. Now which is the cheapest system to equip and maintain to obtain this object at sea, not forgetting speed?

I think, sir, that you have done the electrical and marine industries a good turn in issuing this very interesting Marine Number.—I am, &c.,

Golder's Green, June 23. A. H. BINYON.

FARADAY SOCIETY.

At the meeting of the Faraday Society held on Tuesday, June 21st, in the rooms of the Chemical Society, Burlington House, W., Dr. F. M. Perkin, treasurer, in the chair, M. PAUL GIROD sent in a Paper entitled

"Studies in the Electro-metallurgy of Ferro-Alloys and Steel," which, in the unavoidable absence of the author, was read by Mr. F. W. Harbord.

The first portion of the Paper describes the various ferro-alloys which are manufactured in Girod furnaces at the works of the Girod Company at Courtepin (3,000 H.P.) and, principally, at the new works at Ugine (20,000 H.P.), where the furnace electrodes are made.

Ferro-Vanadium.—Two varieties are made, one containing 45 to 55 per cent. vanadium and 3 to 3·5 per cent. carbon, and the other 30 to 40 per cent. vanadium with 0·5 to 1·5 per cent. carbon. This alloy is employed almost entirely in the manufacture of rapid tool steels with great cutting powers.

Ferro-Tungsten.—Three alloys are made, containing respectively 83, 78·5 and 73 per cent. tungsten and 0·6, 1·7 and 3·5 per cent. carbon, mostly used for steels to be tempered in air.

Ferro-Molybdenum.—This alloy carries 75 to 80 per cent. molybdenum and 3 to 4 per cent. carbon. The sulphur is removed from the high sulphurous ores in the electric furnace in one operation. Experience has shown that the high carbon content facilitates the fusion and the mixture of this and the vanadium alloys.

Ferro-Chromium.—The principal alloys made contain about 60 per cent. chromium and from 0·6 to 9 per cent. carbon, with 0·2 to 2·25 per cent. silicon. For the removal of oxygen from fine steels silico-manganese-aluminium and silico-calcium-aluminium alloys are made.

Ferro-Silicon.—This is the alloy most largely used, and the varieties made contain 25-30, 40-75, 75-80 and 90-95 per cent. silicon. The first of these is employed principally in converters, and the richer alloys chiefly for the removal of oxygen and for silicon-steel to be converted into transformer iron. There are 30 furnaces at Ugine, 18 utilising 300-750 H.P., and nine about 500 H.P.

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Electric Steel Furnace.—The second portion of the Paper describes the Girod steel furnace with conducting hearth now in wide use for converting scrap-iron into best quality steels. A feature of the furnace is that the metal conductors have only to be slightly water-cooled, at the parts not in contact with the molten metal, and their life is almost infinite. The large furnaces have a capacity of 15 tons. The mean content of the charge used at Ugine includes 0·3 to 0·4 per cent. carbon, 0·1 to 0·3 silicon, 0·6 to 0·8 manganese, 0·07 to 0·12 sulphur and 0·07 to 0·12 phosphorus, while the best refined product contains 0·05 to 1·5 per cent. carbon, 0·15 to 0·25 silicon, 0·25 to 0·35 manganese, 0·015 sulphur and 0·015 phosphorus.

The Paper concludes with an outline of the two processes, oxidation and reduction, which constitute the refining action of the electric furnace. Tables showing the mechanical qualities of the products are appended.

The CHAIRMAN, in opening the discussion, remarked on the comparative backwardness of this country in the adoption of electric steel refining. The question of cheap power in this connection was not so vital as was sometimes supposed.

Dr. W. ROSENHAIN thought that if the claim that best tool steel could be made from scrap was true, it would revolutionise the Sheffield steel industry. He believed the Sheffield manufacturers were alive to this, and were experimenting in a careful and systematic manner.

Mr. W. R. COOPER also remarked on the fallacy of attaching undue importance to cheap power.

Mr. E. RISTORI pointed out that practically all types of electric furnaces in use absorbed about the same amount of energy per ton of steel. England had not taken the lead in this matter of electric refining, and she was not following quickly enough.

Mr. F. W. HARBORD, referring to the remarks of the previous speaker, said the value of the results obtained in an electric furnace depended on the facilities present for removing slag carrying the impurities. Recent forms of induction furnaces now made provision for this. He personally had no doubt that steel equal to the best crucible steel could be made from scrap in the electric furnace.

Mr. ERNEST F. LAW then read a Paper on

"The Failure of the Light Engineering Alloys, particularly the Aluminium Alloys."

The author draws attention to the fact that recent developments in aviation and other branches of modern engineering have created a rapidly increasing demand for suitable light alloys, and that up to the present the metallurgist has not been able to meet this demand satisfactorily. Considering the expectations which were entertained for the aluminium alloys a few years age, we are forced to the conclusion that in this respect aluminium has been somewhat of a failure.

The constitution of the alloys is then briefly dealt with, and the fact noted that aluminium does not alloy in the true sense of the word with most of the common metals, but combines with them to form brittle metallic compounds. These alloys, during the course of time, spontaneously disintegrate and fall to powder. This fact appears to have been first noticed by the late Sir Wm. Roberts-Austen, and is due to a molecular or allotropic change taking place in the solid alloy. As so many of the alloys undergo this molecular change, it is probably due to an inherent property of the aluminium, and the question is raised as to whether it is possible that aluminium itself exists in two allotropic forms, and that the change from one to the other becomes apparent when the metal is alloyed with another metal. It is shown that there is evidence in favour of this view, inasmuch as aluminium is known to undergo physical changes during cooling. The evidence is considered briefly, and it is pointed out that, judging by the experience we have gained in the case of the allotropy of iron, if aluminium also proves to be an allotropic metal, then a study of the molecular changes may lead to results of the utmost practical importance.

The CHAIRMAN said that metals other than aluminium, such as calcium, manganese and chromium, disintegrated in the way described in the Paper.

Dr. R. SELIGMAN said the lack of cohesion in aluminium below its melting-point existed in the very purest specimens. He, therefore, questioned whether the phenomena described was due to impurities.

Dr. J. A. HARKER described some experiments he had made in the cooling curve of very pure aluminium. An indication of a kink in the curve appeared at 630°C. (m.p. 657 deg.), but the results were not satisfactory.

Dr. W. ROSENHAIN thought the failure of aluminium alloys was less than the Paper would seem to suggest. He described the microscopic changes that he had observed when Al-Mg alloys disintegrated. These polymorphic changes that took place were not confined to metals; they occurred, *e.g.*, in certain silicates of calcium. He believed that allotropic changes in metals depended on the presence of other metals.

Mr. W. H. MERRETT described experiments he had made which confirmed what had been said regarding the anomalous behaviour of aluminium and its alloys. It was interesting that the addition of 5 per cent. bismuth greatly facilitated the turning and casting of aluminium.

Dr. T. M. LOWRY said it was remarkable that, unlike other metals, the addition of aluminium and silicon did not harden iron, while it increased its magnetic permeability and decreased its retentivity.

NATIONAL TELEPHONE CO.'S STAFF DINNER.

The sixteenth annual dinner of the staff of the National Telephone Co. was held at the Trocadero Restaurant, London, on Thursday evening last, and was, as usual, numerously attended, the staff and guests numbering about 300. The chair was occupied by Mr. ALBERT ANNS, who was supported immediately by Mr. Geo. Franklin, Litt.D., president of the company; Lord Harris, Sir Albert Rollit and Mr. W. A. Smith, directors; Sir Robert Hunter, C.B. (solicitor to the Post Office); Sir John Gavey, C.B., Sir Alex. Kennedy, LL.D., Major O'Meara, C.M.G., Mr. Leonard Stokes, R.I.B.A., Mr. A. H. Norway, Mr. Frank Gill (engineer in chief), Mr. S. J. Goddard (general superintendent), Mr. Edward Morton, K.C., Mr. H. H. Gaine, Col. C. B. Clay, Mr. H. Laws Webb, Mr. H. Graham Harris, Mr. G. F. Preston, Dr. R. M. Walmsley, &c., &c.

After the loyal toasts, and a feeling reference to the death of the late King Edward,

The CHAIRMAN said they would join with him in regretting that neither the Postmaster-General, nor the Assistant Postmaster-General, nor the Secretary of the Post Office were able to be present that evening. Sir Matthew Nathan had accepted their invitation, but owing to the fact that the Post Office Vote was being discussed in Parliament he was unable to be amongst them. The British Post Office was a marvellous organisation, and they were justly proud of it. The last 12 months had been, like many years before it, a period of hopes and disappointments. Last year there were rumours of an early settlement of the main points that had arisen in connection with the transfer of the National Company's undertaking to the State, but the present moment found them preparing for the great fight which was apparently inevitable. There were many gentlemen present, as their guests that evening, who would become their adversaries when the time came for the final struggle. They were great fighters, but they were fair fighters, and whoever came out on top would, he hoped, deserve that desired situation. He put the cost of fighting the final settlement as not far short of £100,000. With regard to the development of the telephone, the National Company were spending about half the amount on the development of their business that they were spending two years ago. This notwithstanding, their revenue and their profits were progressing in a most satisfactory manner, and they hoped next year to be reaping a golden harvest from the seed which had been sown in past years. He regarded the prospects from the shareholders' point of view as very bright. He did not, however, think they were quite so brilliant from the staff's point of view. Reduction in capital expenditure, of course, meant less employment, and although successful efforts had been made to provide work for the construction staff, it had still resulted in hundreds of the company's men having to seek employment elsewhere. They were sorry to lose these men, and heartily wished them the best of good luck in their new surroundings. There was still the municipal competition at Hull and Portsmouth, but he thought it would not be long before this would be extinguished. With regard to the transfer they would be handing over to the State over 500,000 clients and a revenue of between 3½ and 4 millions a year. He thought it would be agreed that the transfer of such a highly valuable undertaking and organisation was one unique in the annals of this or any other country. The dead assets—the poles, wires, switchboards, instruments and so forth—were to be scheduled and valued, but the live assets, the brains and the energy and the devotion which had created that wonderful business would not be valued; but they were priceless assets. He knew that many of the staff were worried and unhappy as to their future prospects, and he could only echo the regrets of the president and other members of the board of directors of the National Company that they were unable to give the staff those full assurances that would make them as happy and contented as they deserved to be. He still hoped and believed there would be a happy issue out of all their afflictions. He took that opportunity of congratulating the Staff Transfer Association upon the good work it had done. He understood that the outstanding burning question was the claim made by the association on behalf of the staff that service with the company should count for the purposes of pension and other matters as service for the State. He hoped their future masters would remove any doubt on this point. He asked them to drink to the toast of "Success to the National Telephone Company," coupled with the name of their esteemed president, Mr. Geo. Franklin.

The toast was drunk with great cordiality.

Mr. FRANKLIN said it had been for several years his good fortune to respond to this toast and to acknowledge, on behalf of the directors, the hospitality of the staff. At present the subject they were all chiefly concerned in was what a Scotch divine had called their "latter end." The transfer of their undertaking to the State involved questions of the highest importance and the utmost delicacy of treatment, and just as in the past the company had been able to count upon the loyalty and devotion of a united staff, he ventured to hope this co-operation would continue until the transfer was an accomplished fact. Those who had shown such loyalty to the company might be relied upon to show equal loyalty to the State, their new masters. When the Post Office took over the 18,200 servants of the National Company, they would find this a most important asset. During the past year the company had added 32,153 stations, bringing the number up to 516,888. The company had now 1,569 exchanges, an addition of 14 for the year, and the total messages transmitted over their lines had been 1,362,000,000, an increase of 39,000,000 on the year, the cost per message being 0·51d. It was to the credit of the company that within a year's expiry of its licence it had still put on 30,000 subscribers in a year and was spending money in catering for the needs of this large addition to its customers. He

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could imagine companies with less public support and a less high ideal might be content with letting matters go. The board of the National Telephone Co. would cordially join hands with the Post Office in order to arrive at a satisfactory solution of the problems before them, which he hoped would result in justice being done alike to the staff and to the shareholders of the company (cheers).

Col. C. B. CLAY proposed "Our Guests," and expressed the happiness of the staff in having among them a number of their directors, a number of representatives of the Post Office, and an old colleague, Mr. Preston, engineer of the State Post Office telephone service. There were also present many representatives of the engineering and legal professions, whom they cordially welcomed. He would specially mention Sir Alex. Kennedy, Mr. Edward Morten, K.C., and Mr. Leonard Stokes, who had been chosen as president of the Royal Institution of British Architects. He coupled with the toast the names of Sir Albert Rollit and Sir Robert Hunter.

Sir ALBERT ROLLIT said he appreciated the conjunction of his name with that of Sir Robert Hunter. He appreciated also the kind remarks which had fallen from Col. Clay, and in reply might say that the directors had always tried to be on good terms with those with whom they had been associated in the great enterprise of the National Telephone Co. It was pleasant for the directors to know that this position had been recognised by the staff. They might all be proud of having belonged to the National Company, which might pass away, but that pride would still remain. They had been pioneers of speedy communication. As a guest he greatly valued the splendid hospitality which the staff extended to them, and especially on behalf of the directors he returned hearty and grateful thanks (cheers).

Sir ROBERT HUNTER joined in the regret expressed by the chairman at the absence of other representatives of the Post Office. He had been present at many of these dinners, and looked back upon them with great pleasure. Amongst his memories were those of Mr. James Staats Forbes. He had negotiated with him, had dined with him, and had heard him tender evidence before a Select Committee, and he was not sure in which capacity he most admired him. He also had agreeable memories of their late manager, Mr. Gaine, who had on numerous occasions conducted important and delicate business with him. Amongst recent recollections, he remembered that Mr. Anns, in presiding last year, expressed a presentiment that that dinner might be their last, and it would be remembered by those who were then present that the president, Mr. Franklin, premised that on the next occasion Sir H. Babington Smith (the then Secretary to the Post Office) might be in the chair. Neither prognostication had eventuated. On the contrary, the only difference between their present gathering and that of last year was that Sir Babington Smith had left them. He believed there was a reason for this, and it was that Sir Babington had come to the conclusion that he could make nothing out of Mr. Franklin, and was destined to undergo a crushing diplomatic defeat if he remained at the Post Office. He was now living on the shores of the Bosphorus in comparative poverty (laughter). Coming to the transfer, one thing seemed certain, that before long the gentlemen representing the staff of the National Telephone Co. would become, directly, servants of the State, and when that event happened he was sure they would receive a most cordial welcome at the hands of their colleagues already in that service. In fact, he regarded that fellow-service as already existing. For nearly 30 years the company had conducted a great and most important branch of the telegraph service. He thanked them for the cordiality with which the toast had been received.

Mr. A. E. RUDDOCK proposed the toast of the chairman. Mr. Anns' abilities were obvious to every member of the staff, just as his caligraphy was often—at least once a month—very welcome; but it was not so much his ability that appealed to them as his character, his personality, and the absolute assurance that every member of the staff felt in his fairness. There had never been the least suspicion of favouritism of any kind, and it was that feeling which made Mr. Anns what he was to them. When the time came for the transfer, there would be many who would miss the old company, and their old leaders, but whether Mr. Anns remained to take an active part in telephonic matters or transferred his activities to other spheres the staff would always remember him with esteem and affection (cheers).

The toast was drunk with musical honours.

The CHAIRMAN having briefly replied, a very enjoyable function terminated.

During the evening an excellent musical programme was provided.

L.C.C. TRAMWAY ACCOUNTS.

On Tuesday the Finance committee of London County Council reported on the accounts of the tramways department for the year ended March 31.

The total capital expenditure to March 31, 1910, amounted to £10,709,504, of which £1,225,942 was incurred during 1909-10. The outstanding debt was £9,017,507, the difference (£1,691,997) having been paid off, including £1,372,337 (12·8 per cent.) out of revenue. Deducting the value of surplus lands held as an asset against debt (£118,408), the net debt was £8,899,099. There is a reduction of £9,010 in the amount (£1,032,446) of debt outstanding on account of obsolete capital expenditure.

The available surplus, after meeting charges for interest, repayment of debt and other items, was £192,109, an increase of £3,783 over the original estimated surplus (£188,326). £7,273 of the surplus is due to an unusua credit in respect of income tax overcharged in previous years. The committee think that, considering the magnitude of the estimates and the difficulty of forecasting the dates when various sections of the lines will be reconstructed for electric traction, the close approximation of the actual to the estimated results is very satisfactory.

Taking the result of the electric system by itself, the surplus on working is equal to 44·11 per cent. of the gross receipts, against 42·99 per cent. in the previous year. The traffic receipts obtained from the working of the electric lines averaged 11·21d. per car-mile, and, including advertisements and other sundry receipts, the total receipts were 11·48d. a car-mile, against 11·81d. The decrease was due to the abnormally wet summer. The average fare was 1·06d., compared with 1·07d.; the expenses worked out to 6·42d. a car-mile, including 0·85d. for power. Adding 0·73d. for debt charges in respect of power, the total expenses for power were 1·58d. a car-mile, against 1·71d. in 1908-9. The decrease in cost of power, due to the development and fuller use of Greenwich generating station, was to be noted with satisfaction. In 1906-7, the first year of working the station, the total cost of power was 2·07d. a car-mile. Including debt charges for power, the total expenses worked out at 7·15d. a car-mile, compared with 7·37d. There was also a slight decrease per car-mile on the other heads of expenditure in respect of electric traction. The surplus on working was 5·06d. a car-mile, against 5·07d., 5·16d. and 5·17d. in the three preceding years. Although the receipts per car-mile were decreasing, the expenses were also decreasing, with the result that the surplus of 5d. a car-mile, on which financial estimates for some years have been based, has been maintained, but with an increasingly small margin. Only about 20 miles of horse lines remained open at the end of the year, and the estimates of 1910-11 provide for the electrification of about 14½ miles of horse lines, which will leave 5½ miles still to be dealt with.

Provision for renewals at ¾d. per car-mile run on lines worked by the Council required £110,060 out of the net surplus of £192,109. Adding to this £21,571 for shortage of previous years and £600 in respect of the Harrow-road lines, which are not worked by the Council, the total provision made in the year for renewals was £132,231, leaving £59,878 to be transferred to general reserve. The total in the renewals fund was £395,022, of which £336,266 had been invested. The general reserve fund had been increased during the year by interest on the corpus of the fund and by £59,878, the balance remaining of the surplus on the year's working after providing for renewals. After deducting expenditure of £25,265 in connection with the reconstruction of the Aldgate to Bow lines, the balance of the fund was £70,752. Out of a total of £723,386 chargeable to the tramways account in respect of street improvements, £305,090 has been brought into charge up to March 31, 1910.

Discussion.

Mr. E. WHITE, in moving the adoption of the estimates, said the committee were dealing with the question of the electrification of the horse lines, and 14 miles of such tramways were practically in hand. They still had some 9 miles of single track to deal with, but there they had to contend with difficulties. The Council were very generous in the matter of workmen's fares, and the total number of people who availed themselves of such facilities last year were 29,969,000. There had been a great increase in ½d. fares, of which there were some 236 stages. The number of passengers carried on the ½d. stages had increased from 20·12 per cent. in 1906-7 to 25 per cent. If the Council insisted upon reducing fares and extending the length of the stages the Highways committee must not be blamed if the financial results were unsatisfactory. The rate per car-mile had already fallen 11·48d., and if the amount fell by another ½d. the balance now shown would disappear. The Board of Trade had granted permission for the use of trailer cars in order to obviate the difficulty of overcrowding, and experiments would shortly be tried on the Euston-road to Hampstead Heath line.—The estimates were passed.

TECHNICAL EDUCATION CONFERENCE.

The fourth annual conference of the members of the Association of Teachers in Technical Institutions was held at Birmingham last week.

The president (Mr. J. WILSON, of the Battersea Polytechnic), in the course of his presidential address, said that their membership was steadily increasing, and with it their prestige, influence and usefulness. The future position of England as a front-rank commercial nation depended mainly upon the increased application of scientific knowledge and methods to industry and commerce, and the thorough technical training of all ranks of the industrial army. Public opinion was gradually awakening to the claims of technical education, but the progress was slow. In its utilisation of science and its attitude to higher education the English manufacturing world, despite recent advances, was some decades behind its chief competitors, the German and American manufacturers. Let them consider, for instance, the new industries which had come into existence during the last 15 or 20 years, as, for example, the manufacture of motor cars, aeroplanes, metal filament lamps, incandescent gas mantles, machine tools, high-speed steels, synthetic indigo, calcium carbide, artificial silk, and many other examples which might be selected from the engineering, electrical, chemical or metallurgical industries. All of these were either German, French, or American in their origin or commercial development; none English. It was true that certain of the above industries were now in more or less profitable operation in England, but the English manufacturer, coming later in the field, was handicapped by the fact that he had to

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fight against the acquired knowledge and the business connections already obtained by the Continental manufacturer in the early years of the industry. In their work as technical educators there were two distinct problems to be considered: (1) The training of the manager, the scientific director or the "captain of industry." (2) The training of the foreman, the artisan and the craftsman. At present, owing to the lack of a sufficiently wide and far-reaching scheme of national education as a whole, the country was making but little use of what might be one of its greatest assets, the practical and mental genius of its people. The greatest weakness of our present system of technical education lay in the higher branches, especially in the matter of day technical work. Thus, whereas in Germany there were in attendance during the session 1907-8 at the 10 technical universities no fewer than 11,692 fully-qualified and 2,299 partially-qualified day students; in England during the same period there were only 4,068 more or less qualified day technical students attending the various university colleges of university rank, and the London and provincial technical schools. Compared with the German students, the English students were much younger, their preliminary training was less thorough, and their period of study shorter. The equipment and courses of study of the English institutions were undoubtedly inferior to those provided by the German technical high schools. The reason was the relatively small demand in England for the highest form of technological training. Given a greater demand, the equipment and courses of study at English technical institutions would speedily equal, if not surpass, those of any of the Continental technical institutions.

One of the problems now demanding consideration was the question of the relationship of the higher work of technical institutions to that of the technical departments of local provincial universities. At present the question was in a very unsatisfactory state, resulting at times in preventing much needed developments of their work, in the dissipation of educational energy, and the waste of money through unnecessary duplication of buildings and equipment. The two essential points in any schemes for the co-ordination of university and technical institution work were: (*a*) There must be no curtailment of already existing facilities offered to students, especially to evening students who could not afford the time or the money to make long journeys to distant centres, and (*b*) the position of teachers must be adequately safeguarded. One of the most pressing requirements of English higher technical education at present was the need for an adequate system of scholarships with maintenance allowances whereby evening students who had reached the necessary standard could be enabled to devote two or three years to further specialised study in the daytime at a fully equipped technical college. The present systems of scholarships rarely reached this class of student. A beginning had been made in this direction, notably in London and Leeds, but the system was only in its infancy. Much of the money now spent in the provision of scholarships and bursaries for the training of elementary school teachers, some of whom could not secure appointments at the close of their college career, might well be diverted for that purpose. Under present conditions only a relatively small proportion of those to whom technical education would be beneficial attended any day or evening technical courses. The technical institutions of this country reached at the present time only a very small percentage of those who yearly entered our great industries. They believed that the following reforms would materially lessen the evils indicated: (1) No child should be allowed to leave school before the age of 15, and the half-time system for children under 15 should be abolished; (2) improvements in the curricula and methods of the elementary school; (3) the institution of a system of "technical" secondary schools (including trade schools) in addition to, or in partial replacement of, the existing type of "literary" secondary school; (4) compulsory attendance at day or evening (preferably day) continuation schools, coupled with a limitation of the hours of labour of adolescents; and the affiliation of the continuation schools to the technical school.

A number of resolutions dealing with technical education were approved and passed.

The congress of the Irish Technical Instruction Association was also held last week, the meeting taking place at Sligo under the presidency of Mr. F. C. Forth, of Belfast. A number of interesting Papers relating to technical education were read and discussed.

PARLIAMENTARY INTELLIGENCE.

P.O. TELEGRAPHS AND TELEPHONES.

In the House of Commons on the 23rd inst., the POSTMASTER-GENERAL (Mr. Herbert Samuel), in dealing with the Post Office Estimates, said that the total sum for which he had to ask the sanction of the House was nearly £20,000,000. Fifteen years ago the Post Office Estimates amounted to about £10,000,000. Fortunately, the receipts had nearly doubled also, and the profits remained about the same as they were 15 or 16 years ago. The Post Office dealt with 15,000,000 letters and ½d. packets every day. They handled about 250,000 telegrams daily. During the past year the telephone business had shown considerable expansion. 123 new exchanges had been opened, the number of subscribers to the Post Office system had increased by 12 per cent., the number of conversations on the trunk lines had increased by 15 per cent., and they were looking forward at a very early date to taking over the whole of the vast enterprise of the National Telephone Co. Arrangements were now being rapidly pushed forward to take up the transfer at the end of next year. Two Departmental Committees were at work within the Post Office, one dealing with the question of telephone plant and the other dealing (among other details) with the important question arising out of the transfer of the telephone staff and the arrangements for taking a general inventory. A Bill would be required for the purpose of the transfer. It was not intended, as at present advised, to introduce it this year, but probably at the beginning of next session, and that would be the moment to consider the question of finance; but it was anticipated that the terms of the transfer would be in accordance with the agreement entered into by the late Government, and he had very small hope that those terms could be settled otherwise than by arbitration as provided for in the agreement.

Wireless Telegraphy.—The system of wireless telegraphy also showed very rapid expansion. One of the many items of enterprise which made the administration of his predecessor noteworthy was the purchase last autmun of the wireless telegraph stations round the coast belonging to Marconi's Wireless Telegraph Co. and to Lloyd's. That purchase had been amply justified by results. The wireless stations were working with complete success, and within the last three months the number of messages received and sent had doubled, showing that the services of those stations were appreciated by shipowners. He was now holding an inquiry as to the distribution of those stations round the coast, and as to the desirability of opening up new ones in places such as in Newcastle and district where no stations were at present in existence; and hoped to have before long a complete ring of stations all round the coast and parts of Ireland which would be of great service to shipowners, who would therefore be well advised to proceed as rapidly as might be with the equipment of their vessels.

Telegraphs.—The telegraphs also, after several years of decline, had begun to show some expansion. The figures, which had suffered in recent years from the competition of the telephone, now began to show some revival. The Post Office had spent £2,000,000 in laying down underground cables in various parts of the country to protect the telegraphic system from interruption by storms, and that work was being continued, a considerable sum being taken in this year's estimates for the further extension and completion of the underground telegraph service.

On the subject of international penny post he wished it were possible to be able to confer what was undoubtedly a great boon, the extension of their system of penny postage. But he did not think it possible for that question to be considered as though it related only to an arrangement with themselves and a country. The present Imperial loss on Imperial penny postage was £155,000, and it increased as their correspondence increased.

Contractors and Fair Wages.—With respect to the workpeople employed by contractors, the new fair wages clause sanctioned by the House of Commons was, of course, being inserted in all new contracts with the Post Office. They had an inspector continually at work, devoting his whole time to inspecting the conditions of employment of workpeople under contractors working for the Post Office, and seeing that the terms and conditions of the contract were properly observed.

Telegraphists' Cramp.—A committee had been appointed in the last few weeks to investigate the question of telegraphists' cramp. He had long felt that it was a reproach to any industry that the workers should be exposed by its processes to the contraction of disease peculiar to that trade. As chairman of the Departmental Committee on Industrial Diseases, he was instrumental in having telegraphists' cramp scheduled in the bill dealing with compensation for injuries, and now that he was at the Post Office he was eager to adopt any means that science could devise in order to secure what was far better than either compensation or cure for industrial disease—and that was prevention. With respect to operators in the telephone exchanges there had lately been sensational statements in the Press as to the effect upon their physique of the employment on which they were engaged. Grossly exaggerated figures had been published, which on inquiry proved to require to be divided by two or three, or sometimes by ten, in order to give a fair picture of the facts. But the truth remained that the work of the telephone operator was of a character that imposed a certain strain on the nervous organisation, and a medical inquiry into the conditions of employment in the telephonic exchanges, which was conducted by the second medical officer of the Post Office and the principal female medical officer, had reported on the subject. The report reached him two days ago. A number of suggestions for improvement in the allocation of hours, intervals for meals and rest, some small improvements in the instruments, &c., had been made. He had given instructions that the recommendations of the report should be regarded as matter of urgency, and he hoped in the near future to be able to effect any improvement that might be found by the medical officers and technical advisers to be practicable in that branch of the work of the Post Office.

Several members criticised the Estimates, and, in replying,

The ASSISTANT POSTMASTER-GENERAL (Capt. C. Norton) said that in regard to submarine cables, the whole system of telegraphy was in a state of change. With a State system of cables there would be competition with companies and difficulties as affecting departmental relations with those companies, most of them British, and difficulties with self-governing Colonies. A committee had been considering the subject, and the recommendations of that committee were under the consideration of the Department. On the question of municipal powers in relation to the telephone service, he could give no pledge. Every effort would be made to acquire the National Telephone Co.'s undertaking on the best conditions for the public interest, with no payment for goodwill.

Ultimately, the Post Office Vote was agreed to.

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LC.C. (TRAMWAYS & IMPROVEMENTS) BILL.

Last week a House of Commons Committee, presided over by Mr. Soames, passed the preamble so far as related to the proposed new tramway from New North-road to Southgate-road, on the north side of the Regent's Canal, and the reconstruction of the existing horse tramways from Highbury Corner to City-road and from Finsbury Park to Old-street (via Green-lanes, Southgate-road). The Committee refused the request of the Regent's Canal Co. for a clause obliging the County Council to build a bridge over the canal at New North-road.

The proposal for a tramway from Brixton to Norwood-road, via Effra-road and Dulwich-road, was next considered, and the Improvements committee were unable to agree to a clause binding them to widen the road by taking off a strip of Brockwell Park. Mr. E. White, the chairman of the Highways committee, suggested that the difficulty might be overcome by making a single line for 50 yards, that being the longest distance it was found convenient to work with a single line.

Ultimately the Committee approved a clause providing that unless the Council widened Dulwich-road, Herne Hill, to the full extent the tramway there should be a single line for about 100 yards from the main entrance to Brockwell Park between points marked on the deposited plan.

The Committee also approved the proposal to construct a new tramway, about 1½ miles long, from the southern approach to Putney Bridge, joining the existing line there and passing along High-street, Putney, Putney Bridge-road and High-street, Wandsworth, joining the existing tramway in York-road. The estimated cost of construction was £43,700, but widenings and acquisition of property would cost £167,200. A small supplementary line will connect the new line with the existing line in Lower Richmond-road. The Board of Trade are to decide the question whether the cross-over where the line would join the Tooting and Balham line should be worked as a single line.

L.C.C. (GENERAL POWERS) BILL.

The clauses of this Bill which deal with the smoke nuisance have been further considered by the Local Legislation Committee of the House of Commons, presided over by Sir F. Layland-Barratt.

Mr. H. F. DONALDSON, chief superintendent of ordnance factories, stated that since 1906 the War Office had received no complaints at all from outside as to smoke nuisance at Woolwich. During the past 10 years they had tried at least a dozen appliances for smoke consumption, and investigated something like 40 different systems. They had the strongest possible reason, that of economy, for not emitting smoke if it could be avoided.

Mr. R. R. BANNATYNE, of the Home Office, objected to the proposal in the Bill to extend sec. 24 of the Public Health (London) Act, 1891, so as to include "the chimneys of any factory or workshop, as defined by the Factory and Workshop Act, 1901, belonging to or used by the Crown."

The Committee decided that they could not grant the powers over Government departments asked for in the clause.

Mr. OLIVER L. PEAR, testing superintendent of the City of London Electric Lighting Co., stated that 95 per cent. of the smoke nuisance in London was caused by domestic chimneys. He had made calculations which showed that, while 11,250 tons of smoke were sent annually into the atmosphere from factory chimneys, the amount issuing from domestic chimneys was 250,000 tons a year, while the proportion of tarry matter in the smoke were 4 per cent. and 15 per cent. respectively. The smoke nuisance problem in London would never be solved until domestic chimneys were dealt with.

On Tuesday the CHAIRMAN announced that the Committee had come to the unanimous conclusion that no evidence had been put before them which would justify them in assenting to the omission of the word "black" from the Act of 1891.

WIMBLEDON & SUTTON RAILWAY BILL.

This bill, which has already passed the House of Lords, came before a House of Commons Committee on Tuesday, Mr. Ashton, M.P., presiding.

Mr. H. LLOYD, K.C., for the promoters, said the proposal was to extend the District Railway from Wimbledon to Sutton. The scheme was promoted by local landowners to the value of about £750,000 in the neighbourhood, many of whom would be prepared to take payment in shares for land required for the line, while some would give land. It was proposed to raise £350,000 capital with the usual borrowing powers. The estimated cost of construction was £311,554. The only opposition was from the L.B. & S.C. Co. The L. & S.W.R. Co. had agreed to the junction at Wimbledon and the District Company were willing to work the traffic electrically, their trains running through Wimbledon.

Evidence in support of the bill was given by Mr. H. R. Searles-Wood, chairman of the promoting syndicate, and by Mr. W. E. R. Innes, chairman of the Merton Park Estate Co.

Mr. R. H. SELBIE, general manager of the Metropolitan District Railway, said the proposed line (5½ miles in length) would serve a present population of 100,000, would be a cheap railway to work, and he thought (allowing £23,100 working expenses on gross receipts £42,000) a net revenue of £18,900 might be expected, increasing with the growth of population.

Mr. W. V. GRAHAM, C.E., engineer for the scheme, said that the proposed stations would be in most instances a mile from the existing stations on the L.B. & S.C. Railway from Sutton to Wimbledon via Mitcham. The estimated cost of the works and land was £311,554. In the estimate of £181,140 for works, the electrification of the line (costing probably £40,000) and the provision of rolling stock had not been included. It was usual to make provision for equipment and rolling stock by the exercise of borrowing powers, and these matters would be subject to arrangement with the Metropolitan District and L. & S.W. Companies in regard to goods traffic.

Sir G. GIBB thought the proposed line would be a useful addition to the railway accommodation for the outer zone of London. It would not injure the Brighton Company's traffic and their service to Victoria and London Bridge. It would be an advantage to have the through connection at Wimbledon for Earl's Court. The District Company intended to enter into an arrangement for working the proposed line.

Sir J. WOLFE BARRY, K.C.B., said the line was well conceived for the purpose of opening up that new residential district. The estimates had been examined by his staff and found sufficient. Existing requirements perhaps would not support the line, but the district would rapidly develop.

At the suggestion of the Chairman the promoters, having formally proved a resolution from Carshalton in favour of the Bill, did not put forward further evidence, and the case for the Bill closed.

Mr. W. FORBES, general manager for the L.B. & S.C. Railway Co., explained the arrangements of his company for the London and Sutton traffic. There were quicker trains in the morning and evening. The journey to Victoria by the proposed line would occupy 44 minutes. His company contemplated further electrification of their lines in which Sutton would be included, but he did not find that there was a demand for a more rapid service between Sutton and Wimbledon. He had tried it a few years ago, and in the present month had been running motor trains in addition to the regular service, but had only carried an average of four passengers per train. There was not the traffic to cater for between Wimbledon and Sutton. His company having incurred large expenditure and being prepared to meet all public requirements, should, he urged, be left alone.

SMETHWICK PROVISIONAL ELECTRIC LIGHTING ORDER.

On Wednesday a Select Committee of the House of Commons, presided over by Sir Henry Kimber, considered the Electric Lighting Orders (No. 1) Bill, which confirms various provisional orders made by the Board of Trade, including the Smethwick order.

Mr. FREEMAN, K.C., for the promoters, said the bill was to confirm a provisional order authorising the transfer of an order from the Birmingham & Midland Tramways (Ltd.) to the Shropshire, Worcestershire & Staffordshire Electric Power Co. In 1898 an agreement was entered into between Smethwick Council and the Birmingham Co. by which the company was to work the order, and in 1906 the Board of Trade drew the attention of Smethwick to the fact that the action practically amounted to the divestment of the order, and they suggested that it should be transferred to the Tramway Co. In 1907 that transfer was carried out. It was, however, agreed that it should not be done without the sanction of Smethwick Corporation, and such consent was not to be "unreasonably" withheld so long as the company who took the order were reliable and responsible. The Shropshire Co. now sought to take over the order. At an inquiry held by the Board of Trade in 1908 all the details were considered, and every question raised was satisfied, except a personal one as to whether the Town Clerk of Smethwick should be allowed his expenses. The Corporation stated that they had reason to doubt whether the pecuniary position of the Shropshire Co. was of such a satisfactory nature as to warrant their undertaking the powers, duties and obligations of the order. He would point out that the company, before taking over an order, had to raise a definite sum, and the Shropshire Co. had the certificate of the Board of Trade to that effect.

Mr. SIDNEY MORSE gave evidence in support of the Order.

Mr. ERSKINE POLLOCK, K.C., addressed the Committee on behalf of petitioners, and said he did not object to the transfer under certain conditions, but they wanted to be safeguarded with regard to the price to be charged for street lighting, and that words should be put in the order so as to make it clear that the transfer should not absolve the Shropshire Co. from various obligations entered into with Smethwick Corporation.

The Committee passed the preamble, and asked Mr. Pollock to bring up a clause which would satisfy both parties. The Committee would consult the Board of Trade and the speaker's counsel before giving their decision.

Ardrossan and Cambuslang Provisional Orders.—The Court of Referees of the House of Commons have disallowed the locus standi of the Caledonian & Glasgow and S.W. Railway Companies in regard to the Bill confirming the provisional electric lighting orders for Ardrossan and Cambuslang, except in relation to the provisions as to carrying electric cables over railway bridges.

North & South Shields Electric Railway Bill.—This bill has been withdrawn.

LEGAL INTELLIGENCE.

Wireless Telegraph Patents.

Last week the case of Taylor *v.* W. Bingham was mentioned to Mr. Justice Parker by Mr. Walter, K.C., who stated that the action related to certain wireless telegraph patents, and he had a motion for an interlocutory injunction. He had, however, arranged with Mr. Mark Romer, K.C. (who appeared on the other side) for the motion to stand over until trial.

His lordship assented to this.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Governors of Robert Gordon's Technical College (Aberdeen) are about to appoint an engineer graduate of distinction as head of the engineering department of the college. Salary £500 per annum. Applications to the principal (Mr. Chas. Stewart, M.A.), by July 16. See also an advertisement.

A competent selling electrical engineer is wanted at once for India. See an advertisement.

A foreman is required with experience in pivoting, balancing, and calibrating delicate moving coil instruments. Applications to Mr. R. W. Paul, Newton-avenue Works, New Southgate, London, N. See advertisement.

A first-class tracer is wanted at electrical engineering works at Chiswick. See an advertisement.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

A senior demonstrator is required in the technical optics department of the Northampton Institute, London. Salary £175. Forms, &c., from the Principal, to whom applications by July 5.

A radiographer is required at the Hospital for Consumption and Diseases of the Chest, Brompton, London, in succession to Dr. Greg. Honorarium 50 guineas per annum. Applications by July 7.

Owing to Mr. C. W. Salt having recently resigned his position as chief assistant electrical engineer at Bradford to take up the position of chief electrical engineer of Torquay municipal electricity undertaking, Bradford City Council, acting on the recommendations of the Electricity committee, have appointed Mr. Harry S. Ellis, assistant electrical engineer, to be deputy electrical engineer and manager, and Mr. J. H. Schnauber, chief draughtsman, has been appointed assistant electrical engineer.

Mr. J. C. Johnson has been appointed senior charge engineer at Willesden, and Mr. J. D. Ravenscroft is to take Mr. Johnson's place and a third assistant is to be appointed.

Mr. James Robinson, M.Sc., Ph.D., has been appointed junior lecturer and demonstrator in physics at the University of Sheffield.

Mr. Thomas Thompson, B.Sc. (Eng.), B.A., has been appointed assistant engineering lecturer at the Municipal Technical Institute, Coventry.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

Northampton Polytechnic Institute.—The silver medal offered by the Women's Aerial League to the best student in the pioneer courses in aeronautics held during the session 1909-10, has been awarded to Mr. Duncan George, Mr. E. R. Moffat being proxime accessit.

Extended courses of a more complete and practical nature are being arranged for next session, and Mr. F. Handley Page (Handley Page, Ltd.) has been appointed to take charge of these courses. In addition, there is under consideration the establishment of full-time day courses in aeronautical engineering, extending over four years, and similar to the well-known day courses in electrical and mechanical engineering established some years ago. Fuller particulars will be ready shortly.

Heriot-Watt College (Edinburgh).—This college provides theoretical and practical training for mechanical, electrical and mining engineers, technical chemists, brewers, &c., and printers and publishers. The training for engineers consists of three years in the college and a three years' apprenticeship on the "Sandwich" system in a local engineering works. The course in mining extends over two years, and the training is also recognised by the University of London for the B.Sc. degree in mining. Complete courses of instruction, extending over four years, are provided for students studying for the fellowship of the Institute of Chemistry, &c. An entrance bursary of £25 will be offered for competition on Sept. 27 and 28 next. Particulars of fees, &c., may be obtained from the principal, Mr. A. P. Laurie, M.A., D.Sc.

BRITISH AND COLONIAL.

Aberdare.—The Council have decided to promote a Bill to authorise the construction and working of an electric tramway from the cemetery to Cwmaman and to confer powers to carry out other improvements.

Acton.—On Wednesday the Council decided by 11 votes to four that the necessary notice be given to terminate at December, 1913, the agreement with the Metropolitan Electric Supply Co. for the supply of electricity in bulk to the Council. The proposal to hand over the Council's electricity undertaking to the company was rejected by 14 votes to six.

Amalgamated Society of Railway Servants.—Mr. J. E. Williams has been elected secretary of this society in succession to Mr. R. Bell.

Australasia.—The "Australian Mining Standard" states that a meeting of Kapunda (S. Australia) ratepayers is to be called to discuss the question of lighting the town electrically.

Customs.—Under an order dated June 7 the list of goods which may be imported into Canada duty-free includes fuse heads of metal foil and cardboard imported by manufacturers of electric fuses for use only in their own factories in the manufacture of such fuses.

Dewsbury.—The new Council schools at Batley Carr are to be wired.

Earnings of Workmen in Electricity Supply, Tramway and other Public Services.—A report of an inquiry by the Board of Trade into the earnings and hours of labour of workpeople in public utility services in 1906 states that no statistics are available showing the total number of persons engaged in such services, but returns have been received from nearly all local authorities directly employing labour and from most of the private companies of importance, and the number of persons with regard to whom returns have been obtained is 268,000.

The average earnings of workpeople in the electricity supply service was 29s. 6d. and of men only 31s. 7d. per week; in the tramway and omnibus services (combined) 29s. 3d. and 30s. 6d. respectively. Wages in the gas service were 31s. 7d. for all persons and 32s. 6d. for men only, an increase of 18 per cent. compared with the year 1886, but no comparison is given with 1886 in regard to the electricity and tramway and omnibus services. The average hours in a full week's work in the electricity supply service were 51·9 (compared with 52·6 in the gas service) and in the tramway and omnibus service 58·7. The average number of holidays allowed (to persons allowed recognised holidays) was 10·4 in the electricity, 7·4 in the gas and 6 in the tramway and omnibus services. A footnote states that in the gas and the tramway and omnibus services there were no recognised holidays allowed in a number of cases, and if all the workpeople were included the average would be 6·6 days in the gas and 3·8 days in the tramway and omnibus services. The average earnings in the electricity supply service in the whole of the U.K. were: For foreman 48s. 4d., meter inspectors 30s. 11d., switchmen 31s. 11d., jointers 38s. 11d. and wiremen 35s. 11d. per full week. In London the comparative figures were: Foremen 52s. 3d., meter inspectors 32s. 6d., switchmen 35s. 9d., jointers 41s. 7d. and wiremen 36s. 7d. The average earnings of certain classes of tramway and omnibus workers was as follows, for the whole of the U.K.: Motor tram drivers 30s. 8d., horse and cable tram drivers 33s. 9d., omnibus drivers 35s. 9d., conductors 26s. 11d., regulators 33s. 1d. For London the wages for the same classes were 32s. 4d., 34s. 9d., 38s., 30s. 9d and 38s. respectively.

Electricity in Mining.—The report of the directors of the Maltby Main Colliery Co. states that a portion of the electric power installation is at work, and the remainder of the plant required in the near future is in process of erection. The permanent electric pumping plant has been erected and is at work. The fan and engines are ready for starting immediately the shafts are down to the coal.

The new electric power and lighting plant at the Deep Navigation Ocean Collieries, Treharris, was formally started by Mrs. Davies, wife of Mr. D. Davies, M.P., on the 23rd ult. Electric current will be used for surface and underground lighting, pumping, &c.

Gloucester.—On Wednesday the City Council increased the salary of the general manager of the tramways (Mr. L. Johnston) to £350.

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Hackney (London).—The borough electrical engineer (Mr. L. L. Robinson) has denied a statement in the Press to the effect that the Council had decided to replace their electric arc lamps with gas lamps.

For a number of years (states Mr. Robinson) the more important main streets in Hackney, extending some 20 miles, have been lighted by electric arc lamps, which have given thoroughly satisfactory results. There is not the slightest inclination on the part of the Council to have this electric lighting replaced by gas lighting. In the less important streets gas has not yet been displaced. A few months ago, in consequence of the enormous economy in electric lighting effected by the introduction of the metal filament lamp, the Electricity committee were in a position to offer a lower price for this "side street" lighting than was charged by the gas company, but unfortunately they could only make their offer in respect of some 600 lamps, because supply mains are not yet laid throughout every street in the borough. Nevertheless, the threatened competition of the electric light has had a beneficial result, in so far as that it has drawn from the gas company an offer to replace all the existing upright mantles in the public street lamps with inverted mantles, and to reduce the bill by some £2,000 per annum, provided they got the contract for the whole of the existing lamps for five years.

Howth and Sutton (co. Dublin).—At a recent meeting of ratepayers the electric lighting scheme of the Improvements committee was approved.

The scheme has been prepared by Messrs. W. Coates & Co., and it is proposed to request the County and District Councils to grant wayleaves for laying cables along the roads, and the firm undertake to finance the scheme and to supply electricity at a charge not exceeding 6d. per unit to consumers.

Islington (London).—Sir Alex. Kennedy, who has reported upon the desirability of increasing the capacity of certain electricity supply mains, is of opinion that the present high-tension feeders to four areas are seriously overloaded and that the extensions proposed by the borough electrical engineer (Mr. A. Gay) are necessary.

Sir Alex. Kennedy also considers the adoption of sub-stations for present and future extensions is very advisable to enable the Council to obtain satisfactory regulation of their supply pressure, and to take advantage of the economical working of transformers so placed. At the same time the low-tension distributors from these sub-stations should be laid so as to make use of the three-wire system and higher voltage which is already successfully in use in other parts of the district.

The Electricity committee report that they are satisfied from the report of Mr. Gay that it is necessary to carry out the works indicated, at an estimated amount of £19,872, without delay.

Mr. Gay has reported that it is necessary, in order to comply with the regulations issued by the Home Office under sec. 72 of the Factory Act, to provide a new main switchboard, at a cost of £3,000, and the Lighting committee has decided to invite tenders for the work.

Kingsbury.—The Council have approved the action of the chairman (Mr. J. Diaz) in communicating with the North Metropolitan Electric Power Supply Co. offering to continue negotiations for the supply of electrical energy for public and private lighting.

Leicester.—It was reported to the Corporation on Tuesday that the Gas and Electric Lighting committee had considered the effect of the recent judgment of Mr. Justice Neville in regard to the municipal electrical fittings department.

After carefully considering the matter the committee came to the conclusion that, as there were other Corporations likely to be affected by the decision, before taking any further steps they should be communicated with. The committee will meet again shortly to consider the course to be adopted.

The chairman of the committee (Ald. Smith) said that they thought the present was an opportune moment for suggesting a change in the administration of the management of the gas works. The committee were of opinion that there was no insurmountable difficulty in separating the gas from the electricity department. The committee had also considered the matter from the point of view as to whether the present electricity works at Aylestone and Belgrave-road should be run as separate concerns, or whether, in the public interest, there should be an amalgamation of the two under one committee. The capacity of the plant at Aylestone was equal to 4,400 kw. The maximum load on the station in 1909 was 1,962 kw., so that if a 1,000 kw. set were allowed as reserve, there would remain one 1,000 kw. set available for power or other purposes. The sales for lighting last year reached 1,546,635 units, and for power 405,305 units, and the cost per unit worked out at 3½d. per unit in 1907, against 3¼d. in 1909. There had been a considerable decrease in revenue since the introduction of metal filament lamps. Since 1907 the total revenue had fallen from £33,882 to £28,832, a difference of £5,000, while the net profit had only dropped £2,600. The total generating capacity of the plant at Belgrave was 2,500 kw., and the total output last year was 6,616,650 units. The total works cost was ½d. per unit. The output for the current year would be at least 8,000,000 units. They were supplying 1,500,000 units per annum for power alone, and this figure would increase considerably before the end of the year. The total horse-power of motors coupled up this year amounted to 759 H.P., and the total up to the end of December last year was 669 H.P., making a grand total of 1,428 H.P. The advantages of unification might be briefly summarised as follows:—

(1) The whole electricity production and supply for lighting and power would be under the control of one special committee, whose duty it would be to supply electricity at the cheapest possible rate; (2) it would stop friction between committees, and abolish insane and unnecessary competition; (3) consumers and users of light and power would have free choice in taking alternating or direct current—whichever suited them best—at equal rates; (4) the present ducts, cables and machinery could be more economically used for the present purposes and future extensions of supply; (5) one central office—part of the present gas offices being available—could be extended, where all requiring electricity for light or power could apply; (6) amalgamation would mean the retention of the present engineering and clerical staffs, with less friction and better control and economy of management.

The committee's recommendations were adopted.

Liverpool Tramways.—To meet the heavy call on the tramway service in Liverpool for the conveyance of passengers to and from the Royal Agricultural Society's Show held at Wavertree last week, we learn that 200 additional cars were provided. During the greater part of the five days of the show 150 of these extra cars were in use, 50 being held in reserve to meet any exceptionally heavy demand. The consequence was that the very heavy traffic was handled in a most admirable manner, and there was no waiting or crushing at any point of the different routes or at any of the entrances to or exits from the show. Much credit is due to Mr. C. W. Mallins, the tramways manager at Liverpool, for the effective arrangements made to meet this particularly exacting demand. We know that the excellent service was highly appreciated by the visitors to the show, whose time was greatly economised thereby.

Llandudno.—The salary of the electrical engineer (Mr. Harold Morton) has been increased.

London County Council.—On Tuesday it was agreed to allow Poplar to alter the terms of their electricity loans and make the repayments quarterly.

New Tramways.—The Highways committee's recommendation to expend £35,250 on capital account for the construction of authorised tramways from Battersea Park-road to King's-road, Chelsea, was agreed to.

Marylebone (London).—The Electricity committee report that the general manager (Mr. A. Hugh Seabrook) has advised that in future the annual charge in respect of the use of electricity for all domestic residential purposes (other than lighting) should be discontinued, and the annual charge for lighting considered to cover all uses of electricity.

The proposed reduction will only apply to private consumers who adopt the "telephone" system of charging in their residences. The committee are satisfied that, though there will be a trifling decrease in revenue, the increased business will recoup the concession.

42 public lamps have been converted from gas to electricity, making a total of 2,262 electric lamps.

Monaghan (Ireland).—The Council have passed a resolution in favour of an electricity supply scheme.

Nuneaton.—The Highways committee are not prepared to supply the c.-i. columns and brackets for future street lighting extensions, as recently suggested by the L.G. Board inspector, and the Board have been asked to sanction the raising of £240 for street lighting extensions.

Ald. BATES, in moving the adoption of the report, said that when the big flywheel broke at Messrs. Fielding & Johnson's cotton factory the electricity department were asked to supply about 300 H.P. of electrical energy, and that had been promptly supplied, thus enabling the factory to continue working without much delay. Otherwise the factory would probably have been idle for several weeks and 400 workpeople thrown out of employment. He thought the department was to be congratulated on the expeditious way it had coped with that work.

Personal.—Mr. G. H. J. Hooghwinkel, M.I.M.M., M.I.E.E. (Messrs. Hooghwinkel, Anthony Brown & Partners), is leaving for the West Indies and Mexico on July 6 on professional business.

Poplar (London).—The Finance committee has been asked to report upon certain proposals of the electrical engineer (Mr. J. H. Bowden) for a revised system of charging, with a view of securing greater diversity of load.

In March, 1909, the Council approved the wiring of 25 houses at a tariff of 12½ per cent. on the Council's cost of installation to cover interest, depreciation and repairs, with a further charge of £4 per annum per kilowatt in respect of the capacity of the lamps connected, and £1 per kilowatt for heating, &c., plus ½d. a unit in each case for all current consumed, lighting in cellars, lavatories, &c., not extensively used at time of maximum load, being charged at the same rate as for heating. The Electricity committee report that the results appear to have been satisfactory, and they are of opinion that this class of installation may be usefully extended. It is also suggested that a similar system of charging should be adopted in respect of lighting business premises, but in these cases, while the charge for consumed current will remain the same, it is proposed to fix the rate per kilowatt installed at £13 for inside lighting and £6. 10s. for outside arc lighting, the latter demand coming only partially on the peak of the load.

With regard to power consumers, it is proposed to establish a general rate of £4 per kilowatt demanded, plus ½d. per unit for all current consumed, discarding the rate of £3 per kilowatt and 8d. per unit, and to

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offer rebates to large consumers. The committee recommends that Mr. Bowden be authorised to wire a number of premises, not exceeding 50, for domestic and business supplies on the terms and conditions stated, at a cost not exceeding £20 for any one installation; also that the proposed rate for direct-current power be £4 per kilowatt demanded, with ½d. per unit for current supplied, subject to rebates.

Preesall (Lancs.).—The Council are considering electric lighting schemes submitted by the Trafford Electric Works Co. and Mr. Swarbrick, Leigh.

Presentations.—The shareholders of the Lymington Electric Light & Power Co. have presented a silver cigarette case to Mr. Glynn Slater, Engineer and Secretary, who has been appointed engineer and manager of the Hamilton Electricity Works.

The staff and employés at Swadlincote of the Burton-on-Trent & Ashby Light Railway Co. have presented a pair of bronzes to Mr. R. O. Baldwin, traffic manager, who has accepted a similar post at Bournemouth.

Last winter Hanley Education committee initiated a course of electrical engineering lectures at the municipal secondary school. Practical demonstrations and testing work were also carried out at the power station (by permission of Hanley Electricity committee). The whole course, lasting from September to April, was under the auspices of the City and Guilds of London Institute.

Mr. C. H. Yeaman, borough electrical engineer, was the lecturer and demonstrator, and on Friday evening last the students presented Mr. Yeaman with a silver fountain pen as a slight appreciation of the indefatigable and thorough manner in which he had conducted the lectures.

Mr. Yeaman, who was taken by surprise, thanked the members for their useful present, and said that it gave him great pleasure to take up work of that kind and help anyone who took a real interest in the subject, and strove to become efficient, remarking that it was a kind of recreation to himself after the usual business of the day.

Rail-less Trolley Traction.—The manager of the Plymouth tramways (Mr. C. R. Everson) has reported to the Tramways committee on the exhibition of the rail-less trolley system of traction recently given at Hendon.

Mr. Everson states that the experimental running of the car was pronounced to be very satisfactory. He was favourably impressed, and convinced that whenever the Council considered the question of meeting the public requirements of places like Laira and Crownhill, that mode of traction would be very suitable for connecting up such places, to act as feeders to their present tramway service.

Consideration of the report has been deferred.

St. Pancras (London).—Tenders are to be invited for the temporary boiler plant required at the King's-road electricity works to provide for next winter's demand.

Southend.—The Council have applied for a loan of £2,552 for additional feeders.

The salary of the borough electrical engineer and tramways manager (Mr. R. Birkett) has been increased from £500 to £700, rising to £1,000 by £30 a year.

Tottenham.—In regard to the public lighting, the North Metropolitan Electric Power Supply Co. have asked the Council to allow them to tender for a minimum of five years for the whole district, but they may tender only for three years for those portions where their mains are laid.

The Tottenham Gas Co. has been asked to reduce the charge for public lamps, and in reply the secretary has stated that the price is at present so low compared with the charge to the general public that there is little margin for reduction. Anticipating, however, that during the next 10 years economies would be made in gas manufacture, the company offer a reduction equal to 2s. per lamp, with 1·61d. per lamp per night for supplying gas mantles, &c., for cleaning each lamp weekly, for lighting and extinguishing it and for supervision, &c.

Both communications have been referred to a committee.

Victoria-Crystal Palace Tube Railway.—Particulars have been published of an amended scheme for the construction of a tube railway from Victoria to the Crystal Palace.

It is proposed that the terminus should be at the Penge entrance to the Palace instead of at Upper Norwood. The line will be 6¾ miles in length, with a branch line of 1½ miles running to the Elephant and Castle from a point near Walworth-road. The stations on the amended scheme will be Penge, Upper Sydenham, Lordship-lane, Dulwich, East Dulwich, Denmark Hill and Camberwell, where it branches off to Walworth, and the main line goes on to the Oval, the Albert Embankment and Victoria. There is a further suggested line which would carry the railway on to Cricklewood, going through Marble Arch and Hyde Park Corner. The cost of the new tube will be £340,800 per mile.

It is also stated that the directors of the London, Brighton & South Coast Railway Co. will next month recommend the extension of electric traction to that portion of the line between Peckham Rye and the Crystal Palace.

Wireless Telegraph Notes.—Capt. Howland, of the Norwegian Navy, is about to visit London and other cities, in order to demonstrate an improved wireless telegraph apparatus, designed to more effectually systematise wireless messages.

It is announced that the War Office are in negotiation with the Marconi Wireless Telegraph Co. for the purchase of about 300 sets of a simple portable wireless telegraph apparatus, the invention of Major Beddington, of the Yeomanry. This apparatus can be erected and completed for transmitting messages in about 15 minutes. It is light and easily transportable.

The Postmaster-General has under consideration the complete linking-up of the islands on the West Coast of Scotland by means of wireless telegraphy, there being little or no traffic to justify laying a submarine telegraph cable on a coast where the submerged lines would be liable to frequent interruption.

The Under Secretary of State for India in the House of Commons on Wednesday stated that the scheme for the establishment of certain inland wireless telegraph stations in India had been approved.

Workhouse Lighting.—The House committee of Hungerford Guardians are preparing a report on the electric lighting of the workhouse.

Annual Outing.—On Saturday last the employees of Messrs. Siemens Bros. Lamp Works (Dalston, N.E.) visited Brighton for their second annual outing. The weather was showery in the morning but cleared later and became splendidly fine. The party numbered over 500, and left London Bridge at 7 a.m.

An excellent luncheon was provided by the company at the Aquarium.

A vote of thanks to the committee and Mr. Hicks (the secretary) for the success of the outing was proposed by Mr. Holmes and carried with acclamation. A musical programme was provided at the Aquarium. The party then dispersed and many of the surrounding places of interest were visited. The outing proved thoroughly enjoyable and successful.

FOREIGN.

Brazil.—Vice-Consul Simpson states that the company owning the electricity supply works at *Maceio* is in a healthy condition and has largely increased its plant recently.

Vice-Consul Garcia says the town of *Natal* is lighted by acetylene gas, but the introduction of electric light is under consideration.

Consul W. H. M. Sinclair states that electric lighting is making considerable headway in *Bahia*. Fittings are, as a rule, very plain and all installations are in the hands of the lighting companies. Fans are at present little used.

France.—The report of Consul A. McMillan on the *Nice* district for 1909 states that it is probable electric traction will be used on the Nice to Antibes and the Vesubie to St. Martin Vesubie tramways before the end of the current year.

The development of the network of telephones in the Alpes Maritimes continues to make progress, a number of communes having been connected with Nice.

Consul R. Macdonald states, in his report on the *Bordeaux* district, that the imports of machinery and parts of machinery (exclusive of agricultural and sewing machines) from the U.K., amounted to 1,407 tons, a slight decrease compared with 1908. There was a decrease in dynamos and an increase in machine tools.

Franco-German Telegraphs.—It is announced from Paris that an agreement has been concluded between the French and German Governments with regard to the common use of their respective submarine telegraph cables at any time that accidents of a technical or other nature interfere with the normal working of the service.

Holland.—The "Vaderland" states that Dordrecht municipality have decided to construct an electrically-operated swivel bridge at a cost of about 98,000 florins (£8,166).

International Competition of Practical Telegraphists.—The Italian Minister of Posts and Telegraphs has issued invitations to the Government Telegraph Administrations and the telegraph companies adhering to the International Telegraph Convention, the Imperial Chinese Telegraph Department, and the other principal private telegraph companies to participate in a competition in the transmission and reception of messages with Morse, Hughes and Baudot apparatus at the Turin International Exhibition. A list of the money and other prizes and medals which will be awarded is to be published later. Signor Ciuffelli, Minister of Posts and Telegraphs, Rome, will be pleased to receive notices of intention to compete.

Japan.—The report of Consul A. M. Chalmers for 1909 states that the imports at *Nagasaki* included steam engines and boilers £8,769 (compared with £728 in 1908 and £40,367 in 1907), steam turbines £1,169 (against £43,623 and £52,861), dynamos £1,561 (£8,542 and £20,132).

Acting-Consul W. M. Royds states that electric light was first seen in *South Formosa* in December last, when a power station was established at Chikushimon to supply electric light and power to the towns of Tainan Anping, Hozan and Takow.

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H.M. Commercial Attaché at Yokohama (Mr. E. F. Crowe) states, in his report for 1909 that there has been a boom in electric tramway undertakings, particularly in the district round *Osaka*, and *Kobe*, and in the south of Japan. Mr. Crowe advises that great caution should be exercised before attempting to take part in any proposed new ventures of this kind, and there are several engineers on the spot whose business it is to watch these enterprises, and who know long before the general public if anything at all good is forthcoming. Orders for machinery, rolling stock, &c., are in most cases accompanied by requests for very easy payments.

Imports of machinery to Japan were valued at £2,072,400 (compared with £3,498,600 in 1908). The imports of machinery from the U.K. were £1,409,000 (against £2,070,400, and £158,200 in 1908 and 1907 respectively), from the U.S.A. £382,500 (against £916,200 and £851,100), from Germany £252,800 (£453,400 and £328,000), France £12,000 (£18,300 and £41,900); other countries £16,100 (£40,300 and £24,600). The total imports of dynamos and motors were valued at £184,400 (against £209,200 in 1908) and of other electrical machinery £121,800 (£170,600); telephones £12,200 (£11,500); steam-engines £72,000 (£180,300); gas, oil and hot air engines £39,100 (£98,700); steam turbines £23,700 (£76,500), and lifting machines £189,900 (£116,200).

Madeira.—H.M. Consul (Capt. J. Boyle) states that the concession recently held by the Madeira Electric Lighting Co. has been transferred by the Camara to the *Madeira* Electric Lighting Co. (1909) Ltd., which has been registered in London and Portugal. The present generating plant is to be scrapped and the latest type of machinery put in. Afterwards the mains will be extended to the whole of the Concelho of Funchal. There is a local advisory board of directors, with Mr. A. Barron, M.I.C.E., as engineer-in-chief. It is believed that the telephone concession is to be taken over and worked by the Government, and that the cost per telephone will be about 22 dol. 500 reis (£4. 12s.) per annum, with an additional charge of 6 dol. (£1. 4s.) at the time of installation.

Mexico.—Consul L. J. Nunn states that large sums will be spent in the near future by the *Vera Cruz* Terminal Co. in the equipment of hydraulic cranes for the water front work, and electric cranes for warehouses, &c.

Consul H. W. Wilson (*Tampico*) says an electric 30 ton crane has recently been erected on the Fiscal Wharf and can travel the whole length of the wharf (about half a mile).

Vice-Consul J. B. Sanford states that the Monterrey Railway Light & Power Co., by arrangement with the City Council, are about to lay 3 kw. (1¼ miles) of underground cable to supply light and power in the main business portion of *Monterrey*. The Company is remodelling its plant and installing five steam turbo-generators of 500 kw., which will supply current for lighting, tramways and motive power.

Roumania.—Vice-Consul Pyke states that the Dock Administration at *Galatz* are removing the steam cranes at present in use to up-river ports, and will replace them by eight electric cranes.

Vice-Consul Watson says an electric light installation has been introduced at the Port of *Sulina*.

Russia.—The report of Consul P. Stevens on the *Batoum* district for 1909 states that it is intended to construct an electric railway from Vladikavkaz over the main Caucasas Pass to Tiflis. It is also reported that it is proposed to lay an electric line between Sochi and Tuapse and the Black Sea coast. Batoum municipality are considering a scheme for electric tramways. Mr. Stevens points out that any decisive and final action with regard to these schemes must emanate from St. Petersburg, and therefore engineers and capitalists who may wish to engage in such enterprises should communicate with the Government there.

Vice-Consul McDonell (*Baku*) says the Baku municipality have raised a loan of about £2,842,000, of which certain sums have been set apart for the electric lighting of the town and the electrification of tramways. Foreign tenders will be invited. For the public lighting 960 arc lamps will be required, but it has not yet been decided whether the municipality will erect their own station or come to an arrangement with the existing power company.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Belfast.—The annual report of the manager of the tramways department (Mr. A. Nance) for the year ended March has been issued.

The revenue was £203,874. 16s. 10d., and the working expenses £107,335. 1s. 5d., or 52·62 per cent. of gross revenue, compared with 55·87 for 1909. The receipts show an increase of £8,831. 15s. 6d., and represent 9·64d. per car-mile run. The passengers carried included 4,230,814 ½d. fares (persons under 14 who are not allowed to carry luggage or parcels), 38,340,186 1d. fares (87·73 per cent.) and 3,776,591 2d., total 46,347,591. The revenue charges were £50,500, leaving a balance of £50,000, which is to be devoted as follows: Depreciation £13,000, sinking fund £23,000, statutory reserve £14,000.

ELECTRICITY SUPPLY TABLES AND DATA.

This Valuable Set of Tables and Engineering Data relating to Electricity Supply and to Electric Traction on Railways and Tramways in the United Kingdom, the Colonies, and some important places abroad, is now ready, and can be obtained complete in handy book form, price 6s. 6d. post free, or on very hard paper for rough or constant use, price 8s. 6d. post free. A complete Index is included.

Blackburn.—The total revenue of the electricity department for the year ended March 25 was £36,716, and included £33,526 net from the sale of current for private public and lighting, traction and other public services.

Working expenses came to £16,142. Gross profit was £19,574, and after paying interest on loans, income tax, sinking fund, &c., transferring £2,000 to reserve for depreciation, there was a net profit of £1,387. 11s. 5d. (against £976), which has been carried to reserve. Battery and booster extensions were carried out at a cost of £2,388. 19s. 3d. out of reserve, and the balance of this fund is now £3,364. Gross capital expenditure is £275,594, an increase of £6,189. 4,308,005 units of current were sold (against 4,212,300), and of these 346,865 (344,132) were supplied to the public lamps (208 arcs and 478 incandescents), the balance being sold by meter. The maximum supply demanded was 3,000 kw. (against 2,600 kw.)

In the report of the borough electrical engineer (Mr. P. P. Wheelwright) it is stated that depression in local trade has adversely affected the development of the light and power departments; and the improved financial result is due to the reduced cost of production (0·05d. per unit sold), brought about by the more economical and efficient working of the generating station. There was an increase of 194 in the number of consumers connected. The motor hiring department installed during the year 14 motors (of 49 B.H.P.), in addition to motors totalling 340 B.H.P. owned by consumers. The total connections for motors, heating and lighting in equivalent 30-watt lamps amount to 195,973, an increase of 11 per cent.

Gloucester.—The accounts of the electricity department for the year ended March last show capital expenditure £91,039 (increase £704). £89,158 has been borrowed and £17,591 repaid and placed to sinking fund.

Revenue was £12,806 (against £12,354 in previous year), total expenses £6,300 (£6,738) and gross profit £6,506 (£5,616). Interest required £2,808 (£2,775) and instalment of loans and sinking fund contribution £2,855 (£2,830). £56 has been transferred to capital account, and the balance carried forward is £584 (against £202 from previous year). Units sold were 851,450 for lighting and 600,380 for traction. The total maximum demands were 700 kw. for lighting and 390 kw. for traction.

Hull.—The accounts of the electricity supply department were approved by the Electric Lighting committee at their meeting last week.

The total revenue for the year ended March 31 was £53,839, including £29,915 from the sale of current by meter for lighting and £20,489 for power, and £701 for public lighting. Total expenditure (£27,030) included £14,762 for cost of generation, £5,028 for distribution, £2,874 for management, £1,551 for rents and rates, £1,105 for purchase of meters, £750 for switchboard renewal, £619 for show room and £274 for public lamp maintenance. The gross profit was £26,809; interest on stock, short loans, &c., absorbed £11,795 and loan instalments £11,983. The net profit, after allowing for income tax, was £3,289, but £855 was devoted to meeting portion of the capital outlay on show room and stores equipment, &c., leaving £2,438 to be carried to reserve. The capital expenditure is £398,363, an increase of £8,886. 13s. 11d. during the year. The works cost was 0·75d. per unit (against 0·83d.); the total working cost was 0·94d. (against 1·03d.); and the total cost (including interest and sinking fund) 1·83d. (against 1·92d.). 9,431,836 units were generated (against 8,431,114); 6,262,307 were sold for private lighting and power, and 83,700 supplied to the public lamps. There are 3,289 consumers, and the total maximum supply demanded was 4,790 kw.

In presenting the accounts, the chairman of the committee (Mr. E. HANGER) said that the figures had justified the statement in his report of 12 months ago that the electricity undertaking was becoming an increasingly valuable asset of the Corporation. An examination of the details of working expenses showed that for the last few years considerable sums had been allocated to the purchase of new plant and materials, a policy which must necessarily have the effect of strengthening the financial position of the undertaking; in addition, the gradual process of entire renewal of the old type mains in the centre of the town had been steadily proceeding, and in the year under review the whole of George-street, as well as a large number of small isolated portions of the mains, had been so renewed. In spite of the general reduction in sales, which had been going on all over the country, due to the advent of metal filament lamps, the income of the department had increased by over £500. The increased revenue from power supply was over £2,500, and experience in other towns had shown that it would be largely due to increased sales in that direction that they must look for developments of the undertaking in the future. Commendable improvements in working costs have been made by the engineer (Mr. H. Bell) and his staff, and they were for the first time able to record the figure of ¾d. as the works cost, and under 1d. per unit sold for the total cost. During the year they had put down no additional generating plant, as that already installed

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had proved adequate for present requirements, largely due to the increased use of more economical lamps, but there was abundant evidence to show that at no distant date they should have to be prepared to instal extensive additions.

Islington (London).—The total income of the Electricity department for the year ended March was £55,135 (against £55,615), including £37,658 from the sale of current for private lighting (£36,391) and £12,100 for public lighting (£15,734).

Total expenses were £27,598 (against £29,862), and included £14,944 for cost of generation (£16,694), leaving a gross profit of £25,537 (£25,753). Interest on loans and income tax absorbed £13,791, repayment of loans £8,647, and after allowing for bad debts, &c., the balance (£3,027) was carried to reserve. The works costs per unit sold were 0·77d. (0·9d.), and the total costs (including interest and sinking fund) 2·12d. (2·31d.) 5,301,899 units were sold (4,974,901); there are 2,130 consumers (1895), and the total connections in 30 watt lamps are equal to 213,688 (200,430). There are 615 street arc lamps (610), and the load factor was 15·67 (15·80) per cent. The net capital expended during the year was £11,782, making a total of £488,069. 12s. 2d.

The report of the engineer and manager (Mr. A. Gay) states that every item of the costs per unit sold has been reduced, with the exception of repairs and maintenance, and that the works costs (0·77d. per unit) are below the average for the whole of the Municipal undertakings in London. The reduction in the price of coal was responsible for a saving of £1,291, while other economies represented £1,431. About 2,500 tons less of coal were consumed, although 327,000 more units were generated. The increase in the number of units sold was due to the demand for power. During the year 53 motors and 25 radiators were connected, which, together with the additional lamps connected, represented an increase of 13,258 30 watt lamps.

Leigh (Lancs.)—At their last meeting the Town Council adopted the report and accounts of the electricity department for the year ended March, which state that the capital expenditure is £46,421 (increase £673).

Revenue was £7,890 (against £7,767 in previous year), total working costs £4,629 (against £4,294) and gross profit £3,261 (£3,473). After providing for interest £1,237 (£1,273), sinking fund contribution £1,367 (£1,326) and £545 for depreciation of motors and purchase of plant out of revenue (against £514), there was a net profit of £112 (£360). The maximum load was 471 kw. (440 kw.) and the load factor 19·5 (20) per cent. Average price obtained for current was 2·10d. (2·14d.) Units sold for lighting were 239,782 and for power 569,493, total 809,275 (increase 40,163). The revenue included £388 (against £387) rentals of motors, &c., on consumers' premises and £426 (£493) from sales of lamps, fittings, &c. The decrease in net profit is attributed to abnormal charges for repairs and maintenance. There are 432 (399) consumers connected, with 20,919 (20,363) equivalent 8 c.p. lamps, and the number of motors connected is 174 (= 1,085 H.P.), the same as at March, 1909.

Rotherham.—The total revenue of the Electricity department for the year ended March 31 was £14,824, including £14,530 from sale of current (303,362 units for lighting, 465,553 for power and 1,209,097 for traction.)

Working expenses were £7,906 and gross profit £6,918. After paying interest, sinking fund, &c., there was a net profit of £2,922, of which £2,000 was voted to relief of rates, and the balance placed to renewal fund. Capital expended is £57,663, an increase of £2,869.

Traffic receipts of the tramways department were £31,059, and total receipts £31,278. Expenses came to £22,363, and gross profit was £8,915. After allowing for the contributions from electric lighting department for loan charges and renewals fund, &c., and paying sinking fund, interest on mortgage debt, &c., there was a balance of £3,807. 19s. 9d. 6,341,671 passengers were carried and 666,800 car-miles run. The capital expended is £151,919. 11s., an increase of £15,971. 10s. 9d.

Stalybridge, Hyde, &c., Tramways and Electricity Board.—The accounts for the year ended March 31 have been issued.

Traffic revenue of the tramways department was £37,922 (including £280 from parcels). Total income was £38,055. Working expenses were £28,962, leaving a gross profit of £9,093. Interest came to £8,513, bank charges to £467, and sinking fund to £6,562, making the net deficit £6,449. 10,190,944 passengers were carried and 1,295,018 car-miles run.

The income of the electricity supply department was £30,103, including £29,842 from sale of electric current for lighting and traction. After paying expenses the balance was £13,348. Interest came to £7,457, bank charges to £409 and sinking fund to £5,951, leaving a deficit of £469. 10,023,140 units were sold to private consumers, 2,055,012 were supplied to the tramways department and 4,000 for public lighting. The total capital expended on the electricity department is £258,287 and on the tramways £279,475.

Wolverhampton.—The total income of the municipal tramways worked on the Lorain surface contact system) for the year ended March 31 was £45,499. 17s. 9d., and included £44,757 for traffic receipts.

Working expenses were £27,584 and the gross profit £17,915. After paying interest and sinking fund there was a net profit of £5,667. Gross capital expenditure is £277,195. Passengers carried were 9,670,657 and car-miles run 1,030,720. The number of units of current used per car-mile was 1·408, and the percentage of working expenses to total revenue was 60·6. Of the net profit £4,891 was placed to reserve and renewals fund, which now amounts to £32,395.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

St. Pancras (London) Borough Council invite tenders for supplying a marine type water-tube boiler, fitted with induced draught. Copies of specification, &c., from the electricity department offices, 57, Pratt-street, Camden Town, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett), Town Hall, Pancras-road, N.W., by 10 a.m. of Monday July 11. See also an advertisement.

London County Council invite tenders for wiring and fitting for electric light of the second portion of the central car repair depot Woolwich-road, and the supply and delivery of l.t. cables, cable boxes, &c., at the central depot. Specifications, forms, &c., from the Clerk of the Council, Mr. G. L. Gomme, County Hall, Spring Gardens, S.W. No tender received after 11 a.m. of July 12, will be considered. See also an advertisement.

London County Council also require tenders by 11 a.m. July 6 for electric wiring at St. Mark's-road and Haverstock Hill schools. Specifications from the Chief Engineer, Spring-gardens, S.W.

London County Council also require tenders by 11 a.m. July 5 for supply of 250 electric tramcar bodies and 250 electrical equipments for conduit and overhead systems. Specifications from the Clerk.

Tenders are invited by July 6 for the supply of cordless switchboards to the Postmaster-General's Department in South Australia. Tender forms and specification may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Fleetwood Council require tenders by noon July 15 for supply of a 300 kw. steam dynamo, a.l.-t. main switchboard and a 10-ton overhead travelling crane. Specifications, &c., from the Electrical Engineer, Albert-square, Fleetwood.

Newport (Mon.) Corporation want tenders by first post July 8 for a wooden water-cooling tower (capacity 200,000 gallons per hour) for the electricity department. Particulars from the Borough Electrical Engineer.

West Ham Education committee want tenders by 6 p.m. July 18 for electric lighting installation work at West Silvertown school. Specifications, &c., from Mr. Wm. Jacques, 2, Fen-court, E.C.

Swansea Harbour Trustees require tenders by 10 a.m. July 15 for three 2-ton electric transporters and overhead travelling cranes. Forms of tender, &c., from the Clerk.

Salford Corporation require tenders by noon July 18 for a bore-hole pumping plant for their electricity works, Pendleton. Particulars from the Borough Electrical Engineer.

Hornsey Council want tenders by 10 a.m. July 9 for the electric wiring and fitting of Stroud Green school. Specification, &c., from the Borough Electrical Engineer.

Rotherham Corporation require tenders by July 9 for 12 months' supply of cable and electricity meters. Further particulars from Borough Electrical Engineer.

Tenders are wanted by July 11 for wiring and fitting of Bridlington Grammar School on the O.S. system. Specification from the Electricity Works.

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BELFAST Guardians want tenders by noon July 5 for an electrical installation for the Abbey auxiliary workhouse. Specification, &c., from the Clerk.

WELLINGTON (N.Z.) Corporation want tenders by 4 p.m. June 30 for supply of three electrically driven multi-stage turbine pumps. Some particulars obtainable at 73, Basinghall-street, London, E.C.

The NEW SOUTH WALES State Railways Department require tenders by July 18 for supply and erection of three 5-ton overhead electric cranes and one 1½-ton and one 1-ton electric travelling crabs. Particulars from the Electrical Engineer, Sydney, N.S.W.

Tenders are invited for the supply to the Postmaster-General's Department, NEW SOUTH WALES, of one dust extractor, electrically driven, to work on a 24-volt d.c. circuit. Tender forms, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Aug. 2 for the supply and delivery of 1,820 private letter box fronts to the Postmaster-General's Department in the States of VICTORIA, QUEENSLAND, SOUTH AUSTRALIA and WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to July 27 for supply of a pneumatic tube service to the Postmaster-General's Department at ADELAIDE (S. Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to July 19 for supply and delivery of 4,200 telephone sets (as per schedule No. 231) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The Société Nationale des Chemins de fer Vicinaux, BRUSSELS, want tenders by July 20 for underground cables, and by July 27 for the equipment of a transformer station.

The Ministerio de Fomento, MADRID, will receive tenders until July 30 for the construction of an electric (or steam) strategic railway from Requena to Alcaráz, via Casas Ibáñez and Albacete. The contract is open to Spanish firms only.

The Ministerio de Obras Publicas, SANTIAGO (Chili), will receive tenders until July 15 for the substitution of electric for steam traction on the first section of the Chilian State Railways—from Valparaiso to Santiago and Los Andes.

SHANGHAI Municipal Council invite tenders for supply and delivery (c.i.f. Shanghai) of two 940 k.v.a. two to three-phase step-up transformers, e.h.t. switchgear, e.h.t. underground mains and feeder pillars. Specifications from Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, S.W., to whom tenders before noon July 5.

Tenders will be received at the State Railway Offices, VILLACH, Austria, until July 15 for the construction of two electrically driven locomotive turntables.

TENDERS RECEIVED AND ACCEPTED.

Erith Council received seven tenders for a 750 kw. three-phase turbo-alternator, surface condenser, air and circulating pumps and pipework (from the General Electric Co., the British Westinghouse Co., Willans & Robinson, the British Thomson-Houston Co., C. A. Parsons & Co., Jas. Howden & Co. and Fraser & Chalmers); and 12 tenders for a Lancashire boiler, mechanical stokers, superheater and pipework (Babcock & Wilcox, W. Arnott & Co., A. Brown & Co., E. Danks & Co., Yates & Thom, Hawksley, Wild & Co., Ruston, Proctor & Co., Spurr, Inman & Co., Fraser & Chalmers, Clarke, Chapman & Co., John Thompson & Galloways (Ltd.). Consideration of the tenders has been reserved.

London County Council have accepted the following tenders:—

Pinching & Walton (lowest tender) for wiring and fitting Hammersmith Bridge for electric lighting at £230. 19s. 6d. (Three tenders received; highest £328. Chief engineer's estimate £200.)

G. A. Gorden & Sons for enamelled iron advertisement plates for use in connection with the tramways, at 8¾d., 9d., 9¼d. and 10d. a foot super for two, three, four and five colours respectively, and the Patent Enamel Co. (Ltd.) for finger plates at 6d. each for either two, three, four or five colours.

For the electric lighting of the Stewart Institution, Chapelizod, Dublin, the following tenders were received:—

T. E. Brunker (*accepted*)	£1,537	J. C. Meldon	£1,569
Wm. Coates & Son	1,742	Estate Engineering Co	1,530
C. J. Cummins	1,702	Fletcher & Phillipson	1,520
Macredy, Eaton & Davidson	1,670	Maguire & Satchell	1,510
Egan & Co.	1,579		

Bolton Electricity committee have accepted the following tenders for annual stores:—

T. Moscrop & Co., crank chamber oil, &c.; Wareing & Co., light machine oil, paraffin oil, soda, white lead and soad ash; Joshua Orrell & Co., paint, boiled oil and solidified oil; Geo. Reason, cotton waste; and Messrs. Townson & Sons, timber.

The L.&.N.-W. Rly. Co. have accepted the tender of Wm. Geipel & Co. for the supply of Henrion arc lamp carbons during the year ending June 30, 1911, for the whole of the company's requirements, the total annual consumption amounting to 1,373,000 carbons. This is a renewal of last year's contract.

Belfast Harbour Board have accepted the tender of Hind Bros. & Co. for 22 tubular arc light masts at £7. 15s. 6d. each, less 2½ per cent., in place of the tender of Jas. Allan (Sen.) & Sons, which was withdrawn.

Southend Council have accepted the tender of Smith & Sons for an electric crane at £487; and that of the Brush Co. for lengthening a single-truck car at £200.

We are informed that Londonderry Corporation and the N.S.W. Govt. Railways Dept. have placed orders with Willans & Robinson for turbo-alternators,

Luton Council have accepted the tender of Hughes & Lancaster for a motor-driven air compressor at £375. 10s.

Salford Guardians have accepted the tender of Lightfoot Bros. for wiring the operating theatre at the Infirmary for £52. 10s.

The tender of Walter Scott (Ltd.) has been accepted by Huddersfield Corporation for supply of tram rails for the Linthwaite track.

Commonwealth Tenders.—The Works and Buildings Department (Adelaide) have accepted the tender of Unbehaun & Johnstone for supply and erection of an electric goods elevator at the Government Printing Office at £238. 10s.

The tender of Siemens Bros. Dynamo Works for 1,640 iron telegraph poles at £5,119, has been recommended for acceptance by the Postmaster-General's Department, Melbourne.

The Victorian Railway Department has placed a two years' contract with the Welsbach Light Co. of Australasia for supply of metal filament lamps.

BUSINESS NOTICES.

The telegraphic address of W. T. Henley's Telegraph Works Co. (Ltd.) is now "Henletel London." The word "Henletel" is also registered for use in connection with the company's branches at Glasgow, Newcastle, Manchester and Birmingham.

Hy. Taffs and Chas. F. Toft (trading as H. Taffs & Co.), electrical engineers, 40, Brazenose-street, Manchester, have dissolved partnership. Debts by Mr. Taffs.

American Electricity Supply, Tramway and Railway Undertakings.—From the McGraw Publishing Co., 239, West 39th-street, New York we have received copies of the Lighting and Power edition, and of the Electric Railway edition of the McGraw Electrical Directory for 1910.

The Lighting and Power edition is divided into three sections, (1) a central station list; (2) dealers and contractors' section, and (3) buyers' manual section, which includes a classified list of manufacturers, a dictionary for buyers, and a literary section. In the central station list are included particulars of the various electric lighting and power plants in the whole of the United States, Mexico and Canada. The information given includes the names of the chief officials (president, manager and engineer), voltage of supply, frequency, charges for supply, street lighting statistics, &c., there are over 5,550 central stations in the U.S.A., of which particulars are given, 425 in Canada, 71 in Mexico and 9 in the West Indies and the Republic of Panama, a total of 6,055 stations. The number of plants giving d.c. supply is 1,650, while there are 4,414 a.c. plants. The present edition (April, 1910) contains 210 new entries.

The contractors' section is also a very complete one, and the whole of the information seems to have been carefully compiled and edited. The subscription price is $10 per year.

The Electric Railway edition gives a good list of manufacturers of electric railway plant and apparatus, and this is followed by statistics and data relating to the electric railways in the United States, Canada and Mexico. The information includes the names of the chief officials, power station equipments, length and gauge of line, number of cars, &c. There is also an alphabetical list of street railway officials, together with particulars of the National and State Railroad Commissioners, street and interurban railway associations, &c. The subscription price is $5 per year.

Each edition is published semi-annually, and each book has a good index making it easy of reference.

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CATALOGUES, &c.

TANTALUM LAMPS.—Messrs. Siemens Bros. Dynamo Works send us a leaflet giving full particulars of the reduced prices of tantalum lamps. All voltages, candle-powers and sizes of bulb sare dealt with.

ELLISON STARTERS.—We have received from Mr. Geo. Ellison, of Birmingham, a pamphlet giving details of no-voltage and overload release starters for slip-ring or squirrel cage a.c. motors made by him. These starters can either be totally enclosed, for use in mills and other similar places, or can be made in the usual open fashion. Particulars, prices and capacities are given.

D.P. BATTERY INSTALLATION.—The D.P. Battery Co. have ready a pamphlet describing an installation consisting of a battery and booster recently erected by them at Messrs. Rowntree's works at York. The installation possesses some interesting features and we hope to return to it again.

B.T.-H. CONTINUOUS-CURRENT MOTORS AND GENERATORS.—We have received from the B.T.-H. Co. a list illustrating and describing a new design of B.T.-H. continuous-current motor and generator. These machines can be fitted with various styles of covers and be thus rendered flame, dust or moisture-proof, whilst they can also be protected so as to work satisfactorily in all kinds of inconvenient positions.

ELLIOTT INSTRUMENTS.—Messrs. Elliott Bros. have issued a number of pamphlets illustrating and describing some of the instruments made by them. These include switchboard instruments, current and potential transformers, portable transformers, photometers, as well as galvanometers and keys and switches of various kinds.

O.S. ELECTRIC WIRING SYSTEM.—A pamphlet sent out by Messrs. Siemens Bros. & Co. deals with this system, and consists of a more or less popular description of this method of wiring, which includes illustrations of actual surface Stannos runs, as well as a series of pictures of all sorts of buildings which have been wired with Stannos. Another pamphlet shows Stannos wiring applied to Cambridge Colleges and describes some of the recent installations that have been made in these places.

THERMO-ELECTRICAL PYROMETERS.—A catalogue just issued by Messrs. Siemens Bros. & Co. contains various new features in connection with their thermo-electrical pyrometers. This supersedes the catalogue issued in October, 1907.

"CASTLE" MOTORS AND DYNAMOS.—Messrs. J. H. Holmes & Co.'s new catalogue gives particulars of their continuous-current motors and dynamos.

OIL GOODS.—Messrs. Ragosine & Co. are issuing a catalogue which gives details of various oil goods and varnishes made by them.

EDISWAN BELLS AND TELEPHONES.—The Edison & Swan Company have ready catalogues dealing with their makes of bells and telephones.

BANKRUPTCIES, LIQUIDATIONS, &c.

A first and final dividend of 20s. in the £ will be payable on July 4 at 8, Frederick's-place, Old Jewry, London, E.C., in the liquidation of the Phosphor Bronze Co. (Ltd.)

In the voluntary liquidation of Prockter & Kenyon (Ltd.) a meeting of creditors takes place on July 5 at Mr. T. Walton's, 36, Spring Gardens, Manchester.

A meeting to receive an account of the winding-up of Mackey's Electric Lamp Co. (Ltd.) (in liq.) will be held at 174-5, Aldersgate-street, London, E.C., on Aug. 3.

A meeting to receive an account of the winding-up of the Bradford Electrical Engineering Co. (Ltd.) will be held at Mr. J. H. Haley's, Tyrrel-street, Bradford, on July 25.

A meeting to receive an account of the winding-up of the Electric Sterilizing, Carbonizing and Stripping Co. (Ltd.), will be held at Prudential-buildings, Market-place, Dewsbury, on July 27.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Einführung in die Technische Elektrochemie." Vol. I. "Elektrothermie." Edited by Dr. Paul Askenasy. (Brunswick: F. Vieweg und Sohn.) M.10.

"Die Europäischen Fernsprechgebührentarife." By Dr. Erwin Günther. (Jena: Gustav Fischer.) M.6.

"Messungen an Maschinen und Motorem fur Ein-und Mehrphasen-Wechselströme." By Fritz Hoppe. Part IX. of "Sammlung elektrotechnischer Lehrhefte." (Leipzig: J. A. Barth.) M.5.80.

"Prinnip und Wirkungsweise der technischen Messinstrumente für Wechselstrom." By Fritz Hoppe. Part IV. of "Sammlung elektrotechnischer Lehrhefte." (Leipzig: J. A. Barth.) M.4.

COMPANIES' MEETINGS AND REPORTS.

Aron Electricity Meter (Ltd.)

The thirteenth ordinary general meeting of the company was held on Friday last, under the presidency of Mr. H. HIRST, M.I.E.E., chairman of the company.

The SECRETARY (Mr. M. Aron, F.C.I.S.) read the notice convening the meeting and the report of the auditors.

The CHAIRMAN then said: Gentlemen, it is again our pleasure to submit for your approval the report of a year's trading. The similarity of the figures in the balance-sheets of 1909 and 1910 shows that our business has attained a pleasant stability. Our profits have risen in this year's accounts to the satisfactory total of £35,630, or £1,330 more than last year, which was, up to that time, our record year. The other items on the profit and loss account are within a per cent. or two the same as last year. We have written off £400 more depreciation, not because our plant is in any worse condition, but in an industrial business like ours, which is constantly in process of evolution, one likes to use some of the profit of good years for writing down certain capital items. Maintenance of patents is a few hundred pounds less, and so, naturally, is debenture interest, for our debenture debt decreases every year by the repayment of about £5,000. As regards the balance-sheet, only two figures call for comment. We have added to our leasehold land, buildings, machinery and tools £9,279. This figure is largely composed of additional land and buildings rendered necessary by the increase of our business. We have less cash to the extent of £15,000, if I include in this item loans at short notice. This is accounted for by the greater trading outstandings, which are £58,000 this year, against £40,000 last year, and also to some extent by the extensions of the taximeter business. The taximeter business particularly is at present absorbing money. These instruments, as I have previously stated, are not sold outright, but are hired out, mostly for periods of about five years. We have received very satisfactory contracts in London, Brussels and Vienna for hiring out taximeters, and while we have to manufacture and instal every instrument, the cost of both manufacture and installation has to be defrayed at present from our liquid assets. Payment, however, is received only in monthly or quarterly instalments, and it follows that the outgoings, so far as capital expenditure is concerned, are still greater than the incomings, and this state of affairs is likely to continue for some time if we are successful in obtaining more orders. The profits we have shown in this year's accounts have been made entirely by our old-established meter and clock business. For the safety of the company, the directors have so far used all the income received from taximeters against manufacturing and installation expenses.

It is a matter of great satisfaction to the board, and particularly to Prof. Aron as managing director and to myself as chairman, that we are able this year to recommend the distribution of a dividend which will clear off the last of the arrears due to preference shareholders (cheers.) Our conservative policy, which necessitated in years gone by the accumulation of these arrears, has been vindicated, not only by our ability to pay them back now, but also by having established a business which shows a greater turnover and profit than at any time during its existence. We are firmly planted in nearly every European country, and we have found a particularly useful outlet for our manufactures in the constantly growing and prosperous power companies on the Continent. The average yield per meter is less than in former years, but we have made up for this by selling a very much larger number of meters, and, I may add, by manufacturing more cheaply. I can only add that I sincerely hope—and there is great reason for that hope—that the ordinary shareholders will in the near future be rewarded for their great patience (cheers). Before putting the motion for the adoption of the report and accounts to the vote, I wish to express my pleasure that Prof. Aron is able to be present at this year's meeting, and I am anxious to take this opportunity of thanking him for the hard and great work which he has given unstintingly to our company, and which has been the mainspring of our success (hear, hear). He has been loyally backed up by our excellent staff, whom he has placed in charge of our various undertakings in the different countries, and their efficiency and loyal and strenuous work are greatly due to his master mind which has controlled them. I now move the adoption of the report and accounts.

Sir JAMES PENDER, Bart., seconded the motion, which was carried unanimously.

A resolution approving the payment of the dividend of 9 per cent. on the preference shares was then approved.

Mr. ROGER W. WALLACE, K.C., moved the re-election of the retiring directors, Mr. H. Hirst and Sir James Pender, Bart., and expressed his pleasure in moving the resolution. He said their chairman was a gentleman who was eminently suitable for the position. It was extremely desirable that the head of such a company should be someone in a position such as Mr. Hirst so successfully occupied. With respect to Sir James Pender, he was well known in connection with electrical matters, as he was a director of many other electrical concerns. The qualifications of both gentlemen were, therefore, exceptional.

Mr. HARRY KAHN seconded the motion, and said they could not but realise the tremendous amount of work their chairman had done for the company.

The motion was carried unanimously.

The retiring auditors, Messrs. Price, Waterhouse & Co., were then reappointed, and a cordial vote of thanks to the chairman and to Prof. Aron terminated the proceedings.

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BOMBAY ELECTRIC SUPPLY & TRAMWAYS CO. (LTD.)—The report for 1909 states that the total revenue for the year (including amount represented by sale of current to the tramways) was £197,827, an increase of £19,972. Expenditure was £115,132, an increase of £4,343. The net receipts were £82,695, compared with £67,066. With amount brought forward (£9,385), the available total is £61,550. Deducting preference dividend and transferring £6,000 to sinking fund for capital redemption the directors propose to place £15,000 to depreciation, leaving to be carried forward £4,567. The directors have been in negotiation with the Municipal Corporation with a view to an increase in the rates charged on the tramways for long distance fares, and the Corporation have sanctioned for two years the alterations applied for, as from April 1, 1910. The directors have decided to substitute for the maximum demand system of charging for electricity flat rate charges. The work of erecting the new Kasara generating station, which is to replace the existing generating station at Wari Bunder, is being actively prosecuted. Capital expenditure during the year was £41,136.

BRITISH ALUMINIUM CO. (LTD.)—At the statutory meeting on Wednesday, Mr. A. W. Tait said that the new company was incorporated on April 15, and the whole of the shares to be issued under the scheme of reconstruction had been allotted. The issue of £800,000 5 per cent. prior lien debenture stock, which was also a part of the scheme, was successfully accomplished. The new company would therefore be in possession of funds to the extent of £974,433 when the calls upon the prior lien debentures and the shares which had been allotted were fully received. The scheme of reconstruction had been successfully carried through. The liabilities of the old company had all been discharged, and the repayment of loans in connection with the Martigny-Osnieres Railway had also been effected. The new company was in possession of funds to complete the Loch Leven works, to provide for further capital expenditure, and to have a sufficient sum for additional working capital.

CHILI TELEPHONE CO. (LTD.)—The report of the directors for the year ended March 31 last states that the aggregate number of subscribers at all centres at that date was 8,818, compared with 8,011 at the beginning, a gain of 807. Gross revenue in Chili from all sources was $1,851,689, against $1,720,716 in 1908-9, an increase of $130,973. Expenditure in Chili was $926,387, against $824,082, an increase of $102,305. Net income in Chili was $925,301, against $896,633, an increase of $28,668. The average rate of exchange for the year was 10·49d., compared with 10·09d., an increase on the year of 0·40d. Converted into sterling the figures are: £40,411 for 1909-10, against £37,698, increase £2,713. The liquid assets and liabilities in Chili on March 31, 1910, were valued at 10½d., the current rate of exchange on that day, compared with 11⅛d. on the corresponding date of the previous year. The balance to credit of revenue, including £2,820 brought forward, is £41,091, of which £20,504 has been carried to reserve. An interim dividend of 3s. per share (tax free) was paid on Jan. 15, and a final dividend of 5s. per share (tax free) is now recommended, leaving £2,987 to be carried forward. The total mileage on March 31 was 15,316 miles 812 yds., an increase of 1,195 miles 228 yds. in the year.

ELECTRIC & GENERAL INVESTMENT CO. (LTD.)—The directors' report for the year ended May 31 states that the gross profit was £13,086. 19s. 6d. After deducting all general charges and interim dividend already paid on the preference shares, and providing for proportion of final dividend accrued on the preference shares to May 31, there remained £5,496. 7s. 1d. As a further reserve to meet depreciation in investment and loan securities, the directors have carried £4,296. 7s. 1d. of this amount to contingencies fund, thereby raising this fund to £75,948. 4s. 9d., leaving £1,200, which the directors recommend shall be distributed by the payment of a dividend at the rate of 6 per cent. on the capital paid up on the ordinary shares for the year. The trustee for the ordinary shares reserve fund proposes to distribute 6d. per share out of the dividends received on the trust investments, and the trustee for the founders' shares reserve fund proposes to distribute £7 per share out of the dividends received on the trust investments.

ELECTRIC TRACTION CO. OF HONGKONG (LTD.)—The report for 1909 states that the gross traffic receipts show an increase over 1908 of more than £2,500, in spite of the further decrease in the rate of exchange; and the working expenses show an increase of some £1,200. The result for the year, after providing for working expenses and payment of debenture interest, is a profit of £5,282, which, added to amount brought forward, makes £5,568. The directors consider it desirable to continue the policy of previous years by allocating £5,000 to reserve for depreciation and renewals, the balance (£568) being carried forward. The manager reports that he anticipates being able to recommend in the near future the purchase of 10 further cars to meet the growing traffic, and this will probably necessitate the purchase of additional land for a new car shed. The special valuation of the company's undertaking by Mr. J. H. Garratt has been received and amounts to £240,000. Having regard to that valuation, the board recommend that the share capital of the company be written down from 325,000 £1 shares to the same number of 5s. shares, and a resolution will be submitted to the shareholders for that purpose at an extraordinary general meeting. It is also proposed to change the company's name to the "Hongkong Tramway Co. (Ltd.)."

KALGOORLIE (W. AUSTRALIA) ELECTRIC TRAMWAYS (LTD.)—Gross receipts during 1909 amounted to £45,266, compared with £47,368 for 1908, and the net profits to £16,573, against £15,400. The cars travelled 631,242 miles, against 647,297, and carried 2,936,411 passengers, against 3,028,419 in 1908. The earnings per car-mile were 17·16d., compared with 17·53d., while expenses per car-mile were 10·29d. against 11·25d. The expenses per cent. of earnings in 1909 were 59·99, against 64·17 per cent.

MARCONI INTERNATIONAL MARINE COMMUNICATION CO (LTD.)—The report for 1909 states that the business has now reached the stage when the revenue exceeds the somewhat heavy standing expenditure necessary in such a business. The directors are confident that the business will continue to show considerable extension. The greater facilities to communicate with the shore, the continuously growing number of ships installed, together with the more general custom of communicating with and from ships at sea, should ensure rapidly increasing profits.

At the meeting on Wednesday the directors' report and accounts were adopted.

MARCONI'S WIRELESS TELEGRAPH CO. ((LTD.)—At the meeting on Tuesday the chairman (Mr. G. MARCONI) said it must be satisfactory to all interested in the company that a profit had been made during the past year, notwithstanding the absence of any practical assistance to their revenue through the misfortunes at the Glace Bay Station, which stopped their trans-Atlantic service. The profit earned, it was true, was not large, but the extension of the business was such that the directors felt warranted and had considerable satisfaction in recommending the payment of the 7 per cent. dividend on the cumulative preference shares to June 30, 1909, and they were hoping that it would not be long ere they would be able to make a further payment, paying up the cumulative dividend to the end of 1909. The work which they had in hand and in prospect, the general development of their business, together with the opening of the trans-Atlantic service, gave them good reason to expect that not only should the preference shareholders be able to look in future to the regular payment of their dividend, but that the ordinary shareholders might also look to an early reward for their patience. The future policy of the company was to open a large number of telegraph services throughout the world. In the past they had had to be satisfied with what might almost be termed the profits of a manufacturer's business; but they had always had present in their minds the immense scope of this and their associated companies in turning to account the principal value and utility of wireless telegraphy applied to long distances. They had already submitted a general scheme to the Government, and had every hope that at a not too distant date they should obtain the licences which they required. Speaking for himself it would be impossible for him to give his best attention to the technical and scientific supervision of the company's affairs so long as he was also responsible for its business management. He, therefore, endeavoured to find a person who could take hold of the business management of the company, and last winter he was fortunate enough to find a gentleman possessing the necessary ability and experience to enable him to successfully fill the position of managing director. Mr. Godfrey Isaacs was elected joint managing director last January. Both himself and his colleagues on the board had been agreeably surprised at the thorough grasp Mr. Isaacs had obtained of their business in so short a time. Speaking for himself personally, as well as for the board, he might say that they all felt that Mr. Isaacs was just the man they wanted, and was a gentleman in whose ability and integrity every member of the company could place the fullest confidence. He must say that from shortly after the time Mr. Isaacs became associated with them he had been able to attend in a much greater measure to the technical side of their work, and it was his (Mr. Marconi's) intention to shortly resign from the position of joint managing director in order that he might be able to give his best attention to the work for which he felt most adapted and in which capacity he could be of most value to the company. The directors wished to again put on record their appreciation of the work carried out by the company's staff both at home and abroad, and he himself should also like to acknowledge the assistance he had received from his co-directors.

Mr. GODFREY C. ISAACS said they were practically ready almost at a moment's notice to proceed to any part of the world and erect wireless telegraph stations in the space of a very short time. He could not give them a better instance of that than by quoting an actual fact. H.M. Government placed an order with the company on Feb. 12 last to enable them to communicate across the Gulf of Aden. Within six days the engineers were on their way; the necessary material and drawings followed almost immediately, and by May 12 communication was established by wireless telegraphy and the work completed.

In reply to questions by Mr. Fisher, the chairman said that the greater portion of the £15,000 paid by the Post Office for the purchase of ship-shore stations went to the International Co., which was one of their subsidiary companies, and to whom these stations belonged. The transfer of these stations to the Post Office was very good business for them. Certainly the amount of money paid might have been greater, but still the chief source of revenue from the ship-shore point of view should be the ships. The land stations were necessary in order that the ships should have points with which they could communicate, but he thought it very desirable that those land stations should be worked by the Government. He must say that they were worked very well by the Government, and that their revenue had in no way suffered in consequence.

The resolution was carried unanimously.

Mr. Godfrey C. Isaacs and Mr. Alfonso Marconi were elected directors, and the re-election of Major S. Flood Page, Mr. Henry S. Saunders and Mr. Samuel Geoghegan was also agreed to.

Mr. J. HENNIKER-HEATON proposed a hearty vote of thanks to Mr. Marconi, which was seconded by the Hon. GEORGE MANNERS, and carried unanimously.

PERTH (W. AUSTRALIA) ELECTRIC TRAMWAYS (LTD.)—The gross receipts during 1909 amounted to £74,649. 0s. 5d., compared with £73,338. 12s. for 1909; and the profit was £30,161. 5s. 2d. against

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£28,720. 12s. 2d. Traffic receipts show an increase over 1907 and 1908, and, with the exception of 1906, are the highest since the inception of the company. The sum at credit of profit and loss account is £12,456. 5s. 2d. Adding £1,099. 15s. 11d. brought forward the total is £13,556. 1s. 1d., from which £6,000, preference dividend has been paid. The balance (£7,556. 1s. 1d.) is sufficient for a distribution of 5 per cent. to the ordinary shareholders, but the directors are unable to recommend so large a dividend in view of the repayment of the loan of £4,000 for further rolling stock and construction work on extensions. They therefore recommend that £4,000 be placed to reserve for extensions, and that a dividend on the ordinary shares of 2½ per cent. be paid, leaving £1,056. 1s. 1d. to be carried forward.

RIO DE JANEIRO TRAMWAY, LIGHT & POWER CO. (LTD.)—At the meeting last week it was reported that during 1909 the work of construction was largely confined to the extension in the Federal District of the light and power distribution systems to meet the growing demands and with a view to developing the system, and to the reconstruction of the tramways for electric operation. Additional duct lines, aggregating 225,950 lineal feet and five large transformer vaults were installed, giving a total of 1,598,945 lineal feet of ducts, 79 transformer vaults and 309 manholes completed up to Dec. 31. A large amount of underground and overhead high-tension feeders have been installed including an independent line of cable for supplying power to the Federal Government for lighting and operating the docks, for which at the present time there have been installed transformers of 810 kw. capacity. In the reconstruction of the mule tramway lines there have been laid during the year 73·34 miles, including 3·68 miles of the Villa Isabel system. During the year 132 passenger cars were put into service. The Corcovado rack railway has been electrically equipped with three-phase alternating current locomotives of the Maschinenfabrik Oerlikon. This line has now been put into electrical operation.

With a view to improving the telephone service and to meet future development 52,292 ft. of overhead and underground cables have been installed. A new sub-station has been commenced on Rua General Canabaar to serve the Sao Christovao and Villa Isabel districts. When these additions are completed the Company will possess three stations with a total capacity of 8,700 lines.

The business of the light and power department has grown in a satisfactory manner, with the result that on Dec. 31, the company had contracts for supply of 25,719 H.P. against 15,619 H.P. in 1908. The lighting business has also increased at a rapid rate, there being connected 90,204 incandescent lamps (against 40,179), 2,177 arc lamps (1,882) and 1,094 electric fans (691).

The business of the telephone department has been increased during the year by 572 subscribers, there being now connected 3,991 subscribers, against 3,419 in 1908. The net revenue from operation, after deduction of operating expenses, maintenance, taxes and other expenses in Rio de Janeiro, was $3,438,494·78, from which must be deducted the fixed and other charges of the subsidiary companies and the fixed charges and interest of the company ($2,288,887·29), leaving a net surplus of $1,149,607·49. A first dividend of 1 per cent. ($311,908·54) was paid on Nov. 1 last, leaving $837,698·95, which being added to the surplus in 1908 of $870,236·66, leaves $1,707,935·61.

TUBES (LTD.)—At the meeting on Friday the Chairman (Mr. A Chamberlain) said the net profit after providing for debenture interest, depreciation and all expenses, was £5,168, to which was added £6,123 brought forward. A dividend of 9d. per share (less tax) was declared, and £7,760 carried forward. The Chairman referred to the hot rolling invention and said it had proved a continued success. When the third plant was completed they would have everything there was room for at the Climax factory. In addition to its value for making steel tubes they found it would be equally valuable for copper and brass solid drawn tubes, and they proposed to make the alterations necessary in the machinery to adopt it to the solid drawn brass trade. They had provided a further safeguard for their business in a new and very successful adjunct, in the conduit department. The company had been in that trade two years, and it had proved a real live business. In addition, they had undertaken the business of advertising sign makers. They got hold of an invention which they satisfied themselves was of great value. It was of such a nature that they could replace existing signs, the cost of installing the new ones being paid for by the saving in electric current in the course of six or nine months. By that invention they were able to give a greater amount of light and greater prominence to a sign than before.

WESTERN UNION TELEGRAPH CO.—The report of this company for the quarter ended June 30 states that there was a surplus at Dec. 31, 1909, of $18,584,497.13, and net revenues in the quarter ended March 31, 1910, were $1,794,998.55. Dividend of ¾ per cent., paid April 15, 1910, required $747,711 and interest on bonded debt $433,062.50, leaving a surplus on March 31, 1910, of $19,198,722.18. The net revenues of the quarter ended June 30, based upon nearly completed returns for April, partial returns for May and estimating the business for June, are about $1,950,000, less interest on bonded debt $433,062.50, and after deducting for a dividend of ¾ per cent., about $747,750, there will be a surplus of $19,967,909.68. A dividend of ¾ per cent. is declared payable on July 15.

CUBAN TELEPHONE CO.—A statement is being issued by the London advisory board of the Havana Telephone Co. to the effect that the July interest on the bonds of the Cuban Telephone Co. will be paid by Messrs. Chaplin, Milne, Grenfell & Co. on July 1. The difficulties which have delayed the completion of the recent bond issue of the Cuban Co, have been adjusted, and the issue is now being proceeded with.

NEW COMPANIES, MORTGAGES AND CHARGES AND RECEIVERSHIP.

NEW COMPANIES.

CLOUGH, SMITH & CO. (LTD.) (110,192.)—Reg. June 15, capital £3,000 in 2,990 preference shares of £1 each and 200 ordinary shares of 1s. each, to carry on the business of builders, contractors for and constructors of public works, railways, tramways, &c. Private company. First directors, N. C. Clough and S. G. Smith.

HELSBY WIRELESS TELEGRAPH CO. (LTD.) (110,324.)—Reg. June 22, capital £50,000 in £1 shares, to carry on the business of manufacturers of telegraphic, telephone and electrical instruments and apparatus, &c., to acquire certain patents and inventions relating to wireless telegraphy and telephony, and to adopt an agreement with the Telegraph & Telephone Instruments (Ltd.). First directors, Lieut.-Col. J. Bernard and Capt. C. M. Gonne. Reg. offices, 25, Victoria-street, Westminster, S.W.

NEW ELECTRICITY CO. OF MACCLESFIELD (LTD) (110,388.)—Reg. June 25, capital £5,000 in £1 shares, to carry on the business of an electric light and power company in all its branches. The subscribers are Messrs. W. B. Esson, J. Macgregor, D. Willock, A. W. Money, J. G. Lorrain, W. T. Batho and G. J. Davis.

RIO DE JANEIRO SUBURBAN TRAMWAYS (LTD.) (110,272.)—Reg. June 18, capital £1,000 in £1 shares, to take over concessions granted or to be granted for the construction of tramways and light railways in or near Rio de Janeiro. First directors, S. Ablin, A. Ewens, H. H. Bartlett, G. M. Robertson, C. Piper, E. Sparie and Miss M. G. Smily (provisional directors). Reg. office, 7 and 8, Poultry, London, E.C.

WELDINGS (LTD.) (110,316.)—Reg. June 21, capital £1,500 in £1 shares, to carry on the business of electrical, mechanical and civil engineers and contractors, welders, manufacturers of electrical and other machinery and accessories, &c., and to adopt an agreement with W. H. Lynas and H. F. V. Sadgrove. Private company. First directors, W. H. Lynas and H. F. V. Sadgrove. Reg. office, 80½, Lionel-street, Birmingham.

MORTGAGES AND CHARGES.

F. BURKS & CO. (LTD.)—Particulars of £3,000 debentures, created May 13, have been filed, amount of present issue being £820. Property charged, company's undertaking and property, including uncalled capital. No trustees.

RAIL-LESS ELECTRIC TRACTION CO. (LTD.)—Particulars of £3,000 debentures created April 7 and secured by trust deed dated June 14, has been filed, the amount of present issue being nil. Property charged, certain inventions and patents and company's undertaking and other property, including uncalled capital. Trustees, Sir Charles D. Fox and W. G. F. Nelson.

W. SITCH & CO. (LTD.)—Second debenture, dated May 31, to secure £200, charged on company's undertaking and property, including uncalled capital. Holder, Miss F. Edwards.

"Z" ELECTRIC LAMP MFG. CO. (LTD.)—Amended particulars of £25,000 debentures, created Aug. 13, 1909, have been filed, amount of present issue being £21,700. (Original particulars gave whole amount issued.)

RECEIVERSHIP.

UNITY MOTOR, ELECTRICAL & GENERAL ENGINEERING CO. (LTD.)—J. G. Taylor, 28, Baldwin-street, Bristol, ceased to act as receiver or manager on May 31 last.

CITY NOTES.

MEMORANDA (June 30).—Bank rate 3 per cent. (since June 9, 1910). Price of silver, 24⅛d. per oz. Consols 82⅜—82½ for money; 82⅝—82⅝ for account. Consols Pay Day, July 1; Stock and Shares Continuation Days, July 12 and 26; Ticket Days, July 13 and 27; Pay Days, July 14 and 28; Mining Shares Carry Over Day, July 11.

PRICES OF METALS (London).—*Copper*, cash, 54⅛; three months, 55⅛. *Lead*, English, 13—13¼; foreign, 12⅜—12⅞ *Spelter*, 22⅛—22¾, *Tin*, English, 147—149; foreign cash, 148¾; three months, 149⅛. *Iron*, Cleveland, cash, 48/9, three months, 49/7.

CLONTARF & HILL OF HOWTH TRAMROAD CO.—The directors have declared an interim dividend of 3s. per share.

CORDOBA LIGHT, POWER & TRACTION CO. (LTD.)—At a meeting yesterday (Thursday) it was decided to increase the share capital from £500,000 to £800,000, and to convert the undertaking of the Ciudad de Cordoba to electric traction.

MEXICAN LIGHT & POWER CO. (LTD.)—The directors have declared a dividend of 1 per cent. on the ordinary shares for the quarter ended June 30.

NATIONAL ELECTRIC SUPPLY CO. (LTD.)—The directors have declared an interim dividend of 3s. per share (less tax) on the ordinary shares for the past half-year.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have been asked to appoint a special settling day in 30,000 £1 fully-paid vendor's preferred ordinary shares, and 90,000 £1 fully-paid vendor's deferred ordinary shares of the *National Telewriter Co. (Ltd.)*

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	June 17	225	+ 3	24	5,231	+ 88
Anglo-Argentine	,, 24	43,350	+ 5,478	25	1,103,773	+ 121,221
Ayr Corporation	,, 25	351	+ 25	6	1,816	+ 30
Baker St. & Waterloo Ry.	,, 25	3,255	— 180	25	84,980	+ 1,330
Barnsley	,, 17	173	+ 19	24	4,100	+ 129
Barrow	,, 17	303	+ 61	24	5,854	+ 724
Bath Electric Trams, Ltd.	,, 22	915	+ 144	25	19,014	+ 1,510
Birmingham Corporation	,, 25	6,814	+ 333	12	82,842	+ 956
Birmingham & Midland	,, 10	829	+ 71	23	19,057	+ 318
Blackburn Corporation	,, 22	1,170	+ 120	‡13	13,955	— 793
Blackpool and Fleetwood	,, 25	743	+ 55	..	..	..
Bolton Corporation	,, 25	2,426	+ 160	13	29,422	— 787
Bombay	May 27	2,544	+ 167	21	57,700	+ 3,996
Bournemouth Corporation	June 22	1,701	+ 118	12	19,532	— 600
Bradford Corporation	,, 25	5,317	+ 575	13	62,964	+ 1,221
Brighton Corporation	,, 26	979	+ 74	§12	11,410	— 444
Bristol Trams & Carriage	,, 24	6,281	+ 933	25	142,115	+ 13,784
Burnley Corporation	,, 25	1,220	— 9	25	40,651	+ 689
Burton Corporation	,, 26	267	— 30	12	3,277	— 44
Bury Corporation	,, 26	1,168	+ 89	§12	15,205	— 460
Calcutta Tramways Co.	,, 25	₹51,422	+ ₹1,312	25	₹1,292,422	+ ₹44,458
Camborne-Redruth	,, 25	119	+ 9	25	3,010	— 112
Cardiff Corporation	,, 25	2,379	+ 280	13	27,397	+ 199
Cavehill	,, 17	122	+ 6	24	1,967	+ 154
Central London Railway	,, 25	5,870	+ 9	25	141,701	+ 2,588
Charing C., Euston & H'stead	,, 25	3,700	— 280	25	95,895	— 1,435
Chatham & Dist. Lt. Rys.	,, 23	953	+ 171	25	20,165	+ 1,047
City & South London Rly.	,, 26	3,073	— 249	25	80,681	— 723
City of Birmingham	,, 17	2,901	+ 188	24	68,200	+ 3,149
Colchester Corporation	,, 21	235	— 82	..	..	..
Cork Electric Trams Co.	,, 23	530	+ 15	25	11,704	+ 1,737
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	,, 17	432	+ 69	24	9,861	+ 1,114
Dover Corporation	..	..	..	..	..	..
Dublin & Lucan Railway	,, 24	163	+ 19	25	3,211	+ 46
Dublin United	,, 24	6,352	+ 673	25	132,660	+ 4,944
Dudley-Stourbridge	,, 17	779	— 5	24	17,778	— 657
Dundee Corporation	,, 22	1,240	+ 55	§5	6,656	+ 122
East Ham Council	,, 25	1,075	+ 84	¶12	12,826	+ 266
Exeter Corporation	,, 24	344	+ 26	12	3,947	— 557
Gateshead & Dist. Trams	,, 17	1,027	+ 75	24	23,025	— 384
Glasgow Corporation	,, 25	18,849	+ 1,463	4	68,699	+ 5,522
Glossop Trams	..	..	..	..	..	..
Gloucester Corpn.	,, 22	336	— 193	..	..	..
Gravesend-Northfleet	,, 17	214	+ 8	24	4,685	+ 92
Great Northern & City Rly.	,, 25	1,390	— 10	25	35,795	— 416
Gt. Northern, Piccadilly, &c	,, 25	5,640	— 335	25	149,950	+ 4,835
Greenock & Port Glasgow	,, 17	709	+ 122	24	14,051	+ 1,968
Hartlepool Tramways	,, 17	279	+ 41	24	5,297	+ 191
Hastings Elec. Trams Co.	,, 23	1,035	+ 83	25	21,721	+ 377
Hong Kong	,, 25	$10,995	+ $2,974	25	$331,536	+ $21,595
Huddersfield Corpn.	,, 25	1,781	+ 216	12	21,619	+ 1,067
Hull Corporation	,, 25	2,785	+ 233	12	32,859	+ 2,025
Ilford District Council	,, 25	559	+ 81	12	6,551	+ 258
Ilkeston District Council	,, 22	140	+ 1	12	1,519	— 72
Ipswich Corporation	..	..	..	..	..	..
Isle of Thanet Co.	,, 25	1,009	+ 251	¶37	14,123	+ 467
Jarrow	,, 17	135	+ 19	24	2,779	+ 133
Keighley Corporation	,, 23	219	+ 34	12	2,154	+ 67
Kidderminster & District	,, 17	125	+ 15	24	2,294	+ 61
Kilmarnock Corporation	,, 25	152	+ 5	6	891	— 2
Lanarkshire Trams Co.	,, 23	1,471	+ 132	25	34,131	+ 3,751
Lancashire United	,, 22	1,452	+ 157	25	31,815	+ 306
*Leamington	,, 17	174	— 11	24	3,640	— 107
Leeds Corporation	,, 25	7,320	+ 521	12	85,857	+ 3,386
Leicester Corporation	,, 25	2,509	+ 189	..	..	..
Leith Corporation	,, 25	615	+ 57	6	3,763	+ 161
Lincoln Corporation	,, 25	123	+ 2	13	1,624	+ 5
Liverpool Corporation	,, 18	11,433	+ 657	24	231,634	+ 8,059
Liverpool Overhead Rly.	,, 25	1,521	+ 102	25	35,072	+ 785
Llandudno&ColwynBayRy.	,, 17	272	— 17	§23	4,837	+ 33
*London County Council	,, 11	43,051	+ 8,359	¶10	432,682	+ 60,893
London United	,, 25	7,331	+ 958	25	153,815	+ 9,893
Lowestoft	,, 25	194	+ 17	39	5,955	+ 280
Maidstone Corporation	,, 25	182	+ 11	12	2,054	— 225
Manchester Corporation	,, 25	16,137	+ 1,475	12	190,043	+ 3,995
Mersey Railway	,, 25	2,075	+ 169	25	50,814	+ 1,426
Merthyr	,, 17	219	+ 6	24	4,742	— 260
Metropolitan Dist. Railway	,, 25	11,347	+ 321	25	273,338	+ 24,166
Metropolitan Elec. Trams	,, 17	8,337	+ 1,851	24	172,248	+ 32,336
Middleton	,, 17	382	+ 20	24	7,233	— 582
Nelson Corporation	..	..	..	..	..	..
Newcastle-on-Tyne Corp.	,, 25	6,701	+ 652	¶12	49,797	— 769
Newport (Mon.)	,, 25	693	+ 73	13	8,878	+ 319
Northampton Corporation	,, 24	523	+ 75	§12	5,979	— 27
Oldham, Ashton & Hyde	,, 17	585	+ 28	24	13,000	— 129
Oldham Corporation	,, 25	1,822	+ 34	13	24,816	— 975
Perth (N.B.) Corporation	,, 22	173	+ 20	§5	920	+ 56
Perth (W.A.) Elec. Trams	,, 21	1,459	+ 119	25	33,777	+ 2,859
Peterborough	,, 17	117	+ 2	24	2,533	— 31
Portsmouth Corporation	,, 25	2,418	+ 331	12	24,435	— 1,148
Potteries	,, 17	1,737	+ 55	24	41,513	— 455
Preston Corporation	,, 22	741	+ 23	12	8,711	— 325
Rotherham Corporation	,, 23	655	+ 30	12	7,422	+ 25
Rothesay	,, 17	358	+ 7	24	2,573	+ 33
Salford Corporation	,, 27	4,738	+ 350	†13	53,765	+ 514
Sheerness	,, 17	53	..	24	1,064	— 37
Sheffield Corporation	,, 25	6,030	+ 333	¶13	79,522	+ 4,378
Singapore Trams	,, 25	$9,482	+ $496	25	$217,603	+ $6,442
South Metropolitan	,, 17	911	+ 85	24	18,892	+ 1,099
South Staffs	,, 17	851	+ 48	24	19,635	— 45
Southend Corporation	,, 22	657	+ 142	12	6,209	+ 582
Southport Tramways	,, 17	323	+ 11	24	6,436	+ 219
Stalybridge, Hyde, &c., Jt. Bd.	,, 25	1,765	+ 61	¶12	8,753	— 990
Sunderland Corporation	,, 26	1,250	+ 122	13	14,051	— 310
Sunderland District	,, 22	452	+ 22	34	13,732	— 1,445
Swansea Trams	,, 17	1,097	+ 163	24	21,425	+ 2,656
Swindon Corporation	,, 22	154	+ 27	..	..	..
Taunton	,, 17	39	..	24	967	+ 109
Tynemouth and District	,, 17	344	+ 53	24	4,492	+ 342
Tyneside Trams Co.	..	..	..	..	..	..
Wallasey District Council	,, 25	934	+ 64	§12	11,260	— 420
Walsall Corporation	,, 25	521	+ 27	25	13,252	+ 659
Warrington Corporation	,, 23	400	+ 35	12	4,533	+ 123
West Ham Corporation	,, 16	2,559	+ 292	11	26,927	+ 620
Weston-super-Mare	,, 17	181	..	24	1,774	— 85
Wolverhampton Co.	,, 17	423	+ 20	24	9,877	+ 124
Wolverhampton Corpn.	,, 22	925	+ 142	12	10,780	+ 1,850
*Worcester	,, 17	294	+ 41	24	6,249	+ 134
Wrexham	,, 17	102	+ 3	24	2,283	+ 26
Yorkshire W.R. Trams	,, 25	1,181	+ 85	25	31,873	..
Yorkshire Woollen District	,, 17	1,018	+ 69	24	23,086	+ 2,118

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shrs	Last Dividend	NAME.	Price Wed., June 29	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to June 29 Highest.	Business Week to June 29 Lowest.
		Electricity Supply.					
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	9⅜	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9⅜	4 12 0	Feb, Aug	..	..
10	6/C	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 15 0	Feb, Aug	10⅜	..
St.	4½%	†Do 4½ per Cent. Deb. Stock (red.)	100—103	4 7 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼—7⅜	6 9 0	March	7⅜	..
5	3/6	Do. 7 per Cent. Pref.	7 —7⅛	4 13 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3½—4	6 5 0	Feb, Aug	..	..
5	2/3	†Do. 4½ per Cent. Pref.	4 —4⅛	5 0 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 —98	4 1 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101½—103½	4 7 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¼—4⅜	5 3 0	Jan, July	4⅜	..
5	2/6	Chelsea Electric Supply Ord.	3⅜—4⅛	5 9 6	March	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11½—11⅞	5 19 0	Feb, Aug	11⅞	11⅝
10	6/0	Do. 6 per Cent. Cum. Pref.	12 —13	4 12 0	Jan, July	..	..
St.	5%	†Do. 5 per Cent. Deb. Stock (red.)	119 —123	4 1 6	June, Dec	..	..
St.	4½%	†Do. 4½ per Cent. 2nd Deb. Stock (red.)	99 —102	4 8 0	Jan, July	99¼	..
5	..	County of Durham Elec. P. D. Ord.	1¼—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¼—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7⅛—8	6 0 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½—11⅜	5 5 0	Mar, Sept	11	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103½—10⅜	4 4 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	99 —102	4 9 0	May, Nov	101	100½
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅛—4¾	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7⅛	5 5 0	Feb, Aug	7⅛	..
5	6%	Do. 6 per Cent. 1st Pref	5⅛—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94¼—96¼	4 3 6	..	..	..
St.	4%	Kensington & Knghtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 —100	4 0 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4¼—5⅛	5 14 0	Mar, Sept	4⅜	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	3½—4	5 9 0	April, Oct	3⅝	..
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4⅛—4⅜	4 14 9	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock 1st Mort.	102 —105	4 5 0	June, Dec	..	..
St.	3½%	†Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	97 —99	4 11 0	June, Dec	..	..
5	4/0	Newcastle Elec. Supply Ord.	3¼—4⅜	4 11 6	Feb, Aug	4⅜	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4⅞	5 2 6	Feb, Aug	..	..
100	4½%	†Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	99½	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	100 —102	4 18 0	..	..	..
10	6/0	†Notting Hill Electric Ord.	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6¼—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅛—8⅜	5 9 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¼—7⅛	4 15 0	Feb, Aug	..	..
St.	3½%	†Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1⅛—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2⅛—3⅛	6 11 0	April	..	..
St.	5%	†Do 5 % 1st Mort. Stock (red.)	99 —102	4 18 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—⅜	..	..	..	..
1	0/8	Do. 7 per Cent. Cum. Pref.	⅛—1⅛	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	¼—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	⅛—8⅞	5 12 6	Mar, Sept	8⅜	8⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5⅛	4 2 0	Jan, July	5⅛	5
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97	96½
1	..	Bath Elec. Trams Pref. Ord.	⅛—⅜	..	April	..	..
1	0/6	†Do. 5 per Cent. Cum. Pref.	⅛—⅛	6 12 9	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	†B'ham & Midland Trams 4½ 1st Deb. Stock	81 —81	5 7 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6¾—7	8 11 6	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7⅛—8	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅞ —1⅛	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅛—3	10 0 0	Feb, Aug	2⅞	..
St.	5%	Do. 5 Cent. Perpetual Debs.	89 —93	5 7 6	April, Oct	90¼	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 —73	6 3 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	65 —67	4 9 9	Feb, Aug	67⅛	65⅛
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	88⅛	86¼
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	50¼	49
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	†Charing X, Euston & Hmpstd Per. Deb Stk	93 —95	4 5 0	Jan, July	96⅛	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1¾%	City & South London Rly. Con. Ord.	31 —32	3 14 3	Feb, Aug	32	31⅛
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	98 —100	4 0 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	93 —95	4 5 0	Jan, July	96⅛	94½
5	..	Hastings & District Elec. Trams, 6% C. P.	⅝—1⅛	..	Mar, Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3¼—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	63 —72	6 5 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅛—1⅜	4 14 0	Mar, Sept.	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	61 —66	6 1 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10⅛	5 18 9	Feb, Aug	..	..
St.	5%	†Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Deb. Stock	65 —69	5 15 0	Jan, July	69	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅝—⅝	..	..	..	..
1	..	Do. Deferred	⅛—⅛	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—⅝	5 0 9	Feb, Aug	⅝	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock	96 —99	4 11 0	Jan, July	96⅜	..
St.	1%	Metropolitan Railway Consolidated	40⅜—41⅛	2 9 6	Feb, Aug	41⅛	40⅜
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	67	66⅛
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90⅛	89⅛
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	86⅛	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87⅛	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	93⅜	93⅛

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Electric Railways and Tramways—*Continued.*

Shre.	Last Dividend	Name.	Price Wed. June 29	Rate per Cent. Yielded £ s. d.	Dividend Due.	Business Week to June 29 Highest	Lowest
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	91—93	3 15 0	Jan, July	92	91½
St.	..	Metropolitan District Railway Ord.	22—22½	..	Feb, Aug	22⅜	21⅛
St	..	Do. Extension Pref. (5 per Cent.)	68—70	..	Feb, Aug	69⅜	68
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71—73	4 16 6	Feb, Aug	71½	..
St	3%	†Do. 3 per Cent. Consoltd. Rent-charge	74—76	3 19 0	Jan, July	76	..
St.	4%	†Do. 4 per Cent. Midland Rent-charge	99—102	3 18 6	Jan, July	101¼	..
St.	4%	Do. Guar. Stock 4 per Cent.	102—104	3 17 0	Mar, Sept	102	..
St.	6%	†Do. 6 per Cent. Perp. Deb. Stock	140—142	4 4 6	Jan, July	..	..
St.	4%	†Do. 4 per Cent. Ditto	94—96	4 3 6	Jan, July	..	..
1	4⅛d.	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	82—85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—⅝	..	..	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	66—70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoups	36—38	..	June, Dec	37¾	36⅞
..	5%	Do. 5% Prior Lien Bonds	101—102	4 18 0	..	101¼	101⅛
..	4½%	Do. 4½% Bonds with coup. 5	89—91	4 19 0	..	89⅝	..
..	4%	Do. 4 per Cent 1st Power Ho. Dbs.	98—100	4 0 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—¾	..	March	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	..	..	..	..
St.	4½	†Do. 4½ per Cent. 1st Debs.	77—80	5 12 6	Jan, July	..	..

Electric Manufacturing, &c.

Shre.	Last Dividend	Name.	Price Wed. June 29	Rate per Cent. Yielded £ s. d.	Dividend Due.	Business Week to June 29 Highest	Lowest
St.	4½%	†Ancho Cable Co. 4½ % Deb. Stock	99—101	4 9 0	..	..	..
1	..	Aron Electricity Meter Ord.	⅜—⅝	..	..	..	..
1	1/9⅗	†Do. 6% Cum. Pf. .... xd and arrears	¾—⅞	6 15 0	April, Oct	29/32	..
1	3/2⅗	Babcock & Wilcox Ord.	5⅛—5⅜	5 16 6	April, Oct	5 5/16	5 9/32
1	0/7⅓	Do. Pref.	1 7/16—1 9/16	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7	7 3 0	July, Feb	6 13/16	..
5	3/0	Do. 6 per Cent. Pref.	5¾—6¼	4 16 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.)	101—104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101—104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	5/16—9/16	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	98½—100½	5 19 6	..	..	..
St.	4%	†Do. 4 per Cent. Mort. Deb. Stock	58—60	3 6 6	Jan, July	..	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39—44	10 4 0	Mar, Sept	..	..
St.	4½%	†Do. Perpetual 2nd Deb. Stock	23—27	16 12 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9¼—10¼	6 8 0	Jan, July	9⅝	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	4⅞—5¼	4 15 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort Debs. (red.)	100½—102½	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.	2⅜—2⅝	5 8 9	May, Nov	2 11/32	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	106—109	4 3 6	Feb. Aug	..	..
..	0/7⅓	Chadburn's (Ship) Telegraph Ord.	15/16—1 1/16	6 11 9	March	..	..
1	0/7⅓	Consolidated Electrical Co.	⅜—½	7 0 0	August	..	..
1	0/6	Consolidated Signal Co.	⅞—1	7 0 0	April, Oct	..	..
1	0/7⅓	Do. 6 per cent. Cum. Pref.	⅞—1	6 0 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	¼—½	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	87—90	5 11 0	Jan, July	87½	..
1	0/7⅓	Davis & Timmins	⅞—1¼	..	Mar, Sept	..	..
5	1/2⅗	Dick, Kerr & Co. Ord.	1 1/16—1 3/16	5 0 0	Sept.	1½	..
5	0/7⅓	‡ Do. 6 per Cent. Cum. Pref.	1—1⅛	5 6 6	Sept	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock	97—100	4 10 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	1/16—3/16	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1—1¼	9 3 0	Feb. Aug	..	..
St.	4%	†Do. 4 per Cent. Mort. Deb. Stock (red.)	63—68	5 18 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79—82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	3/16—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1¾	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	74—77	5 16 6	Jan, July	..	..
2	..	Electric Construction Co.	¼—½	..	Jan, July	..	..
2	2/9⅗	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	8 12 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs	61—66	6 1 0	Jan, July	..	..
10	5/0	†General Electric (1900) 5% Cum. Pref.	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs	82—86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	11⅞—12⅜	6 1 0	Feb, Aug	..	12
5	2/3	Do. 4½ per Cent. Pref.	5—5⅜	4 3 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	103½—105½	4 5 6	Mar, Sept	..	..
10	5/0	†India Rubber, Gut. Per., &c., Works	14½—15½	6 10 6	Feb, Aug	..	..
10	5/0	*†Do 5 per Cent. Cum. Pref.	10¼—10¾	4 14 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97—99	4 1 0	April. Oct	97	..
1	..	National Elec. Construction Co.	¼—½	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	5/16—7/16	..	Nov	⅝	..
1	..	Do. 6 per Cent. Cum. Pref.	5/16—7/16	..	May, Nov	..	..
St.	4½%	†Do. 4½ per Cent. Perp. Deb. Stock	78—83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5—5½	..	..	..	..
12	30/0	Telegraph Construction & Maintenance	33—35	6 0 9	Mar, July	..	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	101—103	5 17 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2 11/32—2 15/32	4 8 6	..	2 3/32	2 1/16
1	0/6	Dc 5 per Cent. non-Cum. Preference	1⅛—1½	4 0 0	..	1 3/32	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	108—111	4 10 0	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102—104	3 17 0	June, Dec	101⅛	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103—105	4 6 0	June, Dec	103	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip	103½—105½	4 15 6	..	104½	..
10	10%	J. G. White & Co. 6% Cum. Pref	11½—12½	8 0 0	..	..	..
1	..	Willans & Robinson Ord.	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1¼—1¾	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	60—70	5 14 0	May, Nov	..	..

Telegraphs.

Shre.	Last Dividend	Name.	Price Wed. June 29	Rate per Cent. Yielded £ s. d.	Dividend Due.	Business Week to June 29 Highest	Lowest
10	..	Amazon Telegraph	3⅛—3⅜	..	June, Dec	3⅛	3⅜
100	5%	Do. 5 per Cent. Debs. (red.)	100½—102½	4 17 6	June, Dec	..	..
St.	15/0	Anglo-American	65—67	5 6 6	F,My,Ag,N	63	..
St.	30/0	Do. Preferred	107—109	5 10 0	F,My,Ag,N	109⅛	105¼
St.	25/0	Do. Deferred	26¼—26½	4 11 6	F,My,Ag,N	27¼	23⅜
St.	4%	†Commercial Cable 4 per Cent. Deb. Stk.	85—87	4 12 0	Jn,Ap,Jy,O	87⅛	85⅝
10	6/0	Cuba Submarine Ord.	8¼—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16¾—17¼	5 15 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3⅛—3⅜	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7⅞—8¼	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100—102	4 18 0	Jan, July	..	..
20	4/0	Direct United States Cable	14¾—15¼	5 11 6	Ja,Ap,Jy,O	15	14¾
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.)	100—102	4 18 0	June, Dec	..	..
St.	65/0	Eastern Ordinary	133—135	5 3 6	Ja,My,Jy,O	35	133
St.	17/6	Do. 3½ per Cent. Pref. Stock	85—87	4 0 6	Ja,My,Jy,O	86	85⅝
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	101—103	3 17 6	May, Nov	102¼	..
St.	6/6	Eastern Extension	12⅞—13⅛	5 10 0	Ja, Ap, Jy,O	12¼	..
100	4%	Do. 4 per Cent. Deb. Stock	101—103	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101½	3 18 6	May, Nov	..	..
10	26/0	G.N (of Copenhagen), with Coupon 79	30½—31½	5 14 0	Jan, July	31	30½
25	52/6	Indo-European	53—55	5 18 6	May, Nov	..	..
100	5%	Mackay Companies Common	88—92	5 9 0	Ja,Ap,Jy,O	..	..
100	4%	Do. Preference	77—81	4 19 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	25/32—27/32	..	April	13/16	25/32
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	97—99	3 19 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅝—1⅞	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	98—100	4 0 0	Jan, July	..	..
10	..	West India & Panama	⅝—⅞	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9	6 12 6	May, Nov	8 3/16	..
10	9/0	Do. 6% 2nd Pref.	8—9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	101—103	4 17 0	Jan, July	..	..
10	3/0	† Western Telegraph	13½—14	5 0 0	Mr,Jn,O,D	14⅛	13⅜
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	99—101	3 19 0	June, Dec	102¼	101¼
	4%	Western Union Telegraph, $1,000 4% Bds.	101—104	3 16 6	—	..	..

Telephones.

Shre.	Last Dividend	Name.	Price Wed. June 29	Rate per Cent. Yielded £ s. d.	Dividend Due.	Business Week to June 29 Highest	Lowest
100	2$	Amer. Telephn. & Telegh. Cap. St.	136—138	5 16 6	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93—95	4 4 6	Jan, July	94⅜	..
St.	4%	Do. 4% Cons. Bonds 1936	103—105	3 16 0	..	105	104⅞
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100—102	4 18 0	Mar, Sept	..	..
5	3/0	Chili Telephone	7 15/16—8 3/16	4 15 9	August	..	..
1	0/7⅓	Monte Video Telephone Ord.	⅞—1	7 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	25/32—29/32	5 13 9	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106½—108	5 11 0	Feb, Aug	106¼	..
St.	6%	Do. Def. Stock	127—129	4 13 0	Feb, Aug	126½	124
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10—10¾	5 10 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10—10¾	5 10 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅜—5	4 8 6	Feb, Aug	5½	..
St.	3½%	†Do. Deb. Stock 3½ per Cent. (red.)	95½—97½	3 12 6	June, Dec	..	97⅜
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	98—100	4 0 0	Jan, July	..	..
..	4½%	New York Telephone Co. 30 yr. Bnds.	97½—98½	4 11 6	..	98⅜	97⅛
1	1/0	Oriental	1 1/16—1 3/16	4 15 0	April, Oct	1	..
1	0/7⅓	Do 6 per Cent. Cum. Pref.	1 1/16—1 1/16	4 11 0	April, Oct	..	..
St.	4%	†Do. 4 per Cent. Red. Deb. Stock	86—88	4 11 0	Jan, July	86¼	..
St.	4½%	†Telephone Co. of Egypt 4½%Db.Stk.(red.)	98—100	4 10 0	Jan, July	..	..
5	3/0	United River Plate	7¼—7½	5 9 0	July	7 7/16	7¼
5	2/6	†Do. 5 per Cent. Cum. Pref.	5 1/16—5 3/16	4 14 9	June, Dec	..	..
St.	4½%	†Do. 4½ Deb. St. Red.	101—103	4 12 6	Jan, July	..	..

Financial, Investment, &c.

Shre.	Last Dividend	Name.	Price Wed. June 29	Rate per Cent. Yielded £ s. d.	Dividend Due.	Business Week to June 29 Highest	Lowest
5	3/0	†Elec. & Gen. Investment 6% Cum. Pref.	2¾—3¼	9 4 6	Jan, July	..	..
10	5/9	†Globe Telegraph & Trust	10¼—10¾	5 8 3	Sp,DcMrJu	10⅝	10⅝
10	3/0	†Do. 6 per Cent. Pref.	12¾—13¼	4 8 9	Sp,DcMrJu	13⅛	13 1/16
10	6%	Submarine Cables Trust (Cert.)	128—131	4 10 6	April, Oct	128	..

Colonial and Foreign Electric Railways, Tramways, &c.

Shre.	Last Dividend	Name.	Price Wed. June 29	Rate per Cent. Yielded £ s. d.	Dividend Due.	Business Week to June 29 Highest	Lowest
5	2/6	†Anglo-Argentine 5% Cum. 1st Pref.	4¼—4⅜	5 5 0	April, Oct	4 7/32	4 3/16
5	2/6	†Do. 5% C um. 2nd Pref.	4¼—4½	5 9 0	Jan, July	4 3/16	4¼
St.	4%	†Do. 4% Deb. Stock	88½—90	4 9 0	June, Dec	91¼	87
St.	4½%	†Do. 4½% Deb. Stock	93½—96½	4 13 6	..	97½	93¾
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	103—105	4 15 3	Jan, July	..	..
5	4/6	Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 1/16—5 5/16	4 13 9	May, Nov	..	..
St.	4½%	†Do. 4½ per Cent. Db. Prov. Certs.	99—102	4 8 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	142—147	5 9 0	Mar, Sept	..	..
St.	6%	Do. Pref. Ord. Stock	123—127	4 13 6	May, Nov	126½	125¼
St.	5%	Do. 5% Cum. Perp. Pref. Stock	110—113	4 8 3	Jan, July	..	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102—104	4 6 6	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	102—105	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	104—106	3 19 0	..	104¼	104⅛
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98—101	4 19 0	Mar, Sept	101	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	96—99	6 1 0	Feb, Aug	98½	..
5	2/6	Calcutta Tramways (1 to 137,610)	4⅛—4⅝	4 7 6	Mar, Sept	4 3/16	4⅛
100	2/6	†Do. 5 per Cent. Cum. Pref.	4⅜—4⅞	5 2 6	Jan, July	4¼	..
1	4½%	†Do. 4½% 1st Deb. Stock (red)	96—99	4 11 0	Jan, July	98⅛	..
St.	..	Cape Electric Tram Shares	¼—½	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 5/16—5 13/16	4 9 6	F,My,A,N	5 11/16	..
St.	4%	†Do. 4 per Cent. Deb. Stock	97—100	4 0 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	95—98	5 2 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	78—81	6 3 6	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	96½—99½	5 0 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	1/16—3/16	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	92—96	5 3 6	Jan, July	..	..
5	6%	†Do. 6 per Cent. "B" Ditto	71—75	8 0 0	Jan, July	..	..
5	0/7⅓	Lisbon Elec. Trams. Ord.	1 1/16—1 3/16	5 4 0	July	..	..
100	0/7⅓	Do. 6 per Cent. Cum. Pref.	1 3/32—1 [illegible]	5 5 3	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	100—104	4 16 0	Jan, July	..	..
St.	5%	†Madras Elec. Trams. 5% Deb. Stk.	95—93	5 2 0	Jan, July	..	..
100	..	Manaos Trams and Lt. Co. 5% Debs.	88½—90	..	..	88¼	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	98—100	5 2 0	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	127—129	4 19 0	..	129	127¼
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	98—99	4 1 0	..	98⅝	98
St.	6%	Do. 6% 50 yr. Mort. Bds.	102¼—103¼	5 16 9	..	102¼	102
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101—103	4 7 6	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	100—102	4 8 0	..	102	..
1	0/6	Perth Elec. Trams Ord.	9/16—11/16	5 15 5	May	11/16	..
St.	5%	†Do. 1st Mt. Db. Stock	99—102	4 18 0	Jan, July	101¾	..
5	3/0	†Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅝—5⅞	5 2 6	..	..	..
St.	4½%	†Do. 4½% 1st Mort. Deb. Stk.	99—102	4 18 0	..	..	..
100	$1	‡Rio Janeiro Tram, Lt. & P. Co.	95—97	4 2 6	..	96¼	96
..	5%	Do. 30 yr. Gold Bnds.	99¼—100¼	4 0 6	..	100¼	99½
100	5%	Do. 50 yr. Mt. Bnds	87½—88½	5 12 0	..	85½	87½
..	$2½	†Sao Paulo Tramway, Light & Power Co. $100 Stock	147—149	6 16 0	..	151½	149
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	102—104	4 16 6	June, Dec	103¼	102½
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100—102	4 8 0	Feb, Aug	101⅛	..

Colonial and Foreign Electricity Supply, &c.

Shre.	Last Dividend	Name.	Price Wed. June 29	Rate per Cent. Yielded £ s. d.	Dividend Due.	Business Week to June 29 Highest	Lowest
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅝—5⅞	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 9 0	..	10⅝	..
St.	4½%	†Do. 4½ per Cent. Deb. Stk. (red)	93—95	4 14 6	Jan, July	94	..
..	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock	98—100	5 0 0	..	..	..
5	4/9	Calcutta Elec. Supply Ord.	6⅜—6⅞	5 17 6	April, Oct	6 11/16	..
100	7/2½	Canadian Gen. Elec. Co. Com. St.	106¼—110¼	6 7 6	..	..	..
100	$3½	Do. 7% Cm. Pf. Stock	120—123	5 14 0	..	..	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	98—102	4 18 0	Jan, July	..	..
500	5%	Elect. Development Co. of Ontario	85—88	5 12 6	..	86½	..
St.	5%	†Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87—90	5 9 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	1/16—3/16	..	..	..	..
1	0/7⅓	Do. 6 per Cent. Cum. Pref.	⅞—1	8 0 0	April, Oct	..	..
..	5%	Kaministiquia Power Co.5% Gold Bnds.	102—104	4 16 6	..	103⅜	103½
5	..	Madras E. S. Corp. Ord.	2⅝—3⅛	..	..	..	..
St.	..	Melbourne E. S. Co. 6%Cum. Pref.	33—38	..	..	..	..
St.	5%	†Do. 5% 1st Mortg. Deb. Stock	90—92	5 7 6	..	93½	92¼
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	87½—88½	5 13 0	..	88⅜	87
St.	$1	Mexican Lt. & Power Co. Com. St.	79—81	4 18 6	..	80	..
St.	$3½	Do. 7% Cum. Pref. St.	103—105	6 13 6	..	104¼	103½
500	5%	Do. 5% 1st Mort. Gold Bnds.	92¼—93¼	5 7 0	..	93⅜	92¼
100	$1¾	Montreal Lt. Ht. & Power Co. Cap. St.	135—139	5 6 6	F,My,A,N	..	..
1	1/9⅗	River Plate Electricity Co. Ord.	2 1/16—2 3/16	5 12 9	April	[illegible]	[illegible]
1	1/2⅗	Do. 6 per Cent. non-Cum. Pref.	1 1/16—1 3/16	5 2 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
5	3/0	Rosario Ele.. Co. Ord.	8½—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6—6½	4 12 0	April, Oct	..	..
5	3/0	Do 2nd Pref.	8⅛—8⅞	6 14 6	..	..	..
100	$1	Shawinigan, Water & Power Co.Ca.	101½—103½	4 7 0	..	103½	[illegible]
..	5%	Do. 5 per Cent. Bds.	107—109	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ Per Con. Mt. Db. St.	101—103	4 7 6	..	102½	99½
St.	4½%	Toronto Power Co. 4½% Db. St.	99—101	4 9 0	..	100½	100¼
..	6d.	Victoria Falls Power Co. Pref. (1 to 808,000)	⅜—⅝	5 6 6	Jan, July	..	—
1	..	Do. (803,081 to 1,700,000)	¼—⅜	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,677. [No. 13. Vol. LXV.] FRIDAY, JULY 8, 1910. PRICE SIXPENCE (by post. 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

L.B. & S.C. Electrification.

WE referred last week to the forthcoming notification by the directors of the L.B. & S.C. Railway of their decision to proceed with the electrification of their line to the Crystal Palace, and we indicated that this decision had been made to embrace the routes to the Palace both from Victoria and from London Bridge. A journey this week on the Brighton line shows that not only has this decision been come to by the directors, but that the work is in active progress. A large number of foundations have already been put down, and it is fairly obvious that the electrified line will be ready for running next summer. This is good news, not only for the Crystal Palace Co., but for the public. We may say that there are indications that the electrified line will be extended to Norwood Junction, and those who know the Brighton line will understand what connection at this point means.

FROM incidental inquiries we have made we consider ourselves in a position to state that the electrical working of the suburban service of the Brighton Railway has been more than a success—it has proved a revelation. We believe when the figures are published it will be found that the energy consumption is very much below the estimate; that there has been no hitch of any kind whatever to disturb the regular flow of traffic; that the effect upon the revenue of the Company has been extraordinary; that, in fact, everything claimed by electrification experts as likely to follow the experiment has occurred, and that every estimate of good results has been largely exceeded. We venture to prophesy that the time is not far distant when the directors of the Brighton line will take into serious consideration the question of extending the electrification over the whole of their system. If we are right, as we think we are, it is not out of place to congratulate heartily the Company's consulting engineer, Mr. PHILIP DAWSON, and all the contractors, on the excellence of their work. The simplicity and smoothness of working on the Brighton electrified line is a subject which is being considered, we understand, from every point of view by the boards of railway companies in all parts of the world.

Variable-Speed Polyphase Commutator Motors.

ELECTRICAL engineers have already become hardened to the illogical use of commutators with alternate-current machines, and the days have now passed when the absence of a commutator can be regarded as the chief asset of an alternating-current motor. So long as its continuous-current rival alone possessed the advantage of economical speed regulation, so long was the alternating current system at a discount. Gradually, however, the difficulties in the way have been overcome, one by one, and already various types of single-phase commutator motors, suitable for all kinds of traction and stationary work, are on the market. Nor were sparking troubles—so long the enemy of the continuous-current machine—to prove an effective hindrance to the new departure, for satisfactory means have now been discovered whereby these motors also have been made practicable.

IT was to be expected, therefore, that the three-phase motor, with its splendid starting torque and other qualities, would not long be allowed to remain behind in the matter of speed regulation. It is true that up to the present only machines of moderate output—equivalent to a few hundred K.V.A.—have been built, but it has already been conclusively proved that the three-phase commutator motor

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is no less a success than the single-phase type. Were no other evidence at hand to support this, it would be quite sufficient to mention that almost, without exception, all the large Continental electrical firms have a special department set apart for the development of these machines. Whether this is actually a pleasant reflection for us here in England need not now be discussed, but certainly we cannot claim the lion's share in the development of alternating-current work, nor do we appear to be anxious to obtain it.

ALTHOUGH, as we have said, the three-phase commutator motor has not yet fulfilled all requirements, yet thereby it has been possible to impart to the induction motor the desired variable-speed characteristic. In our present issue we publish an article, by Mr. R. O. KAPP, showing how this is achieved by means of the cascade arrangement when the commutator motor alone cannot be satisfactorily built for the total output. In the main there are two systems whereby such cascade working can be arranged. In the one, due to KRÄMER, the commutator machine is mechanically coupled to the shaft of the main induction motor and receives from the slip-rings the energy which would otherwise be dissipated in resistance. In this way the slip-energy, less loss, is restored to the shaft and performs useful work. In the other system, due to SCHERBIUS, the slip energy is also taken from the induction motor and supplied to the commutator motor; but this latter machine now drives a generator, by means of which it pays back to the network an amount of energy proportional to the slip of the main motor, of course, minus the losses. A further advantage gained by the addition of a commutator motor is to make it possible to compensate for a lagging power factor. We need scarcely say that there are still several technical difficulties in the design of commutator motors of large output and high frequency, especially sparking difficulties, but the great strides already made cause us to be optimistic for the future.

British Engineering Exhibits at Brussels.

ON another page of this issue we publish some particulars of the visit of the British Press to the Brussels Exhibition, which took place last week, under the auspices of the Executive Committee of the Board of Trade Exhibitions Department, the Belgian State Railways, and the Commissioners of the Brussels International Exhibition. The technical Press was not particularly well represented, the majority of the delegates being drawn from the British daily papers. We have already dealt with the principal objects of electrical and engineering interest in the Exhibition in two previous issues, but the visit last week afforded us a special opportunity of gaining some impressions of the Exhibition itself. The members of the lay Press are not quite in the same position as the technical journals to appreciate the work which the British Government, through the Exhibitions Department of the Board of Trade, has carried out at Brussels and is carrying out in connection with other exhibitions. The delegates were brought into intimate touch with Lord LYTTON, the Chairman of the Executive Committee, and Mr. U. F. WINTOUR, the Commissioner-General, and gathered some idea of the difficulties experienced in making the British section of the Exhibition thoroughly representative of British art, science and industry. This matter is one upon which great emphasis should be laid, because it helps to explain in some measure the unrepresentative character of the British section of the Exhibition. Whether the British manufacturer is already convinced of the ineffectual nature, from a commercial point of view, of international exhibitions is, perhaps, a matter for some speculation.

IN an electrical and engineering sense, the British exhibits at Brussels are not anything like so impressive as the magnitude of British industrial achievements would lead one to expect. The number of electrical manufacturers exhibiting is small, and the machinery and apparatus shown gives a poor idea of the amount of capital invested in British electrical enterprises and the work which has already been carried out therewith. The difficulty of persuading English electrical manufacturers to exhibit at Brussels has probably arisen mainly on account of the comparatively small return which may be expected from the outlay involved. Belgian and French electrical industries are very much to the fore, but the exhibitors are naturally able to bring to the Exhibition men from whom they can directly expect to receive orders for plant and machinery. We understand that the duty on imported electrical machinery into Belgium is low, but it cannot be argued for a moment that the British electrical manufacturer would be able to compete in Belgium with the many firms there already well established and keenly intercompetitive. It is none the less a pity that this country cannot make a braver show at an exhibition of such industrial importance as that at Brussels. The executive staff of the Exhibitions Department have exhausted a voluminous and varied stock of argument in favour of an exhibit, but British manufacturers are slow to move in these matters and the result is disappointing. We do not think that it represents in any degree the amount of thought, energy and time which the Board of Trade Exhibitions Department have put into it. It does not appear to be in any sense indicative of lack of wisdom in the establishment of such a department by the Government; on the contrary it only serves to emphasise the necessity for further effort, the need for vigorous propagandist work amongst British manufacturers, and the desirability of driving home the international importance of fully representative British sections at all forthcoming international exhibitions.

Franco-German Cable Agreements.—Reuter's Agency states that, according to one of the leading German journals, as an outcome of the Franco-German cable agreement (referred to in our last issue) it is proposed to lay a submarine cable between Emden and Brest. It is also understood that the French Government will lay a cable from Brest connecting up with the now disused German cable from Emden to Valentia.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repairs.
Assab—Perim	July 8, 1909	—
Malta—Tripoli	April 20, 1910	—
Madagascar—Reunion	May 12, 1910	—
Reunion—Mauritius	May 20, 1910	—
Latakia—Palura	May 26, 1910	—
Obock—Djibouti	June 24, 1910	—
Fort de France—Paramaribo	June 25, 1910	July 4, 1910
Gibraltar—Tangier	June 30, 1910	July 4, 1910
Falmouth—Bilbao	July 4, 1910	—
Zanzibar—Mombasa	July 4, 1910	July 7, 1910

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New Submarine Cable.—The Commercial Cable Co. has completed the laying and has opened for traffic a new submarine cable from Waterville, Ireland, to Weston-super-Mare, England, where it is connected with London by underground lines. The Company also announces that it has replaced long sections of submarine cable from Waterville, Ireland, westward, with a much heavier type of cable where the old cables had been disabled and in large part destroyed by fishing trawlers.

University of Leeds.—Arrangements have now been completed for the establishment of a professorship of Coal, Gas and Fuel Industries at the University of Leeds as a memorial to the late Sir George Livesey. Upwards of £10,500 has been subscribed to the fund initiated for this purpose by the Institution of Gas Engineers. In connection with the work to be carried out by the professor, an advisory committee has been formed, the members of which represent the University, the Institution of Gas Engineers and the Society of British Gas Industries.

Electrical Properties of Selenium.—In our issue of November 5th last, we described briefly some experiments by L. S. McDowell dealing with the rate of recovery of the normal resistance of a selenium cell after exposure to light. The recovery curves were found to resemble those for the decay of phosphorescence. In a recent issue of "The Physical Review" the author describes further researches on selenium, the recovery from excitation by X-rays being investigated. The results of the investigation are summarised as follows: The forms of the recovery curve for X-ray excitation and for light excitation are identical. The form of the recovery curve for excitation by light depends only upon the magnitude of the initial change in conductivity, and not at all upon the time required to produce that change. The rate of recovery from excitation by X-rays is slower than from excitation by light. Hence diffusion is probably not an important factor in producing the deviation from the straight line of the selenium recovery curves.

Carbon Brushes on Traction Motors.—A recent issue of the "Electric Railway Journal" states that the Virginia Railway & Power Co. have recently adopted the practice of slotting its commutators and using Le Carbone brushes in connection with them. This decision was the result of a series of careful tests carried out on a number of motors which had been giving considerable commutator trouble. After the commutators were slotted and used with the new brush, their wear was reduced to practically nothing. Not only was flashing largely eliminated, but it was also found feasible to adopt a lighter brush-holder spring tension. The old tension varied from 5 lb. to 15 lb. per holder according to the condition of the brush-holder springs. It is the practice of the Virginia Railway & Power Co. to reduce this pressure to 4½ lb. per square inch of brush contact area. The Le Carbone brush is also giving three to four times the life of the replaced brushes, a result which is due in part to the lowering of the brush-holder pressure.

Large Electro-Magnetic Clutch.—According to "The Times Engineering Supplement" a new method of driving a blast furnace blowing engine has lately been introduced by Messrs. Cochrane & Co., at their Ormesby Ironworks, Middlesbrough. Messrs. Cochrane, who utilise the waste gas from their blast furnaces to drive gas engines for dynamos and for blowing, found they had about 1,000 H.P. of electrical energy available, which they decided to utilise in driving a new blower. For this purpose a motor capable of giving 700 H.P. continuously, or 1,000 H.P. for one hour at 75 revs. per min., is direct connected to a vertical blowing engine, by Messrs. Richardson, Westgarth & Co., which has a flywheel weighing 23 tons and is 16 ft. 9 in. in diameter. For starting it was decided to adopt a method of gradual acceleration, and by arrangement with Messrs. C. E. Lugard & Co., of Chester, a Vulcan patent magnetic clutch has been utilised. The clutch fitted at the Ormesby Ironworks is stated to be the largest electro-magnetic clutch in the world, as it is 7 ft. 3 in. in diameter, weighs 6¼ tons, and is capable of transmitting 1,000 H.P. at 75 revs. per min. It was specified that the blower should be started up so gently and slowly that the demand from the gas engine generator would not exceed 1,000 H.P., and since its installation it has been possible to start up in one minute, the load on the gas-engine generator not exceeding 350 H.P. The electrical energy required to keep the clutch in operation is 2 kw.

Electrical Supply in the Potteries.—The first step in the unification of electrical supply in the Potteries having been taken by the appointment of Mr. C. H. Yeaman as electrical engineer of the new county borough of Stoke-upon-Trent, the future policy as regards the existing electricity undertakings is naturally arousing much local interest. The "Staffordshire Sentinel" last week published a prominent article questioning the advisability of the proposed expenditure of £15,000 for extensions to the Hanley electricity undertaking, and urged the necessity of a full and exhaustive enquiry as to the merits of the alternating and continuous current systems before any policy as to the future of electricity supply in the Potteries is adopted. The subject is treated on the assumption that continuous current alone is "fit to distribute" for immediate use. The single-phase 100 cycle system at Hanley—in contrast with the continuous-current system at Burslem, Stoke and Longton—although answering for ordinary lighting, is rightly stated not to be best adapted for power purposes and arc lamps. In proof of this, it is mentioned that the Hanley undertaking, which has been in existence for fifteen years, has but a relatively small power load, whilst the other more recent local systems are largely occupied in supplying current for power. In this connection it is interesting to notice that on February 28th last there were 1,077 H.P. of motors connected to the Hanley mains, whilst at April 30th the Burslem power connections totalled 1,033 H.P., and Stoke 1,057 H.P. It must be remembered, however, that power supply on an extensive scale is only a recent development, and the results at Hanley are certainly by no means unsatisfactory. The qualifications of the writer of the article for dealing with the subject are somewhat discounted by the fact that he calculates the value of the units unaccounted for at Hanley on the basis of the average cost *per unit sold* (2·40d.); and also by his explanation of the difference between continuous and alternating current, the latter, he explains, not being collected "continuously," but alternately, from different points, whilst in the direct current system the current is collected "continuously"!

Walbrook Telewriter Exchange.—This Exchange, of which a description was given in our last issue, was formally opened last Friday by the Lord Mayor of London, who transmitted by means of the telewriter the following message to the Postmaster-General: "The Lord Mayor congratulates the Postmaster-General on the opening of the Telewriter Exchange, which will enable the transmission of facsimile written messages within the City area. The enterprise of the National Telewriter Co. and the Post Office authorities in placing this facility at the disposal of the public should meet with cordial recognition, and I wish the undertaking every success." The Postmaster-General, in reply, expressed his interest in the telewriter and hoped the new Exchange would be successful. In addition to the arrangement with the Post Office whereby telewriter subscribers may transmit telegrams direct to the Central Telegraph Office, and also receive telegrams by the same means, it is interesting to learn that similar arrangements are being made with the principal cable companies. A telewriter exchange is also to be opened in the West-end of London for serving the theatres and large hotels, and a branch office will shortly be inaugurated in Manchester, so that it is hoped a complete system will in time be available throughout the country. The current which is employed for operating the instruments varies between 10 and 100 milliamperes, and is furnished from accumulators on each subscriber's premises. Eighteen cells are installed, and when the instruments are in use the cells at the receiving and transmitting ends of the line are in series, so that normally a pressure of about 72 volts is employed. For trunk line working, however, a pressure of 150 volts is necessary. The method of charging subscribers' accumulators is interesting. Charging is in progress whenever

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the telewriter is not in use, current being sent over one of the line wires from a 60-volt battery at the Exchange. This current is only small, being limited by the resistance of the circuit, and an earth return is employed. In order to obtain accurate transmission of writing it is essential that the voltage employed should be constant. This result is obtained by a voltage regulator fixed at the side of each telewriter. The regulator consists of a moving coil in a permanent magnetic field, the position of the coil varying with the pressure of the accumulators. As soon as the telewriter is put in operation the moving coil is pressed on to the contacts of a rheostat, so inserting the necessary amount of resistance in the accumulator circuit. We notice that among the subscribers already connected to the Exchange are Messrs. Dick, Kerr & Co., and the British L. M. Ericsson Mfg. Co. It may also be mentioned that the latter firm manufacture the apparatus employed in the telewriter.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. R. O. Kapp contributes an article on "The Scherbius Motor and Some Methods of Working it in Cascade with Induction Motors."

We give a further account of the International Exhibition at Brussels. A party of press representatives visited the Exhibition last week as guests of the Commissioners.

In our Correspondence columns Mr. Béla Gáti gives some interesting telephonic results, and Mr. F. Jacob deals with the effect of leakance in loaded telephone cables.

The Electric Construction Co. have placed upon the market a new type of three-phase motor, the particular feature of which is the use of starting resistances, which rotate with the rotor and are automatically cut out step by step (20 to 30 per phase) by a centrifugal short-circuiting device as the speed rises. Thus the usual motor starter is eliminated and the simplest manipulation is secured.

Hampstead (London) Council have decided that, as far as possible, electric lighting shall be used in preference to gas in the public thoroughfares. In pursuance of this policy, the work of converting 237 additional lamps from gas to electric lighting, at a cost of £1,580, is to be commenced at once, and further conversions will be subsequently undertaken.

An inquiry was held on Wednesday at Carlisle into the application of the Corporation for sanction to borrow money for extensions of the electricity undertaking.

Parliamentary.—A House of Lords Committee has refused to sanction a clause in the Glasgow Gas Consolidation Bill to enable the Corporation to devote surplus profits to relief of rates.

The preamble of the Wimbledon and Sutton Railway Bill, which has already been passed by the House of Lords, has been found proved by a Select Committee of the House of Commons.

The Baker Street & Waterloo Railway and the London Electric Railway Amalgamation Bills have also passed the Committee stage, and have been ordered for third reading in the House of Commons.

Legal.—On Friday last Mr. Justice Parker dismissed a motion on behalf of defendants to discharge an order for trying issues as to two patents in Osram Lamp Works (Ltd.) *v.* G. M. Boddy & Co. The patents dealt with the manufacture of tungsten metal filaments, and the attachment of the filaments to the leads, and it was contended that it was undesirable to try the two together. For plaintiffs it was stated that the history of the two patents was practically identical, and that time and cost would be saved by trying them together.

INSTITUTIONS AND SOCIETIES.

Institution of Mechanical Engineers.—As already announced a joint meeting of the American Society of Mechanical Engineers with the Institution of Mechanical Engineers will be held in Birmingham and London, from July 26th to 30th. The proceedings will commence at Birmingham on Tuesday 26th inst., when the Lord Mayor of Birmingham and the members of the local committee will welcome the president (Mr. George Westinghouse) and members of the American Society of Mechanical Engineers and the president (Mr. John A. F. Aspinall) and members of the Institution of Mechanical Engineers. The reception will take place in the Lecture Hall of the Birmingham and Midland Institute and will be followed by the reading and discussion of Papers, whilst the afternoon will be devoted to excursions in the neighbourhood. The day's proceedings will conclude with a garden fête in the Botanical Gardens. Wednesday morning will be given over to the reading and discussion of Papers, and in the afternoon visits will be paid to local works. In the evening the Lord Mayor of Birmingham will hold a reception at the Council House. On Thursday, excursions to Coventry, Rugby, Warwick, Leamington, Kenilworth and Lichfield have been arranged. The centre of interest will then move to London, the Conversazione of the Institution of Mechanical Engineers being held on Thursday evening, 28th inst., at Storey's-gate, Westminster. On Friday morning, Papers will be read and discussed in the Lecture Hall of the Institution of Civil Engineers, whilst a dinner will be held in the evening at the Connaught Rooms, Freemasons' Hall, Great Queen-street, W.C. For Saturday, the 30th inst., excursions are being arranged. The Papers to be read at the meeting in London include the following:—"Electrification of Suburban Railways," by F. W. Carter; "Cost of Electrically Propelled Suburban Trains," by H. M. Hobart; "Economics of Railway Electrification," by W. B. Potter; "Electrification of Trunk Lines," by L. R. Pomeroy; and "Electrification of Railways," by G. Westinghouse.

Committee for the Protection of Electrical Interests.—The Hon. Arthur Stanley, M.P., has accepted the position of President of the Committee. Mr. Robert Hammond has agreed to act as Vice-President, Mr. Arthur H. Preece as Honorary Treasurer, and Mr. R. Borlase Matthews as Honorary Secretary. It has been arranged that for the present the Committee shall hold fortnightly meetings on alternate Wednesdays, and endeavours will be made as soon as possible to arrange for the formation of a Parliamentary Party in the House of Commons to represent electrical interests. We are informed that the Committee are making every effort to work in co-operation with other existing associations and societies, and all questions which can be dealt with by other associations are referred to them, the Committee endeavouring to secure for each society the general support of the collective electrical industries. The Committee have already had brought before them, and have under consideration, a large variety of matters, and it is felt that it will probably be necessary to make a selection of the more urgent or more important for their early attention. It would be a convenience to the Committee to receive notifications from time to time of matters which, in the opinion of any member of the industry, require to be dealt with, and it is suggested that any member of the industry, although not himself a member of the Committee, desiring any matter to be considered, shall communicate either with a member of the Committee or the Honorary Secretary, Mr. R. Borlase Matthews, Bank Buildings, Kingsway, W.C.

Royal Society of Arts.—The Society's Albert Medal, which is conferred annually for "Distinguished merit in promoting arts, manufactures or commerce," has this year been awarded by the Council to Madame Curie for the discovery of radium, which was due to the work of Madame Curie and her husband, Prof. Curie, jointly. Madame Curie is the second woman to receive the Society's Albert Medal, it having been conferred, in 1887, on H.M. Queen Victoria "In commemoration of the progress of arts, manufactures and commerce throughout the Empire during the 50 years of her reign."

Junior Institution of Engineers.—Sir J. J. Thomson, F.R.S., has been elected president in succession to Sir Henry J. Oram, K.C.B.

Royal Institution.—At the general monthly meeting, held on Monday last, the chairman, Sir James Crichton Browne, announced that His Majesty the King had graciously consented to become Patron of the Institution.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, July 8th (To day).

Physical Society.

5 p.m. Meeting at the Imperial College of Science, Imperial Institute-road, South Kensington. *Agenda:* "A Thermo-electric Balance for the Absolute Measurement of Radiation," by Prof. H. L. Callendar, F.R.S.; "The Convection of Heat from a Body Cooled by a Stream of Fluid," by Dr. Alex. Russell; "On Hysteresis Loops and Lissajous' Figures, and on the Energy Wasted in a Hysteresis Loop," by Prof. S. P. Thompson, F.R.S.; and on "The Energy Relations of Certain Detectors used in Wireless Telegraphy," by Dr. W. H. Eccles.

SATURDAY, July 16th

Junior Institution of Engineers.

Summer meeting in Ireland. Reception at Trinity College, Dublin. Inspection of the Engineering School and visit to the Ringsend power station of the Dublin United Tramways Co. Reception (in the evening) by the Institution of Civil Engineers of Ireland.

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THE VIBRATION GALVANOMETER.*

BY F. WENNER.

Summary.—The importance of the E.M.F. developed by the relative motion of the magnet and the winding of a galvanometer is pointed out, and the general theory of the vibration galvanometer is developed. A method of tuning is described possessing several advantages, and the principles to be followed in the design of a high-sensibility instrument for bridge work are considered.

The vibration galvanometer is an instrument for the detection of alternating currents or E.M.F.s. It differs from other instruments for the same purpose mainly in having the moving system tuned to the frequency of the current or E.M.F. to be investigated. If the period or frequency of the current is changed while the free period of the instrument is kept constant, it is found that the instrument has a high sensibility at and near the resonating frequency, while at frequencies differing by more than a few per cent. from the resonating frequency the sensibility is very small. The instrument, therefore, responds only slightly to the harmonics in the current or E.M.F. wave, so that usually no error is introduced when measurements and calculations are made on the assumption of a pure sine wave. This property makes the instrument especially suitable for those measurements in which frequency enters and in which null methods are used.

Max Wien† pointed out some of the advantages of a tuned instrument when he described his optical telephone, a vibration galvanometer in which the essential part of the moving system consists of a piece of soft iron on a very flexible diaphragm. Rubens‡ next brought out an instrument in which the mirror and soft iron piece are mounted together on a metal suspension instead of a diaphragm.

Max Wien§ later developed an instrument having a very small permanent magnet mounted on a brass wire suspension, the lengths and tension of which may be changed so as to give a considerable range in the number of vibrations per second. In 1907 Campbell‖ described a very convenient instrument of the D'Arsonval type. This instrument is suitable for frequencies of from about 50 to about 750 vibrations per second and is easily adjustable over this range. In sensibility this instrument compares favourably with Wien's when both are adjusted to the same frequency. Concerning the theory of the instrument, Campbell points out that the sensibility is independent of the moment of inertia and inversely proportional to the frequency. He also states that the damping is "both mechanical and electrical" and should be kept small.

Theory of the Vibration Galvanometer.—In any galvanometer, a current through the winding produces a force tending to cause a relative displacement between the fixed and moving system. The resulting relative displacement causes a part of the flux from the magnet to cut through the winding, and thus develops a counter-E.M.F. The energy available for producing a deflection is the time integral of the product of the current and the counter-E.M.F. As galvanometers are ordinarily used, this energy is small, due to the fact that after the moving system has reached a displacement equal to the final deflection the time integral of the product of the counter-E.M.F. and current is either equal to or less than zero. If the motion is only slightly damped, a reversal of the current at the end of the first deflection will cause a second deflection in the opposite direction larger than the first. This is due to the fact that the motion of the system again causes a counter-E.M.F., and thus more electrical energy is converted into mechanical energy. However, not all this energy is added to the system, since some is lost by air friction, induced currents, &c. By reversing the current at the end of each deflection the successive deflections can be increased until the average rate at which energy is lost by damping becomes equal to the average rate at which electrical energy is converted.

The author considers first the case where the impressed E.M.F. and current waves are both of a sine form and later the effect of harmonics. With a sine wave current and E.M.F. we may assume a simple harmonic vibration and a sine wave back E.M.F.

In use the free period is adjusted to or near that of the current to be investigated. If this adjustment is good the displacement of the moving system leads the driving current by 90 deg., and since the back E.M.F. depends upon the rate of change of this displacement it is in phase with the current. If, however, the tuning is not good the moving system leads the current by an angle greater or less than 90 deg., and consequently the phase angle between the current and the back E.M.F. is not zero. As the power converted depends upon the cosine of this phase angle, the tuning may have a marked effect upon the deflection. As the amplitude of the vibration increases the back E.M.F. increases, and unless the resistance is very high it has a marked effect on the value of the current. If the three vectors—the current, impressed E.M.F. and back E.M.F.—are in the same line, the power converted and consequently the deflection is a maximum, if after a steady condition is reached the back E.M.F. is equal to one-half the impressed E.M.F.

The relations between the amplitude of the vibration, current, E.M.F., frequency, &c., may be expressed in terms of the working constants, the more important of which are: (*a*) The current sensibility, (*b*) the E.M.F. sensibility, (*c*) the power sensibility, (*d*) the ratio of the back to the impressed E.M.F., (*e*) the time constant for current indication, (*f*) the time constant for E.M.F. indication, (*g*) the resonance range for current indication, and (*h*) the resonance range for E.M.F. indication. By resonance range is meant the fractional part by which the period of the current or the impressed E.M.F. is changed to reduce the deflection by half. These working constants depend upon the intrinsic constants of the instrument, which are: (*a*) The moment of inertia, (*b*) the moment of damping (by which is meant the ratio of the retarding torque to the angular speed when the coil is on open circuit), (*c*) the moment of restoration (the ratio of the torque, tending to bring the moving system to the null position, to the angular displacement), (*d*) the moment of displacement (the ratio of the torque produced by the current to the current), and (*e*) the resistance.

The author next states the fundamental equation and obtains a solution under certain conditions. Taking θ = angular displacement, α = moment of inertia, β = moment of damping, γ = moment of restoration, ψ = moment of displacement ρ = resistance of galvanometer, r = resistance of complete galvanometer circuit, I = effective value of current, f = frequency of current, f_0 = natural free frequency of moving system, $p = 2\pi f$, $p_0 = 2\pi f_0$, ϕ = amplitude after a steady condition is reached, E = effective value of impressed E.M.F., ω = the angle by which the impressed E.M.F. leads the current, η = the angle by which the impedance E.M.F. leads the current, σ = the angle by which the back E.M.F. leads the current, A = current sensibility, V = E.M.F. sensibility, A′ = direct current sensibility, W = power sensibility, D = ratio of back to impressed E.M.F., and r_1 = resistance of primary circuit. Then he shows

$$\phi = \frac{\sqrt{2}\psi E \cos\omega}{r\sqrt{p^2\beta^2 + \alpha^2(p_0^2 - p^2)^2 + p\psi^2\cos\sigma}}. \quad . \quad . \quad . \quad . \quad (1)$$

Or if $p = p_0$ σ becomes zero,

$$\phi = \frac{\sqrt{2}\psi I}{p\beta} \text{ and } \phi = \frac{\sqrt{2}\psi E\cos\omega}{p(r\beta + \psi^2)}, \text{ so that } \phi^2 = \frac{2\psi^2 IE\cos\omega}{p^2\beta(r\beta + \psi^2)}. \quad . \quad (2)$$

Defining the current sensibility as the ratio of the amplitude of the vibration to the effective value of the current, the E.M.F. sensibility as the ratio of the amplitude to the effective value of the E.M.F. at the terminals of the instrument, and the power sensibility as the ratio of the square of the amplitude to the power supplied gives

$$A = \frac{\sqrt{2}\psi}{p\beta}, \qquad V = \frac{\sqrt{2}\psi}{p(r\beta + \psi^2)}, \quad \text{and} \quad W = \frac{2\psi^2}{p^2\beta(r\beta + \psi^2)}.$$

In this $\cos\omega$ is taken as unity; this may generally be done without introducing an appreciable error, since in most instruments the impedance E.M.F., between terminals, is small in comparison with and very nearly in phase with the impressed E.M.F. The time constant is given for current indications by $T = 2\alpha/\beta$.

In those measurements in which the frequency enters and null methods are used, an exact balance cannot be obtained except when the E.M.F. and current waves are of a pure sine form. In practice this condition is seldom if ever fulfilled, so the vibrations caused by the harmonics may limit the precision attainable. One of the chief characteristics of the vibration galvanometer is that the amplitude of the various harmonic vibrations is small. This is because there is no resonance, and the turning moment changes direction at intervals short in comparison with the half free period of the moving system. The amplitude of the vibration produced by any particular harmonic in the E.M.F. wave is given by equation (1) above when the corresponding value of p is substituted.

By reference to equation (1) it will be seen that the denominator can be decreased (if ψ is large in comparison with $r\beta$) by a decrease in $\cos\sigma$, even though in so doing the first term is increased, as it necessarily is when the instrument is thrown slightly out of resonance. If at the same time $\cos\omega$ can be kept near unity, the deflection will be increased. By referring to a vector diagram it will be seen that if a large inductance is placed in the galvanometer circuit, so as to make the angle η nearly 90 deg., and the frequency of the impressed E.M.F. is increased slightly, so that the angle σ assumes a negative value somewhat less than 90 deg., it is possible for the back E.M.F. to be much larger than the impressed E.M.F. and the latter still have the larger component in phase with the current. The combination of the inductance and the slightly high frequency of the

* Abstract of an article in the "Bulletin" of the Bureau of Standards.
† "Wied. Ann.," 42, p. 593, and 44, p. 681, 1891.
‡ "Wied. Ann.," 56, p. 27, 1895.
§ "Ann. der Physik," 309, p. 425, 1901.
‖ THE ELECTRICIAN, Vol. LX., p. 60.

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impressed E.M.F. results in bringing the back and impressed E.M.F. somewhere near quadrature, and the latter somewhere near the phase of the current. If the frequency of the impressed E.M.F. is not too much above the resonating frequency, the result may be an increase of the component of the current in phase with the impressed E.M.F. This means an increase in the power supplied to and consequently an increase in the amplitude of the vibration of the moving system. A condenser in series with the galvanometer and the lack of tuning in the opposite sense should give corresponding results.

In expressing the sensibility or deflection it will be convenient to use as the unit of current the microampere, of E.M.F. the microvolt, of power the micro-microwatt, of deflection a millimetre broadening of a line image 1 metre in front of a plane mirror ($=25\times10^{-6}$ radians), and C.G.S. units for the other quantities. The resistance must then be expressed either in ohms or electromagnetic units to correspond with the quantities with which it is associated. When the sensibility is expressed in the arbitrary units or the resistance in ohms, it will be here indicated by a line over the symbol representing the quantity.

The intrinsic constants can all be determined from five independent measurements. Measurements which are easily made and from which the constants can readily be calculated are: The resistance, the direct-current sensibility, the current sensibility, the E.M.F. sensibility and the resonating frequency. Then

$$\alpha=\frac{0{\cdot}91(\bar{A}-\bar{V}\rho)}{f_0^2\bar{A}A'\bar{V}},\qquad \beta=\frac{8{\cdot}1(\bar{A}-\bar{V}\rho)}{f_0^2A^2\bar{V}},$$

$$\gamma=\frac{36(\bar{A}-\bar{V}\rho)}{f_0\bar{A}A'\bar{V}},\qquad \psi=\frac{90000(\bar{A}-\bar{V}\rho)}{f_0A\bar{V}}.$$

Basis of the Equations.—In the derivation of the equations, it has been assumed that the moving system experiences an angular acceleration proportional to the resultant torque, a retarding torque

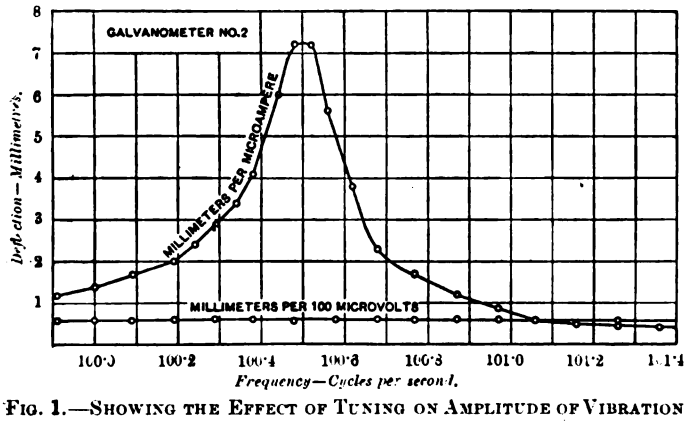

FIG. 1.—SHOWING THE EFFECT OF TUNING ON AMPLITUDE OF VIBRATION WITH CONSTANT CURRENT AND CONSTANT E.M.F.

proportional to the angular speed, a restoring torque proportional to the angular displacement, and a displacing torque proportional to the current and independent of the displacement and the rate of change of the current. That is, (*a*) the moment of inertia, (*b*) the moment of damping, (*c*) the moment of restoration, and (*d*) the moment of displacement are all constant. It is further assumed that harmonics in the E.M.F. or current wave produce no effect on the behaviour of the instrument toward the fundamental, but cause an additional vibration depending upon their magnitude and frequency. It should be mentioned that the effect of the time constant of the circuit, which is generally small in comparison with the time constant of the instrument, has been neglected. If the time constant of the circuit is large it may materially affect the rate of change of the amplitude of the vibration.

Method of Tuning.—The method first used consists of applying to the terminals of the galvanometer a small alternating E.M.F. and adjusting its frequency or the free period of the moving system until a maximum deflection is obtained. This is the method usually used and for some purposes it is very satisfactory. In general, however, the change in amplitude of the vibration with a change in tuning is small, especially near resonance. If the tuning is made in this way, and observations taken for the E.M.F. and current sensibility, a correct value is obtained for the former, but there may be an error of 50 per cent. or more in the latter. If, however, a high resistance (of the order of 100,000 ohms) is placed in series with the galvanometer, an E.M.F. of suitable value used, and the adjustment made for a maximum deflection, the tuning is very much better. This gives a sufficient accuracy in the tuning for most purposes, including the determination of the constants.

However, even with the high resistance a sufficient precision in the tuning could not be obtained for some of the work. It was therefore necessary to use some other method, and the one chosen makes use of the phase angle between the displacement of the moving system and the driving force. On the shaft of the generator is mounted a large disc, behind and slightly above which is placed the line source of light. The disc cuts off about half of that portion of the line which it is desired to use except when exposed by notches, one for each pair of poles, cut in the edge. These notches are so placed with respect to the windings that they expose the lower half of the line only at the instant when the E.M.F. is a maximum. Relatively large resistances are used, especially in the galvanometer circuit, so that the resonance curve is sharp and the current may be assumed to be in phase with the E.M.F. One observes then a band of light above and a line of light below the edge of the disc. When the tuning is good the line appears below the centre of the band. When it is disturbed the line moves toward one side or the other, depending upon the sign of the disturbance, and the displacement is considerable before the shortening of the band is appreciable. A glance at the image tells at once the sign and gives an indication of the magnitude of the lack of tuning so that the adjustment can easily and quickly be made. By using a large resistance in series with a galvanometer having a small moment of damping, this method indicates a lack of resonance when the difference in the frequencies is of the order of 0·01 per cent. of the resonating frequency.

Galvanometers Used.—The galvanometers used were one of the Rubens type made by W. Oemke, one of the Campbell type made by R. W. Paul, and one built in the Bureau of Standards' instrument shop. The galvanometers are referred to below as Nos. 1, 2 and 3 respectively. No. 3 was designed with the idea of getting an accurately balanced system of known moment of inertia and of investigating the effect of air pressure. The general construction is

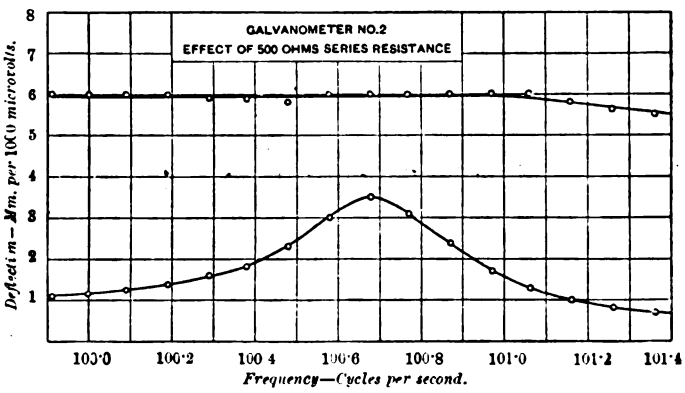

FIG. 2.—SHOWING EFFECT OF RESISTANCE IN DECREASING AMPLITUDE OF VIBRATION WITH CONSTANT E.M.F. IN THE CIRCUIT.

somewhat like the Rubens type, except that a single magnet is used. The constants of these galvanometers are tabulated in the Paper.

Some of these constants are given in the following table, whilst Figs. 2, 3 and 4 show further characteristics.

—	Galvanometer No. 1.	Galvanometer No. 2.	Galvanometer No. 3.
Alternating current sensibility	1·5	7·3	4·2
Direct current sensibility	0·018	0·10	$5{\cdot}5\times10^{-4}$
E.M.F. sensibility	0·0014	0·0061	0·0075
Resonating frequency	100	100	100
Resistance	231	30	71
Power sensibility	0·0021	0·045	0·032
Resonance effect	39	116	2,700
Ratio of back to impressed E.M.F.	78%	97·5%	87%

An inspection of the curves will show that resonance has a marked effect upon the amplitude of the vibration. It seems to have been the idea that the effect of resonance* was to increase the sensibility by about 100 times. Taking the ratio of the alternating to the direct current sensibility gives: for No. 1, 83; for No. 2, 730; and for No. 3, 7,600. If, however, by the effect of resonance we mean the ratio of the amplitude produced by a certain amount of power supplied at the resonating frequency to the deflection produced by the same amount of power supplied by direct current, these figures are too large, since no account has been taken of the back E.M.F. A matter closely associated with the resonance effect is the change

* Campbell, "Phil. Mag.," 14, p. 497, 1907.

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in the ratio of the amplitude of the vibration to the current, with changes in the frequency of the latter. This ratio in the neighbourhood of the resonating frequency is shown by Fig. 1, for galvanometer No. 2, and it will be seen that the ratio has a sharp maximum at 100·5 cycles per second and falls to one-half for a change of 0·14 per cent. in the frequency. Fig. 2 shows the ratio of the deflection to the E.M.F. at the terminals of the instrument and when 500 ohms are placed in series. The 500 ohms in series makes the resistance of the circuit 18 times larger, yet at the resonating frequency the ratio of the deflection to the E.M.F. is reduced by only about 45 per cent. It is evident, from the behaviour of this instrument, that when it is used in bridge work with a constant impressed E.M.F. the resistance of the galvanometer circuit, if under 300 ohms, has but little effect upon the sensibility.

The effect of air damping on galvanometer No. 3 is shown by Fig. 3. It will be noticed that the air reduces the resonating frequency by about 0·75 per cent. This change in frequency is accounted for if we assume that the system drags with it a quantity of air whose moment of inertia is equal to that of a sphere of air having a radius slightly larger than the radius of the disc. It is also to be noticed that the removal of the air makes the resonance curve much sharper. The effect which is of real importance is the reduction of the sensibility by the air friction. Since the back E.M.F. is proportional to the amplitude, the power supplied per micro-ampere is, according to the curves, about 9 per cent. less when air damped. For the same deflection, then, the power supplied, when air damped, is about 11 per cent. greater.

Fig. 4 shows for galvanometer No. 2 the effect of a large inductance on the ratio of the amplitude of the vibration to the E.M.F. The inductance used was the 480-volt winding of a 600-watt transformer and the increase in the ratio was 125 per cent. While the resonating frequency was 100·52, as shown in Fig. 1, yet the maximum amplitude of vibration occurred with a frequency of 101·03

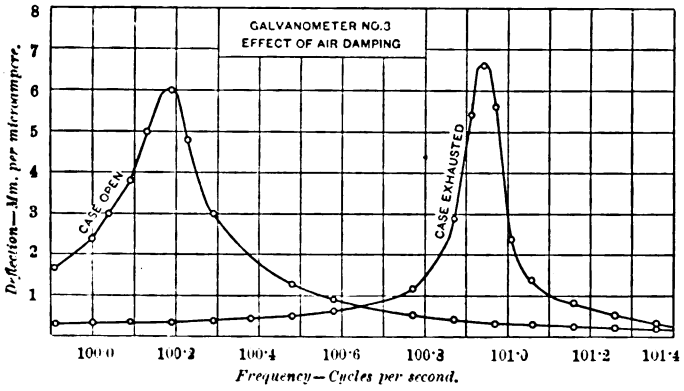
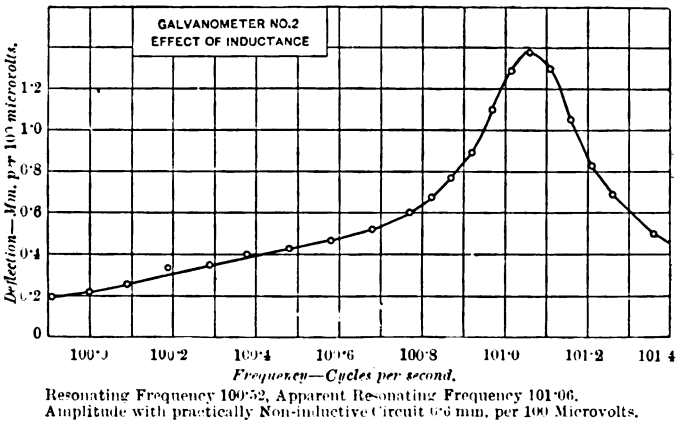


FIG. 3.—SHOWING CHANGES DUE TO AIR DAMPING, IN RESONATING FREQUENCY, SHARPNESS OF TUNING, AND CURRENT SENSIBILITY.

cycles per second. The effect observed was much more marked with an inductance about a quarter as large. No effort was made to get an inductance of the most suitable value.

The consideration of the precision which may be attained in the balance of any one of the alternating current bridges will show the bearing of some of the above work on problems of this kind. To illustrate this the author chooses the comparison of the product of a capacity and self-inductance with a frequency by the "series" method. The advantage of using a transformer with an instrument developing a relatively large back E.M.F. is also shown. Where a transformer is to be used, equation $\rho = r'(1-D)$ serves to determine the ratio which makes the sensibility of the whole combination a maximum. Since in well-designed and constructed instruments the power necessary to maintain a vibration of any specified amplitude depends only slightly upon the resistance or the ratio of the back to the impressed F.M.F. (provided this ratio is over 75 per cent.), the condition for maximum power converted is at least very nearly the condition for a maximum sensibility of the combination. This equation will therefore be of service in determining conditions which will give the best results with a particular instrument. The use of a transformer in connection with a galvanometer reduces the resistance of the galvanometer inversely as the square of the step-up ratio without changing its power sensibility or the ratio of the back to the impressed E.M.F.

Design.—A brief consideration of the theory and data given above will bring out a few of the principles involved in the design of vibration galvanometers. The consideration will be limited to instruments to be used in circuits of fairly low resistance, generally under 500 ohms and low E.M.F. This is the condition met with in alternating-current bridge work which at the present constitutes the main field in which the vibration galvanometer is used. The instrument may be connected directly in series with the circuit, or to the secondary winding of a transformer the primary of which is connected in series with the circuit. When the galvanometer is connected directly in series with the circuit, the relation between the amplitude of the vibration, the impressed E.M.F. and the various intrinsic constants of the instrument is given by equation (2). It should be noticed that the amplitude is a maximum for a particular value of the moment of displacement, that is, when $\psi^2 = r\beta$. This signifies that the mechanical power received by the moving system is a maximum when the back E.M.F. is equal to one-half the F.M.F. impressed on the circuit. With galvanometer No. 2 used on a bridge having a resistance of 100 ohms in each arm it will be seen that ψ^2 is about eight times as large as $r\beta$. As ψ is proportional to the field strength of the magnet, it follows that a reduction of 60 per cent. in the field strength results in an increase in the sensibility of the combination of about 70 per cent. This change results in a decrease of about 40 per cent. in the power sensibility. Where $\psi^2 = r\beta$, equation (2) takes the form $\phi = E/p\sqrt{2r\beta}$. As r is made up of the resistance of the galvanometer and the arms of the bridge in a series parallel combination but little is to be gained by making the resistance of the galvanometer excessively small. In inductance and capacity bridges p is generally fixed from other considerations, so we have β as the only factor under this condition which materially affects the sensibility of the combination. The power necessary to maintain a vibration of a given amplitude is proportional to the moment of damping. *The design then should be such that the back E.M.F. is approximately equal to one-half of the E.M.F. impressed on the total galvanometer circuit, and the mechanical power necessary to maintain at the chosen frequency a vibration of any particular amplitude should be as small as possible.* It is necessary also to take into



Resonating Frequency 100·52, Apparent Resonating Frequency 101·06.
Amplitude with practically Non-inductive Circuit 0·6 mm. per 100 Microvolts.

FIG. 4.—SHOWING SHIFT OF APPARENT RESONATING FREQUENCY AND INCREASE OF AMPLITUDE OF VIBRATION DUE TO INDUCTIVE CIRCUIT.

consideration the resolving power of the optical system to be used, as this often limits the amplitude of vibration which may be detected. Where the galvanometer is to be used regularly with a transformer the ratio of the back E.M.F. to that impressed at the terminals should be large, though there is little to be gained by making it over 90 per cent. Here, as before, the moment of damping, or the mechanical power necessary to maintain at the chosen frequency a vibration of any particular amplitude, when the circuit formed by the winding is open, should be as small as possible.

It will be seen that the moment of inertia of the moving system does not affect directly the sensibility. It does, however, affect very materially the resonance range and the sensibility to the various harmonics. Where the balance depends upon the frequency or the wave-form the moment of inertia should be relatively large. On the other hand, where the balance is independent of the frequency, and especially if no special device is available for controlling the frequency, the moment of inertia should be very small to make the resonance range large. We have seen that the power lost by air friction by galvanometer No. 3 for a vibration of unit amplitude is 3·5 micro-microwatts. If we assume that 75 per cent. of this is lost by friction and pressure against the mirror we see that the power sensibility of a galvanometer having a frequency of 100, a mirror 1 cm. in diameter and operating in air is limited to 0·4, or about 10 times the sensibility of galvanometer No. 2. The sensibility may be made higher than this by changing the shape and reducing the surface of the moving system, yet if a very marked improvement is to be made in the sensibility it may be necessary to do away with the air damping by placing the instrument, or at least its moving system, in a vacuum.

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PUBLIC LIGHTING FROM A MUNICIPAL POINT OF VIEW.*

BY JACQUES ABADY.

Summary.—The author first considers the different forms of street lighting contracts which are in vogue and discusses the relative merits of each form, reaching the conclusion that to buy street lighting by light value is the most advantageous course. He then passes to the question of the position of the lamps and the distribution of the light, emphasising the fact that street lighting in many cases degenerates into a haphazard scheme of point lighting. He urges the desirability of decreasing the candle-power of light units and placing them closer together.

To the casual observer the question of public lighting appears to be, no doubt, a simple and straightforward matter, involving no more difficulty than placing lamps upon columns, lighting them when dusk approaches, and extinguishing them at the break of day. As a matter of fact, however, the problem is one of very considerable difficulty because it concerns so many diverging interests. The public, for instance, as it becomes more and more used to improved lighting in dwellings and shops, expects that the lighting of highways will keep pace with such improvements, but does not, of course, expect to pay more for it. The municipality has to consider the question of cost, and its relation to rateable value; while those supplying the light regard public lighting as something of an advertisement, and naturally enough desire to introduce whatever improvements may be forthcoming from time to time.

Although, from a municipal point of view, the form of illumination would appear to be of secondary importance compared with the volume and distribution of the light itself, yet there is no doubt that the severe competition between gas and electricity almost invariably comes into fierce play when lighting schemes are under consideration; and the relative positions of gas and electricity might, perhaps, form part of a discussion upon the subject of public lighting. I am, however, free to admit that, given a light of a certain value, distributed in a certain manner, it does not seem of importance to the public whether that light is produced by gas or by electricity; the sole consideration should be the question of relative cost. It will, therefore, be more profitable to examine the following different forms of street lighting contracts which are in vogue:—(A) The contract for supply of energy with maintenance, payment being made for so much energy and not for so much light. (B) The contract for supply of energy only, maintenance being undertaken by a contractor acting for the municipality or the municipal public lighting department itself. (C) The contract for supply of light, payment being made for so much light irrespective of the energy required to produce it.

What are the relative merits of these forms of contracts, always assuming them to be equally well drafted in the legal sense, and how do they assure what I venture to point out as desiderata (which will be termed points 1, 2 and 3), viz., (1) The due observance of the terms of the contract entered into: (2) the efficient maintenance of the standard of lighting contemplated by both parties when the contract was entered into; (3) the facility or encouragement for either party to take advantage, during the contract period, of the introduction of improved methods, either to reduce the cost of producing the light, or to obtain a greater light for the same cost?

Let me say at once that I look upon a contract as something very difficult to draw up, but comparatively easy to break, in spirit at least; and it should be borne in mind that it is of the utmost importance that the terms of any contract should establish a mutuality or community of interest—that is to say, it should be to the advantage of both parties to keep to the terms agreed upon.

Contract A.—Point 1.—The due observance of the terms of this contract naturally hinges upon the facility for measuring the energy supplied. This may be gas or it may be electric current. If the former, it may be agreed to supply through burners with nipples which, tested in the laboratory at a certain pressure, will pass so much gas. To make such a test involves the removal of the burner from the post; and the removal and test of one or a few burners is no guarantee that the bulk are under the same conditions, nor that the pressure under which the burners are tested in the laboratory will be maintained in every street and at every lamp. This can only be ensured by a liberal and constant use of pressure recorders; and the presence of these might easily stop progress in the direction of improved means of gas distribution. If, however, the contract stipulates a certain consumption by the nipple test, and the maintenance of a certain pressure all over the district, with damages for failure in pressure, it will be seen that by this method a general penalty would be inflicted in respect to many lamps when a failure in pressure is found. Alternatively the agreement may involve the use of a governor at each burner; and, assuming for a moment the invariability of governors, their introduction is also unsatisfactory, because efficiency of incandescent gas lighting is hampered by limitation of pressure, and therefore the use of increased pressure should be encouraged and not discouraged, as it is by the use of governors.

These two methods of fixing the basis of payment, therefore, seem to fall short of efficiency, and are not to be recommended on this account. The further method of fixing the basis of payment is either by an average-meter system or by tests of consumption *in situ*; and as to these I think the former is unsatisfactory because it naturally induces a tendency to excessive consumption of gas, and does not ensure a community of interest; while the latter, the *in situ* method, is one which presents very considerable difficulty in carrying it out.

Examine the method of measuring energy as applied to electric current, and we find the same unsatisfactory state of affairs. If a lamp is removed and tested in the laboratory, there is firstly no guarantee that the pressure or voltage in the district will be the same as in the laboratory, and there is further, in the case of arc lighting no guarantee that the pressure is being effectively applied at the arc itself, or whether, instead, it is being reduced by the lamp mechanism.

Point 2 (the efficient maintenance of the standard of lighting).—Assuming bona fides and willingness on the part of the gas company, there is nothing in this form of contract to prevent the standard of lighting being maintained. From the municipal side, however, there would be considerable difficulty, in the case of a careless or unwilling gas management, in ensuring that the condition of the public lights shall always be satisfactory. New mantles might be fitted when required; but the quality of the mantles might be poor, and a poor illumination obtained, notwithstanding that the maintenance terms may be adhered to literally. Similarly with an electricity contract.

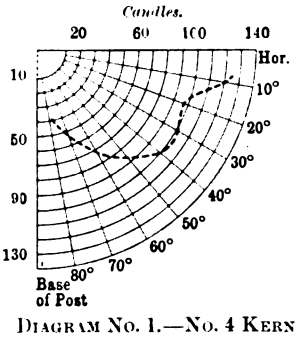

DIAGRAM NO. 1.—NO. 4 KERN BURNER, IN 16 IN. LANTERN.

Candle-power: 93 Candles.

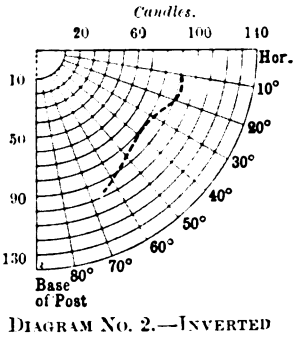

DIAGRAM NO. 2.—INVERTED BURNER IN LANTERN.

Candle-power: 86 Candles.

Point 3 (encouragement to introduce improvements).—In this important respect I think this form of contract is particularly weak. An example of the stop to progress and improved lighting which follows on this form of contract is to be found in an agreement entered into by the City of Westminster with the Westminster Electric Supply Corpn. It is for supply and maintenance of arc lamps and filament lamps, all to consume specified energy at a specified pressure at an inclusive charge per lamp per annum. This contract is, I admit, for a very long period; but this does not affect the point. Open arc lamps, with ordinary carbons and carbon filament lamps are used; and the consequence is that there is an enormous consumption of current for a poor lighting effect, whereas the substitution of more modern lamps would either enable the same light to be produced for very much less cost or a vastly improved light to be obtained for the same consumption of current. This example shows clearly how the public interests suffer from a contract of this nature.

Contract B.—Point 1.—This form of contract is to a great extent similar to the first form already discussed; and the preceding remarks with regard to the due observance of its terms apply.

Point 2.—With regard, however, to the efficient maintenance of the standard of lighting, it is on a different footing, for while it is obvious that the municipality has greater control over efficiency in this respect, yet it will be equally obvious that the interests of the contractor for the energy are very much at the mercy of the municipality. Thus, if the maintenance contractor neglects the maintenance, the energy contractor suffers; while if the municipal lighting department (taking, as it often does, the energy from another municipal department which is in competition with a com-

* Abstract of a Paper read before the Institution of Gas Engineers.

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petitive form of lighting) is interested in doing what it can for its sister department, it is plain that the competitive form of lighting suffers, and real competition is at an end.

It would be affectation to deny that there are many corporations with a municipal gas (or electric) service, a lighting department, and an electricity (or gas) company in competition; and that the outside competitor is denied a fair chance, and on this account the public interest is sacrificed. From my municipal point of view, I hold this to be an unsound position, and I am trying to make clear how this sort of position can arise under the form of contract now being discussed. Where an outside contractor carries out the maintenance, the situation is almost as bad from the energy contractor's point of view, and certainly as bad from the public point of view. An instance of this is Marylebone. Here the gas company undertook to supply gas at so much per thousand. The borough employed a contractor to maintain. Tests which came under my immediate notice showed that the efficiency of the gas lighting was bad—due to insufficient attention to the burners and lamps. The Council, which owns an electricity service, was able to put forward a scheme of electric lighting which was obviously better than the results being obtained from the gas lighting; and so the gas company, whose position was prejudiced and whose hands were tied by the state of the gas lighting over which it had no control, lost the public lighting. This is put forward here as an example of the weakness to the contractor of this form of contract.

Point 3.—There is a position strikingly different from that under the first form of contract. Provided the contract does not limit the pressure of the gas supply, the municipality can obviously, if it chooses to pay for them, instal improved burners and give its public a better light, without affecting the contractor's position in the least. What it cannot do, however, is to give the same light by the introduction of improved burners, and so reduce the cost to the public of its lighting bill.

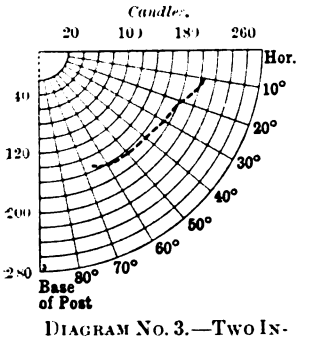

Diagram No. 3.—Two Inverted Burners in Lantern.
Candle-power: 174 Candles.

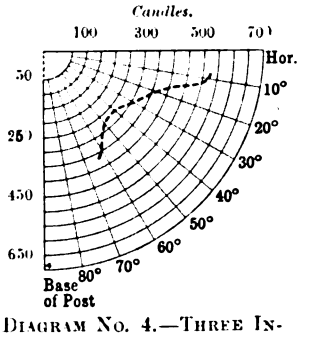

Diagram No. 4.—Three Inverted Burners in Lantern.
Candle-power: 319 Candles.

An interesting example of the contract in which the company supplies energy, and the municipality maintains, is to be found in the recently executed Calcutta Corporation contract, the salient clauses in which are set out in an appendix to the present Paper.

There appears to be one matter which both the "A" and "B" contracts seem not to provide for—that is, decreased quality of gas and increased pressure. Now it seems to me that a direction in which future improvements in the efficiency of gas lighting are to be found will be in a reduction of the quality of the gas, and an increase in the pressure at which it is supplied, so that by reducing on the one hand the amount of air theoretically required for perfect combustion, and increasing on the other hand the mechanical means by which that theoretical amount of air is obtained in practice, we shall be enabled to burn the right quality of gas under conditions of absolute maximum efficiency. Contracts "A" and "B" specifying as they do either (or both) consumption, pressure or quality, prevent improvements in the direction suggested.

In connection with contract "B," there is a point of very vital interest to the public which should not be overlooked—that of expense. It is obvious that there are limitations, both by statute and commercial expedieney, which govern the price at which it is possible or lawful for electric or gaseous energy to be supplied. There is, however, no limit to what a company (gas or electric) may do in the way of cheap maintenance; and so it will be found, I think, that "Energy + Cost of Maintenance by a Corporation Lighting Department" is, or may be, considerably more expensive than "Energy + Maintenance by the Energy Supplier." On the question of expense, again, where there is a contract "B," there is the possibility of a cheeseparing policy of maintenance being adopted by the municipality, so that for a more or less unimportant annual saving (too often a paper one), the efficiency of the lighting is sacrificed, and the odium falls upon the contractor for energy. The tendency to show savings on estimates is one which the average councillor finds almost irresistible.

Contract C.—Point 1.—The question as to control over the proper fulfilment of this class of contract is one about which there is undoubtedly considerable difference of opinion, and plenty of room for discussion; and, in order that there may be something concrete to discuss, in an appendix are set out the salient clauses of the contract for lighting entered into by the Westminster City Council. The testing clause is one to which attention is particularly directed, because this is the centre of gravity, as it were, of a contract which is for the supply of so much light. I am not personally responsible for the drafting of the clause, and frankly admit that there are many alternative methods of framing a clause to a similar effect. I append one hereto as follows:—

Each lamp is to be fitted with burners, mantles, globes, and fittings, as the case may be, giving a minimum of ——— standard candle power, respectively, as directly measured by the Council's portable photometric apparatus placed at an agreed distance above ground level, and is to burn ——— hours per annum in accordance with a daily schedule to be hereafter supplied by the Council. The fittings and lamp must be in every respect to the satisfaction of the city engineer; and in particular the reflectors above are not to be shaped so as to concentrate the illumination at the foot of the lamps, but horizontally flat or slightly convex or otherwise as may be approved by the city engineer, so as to disperse the rays. The tests will be taken in such a manner as to ensure that the glazing bars shall not interfere with the results obtained.

The candle power shall be arrived at by taking the average of two sets of readings in any position with regard to the light under test—one set at an angle of 20 deg. and a second set at an angle of 50 deg. to the horizontal. The photometer used shall be one working on the law of inverse squares, and so constructed as to read accurately whatever the respective colours of the light under test and standard light. Not less than three and not more than six readings, at regular intervals of not less than 30 or more than 60 seconds, shall be made at each angle; and the average of the readings shall be termed the reading or illuminating power at that angle. If, upon a test being made, the illuminating power of any lamp falls below the prescribed standard and is not more than 10 per cent. below it, a test may be made of each of the two nearest lights; and if the aggregate of the light from the three lamps equals the aggregate required by the contract, no damages shall be recoverable. The tests only to be made in reasonably clear weather—not during rain, mist or fog—and in the presence of a representative of the contractor should he so desire.

The intention of this contract is that the contractor shall assure himself, by continued test and inspection, that the lamps he provides are, during lighting hours, fulfilling in all respects the requirements of this contract; and he shall not claim relief from the conditions of this contract on the grounds of non-notification on the part of the Council of any failure to comply with the terms of this specification. The light given shall be of a steady, invariable character, of a white or yellowish white colour.

Now the questions that arise on this clause are two. Firstly, does the manner of applying the photometer test ensure an adequate fulfilment of the contract; and, secondly, is the method of making the test itself such as to remove all ambiguity and ground for dispute with respect to any test—in other words, is a photometer test sufficiently definite and certain? On the first of these points it should be observed that no question of gas or electricity consumption or pressure is involved, but merely a direct photometrical comparison at two definite angles; and the following is the reason why the two angles of 20 deg. and 50 deg. were selected. It must be recognised that to select any particular angles favouring one form of light would be most unfair. It will also be recognised that to take the mean hemispherical candle power is not practicable, as the comparison involves readings at each angle from 90 deg. to 0 deg., which is impossible with a test *in situ*, besides being a tedious matter. It will further be recognised by those who have studied street-lighting problems, that to include in such a photometrical test either of the angles of 80 deg., 70 deg., or 60 deg. would be highly undesirable, because it is at these angles (*i.e.*, in the vicinity of the lamp-post) that one usually gets an excess of light to the detriment of the rays thrown upon the area more distant from the lamp, and their inclusion would encourage, instead of discourage, the distribution of a large volume of light near the post. Now, it so happens that if the lighting curves of all types of lamps are examined—electric and gas, arcs, filament, upright and inverted mantles (high and low pressure)—it will be found that in the majority of cases the mean of the light given at 20 deg. and 50 deg. practically coincides with the mean hemispherical intensity, and therefore represents the value as candle power.

I emphasise the fact, before leaving this point, that there is no question of the light being defined by a foot-candle test; for one must admit that, had this been done, there would have been introduced all kinds of difficulties and problems (as to the behaviour of light rays with respect to surfaces and view point), about which photometrists themselves are not agreed. The test specified

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involves simply the light of the lamp itself and the photometer. There is, moreover, no ground for ambiguity as to the meaning of the contract, because certain candle powers on columns of certain heights are specified throughout. Thus, in the competitive sense, it is a question of price against price for the supply of the same light without any quibble whatever.

The remaining question then is whether it is possible to test in such a manner as to remove all grounds for ambiguity and dispute. As a photometrist, I naturally see no difficulty at all in the matter. But it is possible that those who are not photometrists will look upon a photometer as a very indefinite and indifferent foot-rule indeed; and, of course, it must be admitted that it is necessary to define the kind of instrument and the way it shall be used, in the clearest possible manner. It appears to be quite satisfactory to take an instrument based upon the law of inverse squares, and in which such means of obviating reading errors—due either to colour difficulty or to stray light—are provided, as may be agreed upon between the parties entering into the contract. It is also quite simple to agree upon a definite primary standard of light; and it is equally simple to agree upon the secondary standard. This being the case, and it seems that these are all points which are demonstrable, What safeguards against error or chances of dispute should there be provided?

I think these are three—viz., (1) A definition of the weather in which official tests are permissible; (2) absence of infliction of damages if the two lamps nearest to a defective lamp are giving such light as will bring the average of the three up to standard; and (3) the presence of a contractor's representative should be permitted during any test. Upon the question of the practicability, in working, of such a test clause, it might be pointed out that in Westminster we have had five years' experience with a gas and electric light contract; and I am not aware of a single dispute, although defects have been found, charged and paid for. Further, as members will know, invitations were recently issued by the Westminster Council to the Gas Light and Coke Co. and to several electricity companies, to tender for lighting on this basis, and several offers were received. So certain, apparently, were the Gas Light & Coke Co. of the soundness of the basis of the contract and their ability to comply with its terms, that they quoted such prices as have not only ensured to them the continuance of the present gas lighting, but the transfer of several west-end thoroughfares which have been lighted by electricity for some years. And this is after they have had five years' experience of a contract on a photometer basis, made with a corporation which is most stringent in the carrying out of all its agreements.

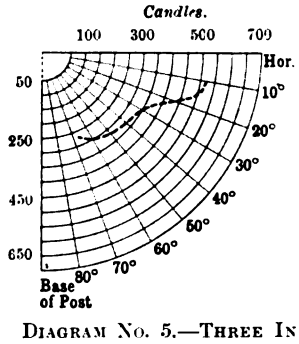

Diagram No. 5.—Three Inverted Burners in Lantern.
Candle-power: 368 Candles.

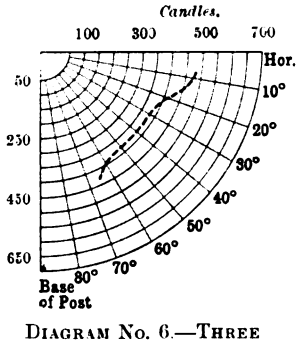

Diagram No. 6.—Three Metal Filaments in Lantern.
Candle-power: 387 Candles.

If, then, we assume the practicability of the photometrical valuation, how does this contract "C" affect the points 2 and 3?

Point 2.—It is unnecessary to labour the point that this contract ensures—so far as any contract can—"the efficient maintenance of the standard of lighting contemplated by both parties when the contract was entered into."

Point 3.—Does this contract facilitate or encourage the adoption by either party of improved methods? It seems to me that it does, because if the contractor finds he can produce the same light at a cheaper cost, or a better light for the same cost, he would surely approach the corporation and offer to share the benefit of such improvement. As an example of this, an incident occurred only last year when the St. James & Pall Mall Electric Lighting Co. approached the Westminster Corporation with an offer of this kind, which was accepted, and we have been obtaining two or three times the light originally contracted for, without any increase in annual cost. On the other hand, if the municipality wished to adopt, say, a new burner or lamp, consuming the same or less gas or electricity, and costing no more for maintenance, there would surely be no contractor so dead to his own interests as to refuse such a proposal. A clause to cover such contingencies should properly be inserted in the agreement; and under these circumstances it seems to me that contract "C" is best from a municipal point of view, and best for the contractor as well.

A great deal of the matter put forward does not apply with equal force to cases of a municipal light supply and municipal lighting department; but I suggest that if, as I think has been shown, it is practicable to buy and sell street lighting by light value, then that is the most direct, simple, and generally advantageous course.

Whatever arrangement, however, may exist in a town between suppliers of light and the local authority as to the contractual basis of the public lighting, it is plain that, from a municipal point of view, the selection of suitable units, the proper arrangement of them, and the general distribution of light are also questions of the utmost importance. And yet, if one may judge from specimens of street lighting, it is evident that these questions are very imperfectly understood; and in place of scientific arrangement of lamps of candle powers suited to the financial ability of a town, one often sees a motley and haphazard positioning of lamps, of all descriptions—exhibiting the crudest and most harmful contrasts of strong glaring light on one spot and next to none in another.

I am well aware that in many instances—too many instances—the suppliers of light have little or no voice in the selection of positions for lamps or the general drafting of lighting schemes; and it seems to me that this fact makes it all the more important that, by a clear grasp of the principles underlying the scientific arrangement of street lighting units, they should be in a position to offer criticism to lighting schemes which are open to criticism, and thereby gradually effect an improvement in public lighting on sound and rational lines. I therefore venture to draw attention to some statements of principles and facts, tabulated and collated, bearing upon the distribution of light, even though in so doing I may be travelling over well-worn ground and be laying myself open to the charge of being dogmatic.

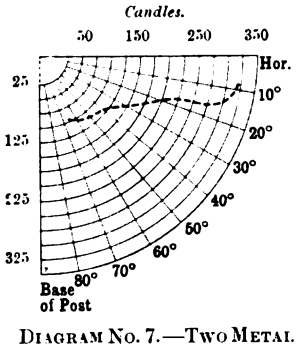

Diagram No. 7.—Two Metal Filaments in Lantern.
Candle-power: 161 Candles.

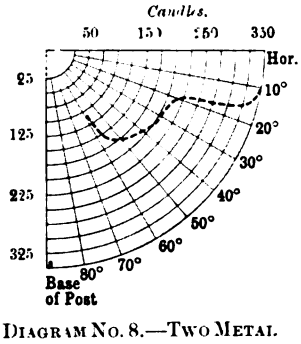

Diagram No. 8.—Two Metal Filaments in Lantern.
Candle-power: 201 Candles.

Now, the first point to be thoroughly grasped is that if one has a lamp of a certain candle power, the distribution of the light in the area affected by such a lamp will vary enormously—getting less and less as one gets more distant from the source of light. This variation in distribution depends upon the distance from ground level at which the light is placed; and, secondly, the proportion of light emitted at different angles. The author gives a table of measurements at various angles with different heights of the light source to render the point quite clear. It is seen that given a light of a certain candle power upon a certain height of column, if it is required to place it upon a higher column in order to illuminate a larger area, the light itself must be increased in candle power if the same illumination is required. In a second table are set out these two relative properties. Thus, suppose it is required to replace 11 ft. columns by 20 ft. columns, and get the same normal illumination, the candle power must be increased 3·3 times, but the area or length of street illuminated will be 1·78 times as large. That is to say, if there are 17·8 100 c.p. lamps 100 ft. apart in a road 1,780 ft. long, one would require 10 330 c.p. lamps 178 ft. apart to yield the same light. It will be gathered from this that, unless the relative cost of providing a 330 c.p. lamp is less than is the ratio of 3·3 to 1·78, then it would not be a paying proposition to make the substitution suggested in the example. The overlooking of this simple rule is the cause of much mystification of councillors, and much harm to public lighting. If it is overlooked, it might be said that 20 1,800 c.p. lights, which equal 36,000 candles (neglecting the rule referred to) will give twice as good a normal illumination as 200 90 c.p. lights, which equal 18,000 candles; and yet, of course, such a comparison

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would be totally fallacious. But is not this sort of comparison made very often, and is it not only by a clear grasp of this question of relative distribution that one can deal with such fallacious comparisons? As a matter of fact, it is only when considering lights with reference to the same height from the ground that the candle power shows the true proportion of increase. Thus, 200 candles on a 15 ft. column is twice 100 candles on a 15 ft. column, but is not twice 100 candles on a 11 ft. column.

Before dealing with the part of the subject which I approach with some diffidence—viz., the proper spacing of lamps—I wish to make three points clear. Firstly, I reckon the distances in feet on a line parallel with the kerb to the nearest lamp, whether considering central lighting or whether the lamps are placed hit-and-miss fashion. Secondly, all such distances are approximate only, because naturally they will vary as the width of the carriage way varies. Thirdly, in considering the candle power on the ground surface, I simply divide the candle power at the angle by the square of the distance, and do not multiply by the sine of the angle of depression (equivalent to the cosine of the angle which the rays make with the normal to the illuminated surface). Had this course been followed, it would have been introducing something problematical, because the propriety of the application of the cosine law is affected not only by the angle of incidence, but also the angle at which the illuminated spot is viewed, by the nature or condition of the surface, and so on. I would point out, however, that had I multiplied by the sine of the angle of depression, I would be multiplying the disproportion of the lighting enormously, and making my point stronger; so that this multiplication is not omitted from any motive of "special pleading." Moreover, the object of street lighting is not only to illuminate the flat ground surface to which the sine multiplication only applies but also objects lying upon it and vertical moving figures as well. The figures given, therefore, are all comparative, and are literally true in terms of an imaginary surface receiving normal illumination.

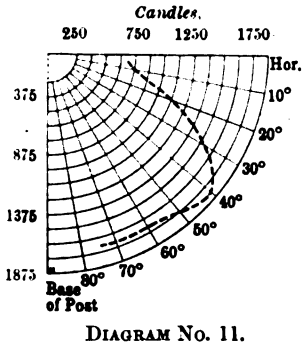

Diagram No. 11.
8-ampere Flame Arc
(Old Pattern).
Candle-power: 1435 Candles.

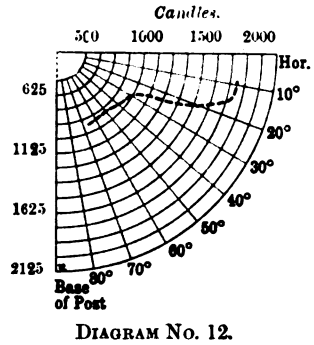

Diagram No. 12.
10-ampere Flame Arc.
Candle-power: 1926 Candles.

From the specific example in the first table mentioned above, it is seen that as between 80 deg. (near the column) and 10 deg. (away from the column) the illumination will decrease to $\frac{1}{32}$nd. If, therefore, one does not desire a greater unevenness of illumination than 1 to 32 (surely an enormous variation) one must place the lamps at a distance apart equal to twice the radius of the 10 deg. angle, so that the 10 deg. ray of one lamp meets the 10 deg. ray of the next. These approximate distances for various heights of light are as follows:—

11 ft.	125 ft.
12 ,,	136 ,,
13 ft. 6 in.	153 ,,
15 ft.	170 ,,
20 ,,	227 ,,
25 ,,	284 ,,

A variation of from 1 to 32 cannot be considered a satisfactory one; and it is a mistake to think that, in order to make the light stronger at the distant points, all that is needed is to increase the candle power of the source. Naturally, this does increase the light at the distant points; but it also increases the light round the column in the same proportion, and if carried to its extreme (as it often is), this course only results in a big glare of light round the column, which glare, by reason of the contrasts it introduces, makes the disproportion apparently worse. Reverting to the list set out above, if they are compared with the distances at which lamps are actually placed, it will be found that in many cases the distances are far greater, and that there are small areas of over-bright light and larger patches with practically none at all. Thus, through want of a little thought and the application of simple rules, street lighting in many cases degenerates into a haphazard scheme of point lighting, instead of being, as it should be, the even and uniform distribution of artificial light.

The more attention is drawn to it, the more will this disproportion of light diffusion and the unevenness of distribution probably be noticed, and it is hoped in course of time remedied. The question is, What can be done to improve this state of things, even though the standard set up for attainment is ideal? It appears to me that there are two ways. The first way is to select lamps with lighting curves which are greater at 10 deg. than at 15 deg., greater at 15 deg. than at 20 deg., and which get less and less as they approach the 80 deg. angle. To do this involves the use of dioptric arrangements or reflectors, and, of course, the disproportion can at best only be partially remedied. Attention may here be drawn to the polar curves in Diagrams 13, 15 and 16. These show what can be done by makers of electric and gas lamps if the necessity to do it is grasped

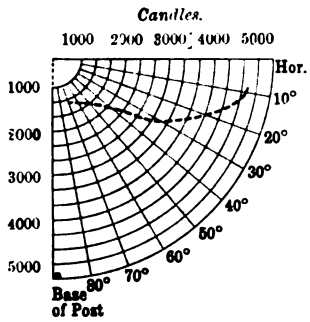

Diagram No. 13.
"Excello," 660-watt Flame
Arc with Dioptric Globe.
Candle-power: 2812 Candles.

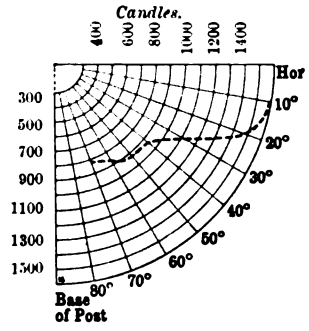

Diagram No. 15.
High-pressure Upright
Burner in Lantern.
Candle-power: 1193 Candles.

and insisted upon. A bad example is Diagram 11, a flame arc without dioptric globe. A bad example of a gas lamp is No. 2—an inverted burner in lantern.

The second way in which evenness of illumination can be procured, perhaps a costly method, but certainly an effective one, is to bring the lighting units closer together. It will also be possible to reduce the candle power of the sources of light, because there is always an excess of light near the column on account of the initial candle power necessary to give enough light at the distant points. I, therefore, urge attention to this view—viz., the desirability of decreasing the initial candle power of light units and placing them closer together. I am well aware that cost enters largely into the question of street lighting, and with this in mind suggest that it is better lighting to give a comparatively feeble but even illumination than it is to give a more powerful illumination full of contrasts

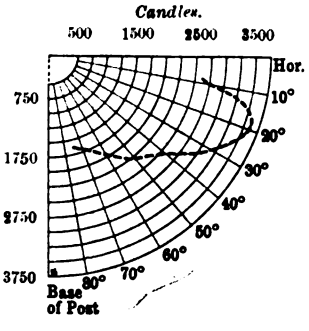

Diagram No. 16.—Three
High-pressure Inverted
Burners in Lantern.
Candle-power: 2963 Candles.

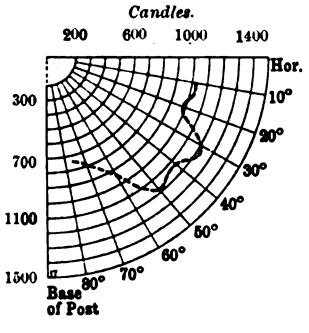

Diagram No. 17.—Three
High-pressure Burners
(small) in Lantern.
Candle-power: 960 Candles.

between the light near the columns and that towards the midway position between them. I find that a suitable arrangement (though possibly an ideal one) of what might be termed "overlapped" lighting, is to plot the positions so that the 20 deg. angle of one lamp meets the 20 deg. angle of the next.

If this method sets up an unattainable ideal on account of cost, at any rate it sets up something to approach if not to attain, and indeed if the question of a suitable polar curve (greater light at 10 deg., 15 deg., and 20 deg. than at the nearer points) is also considered and properly made lamps insisted upon, then it is not necessary to do more than to arrange the distances so that the 15 deg. ray of one approximately overlaps the 20 deg. ray of the next, or

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even overlaps the 15 deg. only. Applying these methods to the curves in Diagrams Nos. 13 and 16, we arrive at the following effects:—

	60°	50°	40°	30°	20°	15°	10°	10°	10°	
		10°	10°	10°	15°	20°	30°	40°	50°	60°
No. 13 ...	1·8	1·78	1·60	1·44	1·2	1·2	1·44	1·60	1·78	1·8
No. 16 ...	2·3	2·33	1·83	1·39	0·99	0·99	1·39	1·83	2·33	2·3

	60°	50°	40°	30°	20°	15°	10°	10°			
				10°	10°	15°	20°	30°	40°	50°	60°
No. 13 ...	1·8	1·55	1·37	1·44	0·97	0·92	0·97	1·44	1·37	1·55	1·8
No. 16 ...	2·3	2·2	1·7	1·39	0·78	0·68	0·78	1·39	1·7	2·2	2·3

Assuming, then, that either of these three arrangements is possible, or perhaps it would be better to say attainable, the distances are as follows, and in setting them out the distances for the first arrangement of lamps with practically no effective overlapping are repeated by way of contrast:—

Height of light.	10° meeting 10°.	15° meeting 15°.	15° meeting 20°.	20° meeting 20°.
11 ft.	125 ft.	82 ft.	72 ft.	60 ft.
12 „	136 „	90 „	78 „	66 „
13 ft. 6 in.	153 „	101 „	88 „	74 „
15 ft.	170 „	112 „	98 „	82 „
20 „	227 „	150 „	130 „	110 „
25 „	284 „	187 „	162 „	138 „

It is very difficult indeed to lay down any standard of lighting, and to say what lighting is suitable for a particular street. In all cases, naturally, positions have to be varied to coincide with street corners and to give greater light at crossings, &c., while the demands of a business street with heavy traffic will naturally not be the same as those of a residential street. Nor even if the demand were made or put forward in competition would the same type of light suit all streets. Thus, high unit lights on tall columns would be most unsuitable for a residential street, because the direct light produced at the level of bedroom windows is not to be desired. All one can do is to point out what effect, with respect to evenness of distribution, will be produced by various combinations of heights and distances. In case it will be of any guidance, I give some approximate particulars of some streets in Westminster; but in looking at these it should be borne in mind that when the new scheme of lighting is completed at the end of the year, the City of Westminster will be lighted by the following units spaced as regard heights and distances as nearly coincident with the figures given above, having regard to the character and needs of each individual street:—

Units now adopted by Westminster City.

12 ft. by 90 candles; 12 ft. by 180 candles; 13 ft. 6 ins. by 300 candles; 20 ft. by 1,800 candles; 25 ft. by 3,000 candles.

Some Examples of Existing Lighting in Westminster.

Street.	Description.	Height of light. (Approx.)	Dist. apart. (Approximate.)	Approximate arrangement.
Atterbury-street ...	60 c.p. incand.	12 ft.	130 ft.	10° meets 10°
Berwick-street	100 „ „	12 „	80 „	15° „ 20°
Bond-street	500 „ open arc	20 „	140 „	15° „ 15°
Bow-street	100 „ incand.	12 „	55 „	20° „ 20°
Kensington— (main road).....	60 „ „	12 „	60 „	20° „ 20°
Palace-street	60 „ „	12 „	90 „	15° „ 15°
Princes-gate	60 „ „	12 „	45 „	20° „ 30°
Regent-street	3,000 „ flame arc	23 „	170 „	15° „ 15°
Sackville-street	100 „ incand...	12 „	80 „	15° „ 20°
St. George's-road ...	500 „ open arc	20 „	150 „	15° „ 15°
St. James's-street ...	900 „ arc	20 „	145 „	15° „ 15°
Shaftesbury-avenue	100 „ incand...	11 „	45 „	20° „ 30°
Tachbrook-street ...	500 „ arc	20 „	150 „	15° „ 15°
Tothill-street	60 „ incand...	12 „	45 „	20° „ 30°

Extracts from the Calcutta Corporation street lighting contract and from the Westminster City street lighting contract are given in two appendices.

Constantinople Telephone Concession.—It is announced that the Council of Ministers have ratified the telephone concession for Constantinople granted some time ago to the British syndicate (represented by Mr. H. Laws Webb), and that the contract will be signed in Paris this week by the Minister of Finance. The concession runs for 40 years, but the Government can purchase the undertaking at the end of 10 years. A number of companies including the Thomson-Houston Co., the National Telephone Co., and the Western Electric Co. are interested in the concession. The installation must be finished within two years. It is thought that Salonica, Smyrna and Beyrout will shortly follow Constantinople's lead.

THE SCHERBIUS MOTOR* AND SOME METHODS OF WORKING IT IN CASCADE WITH INDUCTION MOTORS.†

BY REGINALD O. KAPP, B.SC.

Summary.—Although the three-phase induction motor has many advantages, it is at a disadvantage when a variable speed is required. This difficulty has been overcome to some extent by winding the motor so that the number of poles can be varied, and by cascade working, but such methods do not give the equivalent of the continuous-current motor. Another system is here described in which a three-phase Scherbius commutator motor is connected in cascade to the rotor of an induction motor, thus giving the necessary back E.M.F. to effect speed variation. The power given by the commutator motor may be used in various ways, such as on the main shaft or for driving a generator to return power to the mains.

Three-phase current has such very great advantages over direct current that it has been employed in almost all cases where power in large quantities is used. The ease and efficiency of transformation of alternating current from the high voltage of the transmission line to that required by the consumer, as well as the saving in copper in the line, has caused three-phase current to be used more extensively as the supply stations for electricity became larger and more centralised, and recently, with the advent of the steam turbine, the advantages of three-phase generators over direct-current machines have become even more apparent. In fact, it is not yet possible to build direct-current generators up to the size and speed most suitable for working with steam turbines, whereas alternating-current machines have been readily adaptable to the conditions of

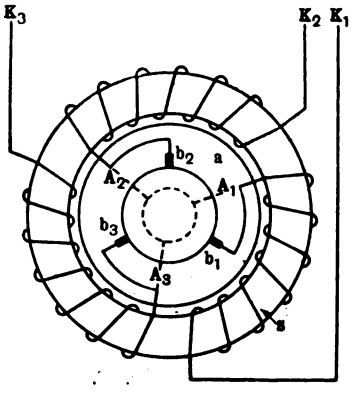

Fig. 1.

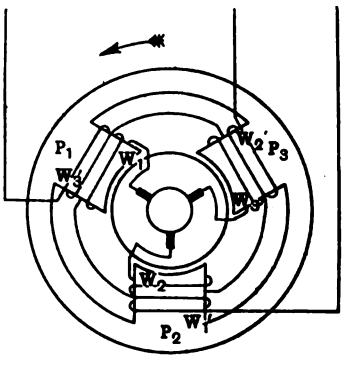

Fig. 2.

very high speed at which turbo-generators must run. From the consumer's point of view, the cheapness, simplicity and low cost of upkeep make three-phase induction motors the most suitable moving agent for machinery that does not require speed regulation.

Even when the speed has to be varied it is often found more desirable to couple an induction motor to the machinery to be driven rather than to transform the energy supplied from the network into direct current. The commonest method of regulating the speed of an induction motor, by inserting resistances into the rotor circuit, has the obvious disadvantage that a considerable amount of power is consumed as I^2R loss. Again, the speed may be altered by changing the number of poles. If the stator has two windings with different numbers of poles, it is possible to get four speeds. The principal disadvantages of such an arrangement for many kinds of working are that these speeds rigidly depend on the frequency of the supply current, intermediate steps are not possible, and the power factor becomes very bad, particularly for large motors running at a low speed.

Another method is the cascade working of induction motors. A second induction motor on the same shaft as the main motor is supplied from its rotor. If the cascade motor has one-half the number of poles of the main motor, the set will run at two-thirds the speed of the one motor alone, and the losses will be small. For more steps a third motor may be

* British patent No. 18,817/06. † British patent No. 16,087/06.

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worked in cascade with the second, but the method cannot be extended indefinitely, as the power factor becomes very bad. In fact, for large machines running at a low speed the power factor is reduced so much that cascade working of even two induction motors becomes altogether impracticable. Intermediate speeds can only be obtained by the use of resistances.

Ideal electric driving for most cases would combine the use of three-phase current with a single motor capable of perfect speed regulation. These conditions have not as yet been fulfilled. They might be possible if a three-phase commutator

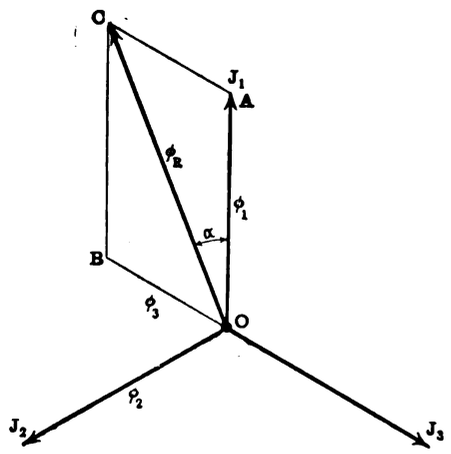

Fig. 3.

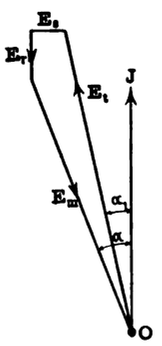

Fig. 4.

motor could be made to work directly on the mains. But technical difficulties in the design of commutator motors for large power and high frequency, particularly difficulties of commutation, have yet to be surmounted before such an ideal can be realised.

An alternative is the system of cascade working here described. An ordinary induction motor works directly on the mains, and has in its rotor circuit a three-phase commutator motor which supplies the necessary back E.M.F. to effect speed variation, and gives up the power it absorbs either to the main shaft or to some other shaft running at a constant speed, or drives a generator, which puts power back into the mains.

The advantages of this system are: (1) The speed can be regulated in as many steps as are required; (2) the loss of efficiency is very small; (3) the power factor can be improved, so that cos $\phi = 1$, thus making a smaller induction motor possible; (4) any required relation between speed and load is possible, as in the case of direct-current machines.

For satisfactory working on this system it is necessary that the behaviour of the commutator motor should be independent of the frequency of the current supplied to it. It is also important that it should commutate sparklessly when fed with current of various voltage and frequency and when run at varying speeds. These conditions are fulfilled by the Scherbius motor, and in consequence a system of cascade working has been perfected by Messrs. Brown, Boveri & Co., which employs a motor of this type.

The chief feature of the Scherbius motor is that it has the characteristics of a direct-current machine. The rotor is a drum-wound armature with commutator. The stator has two windings. One is for excitation, the other is a "compensating" winding. The latter is a drum winding arranged to be electrically an exact counterpart of the rotor. Its function is to counteract the transformer E.M.F. induced in the rotor by the rotating field. In a Latour or Heyland three-phase commutator motor the E.M.F. between the brushes is that induced in the rotor by the rotating field, and is proportional to the difference of speed between the field and the rotor. At synchronous speed this E.M.F. would be 0, at standstill a maximum. In the Scherbius motor the compensating winding is connected to the brushes in opposition to the armature, as shown in Fig. 1. The exciting winding is not shown. When the machine is at rest the transformer E.M.F.s generated in the compensating winding and the rotor are equal and vectorially opposed, so that the resultant E.M.F. between the brushes is 0. When the machine starts running the rotor E.M.F. becomes lower as the difference of speed of rotation between field and rotor decreases; but the E.M.F. induced in the compensating winding remains constant. These no longer balance and a voltage remains at the terminals equal to their difference. Eventually no E.M.F. is induced in the rotor, and the back E.M.F. is equal to that of the compensating winding only.

The motor runs equally well above synchronous speed if a higher E.M.F. is impressed, the back E.M.F. of the rotor and the compensating winding then acting in the same direction. It will be seen that the back E.M.F. is proportional to the speed, precisely as with a direct-current machine. A secondary advantage of the compensating winding is that it makes commutation easy for various reasons. Firstly, the effect of armature reaction is neutralised. Secondly, a field is produced in the neutral zone which cancels the reactance voltage in the short-circuited coils, so that the brushes stand exactly between the poles, and the machine commutates equally well when running at various speeds and in either direction.

In order to compensate for the lag of the current behind the voltage in the main motor, the commutator motor must have a leading current. To obtain this each field magnet is wound with separate windings from two phases, as in Fig. 2. The flux vector is then the resultant of the current vectors in the two phases, and its position depends on the proportion of the number of coils from each phase. In this way it becomes possible to produce any required angle between current and E.M.F. by choosing a suitable combination of the exciting coils. In Fig. 3 OJ_1 and OJ_3 represent the direction of the current vectors in phases one and three. The lengths OA and OB are

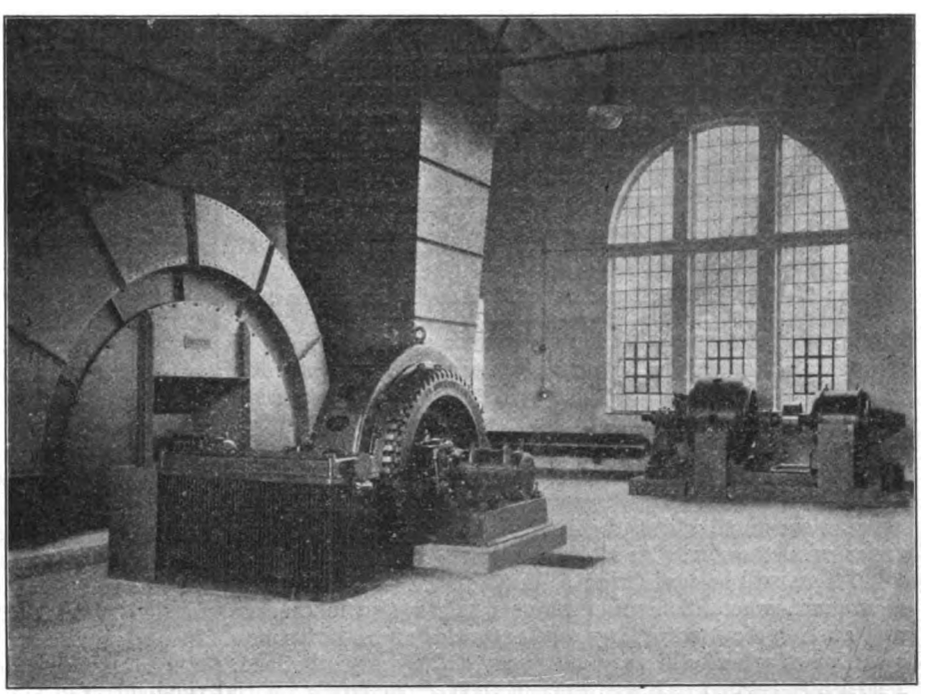

Fig. 5.—Fan with Electric Drive for Gelsenkirchen Bergwerks-Aktiengesellschaft, in Gelsenkirchen, Luftschacht Rheinelbe I./II., with Regulating Set in Background.

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proportional to the number of field coils with which pole 1 is wound from each phase. Then these windings will produce fluxes ϕ_1 and ϕ_4, respectively, for which the ampere turn vectors can serve, and the resultant flux will be $\phi_R = OC$. As the E.M.F. of the machine is entirely due to rotation of the armature in the field, the E.M.F. is in phase with the flux. Therefore the vector of the back E.M.F. E_m in Fig. 4 has been drawn parallel to ϕ_R. If we make allowance for ohmic drop and self-induction, we obtain the vector of the terminal E.M.F. E_t, which is behind the current J by angle α_1. If the proportion of exciting coils are so arranged that α_1 shall equal the lag in the induction motor, the whole set will have a power factor equal to unity.

An advantage of this type of motor is that it may be shunt, series or compound wound, and in each case its behaviour is precisely the same as that of a direct-current machine, and these properties are imparted to the whole set when it is worked in cascade with an induction motor. If the motor is series wound, its back E.M.F. is, for low saturation, proportional to the current in the induction motor, that is to the load. The main motor will then run more slowly the greater the load, and we have the same effect as when a resistance is put into the rotor circuit, with the difference that the only loss is that in the machines themselves. If the motor is shunt wound, the back E.M.F. becomes nearly constant whatever the load is, as the flux is independent of the armature current. Further, the back

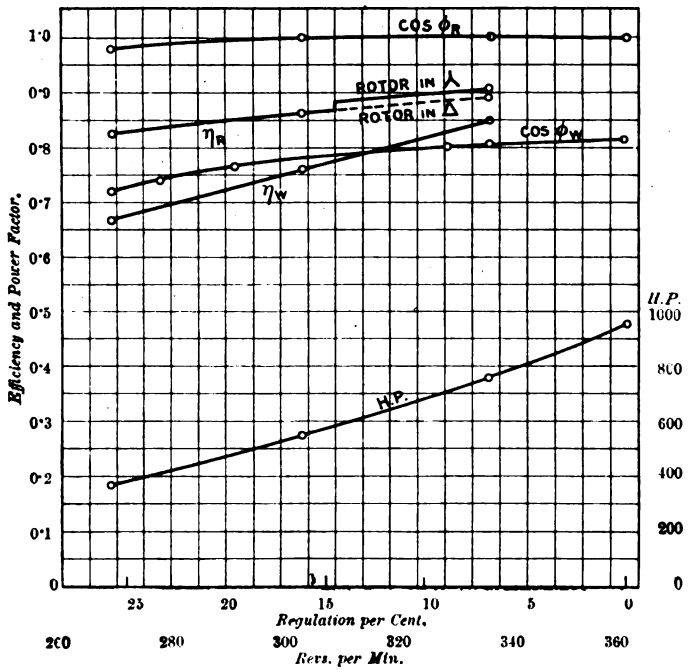

FIG. 6.—CURVES FROM TESTS ON THE SET AT GELSENKIRCHEN.

E.M.F. of the commutator motor depends on the strength of the field, that is on the amount of exciting current, and this equals the E.M.F. over the slip-rings divided by the resistance. As the resistance is mainly inductive, it rises with the frequency, that is with the slip. $E/\sim$ is constant if E is the E.M.F. of the rotor and $\sim$ the frequency of the slip. From this it follows that, if the cascade motor runs at constant speed, its E.M.F. remains constant, whilst the E.M.F. of the induction motor varies with the slip. At the point where both voltages are equal there will be equilibrium. Hence, by adjusting the field of a shunt-wound Scherbius motor which works in cascade with an induction motor, any constant speed of the latter may be obtained which will vary only very slightly with the load. This is not possible with any other method of regulating. With compound winding the speed may be arranged to drop by a required amount as the load increases, an effect often needed in rolling mills.

As any relation between load and speed is obtainable, this method of cascade working has become adaptable to the driving of machinery with very various conditions of working. The applications which have hitherto been developed are: (1) The driving of ventilating fans for mines; (2) the driving of rolling mills; (3) relief of the central station of sudden loads with the help of a flywheel; (4) the working of turbo air-compressors which require a motor that can run above synchronism.

As each of these is typical of different conditions of working, it is interesting to consider each one in detail.

It nearly always happens that for the first years a mine is worked the ventilating fans have to be run at a lower speed than they are built for, because the full draught is not required until the mine is completely extended. As the mine is built out, the power required for ventilation increases gradually, and to meet this increasing demand the fans are driven at a higher speed. If the fan is driven by a three-phase motor, and the speed regulated by resistances, energy is consumed day and night in these for several years, so that the efficiency of such a set is very low till it can be run at normal speed. With a commutator motor to regulate the speed the efficiency of the whole set is high and the power factor is unity. The curves in Fig. 6 compare the efficiency and cos ϕ for regulation with a commutator motor and with resistances. These curves are taken from an installation supplied by Messrs. Brown, Boveri & Co. to a mining firm near Gelsenkirchen in Westphalia. The fan has been supplied by Messrs. Schüchtermann & Krämer in Dortmund, and is capable of giving 230,000 cubic ft. of air per minute at a vacuum of 18·5 in. of mercury, when running at 363 revs. per min. When running at 268 revs. per min. it

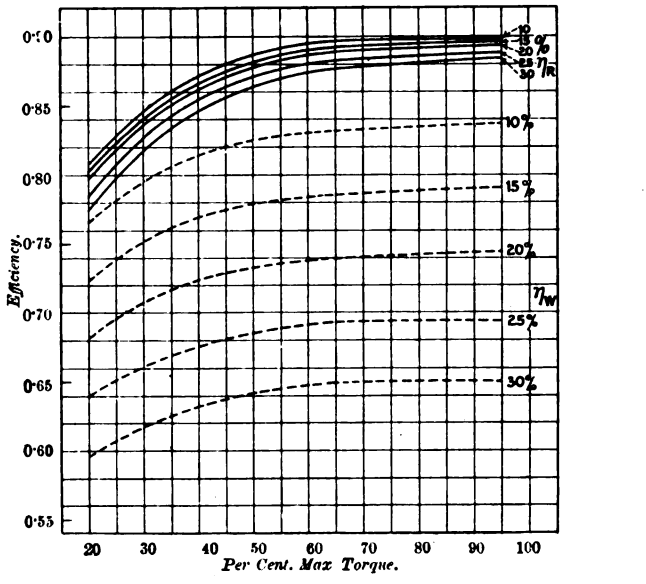

FIG. 7.—COMPARISON OF EFFICIENCY WHEN THE SPEED IS REGULATED BY RESISTANCES, AND BY A COMMUTATOR MOTOR ON THE SAME SHAFT AS THE INDUCTION MOTOR AND CONNECTED IN CASCADE WITH IT.

yields 150,000 cubic ft. of air per minute at a vacuum of 10 in. of mercury. This fan is driven by a three-phase induction motor for 5,000 volts and 50 $\sim$. It must give 1,000 H.P. at 363 revs. per min. and 370 H.P. at 268 revs. per min. At the present stage of the mine the lower speed is required, and this is achieved by a Scherbius motor connected in cascade across the slip-rings and driving an asynchronous generator, which works on the mains. Fig. 5 shows the whole set. The induction motor was designed for 850 H.P., but is enabled to give 1,000 H.P. on account of the phase compensation. The motor is able to work at 20 different speeds with a total range of 26 per cent.

The commutator motor is built for a power of 200 k.v.a., the generator coupled to it for 85 kw. The difference in size is accounted for partly by the losses in both machines; the power given back to the mains is, of course, that absorbed by the commutator motor less the losses. Besides this the current in the Scherbius motor has a considerable lead ($\cos\phi = 0{\cdot}7$) in order to cancel the lag of the main motor, but the chief reason for the difference in size between the two machines is that maximum E.M.F. and maximum current do not coincide. The torque of a fan is approximately proportional to the square

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of the speed. Therefore at a low speed the rotor current in the induction motor is a minimum; the slip being greatest, the E.M.F. between slip-rings is a maximum. When the fan is running near synchronous speed the conditions are reversed. The load is high, so the commutator motor must take a high current at low pressure. It is necessary to build the motor for both conditions, so it becomes larger than the power it is required to take. The size can be reduced considerably by connecting the rotor of the main motor in mesh at low speeds and in star when the speed exceeds a certain amount. The current flowing into each brush is equal to $\sqrt{3}$ times the current per phase in the main motor when the connections are mesh and the voltage is equal to that induced in each phase. When the rotor

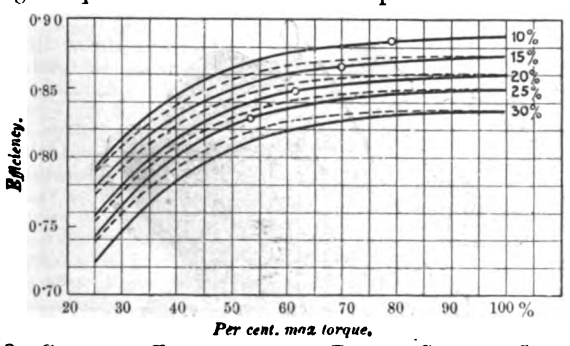

Fig. 8.—Curves of Efficiency for a Drop of Speed of 5 per cent. between No-load and Full Load.

is put in star, the brushes get a voltage equal to $\sqrt{3} \times$ phase voltage, and the current is the same as that flowing in the coils of the induction motor. By this means the cascade motor may be reduced to about 58 per cent. of the size it would have to be, without the change from mesh to star, if the range of speed variation is large.

The curves Fig. 6 were obtained from observed results after the plant was installed. Curves η_w and $\cos\phi_w$ were taken when the speed was regulated by resistances. η_R and $\cos\phi_R$ are for regulations with a Scherbius set. From 310 revs. per min. upwards tests were made with the rotor in star and in mesh connection. The curves show that there is some advantage as regards the efficiency in the change of connections. The curves in Fig. 7 have been calculated from measurements on the same set. They have, however, no bearing on the driving of ventilating fans, but they are interesting in connection with the application to rolling mills. The ordinates are efficiency, the abscissæ represent percentage of the maximum torque. Each curve is for a different constant slip. The curves were obtained from separate measurements on each machine, and assume that the regulating motor is on the same shaft as the induction motor,* so that the losses in the generator are done away with. In rolling mills it must be possible to apply any torque at any speed. Either a shunt or a compound wound machine is employed. With the former the speed remains practically constant with varying load. With the latter the series winding may be so arranged that the back E.M.F. rises by a fixed amount as the load comes on, producing a given drop of speed. This is often useful to enable the moving parts, which are usually designed to have a considerable moment of inertia, to supply a part of the maximum power.

Fig. 8 shows in the dotted curves the efficiency of a machine so compounded that a drop of speed of 5 per cent. takes place between running light and at full load.

In the driving of rolling mills, as of all machinery subject to large change of load, a flywheel combined with some means of automatically utilising the energy at moments of maximum demand, is indispensable. In this connection a system of relieving the supply station of sudden overloads with the help of a flywheel and a Scherbius set has been developed.* As in the well-known Ilgner system of working rolling mills, a flywheel is also employed to equalise the load, a comparison of the main principles of the two methods may be of interest. In the Ilgner system, where the supply current is three phase, the usual method is to have an induction motor, a direct-current generator and a flywheel on one shaft. The generator supplies current to a motor which drives the machinery. These two machines must be built large enough for the maximum power. The advantage of the flywheel is that the induction motor need only be large enough for a little more than the average power, and the load on the central station is kept almost steady. In order to cause the flywheel to give up its energy, resistances are put across the slip-rings of the motor, and thus a drop of speed obtained. It is also possible to lower the speed by strengthening the field of a commutator motor connected across the slip-rings. But the use of a commutator motor makes a different method of working with a flywheel possible, which has in some cases certain advantages over the system described above. Fig. 9 shows the connections of an equipment under construction for the Stordö Kisgruber in Norway. I is the main motor, and in this case a double commutator motor is used, of which the speed is regulated by means of the lever *h*. The flywheel is not on the same shaft as the motor, which takes the full power, but on the shaft of a separate set connected in parallel with the main motor. This set consists of the Scherbius motor *b*, the flywheel *c* and a three-phase induction motor all on one shaft. A current transformer, P, in the mains is connected to a relay, *r*; *t* is an autotransformer, through which the motor *b* is excited. When the load becomes heavy, the relay *r* works a regulating device in the autotransformer, which strengthens the field of the shunt-wound commutator motor *b*. This motor is connected across the slip-rings of *a*, which starts to run slower owing to the

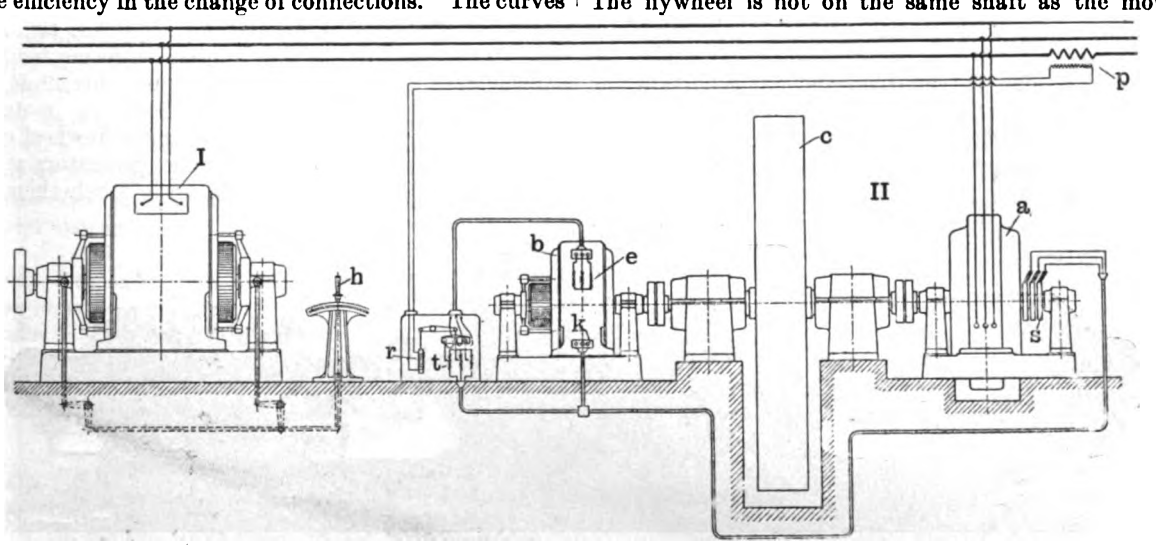

Fig. 9.—Diagram of Connections for Flywheel Buffer Set.

* British patent 5,153/06, owned by Messrs. Felten, Guilleaume, Lahmeyer & Co.

* British patent 21,580/08.

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increased back E.M.F. The flywheel is made to give up some of its energy and drives *a* as an asynchronous generator, which supplies current to the mains. In order that this may happen, the E.M.F. of *b* must exceed that across the slip-rings of *a*. The field of *b* must be adjusted so that this happens at the required speed. *a* will act equally well as a generator whether it be running above or below synchronism. In this method by far the greater part of the energy is taken directly by the working motor, and only that which varies above or below the average goes through more than one machine, so the efficiency is good. The efficiency is not much affected however great the drop of speed. In the usual arrangement, when the flywheel is on the same shaft as the motor, through which the full average power must pass, it is not advisable to drop the speed by more than about 14 per cent. when the flywheel energy is to be utilised, as a drop of speed is accompanied by a reduction of the output of the motor and of its efficiency. Therefore only a small portion of the energy stored in the flywheel can be taken out. When the flywheel is on a separate shaft it does not matter how far the speed of this is lowered, the main motor continues to give the same power, and so the flywheel is made use of to a much greater extent than with the Ilgner system. The flywheel may, therefore, have 0·5 to 0·3 times the weight otherwise required. Another advantage of the method that sometimes is important is that one set may be used to equalise the load due to a number of different machines, and the same set may serve to improve the power factor. A different method of equalising the load by means of a flywheel, and that also employs a Scherbius motor, is at present under construction for the power station at Bardonnecchia. This station generates three-phase current at 50 ∼, and a part of the power is to be used by the electric locomotives on the Mont Cenis tunnel, which require current at 16 ∼. For transforming the frequency three 1,800 kw. motor-generator sets are to be put down, each having a flywheel on the same shaft to keep the load on the main generators steady. The motors are ordinary induction motors. A Scherbius motor is to be connected across the slip-rings, and the field of this will be strengthened by the help of a relay at moments of heavy load. The power factor is automatically kept equal to unity.

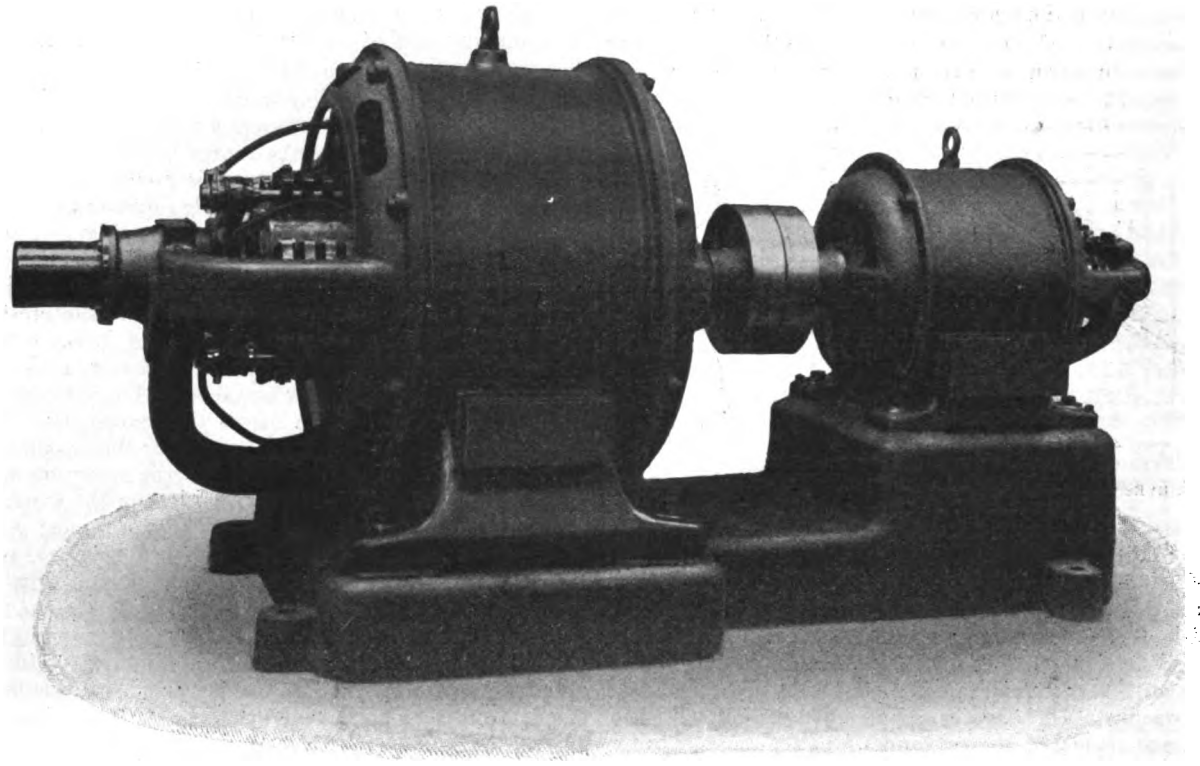

FIG. 10.—REGULATING SET FOR LES PETITS FILS DE WENDEL & CIE, KLEIN RÖSSELN, FOR A FAN MOTOR OF 300 H.P., 182 REVS. PER MIN., WITH 20 PER CENT. SPEED VARIATION.

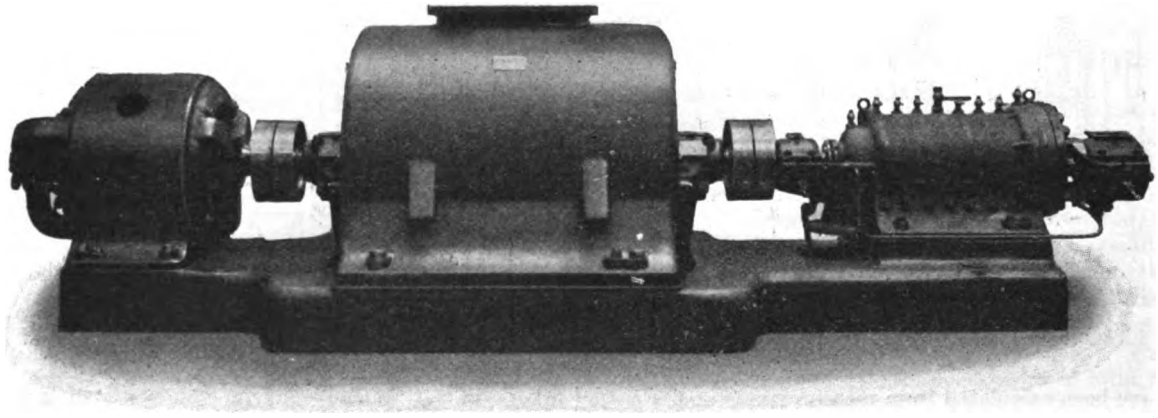

FIG. 11.—TURBO PUMPING SET FOR THE SOCIÉTÉ DES ACIÉRIES BOEL, LA LOUVIÈRE, BELGIUM, WITH COMMUTATOR MOTOR ON SAME SHAFT AS PUMP MOTOR, 225 H.P., 3,000 REVS. PER MIN., SPEED REGULATION 10 PER CENT.

What makes this system useful in the driving of turbo air compressors is the possibility of running above synchronous speed. At 50 ∼ a two-pole induction motor will run at $50 \times 60 = 3{,}000$ revs. per min. The most advantageous speed

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Table of Equipments installed or under construction at June 1st, 1910.

Name of user.	Data of induction motor. Nature of machinery driven.	H.P.	Volts.	Revs. per min.	Frequency	Percentage regulation of no-load speed.	Drop of speed from running light to full load.	Data of com. motor. k.v.a.	Revs. per min.	—
Les Petits Fils de Fois de Wendel & Cie. Klein-Rosseln (Mining Co).	Fan.	300	3,000	182	50	20	...	70	1,000	Com. motor drives a 3-ph. generator.
Deutsch - Luxemburgische Bergwerks und Hütten A.-G., Differdingen (Coal & Iron Co.)	Rolling mill.	2,000	5,000	150	50	...	10%	240	750	Ditto.
Union A.-G. für Bergbau, Eisen und Stahlindustrie, Dortmund (Coal, Iron & Steel Co.)	Fan.	200	5,000	294	50	28	...	60	1,000	Ditto.
Gelsenkirchener Bergwerks A.-G. Gelsenkirchen (Mining Co.)	Fan.	850	5,000	365	50	26	...	200	750	Ditto.
"Gewerkschaft Deutscher Kaiser," Bruckhausen (Coal & Iron Co.)	Rolling mill.	1,800	5,000	375	50	50	50%	400	750	Ditto.
"Königliche Berginspektion Buer," Buer in Westphalia (Mining Co.)	Fan.	1,200	3,000	295	50	33	...	300	600	Ditto.
Electricity Works, Chemnitz.....	Pump.	52–102	120	600	50	17	...	12	1,500	Ditto.
"Société des Aciéries Boel," La Louviere Belgium (Coal & Iron Co.)	Pump.	225	2,000	3,000	50	10	...	25	3,000	Com. motor dir. cpld. to pump motor.
Italian State Railways, Sub-station at Bardonecchia	Converter set with flywheel	3 of 2,500	7,000	495	50	20	...	500	495	Com. motor on same shaft as converter set and flywheel.
"A. S. Stord Kisgruber," Stord in Norway (Mining Co.)	Flywheel buffer set.	60	500	1,500	50	30	...	215	1,500	Com. motor on same shaft as a separate buffer motor & flywheel.
"Gewerkschaft Deutscher Kaiser" Bruckhausen (Coal & Iron Co.)	Rolling mill.	2 of 800	5,000	500	50	18	...	144	750	Com. motor drives a 3-ph. generator.
Ditto.....	Rolling mill.	2 of 300	5,000	600	50	15	...	45	1,000	Ditto.

for turbo air compressors is in many cases above 3,000 revs. per min., or between 1,500 and 3,000, so that it is too low for a two-pole and too high for a four-pole motor using current of 50 ∿. With a Scherbius motor working in cascade the set will run as well above synchronism as below, mechanical considerations alone limiting the speed, so that 3,000 revs. per min. at 50 ∿ can be considerably exceeded.

To make the induction motor run above synchronism it is necessary to impress on the rotor an E.M.F. equal to the vectorial sum of the ohmic drop and the induced E.M.F. due to the difference of speed of the rotating field and the rotor. Such a voltage can be supplied by a Scherbius motor working in cascade, as such a motor has a definite voltage, and supplies a direct current at synchronous speed, so that with a suitable method of excitation it is able to supply the current to the induction motor necessary for running at or above synchronous speed.

In conclusion, a table of equipments at the present moment either running or under construction, is appended which gives data of the induction motor and the commutator motor working in cascade with it for each case. Figs. 10 and 11 show two of the sets that have already been installed.

APPLICATION OF THE CRADLE-DYNAMOMETER TO THE TESTING OF ELECTRICAL MACHINERY.*

BY J. DAVIES AND F. SHAW.

Summary.—After referring to early applications of the cradle-dynamometer principle to the testing of electrical machines, the authors describe a dynamometer used at the Manchester School of Technology, the cradle being supported on ball bearings instead of the customary knife edges. Particulars of experiments with this machine are given, and also some results for the relation between hysteresis and eddy current loses and the flux density in the air-gap.

Introduction.—The essential part of a cradle-dynamometer is a steel framework provided at either end with an arrangement of knife edges, centres, or other suitable means for supporting it in such a manner that it is free to swing about a horizontal axis. The machine to be tested is mounted on a swinging platform, and the position of the machine is adjusted until the centre line of the shaft coincides with the line joining the points of suspension of the cradle. By means of counterweights moving along vertical standards the centre of gravity of the whole moving system, including the motor, may be raised or lowered at will. These weights are adjusted until the centre of gravity is slightly below the axis of suspension, and a third weight on the platform itself is adjusted until the moving system is in stable equilibrium with the platform horizontal. A pointer may be fixed to the frame in order to indicate the horizontal position.

When the machine is run as a dynamo the drag of the armature on the pole pieces, the friction of bearings and brushes, and also a portion of the wind friction, tend to rotate the entire moving system in the same direction as the armature is driven, the actual amount of deflection, *i.e.*, the sensitiveness, depending on the position of the centre of gravity and on the magnitude of the current in the armature and the losses in brush and bearing friction, &c. This rotational couple may be balanced by means of a calibrated spring balance or a sliding weight on a lever arm attached to the platform, and thus the pointer brought back to its zero position. When this condition is obtained, the sum of the unknown couples resisting the rotation of the armature is given by the reading of the balance or weight multiplied by the radius at which it is acting. It is then easy to calculate the total power spent in driving the dynamo if the speed is known, since horse-power $= 2\pi nT/33{,}000$, where n = revs. per min. and T = torque in pound-feet. The efficiency of the machine is obtained at various loads by measuring the output by means of suitable electrical instruments and dividing it by the input as obtained by the above method. If the machine being tested is a motor, and is loaded by causing it to drive another machine, the total input, including losses, is measured electrically and the dynamometer then gives the mechanical output. In either case the power generated may be supplied back to the mains, so that a complete heating and efficiency test can be performed without much waste of power.

Historical.—The first account of any tests being made on this principle appears to be in 1881, when the Rev. F. J. Smith tested the efficiency of some small direct-current dynamos by mounting their armature spindles between centres and then balancing the field system and frame by counterpoise weights. On driving the machine the magnet system was deflected and a weight applied to restore it to its original position. The machine thus became its own dynamometer.

Some time later, in the "Electrical World" (N.Y.), of January 5, 1884, Prof. C. F. Brackett, of Princetown, N.J., described a cradle-

* Paper read before the Manchester Students' Section of the Institution of Electrical Engineers; somewhat abbreviated.

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dynamometer he had designed for testing electrical machines. The cradle was constructed of steel and was supported on knife edges. Machines as heavy as 4 tons were tested on this dynamometer. This form of apparatus has been called the "Brackett dynamometer," although Keith, in the "Electrical World" of January 19, 1884, claimed that a similar instrument was in use by the Fuller Electrical Co. (N.Y.) in the year 1879.

Dr. Drysdale, in an article on "The Testing of Electrical Generators and Motors," in "Engineering" of November, 24, 1905, after pointing out the inaccuracies in all indirect methods of measuring efficiencies and the disadvantages and waste of energy involved in the use of an absorption dynamometer, described a cradle dynamometer designed by him for the laboratories of the Northampton Institute. This dynamometer, with the machine in position, is shown in Fig. 1. In this arrangement the machine under test M is not mounted on the dynamometer, but is coupled up to another machine G, the frame of which is supported on ball bearings. In order to increase the sensitiveness the weight of the machine may be taken off the ball bearings by turning the hand wheel shown. The machine G is then supported on 10 knife edges, and Dr. Drysdale claims that this increases the sensitiveness many times.

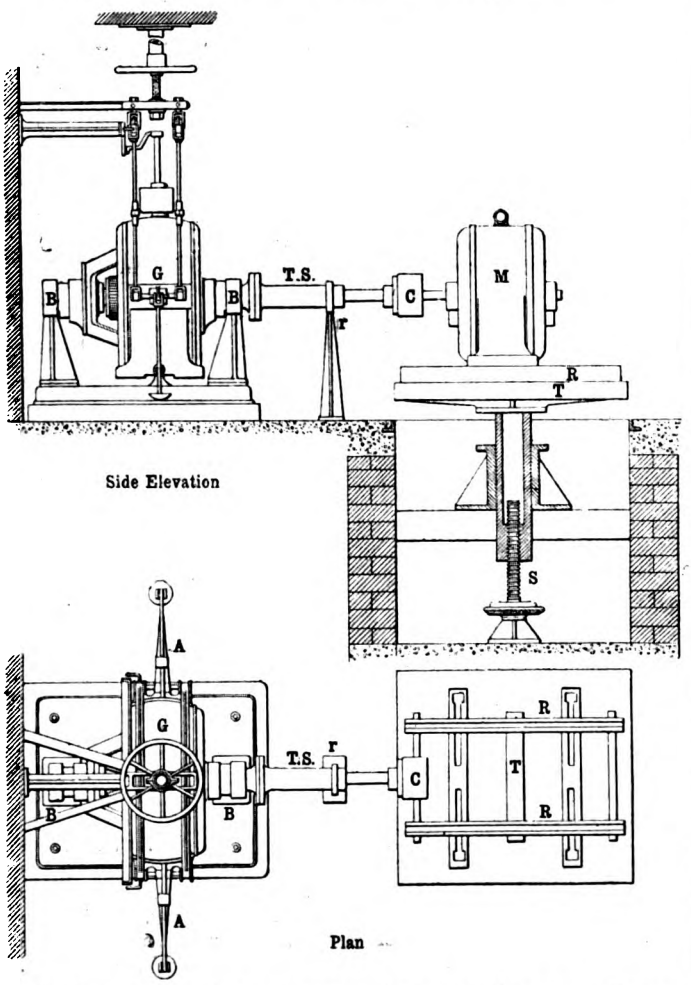

FIG. 1.—GENERAL ARRANGEMENT OF MOTOR AND GENERATOR TESTING PLANT IN THE ELECTRICAL ENGINEERING LABORATORY OF THE NORTHAMPTON INSTITUTE.

To determine the efficiency of a motor the machine G is driven as a generator, the power generated being supplied back to the mains. The dynamometer then gives the input to this machine, which is equal to the mechanical output of the motor. The load on the motor may be varied over a wide range by varying the excitation of the generator. The efficiency is obtained by dividing the mechanical output by the input measured electrically. In testing a dynamo the machine G is used as a motor, its mechanical output, which is now measured by the dynamometer, being equal to the input of the generator.

It appears to us that a cradle dynamometer supported on knife edges has the disadvantage of requiring the machines either to be direct-coupled or, if belt-driven, to have a vertical drive. These conditions are often inconvenient to attain in practice, and when to this is added the trouble due to wear and necessary adjustments when heavy moving masses are supported on knife edges, we are scarcely surprised that the cradle dynamometer, even with its great simplicity, has not achieved a larger measure of success.

In the dynamometer used by the authors, which was designed by Mr. A. E. Moore, of the Manchester School of Technology, the above mentioned difficulties have been done away with by supporting the cradle on ball bearings instead of knife edges. Figs. 2 and 3 show the dynamometer with a machine in position ready for test. The ball races BB are mounted on hollow steel cylinders $5\frac{1}{2}$ in. long and 2 in. in diameter, and contain steel balls $\frac{5}{16}$ in. in diameter. The object of having the ball races on hollow cylinders is to allow a shaft to pass through the end, so that, if occasion demand, a machine

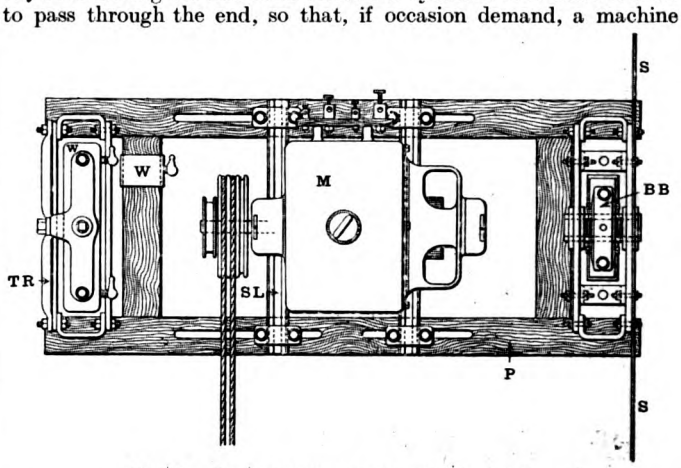

FIG. 2.—DYNAMOMETER USED BY AUTHORS.

under test may be direct-coupled to the driving or driven machine. The authors have found that, even with a tight belt drive, errors due to friction of the ball bearings can be made negligible (when the machine is running above 300 revs. per min.) when a torque of only 1 lb.-ft. is being measured. Fig. 4 illustrates the apparatus used.

Experimental.—Our first experiments were made with the object of finding out how the cradle method of determining the commercial efficiency of a machine compared with the other methods as regards accuracy and speed. We selected for this purpose a 3 kw. 200-volt enclosed machine made by the Electrical Co. The torque was measured by a Salter's spring balance, acting at a radius of 1 ft., and the speed by a direct reading tachometer driven from a small

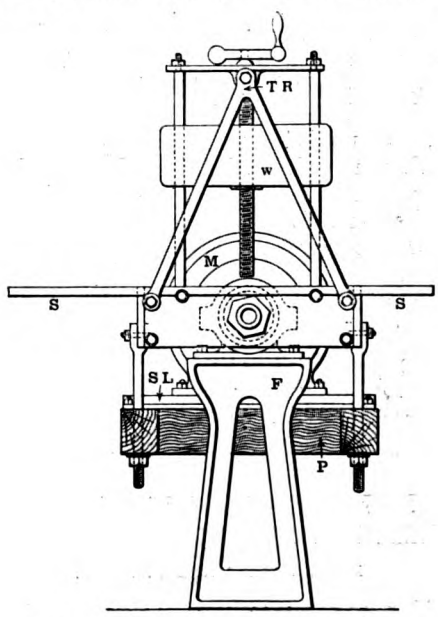

FIG. 3.—DYNAMOMETER USED BY AUTHORS.

pulley on the shaft. The results obtained are shown by the curves in Fig. 5 from which the efficiency, input and losses may be read for any output. The readings for these curves were obtained in about 15 minutes, and the authors have every reason to consider the dynamometer satisfactory for rapidly and accurately determining the efficiency of machines.

We were led to believe as the results of these tests that the cradle dynamometer might be employed for the purpose of making more refined measurements than those for which it has previously been used. As an example of its use for making delicate measurements we chose the problem of separating the various losses which occur

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in a dynamo. Since the torque due to the losses was now only of the order of 1 lb.-ft. we abandoned the spring balance and used instead sliding weights on a lever 3 ft. long. The sensitiveness of the dynamometer was increased as much as possible by raising the counterweights, and in order to determine the horizontal position very accurately a small concave spherical mirror of 2 metres focus was fixed to the moving system, arrangements being made to form an image from this mirror on a vertical scale.

We first attempted to obtain the bearing friction loss by driving the machine without excitation and with brushes lifted. On comparing the results obtained in this manner over a wide range of speeds, it was found that there was no satisfactory agreement. It was thought this was due to the oil gumming, so the bearings were washed out and a better quality of oil was substituted. Various samples of oil were tried in this way, and the one which gave the best results finally adopted and used throughout in the subsequent work. Better agreement was now obtained although great care had still to be taken to have the temperature of the bearings constant while taking readings.

In order to separate the iron losses into their component parts, it is necessary to determine the total iron loss at various speeds. With this object in view the machine was driven for a long time at a particular speed and after about two hours, when the friction was constant, readings were taken of the torque produced when the machine was excited with a wide range of field currents. The torque due to iron losses was obtained by subtracting the frictional torque

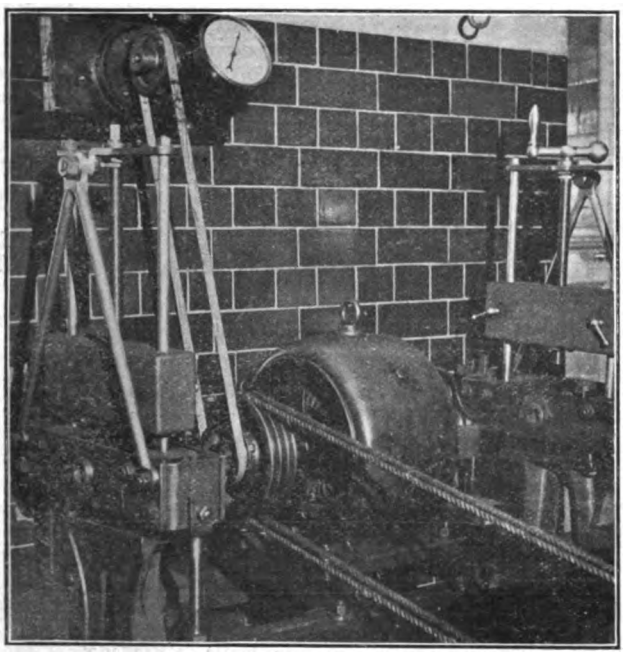

Fig. 4.—View showing Apparatus used.

from the total torque produced. This was repeated for a large number of speeds, readings being always taken for both directions of rotation. The mean of these readings, which did not greatly differ, was taken in order to eliminate errors due to imperfect centring and balancing. Another series of curves was plotted showing the relation between torque and speed for different values of the field current, but the results were far from satisfactory because theory clearly shows that there is a linear relation between torque and speed, whereas our curves show a tendency to bend downwards at low speeds. Much more reliable and consistent results, however, were obtained by reducing the end play of the armature of the machine tested, the readings so obtained lying very well on straight lines, as will be seen from Fig. 6.

It may be shown that the work done per revolution in overcoming hysteresis in the armature is, for a given flux density, independent of the rate at which the flux is being changed in direction. Thus, the torque due to hysteresis will, for given excitations, be constant and independent of the speed of rotation. If, therefore, the curves in Fig. 6 are produced to meet the axis of Y, the height of the point of intersection gives the torque due to hysteresis alone, because at zero speed the eddy current loss is nothing. It is also clear that for any speed and excitaiton the torque due to eddy currents will be equal to the difference between the height of the curve at that speed and the height at zero speed.

In order to obtain the relation between hysteresis loss and the flux density in the air-gap, the values of torque due to hysteresis were taken from Fig. 6 and values proportional to flux density were read off from the magnetisation curve. The law connecting these quantities was found by plotting log H against log B. It was found in this way that the hysteresis loss was proportional to $B^{1\cdot6}$ and the loss due to eddy currents proportional to $B^{2\cdot1}$. In connection with these results it is interesting to note that Mr. Dexheimer, in an investigation on "The Effect of Armature Teeth on Eddy Current Losses in Pole-shoes," found that the eddy current loss was proportional to $B^{2\cdot2}$ in the particular machine tested. Messrs. Wall and Smith in their Paper on the same subject (Proc., I.E.E., February 3, 1908) found the eddy current loss in pole-shoes to be proportional to $B^{2\cdot1}$.

Dr. Steinmetz has shown that the loss due to hysteresis in iron subjected to an alternating magnetomotive force—for example, in a

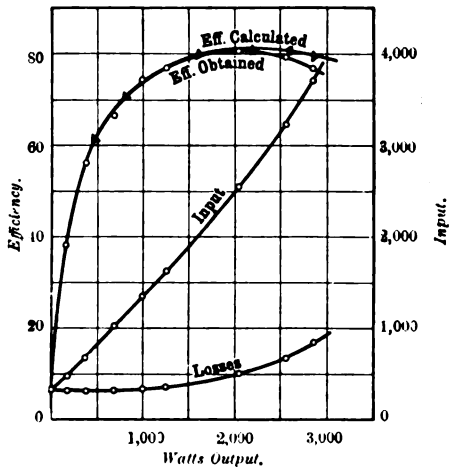

Fig. 5.—Curves connecting Output of Generator with Efficiency, &c.

transformer—is proportional to $B^{1\cdot6}$ between certain limits of B. The apparent discrepancy from this in our results may perhaps be explained in two ways. Firstly, the iron in a rotating armature is never de-magnetised as is the case with iron in an alternating field, but simply has its direction of magnetisation constantly changed. Secondly, the flux density in that part of the magnetic circuit where the loss actually occurs is much greater than the air-gap flux density and is probably very far from uniform. This second statement also explains why the index differs from 2 in the case of the eddy current loss, the fact that the divergence is less for eddy current loss than for hysteresis being probably due to the occurrence of a large part of the former loss in the pole-shoes, where the flux density is more like the flux density in the air-gap.

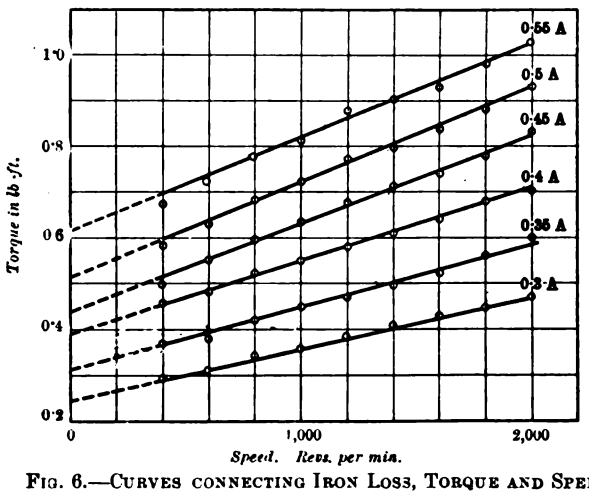

Fig. 6.—Curves connecting Iron Loss, Torque and Speed.

We do not wish to put forward the above as a complete explanation of the abnormally high value obtained for the hysteresis index, but we consider the unexpected result obtained rather suggests a suitable field for further investigation.

The torque due to brush friction was finally determined by measuring the torque produced by bearing and brush friction together, and subtracting that due to bearing friction. This was repeated for different speeds and the torque due to brush friction found to be practically constant over a wide range of speed. A remarkably good agreement was obtained between the observed efficiency and the efficiency calculated from the formula, output/(output + losses), the calculated value being slightly higher at high loads.

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RAILLESS TRACTION.*

BY H. ENGLAND.

Summary.—The author first refers to the unsatisfactory financial results shown by the majority of tramways, and discusses the conditions under which a tramway running in a sparsely populated district can be made a profitable investment. At present railless traction seems to offer the only satisfactory method of extending operations. He then describes the various systems of railless traction in use and gives particulars of the working costs and cost of construction; and finally refers to the difficulty and expense in obtaining powers for the operation of railless schemes.

The qualified success of tramways and light railways laid in public streets has practically entirely stopped extensions into suburban districts. During the boom years, from 1897 to 1903, it was imagined that electric overhead trolley tramways and light railways would pay a substantial return upon the capital invested, even in suburban, inter-urban, and sparsely populated districts. Both municipalities and companies have been disillusionised, and when we glance at the Board of Trade Returns we find there overwhelming evidence of the fact that only in the larger cities and towns are tramways a profitable investment. In launching schemes for the construction of lines, neither municipalities nor company promoters have paid sufficient attention to the influence standing charges have upon tramway and light railway projects.

In my opinion, when first considering the prospects of a proposed undertaking, the first thing to be taken into account is the density of population to be served and the car mileage per mile of route the district will bear to return drawings at the generally accepted minimum figure of 10d. per mile. To illustrate the argument used in this Paper, I have taken throughout a route 4 miles in length, with a 16 hour car day, and 365 working days per annum. A tramway running in a sparsely populated district would be constructed with single track and passing places, and to bear a light service the cost of the cable would be small. I therefore estimate that such a tramway could be constructed for £40,000, or £10,000 per mile (not an extravagant sum). The interest and sinking fund repayments—calculating that the money would be borrowed by a local authority at 3½ per cent. per annum, and that the sinking fund repayments would be spread over a term of 15 years—would amount, to £5. 3s. 7¾d. per cent., and this on a capital of £40,000 would mean an annual payment of £2,072. 18s. 4d. I think it only reasonable to set aside for depreciation 5 per cent. on the capital employed; therefore the amount of capital account standing charges per annum would be £4,072. 18s. 4d. It may be argued that in the case of a company no amount would have to be set aside for sinking fund charges, but on the other hand, the shareholders would be entitled to some return upon their invested capital, and I think that £5. 3s. 7¾d. per cent. is not too much to earmark for this purpose.

The author shows in a table the standing charges per car-mile and the mileage per annum on the above basis for services from one minute up to 30 minutes. Thus, for a 10-minute service, the mileage per annum is 280,320, and the standing charges per car-mile 3·487d. This table clearly shows that with average working expenses of 6·504d. per car-mile it is absolutely necessary to run a minimum average 10 minutes' service, and that any less frequent service cannot possibly pay.

It may be said that a less frequent service, with a higher return per car-mile than 10d., would be profitable; and although better traffic drawings per car-mile would neutralise the higher standing charges, still I do not think it is sound policy, or good for the ultimate success of any undertaking to fail to increase the car service when the receipts amount to 10d. per car-mile.

It must be understood that I am now discussing a suburban car service, because in large cities and towns it is often quite impossible, and indeed inadvisable, to run a service to keep down receipts to the level mentioned; but generally speaking, the quicker the service the more people are encouraged to travel, and I am strongly of opinion that it is the wisest course to cater rather in advance of public requirements than to draw big receipts per car-mile.

I do not think it is necessary for me here to discuss the advantages of tramways over any other form of mechanical traction for normal traffic conditions. There is a consensus of opinion that where traffic warrants, tramways are pre-eminent in handling such traffic, but as the economic limit of tramways has been almost reached in the provinces, we are called upon to find some method of traction less costly in construction, and at the same time cheap to work and inexpensive to maintain. Many of the progressive corporations and companies have been looking for some method of extending their undertakings into the less-populated districts in the hope of encouraging and stimulating traffic on their existing lines.

Motor 'buses have been used for this purpose, and in many cases have been abandoned after exhaustive trials, on the ground that they were too expensive to operate and maintain. It is quite true that great improvements have been made in motor 'buses during the last three years, but even now, in London (where the road surfaces are probably the best in the world for mechanically propelled vehicles), motor 'buses are noisy, unreliable, costly to maintain and operate, and generally inefficient. There are a few successful provincial motor 'bus companies, and I may instance the Scottish Motor Traction Co., which operates in the suburbs of Edinburgh. Some years ago this company came to the conclusion that short-distance traffic with motor 'buses was quite unremunerative, and having realised this they extended their operations, and now I believe their average fare per passenger is approximately 5d., and they are giving a service at about two-hour intervals. They are operating over good macadamised surfaces, and are now paying their shareholders a reasonable dividend. This points to the fact that motor 'buses will pay, given long distance fares and suitable running conditions; but it has been many times demonstrated that such 'buses are not financially successful when dealing with short-distance traffic. Omnibuses driven by electric batteries, steam, and by petrol and paraffin internal combustion engines, have been tried with the same result, and I am therefore forced to the conclusion that we must look elsewhere for economic means of extending our operations further afield.

Some 12 years ago, a system of railless traction was installed in Paris, but did not gain much attention. Since that time great progress has been made, and we now find there are, on the Continent, three systems of railless cars working successfully, both in an engineering and commercial sense. Many of the leading officials in the tramway world have examined and reported upon various installations working under these systems, and in all cases, so far as I am aware, the reports have been distinctly favourable.

The "Filovia" system, in use in Italy, is already in operation over a total route mileage of upwards of 60 miles, and is installed in the following places:—

Pescara–Castellamare and Extension	2½	km. long.
Spezia–Fezzano (Portovenere) 7½ km. working	15	„
Aquila Railway Station—Aquila Town	5	„
Siena Town and Extension	7	„
Ivrea–Cuorgne (Piedmont)	26	„
Cuneo Railway Station—Cuneo Town	3	„
Valle Intelvi	8	„
Stresa (in construction)	15	„

The "Mercédès-Stoll" system, the invention of Herr Ludwig Stoll, of Vienna, is in use at Pötzleinsdorf-Salmannsdorf district of Vienna, Weidling (near Vienna), Gmünd (Lower Austria), Budweis, and Pressburg (Hungary) in course of construction.

The "Max Schiemann" system is in use at Grevenbruck-Westphalia (short mineral line, opened in 1903), Monheim–Langenfeld, near Cologne (mixed line, opened in 1904), Veischedethal–Westphalia (goods line opened in 1904), Wurzen–Saxony (goods line, opened in 1905), Grossbauchlitz–Saxony (mill produce, opened in 1905), Lyons–Charbonnieres, France (passenger line, opened in 1905), Neuenahr–Abrweiler, Germany (passenger line, opened in 1906), and Mulhausen, Germany (passenger line, opened in July, 1908).

Filovia System.—This system has undoubtedly been brought to a degree of simplicity and reliability. The chassis of the vehicle is built with pressed steel frame, with wheel base of 11 ft. 6 in., and wheel gauge of 5 ft. 8 in. The cast steel wheel centres run on ball bearings, and the rear wheels are shod with twin solid rubber tyres and the front wheels with single solid rubber tyres. The electric equipment consists of two 12 H.P. traction motors, mounted upon the chassis. The motors drive quite independently through spur reduction gear, through sprocket wheels and chair rack, to the road wheels. With this independent drive to each of the rear road wheels no differential is necessary, and it has been found in practice that curves of very sharp radii are negotiated in an entirely satisfactory manner. The controller of the series-parallel type is fitted with magnetic blow-out, and is provided with five forward contacts and reverse. There is an electric brake and two mechanical brakes: one operated by a pedal and braking on the motor counter shaft; the other controlled by a hand lever and braking on the inner rims of the driving wheels. The chassis is fitted with a single-deck body, seating 24 passengers, and weighing, with passengers, 53 cwt. A speed of 18½ miles per hour on level roads is obtained, and half that speed up a grade of 5 per cent.

* Abstract of a Paper read before the Tramways and Light Railways Association, at the Dublin Congress. A short account of the discussion which followed the reading of the paper was given in our issue of June 17th.

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The trolley, built on the "Cantono" patent, consists of an ordinary trolley boom fixed to the car by a trolley base similar to the bases used in this country on single-deck and covered cars. The trolley-head consists of a four-wheeled truck, which is affixed to the trolley boom by means of a ball socket joint. This allows the trolley-head to move easily and adapt itself to any irregularities in the overhead line. The overhead work is, to all intents and purposes, similar to the overhead work for ordinary rail traction, with the difference, of course, that there are both positive and negative wires. This construction appears to answer admirably; the trolley showing no disposition to leave the wires at high speeds, or when the vehicle has to move laterally to pass other vehicles journeying in the same direction.

Mercédès-Stoll System.—This system, as installed in Vienna, is the invention of Herr Ludwig Stoll, a leading official in the Austrian Daimler Motor Co. In this case the chassis is made of pressed steel, fitted with steel wheels which are shod with solid rubber tyres. Motors of 20 H.P. each are fitted in the hubs of the rear driving wheels, so that the motors form an integral part of the driving wheels themselves. This arrangement does away with the necessity for any mechanical transmission, and it is claimed that very little lubrication is required, as all the wheels and motors are fitted with ball bearings. The cable is carried through the interior of the axle, and the armature of the motor is fixed by means of keys on the axle itself, and so acts as the nave of the wheel. The controller is designed for six forward positions; three series and three parallel, and three positions for reverse. Three brakes are fitted, an electric brake and two mechanical brakes; and the steering is irreversible. The body in use in Vienna is constructed to seat 12 passengers, and standing room is provided for 12 more, as is the case on all Continental tramway systems. The car complete weighs 2½ tons. The trolley consists of a frame or carriage fitted with four wheels. The wheels run on the tops of the wires, and the current-collecting device is attached to the car by means of flexible cables. A pendulum weight is attached to the centre of the trolley carriage to keep the carriage balanced and the wheels well pressed down on the wires. The conducting cable is wound round a small drum which is mounted upon the chassis, and about 12 yds. of spare cable is carried which can be played out to allow the car to run on the whole width of the road. Four wires are used in Vienna. In other places where only two wires (positive and negative) are erected, when two cars, running in opposite directions meet, the drivers interchange the trolleys by means of detachable cable contact boxes, and it is said the operation does not usually take more than a few seconds.

Max Schiemann System.—The chassis at Mulhausen is of the built-up composite type, with wooden wheels. The rear wheels, which are 4 ft. 6 in. in diameter, are shod with steel tyres, but the front wheels have solid rubber tyres. One 22 H.P. motor only is used, and this is suspended from the chassis immediately behind the front axle in a manner similar to the tramway motor suspension, and the drive is by means of a pinion and gear wheel which is keyed on to the front axle. Each car is provided with three brakes, viz., electric, Bowden, and driving wheel brakes. The body is seated for 13 passengers, but as many as can get on are allowed to stand, space being provided for this purpose. The weight of the car is stated to be 2 tons 16 cwts., and a speed of about 12 miles an hour is obtained on the level. The trolley is similar to that used on our tramways, with a boom from 14½ ft. to 16 ft. in length. The trolley is fitted with two sliding contacts, and an arrangement permits the car to deviate for distances of 10 ft. on either side of the wires. The overhead work is similar in all respects to ordinary tramway practice, except that four wires are used.

Railless Electric Traction Co.'s System.—This Company, who are stated to have acquired the patent rights of Messrs. Max Schiemann & Co. in Great Britain, in September last arranged a demonstration* at the Hendon depôt of the Metropolitan Tramways Co. In this case the chassis follows the design of the usual motor omnibus chassis, and wheels with single solid rubber tyres on the front, and twin tyres on the rear, are employed. Two 25 H.P. motors, mechanically independent, each motor driving one half of the counter shaft through bevel gears, are used. A controller of the series parallel type is fixed, and foot and hand brakes are provided for the driving wheels and counter shaft. A single-deck body, with seating capacity for 24 passengers, is used. The trolley of the double pole type is fitted with a head of new design. The Company state they are about to place on the market heads of different patterns; one head carrying three trolley wheels, the two outer wheels of which are connected, both making contact with positive wires, and the centre wheel with negative wire. Another design employs two trolley wheels, one for positive and one for negative wires.

Criticism of Systems.—The "Filovia" system undoubtedly works well, and the managers and engineers of tramways who have inspected it find little to criticise; but there is a feeling that the cars are not just what we require here. The chain drive may give trouble, so it is said, but anyone who has mechanically propelled vehicles with chain drives knows well that chains receiving reasonable attention are not troublesome, and I personally cannot see any better way of transmitting power to the road wheels.

The "Mercédès-Stoll" system obviates any necessity for a mechanical drive, and this, of course, is a great advantage. On the other hand, the motors forming part of the road wheels, are subject to all shocks from road inequalities, and it would seem to be better to have them spring borne. Again, the very low speed at which the motors must work does not conduce to electrical efficiency. The trolley necessitates special suspension of the trolley wires, and as the trolley carriage is not designed to be detached from the wires at the termini, loops are necessary at the termini where four wires are used. As the great majority of lines which may be equipped on the trackless trolley system in this country will probably be built and operated by corporations and companies already running tramways and light railways, as extensions to their existing systems, it would be an advantage to be able to run the trackless cars to the central repair depôt for periodical overhaul and repair. With an over-running trolley this would be impossible, and I think this is the strongest objection that can be raised against this type of trolley.

The "Schiemann" system was, I believe, orignially designed for use in agricultural districts for carrying both produce and passengers, and the cars used in Germany are not as suitable for passenger traffic as the cars employed in Austria and Italy. The motor being mounted upon the front axle makes the steering heavy and cumbersome, and it is generally agreed that the rear wheels of a vehicle of this kind should be called upon to do the driving.

The system evolved by the Railless Electric Traction Co. is more up to date, and the Company has attempted to avoid any risk of "live" cars by designing a three-wheeled trolley head mounted upon two connected trolley booms; the two outer wheels being for positive wires and the inner wheel for the negative wire, the idea being to connect the steel frame and metallic parts of the car through the trolley wheel to the negative wire. This construction necessitates the use of three wires instead of two, and six instead of four, which, I think we shall all agree, is expensive and objectionable. The Company has devised an alternative design employing a head with positive and negative trolley wheels, and using two wires only; and an arrangement is fixed to give audible warning should the polarity of the wires be through any cause reversed.

Cost of Construction.—It is estimated that a trackless trolley system can be fully equipped, provided current is purchased from a supply authority, at about £3,000 per mile of route, but, of course, much would depend upon the local conditions in each case. Considering again the 4-mile route mentioned at the beginning of the Paper, the cost of construction would probably be as follows:—

Railless Traction.

Overhead line and cables at £1,500 per mile	£6,000
Five motor cars at £600 each	3,000
Five trailer cars at £250 each	1,250
Land and depôt	800
Spare parts, tools, &c.	950
	£12,000

Tramway.

Permanent way at £7,000 per mile	£28,000
Overhead line and cables at £1,500 per mile	6,000
Five motor cars at £675 each	3,375
Land and depôt (including rails)	2,000
Spare parts, tools, &c.	625
	£40,000

There is no reason, so far as I can see, why wooden poles should not be used, and as the average service would be 20 minutes, with a maximum of 10 minutes at certain parts of the day, the cost of the necessary cables should be light. In the estimate I have provided for a car with trailer per mile of route, and 25 per cent. spare. With railless traction a cheap corrugated iron building sufficient to protect the cars and cleaners from the weather would be all that would be necessary, and I do not see any reason why such a building should not be erected for less than the sum I have allocated. A tramway depôt would necessarily be more costly, even if a building of a similar kind were used.

Cost of Operation.—The working expenses of the "Mercédès-Stoll" system in Vienna are stated to be 4·52d. per car mile, but no

* Particulars of the demonstration and of the equipment were given in THE ELECTRICIAN, October 1, 1909, p. 1002.

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conductor is employed, the driver collecting fares in addition to his other duties. The particulars are as follows:—

Current	0·40d.
Tyres	1·33d.
Wages (driver only)	1·20d.
Depôt expenses	0·26d.
Taxes, management, insurance, &c.	0·80d.
Repairs and renewals	0·53d.
	4·52d.

The "Elovia" system at Specia is stated to cost 5·645d. per mile; the tyre renewals account for 2·160d. of this sum; but the road surfaces are always very bad. The costs are set out as follows:—

Electric energy	0·415d.
General expenses	0·594d.
Renewals of rubber tyres	2·160d.
Wages and salaries	1·400d.
Maintenance of vehicles and line	0·620d.
Repairs	0·456d.
	5·645d.

The "Schiemann" system at Mulhausen is stated to cost 6·95d. per car-mile, but as the system has not been working a complete year, no returns are available giving particulars of these costs. I am informed that the current consumption is 0·8 units per car-mile, and the cost of tyres 0·84d. per car-mile.

The best way of estimating the operating cost of trackless trolley cars in Great Britain is to take the standardised form of tramway accounts, and set out opposite each item the average working expenditure on tramways in this country, and place opposite the estimated expenditure for running a system of railless cars. The author sets out the expenses in this way in the Paper, and the total are as follows:—

	Tramway.	*Railless.*
Traffic expenses per car-mile	2·806d.	2·724d.
General expenses per car-mile	0·786d.	0·411d.
Repairs and maintenance per car-mile	0·902d.	1·779d.
Power expenses (at 1¼d. per unit) per car-mile	2·000d.	1·250d.
Totals	6·494d.	6·164d.

The difference under traffic expenses is entirely accounted for by cleaning, salting and sanding tramway track (0·082d. per car-mile). The difference of 0·375d. under general expenses, in favour of railless traction, is due to rates and taxes averaging 0·500d. per car-mile in the case of tramways, as against 0·125d. for railless traction.* The items under repairs and maintenance showing a difference between the two systems are: permanent way (0·201d., tramways only), electrical equipment of line (tramways 0·125d., railless 0·187d.), cars (0·527d. tramways, 1·543d. railless), miscellaneous equipment (0·021d. tramways, 0·001d. railless). The overhead line would probably be rather more costly to maintain in the case of railless traction, as four wires would generally be used instead of two, and 50 per cent. more for this purpose has therefore been allowed. The cars themselves should be cheaper to maintain, but rubber tyres are costly, and taking some credit for saving on steel tyres, gears, pinions, motor suspensions, &c., at least 1d. per car-mile more should be set aside for the maintenance of cars than in the case of a tramway.

In putting forward the above figures, the author does not wish it to be thought that railless cars cannot be worked at a less sum than 6·164d. per car mile.

He has not taken into account the question of contributions to the county authorities for road maintenance. In county boroughs, where railless cars are run entirely within the area of such county boroughs, this question will not arise, but an attempt will probably be made by county authorities to secure clauses in any Bills which may be promoted by companies or corporations, seeking to operate outside their own county boroughs, levying a contribution for road maintenance. A similar service of motor 'buses would have to contribute nothing to road maintenance, and he cannot see why railless cars should do so. But we must be prepared to deal with this point, and any one of us concerned in the promotion of a Bill should use every endeavour to prevent such a clause being inserted.

There is a very wide field for some cheap system of traction in our country districts for dealing with goods, produce and people, and I cannot see why two different types of vehicles should not be employed—one specially equipped for dealing with goods traffic, and the other for passengers. Many of us fondly imagined years ago that we were going to obtain a very large goods traffic on our tramways and light railways. I have made repeated attempts to secure such traffic, but I am sorry to say my time has been entirely wasted, as I have been quite unable to make satisfactory arrangements. I have many times approached consignees and consignors of goods and minerals, and after showing them that I could handle their material at a cheaper rate than it was then costing them, I have had to raise the question of payment for the necessary siding into their premises, or, as an alternative, a guaranteed tonnage over a term of years.

In this district, surrounded as we are by collieries on every side, manufacturers place their coal contracts with different collieries every year, and they would not, of course, entertain the idea of being bound to one colliery. With other goods different objections were raised. First, that although we could make arrangements at one end to load the goods, they were sent to so many different places that we could not deliver. One has to recognise the truth of these arguments, and because of this I am afraid there is little likelihood of cars running upon rails getting any large amount of such traffic, except under very special conditions.

With railless cars the expense of running two trolly wires into a mill is comparatively small, and I think there ought to be a considerable volume of business of this character. In inter-urban districts, with small towns a few miles apart, I think there are numerous possibilities for any system of traction which can be cheaply installed and worked at a low cost. Under such circumstances, goods could be conveyed at a cheap rate, much to the benefit of both producer and consumer, and it is common knowledge that to-day much agricultural produce is unremunerative to the grower simply because of the difficulty of getting it quickly and cheaply to the nearest market. This traffic does not, at present, touch the railways, so that no harm would be done to them; but, on the other hand, I think railways would benefit by reason of the enhanced prosperity of the district.

Unfortunately, powers to operate railless cars have to be obtained by Parliamentary Bill. This fact is a serious stumbling block to the development of railless traction. The cost of securing the consent of Parliament may cost as much as the equipment of a small system, and promoters will therefore hesitate before embarking upon any scheme. The Board of Trade seem to look sympathetically upon railless traction, and I had hopes that Parliament would authorise the Board of Trade to grant licences, but I am afraid we shall have to wait some time before we can make an application at a very small cost to enable us to instal railless cars.

* The assumption is that the poles and wires would be assessed at one fourth the total sum that would be charged were rails laid.

THE BRUSSELS INTERNATIONAL EXHIBITION.—III.

We have already published a summary of the principal objects of engineering and electrical interest at the Brussels Exhibition in our issues of May 27th and June 3rd. We were last week given an opportunity of visiting the Exhibition with a number of British journalists, who were the guests of the Belgian State Railways and the Commissioners of the Brussels International Exhibition. The party was officially welcomed in the British section of the Exhibition by the executive staff, at the head of which is the Commissioner-General, Mr. U. F. Wintour, who is assisted by Mr. N. S. Reyntiens. Sir Boverton Redwood, D.Sc., chairman of the Chemical Industries Committee, was also present, and personally escorted the party round the British chemical exhibits. Sir Boverton is well known in connection with British chemical industries, and his lucid explanation of the principal objects of interest in the section was greatly appreciated. There is nothing particularly electrical in this section, but it is noteworthy that the exhibit is the largest of its kind which has ever been got together. It even exceeds in size and general interest that of the St. Louis Exposition of 1905. British enterprise in this field appears to be holding its own against severe competition from foreign countries. This is particularly noticeable in the exhibit of the Burma Oil Co., whose business is based upon a world's trade in candles, and which has been developed into the supply of fuel, internal combustion engine and lubricating oils of every class. The Company operates a large fleet of steamers, and is the principal oil company operating under the British flag. While on the subject of oils, Sir Boverton Redwood directed special attention to the instruments exhibited by Messrs. Griffin & Sons, Townson & Mercer and Baird & Tatlock for testing oils as to uniformity of quality, viscosity, vaporising temperatures, flash points, &c. Upwards of 50 chemical and allied firms are represented in this exhibit, and a separate catalogue dealing specially with the exhibits has been prepared by the executive staff, under the supervision of a special editorial committee presided over by Sir Boverton Redwood. Compared with other nations, British chemical industries appear at their best, and too much attention cannot be directed to this fact, having regard to the many persistent attempts of the lay press to belittle the work of Great Britain in this important field of research.

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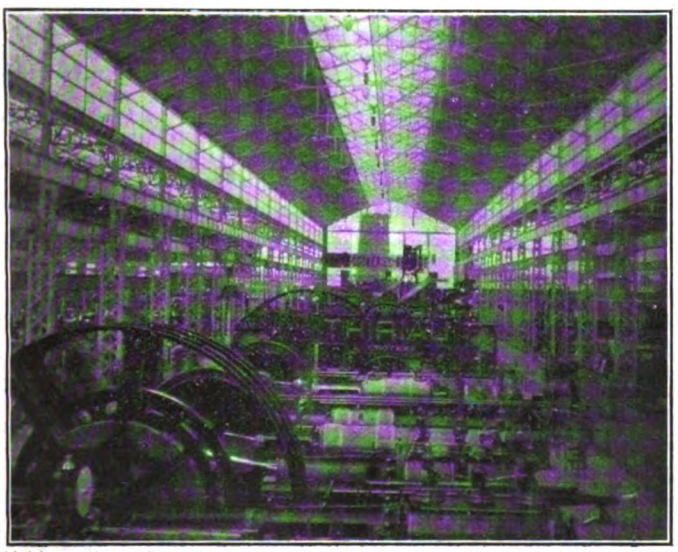
The press visit was naturally marked by a number of functions which were arranged in honour of the delegates. The first of these was a luncheon given on June 29th by the British Executive Committee. This was presided over by the Commissioner-General, Mr. U. F. Wintour, who was supported by Sir Swire Smith, Vice-President of the Royal Commission, Sir Cecil Hertslet (British Consul-General for Belgium), the Earl of Granville, Baron Janssen (President of the Executive Committee), and a number of other officials. In the evening a dinner was given to the party, and Baron Janssen was in the chair. Much the same company sat down, but the Earl of Lytton, who is Chairman of the Executive Committee of the British section of the Brussels Exhibition, was present.

On Thursday, with their customary enterprise, the German section of the exhibition, which is presided over by Dr. Albert, entertained the delegates to luncheon in the Kaiser Hof. The object of this little function was to direct the attention of the press to the importance of the German exhibit and its outstanding excellence in the exhibition. Unfortunately, the time at disposal only permitted a cursory glance through the German section. The act of courtesy on the part of the German Commissioner was none the less appreciated, and, being as it was an isolated instance of the extension of hospitality on the part of the exhibiting nations, it was all the more noticeable. The Germans have not been satisfied at occupying an ordinary position amongst their international rivals at the Brussels Exhibition. They made a bold bid for prominence by taking a special piece of land and erecting upon it the whole of the buildings required for the different sections representative of German educa-



Electrician Photograph.

GENERAL VIEW OF ONE OF THE THREE BAYS IN THE INDUSTRIAL MACHINERY HALL, BRUSSELS EXHIBITION.

tion, art, science and industry. They are even independent of the exhibition authorities in the matter of power supply, their buildings including a special machinery hall, which contains running electrical generating plant of distinctive types to furnish energy for lighting and power throughout the German section. This example of German commercial enterprise is worthy of note at this point by British manufacturers, and should serve to impress upon them the necessity for supporting the exhibitions department of the Board of Trade to the utmost possible extent in its work in the organisation of representative British sections in these international exhibitions. We yield to none in the belief that British manufacturers, and more particularly British electrical and allied engineers, can produce an exhibit which will bear comparison with the best of any other country. At the same time, the Brussels Exhibition displays a singular lack of appreciation on the part of British engineering firms of the advertising value to the home country of a display which shall represent every phase of British activity in art and applied science. These sentiments were expressed by Lord Lytton in a speech which he made at the German luncheon. He dwelt upon the necessity for the maintenance of political peace between the two countries, but he regarded industrial and commercial rivalry as a species of warfare which, while constructive in its object, would unquestionably prove the merit of one or other of the nations to survive the effects of the struggle. He did not decry in any way the work which Great Britain was carrying on in every known sphere of human activity, but he was bound to confess that our country was deficient in matters of organisation, and also was lacking in the appreciation of the value of publicity which international exhibitions afford. He thought that this was proved by the amount of money which the German manufacturers had spent in the organising of their section, and also in the fact that the German Government contributed largely to the exhibition funds. The general opinion was that, though much money had been spent, a profitable return would be experienced from the outlay.

THE ELECTRICAL AND ENGINEERING EXHIBITS.

The majority of the British exhibits are placed under the cover of a large hall adjoining the Belgian industrial building, but the electrical and engineering exhibits have been assembled in the Industrial Machinery Hall, which is beyond the French and Italian sections, and is reached from the British hall by crossing the bridge over the Avenue du Solbosch. This sub-division of the exhibits is a little disappointing, because the result is not anything like so impressive as a collective display. We have already dealt with the principal British exhibits in the International Machinery Hall. These, from the electrical point of view, are mainly confined to a steam turbine exhibit by Messrs. C. A. Parsons & Co., and an exceptionally fine display of English machine tools, all of which are electrically driven. The latest triumph of British engineering, in the shape of the Humphrey gas pump, is given a prominent position at the top end of the hall, close to the main switchboard. This is the first public exhibit of this invention since Mr. Humphrey read his now historic Paper before the Institution of Mechanical Engineers some 18 months ago. The exhibit takes the form of a pumping plant which is designed to lift 250,000 gallons of water per hour to a height of 35 ft., the coal consumption being 1·06 lb. per pump horse-power-hour. Most of our readers will be familiar with the fact that this pump has no moving parts, such as piston, crank, flywheel, and is without non-return valve in the delivery pipe, and also has no glands. The only working parts are the water valves and the admission and exhaust valves.

The principal impression given by the exhibits in the International Machinery Hall is the preponderance of the steam turbine in modern electrical power stations. The principal French and Swiss manufacturing firms exhibit steam turbines which range in power from 3,000 kw. downwards. No particular novelties are shown, but it is interesting to observe how the various manufacturers deal with the problem of ventilation of the generator winding and the revolving field. Probably there has been no such representative collection of steam turbines since the development of the modern high-speed type with enclosed generators.

While on the subject of steam turbines, reference should be made to the Le Rond rotary engine, which is exhibited in the Machinery Hall, and which at the time of our visit was not complete. This machine is designed to develop from 700 H.P. to 900 H.P., and has one main and two subsidiary rotating pistons, which provide for five expansions of the steam. The speed is 400 revs. per min., and the working steam pressure 150 lb., with or without superheat. The machine operates in conjunction with a Westinghouse-Le Blanc condenser, and is coupled to a Lahmeyer three-phase generator. Evidently some doubts are entertained as to the smooth running of the engine, as a flexible coupling, such as is employed on most hydro-electric schemes, is placed between the rotary engine and the generator.

International Congress of Mathematicians.—The fifth meeting of the Congress, which is held every four years, will take place at Cambridge in 1912. An International Commission on Mathematical Teaching has been constituted in connection with one of the sections, and includes delegates appointed by the various governments interested in the Congress. A series of national sub-commissions has also been established to assist the International Commission. The President of the Board of Education has appointed Sir George Greenhill, M.A., F.R.S., Prof. W. W. Hobson, Sc.D., F.R.S., and Mr. C. Godfrey, M.A., to be the British delegates, and he has further appointed an advisory committee to assist the Commission in the collection of Reports and Papers on the teaching of mathematics, and this committee, which is to act also as the British Sub-Commission, has been constituted as follows :—Mr. C. E. Ashford, M.A., Sir G. H. Darwin, F.R.S., D.Sc., Mr. C. Godfrey, M.A., Sir George Greenhill, M.A., F.R.S., Mr. G. H. Hardy, M.A., F.R.S., Prof. W. W. Hobson, Sc.D., F.R.S., Mr. C. S. Jackson, M.A., Sir Joseph Larmor, D.Sc., F.R.S., Prof. A. E. H. Love, M.A., D.Sc., and Prof. G. A. Gibson, LL.D. Mr. C. S. Jackson is acting as honorary secretary to the Sub-Commission.

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STREET LIGHTING CONTRACTS.

At first sight it might be thought that the drawing up of a contract for street lighting was a simple matter. Given a type of lamp, number of hours of burning and the cost of energy, the total annual cost is at once obtainable, and therefore a suitable price may be deduced. On this basis all is well if there is no progress in the art of illumination. We live, however, in an age when conditions alter rapidly. A new lamp may be devised, or the cost of energy may fall considerably, and in any case there is ceaseless competition, so that the subject cannot be regarded as one in which the conditions are by any means fixed for any length of time.

The whole question was considered recently by Mr. JACQUES ABADY at considerable length in a Paper read before the Institution of Gas Engineers. In this Paper street lighting contracts were divided into three classes. Hitherto such contracts have taken either of two forms. The first type is a contract for the supply of energy with maintenance, the charge depending chiefly upon the amount of energy required. There are certain inherent difficulties in a contract of this kind. First of all, it rarely happens that the energy can be measured to any degree of accuracy. Approximation must be depended upon rather than measurement, as numerous meters are obviously out of the question.

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The charge, therefore, generally takes the form of an annual sum per lamp, such sum including a certain proportion for the necessary maintenance. There is also some difficulty in ensuring that the condition of the lamps shall be satisfactory. As to whether this part of the contract is carried out properly or indifferently depends very much upon the conscientiousness of the supplier of the energy, as it is difficult to enforce any particular standard without taking elaborate measurements. Perhaps the chief objection, however, to this form of contract is the fact that it gives no inducement to the supplier of energy to put in newer types of lamp in place of the older types, though when a lump sum per annum is charged per lamp it may be thought worth while to put in a more efficient lamp in some cases. This, however, requires an expenditure of money, and more often than not it will be felt that the saving in energy does not justify the additional expenditure. Certainly there is no inducement to put in a lamp which gives greater illumination for the same consumption of energy. Similarly, supposing the municipal authority were to suggest a more efficient lamp taking less energy, the proposition would not be received very favourably by the supply undertaking. This state of things really amounts to a loss both to the public and to the supply authority. As a result, the public does not get the best light, and although the supplier of energy may seem for the moment to be in a satisfactory position, yet it is fairly obvious that if the light given is poor and not up to date it is a bad advertisement, and will tell against the supply authority in the long run. Instances of this kind are to be found in certain parts of London, where extremely antiquated forms of arc lighting are to be seen, but which, in accordance with the lighting contract, may still remain for many years as exceedingly bad advertisements of electric lighting.

The second type of contract is that in which the payment is for energy alone, the maintenance being undertaken by another contractor, or by the municipality itself. This form of contract is not much better than the one to which we have just referred. In some respects it is less desirable, for if the maintenance contractor neglects to keep the lamps in proper condition this may affect the supplier of energy very adversely. This is particularly the case owing to the keenness of the competition between gas and electricity for street lighting. We think it will be generally agreed that, as the maintenance of the lamps is of some importance to the supplier of the energy, it should be left in the hands of the latter. The only advantage of this second type of contract is that it enables the local authority to put in improved lamps without affecting the contract, provided the same amount of energy is taken; but it does not enable more economical lamps to be put in for the same amount of light, or permit the cost of public lighting to be reduced.

The form of contract advocated by Mr. ABADY, and with which our readers are already familiar through recent events, is that by which light is purchased instead of energy. There are certain advantages in a contract of this kind; the cost of energy has a smaller control in the problem, and thus full advantage can be taken of new types of lamp. In such cases it need scarcely be said that the maintenance is carried out by the supplier of the energy, and lamps will necessarily be maintained at such a standard as to ensure the supply of light being not less than a stipulated value. The only serious question that arises is whether the measurement of the light can form a satisfactory basis. Illumination is really what is required, but it is pretty obvious that this effect in itself would not be a suitable basis for such a contract, for the simple reason that the illumination produced by a lamp depends very much upon its surroundings. It therefore seems necessary that candle-power should be the quantity to be measured. Again, a single measurement of a lamp on a particular evening is not sufficient, as it is well known that considerable variations of a momentary character may occur. In the case of the Westminster contracts, not less than three and not more than six readings at regular intervals of not less than 30 or more than 60 seconds are to be made at each angle, and the average of the readings so obtained is to be taken. With regard to the angles, two have been selected—namely, 20 deg. and 50 deg. respectively from the horizontal. In all probability these angles will prove satisfactory. Whether the number of readings suggested will meet all requirements, it is more difficult to say. We note that the photometer may be placed at any position in azimuth, but doubtless such measurements would generally be taken along the length of the street. Certainly this ought to be the case, for the tendency is to make the lamps throw light, by means of reflectors, more particularly lengthways of the street than across it, and the measurements ought to be such as to encourage any development of this kind. Uniform illumination is what is desired, and this can only be approached either by having a large number of low-power sources, or by suitably altering the distribution curves of high-power sources so as to throw more light in dark places.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 3s. Add 10 per cent. for abroad or for foreign books.)

Electric Power Plant Engineering. By J. WEINGREEN. (London: Hill Publishing Co.) Pp. viii. + 451. 21s. net.

Compared with some recent works professing to deal with a similar subject emanating from the other side of the Herring Pond, this book is most disappointing. There does not appear to be any individuality or originality pointing to the author's personal experience of the matters or the subject on which he writes. The book consists mainly of descriptions of apparatus and central and sub-stations. There is nothing, so far as one can see, actually incorrect about it; but it could nearly all have been obtained from a couple of manufacturers' catalogues and the articles appearing in the technical Press describing power-plant equipments.

Even the information that *is* contained in the book is somewhat scrappy and incomplete. Although the book is supposed to deal with electric power plant engineering, there is hardly any mention of a turbo-generator, and the chapter dealing with direct-current generators does not mention any of the difficulties of operation, such as, for instance, carbon brushes on a high-speed turbine generator—in fact, it is not about generators at all. It deals mainly with auxiliary switchgear and equalising bars.

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Some of the subjects dealt with are split up; for instance, in the case of converters one has to look at one end of the book for one part and the other end for the other.

Although minute instructions for starting and stopping various electrical machines are given (which work is usually done by a workman, and not by men who would read a book of this kind), matters of vital importance as regards the efficiency and cost and management of the plant itself, and the applications of the various apparatus for various purposes are barely touched upon. We should not refer to this omission had it not been that the author takes particular care to describe the comparatively unimportant part of the operation of the plant.

There is a chapter on relays which gives useful information, and also an interesting chapter on the valuable but comparatively little used alternating-current feeder potential regulator. After 23 chapters on apparatus, the author turns to central stations, and the introductory chapter, No. XXIV., gives rise to hope for better things to come; but proceeding to Chapter XXV. we are doomed to disappointment, as the descriptions of central stations are in the usual stereotyped form in which they appear in the technical Press from time to time.

The title is altogether too comprehensive, considering the contents of the book. Even as a description of electrical power plant engineering the book is quite incomplete, and, without knowing anything of the author's position or career, one is led to assume that he is treating the subject, not from a point of view of live experience but from a purely academic standpoint. In our opinion the book is dear at a guinea.

A. Hugh Seabrook.

Fire Insurance Handbook By W. S. Coles and H. S. Bell. (London: C. & E. Layton.) 15s. nett.

This book is stated in the preface to be a Fire Insurance Handbook, written for the insurance profession. It is an up-to-date compendium of the general practice and customs governing the complex subject of fire insurance, the settlement of losses alone excepted. The contents are arranged in alphabetical order, so that no index is needed. The book will no doubt be found in every fire insurance office, as well as in the office of every fire insurance broker and surveyor, as a first reference book for the classification of risks and preliminary information in the numerous points which affect the premium rates. The fire surveyor will also find the technical hints given for preparing "specifications" of no little use, as "risks" are daily becoming more and more complicated owing to the exacting requirements of the modern factory, mill and warehouse. Apart from special articles, which are for members of the insurance profession, there is a wealth of information for the engineer and architect, as well as for the commercial manager, on fire resisting construction for buildings, heating by steam and water, fire alarms, sprinklers, fire extinguishing appliances, oil, gas and electricity. The layman will also find useful articles on "Average," "Floating Insurances," "Warranty," "Insurable Interest" and other often but little appreciated points which may affect his policies more than perhaps he realises—until a loss occurs. The electrical engineer will note that electric lighting appears to be viewed most favourably by fire insurance offices; indeed, its use is insisted on in some special risks.

The wiring rules of the Institution of Electrical Engineers are printed at length, and it is stated that "they are adopted by almost all fire insurance companies." The fatal fire at Messrs. Arding & Hobbs may suggest to the offices some modification of their requirements on the lines of the older and more conservative Phœnix Rules. We have looked up a number of subjects at random in this handbook and find much special information clearly and tersely stated; but some of the technical matter necessarily already appears to require additions or amendments to bring it up to date.

The success of the book depends entirely on the reception given it by the fire insurance profession. We believe it will supply a want, and we expect a second edition will be called for very shortly.

THE PROPORTIONING OF ELECTRODES FOR FURNACES.*

BY CARL HERING.

(*Concluded from page 484.*)

Summary.—The author describes an investigation (analytical and experimental) of the principles underlying the proper proportioning of the electrodes for electric furnaces. The author's conclusions differ very considerably from former practice.

Experimental.

The need for heat conductivities being felt, the writer undertook a determination of them for graphite, carbon, iron and copper. The method used was the one suggested in his recent Paper on "A New Method of Measuring Mean Thermal and Electrical Conductivities of Furnace Electrodes."† It is based on the same fundamental principles and formulæ as those of this analysis. Briefly, it consists in operating a pair of electrodes under conditions approximating as nearly as possible those under which they should (according to this analysis) be operated in practice—namely, that the heat gradient at the furnace end shall be zero, represented by a horizontal temperature line, in which case there will be no flow of heat into or out of the furnace through the hot end of the electrode. While thus operating, the current, voltage and cold temperatures are carefully measured for various furnace temperatures. The constants given by this test are the mean values for the electrode as a whole and when operating under the proper conditions. The values are peculiar to operating electrodes, and their relations to the end values or to the mean of the values at equally spaced distances, are different for different materials. For this reason the writer has proposed the term "electrode mean" to designate them. The details of the determination of these constants are described in a Paper to be read before the American Electrochemical Society at its spring meeting. The purpose here is to compare and discuss the results, and to endeavour to point out what they teach us.

The full lines in the accompanying diagrams (Figs. 1 to 6) represent the ranges over which the results were actually measured; the dotted lines are exterpolated, and therefore are only probable values. The exterpolated values were checked at 2,000°C. and 1,400°C. by the fixed relations. Although all the electrodes were very nearly $\frac{5}{8}$ in. in diameter, they differed slightly, hence, for comparing them more correctly with each other, the results have all been reduced to an exact diameter of $\frac{5}{8}$ in. For the same reason they have also all been reduced to a constant cold terminal temperature of 100°C. As the current-densities in some of these runs were extraordinarily high, it may be of interest to mention that the electrodes behaved very well.

The experimental results are given in Figs. 1 to 6.

Carbon (Fig. 1).—As the current curve rises nearly in proportion to the temperature, variations in current affect the losses considerably, and a current considerably greater than the normal for which the lectrode was designed will tend greatly to overheat the electrode within the walls. The electrical resistivity diminishes, at first more rapidly, then less so, tending to become more nearly constant. A decreasing resistivity means that as the current heats the electrode the heat generated per inch will become less and less at the hot end and greater and greater at the cold end than it was before; hence the colder half will be heated more rapidly. This in turn signifies that the heat gradient will tend to approach a horizontal line from the hot end to near the cold one, and will then drop suddenly. This seems to be one of the causes of the burning of the furnace wall in high-temperature furnaces in which carbon electrodes are used. A falling resistivity is therefore an undesirable quality for electrodes. A rapidly rising one would be far better; this is the case with iron.

The thermal conductivity increases (it does not decrease as has been claimed by others) at first more rapidly, then less so, also tending to become more nearly constant. A rising thermal conductivity is an undesirable feature for electrode materials, as it tends to force the higher temperatures nearer to the colder end. Carbon, unfortunately, combines this feature with a falling resistivity, both of which conduce to the same undesirable result. The curves for carbon, furthermore, show that the electrode voltage, which is a true measure of the power loss, also increases with the temperature, but the rate is slower and slower, tending to constancy. The chief conclusion, as far as our present knowledge goes, is that probably no great error would be made by assuming this important quality to be practically a constant—namely, about 0·065 volt. The specific section, which is a true measure of the size of an electrode, decreases rapidly at first

* Abstract of a Paper read before the American Institute of Electrical Engineers.

† "Trans." Amer. Electrochem. Soc., Vol. XVI., p. 317.

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and then more slowly, showing that carbon electrodes become relatively smaller for the higher temperatures. This is a good feature, and especially so for carbon, because such electrodes are much larger than those of other materials.

Graphite (Fig. 2).—The current curve rises more rapidly at first

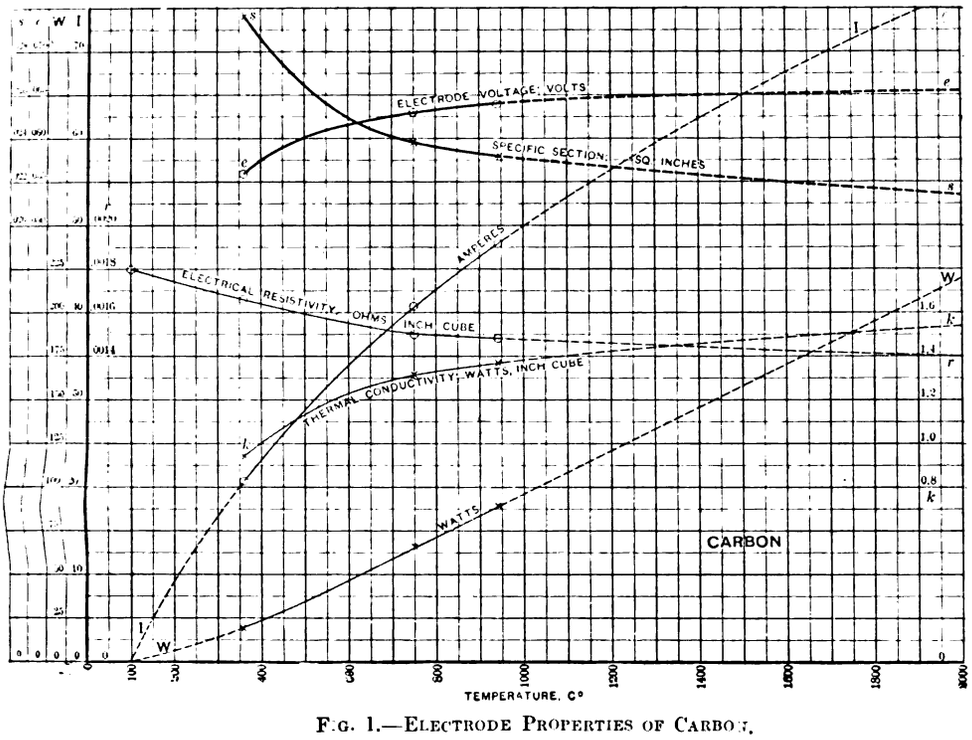

FIG. 1.—ELECTRODE PROPERTIES OF CARBON.

than for carbon, and in this respect graphite apparently possesses properties more like those of the metals. Also it would appear that a graphite electrode is more sensitive to changes of current than is one of carbon. Graphite may be placed among the metals in the desirable quality of forcing the heat back to the hot end.

In thermal conductivity graphite differs decidedly from carbon (for which this curve rises), and is like the metals. The electrode voltage falls slightly, but seems to tend to what for all practical purposes may be assumed to be constant at about 0·040 to 0·045 volts. As this is a measure of the loss, it follows that the loss per degree diminishes slightly with the temperature, instead of increasing, as it does with carbon. Graphite, therefore, is relatively to the temperature more economical of power at higher temperatures than it is at the lower ones. The specific section may be assumed to be constant at 0·007 sq. in. This means that the size of the electrode relatively to the temperature is practically the same at high and low temperatures, and does not decrease per degree, as with carbon.

Iron (Fig. 3).—The current curve shows a marked peculiarity in that it is practically a horizontal line. This is due, no doubt, to the very rapidly rising resistivity. As the hot end becomes hotter the resistance rises so rapidly that it cuts down the current again. Such an electrode is, therefore, nearly self-regulating for a constant current. In the exterpolated (dotted) parts of these curves it has been assumed that the laws of variations continue to be about the same, but it is not unlikely that with materials which melt, like metals, as distinguished from carbon and graphite, there may be decided changes of these physical properties at the melting point.

The rapidly increasing resistivity is a very desirable feature, and forces the heat back to the hot end. The thermal conductivity falls, also a desirable feature. The mean thermal conductivity is less than for graphite. This does not agree with usual comparisons, but is due to the fact that the heat is forced to the hot end more in iron than in graphite. The electrode voltage rises quite decidedly. This means that iron electrodes are relatively less economical in power at the higher than at the lower temperatures. The specific section also rises at about the same rate, showing that the size also becomes less favourable at the higher temperatures. The test bars were cold rolled mild steel.

Copper (Fig. 4).—These tests were the best of the series. The current curve rises extremely rapidly at first and then apparently tends rapidly toward the horizontal; it seems to be similar in shape to the one for iron at lower temperatures. It therefore appears that this shape may perhaps be characteristic of the metals. The electrical resistivity rises very rapidly and in virtually a straight line. The heat will again be forced to the hot end. The thermal conductivity also falls, as in the case of iron, only to a greater degree. This and the rising resistivity should make copper a very suitable electrode material for the temperatures for which it could be used. The electrode voltage rises in almost a straight line proportion. So does the specific section. It is therefore like iron in these respects.

Comparisons.—In the Paper the author plots the above curves to the same scale in order to compare the different materials with each other quantitatively. This shows, for example, that at about 1,500°C. a graphite electrode will carry over three times as much current as will one of carbon of the same size; iron will carry nearly seven times as much as carbon, whilst copper is enormously better than any of the others, its current capacity being about 45 times that of carbon. The relative inclinations of the curves of electrical resistivity make it appear as if they tended to meet at some very high temperature in a common point somewhat below graphite, at which point they would all have the same resistivity. At 1,400°C. the

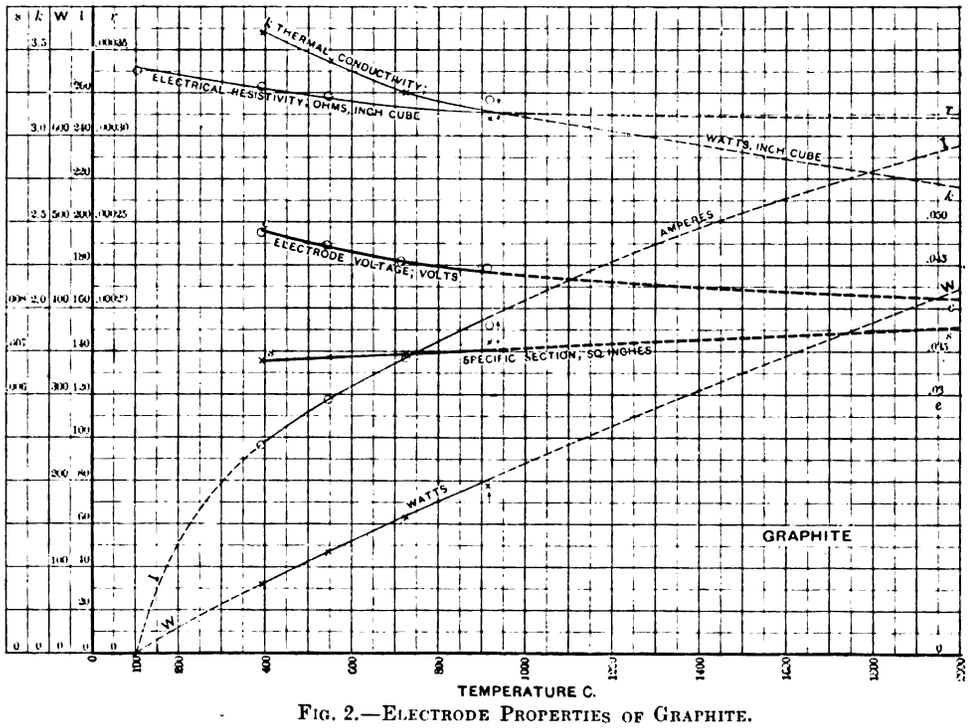

FIG. 2.—ELECTRODE PROPERTIES OF GRAPHITE.

relative values are about: Copper 1, iron 10, graphite 72, carbon 340. The thermal conductivities differ far less than the electrical resistivities; moreover, the usual order is here reversed, graphite being now next to copper. They again all seem to tend to meet in a point, this time iron being the more central one. The relative values at 1,400°C. are about: Copper 1, graphite 0·34, iron 0·22, carbon 0·17.

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It may be repeated that a falling thermal conductivity is a good feature and a rising one is a bad one; also that a high thermal conductivity reduces the size of an electrode but increases the loss; hence it is a good or a bad quality depending upon which of the two economies one desires.

The curves of electrode voltage all show a tendency to rise, except for graphite, which alone possesses the good property of a falling curve. The relative values at 1,400°C. are about: Copper 1, iron 1·5, graphite 5, carbon 7·5. Specific section is a true measure of the size of an electrode when properly proportioned. For 1,400°C. the relative values are about: Copper 1, iron 6·6, graphite 14·6, carbon 45.

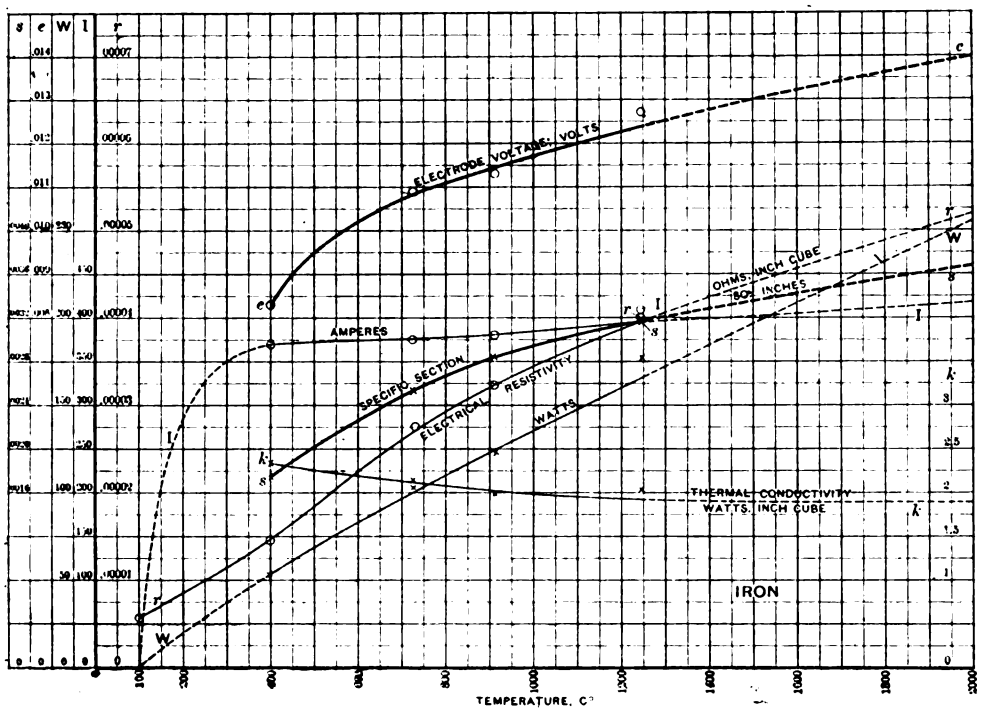

FIG. 3.—ELECTRODE PROPERTIES OF IRON.

Actual Losses and Sizes.—The electrode voltage and the specific section are the two physical constants which the writer suggests using instead of those formerly employed. Like most other physical constants, they vary somewhat with the temperature, though some of them only very slightly; but they nevertheless belong correctly under the heading of physical constants, which can for many calculations be assumed to be constant, or have the differences allowed for, just as is done with resistivities. The usually required calculations may be considerably simplified and reduced to a mere simple multiplication by using instead a tabulated set of numbers. These values are given in Figs. 5 and 6. The watts per ampere are merely the voltage between the two ends of an electrode when operating under the conditions in which there is no loss of furnace heat. Hence these are not deduced figures, but are actually measured during the test, while the figures for the sections per ampere per inch length are merely the cross-sections of the test rods divided by the length of the electrode and by the current. It will be seen, therefore, that it is not at all necessary to determine or even to consider either the electrical or the thermal conductivity in electrode problems if these simple data are at hand. In Fig. 5 the curves have been drawn to different scales, so that they are nearly superimposed, thus enabling their relative inclinations or percentage values to be compared better with each other, while in Fig. 6 they have all been drawn to the same scale, so that they may be compared quantitatively. The loss for carbon is seen to be 1·55 times that for graphite, This is interesting in view of the statements that graphite is much more wasteful of power than is carbon Also it will be seen that graphite is better than carbon in both loss and size, especially in size. Copper is best in both and carbon worse in both, while iron is closer to copper in both than it is to graphite.

This final comparison is shown in a practical way in Fig. 7, in which the sizes and losses in electrodes of the different materials are drawn to scale for a given case, in which the current is assumed to be 10,000 amperes and the end temperatures 1,400°C. and 100°C

In the first set, to the left, the length is made the same for all, namely, 10 in.—hence the sections will be different, and in the proportions of 1, 6·6, 14·5 and 45, the same as above given. The actual sizes in square inches are: Copper 1·38, iron 9·16, graphite 20·1, carbon 62. It will be seen that the proportions for carbon are practically impossible. In the second set, to the right, the cross-section is made the same, the lengths being then different. They are, in inches: 10, 1·51, 0·69, 0·22, dividing which by 10 gives their relative values based on copper. That for carbon is again impossible, as are also those for graphite, and perhaps iron. The losses in kilowatts per electrode are indicated by the lengths of the heavy black lines, which of course apply equally well to either of the two sizes for the same materials. They are, in kilowatts, about: 23·6, 15·2, 4·6 and 3·1, or in the ratio of 7·5, 5·0, 1·5 and 1. When the ratio of the section to the length is a constant, as in this case, the length increases more rapidly than the diameter. Hence, to give the carbon electrode a suitable shape for handling, it must be made still larger, and considerably so. In comparing practical electrodes this feature should be considered, and it will increase still more the difference between the sizes of the carbon and the others. It is evidently not proper to lengthen the carbon electrode of the section shown, so as to give it a better shape and to think that this merely means a small sacrifice in efficiency. Such a lengthening will evidently result in developing a high temperature within the walls, perhaps much higher even than the furnace temperature. This would be likely to burn out the furnace wall, which would be fatal to successful operation. If it is made smaller and shorter the proportions will be still worse, as is seen in the upper

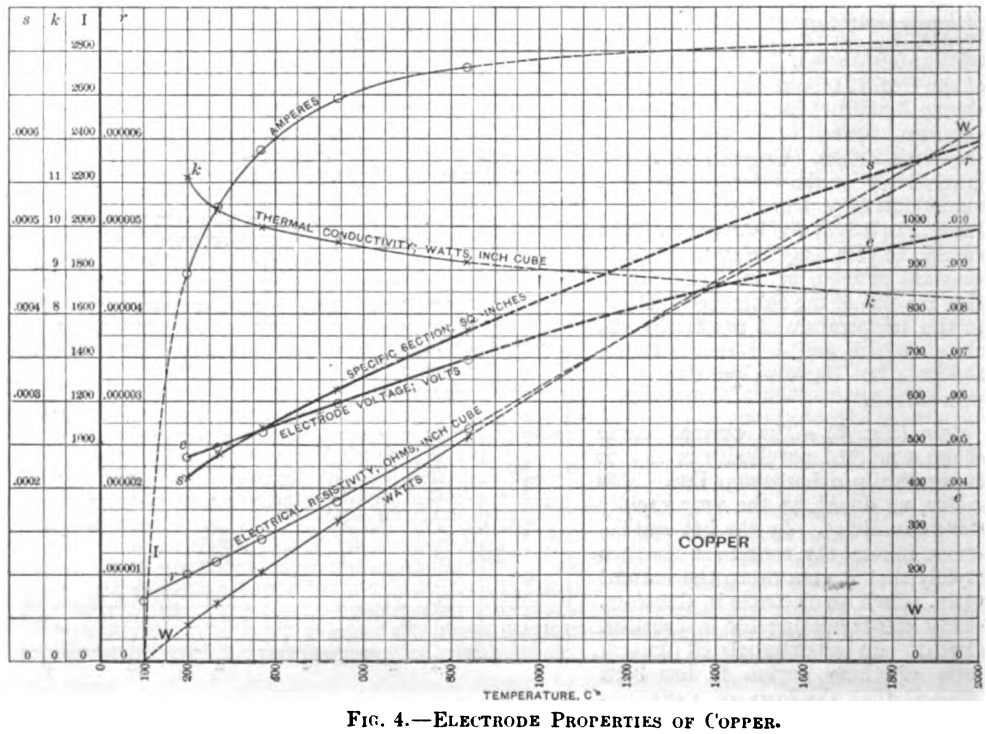

FIG. 4.—ELECTRODE PROPERTIES OF COPPER.

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right-hand illustration. Consequently, there seems nothing left to do but to make it much larger and longer.

This brings out another wrong deduction which has been made by others, based on our former incorrect rules. Suppose the carbon electrode in Fig. 7 had been made with the same section but 20 in. long; it is evident that a high temperature point, higher than that of the furnace, and probably very much so, would develop at a point somewhere between the furnace, and a point 10 in. from the cold end, because 10 in. is the correct length for that section. This would burn out the walls. The conclusion drawn from our former ideas was that the current-density was too high, when the fact is that the electrode was too long for that section. The current-density had nothing to do with the failure, because if the electrode had been made half as long instead of as long again it would have been too cold and would have chilled the furnace, although the current-density was the same. Furthermore, if the electrode had been made half the section and length shown in Fig. 7, it would have operated properly even though the current-density had thereby been doubled. The current-density,

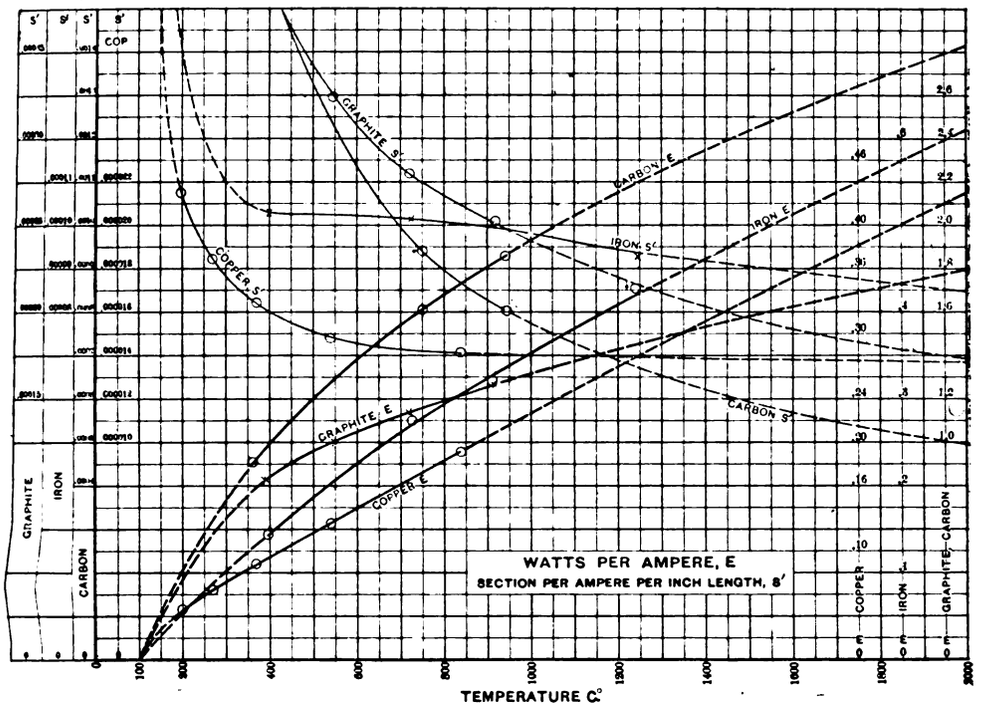

FIG. 5.—LOSSES AND SIZES. Superimposed.

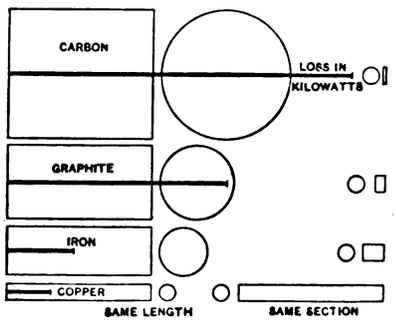

FIG. 7.—COMPARISON OF SIZES AND LOSSES.

therefore, was not the cause of failure; it has often been made responsible for faults which were really due entirely to errors in the length.

Summary of Previous Discussions.—The description of this new way of attacking the problem of the proportioning of electrodes, given by the writer briefly in May, 1909, and more in detail in October, 1909, has given rise to long discussions and attacks. An important part was an ingenious graphical method devised by Dr. A. E. Kennelly,* for representing and studying the relations of the quantities involved. Concerning the temperature correction, Dr. Kennelly has shown in a very able Paper† that under certain approximate premises (including a uniform fall of temperature in the electrode) this correction factor is zero when the electrical resistivity varies according to a straight line law. The correct mean value then is the arithmetic mean between the two extreme values at the two end temperatures. Also that the same is true when the thermal resistivity alone varies in this way. Also that when both vary in this way the total loss is least when half of the heat flow at the cold end is joulean heat and the other half is conducted from the furnace.

Dr. E. F. Roeber* has attempted the complicated mathematical solution of the case when both conductivities vary according to a straight line law, and has carried it up to, but not including, the integration. Although this unfinished formula is probably too complicated for use in practice by engineers, it shows that for given materials at stated temperatures the correction factor is merely the numerical coefficient, and that the relations between the variable factors remain the same. Dr. Roeber also finds that when the electrical conductivity is constant and the thermal conductivity alone varies by a straight line law, this complicated formula reduces to the simple original one in the writer's Paper. Dr. H. C. Richards† gives a very interesting solution of the integration for the complete case when both conductivities vary by straight line laws, and gives the first two terms of the series of coefficients. This enables the correction factors to be determined when the conductivities and their variation with temperature are known.

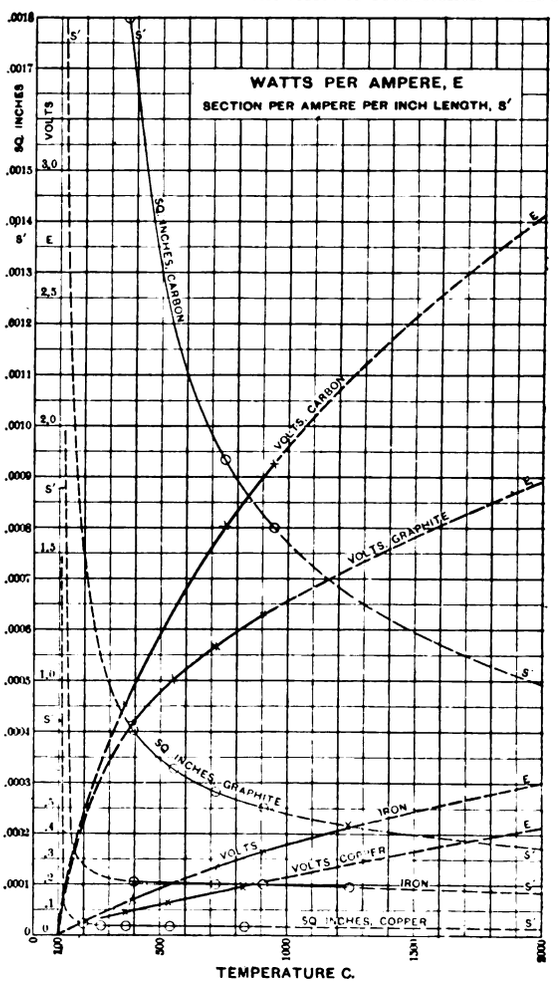

FIG. 6.—LOSSES AND SIZES. Same scale.

* "Trans." Amer. Electrochem. Soc., Vol. XVI., p. 297.

† Read before the American Institute of Electrical Engineers at the present meeting.

* "Trans." Amer. Electrochem. Soc., Vol. XVI., p. 363.

† "Trans." Amer. Electrochem. Soc., Vol. XVI., p. 304.

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CORRESPONDENCE.

A TELEPHONE RELAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. S. G. Brown has discovered quite a new field relating to telephone relays and microphones. I can only congratulate him, with the greatest enthusiasm, so much the more as he had reached his eminent success with the hardest work, probably without the modern aids, without using any barretter measurements or oscillogram records. As I am working on the trans-European (especially London–Constantinople) telephone transmission, permit me to point out some questions relating to long-distance telephony.

GÁTI'S MICROPHONE. DECKERT'S MICROPHONE.

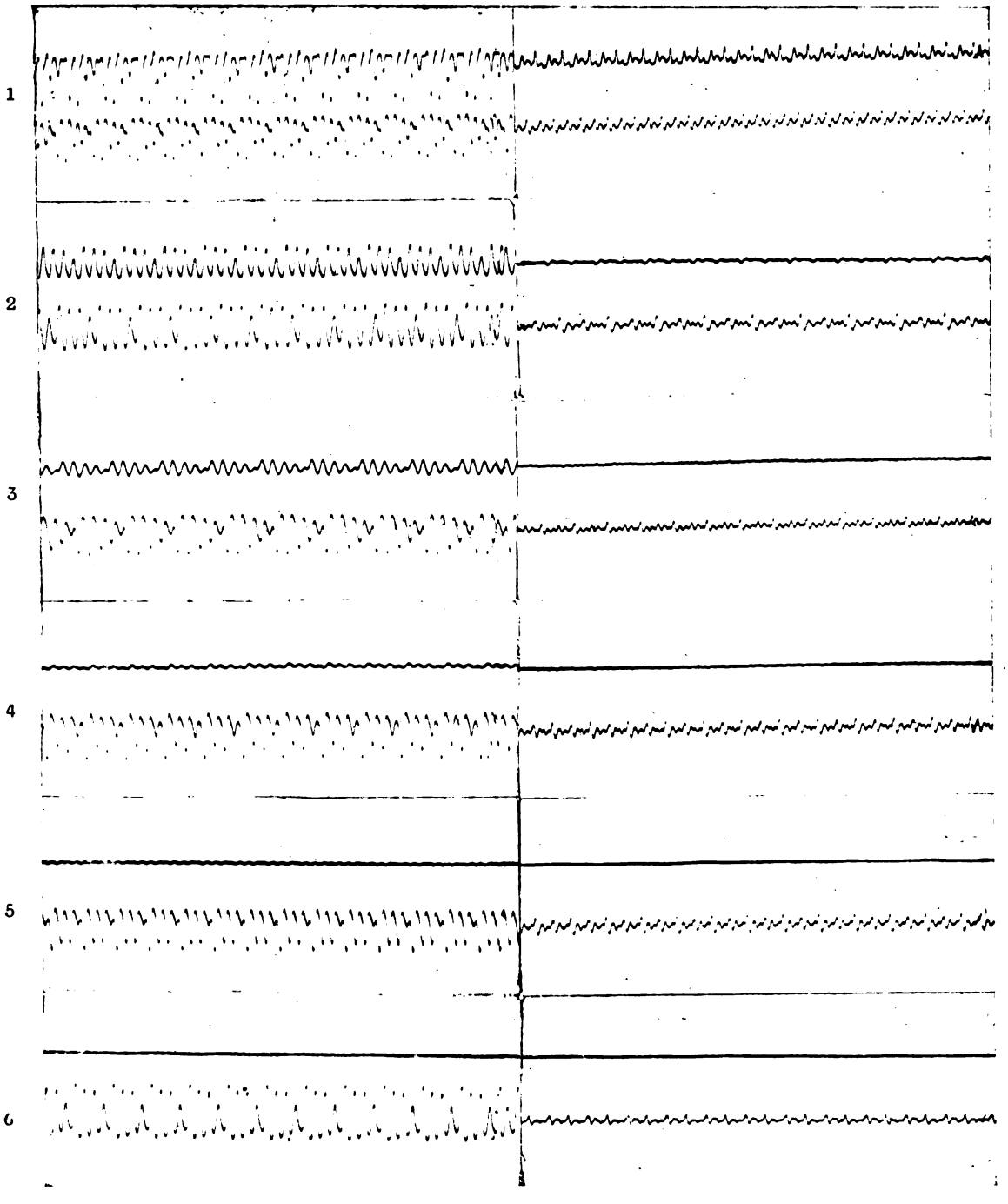

FIG. 1.—MICROPHONE RECORDS.

Table I.

Gáti's microphone.	Deckert's microphone.
The letter *a* (Hungarian).	
In the single oscillograms the upper one is the in-coming current, the lower one is the out-going current.	
1. 404 km. line: 8 km. paper cable and 4 mm. diameter bronze wire aerial.	
2,364 microamperes were received from 16,625 microamperes outgoing current with aid of Gáti's microphone.	878 / 6,125 the same relation with aid of Deckert microphone (comparison).
2. 922 km. = 8 km. cable, 4 mm. aerial.	
1,484 / 17,500 microamperes;	297 / 7,000.
3. 1,188 km. = 8 km. cable, 4 mm. aerial.	
721 / 15,750 microamperes;	191 / 5,250.
4. 1,592 km. = 16 km. cable, 4 mm. aerial.	
265 / 18,025 microamperes;	127 / 7,000
5. 2,110 km. = 24 km. cable, 4 mm. aerial.	
159 / 16,625 microamperes; the incoming current is not measurable.	
6. 2,514 km. = 30 km. cable, 4 mm. aerial.	
50 / 21,875 microamperes. Good acoustic result with Gáti's microphone.	Nothing to be heard from Deckert's microphone.

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The impression of Mr. S. G. Brown, "that the carbon transmitter has been developed to its full extent," seems to be incorrect. I will not mention Messrs. Egner and Holmström, but my microphones, which are water-cooled, work with 1 ampere and speak to a distance of 2,500 km. on a 4 mm. diameter bronze wire circuit. The records are shown in Fig. 1 and Table I.

A 2,500 km. 4 mm. circuit corresponds to $\beta L = 10\,4$. instead of 3-3·5; the resistance of this circuit ($w = 10\,4$) is 15,000,000 ohms, instead of 15,000 ohms with the former microphones. That is, the new microphones overcome a line resistance which is 1,000 times more than before.

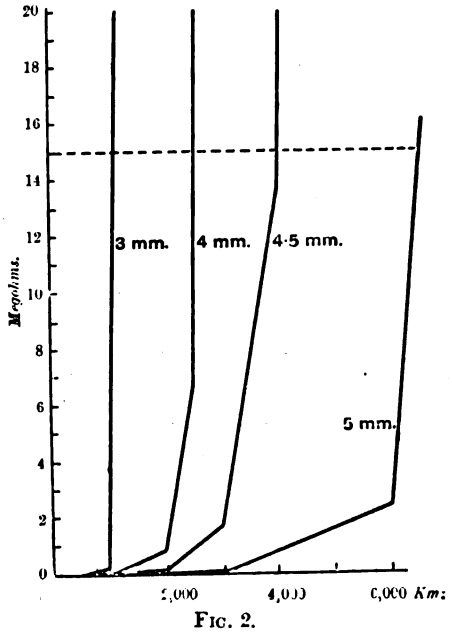

FIG. 2.

According to Fig. 2, 15,000,000 ohms resistance represents 4,030 km. 4·5 mm., or 6,500 km. 5 mm. circuit.

I am not yet satisfied with these results. It is true "that ceaseless efforts have been directed to this end by the engineers of the large telephone companies," but without success, the English National Telephone Co. excepted. But these companies were always shy regarding quantitative measurements, and the greater number of them work still with values of direct-current resistance and number of turns of the coils, instead of high-frequency resistance and self-inductivity.

I show in Fig. 3 and Table II. some records of disturbing currents which occur on the best Hungarian lines, measured with alternating current and inspected from time to time at regular intervals. What strange, disturbing currents can run over lines which are never examined from this standpoint. Over 1,000 km. (4 mm. wires) these disturbing currents have a greater value than the talking currents themselves. What does a telephone relay do now? It strengthens the disturbing currents and produces at the end of the circuit a terrible noise, in which the speech is not to be understood.

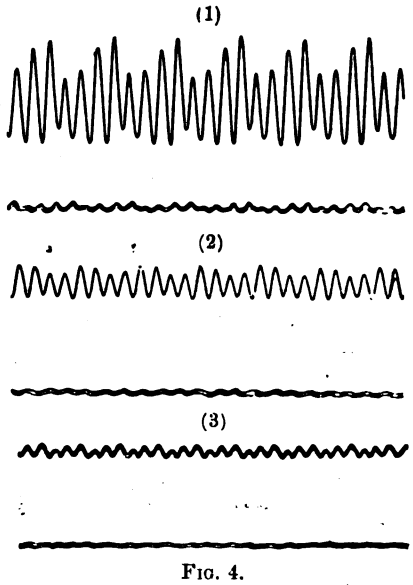

FIG. 4.

Table III.—*Records of the Letter a (Hungarian) over Lines with aid of Gáti's Telephone Repeater Relays (upper ones) and without Relays (the lower ones).*

1. 1,300 km. line (4 mm.).
2. 1,700 km. line (4 mm.).
3. 2,100 km. line (4 mm.).

The relay was connected after 900 km. Gáti's microphones were used.

Therefore the Americans use telephone relays which are actuated from the *strong* talking currents. I have also constructed some types of this relay. Fig. 4 and Table III. are the records.

My opinion is that the relay of Mr. S. G. Brown (his Fig. 4) for this purpose is not yet applicable.

The new microphones will hold very good services. I should be very glad to have some measured data for comparison. If they work over 15 megohms it would be very useful to apply them to the London-Constantinople line. I should be pleased to try them over a 3,000 km. line.

For alternating (high-frequency)-telegraphy I find the

(1)

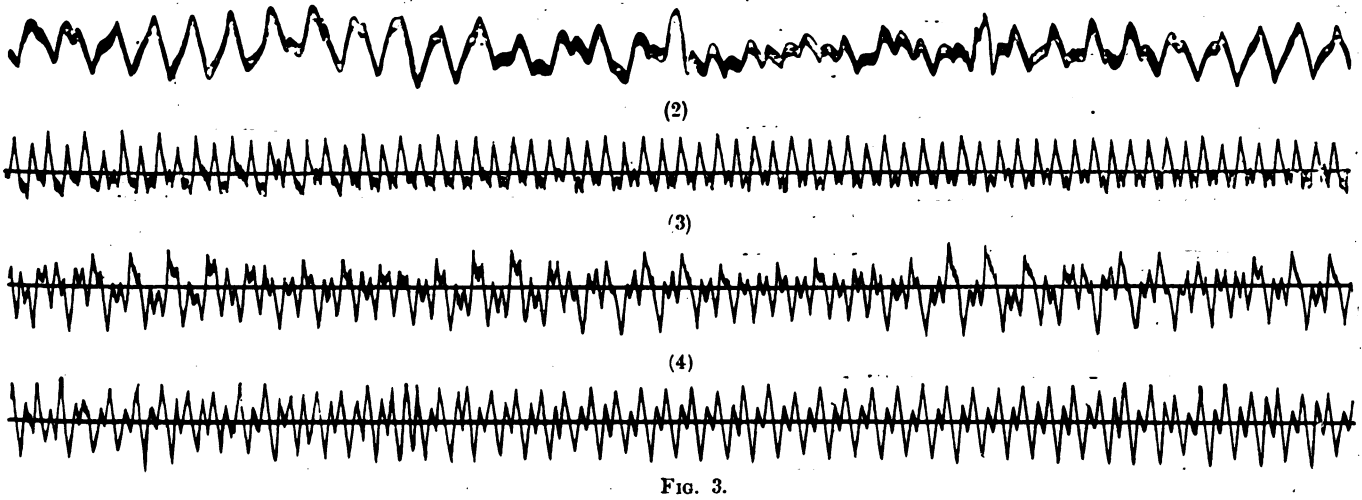

FIG. 3.

Table II.—*Disturbing Currents on Various Telephone Circuits.*

1. 10 mm. = 126 microamperes. 2. 10 mm. = 360 microamperes. 3. 10 mm. = 360 microamperes. 4. 10 mm. = 36 microamperes.

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relays of Mr. S. G. Brown a wonderful help. Working on modern (highly self-inductive) cables, the resonating effect shuts out entirely the disturbing currents; in this case, with aid of the relay, it is possible to actuate, for instance, a Siemens-Halske or Creed rapid-printing set. What it all means I presume it is not necessary to explain more elaborately.—I am, &c.,

Budapest, VI. Hajós u. 33-35, June 25. BÉLA GÁTI.

LEAKANCE IN LOADED TELEPHONE CABLES, AND THE ATTENUATION COEFFICIENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. Ebeling, in a recent communication to the "Electrotechnischer Verein,"* has drawn attention to the effect of leakance on the value of the attenuation coefficient β, as especially evident in circuits where conductors of large section are adopted, and the following treatment of the subject, which has been for some considerable time on the tapis at Messrs. Siemens Bros. & Co.'s cable works, may not be inopportune at the present moment. Let the electrical values of the cable per unit length, determined at the periodicity and current strength which are assumed to represent the equivalent of the complex telephonic currents, be—

R = the loop resistance of the conductor in ohms,
r = the loop resistance of the loadance in ohms,
K = the wire to wire capacity in microfarads.
S = the leakance, wire to wire, in micromhos,
L = the inductance of the loop in henrys, which is that of the cores plus that of the loadance,
$p = 2\pi n$, where n is the frequency (750 ~ is that adopted by the British P.O.).

Then if pL and pK are large compared with R and S respectively, the formula for the attenuation coefficient becomes

$$\beta \cdot 10^3 = \frac{R+r}{2}\sqrt{\frac{K}{L}} + \frac{S}{2}\sqrt{\frac{L}{K}}.$$

As the loading coil is usually of a given size, its time constant, or its reciprocal r/L, may be taken as a constant, the inductance of the core being negligible in comparison with that of the loadance. It has also been found by actual testing that for any given material the ratio of leakance to capacity at any given frequency, or S/K, is also a constant; and converting the above formula we find

$$\beta \cdot 10^3 = \tfrac{1}{2}\sqrt{\frac{K}{L}} \cdot \left[R + \left(\frac{r}{L} + \frac{S}{K}\right) \cdot L\right].$$

Differentiating with respect to L, and equating to zero, the minimum value is shown to occur when $L = R \Big/ \left(\frac{r}{L} + \frac{S}{K}\right)$, in which special case

$$\beta \cdot 10^3 = R\sqrt{\frac{K}{L}}.$$

Inspection of these formulæ shows directly that there is a definite limit to the improvement obtainable by loading and how important it is, especially when R is small, to make the values of r/L and S/K as small as possible.

In the Channel telephone cable recently laid by Messrs. Siemens Bros. & Co., r/L was 55, while S K for ordinary G.P. cores is about 115. S K has been determined for numerous cores at 750 ~, of which the following are instances:—

G.P. cores of various dimensions	111 to 120
A special dielectric	17 to 30
Solid paper under lead	11
Paper and air with tinfoil under I.R.	6
Vulcanised indiarubber core, new	132
Vulcanised indiarubber core, about five years old	240

These values were obtained by a bridge method, which I find, from a recent conversation with Mr. Campbell, of the National Physical Laboratory, was described by M. Wien in "Ann. d. Physik u. Chemie," 1891, XLIV., p. 705, and is that given in Mr. Campbell's communication to THE ELECTRICIAN for December 10, 1909.—I am, &c.,

Woolwich, June 30. F. JACOB.

* THE ELECTRICIAN, May 13, 1910.

ATMOSPHERIC POTENTIALS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your article on "Electricity in Agriculture," in your issue of June 10, experiments are described in which kites were used to collect atmospheric electricity. Dr. Höstermann, in referring to these experiments, estimates the potential at a height of 800 ft. at a value of 25,000 volts and bases this figure on tests made at smaller heights with instruments reading up to a maximum value of 5,000 volts.

Dr. Höstermann is probably overestimating the potential at these heights as it is shown in experiments recently carried out by us, and published this year,* that the potential gradient is considerably greater near the surface of the earth than at great heights, and that on this account estimates of the value of the potential at any height based on the values of the potential gradient measured at lower levels and assuming proportionality between the potential and height from the ground would give values of the potential exceeding those actually existing.

Our tests showed that the potential at 800 ft. was about 15,000 volts and that values of 25,000 volts were reached at heights of 1,500 ft. to 1,800 ft. The greatest potential recorded by us was 40,000 volts at about 3,000 ft.

Our experiments are being continued, and we hope to publish further results shortly.—We are, &c.,

London, July 4. A. J. MAKOWER.
W. MAKOWER.

FISCAL POLICY AND THE ELECTRICAL INDUSTRY,

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have seen the letters in THE ELECTRICIAN in reply to mine. No one has taken up my challenge, as I knew from a long experience of such correspondence no one would. It is impossible for any one who realises that imports of goods can only be paid for by export of goods; and consequently that if, by a duty, you stop goods from coming in, you will stop the goods that used to pay for them from going out; that is to say that the employment you give with one hand you take away with the other—I say it is impossible for anyone who realises this to show that Tariff Reform would increase employment. I have shown how it would diminish it, and till someone shows how it would increase it that proposition stands. Protection would make the present unemployment worse. I ask your readers to observe that no one has taken up my challenge, and to draw their own conclusions.—I am &c.,

Birmingham, July 3. GEORGE HOOKHAM.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Proceedings of the Royal Society." Vol. LXXXIII. No. A.566, Series A—Mathematical and Physical Sciences. (London: Harrison & Sons.) 2s.

"The Telegraphic Transmission of Photographs." By T. Thorne Baker. (London: Constable & Co.) 2s. 6d. net.

"International Language and Science." By L. Couturat, O. Jespersen, L. Lorenz, W. Ostwald, L. Pfaundler. Translated by F. G. Donnan. (London: Constable & Co.) 2s. net.

"Machines Electriques." By A. Mauduit. (Paris: H. Dunot & E. Pinat.) Fr. 27.

"Proceedings of the Royal Society." Vol. LXXXIV. No. A. 567. Series A: Mathematical and Physical Sciences. (London: Harrison & Sons.) 3s.

"Science Abstracts." May, 1910. Vol. XIII. Part 5. No. 149. Section A: Physics. Section B: Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

"Cable-Fault Localisation Graphs in Practice." By E. Raymond-Barker. (London: H. Alabaster, Gatehouse & Co.) 2s.

"A Scheme for the Promotion of Scientific Research." By W. B. Priest. 3rd edition. (London: Stevens & Sons.) 3s. 6d.

"Ueber Ausschaltvorgänge und magnetische Funkentöschung." By Erich Philippi. (Berlin: Leonhard Simion.) M.3.50.

* W. Makower, A. J. Makower and M. White, Quarterly Journal of the Royal Meteorological Society. Vol. XXXVI., No. 154, 1910.

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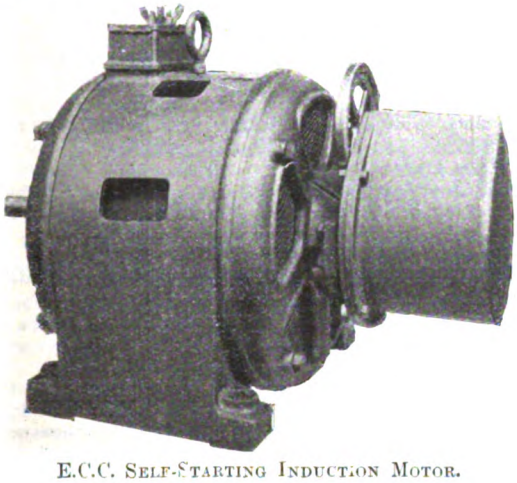
A NEW SELF-STARTING INDUCTION MOTOR.

The Electric Construction Co., of London and Wolverhampton, have been experimenting for some time past with a new type of three-phase motor, the principal points of which are the absence of brushes, slip-rings, rotor cables or outside starter, and which, it is claimed, possesses all the well-known good characteristics of the wound rotor type without its drawbacks. The peculiar features of this new machine (which has been designed and patented by N. Pensabene-Perez) are the method of fixing the resistances to the rotor and the arrangement for cutting them out while the machine speeds up at starting. When the machine works at full speed there are no rubbing contacts whatever, so that no lifting or short-circuiting plugs or similar complicated arrangements are necessary. The revolving resistances are very compact, of strong mechanical construction, are totally enclosed in a cast-iron case, and are cut out either by hand or automatically. An important feature of the machine is that, being started through a large number of steps (from 20 to 30 per phase), there is no sudden fluctuation of the current at



E.C.C. Self-Starting Induction Motor.

starting, but a gradual variation by small steps from the starting to the running value. The automatic type, considering the simplicity of its construction, is an important step forward in the development of induction motors.

A long-distance control, as found necessary in the many applications of electrical drive, is in this way accomplished at small expense, and with the most reliable means, by the simple operation of closing the stator main switch. The automatic type, being controlled by the speed, lends itself to a simple solution of the problem of preventing a rush of current during the starting period. In fact, by a rational choice of spring-tension, frictional resistance and value of centrifugal forces, it is possible to keep the current approximately constant while the machine is speeding up, thus accomplishing what many complicated devices, in the case of hand control, are supposed to do. This motor is, from these various causes, less expensive than the ordinary slip-ring type, and, moreover, no starter or rotor cables are necessary. These merits point to the success of the new type.

BOROID, A SUBSTITUTE FOR CELLULOID.

On Saturday last a demonstration to press representatives was given of the properties of a new substance which is intended to take the place of celluloid, particularly for cinematograph shows. This has been dubbed "Boroid" and is being exploited in Great Britain by the Benobor Synd. Various thicknesses of the new material were subjected to tests which, while productive of fire in the case of celluloid samples, proved the complete non-inflammability of "Boroid." Lighted matches, cigarettes, cigars placed against the substance produced no more than a black smoke, there being no sign of flare or flame. The material also withstood successfully the exceptionally severe test of the heat rays from the condenser in the lantern; the film was clamped in "the gate," and while stationary, the full rays of the lamp were turned on to it. In ordinary cinematograph work the film is kept constantly moving, and the shutter before the condenser is never raised until the film is in motion; similarly it is lowered before the film is stopped. The "Boroid" specimen withstood the concentrated rays of a 60 ampere arc light for 10 minutes, and when examined showed no sign of burning, blistering or discolouration of any kind. The celluloid specimen subjected to the same test fired in 2 seconds. The positive carbon, while red hot, was also held against the same piece of film, which merely melted and gave off a thin white smoke. The material has been produced mainly with the idea of its taking the place of ordinary celluloid in cinematograph films, but we understand that it can be moulded into any desired shape. Samples of the material stamped out in rectangular plates about $\frac{1}{8}$ in. thick to act as a substitute for window glass were shown. The material is stated to be a good insulator, and steps will be taken to produce imitation ivory and porcelain specimens for electrical accessories.

SOUTH AFRICAN ELECTRIC LIGHTING AND POWER REGULATIONS.

On the advice of the Executive Council, the Government of Cape Colony has made additional regulations under the Electric Lighting and Power Act of 1905 for securing the safety of the public, and also certain alterations to existing regulations. The added and altered regulations, which are set out below, came into force on May 1st:—

Additional Regulations (for Motormen).

1. No person under 21 years of age, and no person who is not physically fit, and has not had actual experience in driving as learner, and instruction in the working of all appliances under the driver's control over a period lengthy enough to ensure his complete familiarity with their functions and use, shall be employed as a motorman or be permitted to operate an electric tramcar.

2. If it shall appear, after inquiry made, that any accident has occurred through the default of a motorman, the Government may call upon the undertakers to dismiss such motorman from their service as motorman, in which case he shall not be re-employed as a motorman, except with the consent of the Government first obtained.

3. The Government Electrical Inspector, or any person authorised by him in writing under his hand, may from time to time take such steps as he may deem necessary to assure himself that any motorman is properly qualified for the performance of his duties by requiring such motorman to operate one or more of the appliances on an electric tramcar, or otherwise to test his fitness as a motorman within the requirements of the regulations, and if the motorman is found to be unfit for such duties, the undertakers shall thereupon be prohibited from again employing him as motorman until he is properly qualified.

Alterations to Regulations.

Section 2, sub-section (3).—Where the supply is for incandescent lamps in series:—

(*a*) The consumer's wires forming the connections to the incandescent lamps, or otherwise, in connection with the supply, shall be completely enclosed in strong metal casing, and this casing, together with the switches and lampholders, if metallic, shall be efficiently connected with earth.

(*b*) Switches, efficient fuses or other automatic cut-outs to protect the circuits from excess of current shall be provided, and all switches and cut-outs shall be so enclosed and protected that there shall be no danger of any shock being obtained in the ordinary handling thereof, or of any fire being caused by their normal or abnormal action.

Where the supply is for any special purpose other than those above-mentioned or where the pressure of the supply exceeds the limits of medium pressure, it shall be subject to such other regulations as the Governor may from time to time prescribe.

4. An extra high-pressure supply shall not be given to any consumer's premises other than a factory, a workshop, a mine, a quarry, electric traction works, water works or sewerage or drainage works, and no such supply shall be given except with the consent of the Government and subject to such regulations as the Governor may prescribe.

16. Every support for an overhead line shall be of durable material and shall be properly stayed against forces due to wind pressure, change of direction of the line, or unequal lengths of span. The factor of safety shall be for overhead lines at least 5 and for iron or steel structures at least 6, taking the maximum possible wind pressure at 30 lb. per square foot.

27. Application for permission to employ any overhead line for high pressure or extra high pressure must be made to the Government, and, if approved, such special regulations shall be prescribed by the Governor as he may consider necessary or desirable in each case.

34. Sub-stations shall be established in suitable places, and shall be in the sole occupation and charge of the undertakers. Sub-stations shall be erected above ground wherever possible, but where necessarily underground due provision shall be made for ventilation and drainage.

45. If any consumer is dissatisfied with the action of the undertakers in refusing to give, or in discontinuing, or in not recommencing the supply of energy to his premises, the wires and fittings of the consumer shall, on his application, and on payment of the prescribed fee, be tested for the existence of leakage by the Government electrical inspector; and if the inspector's report is favourable the supply shall not be withheld by the undertakers by reason of supposed leakage. This regulation shall be endorsed on every notice given under the provisions of either of the two last preceding regulations.

48. Where the pressure of a supply between the adjacent conductors of a three-wire system of mains exceeds 125 volts, the intermediate con-

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ductor shall be connected with earth, in accordance with the following conditions :—

(*a*) The connection with earth of the intermediate conductor shall be made at one point only on each distinct circuit, namely, at the generating station, sub-station or transformer, and the insulation of the circuit shall be efficiently maintained at all other parts.

(*b*) The current from the intermediate conductor to earth shall be continuously recorded, and if it at any time exceed one thousandth part of the maximum supply current, steps shall be immediately taken to improve the insulation of the system.

ELECTRIC FOUNTAINS.

Illuminated electric fountains are now no novelty, and many have found their way into the houses of the wealthy and into restaurants in most great cities. An electrically operated fountain appears, however, to be something new, and the idea of utilising a small motor-operated pump to circulate water round and round an ornamental basin via a number of jets should appeal to many. The Electric Fountain Co. have introduced a fountain which employs a vertical spindle motor and a valveless rotary pump for throwing water upwards from a number of jets grouped in a pleasing fashion.

Electric Fountain.

The same water is kept constantly on the move, and the fountain is therefore independent of the supply mains. The power consumption is about 60 watts and either alternating-current or direct-current motors can be used. The adjoining illustration shows that the fountain is compact and ornamental in appearance.

PARLIAMENTARY INTELLIGENCE.

P.O. TELEGRAPHS AND TELEPHONES.

In the House of Commons on Friday a discussion arose on the three reports of the Public Accounts Committee, and in reply to some criticism of the Post Office accounts,

The Postmaster-General (Mr. H. Samuel) said that when the telegraphs were taken over from the companies by the State in 1870 Parliament voted £10,000,000 for the purchase and development of the system, and that sum, having been voted from borrowed moneys, had been regarded as capital expenditure. It should have been repaid year by year out of the profits of the telegraphs, but as they had not yielded a profit the £10,000,000 stands as capital liability. As soon as the purchase was complete, and large extensions had been made, the telegraphs reverted to the normal system of the Post Office, and all the future extensions of the system were paid for out of the annual vote. Therefore, no addition was made to the original capital account. There was no concealment as to the loss on the telegraphs. The total deficiency at Dec. 31 last was £1,046,757. The relation of the Post Office to the telephones were at the moment much the same as to the telegraphs when they were taken over by the State. Vast sums were being expended on the creation of a Post Office telephone system, and other vast sums would be required in the next two or three years to pay the National Telephone Co. what is determined to be the value of their plant. So long as that immense capital expenditure was being made it was obviously impossible that it should be defrayed out of the annual vote, and, therefore, it was essential that there should be a capital account to start the P.O. telephone system. While a capital account was created for the telephones, whereas it did not exist for the present extension of the telegraphs, complication was created, as it was difficult to decide in any given case how much expenditure on an underground cable used by both telegraph and telephone should be treated as being for the telegraph, and so paid out of the annual vote, and how much for the telephone, and so provided for out of the telephone capital account. The matter could not be treated as a whole and put into capital. If that was done it would mean the re-creation of the capital account which Parliament dispensed with 40 years ago. If they put it all to annual expenditure they would be giving a false impression of what was the actual cost of creating the Post Office telephone service. They must discriminate. As soon as the National Telephone Co.'s system had been purchased by the Post Office, and the initial capital expenditure had come to an end, then, as in the case of the telegraphs, a sinking fund would be created, and the telephones, as the telegraphs, would revert to the normal system of finance, and annual expenditure, whether for permanent or for temporary purposes, would be met out of the annual votes of Parliament. In the matter of submarine telegraphs the Post Office acted as agent for the cable companies and paid over to them the amounts received, less Post Office charges.

POST OFFICE AND NATIONAL TELEPHONE CO.

In the House of Commons on Tuesday the Postmaster-General stated, in reply to a question, that the general conditions of the purchase of the National Telephone Co.'s plant were settled by the agreement of Feb. 2, 1905. The purchase will take effect from Dec. 31, 1911. Arrangements were being made to ensure the transfer on or as soon as possible after the date of purchase. The preparation of an inventory of the company's plant had been discussed with the company, and it was hoped that it would shortly be put in hand, and that it would be found possible for the Post Office check on the inventory to proceed concurrently with its preparation.

LONDON ELECTRIC RAILWAYS AMALGAMATION.

The Bill for the amalgamation of the Baker-street & Waterloo, the Great Northern, Piccadilly & Brompton and the Charing Cross, Euston & Hampstead Railways was considered last week by the Committee on Unopposed Bills of the House of Commons.

Mr. Bonner Maurice, agent for the Bill, explained that the companies had been working practically as one for some time, and the object of the Bill was to bring about a complete amalgamation of the three companies.

After a brief discussion of the question of workmen's tickets, the Bill was passed and ordered for third reading.

BAKER STREET & WATERLOO RAILWAY BILL.

On Thursday last week this Bill came before the Committee of the House of Commons on Unopposed Bills. In the Bill power was sought to make a subway at the Oxford-circus station. It is intended to construct a moving staircase, or escalator, 120 ft. long, from the station platform to the street level, by which passengers will be able to ascend without waiting for the ordinary lifts. The escalator is in operation in America, but this is the first application of the principle by an English railway. The plans for the proposed work require the approval of the Board of Trade. The Bill was ordered to be reported for third reading.

WIMBLEDON & SUTTON RAILWAY BILL.

The Select Committee of the House of Commons (presided over by Mr. Ashton) last week found the preamble of this Bill proved.

GLASGOW GAS CONSOLIDATION BILL.

A House of Lords Committee, presided over by the Duke of Bedford, has passed the preamble of this Bill. The Committee allowed the Corporation to create a reserve fund for their gas undertaking, but refused to grant power to devote surplus gas profits to relief of rates. The Corporation have also obtained authority to charge differential rates in favour of large consumers.

HANDSWORTH URBAN DISTRICT COUNCIL BILL.

On Tuesday this Bill, which authorises the construction of additional tramways, &c., came before a Select Committee of the House of Commons. Opposition was offered to certain clauses by Birmingham Corporation who are promoting a bill for the extension of their area. The Committee, however, decided to postpone the consideration of the Bill for a fortnight, or until a decision was come to on the preamble of the Birmingham Extension Order.

CAMBUSLANG and ARDROSSAN ELECTRIC LIGHTING ORDERS.

On Friday a House of Commons Committee (presided over by Sir H. Kimber) considered the bill for confirming the Provisional Order promoted by Lanarkshire County Council for an extension of their electric lighting area at Cambuslang. The Caledonian Railway Co. sought to have a protective clause inserted providing that any additional expense that might be incurred by the company when rebuilding or altering their bridges carrying roads over the railway by reason of the existence of the electric cables of the County Council should be repaid by the County Council.

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On behalf of the promoters it was contended that if any alteration or modification of the general law regulating electrical undertakings were necessary it ought to be dealt with in a public general act and not in a local order.

The Committee decided that special protection should not be given to the company under the order, but the Chairman expressed the opinion that if the point had come up as a general question, as it doubtless might in the future, great consideration would have to be given to both views.

The same decision applied to the Ardrossan Electric Lighting Order.

Metropolitan Railway Bill—Last week the Unopposed Private Bill Committee of the House of Commons passed this Bill, which authorises the Metropolitan Railway Co. to acquire additional lands for their undertaking, to construct (in conjunction with the City & South London and the Great Northern & City Railways) a subway at Moorgate-street connecting the stations of the three companies, and to enlarge and improve Baker-street station, &c.

London Electric Supp'y Bill.—Mr. Brunner, Mr. James Parker and Sir Thomas Hickman have been nominated members of the House of Commons Select Committee to consider this Bill.

LEGAL INTELLIGENCE.

Neals & Lyons v. City of Birmingham Tramways Co. (Ltd.)

On Friday last Mr. Justice Swinfen Eady heard a motion on behalf of Messrs. W. Neale and Mark Lyons for an injunction against the City of Birmingham Tramway Co. and Messrs. E. Garcke, J. A. Christie, G. C. Cunningham, C. Hilton and J. A. Lycett (directors of the company) to restrain them from acting on a resolution passed at an extraordinary meeting of the company on May 19 last (and confirmed on June 9) that out of the accumulated profits of the company £4 per share be paid to the holders of 6,047 fully-paid ordinary shares of the company by way of reduction of capital.

Mr. Buckmaster, K.C. (with whom was Mr. Tyldesley Jones), for plaintiffs, contended that the resolution was ultra vires. That was not a reduction of capital. It was a resolution which purported to be passed under special powers obtained first by an act of 1880, and next by an Act of 1908, enabling the company by special resolution to return its capital.

His Lordship: By the reduction of the capital?

Mr. Buckmaster said the real question was whether the powers conferred by the statute enabled the company to pass the resolution returning to certain members only of one class of shareholders money that had been paid up on their shares. Plaintiffs' submission was that they did not, and that the statute only permitted the return of money to all classes of shareholders, and not to certain members only. The motion would be treated as the trial of the action. The object of the resolution was to alter the rights of the ordinary shareholders who had paid in full, so that with regard to future dividends they should stand on the same footing as those shareholders with only £1 paid up. That was a resolution which could not be passed under the section, the essential feature of which was that the money which was capable of being returned was money which must be available for distribution as dividend among the shareholders.

Mr. Gore Browne, K.C., for the company, contended that the resolution was in accordance with the rights of the shareholders under the Act of Parliament. The company had power to return a portion of its profits to its shareholders in accordance with their rights in the capital of the company. If that were lawful, the Court could not interfere.

His Lordship, in giving judgment, said the holders of the 6,047 shares complained of the resolution, their point being that the remaining ordinary shareholders were using their voting power to resolve that the 6,047 shareholders be repaid £4 per share, to the intent that those shareholders who had received the full dividend on their £5 might henceforth receive a dividend on only £1; and they contended that the case was not within sec. 40 of the Companies' Consolidation Act, 1908. He had no discretion to exercise in considering whether the company ought or ought not to do what they now proposed to do. The only point for him to consider was whether they had the legal power to do so. The sum to be returned was a sum of undivided profits, which, with the sanction of the shareholders, might be distributed among the shareholders in the shape of dividend or of bonus. In his opinion this particular form of repayment was allowed by the Act, and therefore the motion failed. His lordship added that though that might appear somewhat hard on the shareholders who objected, they had taken their shares subject to that liability being paid off.

The motion was accordingly dismissed, with costs.

Metal Filament Lamp Patents.

On Friday last the action of Osram Lamp Works (Ltd.) v. G. M. Boddy & Co. came before Mr. Justice Parker on a motion to discharge an order for trying the case with reference to two patents in the same action.

Mr. Bousfield, K.C., who (with Mr. T. Terrell, K.C.) appeared for defendants in support of the motion, said his application was to discharge an order made in chambers joining the two patents in one action. The question that arose was entirely a question of the convenience of the trial and was not with them a mere question of costs. Defendants objected to the two patents being litigated together, because that course would involve a great deal of difficulty. The real question was how far it was convenient or even desirable with reasonable lucidity to try the two questions together. The action was brought originally on one patent—the general patent of principle. Then a summons was taken out for leave to amend the writ so as to include a second patent, and leave was given. That patent dealt with an entirely different matter to the subject of the first patent. The first related to the manufacture of metal filaments of tungsten, the principle being to mix a metallic powder with carbon, then chemically to discharge the carbon and so obtain a filament of tungsten. The second patent related to the attachment of the filaments to the "leads" that went through the glass. He submitted that the manufacture of the filament and its method of attachment were entirely different, and depended upon entirely different considerations. It was not at all probable that the evidence given at the trial with reference to the one patent would have any reference to the other patent. The joining of the two might result in the saving of a little in cost, but that was not the important matter. The two patents were owned by plaintiffs, and the defendants were the same in both cases and the lamp was the same lamp, but in the first case the allegation was general and in no way was the connection of the filament included. The connection was alleged to infringe another of plaintiffs' patents which was entirely different. Under those circumstances he submitted there was sufficient difference to induce his lordship to say that it was not a good thing to bring the two together in one action. The alternative he suggested was to let the two actions go on together, and try first the question in the one case and then the question in the other. The plaintiffs had chosen to divide them at the start, and though he saw the expediency of them coming on side by side and the distinct advantage of both being tried by the same judge, the specifications confirmed the totally different nature of the two claims, and he contended they should not be joined in one action.

Mr. Walter, K.C., who (with Mr. Colefax) represented plaintiffs, said that both patents were in connection with a particular filament. The second patent related to the amalgamation of that particular filament with another metal so as to form the lead. The evidence must necessarily be much the same in both actions. The same experts would be called and the general history of the thing would be the same. The two patents were owned by the same plaintiffs, the actions were against the same defendants and had reference to the identical filament. The question would largely involve the properties of tungsten, and there would be a very large saving of time and cost if both the patents were tried together.

Mr. Justice Parker said that he was not satisfied that any essential inconvenience would be caused by trying the two actions together and prima facie it was convenient that they should be tried together. He dismissed the application, with costs.

Tramway By-Laws.

Before a Divisional Court last week a motion was made on behalf of the National Motor Carriage & Horse Owners' Accident & Insurance Union, for a rule nisi calling on Manchester Corporation to show cause why a writ of mandamus should not be issued requiring them to frame by-laws under the Manchester Corporation Tramways Act, 1900.

Mr. Forbes Lankester, K.C., for applicants, stated that in 1900 the Corporation acquired the tramways and got powers to make further lines and to use electric power. The Bill was opposed by his clients on the ground that tramways could not be worked by electricity in the central parts of Manchester without danger to the horse traffic and considerable inconvenience to other traffic. To secure the withdrawal of that opposition it was agreed that the clause on which applicants now relied should be inserted in the Bill. Under that clause the Corporation took powers to make by-laws prescribing the distances that must intervene between tramcars. For two years nothing was done under the section. Then the present applicants moved in the matter, and eventually the Corporation passed a by-law directing that the distances should be as the police regulations provided.

Mr. Justice Channell: Is the point whether the by-law deputing it to the police to say what the distances should be satisfies the clause of the statute?

Mr. Lankester: Yes.

Mr. Justice Channell: I think you can take the rule upon that. I don't express any opinion, but it seems to be a point for discussion.

Electricity Supply and Gas Accounts.

In the Glasgow Sheriff Court last week, Mr. Sheriff Scott Moncrieff was asked by the liquidator of Hutson & Sons (Ltd.) (Mr. J. M. Ross, C.A.) to restrain Glasgow Corporation, whose accounts for gas and electricity supplied to the company's works were admitted to be in arrear, from cutting off the supplies. It was contended that the Corporation, by threatening to cut off supplies, were endeavouring to enforce payment of their accounts and thereby secure an illegal preference, while they were only entitled to rank for their claim as ordinary creditors. The Corporation, by their threatened action would also deprive the liquidator of the supplies of gas and electricity which were necessary for carrying on the company's business, and which he was entitled to get on undertaking to pay for what was consumed subsequent to the date of liquidation.

For the Corporation, it was objected that the application was made in the name of the liquidator and not in that of the company as required by the Companies Acts. It was also denied that the Corporation were seeking a preference. The Corporation were empowered by statute to cut off supplies for overdue accounts and, therefore, were within their rights in exercising their statutory powers.

The Sheriff refused the interdict sought.

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Workmen's Compensation.

In the Shoreditch (London) County Court on Tuesday an application was made by Fredk. Statham Sharpe, cable jointer, for a continuance of the payment of compensation by Shoreditch Council. Applicant was injured whilst working at the Council's electricity works in Dec., 1908. He had earned 37s. 6d. a week, and was paid half-wages until April 19, 1910, when the insurance company pleaded that he was cured and declined to pay more. For applicant it was said he tried to work, but had to give it up. It was suggested that the Council should give him a light job.

After hearing evidence, Judge Bray said he thought the insurance company might send him away for a month, and then the Council might try the experiment of giving him light work. The hearing was adjourned for that purpose.

Babcock & Wilcox (Ltd.) v. Edwin Danks & Co. (Oldbury) (Ltd.)

On Wednesday and yesterday (Thursday) Mr. Justice Warrington heard this action, which was brought to restrain defendants from infringing letters patent No. 20,779 of 1898, granted to plaintiffs and Mr. J. H. Harrison for improvements in gas combustion chambers for steam boilers and other furnaces. After hearing evidence, His Lordship came to the conclusion that plaintiffs had failed to establish infringement, and dismissed their action with costs. The defendants' counterclaim, which attacked the validity of the patent, was also dismissed with costs.

Sunderland & District Electric Tramways (Ltd.)—On Friday Mr. Justice Swinfen Eady granted an order to appoint a receiver and manager in a first debenture holder's action. A receiver and manager in respect of a second debenture holder's action had been appointed, and the same gentleman was appointed in the present action.

Postal Telegraph Co. versus Bell Telephone Co. (New Mexico).

From Las Cruces, New Mexico, under date June 25, 1910, we learn that the Postal Telegraph Co. (of New York) has obtained an injunction against a subsidiary Bell Telephone Co. in New Mexico for violation of a contract which the Postal Co. made with an independent telephone company last July for five years by which the Postal Co. reached a number of towns in New Mexico by an extension of its service from El Paso to Silver City, New Mexico. That contract still has more than four years to run. A few weeks ago the New Mexico subsidiary Bell Telephone Co. bought out the independent telephone company with which the Postal Co. had this contract, and then the subsidiary Bell Company notified the Postal Co. that the contract would be repudiated on July 1 and connection cut off. The Postal Co. has obtained an injunction against such repudiation from the district court at Silver City, and has set up that this action is due to a conspiracy between the Western Union and Bell Telephone Companies to suppress telegraphic competition between El Paso, Silver City, and intervening towns and other parts of the country. The validity of the combination of the American Telephone & Telegraph Co. and the Western Union is, we understand, directly attacked by this action.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Governors of Robert Gordon's Technical College (Aberdeen) are about to appoint an engineer graduate of distinction as head of the engineering department of the college. Salary £500 per annum. Applications to the principal (Mr. Chas. Stewart, M.A.), by July 16.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

Bombay Corporation require an executive engineer with knowledge of all branches of municipal engineering, including lighting and electricity. Minimum monthly salary R.1,200 (£80), maximum R. 2,000 (£133. 6s. 8d.). Applications to Mr. G. Midgley Taylor, Caxton House, Westminster, S.W., by July 31.

A professor of pure and applied chemistry is required at the Municipal Technical Institute, Belfast. Salary £350, increasing to £400. Particulars from the Principal. Applications by noon July 20.

On Wednesday Salford Corporation appointed Mr. H. J. Hawkins, deputy borough electrical engineer, to the position of borough electrical engineer at a salary of £500, rising by annual increments of £50 to £700 per annum.

Salford Council have also appointed Mr. H. J. Roscoe, of London, superintendent of the hired motor department of the electricity undertaking at £120 per annum.

Mr. C. H. Yeaman, the electrical engineer to the old borough of Hanley, has been appointed electrical engineer to the new county borough of Stoke-on-Trent, which includes Stoke-on-Trent, Hanley, Burslem and Longton. The salary is £500 per annum, with an allowance of £10 per year for local travelling expenses.

Mr. M. W. J. Fry has been appointed Professor of Natural Philosophy at Trinity College, Dublin.

Mr. E. C. C. Baly, F.R.S., Assistant Professor of Chemistry and Lecturer on Spectroscopy at University College, London, has been appointed Grant Professor of Chemistry at the University of Liverpool.

Mr. John D. Coales, D.Sc., A.M.I.E.E., of the Birmingham University, has been appointed principal of the Wolverhampton Technical School.

Mr. A. R. Owen, manager of the Thames steamboat service, has been appointed tramway and mains claims superintendent by London County Council, in succession to the late Mr. J. Glover, at £500 a year.

The First Commissioner of His Majesty's Works has appointed Mr. Howard McFerran to be chief engineer in succession to Mr. E. G. Rivers, I.S.O., resigned.

Mr. G. Bartholomew, charge engineer at Woolwich, has resigned to take up a similar position with the Electric Supply Corpn.

Mr. C. G. Habgood, of Bristol, has been appointed junior engineer at Wednesbury electricity works in place of Mr. Geo. Garratt, resigned.

Mr. E. J. Walsh, of York, has been appointed mains assistant at Leith.

Mr. L. Hulbert, late of the sales department of the Marylebone Borough Council, has taken up an appointment as sales manager to Messrs. Pooley & Austin.

Bermondsey (London) Council has appointed G. H. Endacott (Chingford) arc lamp repairer to the electricity undertaking. There were 122 applications.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

Heriot-Watt College (Edinburgh).—This college provides theoretic a and practical training for mechanical, electrical and mining engineers, technical chemists, brewers, &c., and printers and publishers. The training for engineers consists of three years in the college and a three years' apprenticeship on the "Sandwich" system in a local engineering works. The course in mining extends over two years, and the training is also recognised by the University of London for the B.Sc. degree in mining. Complete courses of instruction, extending over four years, are provided for students studying for the fellowship of the Institute of Chemistry, &c. An entrance bursary of £25 will be offered for competition on Sept. 27 and 28 next. Particulars of fees, &c., may be obtained from the principal, Mr. A. P. Laurie, M.A., D.Sc.

Armstrong College.—Newcastle-on-Tyne Corporation have decided to make an extra grant to this college of £1,500 per annum far five years.

Imperial College of Science.—In December last the London County Council decided to make a maintenance grant of £8,000 to this college in return for the privilege of nominating 25 students for one year's free instruction.

These studentships are now to be filled for the first time, but only advanced students, qualified to enter on the fourth year of the course, should apply. Candidates must be ordinarily resident in the Administrative County of London, and must be students at an institution aided, maintained, or approved by the Council. No examination will be adopted for the final selection of the students from the applications

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received. The studentships will be awarded on consideration of the past records of the candidates, the recommendations of their teachers, the course of study they intend to follow, and generally upon their fitness for advanced study in science applied to industry. Applications (which will not be considered after July 9) on forms to be obtained from the Education Officer, London County Council, Victoria-embankment, W.C.

BRITISH AND COLONIAL.

Accrington.—The Council are recommended to light Burnley-road electrically from the overhead wires on the tramway route.

Army Pageant Lighting.—During the evening performances the grounds of Fulham Palace (London) were lighted by arc lamps, metal filament lamps and searchlights, as follows:—

Twenty British Westinghouse "Arcturus" flame arcs, 10-ampere size, burning four in series on a 200-volt 50-period a.-c. circuit. Metal filament lamps for lighting the grand stand and two 40-ampere searchlights were used for illuminating the performances.

Australasia.—At the annual meeting of the Electrical Employers' Association of N.S.W., recently, Mr. E. J. Erskine was elected president for the ensuing year. The vice-presidents are Mr. A. J. Hanson and Mr. J. E. Donoghue, and the secretary is Mr. R. Burgin.

The "Australian Mining Standard" says Terang Shire Council have decided to put in additional plant and to substitute incandescent electric lamps for the arc lamps at present used for street lighting.

New plant is being put in at the Golden Horn gold mine, Charters Towers (Queensland), including a Siemens dynamo, driven by a 12½ H.P. gas engine, for lighting the mine.

New apparatus for treatment of slimes at the Cassilis Gold Mine, Gippsland (Victoria) includes electrically-driven centrifugal sand pumps.

Port Pirie (S. Australia) Council have adopted a report by their Lighting committee in favour of electric lighting in the town, and have instructed the committee to appoint an expert to advise them on the subject.

Bispham.—The Council have approved of an electric lighting scheme prepared by Mr. J. W. Speight.

Bray (Ireland).—The electrical engineer (Mr. W. J. U. Sowter) has recommended the Council to adopt the following revised scale of charging for electric current:—

Residences, private hotels, boarding houses, public institutions and churches, hotels open only during the summer months and shops closing at or before 8 p.m. five nights per week, 6d. per unit.

Shops with licensed premises attached and a portion open until 11 p.m. throughout the week, railway and all outside arc lighting where separate meters are fixed, 5d. per unit.

Clubs, licensed hotels open throughout the year, and public houses lighted entirely by electricity, 4½d. per unit.

General flat rate for all other classes 6d. per unit.

Bridlington.—The L.G. Board have sanctioned a loan of £2,975 for the extension of the electricity undertaking, repayable in 17 years.

Buckhaven (N.B.)—Fife Electric Power & Lighting Co. notify that they propose to apply for a provisional order for this district. The Council have decided to oppose.

Carlisle.—An inquiry was held on Wednesday into the application of the Council for sanction to borrow £19,600 for extensions of the electricity undertaking, of which £14,600 was for generating plant, &c., and £5,000 for new cables. The Inspector (Mr. H. Ross Hooper) pointed out, in the course of the proceedings, that the undertaking had no reserve fund, and he strongly urged them to stop paying money to relief of rates until the undertaking had been made financially sound.

Castleford (Yorks.)—The Council have decided to engage an electrical engineer to report on the question of electricity supply.

Customs Duties.—It has been decided that Marconi disc condensers are subject (as electric appliances, n.o.e.) to import duty of 30 per cent. ad val. under the New Zealand General Tariff and to 20 per cent. if of British manufacture.

Under the new customs tariff of the Dominican Republic, promulgated on Jan. 1 last, electrical machinery and apparatus (except lamps and fans) are subject to import duty of 10 per cent. ad. val., instead of the former rate of 73·8 per cent.

Darwen.—The charge for electric current for traction has been fixed at 1½d. per unit, less 2½ per cent.

Derby.—The action brought against the Corporation by Messrs. R. W. Blackwell & Co., the contractors for the local tramways, has been settled by the payment to Messrs. Blackwell of £732. 10s., being half the amount of the penalties deducted by the Corporation, each party defraying its own costs.

Droitwich.—Mr. F. T. Evered, having inquired whether the Council would assent to an application for a provisional electric lighting order, a resolution has been passed to oppose any electric lighting scheme on the ground that it would be detrimental to the gas undertaking.

Electrical Exhibition.—Woolwich Council are desirous of hearing from manufacturers, electrical contractors and others who may be desirous of submitting any electrical apparatus or speciality for exhibition purposes in connection with their central office and showroom which will be opened in a few days. Offers should be addressed to the Borough Electrical Engineer, Town Hall, Woolwich.

Grimsby.—The L.G. Board have sanctioned a loan of £1,420 for providing lampposts, &c., for street lighting.

Hackney (London).—Negotiations are proceeding between the electricity department and Messrs. Lewis Berger & Sons, who already take 300,000 units per annum, and are about to complete the electrification of their factory. They will require about 500,000 units per annum and are disposed to make a three years' contract.

Hampstead (London).—Last week the Council adopted a recommendation of the Lighting committee in favour of lighting the whole of the lamps in the borough (wherever possible) by two 35-watt electric filament lamps at £2. 5s. per annum (and where more powerful lamps are needed at an extra charge of 10s. per annum for each extra 35-watt) until the capital cost of conversion is repaid, and thereafter at £1. 10s. per lamp (with extra for more powerful lamps). The 237 lamps in the Belsize, Fawley-road, Mill-lane and West-end groups of roads are to be converted from gas to electric lighting, each lantern being fitted with two 35-watt lamps, at an estimated cost of £1,580.

Heston and Isleworth.—70 additional gas lamps are to be adapted for electric lighting, and the estimated saving by the conversion is £199. 14s. 10d. per annum.

By increasing the number of 50 c.p. electric street lamps from 226 to 296 the average cost will be reduced from £3. 18s. 7d. to £3, which is within 2s. 11d. of the recently reduced figure for gas lamps averaging 30 to 40 c.p.

After meeting all expenses, excluding any payment for the use of the Baths Hall, there was a net balance of £1. 14s. 6d. on the recent electrical exhibition.

Hull.—The city engineer has been instructed to prepare drawings and specifications for the extension of the Anlaby-road car shed so as to accommodate 24 cars, at a cost of £7,300, and also for the extension of the Hedon-road tramway to the entrance to the new Joint Dock.

Inverkeithing.—The Fife Tramway & Power Co. notify that they intend to apply for a provisional order for this district.

Islington (London).—The Council have adopted the recommendations of the borough electrical engineer (Mr. Gay) as to increasing the capacity of the mains at an estimated cost of £19,872 and also the construction of a new switchboard at a cost of about £3,000.

Leek.—On the recommendation of the Lighting committee it has been decided to increase the price of current for lighting by ½d. per unit on all flat rates, and consumers on the maximum demand system will be charged 7d. per unit for the first hour and 3d. per unit after.

Littleborough.—An unopposed inquiry was held here last week into the Council's application for sanction to borrow £3,500 for the equipment of a transformer sub-station and for laying a distributing network. The Council will take current in bulk from Rochdale Corporation.

L.C.C. Tramways.—On Friday last the running of through cars from Moorgate-street to Whipps Cross, on the border of Epping Forest, was commenced. The fare is 4d.

London County Council.—On Tuesday it was agreed to sanction loans of £10,665 and £5,236 to Hammersmith for electricity purposes.

Ploughs.—It was agreed that the assembling and fitting of the car ploughs required for 40 electric cars should be carried out by direct labour under the management of the Highways committee.

Electricity Meters.—Having considered the draft order proposed to be made by the Board of Trade in pursuance of Sec. 11 of the Electric Lighting Act, 1909, defining the limits of error to be allowed for electricity meters, the Highways committee recommended that no observations be offered on the proposed order.

Maldens and Coombe.—The Council have instructed Messrs. Handcock & Dykes to report on the question of electricity supply in this district.

National Electrical Manufacturers' Association.—The next committee meeting will be held at Balfour House, Finsbury-pavement, E.C., on 12th inst., at 2:30 p.m.

Obituary.—We regret to announce the death of the Hon. Maurice Gifford, C.M.G., of Boothby Hall, Lines., a director of the British Columbia Electric Railway Co. and other public companies.

The death is also announced of Mr. Frederic Nell, a well-known hydraulic engineer, of 46, Queen Victoria-street, London, E.C., and who was associated with many electrical schemes in the early days of the industry.

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Personal.—On Friday evening last a complimentary bohemian concert was held at Holborn Restaurant to mark the retirement of Mr. Alfred Eames, C.I.S.O., Controller of the Central Telegraph Office at St. Martins-le-Grand, after more than half-a-century's strenuous work. Prior to the concert Mr. and Mrs. Eames held a reception in one of the salons, and many old friends availed themselves of the opportunity to tender them their good wishes.

At the concert Sir Matthew Nathan, G.C.M.G., Secretary to the Post Office, presided, and was supported by several heads of departments, including Mr. A. F. King, second secretary; Mr. A. M. Ogilvie, under-secretary; and Mr. A. G. Leonard, assistant secretary. The Postmaster-General was able to be present for a short period.

Sir MATTHEW NATHAN said it was sad the staff should be losing so sympathetic a chief, the department so able an administrator, and the State so valuable a servant. But it was cause for gladness that on the eve of his retirement he should be singled out for high honour. Mr. Eames had grown up and grown old in the service of electric telegraphy. That practical science came to its majority when Mr. Eames, a boy of 12, joined the Electric Telegraph Co., and in 1870, when the private companies were taken over by the Government Mr. Eames commenced a service which had lasted for 40 years. He began as an operator at the lowest rung of the ladder, and he left it as Controller at the top. The staff under Mr. Eames had increased from 500 to 4,500.

Mr. H. SAMUEL, Postmaster-General, said Mr. Eames was remarkable for the fact that he had risen to a high position in a Government department, although he was born south of the Tweed. He found at the Home Office all the four heads were Scotsmen (laughter). Mr. Eames had watched the growth of telegraphy from its infancy to full development. Mr. Eames had seen vast improvements in the telegraphic service, and in his personal dealings with his staff he had proved that official relations might nevertheless be friendly.

Mr. EAMES briefly returned thanks, and said he would not like to go away without saying how grateful he was for the loyalty and hearty co-operation, and willing assistance which had been given him by everybody.

Presentation.—Bournemouth tramway staff have presented a pair of prismatic binoculars to Mr. F. T. Olding, late traffic superintendent, who is leaving for Queensland.

Salford.—Sub-committees of the Electricity and Tramways committees have arranged that electric current is supplied for traction at the present rate (1.3d. per unit) up to 7,000,000 units per annum; for all units in excess the charge will be 1d. per unit.

School Lighting.—The Education committee of the L.C.C. are to invite tenders for wiring the Sherington-street School, Greenwich.

Shoreditch (London).—The Council have concluded agreements for supplying a number of large consumers with electricity for lighting and power, including Messrs. J. Rotherham & Co. and Messrs. Stollwerck Bros. (for three years), Messrs. Waterlow & Sons (seven years), and the London Theatre of Varieties (five years). In Messrs. Waterlow's agreement a special coal clause is inserted, making the price per unit dependent on the price.

Smoke Abatement.—A deputation from the Smoke Abatement League recently waited upon the President of the Local Government Board (Mr. J. Burns) in regard to enforcing the law as to the smoke nuisance, &c.

In the course of his reply, Mr. BURNS said that he was opposed to the allocation of the profits on gas undertakings in relief of rates, as the effect of that was to make gas dearer than it ought to be, and so prevented its freer use as an illuminant and heater. The contentions of the deputation were that penalties should be increased, that central control and inspection should go hand in hand with local administration, that there should be general, as distinct from local, action both in regard to penalties and standards of smoke, and that there should be national and uniform supervision as against intermittent action on the part of a few public-spirited local authorities. Finally, they asked that areas outside cities should have similar penalties to the cities which they adjoined, so that a man could not get over the border and escape from smoke liabilities and responsibilities. Mr. Burns associated himself with the practical object of the deputation. He believed that much improvement could be accomplished if employers would give practical and technical instruction to their stokers, and afterwards some little encouragement in the shape of extra wages. There were several difficulties to be faced. At present legislation, with the exception of Nottingham, struck only at the factory, the workshop and large undertakings. He agreed that legislation should be made possible in many of the directions they had indicated, but they had not dealt with one of the chief causes of smoke nuisance—namely, the domestic house. In that matter he anticipated more from general progress than from legislation. Great progress had been made in the designing of furnaces, and electric and gas power was gradually taking the place of detached and badly constructed factory boilers and smoky chimneys. All those improvements were a step in the direction of abating the smoke nuisance to which they had not perhaps attached sufficient importance. Whilst there were in Greater London about 35,000 factories and workshops, the dwelling houses numbered 1,000,000. Unless anthracite was insisted upon (which he thought impossible) for every one of those 1,000,000 houses, reform could only be looked for by the education of public opinion. Reform was coming more rapidly than some people thought, in the shape of improved stoves and grates and by the supersession of the coal grate and heater by gas and electricity. He hoped that the day was not far distant when manufacturers would be able to obtain power for their factories and workshops from some central works, where combustion could be much more easily controlled than it now was in the smaller units.

South Africa.—Johannesburg Municipality are in the market for poles, cross-arms and fittings, in connection with electric lighting extensions.

Two large h.-t. generators will be required in connection with the proposed scheme for transferring the Natal Government Railways generating station to Durban municipality.

An electric winder has been ordered from England for the Cinderalla Deep mine.

Southend-on-Sea.—On the recommendation of the Light Railways committee, the Corporation have approved an agreement with the Southend & Colchester Light Railways Co. for an arrangement in regard to the mutual conveyance of passenger and parcels traffic on the light railway between Prittlewell and Victoria Corner and between Prittlewell and Rochford.

Stevenage.—The Council have asked the Board of Trade for a further extension of their 1902 Electric Lighting Order, as negotiations are proceeding with the Electric Supply Corpn. and Messrs. Crompton & Co. with regard to the erection and equipment of electricity works.

Torquay.—The Corporation have adopted a recommendation of the Tramway committee not to consent to the conversion of the local tramways from the surface contact to the overhead system; and in the event of negotiations with the Tramway Co. failing to bring about a satisfactory arrangement the committee have been empowered to refer the matter to arbitration.

Mr. PIKE, chairman of the Tramway committee, stated that they were carrying out the Council's instructions, and were pursuing the negotiations. They did not apprehend that the trams would stop on Oct. 31 next, and he had no doubt that the matter would come out all right.

Warrington.—The salary of the tramways manager (Mr. John Telfer) has been increased to £234 per annum.

Wednesbury.—On Monday the Council approved an agreement for continuing the appointment of Mr. William Fennell, engineer and manager of the electricity works, for three years at £275 for two years and £300 for the third year.

West Hartlepool.—The question of the purchase of certain sections of the Hartlepools tramways by the corporation was again discussed by the Council on Wednesday, when it decided to retain counsel for the arbitration proceedings.

Wigan.—The price of electric energy for traction has been reduced from 1½d. to 1¼d. per unit as from April 1 last.

Winchester.—The City Council, which has decided to purchase the local electricity works, has notified that it will apply for a provisional order to extend the area of supply so as to include the whole of the city, and also certain portions of the rural district of Winchester, including Chilcomb, Easton, Compton, Twyford, Weeke, Littleton, Abbots Barton, Headbourne Worthy, King's Worthy, &c.

Wireless Telegraph Notes.—The installation of wireless telegraphy, which the Spanish Government have organised at the Canary Islands is approaching completion. The Popp system has, it is reported, been adopted, and the radius of communication is claimed to be 3,000 miles. The management of the station at Puntales is in French hands, and it is stated that messages have already been successfully received in Paris from this station.

The Australian Commonwealth authorities are linking up Papua with the mainland by wireless telegraphy. The above connection is in addition to the adoption by the Commonwealth Government of the recommendations of the Conference for linking up the British islands in the Pacific by wireless. High-power stations are to be erected at Sydney, Doubtless Bay (N.Z.), Suva and Ocean Island, and smaller stations in the New Hebrides and the Solomons.

Amongst the important lines of steamships now being equipped with wireless telegraph apparatus are the vessels of the Orient Line, the "Otranto" being the first vessel to be completed

Through the mishap to the "Trieste," concerning whose whereabouts and fate great anxiety was shown over a long period, the attention of several Governments has been directly drawn to the subject of the wireless equipment of all passenger ships. Although the "Trieste" was never off the regular steamer ocean route no word was heard of her from June 14 to July 1.

Wireless Telephone Note.—To the "Glasgow Herald" for Tuesday Mr. C. R. Gibson contributed a popularly-written article on the achievements and prospects of wireless telephony.

Woolwich.—Electric supply mains are to be extended at an estimated cost of £270.

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ELECTRICITY SUPPLY TABLES AND DATA.

This Valuable Set of Tables and Engineering Data relating to Electricity Supply and to Electric Traction on Railways and Tramways in the United Kingdom, the Colonies, and some important places abroad, is now ready, and can be obtained complete in handy book form, price 6s. 6d. post free, or on very hard paper for rough or constant use, price 8s. 6d. post free. A complete Index is included.

Sports.—The annual athletic sports in aid of the London United Tramways Employés' Philanthropic Fund took place last week at Twickenham. Mr. A. H. Stanley (general manager) was present, and Mrs. Stanley presented the prizes.

The Manchester Corporation Tramway employés sports took place on two evenings last week at Fallowfield. The weather was cold and unsettled.

Annual Outing.—The staff and employés of Tunbridge Wells electricity department had their annual outing last week.

The party travelled by train to Portsmouth and partook of luncheon and tea at the Speedwell Hotel. Mr. J. W. Beauchamp (borough electrical engineer), who occupied the chair, said he regretted that Mr. Boot, consulting electrical engineer to the Corporation, was unable to be present. They were reaping the advantage of the new machinery installed last year under Mr. Boot's supervision. Mr. Beauchamp also spoke of the excellent work carried out by the local wiring contractors, who were represented amongst the guests. He looked forward confidently to the success of the electricity undertaking.

Mr. J. P. STRANGE (for the contractors) said he trusted the good feeling between the electricity department and the contractors would be strengthened in future.

FOREIGN.

Austria.—The Minister of Railways has granted to the Meran and Bozen communal authorities a concession for the construction and working of a light electric railway in Meran.

China.—Consul Goffe (Nanking) writes in his annual report that an electric light company with native capital was formed early in 1909, machinery being obtained from the U.K. It is hoped to commence supply during the current year.

Denmark.—Consul Liddell reports that a scheme is being planned for the construction of an electric railway between Aarhuus and Randers (Jutland) and the supply of electricity in the districts en route. A similar scheme is proposed for the district between Laaland and Falster, with a power station at Maribo.

Patent Law in Holland.—It is announced that the new patent law has been passed by the Second Chamber of the States General and is almost certain to be adopted by the First Chamber within the year. There is a clause for the granting of compulsory licences at the end of three years for patents which have not been worked by the inventors in the kingdom, and another requiring compulsory working either by the patentee or his licensee within five years from the date of grant of the patent.

Portuguese East Africa.—The "British and South African Export Gazette" states that plant and material will shortly be required for a complete telephone service for Lourenço Marques.

Russia.—The Russian Budget for 1910 includes sums of 5,848,000 roubles (£617.289) for construction and repair of telegraph and telephone lines and 65,156,714 roubles (£6,877,653) for extensions of and rolling stock, &c., for State railways.

Consul H. M. Grove (Moscow) states that Saratoff (at which town there is a great demand for electrical material of all sorts) is very largely inhabited by Germans. British firms desiring to do business in Saratoff should write in German, quoting in marks or roubles.

Spain.—The report of Mr. A. Robertson (second secretary to H.M. Embassy at Madrid) for 1909 states that action has been taken in Madrid against commercial travellers for contravening a provision in the Industrial Contribution Law of 1896, that "sellers of articles of novelty of all kinds who keep no open establishment, but receive orders with the right to sell in the whole peninsula," must pay 1,500 pesetas (£55. 11s.) for the privilege.

Imports into Spain for 1909, 1908 and 1907 respectively included the following: Dynamos, electric motors, &c., up to 400 kilos in weight, £113,486, £101,142 and £97,977; from 401 to 2,500 kilos, £149,031, £124,839 and £137,555; from 2,501 to 5,000 kilos, £22,852, £27,311 and £15,094; over 5,000 kilos, £149,031, £127,724 and £64,865. Electric wire over 1 cm. thick, £61,460, £80,433 and £241,812.

Vice-Consul Lovelace (*Dijon*) says the U.K. is holding its own as regards exports of machinery in general to this district, but no headway is being made in electrical machinery and appliances, although these goods are being imported in ever-increasing quantities from Germany.

Vice-Consul Castro (*Corcubion*) says the Brens river supplies sufficient power for the public electric lighting of the towns of Cée and Corcubion, and the acetylene gas works at Brens obtain 6,000 H.P. from the Ezare waterfall, about 6 miles distant.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Bath.—At the meeting of the Council on Tuesday the chairman of the Electric Light committee (Mr. H. T. Hatt) presented the accounts for the past year.

After paying expenses and providing for interest and sinking fund, there was a deficit of £1,400 on the year's working; but, owing to calling upon reserve and suspense funds, the sum recommended to be raised from the next general district rate was only £580. Mr. Hatt said the loss was mainly due to a rapid change over to metal filament lamps. In 1908 they paid off a £30,000 loan, and thus their expenditure and repayment of capital would be £3,000 a year less than now, while the action of the new lamps would prevent the need of increased power to supply additional customers.

Burnley.—Total receipts of the electricity department for the year ended March 31 was £22,998.

Works costs, management expenses, &c., were £11,912. Gross profit was £11,085, and after paying interest on loans (£2,781) and sinking fund (£4,141), and providing for depreciation (£648), &c., there was a surplus of £3,500, which has been applied in relief of rates. £114,000 has been borrowed for the undertaking, and £30,430 paid off, leaving £83,570. Units sold were 3,249,387 (223,395 for power, 749,145 for private and 7,522 for public lighting, and 2,269,325 for traction), against 3,148,875 in 1909; works costs were 0·621d. per unit (against 0·640d.), and the total costs (including interest and sinking fund) 1·392d. (against 1·335d.) There are 998 consumers (against 864), with the equivalent of 72,908 30 watt lamps connected (against 64,692). There are motors of 710¾ B.H.P. connected (against 591 B.H.P.); the load factor was 20·93 per cent. (against 22·75 per cent.), and the maximum load was 2,640 kw., against 1,890 kw. The units sold for lighting increased by 12·77 and for power by 17·54 per cent.; but there was a small decrease (0·81 per cent.) in the traction sales. Lamps connected show an increase of 12·68 per cent. The increase in capital expended was £11,649 (for boiler house plant, a 750 kw. generating set, condensers, &c.).

Chester.—The income from the sale of electricity during the year ended March 31 was £18,212, including £10,021 from private consumers for lighting, £594 for power, £3,867 for public lighting and £2,324 for traction.

Total working expenses were £9,710, leaving gross profit £9,253. Interest came to £3,794 and sinking fund to £3,424. £1,198 was transferred to renewals fund and the balance (£848) placed to reserve. Capital expended is £122,380, an increase of £4,089. 2,293,669 units were generated, 1,010,675 sold to private consumers, 492,296 supplied to public lamps (197 arcs and 719 incandescents) and 366,102 to the tramways department. The maximum supply demanded was 1,400 kw. Works costs per unit sold were 0·658d. (same as in 1909) and total costs 0·935d. (against 0·986d.).

The traffic revenue of the tramways department was £12,038, and the total income £12,464. Working expenses were £7,999. 16s., leaving gross profit £4,464. 10s. 3d. Interest absorbed £2,784, sinking fund £1,018, and the balance (£707) was placed to reserve. Capital expended is £82,785, against £82,813 in 1909. 2,989,706 passengers were carried (against 2,975,590), the car-miles run 346,701 (342,343) and the total number of units used 306,102 (against 335,836).

Glasgow.—The total receipts of the tramways department for the year ended May 31 were £896,720 (against £892,750 in 1908-9), and the traffic receipts were £893,591 (against £889,530).

Working expenses were £502,911 (against £505,617), leaving a balance of £393,809 (against £387,133). Adding interest on surplus revenue account, &c., the gross surplus was £431,549 (£416,924). Deducting rental of Govan and Ibrox tramways (£5,073), proportion of receipts due to Paisley lines (£4,668), interest (£72,289), sinking fund (£85,086), income tax (£15,985), depreciation (£110,688), permanent way renewals (£82,918) and parliamentary expenses (£1,814), the net surplus was £53,028 (against £66,275), which has been transferred to the common good. The average traffic revenue per car-mile has been reduced from 10·262d. to 10·225d. The amounts expended on rates and taxes, third party insurance, permanent way maintenance, and repairs to cars show a decrease of £1,175, £3,385, £1,243 and £3,725 respectively. The balance of tramway debt owing to the Common Good is £2,534,687, and the balance standing at credit of depreciation and permanent way renewals fund is £1,537,641, and at credit of general reserve fund £68,375. The total length of single track is 195 m. 1 fur. and 103 yds. There are 486 top-covered cars, 206 standard cars and 111 converted horse cars, total 803. The car-miles run during the year were 20,974,016, and the number of passengers carried 222,730,571. The percentage of working expenses to receipts was 56·083d. The average working expenses per car-mile (excluding power) was 5·343d., and including power 5·755d.

Hammersmith (London).—The net income from the sale of electric current to private consumers during the year ended March 31 was £44,756. 12s. 3d., and with public lighting revenue (£5,642), meter rent and miscellaneous receipts the total income was £53,433 (against £55,981).

Working expenses were £28,278, and included £14,092 for generation, £2,787 for repairs and maintenance, £3,666 for distribution, £1,407 for public lamp maintenance, £2,593 for management and £2,669 for rates and taxes. Gross profit was £25,155, and after providing for interest (£8,482), redemption of loan capital (£12,491), accruing loan charges, &c.,

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there was a net profit of £3,483 (against £4,904). The capital outlay is £321,691, an increase of £10,250, but the net debt is only £246,298. 7,054,926 units were sold (against 6,762,861), and the average price obtained was 1·5d. (1·57d.) per unit for public and 1·69d. (1·78d.) for private lighting. There are 2,577 consumers (against 2,336), and there are 385 motors, with the equivalent of 4,587 H.P., connected to the mains, against 339 motors of 2,665 H.P. There are 191 arcs, 63 small arcs and 521 incandescent lamps for public lighting. The maximum supply demanded is 4,653 kw.

The borough accountant (Mr. A. G. Keen), reporting on the accounts, states that the balance of accumulated profit is £850. 18s. 6d., which has been arrived at after writing off amount of loan still unredeemed in respect of plant disposed of (£4,461) and also meeting balance of cost of new turbo-alternator (£2,408), making a total charge against appropriation of profit account for the year of £6,869.

Hull.—The income of the tramways department for the year ended March was £136,985.

Working expenses were £86,098, and after paying interest (£13,776), loan repayment charges (£10,287), contributions towards cost of widening streets (£2,527), and income-tax (£1,355), there was a surplus of £22,942, out of which £16,000 has been voted to relief of rates, leaving £6,942 to be transferred to reserve.

Manchester.—The traffic revenue of the municipal tramways department for the year ended March 31 was £777,219, miscellaneous receipts were £8,546, and parcels revenue £2,264; total £788,029.

Total working expenses were £511,070, including £225,932 for traffic expenses, £74,101 for general expenses, £87,466 for repairs and maintenance and £123,571 for power. Gross profit was £276,959. Interest (£53,500), income tax (£5,661), rent of leased lines (£25,753), &c., were paid, leaving £196,283. Sinking fund (£47,215) and provision for reserve, renewals and depreciation (£70,021) were also met. £75,000 was applied in aid of rates, and the balance (£4,047. 10s. 1d.) in street improvements round the infirmary. The lines open for traffic aggregate nearly 182 miles of single track, of which 876 yds. were opened last year. 159,049,096 passengers were carried, against 155,011,884 in 1908-9, and 17,161,774 car-miles run (17,316,753). Gross capital expenditure is £1,957,594, against £1,837,090.

Newcastle-on-Tyne.—The accounts of the tramways department for the year ended March 31 were approved by the Corporation last week.

The income was £203,339. 4s., but £5,727 had to be paid to the Tyneside Tramways and Tramroads Co., leaving £197,611. 18s. 7d., against £197,885. 4s. 6d. After paying working expenses and providing for interest and sinking fund there was a balance of £15,156 which was carried to reserve and renewals fund.

The chairman of the Tramways committee (Mr. RODGERS), in reviewing the accounts, said that during the nine years the trams had been running they had paid £264,144 off their debt., and had a reserve of £75,272. If they deducted these two sums from the original debt the balance was £836,501.

Oldham.—The report of the borough electrical engineer (Mr. S. Wilmott Newington) states that the capital expended on the electricity undertaking to March 31 was £295,476, an increase of £6,205 during the past year.

The gross revenue was £41,915 and the expenditure £21,772, leaving £20,143 to meet interest (£7,686), sinking fund (£8,237) and interest transferred to sinking fund (£1,824), showing a net profit of £2,203 to be carried forward. 1,859,799 units were sold for lighting and power (against 1,174,067) and the revenue showed an increase of £1,134; 3,860,532 units were sold for traction (against 4,335,972), and the revenue showed a decrease of £3,347. There are 1,226 consumers (against 1,038), and the equivalent of 164,360 8 c.p. lamps is connected (against 146,113). The maximum supply demanded was 1,476 kw. (against 1,363 kw.), and the load factor was 19·68 per cent. (against 21·73 per cent.) Works costs were 0·672d. (against 0·677d.) per unit sold, and the total costs 0·908d. (against 0·910d.).

Sheffield.—The accounts of the electric supply department for the year ended March 25 have been issued and show total receipts from the sale of electricity for lighting power, heating, &c., of £70,641, a decrease of £2,232.

Gross expenditure was £24,354 (against £25,026) and gross profit £51,142 (against £52,702). After providing for interest and sinking fund, &c., there was a deficit of £2,035. There was a drop in receipts for lighting (from £53,117 to £46,265) and there was a decrease of 312,150 in the units sold for lighting owing to increased use of metal filament lamps; but there was an increase of £4,593 in receipts for power (from £18,891 to £23,484), and of £134 for heating.

The chief engineer and manager (Mr. S. E. Fedden) considers that the decrease in the units sold for lighting will probably continue for some time, but as the new connections for the year were 299, against 217 in 1908-9, the department was already beginning to benefit by the reduction in cost to the consumer, and it is expected that the increase in revenue from new connections during next year will counterbalance further reductions from installations changing over to metal filament lamps, so that the lighting revenue during the current year should not be less than this year. The power side of the account was as satisfactory as the light side is the reverse. The figures showed a continuous growth. The power units show an increase of about 1,500,000 over last year's sales, and it is anticipated that there will be a still greater increase during the coming year. Most of the large manufacturing concerns in the city find it to their advantage to take a supply of electrical energy from the Corporation mains. It is also expected that several electric smelting furnaces will be connected during the year, thus largely increasing the power load. The total number of units sold was 10,317,933, compared with 9,029,741. The net decrease in the total revenue was £2,232. Reductions were effected during the year in generation, distribution and management costs. Total costs show a decrease of £672. Total cost per unit was brought down to 0·57d., or 0·09d. less than last year.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

GRIMSBY Corporation invite tenders for supply of 50 c.p. (about) metal filament lamps for 12 months. 300 posts are to be erected. Specifications, &c., from the borough electrical engineer, Mr. W. A. Vignoles, M.I.E.E., Corporation Electricity Works, Grimsby. Tenders by first post July 15. See also an advertisement.

The Lighting committee of DUBLIN Corporation invite tenders for the supply, and the supply and erection of transformers. Specifications, &c., from the city electrical engineer, Mr. Mark Ruddle, Fleet-street, Dublin. Tenders to the Chairman of the Lighting committee, 3, Cork-hill, Dublin, by noon July 16. See also an advertisement.

ST. PANCRAS (London) Borough Council invite tenders for supplying a marine type water-tube boiler, fitted with induced draught. Copies of specification, &c., from the electricity department offices, 57, Pratt-street, Camden Town, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett), Town Hall, Pancras-road, N.W., by 10 a.m. of Monday July 11.

LONDON County Council invite tenders for wiring and fitting for electric light of the second portion of the central car repair depot Woolwich-road, and the supply and delivery of l.t. cables, cable boxes, &c., at the central depot. Specifications, forms, &c., from the Clerk of the Council, Mr. G. L. Gomme, County Hall, Spring Gardens, S.W. Tenders by 11 a.m. of July 12.

LONDON County Council also want tenders by 11 a.m. July 19 for the roadwork and platelaying required for the construction of tramways in Battersea Bridge-road and Beaufort-street, Chelsea, on the underground conduit system, and for paving work. Specifications, &c., from the Chief Engineer, Spring-gardens, S.W.

FLEETWOOD Council require tenders by noon July 15 for supply of a 300 kw. steam dynamo, a l.-t. main switchboard and a 10-ton overhead travelling crane. Specifications, &c., from the Electrical Engineer, Albert-square, Fleetwood.

WALTHAMSTOW Council want tenders by noon July 22 for supply and fixing of a railway weighbridge at the siding adjoining the electricity works. Specification, &c., from the Electrical and Tramways Engineer.

EDINBURGH School Board want tenders by July 12 for the electric lighting of the workshops at the Tynecastle elementary school. Plans may be seen with Mr. Carfrae, 3, Queen-street, Edinburgh.

FULHAM (London) Council want tenders by 4 p.m. July 13 for 12 months' supply of electricity meters. Forms of tender, &c., from the Borough Electrical Engineer, Townmead-road, Fulham, S.W.

WALTHAMSTOW Council want tenders by noon July 22 for supply of car bodies, trucks and electrical and magnetic brake equipments for six double-deck roof-covered tramcars. Specifications, &c., from the Electrical and Tramways Engineer, Priory-avenue, Walthamstow.

WEST HAM Education committee want tenders by 6 p.m. July 18 for electric lighting installation work at West Silvertown school. Specifications, &c., from Mr. Wm. Jacques, 2, Fen-court, E.C.

SWANSEA Harbour Trustees require tenders by 10 a.m. July 15 for three 2-ton electric transporters and overhead travelling cranes. Forms of tender, &c., from the Clerk.

SALFORD Corporation require tenders by noon July 18 for a borehole pumping plant for their electricity works, Pendleton. Particulars from the Borough Electrical Engineer.

MANCHESTER Tramways committee want tenders by 10 a.m. July 19 for supply of h.d. copper trolley wire. Specification, &c., from Mr. J. M. McElroy, 55, Piccadilly, Manchester.

The NEW SOUTH WALES State Railways Department require tenders by July 18 for supply and erection of three 5-ton overhead electric cranes and one 1½-ton and one 1-ton electric travelling crabs. Particulars from the Electrical Engineer, Sydney, N.S.W.

Tenders are invited up to Aug. 2 for the supply and delivery of 1,820 private letter box fronts to the Postmaster-General's Department in the States of VICTORIA, QUEENSLAND, SOUTH AUSTRALIA

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and WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to July 27 for supply of a pneumatic tube service to the Postmaster-General's Department at ADELAIDE (S. Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to July 19 for supply and delivery of 4.200 telephone sets (as per schedule No. 231) to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The Société Nationale des Chemins de fer Vicinaux, BRUSSELS, want tenders by July 20 for underground cables, and by July 27 for the equipment of a transformer station.

The Ministerio de Fomento, MADRID, will receive tenders until July 30 for the construction of an electric (or steam) strategic railway from Requena to Alcaráz, via Casas Ibáñez and Albacete. The contract is open to Spanish firms only.

The Ministry of Marine, PARIS, will receive tenders until July 24 for supply of electrical apparatus. Total requirements about £10.000.

COPENHAGEN Corporation require tenders by noon July 16 for supply of three water tube boilers, with superheaters and mechanical stokers, for the Elektrisk station, Gothersgade 30, Copenhagen, where specifications may be obtained.

TENDERS RECEIVED AND ACCEPTED.

Southwark (London) Council received the following tenders for a turbo-generator :—

General Electric Co. (*prov. accepted*), £3,130; C. A. Parsons & Co., £4,265; Willans & Robinson, **£3,601**; Union Electric Co., £1,167 (generator only); Lancashire Dynamo & Motor Co., £1,509 (generator only); Electric Construction Co., £1,087 (generator only); James Howden & Co., £4,412; British Westinghouse Co., £3,170; P. J. Mitchell £3,192; Bellis & Marcom, £3,372; British Electric Plant Co., £3,950; John Musgrave & Sons, £4,498; Brush Co., £3,375; British Thomson-Houston Co., £3,200.

For condensing plant the following tenders were received :—

Worthington Pump Co. (*prov. accepted*), **£1.888**; J. P. Hall & Sons, £1,495 (piping excluded); C. A. Parsons & Co., £1,974; Willans & Robinson, £1,801 (piping excluded); W. H. Allen, Son & Co., £1,721 (piping excluded); Clarke, Chapman & Co., £2,923; British Westinghouse Co., £1,261 (piping excluded); Cole, Marchent & Morley, £1,643 (piping excluded); Bellis & Marcom, £1,809 (piping excluded); United Brassfounders (Ltd.), £1,520 (piping excluded); Ledward & Beckett, £5,267 (evaporative, and cooling tower); Ed. Deane & Beale, £4,504 (evaporative, and cooling tower); Mirrlees-Watson Co., £1,961; Brush Co., £1,755. 10s.; Klein Engineering Co., £1,766 (barometric); Midland Engineering Co., £1,860; and Davenport Engineering Co., £1,650 (barometric).

The following tenders for a cooling tower were also received :—

Davenport Engineering Co. (*prov. accepted*), **£1,327**; W. H. Roy & Co., £1,595; Midland Engineering Co., £1,371; Worthington Pump Co., £1,850; Hudson Economiser Co., £1,417. 5s.; Balcke & Co., £1,581.

Hull Electric Lighting committee have received the following tenders for supply and laying of electric mains, &c., during the year ending March, 1911 :—

Siemens Bros. & Co. (*accepted*)	**£6,772**
Johnson & Phillips	6,866
British Insulated & Helsby Cables	6,876
Callender's Cable & Construction Co.	6,929
W. T. Glover & Co.	6,935
W. T. Henley's Telegraph Works Co.	6,953
Western Electric Co.	6,978
Lahmeyer Electrical Co.	7,181

London County Council have accepted the tender of the Brush Electrical Engineering Co. (lowest tender) for destination indicator boxes for tramcars at £3. 7s. each (total £603). (Five tenders received; highest £5. 12s. 6d. Chief officer's estimate £575. The Brush Co. are to be allowed to sublet the manufacture of the brass furniture to E. Showell & Sons, Ltd.)

Woolwich Council have accepted the tender of Sanders, Rehders & Co. (at £34. 10s.) for a CO_2 "Sarco" recorder for the electricity works, and that of Carter & Wright for a 15 in. centre lathe with accessories for £135.

The "British and South African Export Gazette" states that the General Electric Co. (N.Y.) recently shipped a quantity of switchgear for the Roodepoort United Main Reef Gold Mining Co., which has also purchased 110 motors from the A.E.G. of South Africa (Ltd.).

Liverpool City Council have accepted the tenders of Pulford Bros for upkeep of three sets of accumulators for electric vehicles at £18. 18s. per set per annum, and W. R. Taylor & Co. for oils, paints, &c., for the tramways and electric lighting departments.

Eccles Council have accepted the tender of Stewarts & Lloyds for steel steam pipework at £14. 12s. 6d., and that of H. J. & A. Coulthurst for c.i. condensing water pipework at £25. 10s.

Kingston-on-Thames Council have accepted the tender of Prestwich & Burt for six feeder panels for h.-t. switchboard and other work, at a cost of £334. 19s.

Staffordshire Education committee have accepted the tender of the Walsall Electrical Co. for wiring the Dorsett-road schools, Darlaston.

Margate Council have accepted the tender of the Jandus Arc Lamp Co. for five arc lamps at £6. 16s. each, and that of Kingston & Co. for wiring the Westbrook Pavilion at £43.

Manchester Tramways committee have accepted the tender of the Lorain Steel Co. (Johnstown, U.S.A.) for the supply of special track work.

Southend Light Railways committee have accepted a quotation of the Jandus Arc Lamp Co. for supply of nine enclosed flame arcs for £73.

Wrexham Council have accepted the tender of the British Insulated & Helsby Cables for the supply of electric cables.

Derby Corporation have accepted the tender of W. H. Keys (Ltd.) for 20 tons of bitumen.

Salford Council have accepted the tender of P. R. Jackson & Co. (at £39. 15s.) for a spare armature.

Rochdale Council have accepted the tender of Whipp & Bourne for boosters, &c.

Leyton Council has accepted the tender of Fraser & Fraser (at £70. 10s.) for an ash elevator for the generating station.

Accrington Council have placed an order with the Brush Co. for two double-deck tramcars at £740 each.

Stoke-on-Trent Council have placed an order with the British Westinghouse Co. for six 30 kw. transformers at £44. 10s. each.

Bridlington Council have accepted the tender of Waring & Gillow for illuminations on the Royal Prince's Parade at £200.

BUSINESS NOTICES.

Mr. John Wood, junr., has been admitted a partner in the firm of Mosses & Mitchell. The style of the firm remains unchanged.

Brook Shaw and Ernest H. Pickford (trading as Brook, Shaw & Co.), mechanical and electrical engineers, 264-266, Ecclesall-road, Sheffield, have dissolved partnership. Debts by Mr. Pickford.

The Asbestos & Engineers' Stores Co., 56, Bermondsey-street, S.E., announce that they have secured the services of Mr. Wm. Deller.

The partnership between J. H. and W. G. Stones, engineers and patent agents, 10, Richmond-terrace, Blackburn, carried on under the style of Stones & Stones, has been dissolved. Debts by Mr. J. H. Stones.

Sale by Auction.—Mr. W. H. Robinson will sell by auction at the Albion Hotel, Piccadilly, Manchester, on Tuesday, July 19, at 5 p.m., a plot of freehold land, containing about 5,089 sq. yds., together with substantially built premises recently occupied by Messrs. W. Brown & Sons (contractors and builders, Salford) and their subtenants. The purchaser will have the option of buying the machinery, plant and fixtures on the premises within seven days from date of sale. The land and premises are conveniently situated, and are opposite to the principal entrance of and in close proximity to the most central portion of the Manchester Ship Canal and its docks. Further particulars from the Auctioneer, Cromwell-buildings, Blackfriars-street; from Messrs. Charles Dunderdale & Co., solicitors, Marsden-street; or Messrs. March, Clayton & Pearson, 22, Bath-street, Manchester. See also an advertisement.

Patent Development.—The proprietor of British patents Nos. 14,304 1899 and 16,489/1902, relating to "Improvements in and the Application of Electric Motors for Automobile Vehicles," desires to enter into arrangements for developing and working same in this country. Applications to Messrs. W. P. Thompson, & Co. 285, High Holborn, London, W.C.

Agent Wanted.—A German firm manufacturing watertight electrical appliances requires an agent to sell goods on commission.

"A.E.G. Bulletin."—The July issue of this Bulletin is of interest mainly on account of its articles on the A.E.G. steam turbine. This

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is written by H. Treitel, and contains a number of efficient diagrams. The Bulletin also includes a description of the lighting of the Kaiser Hof at the Brussels Exhibition.

Small Motors and Vacuum Cleaners.—A small dynamo and motor list is being issued by the Eclipse Electric Co., St. John's-road, Bootle. The dynamos have been built specially for direct coupling to petrol and paraffin engines. The prices of these machines are extremely moderate. The same firm send us details of a motor-driven vacuum cleaner, illustrated herewith, which is suitable for use in hotels, large private houses, flats, public buildings, &c. The double bellows are operated by a connecting rod from a large pulley which is belted up to the motor. The latter develops ¼ H.P. and is compound wound. The motor is protected by a d.p. fuse and a

tumbler switch only is used for starting. The entire outfit is mounted on wheels and with each machine a number of suction nozzles are provided.

CATALOGUES, &c.

Conduit Wiring.—We have received a copy of the third edition of Conduit Wiring, by L. M. Waterhouse, managing director of Simplex Conduits (Ltd.). We understand that this edition brings the total number published of this useful book to 20,000 copies. The present volume contains a number of useful additions, particularly on lamps and illumination, electric ventilation, breakdown of cables, &c. The book is a very complete exposition of Simplex conduit wiring practice.

Waterproof Switch Boxes.—Messrs. Siemens Bros. Dynamo Works are publishing a pamphlet which gives the prices and general particulars of their weatherproof switchboxes and ironclad motor control panels. These are all of the weather-proof type, and are fitted with the latest pattern of "Zed" fuses.

Precision Instruments.—A catalogue of testing instruments, which deals with precision type wattmeters and current and pressure transformers, has been published by Messrs. Siemens Bros. & Co. The instruments are listed with pivoted and suspended movements, both of these being in two types. The current and pressure transformers are quite portable and are guaranteed of high efficiency.

G.E.C. Publications.—From the General Electric Co. we have received a copy of the G.E.C. progress sheet and pamphlets dealing with Osram lamps, cast-iron wall plugs and measuring instruments. Included in the progress sheet is a line of G.E.C. electrically-driven portable vacuum cleaners. Considerable space is also given to Aron motor meters. From the same quarter also we have received copies of a booklet describing portable battery-driven electric fans and the fold-easy telephone bracket. The latter is an extremely convenient device which can be adapted either to the wall, desk or table.

Osram Lamps.—At the recent fancy dress roller skating carnival at Long Eaton, Mr. A. Burns, a local electrician, obtained first prize for the most original costume representing a well-known advertisement. Mr. Burns selected a number of Osram window and show cards and illuminated these with small battery Osram lamps. He also attached coloured Osram lamps to each shoulder, one on each sleeve and one on each leg, while his head dress comprised a peaked cap shaped to represent an Osram lamp. Two 20 ampere-hour accumulators used alternately and strapped on the shoulder supplied the necessary energy.

BANKRUPTCIES, LIQUIDATIONS, &c.

At Liverpool Bankruptcy Court on Friday an application was made to Judge Thomas to grant the discharge of Alfred Horswill Gibbings, electrical engineer.

The Deputy Official Receiver (Mr. T. W. J. Britten) reported that the receiving order was made against debtor in March, and his statement of affairs disclosed liabilities £2,783, and assets (chiefly furniture) £59. The assets produced only £14. After paying a preferential claim there was a balance of £12 for costs, and that amount was insufficient by £15 to cover. No dividend could be paid to unsecured creditors. Debtor had held various appointments as electrical engineer. In 1908 he entered into an agreement to act as consulting engineer to the North British Electrical Power Synd., which completed a scheme of supplying electrical energy at cheap rates by utilising way leaves along railway lines. The scheme was spoilt (according to debtor) by the insertion of a clause in the Electric Lighting Act, 1909, prohibiting a private company from supplying electrical energy in competition with a local authority (or other statutory undertaker) without a provisional order. The syndicate was dissolved, and to that the debtor attributed his insolvency.

On behalf of debtor Mr. Cuthbert Smith said the £250,000 capital needed for the electric supply scheme had been secured. But for the clause referred to that undertaking would have been carried out, and Mr. Gibbings would have realised £15,000 in fees alone and a large permanent income. Most of his debts had been incurred in conducting the negotiations and securing wayleaves for the scheme. The creditors were mostly makers of electrical plant, who were to benefit from the scheme, and had advanced money to him after he had fully disclosed to them his financial position. No creditor opposed his discharge. He was now in employment, earning £4 a week, and in view of the special circumstances he asked for his discharge, offering to find £55 to pay off all the purely domestic debts.

His Honour said the bankruptcy was of an unusual character. He was satisfied most of debtor's liabilities were incurred in the way referred to by him and with the knowledge and willing assent of all the parties concerned. The case, therefore, came very near one that was due to circumstances beyond debtor's control. He thought justice would be met by granting the discharge, subject to consent to judgment against the debtor for £150 and the £15 due for costs, execution not to be levied without leave of the Court. To this course debtor consented.

On Friday the public examination was concluded of E. W. J. Peterson, solicitor, 59, Lincoln's-inn-fields, W.C. whose accounts show a deficiency of £1,549.

Debtor stated that for the past 10 years he had devoted his time to the promotion of light railways and similar undertakings in various parts of England.

A receiving order has been made against Frank Sheppard, electrician, 4, Haslett-road, Kensington, London. First meeting of creditors July 14 and public examination on Aug. 16, both at Bankruptcy-buildings, London, W.C.

An application for the discharge of Alfd. Jas. Hollington, electrical engineer, formerly of Hermon-hill, Wanstead, and 37, Walbrook, London, E.C., will be heard on July 21 at Bankruptcy-buildings, London, W.C.

Mr. Harry Wilson, 23, Devereux-court, Strand, London, W.C., has been appointed trustee in the bankruptcy of John L. P. Donlevy, consulting electrician, 123, Tulse-hill, London, S.W.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

*Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

April 18, 1910.

9,319 Hitch. Electric cable conductors.
9,326 Colwill. Sound-proof box for telephone and other purposes.
9,364 Bourck. Closing an electric circuit automatically at a temperature variable at will.*
9,373 Balachowsky & Caire. Regulation of dynamo-electric machines. (Addition to No. 23,742/02. Date applied for, 26/4/09.)*†
9,387 Booker, Russ & Grevener. Arc lamps.
9,399 Druseidt. Electric switches. (Date applied for, 29/5/09.)*†

April 19, 1910.

9,459 Reid. Electric induction furnaces.*
9,461 Cole. Electromedical instruments.*
9,470 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Electrical mercury switches.*
9,474 Marsden. Ferro-electrodes.
9,480 Murex Magnetic Co. & Lockwood. Apparatus for the wet magnetic separation of minerals.
9,488 Thompson. (Ernst Eisemann & Co. G.m.b.H., Germany.) Devices for automatically controlling the ignition period in magneto-electric ignition apparatus.*
9,491 Malcolm & Appleyard. Induction coils for electric cables.
9,495 Bellem & Bregeras. Electromagnetic devices for controlling the admission of carburetting liquid to internal combustion engines. (Date applied for, 21/4/09.)*†
9,517 Oldham. Miners' electric lamps.

April 20, 1910.

9,530 Rankin. Electric controlling and regulating apparatus.
9,539 Rabinsohn. Devices for producing or tansmitting waves.
9,541 Crompton & Co. & Crompton. Collapsible towers for supporting searchlights and other apparatus.

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9,547 BEARD & TOWNSEND. Electric lamp shade attachments.
9,580 ARNO. Alternating-current power measurement and instruments for the same.*
9,590 BERG. Time switch applicable to electric or other lighting purposes or uses.*
9,592 RABINSOHN. Producing electric waves.
9,603 HARLOW & FAYE-HANSEN. Protective apparatus for alternating-current distribution systems.
9,604 WESTINGHOUSE & GOODSPEED. Power transmission mechanism.
9,611 GRAY. Electric ovens.
9,615 BEUTTELL. Incandescent electric lamps. (Daate applied for, 21/4/09.)*†
9,617 SMITH. Battery connectors.*
9,618 SMITH. Spark plugs.*
9,634 SIEMENS BROS. & CO. (Siemens & Halske A.-G., Germany.) Circuits for registers in automatic telephone exchanges.*
9,637 ALEXANDERSON. High-frequency alternators. (Date applied for, 26/4/09.)*†
9,647 MALCOLM & APPLEYARD. Alternating-current conductors.*
9,649 MUREX MAGNETIC CO. & ANTHONY. Magnetic separation of ores or the like by the wet method.

April 21, 1910.

9,674 TAYLOR. Limiting the current on a short-circuit.
9,722 WRIGHT. Name indicators for telephone users and like purposes.
9,736 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*
9,740 FLOAT ELECTRIC CO. & SANDY. Cells or cases for electric batteries.
9,772 JUSTON. Magneto-electric current generators. (Date applied for, 6/5/09.)*†
9,775 OLVIS. Dynamos for charging accumulators.

COMPANIES' MEETINGS AND REPORTS.

Electric & General Investment Co. (Ltd.)

The twenty-first ordinary general meeting of the company was held yesterday (Thursday), Mr. J. B. BRAITHWAITE presiding.

The SECRETARY (Mr. S. R. Shaw) read the notice convening the meeting and the auditors' report.

The CHAIRMAN said: I think we may be fairly well satisfied with our position. Last year showed an improvement, as you will remember, of roughly, £4,000 on the previous year, and this year shows a further improvement on last year of £1,500, and it is that extra amount which we are proposing to distribute as dividend. Last year we placed the whole of the surplus to the contingency fund, and this year we are putting £4,296. 7s. 1d. to the fund, against £4,098. 8s. 7d. last year, which raises it to a figure close on £76,000. We are distributing 6 per cent. on our ordinary shares, and as trustee for the reserve fund I am distributing 2½ per cent. from that fund on the ordinary shares, so that our shareholders this year will get 8½ per cent. upon their investment, which, I think, in view of all the circumstances, is not unsatisfactory. Turning to the balance-sheet, you will there find that the position has distinctly improved during the period under review. The capital, of course, is unchanged, but whereas last year we had loans from bankers of £67,800, this year that item is reduced to £48,000, which shows that we have paid off close on £20,000 during the year. On the other side, the item of loans against securities has increased from £16,890. 19s. 2d. to £19,513. 8s. 6d., so that we have nearly a further £3,000 there to our credit. Sundry creditors and open accounts at the close of the financial year had increased from £14,474. 10s. 2d. to £22,899. 13s. 4d. That was due to engagements for the settlement on the Stock Exchange in the middle of June. The net result of the year's operations is that we have a profit of £13,088. 19s. 6d. After paying our preference dividend, which absorbs £5,970, the same as last year, and placing £4,296. 7s. 1d. to the contingencies fund, we have a balance of £1,200, which is equal to 6 per cent. on the paid-up ordinary capital. I have had a letter from one shareholder inquiring how it is that we are only distributing a quarter of our surplus profits. Well, I do not think I need say very much on that point, because, as you are aware, we have been steadily building up the contingencies fund to counter-balance in some sort the depreciation shown by many of the securities we hold. This company is largely interested in the British Electric Traction Co., whose securities show a very large depreciaton, a depreciation which, I hope, will gradually be recovered, but at the moment I think we are wise in steadily adding to the provision for contingencies by strengthening the position of the company. (Hear, hear.) If our hopes should be realised, and the British Electric Traction Co. should recover something of its old prosperity, that money will be available for distribution between the ordinary and the founders'shares. Respecting the British Electric Traction Co., no doubt some of you have observed the steady improvement which is going on in the position of that concern. Those of you who have studied its balance-sheet will have noticed the distinct strengthening of the position which it shows. That the traffic receipts are showing such improvement all along the line is very encouraging for the future. The Metropolitan Electric Tramways Co. is showing an increase of a considerable amount, and if one looks down the list of the Traction Company's undertakings in all parts of the country one sees that in almost every case an improvement is going on. In some directions it has reached a very substantial figure. Our investments have appreciated £10,000 as compared with the previous year; we have repaid £20,000 to our bankers, which is satisfactory; and we have earned you a little more profit, which enables us to make an increased distribution. I now move the adoption of the report and accounts.

Mr. EMILE GARCKE seconded the resolution, and added that, with regard to the British Electric Traction Co., he did not wish in any way to minimise what Mr. Braithwaite had said.

The resolution was carried unanimously.

Motions for the approval of the dividends set out in the report, for the re-election of the retiring director (Mr. J. Cecil Bull) and the retiring auditor, were afterwards submitted and approved, and the proceedings terminated.

J. G. White & Co. (Ltd.)

At the meeting last week the CHAIRMAN (Mr. J. G. White) said that the past year's profits amounted to £64,801, against £39,977 for 1908-9, which, in turn, were slightly larger than for any former year. The securities now owned had a total par value of more than £650,000. There had been considerable sales at profitable prices of investments formerly held. The directors considered the investments were valued on an extremely conservative basis. The item "Plant and stocks of material," at £2,645, was unquestionably valued conservatively. Everything was appraised on practically scrap value basis, and the figure by no means represented the working value of the plant and materials to the company in its current business. "Purchase of business" stood at the original figure, £47,975. A considerable item was set down in the balance-sheet as "Percentage due to directors and staff." He did not himself participate in the distribution of this item, and could speak quite freely about it. It was considered that the interests of the company were materially promoted by having a substantial portion of the remuneration of the heads of departments in the business, and of those directors who were also members of the staff and who devoted their time exclusively to the company's affairs, contingent on the profits shown by the company. It obviated the necessity of the actual salary list being unduly high, so that should the company have a period of reduced business and be forced to economise, payments to the more highly paid members of its staff would be automatically reduced without requiring a reduction in salaries or of staff. In a company such as theirs good organisation was one of its greatest assets. Remuneration being contingent on profits of the company harmonised the interests of the staff and of the company, gave additional incentive to hard and earnest work, and contributed to greater general efficiency. After allowing for £15,460 brought forward, and for interim preference dividend and the percentage to staff (£7,882), there remained £67,879 to be dealt with. The profit for the year was the largest by more than 50 per cent. in any year in the company's history. It was now 10 years since their company was formed, and its growth had, on the whole, been continuous and regular, largely, they believed, due to the conservative policy which had been adopted in accumulating reserves. A reserve fund of £100,000 had been created, and there remained a balance of £52,379. The directors felt justified in recommending a dividend at the rate of 10 per cent. on both classes of their shares, which, it was hoped, would not by any means mark the maximum warranted distribution to shareholders. The directors believed that the true present value of the goodwill of the company was very much larger than the figures shown in the balance-sheet. Yet, as that was the only item on the credit side of the balance-sheet which was intangible, it was believed that it would be advantageous to wipe it out as rapidly as might be done, before any further additions were made to reserve or dividends further increased. Therefore it was recommended that out of the balance £32,975 be written off "Purchase of business," leaving it at £15,000, and that £19,404 be carried forward. The directors looked forward with confidence to the future.

The report and accounts were adopted.

EDMUNDSON'S ELECTRICITY CORPN. (LTD.)—The directors' report for the year ended March 31 states that the net profit, after payment of debenture interest amounts to £10,768 (with £14,809 brought forward £25,577), which the directors recommend be carried forward. The dividends and interest received have increased by £5,128, whilst the loss on working the local authorities' undertakings is reduced by £722 and the Urban Electric Supply Co. guarantee is £2,505 less. During the year notice was received from Winchester Corporation of their intention to purchase the Winchester electricity undertaking.

ELECTRIC CONSTRUCTION CO. (LTD.)—The net profit for the year ended May 31, after payment of £9,425 for debenture interest and crediting £5,000 as formerly to depreciation account, is £7,123. 5s. With the amount brought forward (£3,687. 16s. 8d.) the sum available for dividend is £10,811. 1s. 8d. The dividend on the 7 per cent. cumulative preference shares requires £4,394. 12s., leaving £6,416. 9s. 8d. to be carried forward. The directors regret the results for the past year do not entirely fulfil the hopes expressed in their last report. Few orders, however, for large installations have been placed, and consequently the works have not been fully employed. The reduction in gross profit is due to the diminution in the volume of business, but the directors hope that the recent improvement in trade may lead to an increased demand for electrical machinery. Meanwhile, the closest attention continues to be paid to costs of production, and a further reduction in expenses has been effected. The directors have availed themselves of an opportunity of redeeming part of the second mortgage debenture stock on favourable terms, and the amount outstanding has been reduced to £10,000. A considerable saving in interest will thus be effected.

ELECTRIC TRACTION CO. OF HONG KONG (LTD.)—At the meeting on Wednesday the report and accounts (abstracted in our last issue) were adopted. Resolutions were also passed authorising the extension of the borrowing powers, the alteration of the name of the company to the Hong Kong Tramway Co. (Ltd.), and the reduction of the capital of the company to £81,250.

GREENWOOD & BATLEY (LTD.)—At the meeting on Saturday the chairman (Major-Gen. Micklem) expressed regret at the death of Mr. Arthur Greenwood, who had been chairman of the company since its formation. The machinery department had been busy during the year, and the electrical department fairly well employed, but in face of severe competition only a bare margin of profit had been gained. Employers' liability insurance last year cost £576, and rates and taxes £2,594, which together equalled a dividend of 1½ per cent. on the ordinary shares.

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KALGOORLIE ELECTRIC TRAMWAYS (LTD.)—At the meeting on Tuesday the chairman (Mr. A. H. P. Stoneham) said that the gross receipts showed a decrease of £2,100 compared with those for 1908, but the net profit was larger by £1,170. The falling off in receipts was mainly due to depression in the mining industry.

NATIONAL TELEPHONE CO. (LTD.)—The directors have decided, subject to audit, to recommend at the forthcoming meeting of shareholders, the following dividends for the half-year ended June 30, after payment of the dividends on the preference shares: At rate of 6 per cent. per annum on the preferred and deferred stock (less tax), carrying £175,000 to reserve and about £15,000 forward. The transfer books will be closed from the 15th to the 28th inst. inclusive.

NORTH STAFFORDSHIRE TRAMWAYS CO. (LTD.)—At the meeting last week the chairman (Mr. W. C. Bond) said that their liability to the Potteries & District Electric Traction Co. had been reduced to £32,329. The expenditure on capital account during 1909 was £348. After including amount payable by the Potteries Co. and deducting debenture interest the balance profit was £4,958, or including balance forward £6,055. Five per cent. was declared on the ordinary shares, and £1,255 carried forward.

PERTH (W. AUSTRALIA) ELECTRIC TRAMWAYS (LTD.)—The chairman (Mr. A. H. P. Stoneham) on Tuesday reviewed the history of the company. In 1898, when the company was formed, the people of Perth did not subscribe for a single share or debenture, but were now casting longing eyes on the property and openly saying that the tramways should be their property, and, moreover, seemed to think that it should be sold to them at less than cost price, just as they were about to get the reward to which they were entitled for the risks they had run and the enterprise they had shown. The original concession was for 17 miles of track, but in order to meet the convenience of the people they were now operating nearly 30 miles. They were still being asked to build more extensions, and the board requested Mr. Wren to go out to meet the Council and explain to them that they were willing to do anything in reason to meet the convenience of the citizens, provided they on their side were willing to give reasonable facilities for obtaining fair interest and fair security for the money. Mr. Wren found the Council unwilling or unable to make any such arrangements. The company was a commercial concern, and had made a success of their undertaking, and were anticipating the reward of their past efforts. The company had received information that the Council would prefer to buy the company out, and a reply had been sent, stating that if a satisfactory offer were received it would be submitted to the shareholders. They had received an offer which they did not consider satisfactory. The board's view was that if bought, they should be acquired by the State and not by the Town Council. The State of New South Wales bought the Sydney tramways and had made them a great success. The accounts showed considerable improvement upon those of the last three years. For the first six months of this year the traffics were £3,360 in excess of those of last year, and so far as the board could judge the profits were nearly £2,200 in excess.

VICTORIA FALLS & TRANSVAAL POWER CO. (LTD.)—The directors' report for 1909 states that the past year has again been mainly occupied by construction work. The surplus for the year (£50,534), added to that brought forward (£84,863), makes £135,397. In consequence of the unexpectedly large and increasing demand of consumers, necessitating further capital expenditure, which ultimately will be met by increasing the debenture debt, the directors have carried this amount forward, and therefore no distribution of dividend on the preference shares will be made for 1909 before May next, when the new station at Rosherville will be in full operation.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

ACTON LAMP CO. (LTD.) (110,486.)—Reg. June 30, capital £8,000 in £1 shares, to carry on the business of manufacturers of and dealers in electric glow lamps and other electric lamps, &c. Private company.

EAST KENT ELECTRIC SUPPLY CO. (LTD.) (110,494.)—Reg. June 30, capital £30,000 in £5 shares (1,500 preference), to carry on the business of electrical engineers, electricians, practical engineers and contractors, manufacturers of and dealers in electrical apparatus, suppliers of electricity, &c. First directors, G. Holman, S. W. Price and H. F. Holman. Reg. office, 36-8, New-street, Ashford, Kent.

ELECTRO-METALS (LTD.) (110,432.)—Reg. June 28, capital £30,000 in 4,000 preference shares of £5 each and 10,000 ordinary shares of £1 each, to carry on the business of engineers, electricians, metallurgists, miners, contractors, merchants, &c., and to adopt an agreement with Jens Orten-Boving, D. Spencer, and P. R. Cobb (trading as Jens Orten-Boving & Co.) Private company.

INTERNATIONAL "Z" ELECTRIC LAMP ASSOCIATION (LTD.) (110,468.) Reg. June 29, capital £40,000 in £5 shares (4,000 preference), to carry on business as manufacturers of incandescent lamps and other electrical apparatus, fittings and plant, electricians, electrical engineers, &c., and to adopt agreements with the Compagnie Internationale des Lamps Electriques Zircone Wolfram (Soc. Anon.), with the "Z" Electric Lamp Mfg. Co. (Ltd.) and with Kilburn, Brown & Co. First directors, A. Simson, A. Romberg and W. L. Pakenham. Reg. office, Orient House, New Broad-street, London, E.C.

OUDTSHOORN ELECTRIC LIGHT & POWER CO. (LTD.) (110,512.)—Reg. June 30, capital £15,000 in £5 shares, to carry on the business of suppliers of electricity, engineers, &c., and to acquire from the General Electric Co. (Ltd.) the concession granted by the Municipal Council of Oudtshoorn, Cape Colony. Private company. First directors, H. Hirst, G. T. Moody, H. Kahn and A. I. S. Baron. Reg. office, 71, Queen Victoria-street, London, E.C.

UITENHAGE ELECTRIC LIGHT & POWER CO. (LTD.) (110,452.)—Reg. June 28, capital £15,000 in £5 shares, to take over from the General Electric Co. (Ltd.) a concession granted by the Municipal Council of Uitenhage, Cape Colony, for the lighting of the town by electricity and the supply of electrical energy to private consumers. Private company. First directors, H. Hirst, G. T. Moody, H. Kahn and A. I. S. Baron. Reg. office, 71, Queen Victoria-street, London, E.C.

MORTGAGES AND CHARGES.

CASCADE (1906) POWER CO. (LTD.)—A memorandum of satisfaction to the further extent of £43,417 on various dates from February 4 to May 24, 1910, of trust deed dated Sept. 21, 1906, securing £75,000, has been filed.

ELECTRIC LIGHT, POWER & HIRING CO. (LTD.)—A memorandum of satisfaction on June 15 of mortgage dated Feb. 22, 1909, securing all moneys due or to become due from company to bankers up to £9,507.3s.11d. has been filed.

NOTTINGHAMSHIRE & DERBYSHIRE TRAMWAYS DEVELOPMENT CO. (LTD.)—Particulars of £5,000 debentures, created June 22, 1910, have been filed, amount of present issue being £500. Property charged: Company's undertaking and property, present and future, subject to prior charge. No trustees.

PEARSON FIRE ALARM (LTD)—Mortgage dated June 15 (supplemental to trust deed dated March 2, 1908, securing £20,000) charged on certain patents and trade marks. Trustees, T. D. Cocke and A. Hair.

CITY NOTES.

MEMORANDA (July 7).—Bank rate 3 per cent. (since June 9, 1910). Price of silver, 24 1/16d. per oz Consols 81 7/8—82 1/8 for money; 82—82 1/4 for account. **Consols Pay Day, Aug. 4; Stock and Shares Continuation Days, July 12 and 26; Ticket Days, July 13 and 27; Pay Days, July 14 and 28; Mining Shares Carry Over Day, July 11.**

PRICES OF METALS (London).—*Copper*, cash, 54 3/8; three months 55 1/16. *Lead*, English, 12 3/4—13; foreign, 12 5/8. *Spelter*, 22 5/8—22 3/4 *Tin*, English, 148—150; foreign cash, 149 1/2; three months, 150 1/4 *Iron*, Cleveland, cash, 48/10, three months, 49/7.

CAVEHILL & WHITEWELL TRAMWAYS CO.—A resolution has been agreed approving the Bill of Belfast Corporation for the purchase of the company's undertaking.

DUBLIN UNITED TRAMWAYS (1896) (LTD.)—The directors have declared a dividend for the half-year to June 30 at the rate of 6 per cent. per annum, less tax, on the preference and ordinary shares, after setting aside £4,000 for renewal of cars and carrying forward £7,291.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) Interest on this company's 4 per cent. mortgage debenture stock for the half-year ending July 31 will be paid by warrant on Aug. 1. The stock register will be closed from 27th to 30th inst. inclusive.

MEXICO TRAMWAYS CO.—The directors have declared a dividend of 1 1/4 per cent. for the quarter ended June 30.

NATIONAL TELEPHONE STOCK.—It is not surprising that as the time draws nearer for the transfer of the National Co.'s business to the State, speculation is rife as to the proportional distribution of the company's liquid assets over the various denominations of stocks and shares into which the capital of the company is divided. A lengthy review of the position was given in the "Financier" for July 1. In this review it is well stated that "When the time arrives for arbitration as between the Post Office and the company, the scales of justice should be held as even as human judgment can arrive at, but where any doubts may arise that cannot be quite clearly dissipated, the company rather than the Government should have the benefit." In the "Financier's" review this is intended to apply to shareholders' interests; it applies with added force to the interests of the company's staff.

NORTHAMPTON ELECTRIC LIGHT & POWER CO. (LTD.)—A circular has been issued to the shareholders stating that the debentures are to be redeemed on Jan. 1 next at par, and the directors have resolved to issue their 4 per cent. debenture stock, which is at present limited to £50,000.

RIVER PLATE ELECTRICITY CO. (LTD.)—Notices are being issued to the shareholders as to the conversion of 120,000 £1 ordinary shares into £120,000 ordinary stock, and of 100,000 £1 preference shares into £100,000 6 per cent. non-cumulative preference stock.

ROYCE (LTD.)—It is announced that the dividend on the preference shares will be passed.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted quotations to 99,400 £1 fully-paid shares of the *Llandudno & Colwyn Bay Electric Railway (Ltd.)*, 600,000 £1 fully-paid ordinary shares of *Mather & Platt (Ltd.)* and a further issue of £35,326 4 1/2 per cent. first mortgage debenture stock of the *Rangoon Electric Tramway & Supply Co. (Ltd.)*

TRAMWAYS & LIGHT RAILWAYS ESTATES CO. (LTD.)—The accounts for 1909 show a net profit of £527. A dividend of 2 1/2 per cent. is recommended.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	AGGREGATE. No. of weeks.	AGGREGATE. Amount.	AGGREGATE. Inc. or Dec. (a)
		£	£		£	£
Airdrie	June 24	233	+ 22	25	5,464	+ 110
Anglo-Argentine	July 1	44,234	+ 6,601	26	1,148,007	+ 127,822
Ayr Corporation	,, 2	332	+ 31	7	2,148	+ 62
Baker St. & Waterloo Ry.	,, 2	3,490	+ 280	26	88,470	+ 1,610
Barnsley	June 24	175	+ 13	25	4,275	+ 142
Barrow	,, 24	314	+ 78	25	6,169	+ 802
Bath Electric Trams, Ltd.	,, 29	866	− 63	26	19,830	+ 1,447
Birmingham Corporation	July 2	6,785	+ 143	13	89,628	+ 1,100
Birmingham & Midland	June 17	848	+ 57	24	19,905	+ 375
Blackburn Corporation	,, 29	1,044	− 19	‡14	14,999	− 783
Blackpool and Fleetwood	July 2	1,129	− 169	..	..	..
Bolton Corporation	,, 3	2,348	− 197	14	31,770	− 985
Bombay	June 3	2,670	+ 179	22	60,370	+ 4,175
Bournemouth Corporation	,, 29	1,659	+ 152	13	21,191	− 448
Bradford Corporation	July 2	5,049	− 15	14	68,013	+ 1,206
Brighton Corporation	,, 3	963	− 60	§13	12,373	− 504
Bristol Trams & Carriage	,, 1	6,127	+ 251	26	148,242	+ 14,035
Burnley Corporation	,, 2	1,264	− 81	26	41,915	+ 608
Burton Corporation	,, 3	269	+ 1	13	3,545	− 43
Bury Corporation	,, 3	1,172	− 95	§13	15,918	− 555
Calcutta Tramways Co.	,, 2	₹50,590	+ ₹1,688	26	₹1,343,012	+ ₹46,146
Camborne-Redruth	,, 2	119	− 39	26	3,129	− 150
Cardiff Corporation	.. ..	..	.. ..	..	..	..
Cavehill	June 24	112	+ 23	25	2,078	+ 181
Central London Railway	July 2	6,069	+ 424	26	147,770	+ 3,012
Charing C., Euston & H'stead	,, 2	3,770	− 110	26	99,575	− 1,545
Chatham & Dist. Lt. Rys.	June 30	863	+ 195	26	21,028	+ 1,242
City & South London Rly.	July 3	3,257	− 2	26	83,938	− 725
City of Birmingham	June 24	2,990	+ 249	25	71,190	+ 3,398
Colchester Corporation	,, 29	213	− 33	..	..	..
Cork Electric Trams Co.	,, 30	345	+ 8	26	12,249	+ 1,745
Croydon Corporation	.. ..	..	.. ..	..	..	..
Devonport & Dist. Trams	,, 24	445	+ 113	25	10,306	+ 1,227
Dover Corporation	,, 25	224	+ 25	12	2,489	− 14
Dublin & Lucan Railway	,, 30	141	+ 26	26	3,352	+ 72
Dublin United	July 1	6,122	+ 283	26	137,953	+ 5,204
Dudley-Stourbridge	June 24	817	+ 36	25	18,595	− 622
Dundee Corporation	,, 29	1,227	+ 24	§6	7,894	+ 146
East Ham Council	July 2	1,033	+ 45	¶13	13,859	+ 324
Exeter Corporation	,, 1	325	− 17	13	4,172	− 675
Gateshead & Dist. Trams	June 24	1,252	+ 108	25	24,277	− 276
Glasgow Corporation	July 2	18,287	+ 1,161	5	85,986	+ 6,478
Glossop Trams	,, 2	115	− 12	26	2,927	− 144
Gloucester Corpn.	June 30	295	− 250	..	..	..
Gravesend-Northfleet	,, 24	237	+ 19	25	4,922	+ 111
Great Northern & City Rly.	July 2	1,457	+ 74	26	38,253	− 312
Gt. Northern, Piccadilly, &c.	,, 2	6,015	+ 365	26	155,965	+ 5,200
Greenock & Port Glasgow	June 24	743	+ 130	25	14,804	+ 2,098
Hartlepool Tramways	,, 24	323	+ 77	25	5,620	+ 264
Hastings Elec. Trams Co.	,, 30	977	− 14	25	22,698	+ 363
Hong Kong	July 2	$8,693	+ $129	26	$340,229	+ $21,724
Huddersfield Corpn.	,, 2	1,752	+ 89	13	23,370	+ 958
Hull Corporation	,, 2	2,797	+ 235	13	35,667	+ 2,261
Ilford District Council	,, 2	555	+ 24	13	7,110	+ 283
Ilkeston District Council	June 29	130	− 10	13	1,649	− 83
Ipswich Corporation	.. ..	..	.. ..	..	..	..
Isle of Thanet Co.	July 2	921	+ 21	¶38	15,044	+ 488
Jarrow	June 24	202	+ 58	25	2,981	+ 191
Keighley Corporation	,, 30	173	+ 6	13	2,333	+ 74
Kidderminster & District	,, 24	123	+ 22	25	2,422	+ 84
Kilmarnock Corporation	July 2	150	+ 3	7	1,042	− 1
Lanarkshire Trams Co.	June 30	1,551	+ 308	26	35,681	+ 4,058
Lancashire United	,, 29	1,381	− 82	26	33,238	+ 316
*Leamington	,, 24	187	+ 15	25	3,827	− 92
Leeds Corporation	.. ..	..	.. ..	..	..	..
Leicester Corporation	July 2	2,498	+ 194	..	..	..
Leith Corporation	,, 2	635	+ 21	7	4,404	+ 182
Lincoln Corporation	,, 2	180	+ 1	14	1,744	+ 7
Liverpool Corporation	June 25	13,737	+ 2,908	25	275,372	+ 10,968
Liverpool Overhead Rly.	July 3	1,414	− 125	1	1,414	− 125
Llandudno&ColwynBayRy.	June 24	318	+ 3	§39	5,207	+ 36
*London County Council	,, 18	43,535	+ 6,830	¶11	476,217	+ 67,775
London United	July 2	6,656	+ 110	25	160,471	+ 10,003
Lowestoft	,, 2	193	+ 3	40	6,149	+ 252
Maidstone Corporation	,, 2	173	− 11	13	2,237	− 236
Manchester Corporation	,, 2	15,784	+ 272	13	205,827	+ 4,535
Mersey Railway	,, 2	2,012	+ 53	26	52,826	+ 1,479
Merthyr	June 24	234	+ 39	25	4,976	− 219
Metropolitan Dist. Railway	July 2	11,904	+ 1,615	26	285,242	+ 25,781
Metropolitan Elec. Trams	June 24	8,539	+ 2,141	25	180,787	+ 34,477
Middleton	,, 24	384	+ 62	25	7,618	− 520
Nelson Corporation	.. ..	..	.. ..	..	..	..
Newcastle-on-Tyne Corp.	July 2	3,740	+ 194	¶13	53,537	− 575
Newport (Mon.)	,, 2	673	− 16	14	9,551	+ 312
Northampton Corporation	,, 1	511	+ 34	§13	6,489	+ 7
Oldham, Ashton & Hyde	June 24	623	+ 68	25	13,624	− 62
Oldham Corporation	July 3	1,789	− 119	14	26,605	− 1,094
Perth (N.B.) Corporation	June 29	175	+ 15	§6	1,095	+ 71
Perth (W.A.) Elec. Trams	July 1	1,523	+ 155	26	40,305	+ 303
Peterborough	June 24	130	+ 18	25	2,663	− 13
Portsmouth Corporation	July 2	2,145	+ 43	13	25,631	− 1,105
Potteries	June 24	1,859	+ 34	25	43,373	− 422
Preston Corporation	,, 29	769	+ 69	13	9,481	− 256
Rotherham Corporation	,, 30	530	+ 19	13	8,012	+ 44
Rothesay	,, 24	311	+ 23	25	2,940	+ 56
Salford Corporation	.. ..	..	.. ..	..	..	..
Sheerness	,, 24	55	+ 4	25	1,120	− 33
Sheffield Corporation	July 3	5,977	+ 259	¶14	85,499	+ 4,637
Singapore Trams	,, 2	$9,450	+ $81	26	$257,058	+ $6,526
South Metropolitan	June 24	950	+ 142	25	19,842	+ 1,242
South Staffs	,, 24	835	+ 62	25	20,490	+ 17
Southend Corporation	,, 29	627	+ 127	13	6,837	+ 709
Southport Tramways	,, 24	350	+ 65	25	6,787	+ 283
Stalyb'dge,Hyde,&c., Jt.Bd.	July 2	703	− 67	¶13	9,461	− 1,057
Sunderland Corporation	,, 3	1,186	− 20	14	15,248	− 330
Sunderland District	June 29	435	+ 3	35	14,169	− 1,441
Swansea Trams	,, 23	1,137	+ 197	25	25,734	+ 2,901
Swindon Corporation	,, 29	142	+ 9	..	..	..
Taunton	,, 24	44	+ 6	25	1,011	+ 114
Tynemouth and District	,, 24	597	+ 244	25	5,083	+ 585
Tyneside Trams Co.	,, 29	727	+ 129	26	11,761	− 91
Wallasey District Council	July 2	936	− 1	§13	12,248	− 422
Walsall Corporation	,, 2	533	+ 6	26	13,795	+ 665
Warrington Corporation	.. ..	..	.. ..	..	..	..
West Ham Corporation	June 23	2,759	+ 293	12	29,686	+ 917
Weston-super-Mare	,, 24	223	+ 64	25	1,996	− 21
Wolverhampton Co.	,, 24	431	+ 22	25	10,308	+ 146
Wolverhampton Corpn.	,, 29	1,096	− 326	13	11,876	+ 1,524
*Worcester	,, 24	318	+ 101	25	6,567	+ 181
Wrexham	,, 24	100	− 1	25	2,383	+ 25
Yorkshire W.R. Trams	July 3	1,103	− 113	27	32,976	..
Yorkshire Woollen District	June 24	1,033	+ 121	25	24,119	+ 2,239

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

SHARE	LAST DIVIDEND	NAME.	Price Wed., July 6	RATE PER CENT. YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 6 Highest.	BUSINESS WEEK TO JULY 6 Lowest.
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½—9¾	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 15 0	Feb, Aug	..	..
St.	4½%	†Do 4½ per Cent. Deb. Stock (red.)	100—103	4 7 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼—7¾	6 9 0	March	7¼	..
5	3/6	Do. 7 per Cent. Pref.	7 —7¼	4 13 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¼—4	6 5 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4⅝	4 17 6	Feb., Aug	4⅜	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 —98	4 1 6	Jan, July	97	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101¼—103½	4 7 0	..	..	..
5	2/3	†Do. City Undertaking 4½% Cum. Pref.	3¾—4¼	5 9 3	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜—4⅛	5 9 6	March	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11¼—11¾	5 19 0	Feb, Aug	11⅞	11½
10	6/0	Do. 6 per Cent. Cum. Pref.	11¾—12¼	4 14 0	Jan, July	12⅛	¼
St.	5%	†Do. 5 per Cent. Deb. Stock (red.)	119 —123	4 1 6	June, Dec	123	121¼
St.	4½%	†Do. 4½ per Cent. 2nd Deb. Stock (red.)	99 —102	4 8 0	Jan, July	101¾	101
5	..	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¼—3¼	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7½—8	6 0 0	Feb, Aug	7⅞	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¼—11⅜	5 5 0	Mar, Sept	10¼	..
St.	4½%	†Do. 4½ per Cent. Deb Stock (red.)	103½—105¼	4 4 6	Jan, July	105¼	..
St.	4½%	Do. Second Deb. Stock	99 —102	4 9 0	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4⅝	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅞—6¼	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94½—96½	4 3 6	..	..	..
St.	4%	Kensington & Knghbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 —100	4 0 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅛—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5 —5½	5 9 0	Mar, Sept	5⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	3½—4	5 9 0	April, Oct	3⅛	3⅛
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4¼—4½	4 17 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock 1st Mort.	102 —105	4 5 0	June, Dec	..	..
St.	3½%	†Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	†Midland Elec. Corp. for P. D. 1st Mort. Deb.	95 —97	4 12 6	June, Dec	..	..
5	4 0	Newcastle Elec. Supply Ord.	3⅝—4¼	4 11 6	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¼—4⅝	5 2 6	Feb, Aug	..	..
100	4½%	†Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	100 —102	4 18 0	..	103¼	..
10	6/0	†Notting Hill Electric Ord.	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6¾—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8¼—8¾	5 9 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¼—7¼	4 15 0	Feb, Aug	..	..
St.	3½%	†Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3¼	6 11 0	April	..	..
St.	5%	†Do 5 % 1st Mort. Stock (red.)	99 —102	4 18 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—¼	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	½—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
St.	5/0	Westminster Elec. Sup. Ord.	⅞—8¼	5 12 6	Mar, Sept	8⅛	8⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97	..
1	..	Bath Elec. Trams Pref. Ord.	¼—⅜	..	April	..	..
1	0/6	†Do. 5 per Cent. Cum. Pref.	⅜—½	6 12 9	Jan, July	..	..
St.	4½%	†Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	†B'ham & Midland Trams 4½ 1st Deb. Stock	81 —81	5 7 0	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6¼—7	8 11 6	Feb, Aug	..	..
10	4%	†Do. Cum. Pref. (fully paid)	7¼—7¾	5 3 0	..	..	..
St.	4%	†Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¾—1¼	..	June, Dec	⅞	⅞
10	..	Do. 6 per Cent. Cum. Pref.	2¼—3	10 0 0	Feb, Aug	2⅛	2¼
St.	5%	Do. 5 Cent. Perpetual Debs.	89 —93	5 7 6	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 —73	6 3 0	May, Nov	69½	..
St.	3%	Central London Ordinary Stock	66 —68	4 9 0	Feb, Aug	67	66¼
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	87	86
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	†Charing X, Euston & Hmpstd Per. Deb Stk	93 —95	4 5 0	Jan, July	94½	93½
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	31 —32	3 14 3	Feb, Aug	31½	..
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1933)	100 —103	4 17 6	Feb, Aug	102¾	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	98 —100	4 0 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	93 —95	4 5 0	Jan, July	94½	93¾
5	..	Hastings & District Elec. Trams, 6% C. P.	¾—1¼	..	Mar, Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	72	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	†Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅜—1⅝	4 14 0	Mar, Sept.	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	61 —66	6 1 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10⅛	5 18 9	Feb, Aug	..	..
St.	5%	†Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —86	5 16 0	Jan, July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Deb. Stock	66 —70	5 14 0	Jan, July	67½	..
1	1/0	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	..	Metropolitan Elec. Tramways Ord.	⅝—¾	..	..	⅝	..
1	0/6	Do. Deferred	⅜—½	..	April	..	..
St.	4%	Do. 5 per Cent. Cum. Pref.	½—⅝	5 0 9	Feb, Aug	⅝	⅝
St.	1%	†Do. 4½ per Cent. Deb. Stock	96 —99	4 11 0	Jan, July	99⅛	98⅛
St.	2½%	Metropolitan Railway Consolidated	40½—41¼	2 9 6	Feb, Aug	41¼	41
St.	3½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	67	66¾
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90¼	89¾
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87¼	87¼
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	94	93¾

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption. †Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Wed. July 6	Rate per cent. Yielded.	Dividend Due.	Business Week to July 6 Highest.	Business Week to July 6 Lowest.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	91 —93	3 15 0	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.....	21⅛—22⅛	..	Feb, Aug	22⅛	21⅛
St.	..	Do. Extension Pref. (5 per Cent.).....	68 —70	..	Feb, Aug	..	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	..	..
St.	3%	†Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	..	..
St.	4%	†Do. 4 per Cent. Midland Rent-charge	99 —102	3 18 6	Jan, July	101⅛	..
St.	4%	Do. Guar. Stock 4 per Cent.....	102 —104	3 17 0	Mar, Sept	102	..
St.	6%	†Do. 6 per Cent. Perp. Deb. Stock.....	140 —142	4 4 6	Jan, July	140⅛	..
St.	4%	†Do. 4 per Cent. Ditto.....	94 —96	4 3 6	Jan, July	..	..
1	4½d.	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅛—¼	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—¼	..	..	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock.....	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoupo	35 —37	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds.....	101 —102	4 18 0	..	102⅛	101⅛
..	4½%	Do. 4½% Bonds Ex coup. 5	86 —88	5 2 0	..	89⅛	87⅛
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	98 —100	4 0 0	..	99	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	¼—½	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1⅛—2⅛	..	..	..	..
St.	4½	†Do. 4½ per Cent. 1st Debs.....	77 —80	5 12 6	Jan, July	77⅛	..
		Electric Manufacturing, &c.					
St.	4½%	†Ancho Cable Co. 4½ % Deb. Stock	99⅛—101⅛	4 8 6	..	101⅛	99⅛
1	..	Aron Electricity Meter Ord.....	⅛—¼	..	..	⅛	..
1	1/9½	†Do. 6% Cum. Pf. .... xd and arrears	⅜—⅝	6 15 3	April, Oct	⅜	..
1	3/2½	Babcock & Wilcox Ord.....	5⅛—5⅜	5 9 0	April, Oct	5⅜	5⅛
1	0/7½	Do Pref.....	1⅛—1⅜	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7	7 3 0	July, Feb	6⅝	..
5	3/0	Do. 6 per Cent. Pref.....	5⅞—6⅛	4 16 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.)..	101 —104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	⅛—⅜	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	98½—100½	5 19 6	..	100	99⅛
St.	4%	†Do. 4 per Cent. Mort. Deb. Stock.....	58 —60	3 6 6	Jan, July	59½	58⅛
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	†Do. Perpetual 2nd Deb. Stock.....	23 —27	16 12 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9½—10½	6 8 0	Jan, July	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.....	4⅝—5⅛	4 15 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort Debs. (red.)..	100⅛—102⅛	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.....	2⅛—2¼	5 8 9	May, Nov	2⅛	2⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	106 —109	4 3 6	Feb, Aug	..	..
..	0/7½	Chadburn's (Ship) Telegraph Ord.	⅛—1⅛	6 11 9	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	⅛—¼	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	⅜—½	7 0 0	April, Oct	..	..
1	0/7½	Do 6 per cent. Cum. Pref.	¼—1	6 4 0	April, Oct	⅜	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	¼—½	15 0 0	Jan, July	..	..
100	5%	†Do. 5 per Cent. 1st Mort. Debs. (red.)..	84 —87	5 15 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	1⅛—1⅜	5 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	¾—1⅛	5 6 6	Sept	..	..
St	4½%	†Do. 4½ per Cent. Deb. Stock.....	97 —100	4 10 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St	4%	†Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —63	5 15 0	June, Dec	..	..
St	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
5	..	Edmundson's Elec. Corp. Ord.....	⅛—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	..	May, Nov	1⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	76 —79	5 14 0	Jan, July	..	..
2	..	Electric Construction Co.....	¾—1	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1⅜—1⅝	8 12 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	61 —66	6 1 0	Jan, July	63	..
10	5/0	†General Electric (1900) 5% Cum. Pref. ..	7⅞—8	5 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅞—12⅜	6 1 0	Feb, Aug	12	..
5	2/3	Do. 4½ per Cent. Pref.	4⅝—5⅛	4 5 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	103½—105⅛	4 5 6	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works....	14⅛—15⅛	6 10 6	Feb, Aug	..	..
10	5/0	†Do 5 per Cent. Cum. Pref.	10⅛—10⅝	4 14 0	..	10⅝	10⅛
10	4%	Do 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	97	..
1	..	National Elec. Construction Co.	⅛—¼	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅞—1⅛	..	No.	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅞—1⅛	..	May, Nov	⅞	..
St.	4½%	†Do. 4½ per Cent. Perp. Deb. Stock....	75 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5⅛	..	..	..	..
12	30/0	Telegraph Construction & Maintenance..	33 —35	6 0 9	Mar, July	34	33⅛
100	4%	†Do. 4 per Cent. Deb. Bonds (1909)	99 —101	3 19 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2 —2⅛	4 9 3	..	2⅛	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1⅛	4 0 0	..	1⅛	1⅛
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	103 —111	4 10 0	..	110	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104½	3 17 0	June, Dec	103⅛	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	104⅛	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	103⅛—105⅛	4 15 6	..	105	103⅛
10	10%	J. G. White & Co. 6% Cum. Pref	11⅛—12⅛	8 0 0	..	12	11⅛
1	..	Willans & Robinson Ord.....	⅛—¼	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1⅛—1⅜	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅛—3⅜	..	June, Dec	..	..
10	20/2	†Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan, July	..	..
St.	15/0	Anglo-American	64 —66	5 7 6	F,My,Ag,N	64⅛	64⅛
St.	30/0	Do. Preferred	107 —109	5 10 0	F,My,Ag,N	108	106⅛
St.	25/0	Do. Deferred	24⅛—25	5 0 0	F,My,Ag,N	20⅛	24⅛
St.	4%	†Commercial Cable 4 per Cent. Deb. Stk..	84⅛—86⅛	4 12 6	Jn,Ap,Jy,O	86	..
10	6/0	Cuba Submarine Ord.	8⅛—9	6 13 6	Feb, Aug	8⅛	8⅛
10	10/0	Do. Preference 10 per Cent.	16⅛—17⅛	5 15 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅛—3⅜	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	7⅛—8⅛	6 1 6	April, Oct	..	..
50	4½%	†Do. 4½ per Cent. Deb.	99 —101	4 19 0	Jan, July	..	..
20	4/0	Direct United States Cable.....	14⅛—15⅛	5 11 6	Ja,Ap,Jy,O	..	..
100	4½%	†Direct West India Cable 4½% Rg.Db.(rd.).	98 —100	5 0 0	June, Dec	..	..
St.	65/0	Eastern Ordinary	133 —135	5 3 6	Ja,My,Jy,O	135⅛	133
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	85 —87	4 0 6	Ja,My,Jy,O	86⅛	85⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	101 —103	3 17 6	May, Nov	..	..
St.	6/6	Eastern Extension	12⅜—13⅛	5 10 0	Ja, Ap, Jy, O	12⅛	12⅛
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	Eastern & S.Af., 4% Mauritius Sub.Debs	99½—101⅛	3 18 6	May, Nov	..	..
10	5/0	G.N (of Copenhagen), Ex Coupon 79	30⅛—31⅛	5 14 3	Jan, July	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	Mackay Companies Common	88 —92	5 9 0	Ja,Ap,Jy,O	..	..
100	4%	Do Preference	77 —81	4 19 0	Ja,Ap,Jy,O	79	..
1	..	Marconi's Wireless Teleg. Co.	⅛—⅜	..	April	⅜	⅛
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	90 —92	3 18 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 12 9	May	1⅜	..
100	4%	†Do. 4 per Cent. Debs.....	96 — 98	3 18 0	Jan, July	..	..
10	..	West India & Panama	⅜—½	..	May, Nov	½	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9	6 12 6	May, Nov	8⅝	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	†Do. 5 per Cent. Debs.....	99 —101	4 19 0	Jan, July	..	..
10	3/0	†Western Telegraph.....	13¼—14	5 0 0	Mr, Jn, O, D	14	13⅛
St.	4%	†Do. 4 per Cent. Deb. Stock (red.).....	99 —101	4 19 0	June, Dec	..	..
—	1%	Western Union Telegraph. $1,000 4% Bds	101 —104	3 16 6	—	—	—
..	4½%	Do. £1,000 4½% Fdg. & Rl. Est. Gd. Bnds	99 —102	..	..	..	..
		Telephones.					
..	..	†Amer. Telephn. & Telegh. Cap. St.	136 —138	5 16 6	..	..	..
..	..	†Do. Coll. Trust $1,000 4 per Cent. Bds.	91 —93	4 6 0	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	103 —105	4 16 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
5	3/0	Chili Telephone	8⅝—8⅞	4 8 3	August ..	8⅝	8
1	0/6	Monte Video Telephone Ord.....	⅛—¼	7 0 0	Nov	..	..
5	2/6	Do. 5 per Cent. Pref.	⅝—⅞	5 13 9	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	107 —108⅛	5 10 6	Feb, Aug	107⅛	107
St.	6%	Do. Def. Stock	127 —129	4 13 0	Feb, Aug	130	127⅛
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10⅛—10⅝	5 10 0	Feb, Aug	10⅝	10⅛
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10⅛—10⅝	5 10 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.....	5⅛—5⅜	4 7 6	Feb, Aug	5⅜	5⅛
St.	3½%	†Do. Deb. Stock 3½ per Cent. (red.)....	96 —98	3 12 0	June, Dec	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.).....	98 —100	4 0 0	Jan, July	99⅛	..
5	..	New York Telephone Co. 30 yr. Bnds.....	97⅛—98⅛	4 11 6	..	..	97⅛
5	3/0	Oriental	1⅛—1⅜	4 15 0	April, Oct	1⅛	..
1	0/7½	Do 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 6	April, Oct	..	..
St.	4%	†Do. 4 per Cent. Red. Deb. Stock.....	86 —88	4 11 0	Jan, July	..	..
St.	4½%	†Telephone Co. of Egypt 4½% Db.Stk.(red.)	98 —100	4 10 0	Jan, July	..	..
5	3/0	United River Plate.....	7⅛—7⅜	5 5 9	July	7⅛	7⅛
5	2/6	†Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 14 9	June, Dec	..	..
St.	4½%	†Do. 4½ Deb. St. Red.....	101 —103	4 12 6	Jan, July	..	..
		Financial, Investment, &c.					
5	3/0	†Elec. & Gen. Investment 6% Cum. Pref...	2⅞—3⅛	9 4 6	Jan, July	..	..
10	5/9	†Globe Telegraph & Trust	10⅛—10⅜	5 8 3	Sp,DcMrJu	10⅛	10⅛
10	3/0	†Do. 6 per Cent. Pref.	12⅛—12⅜	4 6 3	Sp,DcMrJu	13⅛	13
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 10 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	†Anglo-Argentine 5% Cum. 1st Pref.	4⅞—4⅛	5 6 3	April, Oct	4⅛	4⅞
5	2/6	†Do. 5% C um. 2nd Pref.....	4⅛—4⅜	5 9 0	Jan, July	..	..
St.	4%	†Do. 4% Deb. Stock	88½—90	4 9 0	June, Dec	89⅛	89
St.	4½%	†Do. 4½% Deb. Stock	93⅛—96⅛	4 13 6	..	95⅛	94⅛
St.	5%	†Auckland Elec. Trams. 5% Deb. (red.)....	103 —10⅞	4 15 3	Jan, July	103⅛	..
5	4/6	Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	6⅞	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 13 9	May, Nov	..	..
5	4%	†Do. 4½ per Cent. Db. Prov. Certs.....	99 —102	4 8 6	Jan, July	101⅛	..
St.	4½%	British Columbia El.. Rly. Df. Ord.	141 —146	5 10 0	Mar, Sept	..	..
St.	8%	Do. Pref. Ord. Stock	123 —127	4 13 6	May, Nov	..	..
St.	6%	Do. 5% Cum. Perp. Pref. Stock.....	110 —113	4 8 3	Jan, July	111⅛	111⅛
St.	4%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	103	..
40	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
100	4½%	Do. 4½% Perp. Con. Deb. St.	103½—105⅛	3 19 6	..	104⅛	103⅛
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db.	100 —103	4 17 6	Mar, Sept	101⅛	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	96 —99	6 1 0	Feb, Aug	..	..
5	2/6	Calcutta Tramways (1 to 137,610).....	4⅛—4⅜	4 7 6	Mar, Sept	..	..
100	2/6	†Do. 5 per Cent. Cum. Pref.	4⅛—4⅜	5 2 6	Jan, July	..	..
5	4½%	†Do. 4½% 1st Deb. Stock (red).....	96 —99	4 11 0	Jan, July	..	..
5	..	Cape Electric Tram Shares	⅛—¼	..	..	..	..
St.	4½%	City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 9 6	F,My,A,N	5⅛	..
5	1/3	†Do. 4 per Cent. Deb. Stock.....	97 —100	4 0 0	June, Dec	..	..
St.	4%	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	95 —98	5 2 0	May, Nov	98	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	78 —81	6 3 6	June, Dec	..	..
1	5%	†Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94½—97⅛	5 2 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	⅛—¼	..	..	..	..
1	..	Do. 5 per Cent. "A" Deb. Stock.....	92 —96	5 3 6	Jan, July	93	..
1	..	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	4%	Lisbon Elec. Trams. Ord.	1⅛—1⅜	5 4 0	July	1⅛	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 5 3	Jan, July	..	..
100	5%	Do. 5 per Cent. Reg. Mort. Debs.....	97⅛—101⅛	4 18 6	Jan, July	103⅛	..
1	..	†Madras Elec. Trams. 5% Deb. Stk.	92 —93	5 2 0	Jan, July	..	..
1	..	†Manaos Trams and Lt. Co. 5% Debs	86⅛—87	5 14 0	..	87	..
1	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	99 —100	5 2 0	Feb, Aug	..	..
100	$1	Mexico Trams Co. Com. St.	126 —128	5 0 0	..	129	..
5	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	97⅛—99⅛	4 1 6	..	99⅛	98⅛
St.	6%	†Do. 6% 50 yr. Mort. Bds.....	98⅛—99⅛	6 0 9	..	99⅛	98⅛
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 6	Feb, Aug	..	..
100	..	Do. do. (Nos. 1 to 4,600)	100 —102	4 8 0	..	102	..
1	..	Perth Elec. Trams Ord.	⅛—¼	5 15 5	May	..	..
St.	5%	†Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	100	..
5	3/0	†Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 2 6	..	..	..
St.	4½%	†Do. 4½% 1st Mort. Deb. Stk.	97 —102	4 18 0	..	..	..
1	5%	Rio Janeiro Tram, Lt. & P. Co.....	91 —93	4 6 0	..	96	92⅛
100	$1	†Do. 30 yr. Gold Bnds.	96⅛—97⅛	4 2 9	..	100	97
..	5%	Do. 50 yr. Mt. Bnds	87⅛—88⅛	5 12 0	..	88⅛	87⅛
100	$2½	†Sao Paulo Tramway, Light & Power Co. $100 Stock	144 —146	6 19 0	..	147	146
100	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 6	June, Dec	102⅛	101⅛
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5⅛—5⅜	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.....	10⅛—11	5 9 0	..	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stk. (red).....	93 —95	4 14 6	Jan, July	94	..
..	5%	†Do. 5 per Cent. 2nd Mort. Deb. Stock..	96 —98	5 2 0	..	..	..
100	$1	Calcutta Elec. Supply Ord.	6¼—6⅜	6 4 0	April, Oct	..	..
100	$3	†Canadian Gen. Elec. Co. Com. St.....	106⅛—110⅛	6 7 6	..	..	..
100	5%	Do. 7% Cm. Pf. Stock	121 —123	5 13 0	..	122⅛	122
100	5%	†Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co. of Ontario.....	85 —88	5 12 6	..	..	..
St.	5%	†Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅜—½	8 0 0	April, Oct	..	..
100	5%	†Kaministiquia Power Co.5% Gold Bnds...	100 — 102	4 18 0	..	..	..
5	..	†Madras E. S. Corp. Ord.	2⅜—3⅛	..	..	..	..
5	..	†Melbourne E. S. Co. 6%Cum. Pref.....	33 —38	..	..	..	..
St.	5%	†Do. 5% 1st Mortg. Deb. Stock.....	90 —92	5 7 6	..	..	..
500	5%	†Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84⅛—85⅛	5 17 0	..	85	..
St.	$1	Mexican Lt. & Power Co. Com. St.	78 —80	5 12 0	..	..	..
St.	7%	Do. 7% Cum. Pref. St.	102 —104	6 14 6	..	103⅛	103
500	5%	Do. 5% 1st Mort. Gold Bnds.	92⅛—93⅛	5 7 0	..	93⅛	92⅛
100	$1⅛	Montreal Lt. Ht. & Power Co. Cap. St.	135 —139	5 0 6	F,My,A,N	..	..
100	$2½	River Plate Electricity Co. Ord.	2⅛—2⅜	5 12 9	April	2⅛	2⅛
1	1/2½	Do. 6 per Cent. non-Cum. Pref.	1⅛—1⅜	5 2 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	100⅛—102⅛	4 17 6	Jan, July	..	..
5	3/0	Rosario Ele. Co. Ord.	8⅛—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6⅛	4 12 0	April, Oct	..	..
100	$1	Do 2nd Pref.	8⅛—8⅜	6 14 6	..	8⅛	..
100	$1	Shawinigan Water & Power Co.Ca	101⅛—103⅛	4 7 0	..	102	101⅛
5	5%	†Do. 5 per Cent. Bds.	105 —107	4 13 6	Jan, July	..	..
St.	4½%	Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102	101⅛
5	3/0	Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	100⅛	..
1	..	Victoria Falls Power Co. Pref.(1 to 808,000)	⅛—¼	5 6 6	Jan, July	⅛	..
..	..	Do. (803,081 to 1,700,000)	⅛—¼	..	..	..	..

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,678. [No. 14. Vol. LXV.] FRIDAY, JULY 15, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

The Portability of Standard Cells.

IT has always been a marked feature of the standard cell, as developed during the last 20 years, that it should be portable. Ordinary portability—by which we mean the character that enables the cell to be carried readily from one establishment to another with a little care—is easily secured, but it is generally desirable to go a stage further than this and to secure what may be termed "universal portability." By this we mean a construction enabling the cell to be posted from one part of the globe to another without ill effects, even though it may have been inverted for a considerable part of its journey. Many methods have been proposed to attain this end. Thus, in the old test tube form of cell the platinum was frequently amalgamated and the cell was well packed up with crystals so that there was not anything tending to shift to any great extent. Again, crystal cells, that is, cells made up of damp crystals without any otherwise free solution, were proposed many years ago by Profs. CALLENDAR and BARNES. In the H form of cell the problem is not quite so easy, and it has been customary, as recommended by the National Physical Laboratory, to form a crystalline plug in each leg of the cell below a constriction in the glass tube. This device seems to act satisfactorily, but such crystalline plugs are liable to increase the internal resistance of the cell, and although the E.M.F. is unaffected, a cell with a very high internal resistance is by no means so convenient for laboratory measurements as one with a low internal resistance, while in some cases its use becomes comparatively limited. The modification introduced by Mr. H. TINSLEY, which our readers will find described in another column, seems to be an effective way of getting over the difficulty. Mr. TINSLEY simply uses small perforated corks on to which a disc of linen is sewn, and this is forced down on the top of the crystalline materials. With suitable precautions such a method should give no trouble; there should be no increase of resistance, and it should prove an effectual barrier to any displacement of the ingredients.

Electricity Supply in the Potteries.

IT is not so long ago since we drew attention to proposals that were being made to combine the five pottery towns in North Staffordshire into one county borough. At that time we welcomed the idea and pointed out the advantages which would result from this co-operation. This combination has now been accomplished and among the first steps that have been taken is one towards the unification of the electricity supply, Mr. C. H. YEAMAN, of Hanley, having been appointed to undertake this by no means easy task. Unfortunately the inhabitants of these islands are essentially parochial. They consider simply their own immediate neighbourhoods and their view is correspondingly narrow. When railways first came into general use, lines were laid down in practically the same area with entirely different gauges so that intercommunication was impossible, and even now we see two adjacent tramway undertakings working with different gauges and sometimes on different systems.

THIS lack of foresight will now cause Mr. YEAMAN some trouble in the new borough of Stoke-on-Trent. The borough already possesses four electricity stations, three of which supply continuous current on the three-wire system, and the fourth single-phase alternating current with a frequency of 100. As the alternating current area is right in the middle of the others, it is hard to see how it can be ignored, or this might otherwise have been the easiest solution. The worst of it is that this is the sort of mistake that might have been avoided. The authorities who were responsible for the introduction of electricity supply into these districts might, had they been less self-centred, consulted as to what common method they

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should use. They might have foreseen that a time would come when it would be convenient to combine, and that a variety of systems would not help towards this end. They might even have erected one station to supply the whole of the area involved. But they did none of these things, and Mr. YEAMAN will therefore be faced with unnecessary trouble, and the electrical engineering profession will not advance in the public estimation.

The Board of Education and University Colleges.

IT is, doubtless, a sign of greater civilisation to find a government taking interest in the education of the country over which it rules. In the early days, governments were prone to believe their duty ended in waging wars, or in restraining the high spirits of the King's subjects with a more or less heavy hand. As what they were pleased to consider high spirits often arose from too high an education on the part of the boisterous subject, they, as a result, rather tended to discourage the spread of knowledge, and certainly did nothing actively to help it. Thus it came about that all university, and a greater part of the primary, education of this country depended on the enterprise and munificence of private individuals. Oxford and Cambridge are still self-supporting or, at any rate, sufficiently so to be independent of Treasury aid, but the increasing need for university education and the consequent establishment of many new universities (five have been founded in the last ten years) has made it necessary for special financial assistance to be given. This takes the form of a grant from the Treasury to the provincial universities (with the exception of Oxford, Cambridge and Durham), the university of London, and the three university colleges at Nottingham, Reading and Southampton.

THE Treasury, as a condition of this aid, which is independent of any that may be received from the local authorities, require the institutions concerned to supply accounts and details of their working, and these are collected in a Blue Book which has recently been issued. The information contained therein is summarised in an introductory report of the Board of Education to the Privy Council. This contains some interesting details on present-day university education. It appears that the total amount granted to university colleges in Great Britain is now £100,000, while the three Welsh colleges receive £4,000 each. Compared with the sums expended on the Army and Navy, or even on less worthy objects, this is not a very large sum, though it is sufficient to show that the claims of university education are at last receiving some recognition. These grants, moreover, stimulate private beneficence, as the numerous donations during the past year amply indicate. Further, a very rigorous inspection is made of such institutions as receive this grant, with a view to deciding whether the education provided is of a university class; all of which make for efficiency. The report further points out that specialised adult instruction by university teachers must not be considered of a university character, but only that which "is based on a broad preliminary education of wide range" and which is "conducted under conditions that enable it to become the main interest and occupation of the student." This is a view with which most will be in entire agreement. There is no objection to providing higher education by evening classes or in specialised form, but it should not be called university education. If we keep our standard of university teaching high, we cannot also fail to raise that of the primary and secondary education, so that the Board of Education is well advised to assist as much as possible all institutions that approach these ideals and to cut off university grants from the others.

London Electrical Engineers.—The following notice relative to this Corps appeared in last Friday's "Gazette":—Lieut.-Col. and Hon. Col. (Hon. Major in the Army) R. E. B. Crompton, C.B., M.I.E.E., is retired, under the conditions of paragraph 116, Territorial Force Regulations, and is granted permission to retain his rank and to wear the prescribed uniform; Major (Hon. Capt. in the Army) H. M. Leaf to be Lieut.-Col., Capt. J. H. S. Phillips, A.M.I.E.E., to be Major, Lieut. G. W. C. Kaye, A.M.I.E.E., to be Captain (July 9).

L.B. & S.C. Railway Electrification.—Confirming our anticipations of last week, we now learn that an order has been placed with the Allgemeine Elektricitäts Gesellschaft (Berlin) for supply of electrical equipment for the trains of the L.B. & S.C. Railway Co., to be used on the electrified line between Victoria and the Crystal Palace and between London Bridge and the Crystal Palace, on to Norwood Junction. The contract comprises 28 equipments, each consisting of four 150 H.P. alternating-current motors designed to operate at a pressure of 6,300-6,800 volts and a frequency of 25.

The Telephone Situation.—A recent issue of "The Times" contains a letter by Mr. H. Laws Webb, in which the author points out the inherent difficulties of providing a Government telephone service which shall at the same time be cheap and efficient. Mr. Webb suggests that instead of the Post Office completely taking over the business of the National Telephone Co. a more satisfactory arrangement would be for the company to continue the commercial management while the Government retained control over the rates charged.

Wireless Telegraphy and the Cable Companies.—Mr. Ernest L. Walford, of the Stock Exchange, London, recently communicated to "The Times" his views on the subject of Wireless Telegraphy and the action (or rather the alleged inaction) of the Submarine Companies in adopting this method of communication in combination with their cables. It may be that the cable companies have not made the public fully aware of the steps they have taken to obtain the fullest advantage from all modern means of intercommunication. We are in a position to state that, from the first, many, if not all, the companies have, through their electrical departments or by other means, kept abreast of all developments of wireless telegraphy. For some time past several of the companies have actually been operating wireless where the circumstances or necessities of the case have allowed or have needed it. For instance, the Western Isles (the Azores) have all been linked up by wireless by the Europe and Azores Co. for the Portuguese Government, and negotiations are in progress to establish wireless installations at several of the Eastern and Eastern Extension Companies' stations. The West India and Panama and other companies have wireless stations either in operation or in course of erection. Mr. Walford and the share and stockholders in the cable companies may rest assured that every step in advance is being closely observed and the fullest advantage taken of latest developments. The observations of the chairmen at the meetings of the companies have, we think, satisfied the members that the position, so far as their interests are concerned, are adequately safeguarded.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repairs.
Assab—Perim	July 8, 1909 ...	—
Malta—Tripoli.....	April 20, 1910 ...	—
Madagascar—Reunion.....	May 12, 1910 ...	—
Reunion—Mauritius.....	May 20, 1910 ...	—
Latakia—Palura	May 26, 1910 ...	—
Obock—Djibouti.....	June 24, 1910 ...	—
Falmouth—Bilbao.....	July 4, 1910 ...	July 11, 1910

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The Order of Merit—The King has been graciously pleased to appoint Sir Wm. Crookes, F.R.S., to the Order of Merit. The achievements of Sir Wm. Crookes are well known to our readers, and satisfaction will be felt that he should have been selected to fill the place in the Order of Merit left vacant by Sir Wm. Huggins. Besides discovering thallium he has done a great deal of work on radium and has covered a great part of the field of physics from the chemical side. He has been president of the British Association and of the Institution of Electrical Engineers. He was knighted in 1897.

Electrical Smelting of Iron Ore in Scandinavia.—H.M. Legation at Christiania report that the iron produced at the experimental furnace erected at Tinnfos, near Skien, Christiania Fjord, which can be manufactured at about £3 per ton, is capable of competing with the best Swedish "charcoal iron," costing from £5 to £5. 10s. per ton. The production at Tinnfos is at present 3 tons a day; when the power at the works has been increased to 1,000 H.P., 25 tons a day will be turned out. The ore, which is smelted directly in the furnace, is said to contain 45 per cent. of iron. It is proposed to develop the works for the manufacture of steel, which, it is said, can be produced at from £4 to £4. 10s. per ton, whereas Swedish "charcoal steel" of similar quality costs nearly £10 per ton. H.M. Legation are informed that there is a Swedish patented invention for the same purpose, which is said to give excellent results and to be more reliable, and that some furnaces are shortly to be erected near Christiansand.

H.M. Consul at Stockholm reports that the Swedish installation for the electric smelting of iron which is financed by the Association of Iron Workers is being proceeded with satisfactorily at Trollhättan. At the same time experiments have been resumed with the original electrical furnace at Donnarfvet, and the superintendent has officially announced that the results are even more satisfactory than those hitherto obtained, and that he considers the economic problem of dealing with ore by electricity so as to supersede that of the blast furnace to be definitely solved.

Obituary.—HARRY W. COX.—It is with great regret we record the death, on Saturday last, of a victim to the disease which has many times followed in the wake of the successful application of X-rays. Mr. Harry W. Cox, the patient experimenter whose sufferings have now terminated, had long taken a keen interest in electrical matters, and when the subject of X-rays came forward to be investigated, he from the first put his heart and soul into the work. Unfortunately, his enthusiasm resulted in his exposing himself to the dangers of these rays, with the result that first his hands, then his arms, and ultimately his face became affected by the dreaded "X-ray dermatitis." Mr. Cox, his injuries notwithstanding, continued his earnest work in the X-ray field, adding many useful and interesting instruments and pieces of apparatus to the equipment of the medical profession. Among these instruments may be mentioned an appliance for showing the depth of an embedded object below the surface of the body when seen by X rays. He was responsible for 50 patents relating to coils and other X-ray appliances. Mr. Cox's efforts were recognised in the highest quarters in the land—a fact which greatly softened the fate which was hanging over him for several years. An attempt was made to obtain for him a Civil List pension; unfortunately the Prime Minister was unable to comply with the request, but a grant of £200 was made out of the Royal Bounty Fund. At the instance of Sir William Treloar a sum of £2,800 was raised by subscription to meet, to some extent, the necessities of this pathetic case. Mr. Cox was highly respected in the world of therapeutics, and his death is mourned by many who have benefited by his experiments. The funeral took place yesterday (Thursday) at Abney Park Cemetery.

HON. C. S. ROLLS.—By the untimely death of the Hon. C. S. Rolls engineering is robbed of one of its most consistently practical devotees. The pioneer work of Mr. Rolls in automobilism contributed much to the establishment of the motor car industry in this country, a fact for which the many electricians now conducting a flourishing business in ignition apparatus must feel extremely grateful. Though not closely identified with the electrical industry, Mr. Rolls had many electrical friends who will join us in our expression of sincere sympathy with his bereaved parents.

ALFRED E. IZARD.—We also regret to record the death of Mr. A. E. Izard, which occurred on Monday last at Kingsgate, near Broadstairs. For nearly 25 years Mr. Izard has been associated with the lighter side of the electrical engineering profession in that he, first as an accompanist and afterwards in the dual capacity of accompanist and musical director, in conjunction with Mr. T. E. Gatehouse, did much towards providing that tunefulness for which the Electro-Harmonic Society has long been noted. Mr. Izard became a student of the Royal Academy of Music in 1878, a sub-professor in 1883, and professor in 1885, which position he held until his death.

PROF. THOMAS HAMILTON CORE.—We also regret to record the death of Prof. Thomas Hamilton Core, which occurred on Saturday last at Wellington, Manchester. The deceased was in his 74th year. For thirty-five years he occupied the Chair of Physics at Owens College, Manchester, retiring in 1905 as emeritus professor. Until 1881 he also supervised the more mathematical parts of the physical teaching, but towards the end of his professorship he confined himself to lecturing on experimental mechanics, and withdrew from teaching the more advanced work.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. F. Fernie contributes an article in which he deals with the laying of Cables and Ducts.

Mr. F. J. Chambers describes a new form of liquid microphone for the purpose of wireless telephony.

Mr. H. Tinsley contributes an article on "Weston Cells," in which he describes a method of rendering them portable by the use of a simple diaphragm.

We give a description of the Brown, Boveri system of train lighting.

A further account of the exhibits at the Brussels International Exhibition appears on another page.

Walsall Corporation have decided to expend £23,225 on additional plant, extensions of mains, &c.

At the meeting of London County Council on Tuesday the Fire Brigade committee presented a report on the tenders received for the supply of three electrically-driven motor (escape) vans.

A Bill to make the installation of wireless telegraphy on passenger ships compulsory was read a first time in the House of Commons on Wednesday.

The Board of Trade have issued their report on the applications made for Provisional Electric Lighting Orders during the past year.

The Municipal Council are considering eight tenders received for the concession for electricity supply in Constantinople.

Parliamentary.—A House of Lords Committee has rejected the North East London Railway Bill.

The London Electric Supply Bill, which makes the London County Council the purchasing authority of the five remaining electricity supply companies, has passed the committee stage in the House of Lords.

INSTITUTIONS AND SOCIETIES

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.—The Official Circular of this Association for June contains, in addition to various matters relating to the Association, a copy of the Board of Trade Regulations regarding details of construction and equipment, a copy of the Proceedings of the Board of Trade and of the Light Railway Commissioners up to December 31, 1909, and a verbatim Report of the Discussions on the Papers read at the recent Tramway Congress held in Dublin on June 9 and 10.

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LOCALISATION OF FAULTS ON UNDERGROUND MAINS.*

BY W. A. TOPPIN.

Summary.—After discussing the causes of faults, and the recording of earth leakages, the author describes a simple method of locating earth leakages and the apparatus he has constructed for facilitating the test.

Much attention has been given of recent years to the design and manufacture of underground cables, with the result that cable can now be procured which, if carefully laid, will last for years, giving satisfactory service with little or no repairs. It is now generally recognised that the cable system is at least of equal importance with the generating station. If information were obtained on this subject it would be found that more interruptions of supply have occurred through faults on cable networks and feeders than through all other causes combined. To ensure continuity of supply the details of a cable system must be as carefully thought out and be subject to the same intelligent care and supervision as any portion of the station plant.

The following remarks on the localisation of faults are not based on any particular theory, but are the result of the author's practical experience with a three-wire direct-current system, using single conductors, the distributors generally being laid solid in bitumen and the feeders drawn into conduits. The most fruitful source of trouble on

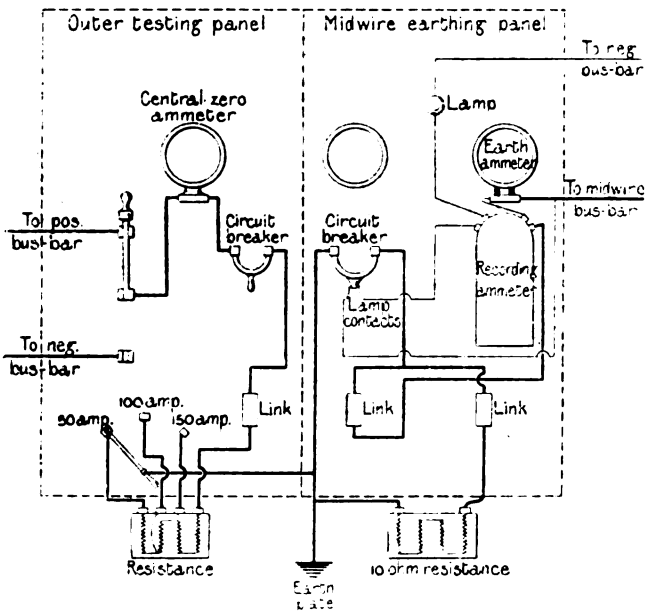

FIG. 1.

such a system is that arising from earth leakages, which may occur on either of the outer conductors or on the middle wire. As a rule these faults develop gradually, and unless localised at an early stage may result in a serious "burn-out" with possible interruption to the supply system. It is therefore wise to take steps to localise and repair a leakage immediately it begins to indicate on the earth-recording ammeter. The author is aware that some station engineers believe in allowing earth leakages to develop to a more pronounced stage before adopting remedial measures, and one engineer at least has indeed advocated the "smoke" test method of localising faults; but the author believes those who have any regard for the prestige of their undertaking will agree with him that, as the primary consideration is reliablity of supply, incipient mains faults should not be permitted to develop to such an extent as will interfere with the supply even to a single consumer. His experience shows that 90 per cent. of mains faults originate in earth leakages, and these can nearly always be located and remedied before reaching the critical stage.

Causes of Faults.—Faults on cable systems may be classified under the following heads: (1) Those due to defects in the manufacture of the cable, such as cracks or pinholes in the insulating material. (2) Those due to improper methods or careless handling of the cable when laying. (3) Those due to disturbance of the ground either by subsidence or street openings by other departments.

Recording of Earth Leakages.—On all direct-current systems where the pressure between adjacent conductors exceeds 125 volts, the Board of Trade stipulate the following conditions: (*a*) The connection with earth of the intermediate conductor shall be made at one point only on each distinct circuit—namely, at the generating station, sub-station or transformer—and the insulation of the circuit shall be efficiently maintained at all other parts. (*b*) The current from the intermediate conductor to earth shall be continuously recorded, and if it at any time exceed one-thousandth part of the maximum supply current, steps shall be immediately taken to improve the insulation of the system.

Fig. 1 shows a testing and earthing panel, the latter designed to meet the Board of Trade requirements. On the right-hand panel the middle wire 'bus bar of the station switchboard is connected through the indicating and recording ammeters, and thence through an automatic circuit-breaker to an earth-plate of ample dimensions. The cut-out is adjusted so that when the current flowing through it to earth exceeds 25 amperes the circuit is interrupted and the current is shunted through a 10-ohm resistance. When open, the circuit breaker arm closes a circuit through an indicating lamp and a relay on the recording ammeter, the latter actuating a needle to record the time during which the cut-out is open. The left-hand panel has been designed for testing the insulation resistance of the outer conductors, the method being to earth each outer cable in turn through a known resistance, and noting the resultant current. It is also used to burn out minor earths which may occur on consumers' premises. If, for example, such a leakage is indicated on the negative outer the procedure is first to disconnect the middle wire 'bus bar from earth and then to earth the positive 'bus bar, and by passing a current which can be varied by the regulating switch, the fault is burnt clear or localised by the melting of the consumers' fuses. In an industrial district where large power users are connected to the supply mains, and especially in places like shipyards and foundries where temporary circuits are often run, many troublesome earth leakages occur, and a careful study of the earth chart will enable the mains engineer, with a knowledge of local conditions, to locate most of these faults. Overhead travelling cranes with bare trolley wires are responsible for many intermittent leakages.

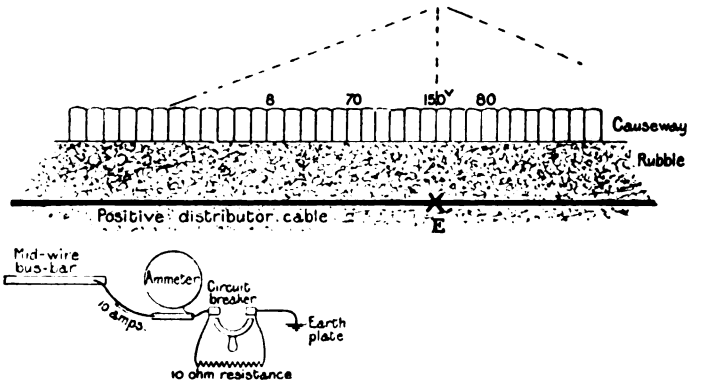

FIG. 2.

It is well known that negative cables are more susceptible to earth leakages than positive cables, and a record of the faults which have come under the author's notice during the last few years shows that fully 80 per cent. of the earths on a supply system occurred on the negative side. In almost every case of breakdown in a negative conductor the core was found saturated with moisture for 4 ft. or 5 ft. on each side of the fault, due apparently to osmotic action, while the bitumen covering, which under normal conditions is unaffected by moisture, is converted into a spongy state, quite independent of its temperature. This peculiar effect is produced on the negative cable only, and in cases of faults affecting both outer conductors, the positive core was found to be quite dry, while the surrounding bitumen was in its normal state, or only affected by the heat generated by the leakage current. A positive earth fault on a feeder cable, which occurred in a draw-in box, due obviously to a crack in the bitumen sheathing, showed a gradually increasing leakage current for a period of three weeks, and on cutting out the faulty section the moisture appeared only to have crept for a few inches along the core on each side of the fault while the bitumen was practically unaffected.

Locating the Faulty Cable on the Network.—The location of faults is rendered easy where cable networks are divided into sections with disconnecting links in convenient pillars. The proper method is to fuse each distributor cable at its feeder pillar, and in the event of a short-circuit the faulty section is automatically isolated from the system. Momentary short-circuits which disturb the pressure are not of great enough duration to melt the fuses, and are consequently the most difficult to deal with. For this reason, among others, the author is of opinion that all feeders should be provided with recording ammeters on each conductor. A defect on the middle wire is not

*Abstract of a Paper read before the Glasgow local section of the Institution of Electrical Engineers.

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easy to locate, and introduces complications when an earth takes place on an outer as the leakage current from the latter may be passing to the middle wire, and no indication given of the fault.

Many methods have been employed for the localisation of faults on underground mains. In most cases the choice is limited by the type of cable and the system of supply. The author will not institute comparisons between these, but proposes to describe a simple method which he has found of service in locating earth leakages without interrupting the supply. He is not aware if the idea is novel or otherwise, but can testify from actual experience of its worth, and the chief claims he puts forward are its simplicity in operation and the absolute certainty of the results obtained by its use. Its operation depends on the fact that when an earth leakage occurs, the earth in its vicinity is charged to a potential above normal earth potential, and this potential will vary at any point in inverse proportion to the distance from the fault. Assume an earth leakage at E on a 250-volt three-wire system of distributors (Fig. 2), the current shown on the ammeter with the 10-ohm limiting resistance in circuit being 10 amperes through the fault. This gives a total resistance between the fault and the earth-plate of 15 ohms and a difference of potential of 150 volts. This pressure will be highest immediately at the fault and will diminish with the distance from the fault. It can be measured by an ordinary voltmeter, but in most cases a special voltmeter, calibrated to read down to very small pressures, is desirable. One terminal of the voltmeter is connected to a rubbing contact and the other to a good earth connection, such as a steel rod pushed into the ground at a distance of 2 yds. or 3 yds. from the cable route. Besides simplicity in operation and accuracy of results, other advantages of this method are that the smallest earth leakages can be expeditiously located without interruption to the supply; the apparatus is cheap and simple in construction, while the test may be made by any one possessing elementary technical skill. The method is applicable to any system of supply, whether direct or alternating. In the case of a two-wire supply it is only necessary to earth the unaffected conductor to give the required P.D. surrounding the fault.

The author has found in practice that it is much more satisfactory to obtain testing current from the supply mains than to employ portable batteries, as the latter require to be maintained in good order, ready for an emergency, while the discharge current may be totally inadequate for the purpose of locating a fault, unless it should happen to be a dead earth. In very few cases is it found impossible to locate faults by the method described by the author, and in these recourse has been had to the well-known but more elaborate Wheatstone bridge methods or to Murray's loop test, these, however, requiring the disconnection of the faulty section. One of the most trying faults to locate is that of a burnt-through cable which still retains its normal insulation resistance to earth. If a leakage cannot be started by subjecting the insulation to a high-pressure test, its position may be found by an elaborate capacity test from either end, or by the crude method of cutting the cable at various points along its length.

Insulation testing sets consisting of ohmmeter and generator are now universally adopted for testing mains, but the author would like to call attention to the inability of the generators in most of these sets to maintain a sufficiently high pressure when testing a cable of low-insulation resistance.

DISCUSSION.

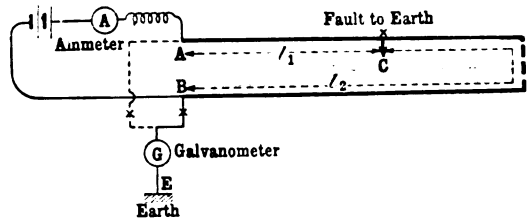
Mr. McLeod (Clyde Valley Power Co.) congratulated the author on the originality and ingenuity displayed in the Paper. He asked if the author had ever tried the system on three-core lead-covered cable and with what results. Further, would it not be very difficult to use in very dry ground, especially with wood paving or granolithic, and was it necessary to go over a considerable area with the apparatus indicated to locate a fault? Supply authorities as a rule found it better to prevent faults coming on than to allow them to develop and burn out. His company took insulation resistance tests at regular intervals. In this connection the pilot wires, such as were used in connection with Merz-Price feeder protection and telephone pilot wires, now pretty generally adopted in all first-class supply systems, came in very handy. Being more lightly insulated, they were more sensitive to any subsidence, and in that way indicated before the heavier insulated cable where and when there was a fault developing.

Mr. W. W. Lackie (Glasgow) said Mr. Toppin had referred to the important part which underground mains played in the supply of electrical energy. They represented quite one-half of the capital expenditure of the undertaking, and, further, they were buried underground and could not be inspected like plant, and when anything went wrong all evidence of the cause was generally burned away. For this reason alone it paid to adopt the very best system of cables. The arrangement in Glasgow was to have a recording ammeter on the positive and negative pole of each feeder, but also to have a shunt in series with the middle wire, on which an ammeter could be connected at any time. Each feeder was isolated and fed its own piece of network, so that the station engineer was able to report at once to the mains department what feeder or area a fault was showing itself on. Mr. Toppin seemed to condemn the drawing of bitumen cable into ducts, and the bitumen was liable to turn spongy with leakage current. The speaker asked if this were really his experience. The subject of osmosis was brought very prominently before the public some years ago. In Glasgow they experienced trouble from this without bare copper strip, and the insulation of the negative wire was practically nil. When Mr. Chamen adopted triple concentric mains he looked into this subject pretty closely, and they once thought of altering the polarity of the triple concentric mains. At present the core was positive, the next conductor negative and the outer was the middle wire. With this arrangement the central conductor would suffer from the osmotic effect, and one might have a breakdown between the central conductor and the negative, or between the negative and the outer. It was thought that if they altered the polarity of the central conductor and made it negative, and the next conductor positive and the outer conductor the middle wire of the system, that the osmotic effect would be confined to the central conductor, and, further, it would probably be protected from osmotic effect. In conclusion, he congratulated Mr. Toppin on his practical contribution to the subject of the localisation of faults.

Mr. McWhirter asked for more information as to how the tests were carried out. Mr. McLeod had advocated tests, while Mr. Lackie said "no tests." Mr. Toppin's system would be quite good while the fault was in the incipient stage. Electrolysis had always been the "black man" with cables. He thought the smoke test, burning out of the fault, was rather rough on the consumer. Lead was being given up as a covering for underground cables.

Mr. W. D. Morgan thought that on the testing panel shown there was a "dead short" circuit through the earth connection. If a pipe ran alongside the cable there might be a case where the enigneer, while using the triangle, followed the pipe instead of the cable down a side street where there were no cables.

Mr. Robertson (Greenock) mentioned that there were cases where the author's method would not do, three-core cables, for example. In Greenock there were cables under high-water mark where fault currents had varied between 1, 2 or even 5 amperes. He advocated the smoke test system, and he questioned if in Glasgow any other system would do. He referred to a method which he had found to answer very well. It was similar to a potential test and was shown in the accompanying diagram.



Calling the distance between A and C, l_1, between B and C, l_2, and the total length of cables = L = $l_1 + l_2$, then with a galvanometer connected between A and E the deflection d_1 is obtained. By connecting the galvanometer between B and E the deflection d_2 is obtained. Then $l_1 = L \cdot \frac{d_1}{d_1 + d_2}$, and, similarly, $l_2 = L \times \frac{d_2}{d_1 + d_2}$. He did not think insulation tests much good, and he did not agree with Mr. Lackie as to isolating the feeders. Distributors with dead ends could scarcely be cheaper than a linked-up system. It meant that there would, of necessity, require to be different voltages for each feeder. The best way of preventing faults was to get a good cable and lay it carefully on the solid system protected with suitable troughing.

Mr. Raphael, in a written communication, asked if the method was suitable for lead-covered cables. He instanced a similar system of fault indication in Berlin, where pilot wires were run from the feeding point back to the station to an indicator there, but that arrangement was not perfect, as the tramway currents sometimes made the indicators come out. He advocated the use of a portable set with a battery.

Mr. Sillery (Partick) advocated separate networks.

Mr. Allan advocated the use of an insulation testing set, and deprecated the use of the smoke test on account of fire risks, especially if a factory was closed for the night.

Mr. Toppin, in reply, said the method had not been tried on three-core cables, but it was quite suitable on lead-covered or drawn-in cables, if the lead had no breaks of continuity in it. It had been successfully tried on cables 2 ft. 6 in. below the surface in the dryest weather. The ohmmeter and generator method was only suitable before putting cables into commission. He had used a compass near boxes where the position of cables was apparent. Electric tramways had no effect on the test in his experience. To prevent the "short-circuit" indicated by Mr. Morgan, circuit-breakers were provided.

Telephony on Trains.—According to the "Telephone Engineer," the Lehigh Valley Railroad has decided to instal a telephone service on its trains running between New York and Buffalo, to be available at stations. Communication will be effected with the outside world at wayside stations through the telephone circuits which run along the lines.

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THE COMPOUNDING OF ALTERNATORS.*

BY A. BLONDEL.

Summary.—The author describes his system of compounding alternators. The exciter rotates in synchronism with the alternator, but with a fixed mechanical phase displacement. Alternating currents are passed into the armature winding of the exciter so as to magnetise the field system and automatically raise the exciter voltage as the load increases. Details of actual installations and test results are given.

A very interesting article, by Dalémont and Herdt, on "Armature Reaction and the Compounding of Alternators" has recently been published.

After recalling M. Blondel's theory of two reactions for the particular case in which variations in permeability can be neglected, the authors of that Paper state that an excellent compounding of alternators can be obtained by compensating for the reaction due to the

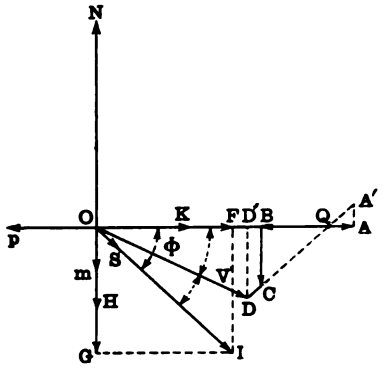

FIG. 1.—VECTOR DIAGRAM FOR THEORY OF TWO REACTIONS.

wattless component (I sin Φ) alone. In fact, the reaction due to the watt component (I cos Φ) is always very small, and serves rather to raise the voltage.

The author (M. Blondel) had already made this remark in August, 1896, at the Congrès des Electriciens de Genève: the study had even been carried further, and a system of compounding proposed.

At the Congrès des Electriciens de Paris (1900) the author expounded this method more fully. Finally, in February, 1904, he added a second exciter for the purpose of obtaining complete stability of running and a large flexibility in the regulation.

This method, which is entirely distinct from any of those described by Messrs. Dalémont and Herdt, has escaped the notice of these latter, who live in Canada, since up to the present the method has only been published in the "Comptes Rendus de l'Exposition de Liége"; but, in fact, the method has been put into practice for several years with satisfactory results.

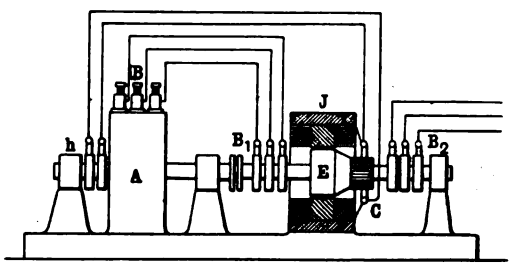

FIG. 2.—PRINCIPLE OF EXCITATION BY THE REACTION OF THE WATTLESS CURRENT PASSED THROUGH THE EXCITER.

The author, then, has thought it of interest to recall the principle of his method of compounding, and also to give some instances of its practical applications.

Let us consider the vector diagram (Fig. 1) mentioned by Messrs. Dalémont and Herdt. The problem to be solved, according to this diagram, was to regulate the excitation of the alternator by creating in the field winding, on load, additional ampere-turns proportional to the vector OG, representing the wattless component of the current (I sin Φ). This result was originally realised by the author's *reaction exciter*, the principle of which he expounded, as follows, in 1896: "The method consists in the use of an exciter of the Rechniewski type, with a small air-gap; the field windings, constructed in the usual manner, are shunt wound, and excited just enough to produce the excitation required by the alternator on open circuit; the armature, which rotates in synchronism with the alternator by a mechanical coupling, has two windings, the one winding being continuous current and exciting the alternator, and the other a compensating winding similar to the alternator winding and traversed by the same currents; the number of turns, and the points at which the current is led into this winding are so adjusted that the reaction field produced by a wattless current has the same direction as that of the main field, and strengthens it in exactly the same proportion that the corresponding armature reaction of the alternator tends to weaken its own field; in addition, the brushes are kept fixed by one of the known methods. Under these conditions, if the alternator and the exciter are both being worked below the knee of their saturation curves, it is easy to see that all the armature reactions, watt or wattless, are compensated automatically."

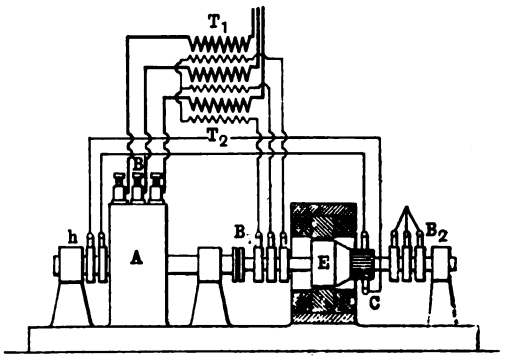

FIG. 3.—COMPENSATED EXCITATION BY WATTLESS CURRENT WITH A SERIES TRANSFORMER.

Fig. 2 represents this arrangement for a three-phase machine with rotating field. A is the alternator, B the terminals from which the currents are led to B_1, the slip-rings connected to the compensating winding on the exciter E, B_2 the main terminals, C the commutator of the main exciter winding and J the shunt winding.

It is obvious that the passing of the alternator current direct into the exciter armature is only practicable for low-tension currents; with high-tension alternators the current must previously be transformed by means of a series transformer. The arrangement is then as shown in Fig. 3, in which T_1 is the primary circuit of the three-phase transformer in series with the main circuit and T_2 the secondary. It will be seen that the three rings B_2 now simply serve to close the supplementary winding, which receives the currents from the secondary T_2 by means of the rings B_1; the rings

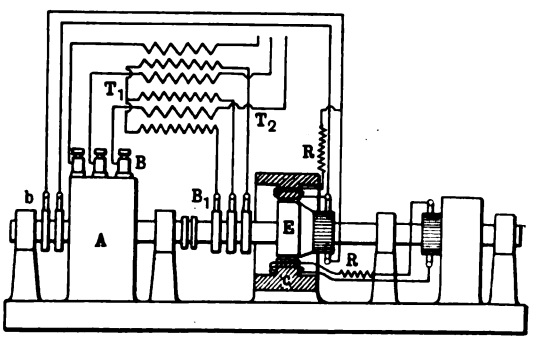

FIG. 4.—DIAGRAM OF COMPLETE METHOD; REACTION EXCITER WITH PARTIAL INDEPENDENT EXCITATION.

B_2 can therefore be dispensed with, and the joint made on the armature according to general practice. By suitably choosing the number of secondary turns T_2 on the transformer, the two armature circuits can be combined just as with a rotary converter.

Fig. 4 represents the scheme of compounding as it is actually applied. In addition to the apparatus already described, there is a small direct-coupled dynamo for a new and important purpose. This machine supplies a part of the excitation for the exciter E, and thus ensures the stability of the magnetic equilibrium of the system at all loads. It is a very small machine and always works on the same load. On the other hand, the exciter E and the transformer do not work at constant and complete saturation of the iron.

Fig. 5 shows the diagram of connections of the exciter E for a bipolar machine. In reality, it is evidently convenient for this exciter to have the same number of poles as the alternator, or else

* From the "Bulletin" de la Société Internationale des Electriciens (slightly abbreviated).

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it must be driven by a multiplying gear. With turbo-alternators the number of poles is, however, almost always two or four.

Fig. 6 shows the mechanical phase displacement of the exciter relative to that of the alternator, supposed star connected.

Principle of the Calculation of Compounding by means of a Reaction Exciter.—As we have already remarked, the wattless current which flows in the exciter armature on load, due to the wattless component of the current in the transformer, must exert a magnetising influence on the exciter; we will represent it, therefore, by OG in Fig. 5, which has the same signification as the vector OG in Fig. 1. In the same manner we will represent the watt component of the current by the vector OF, at quarter centres and in advance of the vector OG. The effect of this watt component in the exciter is to assist rotation and commutation; in fact it is easy to see that this component does work and produces a turning moment: its reaction on the exciter field tends to counteract the reaction of the current collected by the brushes.

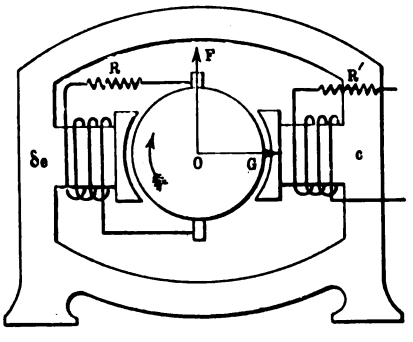

FIG. 5.—DIAGRAM OF MAGNETIC FLUXES IN THE EXCITER.

If e is the E.M.F. between the brushes of the exciter, the E.M.F. between the rings is $\sqrt{\frac{3}{8}}e$ and the E.M.F. between each ring and the neutral point is $e/\sqrt{8}$. This ratio, calculated on the assumption of sine curves, must be corrected in practice, and, in general, it is taken that the E.M.F. between rings is equal to e multiplied by a certain coefficient γ. This E.M.F. is obviously at quarter centres with OG.

In like manner there is a component in quadrature with OF, due to the cross flux of the exciter; but this component is always very feeble, on account of the small ratio that this cross flux bears to the main flux, and, moreover, there is, as we have just seen, a partial compensation between the cross flux due to the vector OF and that due to the current taken from the brushes.*

If n is the ratio of transformation of the transformer, the E.M.F. of the exciter in terms of the primary will be $\gamma e/n$.

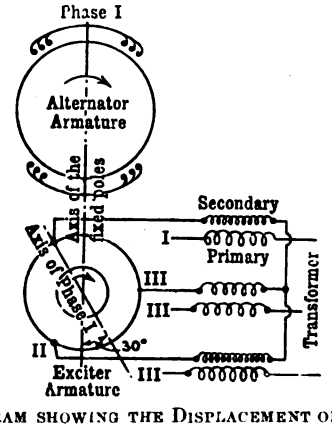

FIG. 6.—DIAGRAM SHOWING THE DISPLACEMENT OF THE EXCITER ARMATURE.

(Alternator star connected, exciter mesh connected.)

This E.M.F., generated by the exciter, is in opposition with E_0; in order to make it as small as possible in practice, the number of secondary turns is made from three to four times the primary turns on the transformer; under these conditions the fall of potential across the primary winding on full load is practically negligible. So far as the action of the series transformer is concerned, it is sufficient to assume that it produces a secondary current approximately proportional to the total primary current taken from the alternator. The watt component of the secondary current is in part converted by the commutator of the exciter, and thus contributes directly to the excitation of the alternator, and also in part produces a turning moment as has been seen above; the wattless component serves to produce a magnetising reaction proportional to the wattless component of the primary current.

It is true that, in order to drive this wattless component through the armature, a certain E.M.F. is necessary, and, in consequence, there must be a certain difference between the "wattless" ampere-turns of the primary and of the secondary, approximately in phase with OG. The author, however, ensures that this vector shall be very feeble and practically negligible by making:—

1. The self-induction of the secondary winding of the transformer very large compared with that of the exciter armature, and consequently the winding acts approximately as if it were closed on itself.
2. The greater part of the necessary magnetising ampere-turns to be furnished by a shunt winding, which will be mentioned again later; the "wattless" ampere-turns of the armature above all serve to regulate this shunt excitation, and only produce in themselves a part of the necessary ampere-turns.

The total ampere-turns on the exciter are composed of a constant part, c, due to the small auxiliary exciter, and a variable amount produced by the reaction of the wattless component of the alternator current, and equal to (in continuous-current ampere-turns)

$$K\frac{I\sin\Phi}{n}\times\frac{m\sqrt{2}}{2}.$$

$\frac{I\sin\Phi}{n}$ representing the current in each ring, m the number of conductors on the armature, and K a well-known coefficient, depending upon the number of phases and conductors.

On open circuit, *i.e.*, when I=0, there is no current in the primary of the transformer; but there is a small wattless current in the secondary, due to the effect of the exciter being short-circuited by it. This can be taken account of, once and for all, by representing it by the equivalent counter ampere-turns, and considering that the excitation ampere-turns of the exciter on open circuit are reduced to a constant amount, obtained by the difference $C-C'=c$; these resulting ampere-turns set up an E.M.F. e_0 at the brushes of the exciter.

On load the current from the exciter to the transformer diminishes, becomes zero, and then changes its sign; the resultant excitation always remains below the knee of the open circuit characteristic of the exciter; the exciter voltage e is therefore proportional to the excitation ampere-turns

$$c+\frac{Km\sqrt{2}}{2n}I\sin\Phi.$$

The ratio of transformation n is so chosen that the term $\frac{Km\sqrt{2}}{2n}I\sin\Phi$ (proportional to the wattless component of the current), with respect to the constant term c, has the value necessary to provide the additional ampere-turns to the alternator, in order to maintain (or to raise) the voltage at the terminals. In order to reduce to a minimum the reaction ampere-turns which have to be supplied by the transformer, as stated already, a shunt winding is added to the exciter E, as shown in Figs. 4 and 5. The expression for the total magnetising ampere-turns becomes

$$\left(c+\frac{Km\sqrt{2}}{2n}I\sin\Phi\right)\left(1+\frac{\delta e_0}{c}\right)$$

where δ is a convenient constant.

It will be seen that the addition of this excitation, due to the shunt winding, does not at all modify the conclusions at which we have arrived; it is even possible to give it a preponderating effect—for example, two-thirds of the total excitation. But it must not be carried too far in this direction, for the shunt winding by itself must not be relied on for the working of the system, for then the system would be unstable.

The great advantage, in practice, of this excitation taken in shunt from the exciter brushes is to reduce to about one-third the current required from the transformer and from the auxiliary exciter. This latter machine in particular can be a quite small bipolar dynamo, or the power can be taken from the continuous-current station 'bus bars when available. As for the transformer, it is much smaller than if it had to assure the whole of the excitation required by the alternator.

Voltage Regulation and Compounding of the Alternator.—The regulation of the system can be adjusted by means of the rheostats R and R'. By regulating the rheostat R in the shunt circuit the total value of the alternator exciting current can be adjusted in a certain proportion, but the relative value of the compounding effect is unaltered; in fact, this operation is equivalent to modifying the numerical value of the coefficient δ in the factor $\left(1+\frac{\delta e_0}{c}\right)$.

* The brushes being fixed in the neutral position and the pole shoes being unsaturated, the cross flux moreover does not appreciably affect the E.M.F.

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By regulating R′, and hence the excitation provided by the small auxiliary exciter, the relative value of the compounding is adjusted; in fact, the value of the term c with respect to $\frac{Km\sqrt{2}}{2n} I \sin\Phi$ is thus modified.

It can be seen, therefore, that it is very simple to modify at will the compounding effect, as well as the absolute voltage of the alternator. This great flexibility and convenience of regulation is one of the characteristics of the system of compounding just described, and contributes largely to its practical value. It is also to be noticed that if for any reason the compounding transformer is damaged, the arrangement permits of hand regulation just as with an ordinary alternator. It is also to be noticed that the two operations of the regulation are exactly equivalent to those employed in the regulation of compound-wound continuous-current dynamos.

There is, moreover, an analogy between the two kinds of compounded machines, and all the known properties of compounded dynamos can be applied to the working of compounded alternators. For example, parallel working can be obtained with the greatest ease; and it is advantageous also to use equalising connections, that is to say, to connect the terminals of the alternators direct on to equalising bars, in order that their mutual synchronising action can take place freely. However the fall in potential in the compound transformers is so small that several compounded alternators on this system operate very well in parallel without equalising connections or special precautions being taken.

Examples of Actual Installations and Test Results.—The author gives brief details of actual machines compounded by his method. They consist chiefly of two-pole turbo-alternators. Test results on two of the machines are also included, and we give below a few details.

1. *Alternator:* 500 kw. 3,000 volts, 50 cycles, 2 poles. Compounding transformer: Primary, 26 turns; secondary, 64 turns (star).

Experimental Results.—Inductive load ($\cos\phi$ 0·8).

Load.	Volts.	Excitation.	Current exchanged i_2.
0 ampere ...	3,000 ...	75 amperes ..	5·9 amperes effective.
93·5 amperes ...	3,030 ...	120 ,, ...	23·0 ,, ,,

(Without compounding and excitation 75 amperes, the voltage falls to 2,350 with a load of 93 amperes.)

Non-inductive Load ($\cos\phi = 1·0$).

	Load.	Volts.	Excitation.
Fixed resistance R′ = 19 ohms ...	0 ampere ...	3,000 ...	75 amperes.
Shunt resistance R = 60 ,, ...	104 amperes ...	3,150 ..	110 ,,

	Load.	Volts.	Excitation.	i_2.
Fixed resist. = 12 ohms ..	0 amp. ...	3,200 ...	85 amp. ...	6·1 amp.
Shunt resist. = 61 ,, ...	108 ,, ...	3,190 ...	116 ,, ...	22·5 ,,

The above figures show plainly how close is the compounding effect and also the ease with which the voltage and the compounding effect can be adjusted by means of the two rheostats. They also show how small the currents exchanged between the transformer and the exciter are in comparison with the exciting current of the alternator. In this particular installation three alternators are connected in parallel without equalising connections or special apparatus of any kind.

2. *Alternator:* 500 kw., 525 volts, 3,000 revs. per min., 50 cycles. The following results have been obtained at unity power-factor:—

Load.	Volts.	Excitation.	R.P.M.
80 amperes ...	530 ...	60 amperes, 21 volts ...	3,010
140 ,, ...	530 ...	64 ,, 22 ,, ...	3,030
180 ,, ...	530 ...	70 ,, 24 ,, ...	3,020
260 ,, ...	540 ...	79 ,, 27 ,, ...	3,020

When running on its distribution system at a speed of approximately 3,000 revs. per min., the following results have been obtained:—

Load.	Cos ϕ.	Volts.	Excitation.	Current exchanged, R.M.S.
0 amp. ...	— ...	525 ...	52·5 amp., 19 volts ...	3·5 amp.
300 ,, ...	0·865 ...	525 ...	76·5 ,, 26 ,, ...	17·0 ,,
386 ,, ...	0·865 ...	525 ...	80·0 ,, 28 ,, ...	24·0 ,,
650 ,, ...	0·80 ...	525 ...	103·0 ,, 40 ,, ...	45·5 ,,

The voltage is thus practically constant. The voltage across the primary of the transformer does not exceed 2 volts on load.

Conclusion.—The chief features of the author's system of compounding are, a very great simplicity, the use of a single series transformer of relatively unimportant power, instantaneous action (due to the laminated field system of the exciter), and the ease with which the voltage can be raised independent of the compounding effect, and the coefficient of compounding regulated independent of the voltage. There is an absence of all delicate mechanism which is likely to get out of order, such as resistances operated automatically, and the operation of the system simply depends upon purely electrical and magnetic reactions.

THE BROWN-BOVERI SYSTEM OF TRAIN LIGHTING.

It is not surprising to find that from its very introduction the use of electricity for train lighting has increased by leaps and bounds. Not only did its employment make it possible to discard the gas containers and other deadweight, but its greater safety in case of accident has been often made apparent. To provide a train with light is, however, not an easy matter, and several systems have been devised, some of which consider each coach as a unit, while in others all the energy for lighting is supplied from an auxiliary set on the engine. In the former case the dynamo is driven from the road wheels, and special arrangements have to be made to ensure the voltage being constant over a wide range of speed.

Among the firms who have devised a system on these lines may be mentioned Messrs. Brown, Boveri & Co. This company designed a marketable arrangement so long ago as 1902, and now has over 3,100 equipments, lighting over 4,000 passenger cars, in use.

With a few minor alterations it remains the same to-day as it originally was. Messrs. Brown, Boveri & Co. early recognising that the system of electric train lighting which ought to be developed was that which provided a separate equipment for each carriage. This, of course, has the advantage that each carriage forms an independent unit, and one which can be used if necessary as part of a train in which gas or other lighting is also used. In addition to this general advantage, the particular system evolved by the firm possesses, it is claimed, the special advantage that no regulation or adjustment is necessary to enable the carriage to be used in fast or slow trains, or to enable it to be employed for long or short lighting periods. Such flexibility of working calls for an equipment provided with a regulating apparatus which can satisactorily deal with such onerous requirements.

In a train-lighting system the battery must be protected from overloads, and the voltage of the lamps must remain constant, independently of changes in the speed of the train. These conditions cannot be fulfilled by any one machine, and in the Brown-Boveri system the work is performed by a standard generator working in connection with a special regulator.

Current is only supplied from the battery when the train is at rest or running at speeds less than 15 miles per hour. Above this speed the lamps are supplied direct from the dynamo, which at the same time charges the battery, if not already fully charged. The dynamo is switched out and replaced by the battery when the train speed drops below the minimum mentioned above.

As regards the apparatus used on this system the dynamo is a continuous-current shunt wound machine of very simple construction, and is freely suspended either from the carriage framework or from the bogie truck. The tension on the belt (which is the usual drive employed) is produced either by means of the weight of the dynamo itself or by springs. Seeing that the dynamo must generate current in both travelling directions, a means of reversing the position of the brushes is provided, so that with each change of travelling direction the brushes are automatically shifted into the correct position corresponding to unvarying polarity. The bearings are constructed with ring lubrication. The dynamo is dust-tight, and in consequence of its simple and strong construction, requires a minimum of attention—in fact Messrs. Brown, Boveri find that the experience gained with the 2,000 equipments already supplied shows that the upkeep costs are almost negligible.

The battery is provided to maintain the lighting during stoppages of the trains; in consequence, its size depends principally on the number and duration of the stops. Usually the battery is so dimensioned that the lighting can be maintained by its aid alone for 7 to 10 hours. It consists of a fixed number of cells, according to the lamp pressure, these cells being arranged in groups and mounted in a wooden case, in such a manner that without any considerable labour they can be placed in, or be removed from, the battery container which is arranged on the long side of the carriage.

The automatic regulator is for the purpose of controlling the pressure of the dynamo and keeping it independent of the travelling speed, so that on the one hand the battery can be charged, and on the other the supply to the lamp circuit maintained. Directly the train starts, the dynamo excites itself, whatever the direction of travel, and as the train speed increases there is a proportionate increase of pressure. As soon as it reaches the battery pressure the dynamo is switched both on to the battery and on to the lighting circuit by means of the automatic switch (C) shown in Fig. 3. As the speed of of the train increases, the dynamo pressure tends to rise. This is prevented by switching resistance into the shunt circuit. The automatic variation of the resistance in circuit is carried out by means of the regulator R, in which the contact sector A rolls over a number of contacts corresponding to the number of subdivisions of the

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resistance, in this way varying the shunt current and thus the pressure of the dynamo. The first contacts are connected to the operating magnet of the paralleling switch, the others to the resistances. The regulator R consists of an electromagnet between the poles of which a bobbin, O, fixed to the contact sector A, capable of partial rotation is placed. The field produced is partly due to an exciting winding, M_1,

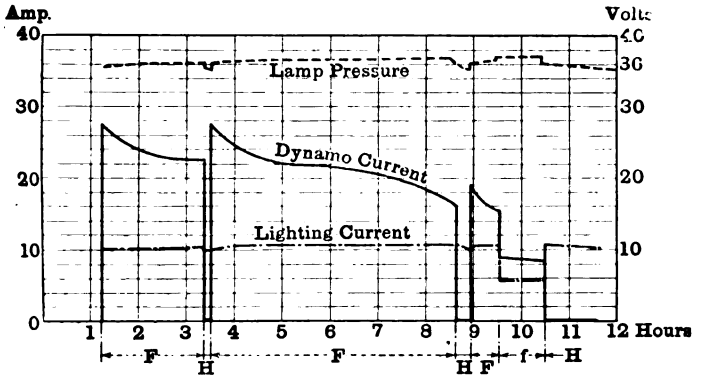

FIG. 1.—CURVE ILLUSTRATING THE CHARGING OF A COMPLETELY DISCHARGED BATTERY DURING THE LIGHTING PERIOD.

in circuit with the movable bobbin O and the shunt of the dynamo, and partly to an exciting winding, M_2, which receives its current from the battery and whose magnetising effect is in the same direction as that of winding M_1. A third exciting winding, M_3, carries the lighting current and produces a magnetising effect in the opposite

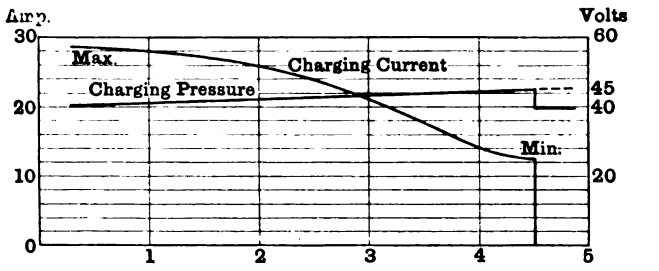

FIG. 2.—CURVE ILLUSTRATING THE CHARGING OF A COMPLETELY DISCHARGED BATTERY WITHOUT CONSUMPTION OF LIGHT.

direction to that of the windings M_1 and M_2. The magnetic field produced by the combined effect of the windings M_1 and M_2, or M_1 and M_3, tends to turn the current-carrying bobbin O, whose movement is opposed by the spring F. This spring is so arranged that it exerts a constant pull on the bobbin O.

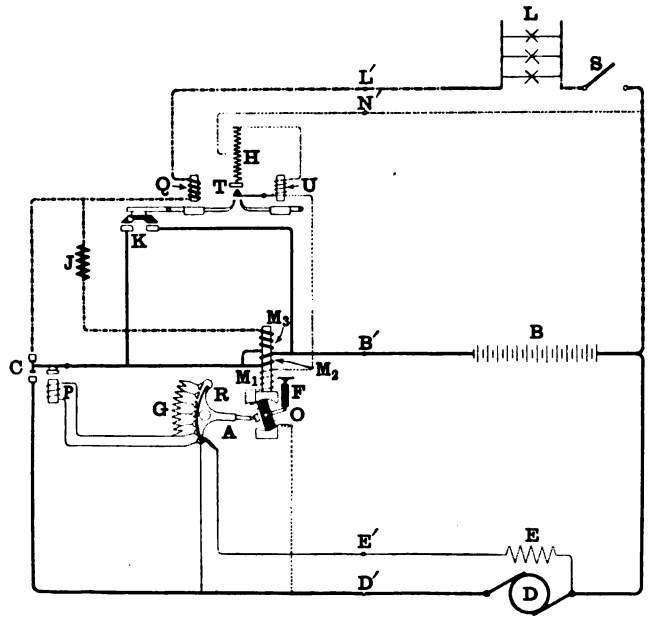

FIG. 3.—COMPLETE DIAGRAM OF CONNECTIONS SHOWING THE INTERNAL CIRCUITS OF THE AUTOMATIC REGULATOR.

The demands made on such a train-lighting equipment are very varied, depending upon whether it is installed on fast or slow trains, and if the journeys undertaken are by day or night. The following are the two extreme cases: A fast train stopping at few stations, and travelling by day only, there being in consequence no considerable demand for light. A slow train stopping at many stations and travelling by night, with, of course, a large demand for light.

In the first instance, once the dynamo has completely charged the battery, its services are no longer required, and the function of the regulating apparatus is to prevent further production of current, as should charging of the already fully charged battery be continued it would be detrimental to the latter. Therefore the output of the dynamo must be quite low, and this under the difficult conditions that it is running for a long time in consequence of the few stoppages at stations and of the greater speed at which it is running on account of the high rate of travelling.

In the second case the dynamo must not only keep the battery continually in a fully charged condition, but during the journey it must in addition supply current directly to the lamps. The machine must thus generate a large amount of electrical energy, as it is imperative that the battery should not become too far discharged, because it could be damaged even more in this way than by being over-charged. Here, again, the production of the electrical energy occurs under unfavourable circumstances, because the working period of the dynamo in consequence of the many stoppages is relatively short, and, further, the speed at which the machine is running is low on account of the slow rate of travelling of the train.

The diagrams (Figs. 1 and 2) show how the charging of a completely exhausted battery takes place, firstly during a journey without any outgoing energy being taken, and secondly on a journey where lighting is used.

It will be seen from the above description of the Brown-Boveri system that the operation of the regulating device is one of the chief features of the system. The principal object of this arrangement consists in the regulation of the shunt rheostat by means of the rolling sector A, in Fig. 3. The ends of the resistance coils are led to wedge-shaped contacts arranged in a row upon which the contact sector rolls. The contact surfaces are made of silver to avoid oxidation.

ELECTRIC CABLES.*

LAYING CABLES AND DUCTS, AND RECORDS AND COSTS.

BY F. FERNIE.

(*Continued from page 438.*)

Summary.—The author describes in a general way the methods followed in laying cables in ducts, on the solid system or simply armoured: also in the shafts of mines. In conclusion, records are considered and the allocation of costs.

LAYING CABLES AND DUCTS.

General.—The most difficult problems in main laying are met with in the principal streets of large towns, and the electric supply engineer, coming, as he does, last of all in the demand for space, sometimes finds but little choice in the matter. Tramway lines may occupy a large part of the carriage-way, and there may be main and distributing gas and water pipes, with services taken off them at various levels; drains of all kinds promiscuously laid, telephone and telegraph pipes, and tramway feeders. In the midst of this medley accommodation must somehow be found for the electrical distributors, usually on both sides of the road, and in many cases provision has to be made for feeders, pilot wires and street lighting cables in addition.

Feeders are often laid in the roadway, as they need not, in the natural order of things, be again disturbed; but it is nearly always best and cheapest to lay distributors in the footpath, for the following reasons:—

1. All service leads are shorter, and therefore cheaper.
2. Cables can be laid much shallower than in the roadway.
3. The ground will be much drier round the cables.
4. There is less excavation, and the work can be done more cheaply and quickly.
5. A proper draw-in system for distributors is almost impossible if installed in the carriage-way, on account of the great cost of the necessarily heavy pits and covers for draw boxes and service connections.
6. The cables are more readily accessible for connections and repairs.

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7. There is generally more room, as gas and water pipes are nearly always in the carriage-way.

8. The permanent reinstatement is usually cheaper than that of the roadway, and can be done once and for all. A trench in a roadway takes time to settle, and if filled up in wet weather has to be gone over several times afterwards to get a good road surface.

After deciding upon their situation, one of the first questions that arise is the minimum safe distance which should separate the cables from gas or water pipes. The mains engineer should be particularly careful to avoid gas pipes, on account of the danger of explosions if they are injured by electrolysis, and naturally the owners of all other pipes are as much concerned about the safety of their property.

If a pipe is within 2 in. or 3 in. of a cable it may be burnt through by a fault, but even at a distance of 4 ft. or 5 ft. it is not immune from danger. The diagram in the section on fault localising shows how the potential of earth varies, as the distance from a fault increases, so that at a radius of 7 ft. there is not sufficient potential gradient to cause any danger. It is, however, as a rule, impossible to keep 7 ft. away from all pipes, and on a properly maintained network it is quite unnecessary, because a fault can be located so quickly that there is no time for much electrolytic damage to take place before it is disconnected. Six inches of intervening earth is reasonable, but even this cannot always be maintained, in particular where cables are laid in footpaths above cellars, owing to the existing gas and water services. One advantage of *insulating* ducts and troughs is that they may be laid with safety much closer to other pipes than those made of clay, for instance.

Apart from the risk of damage due to the proximity of the various pipes, the question of their respective accessibility should be carefully considered. Electric cables must not be laid above any existing drains or underground works, and to guard against this the trial holes should be probed with a steel bar, to make certain that the sub-soil is clear.

When it is necessary to cross other pipes, this should be done at right angles; if the cables cross near a joint in the pipe this should be at the socket end, so that it can be re-staved at any time.

Before opening any ground to lay cables, notices and plans must be sent to the various authorities. These may include the gas and water people, the Postmaster-General and the road surveyor. It is as well to bring the foreman and a few men to the job the day before the gang commences, and let them open up trial holes on the proposed route in order to find a clear course. Often the position of existing pipes can be ascertained previously from the different authorities, but in old streets this is never the case, and a number of pipes, particularly drains, will be discovered of which there is no record.

When the main body of men arrives, the track should be marked off ready, and they can at once get to work. We do not consider it a good plan to let each navvy open up a section of trench by himself, because the pace will then be regulated by that of the slowest. It is better to mix the men's work up as much as possible, so that it is not easy for them to recognise when the too energetic members of the gang should be advised to slow down.

The length of trench that can be opened at one time depends on the nature of the traffic and on the police regulations, but usually 100 yds. or so is sufficient. The work must be safely barricaded, and for this purpose wooden trestles and planks are to be preferred to iron spikes and ropes, which are sometimes dangerous. All bridges, &c., over the track should be carefully fenced. Corporations are particularly liable to claims for damages, and generally have to pay, so that extra time and trouble on barricading, &c., is not wasted. Canvas screens should be used to protect the passers-by and shop windows from the fragments that fly when a hard macadam or concrete road-bed is broken up. It is also well to make a note of all broken windows in a street before beginning work, as fraudulent claims for damages have sometimes been made. The men must be impressed with the necessity for reporting any pipes they may accidentally damage, and they should not be penalised for this, otherwise they will cover up the damage with soil, and when, later on, it is inevitably discovered the cost of rectifying it will be much greater than if it had been reported and admitted at once. The position of gas and water services can generally be found from the stop cocks, and should be chalked on the wall for the men's guidance.

Ducts.—The trench being opened, some fine soil is riddled into the bottom to serve as a bed, and the pipes are then laid in and jointed. If rows of single pipes are used, they should be kept everywhere apart with the joints staggered, and distance pieces of wood or broken clay pipe put in here and there. This prevents a bad short circuit between cables in adjacent pipes, and represents an advantage over composite ducts. All ducts must be laid so as to drain into draw boxes, and any dips or hollows in them are quite inadmissible. The slope must be such as to drain from one box to another, or high in the middle, so as to drain both ways into a box at either end. Two feet of depth is enough for cables laid in carriage-ways, or less if they are concreted. In footpaths it may be much less, and we consider that under flagstones the pipes containing the cables should be visible as soon as the stones are lifted. There will then be less risk of *accidental* mechanical injury. A spirit level is used in setting each length of duct so as to keep the "run" right.

If concrete is used as a protection, it may be made up of 1 part cement to 6 or 7 parts sand and metal (by volume). If the concrete is intended to save the pipes from a crushing strain, like that caused by a steam roller, it should be placed underneath and packed well round the sides and between, as well as on the top, so as to form a kind of bridge. If it is intended merely as a protection from picks, it need only be placed on the top and at the sides. In any case, the concrete should have a smooth surface, and thus be easily recognised by any workman opening the ground later as something to be respected, and not to be smashed up as a casual obstruction.

A smoke testing apparatus, similar to that used for drains, should be used on every length of pipes laid before filling in. This is a very sensitive test, and will show up any bad joints or fire cracks. When this test has been made, the ground is filled in, first with sifted earth, which is carefully packed round the sides and between the pipes; more earth is then shovelled on and lightly rammed or punned—very carefully at first or the joints will be spoiled. When the trench is nearly full the ramming should be as vigorous as possible, and two men should be ramming for each man shovelling in soil. In dry weather more stuff can be got back if water is mixed with it, and the surface of a macadam road is generally washed in with water.

"*Solid*" *System.*—When laying cables "solid" there are one or two points to notice. The troughs are first laid in, jointed and bedded on sifted earth. The saddles can then be put in place, being stuck down with little patches of bitumen poured in hot. If this be done the cables must be drawn in *alongside* the troughing, and afterwards lifted into position.

Those who have not had actually to do this kind of work always suggest that the drum of cable should be rolled along over the trench and the cable paid off direct, forgetting that it has, at least in towns, to be threaded under pipes crossing the trench at right angles. The other method is to draw the cables into the troughs and afterwards to slip the saddles under. Perhaps the troughing is kept cleaner by the first method, as loose soil is very liable to be knocked into it at all stages of the operation. To prevent this, strips of canvas are often laid along the sides of the trench.

Before filling in the bitumen everything should be perfectly dry and clean. We think, if lead-covered cable is used, there should be no braiding on it, because this may act as a capillary passage for moisture to travel along the cable, and also because it is nearly impossible to dry it properly after a shower of rain; and, since the trench cannot be kept open indefinitely, the work cannot be satisfactorily carried out in showery weather. Braiding would appear to be far more necessary for conduit work, where the cable may have to be drawn in and out several times, and cannot be examined after it is pulled in.

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If the cable be pulled alongside the troughs first, it can all be examined for injury, and cleaned whilst it is being lifted into its final position. The saddles should be from 1 ft. to 2 ft. 6 in. apart, being nearer together the more flexible the cable.

The first pouring of bitumen should be very hot and thin, so that it is sure to get underneath the cable; if it is not hot enough it is very liable to chill and partly solidify on first coming in contact with earthenware or lead, and thus air spaces may be formed. After this bitumen has hardened a little the troughs may be finally filled up with bitumen not so hot, the right temperature being ascertained by its appearance. The cables are liable to buckle with the heat if the troughs are filled right up at first, and they must be watched during the first filling, and, if necessary, pressed into their proper position with sticks. If the troughing is covered with bricks or tiles, they are generally put on whilst the compound is hot, so as to make them stick in position. If the troughs are laid on a gradient, it is necessary to start at the bottom and to work up hill when filling.

Where "solid" cables enter a brick pit they must be led through glands of some kind, since the bitumen will always tend to flow, even at ordinary temperatures. Asphalt forms a suitable material for the glands; but wood should be avoided if possible, as it always gets wet, and the cable may then be damaged by either electrolysis or chemical action.

The last two or three feet of the cable outside the pit should not be laid "solid," but in a pipe; this prevents it from being sharply bent where it leaves the "solid" trough, and it is held

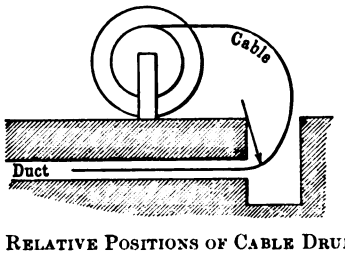

Fig. 1.—Showing Relative Positions of Cable Drum and Draw Box.

rigid. If the cable has to be often handled it is sure to give way just where it leaves the "solid" should this precaution be neglected.

Armoured Cables.—Armoured cables are the easiest to deal with. After they are laid in position, two or three inches of soil is sifted over them and the protecting boards then put on. It is said* that armoured cables should not be laid in clay, as it attacks the armouring. Our own experience is the reverse of this, and we should suppose that the bed of sand, recommended as a remedy when the soil is clay, would form a natural drain in the ground, and result in the accumulation of moisture round the cable, thus affording an opportunity for many dissolved substances to be brought into contact with the cable, some of which might be harmful.

Drawing-in Cables.—If the ducts have not had yarn threaded through as they were laid, they must be wired so that the hauling rope can be drawn in. This is done by pushing a No. 14 or 12 gauge iron wire, bent into a hook at the end, into the duct from either side, and when they meet in the middle the wires are twisted in opposite directions until they catch. An 80 yds. run of ducts can easily be wired in this way. Lengths of canes screwed together, as used for drains, are also useful, especially for very long lengths, and when additional cables are being subsequently drawn in.

When the hauling rope is ready the drum is mounted on jacks, or on its carriage, a few feet from the draw box and behind it, which prevents the cable from being rubbed against the edges of the duct or pit (*see* Fig. 1). Men are stationed to revolve the drum at the proper speed and watch that the cable does not foul anything when being fed into the duct. With a heavy cable a wooden batten is used for this, as shown by the arrow in the figure, and of course the pulling is done very slowly.

* "Practical Notes on Electric Mains."—B. L. R. Lee.

A heavy cable must be liberally greased as it goes in, petroleum jelly being excellent for this purpose, as it has no injurious effect on the lead.

It is preferable to attach the *core* of the cable to the loop formed at the end of the rope. This is done by dividing up the copper strands into two bundles, which are passed through the loop in opposite directions and then bound back on themselves with copper wire. If the duct is wet, a mop should first be pulled through to clear it. The actual pulling may be done by hand or with a winch. Hand pulling is generally the quickest, but for long lengths of heavy cables a winch is necessary.

When drawing in by hand the men should be well spread out on the rope, and should be taught to time their efforts, so that they pull together.

When adding to the number of cables already in a duct, it is better, as mentioned above, to pilot the hauling rope through by means of screwed rods, as a wire may twist about among the cables, so that the new cable is threaded amongst the others, which may not only damage them at the time, but may also prevent any individual cable being withdrawn at a future date.

Cables, particularly those with impregnated braiding, sometimes stick to the pipe or other cables, and cannot be immediately pulled out. The sticking is not confined to one place, but is due to adhesion along the whole length. The following device will often overcome this difficulty: An iron wire is pulled through the duct and a loop formed at one end, which is passed over the sticking cable. If the wire be now pulled from the other end the loop is pulled through, encircling the cable, and cuts away the adhering compound (Fig. 2). If there is a bend in the pipe near one end, the cable

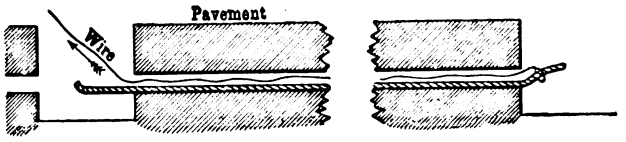

Fig. 2.—Diagram showing Method of Freeing an Adhering Cable

drum should be mounted at the opposite end, so that only a short length has to be pulled round the bend.

Mining Cables.—The installation of mining cables depends on the character of the mine, depth of shaft, &c. The simplest way of dealing with the shaft cables is to hang them from a special suspender at the top, but this is only applicable to armoured cables in short shafts. The armour, carrying as it does the whole weight of the cable, is subjected to a continuous strain, which may in time stretch it so that the insulation is impaired. This method, although cheap, is not to be recommended as the most permanent, but if the cage guides are wire ropes and there are no stays to cleat the cables on to, there may be no choice in the matter. It cannot, however, be used in narrow or very deep shafts. One advantage is that falling bodies are unlikely to damage it, owing to its having a certain amount of give and take.

A suitable suspender is described by W. R. Morton.* "The suspender best suited for the job is in the form of a cone, bored in the centre to take the cable over the armour. Over the half rounded top of the cone the armour wires are bent back and taken down the outside. The outside smallest diameter of the cone should be sufficient to permit all the armour wires to lie side by side without overlapping. This cone, with the armour wires correctly bent into place, sits in a taper seating of the same taper as the cone and provided with wings bored to take the D links of the supporting chains. The seating should be carried up above the top of the cone and the cup thus formed filled with bitumen or other waterproof compound to prevent corrosion at this point."

Another method, not always possible, is to instal the cables "solid" in wood casing filled up with bitumen. A successfu instance of this method is at Parton Collieries, Whitehaven, an armoured paper, lead sheathed cable being dealt with in

* The Electrician, October 29, 1909.

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this way.* Each length of casing is filled solid with bitumen before the next length above is fixed. Owing to the difficulty experienced in filling the casing the bitumen should be made very hot and fluid. There is a difficulty in keeping the casing compound tight, on account of the quasi-hydrostatic pressure exerted by it, especially when the height is considerable; but this trouble can be overcome by the insertion of wooden glands at intervals. We have seen instances of the wooden capping having been burst off by the weight of bitumen, even with quite moderate vertical distances.

Shaft cables may also be installed in iron pipes, and although this affords an excellent mechanical protection at first, when the cables may be sufficiently "wavy" to grip the pipes at the sides, they will eventually straighten owing to their own weight, and the top suspension should thus be designed of ample strength for this ultimate condition.

Joints should be avoided, but in deep shafts, where they are a necessity, the cable lengths should be ordered so as to bring the joints at headings, or, if this is not possible, a special chamber should be cut in the wall, big enough to give plenty of room to a jointer and mate. If the joint must be made on the wall of the shaft, the cable both above and below the joint should be cleated with several good long cleats, to take all weight off the joint, which should be protected by a stout wooden fender. A variety of methods are employed to instal cables in the roads. G. G. L. Preece, in "Electric Cables for Collieries," says: "Where there is a good bottom to the roads and no danger of floor movement, a splendid permanent job can be made by burying the cables underground, out of harm's way from tubs running off the line. In non-fiery mines these troughs can be filled solid with bitumen. The usual plan with single cables is to run the two conductors along opposite sides." Cables are frequently suspended to the roof or to timber props along the sides. The suspenders should be designed to break away easily if roof falls occur, and should have a large bearing surface. The closer they are put together the better, and the cable should be allowed to lie fairly slack between them. The suspenders are made of leather or impregnated yarn or canvas, and may be held by hooks or nails driven into the timber. Earthenware insulators are also sometimes run, or a shelf may be cut in the sides to carry the cables.

No special difficulty presents itself in making joints in underground cables. In fiery mines sweated joints cannot be made, and clamp fittings in joint boxes are generally used. "Safety" cables have been designed for mining work which are supposed to prevent any sparking taking place when a live cable is cut. "The general method is to provide a small auxiliary cable in parallel with the main conductor, which, in the event of a fall cutting the cables, is arranged to break either before or after the main conductor, and in each case actuates a magnetic cut out, which opens the main circuit."†

Records of Mains and Cables and Allocation of Costs.

The importance of accurate records of underground mains and boxes cannot be over-estimated. On a large network, plans have to be referred to many times daily. The methods adopted by large undertakings have generally been built up from some very simple beginning, which has been elaborated as the necessity for accurate plans came to be recognised. Most systems in use bear a family resemblance to the one described below, with variations in detail.

A number of skeleton maps of the district served are first obtained. On one may be indicated by a coloured line all the distributors, with different coloured circles representing feeding points, disconnecting boxes, network fuses, &c., and a line in some distinctive colour may be drawn joining up the fuses, and thus indicating the limits of each feeder district. This map will be used for obtaining a comprehensive view of the whole network when planning extensions or alterations, and also when splitting up the network to locate faults.

A second map may have all the feeders drawn on it, a third may show all the public street lighting, and a fourth the high-tension cables, feeding sub-stations or buried transformers. Obviously the more "mixed" the supply system is the more maps would be used. The maps are all ruled into numbered squares corresponding to sections of the 10 ft. scale Ordnance maps. Thus any street or cable on which information is required is first looked upon the skeleton plan, which gives the number of the Ordnance map on which it appears. These skeleton plans are conveniently kept clean by hanging them against the wall one behind the other, and allowing them, when not in use, to roll up into a box, exactly like a roller blind.

The Ordnance maps, mounted on strong linen with bound edges, are kept in a series of drawers, arranged so that any particular number is readily found. On these are drawn all the ducts, manholes, cables, &c., different kinds of ducts or methods of laying cables being distinguished by employing different coloured inks. All service lines and buried joints are clearly shown, with as much detail as possible. The scale on which the boxes and cables are represented is sufficiently accurate to measure up the position of a joint, say, within 1 ft.

Where there are a number of cables crossing each other, or several joints at disconnecting boxes, transformers or sub-stations, or in any case where the scale of the Ordnance map is too small for the drawing to be clear, a reference number is given corresponding to a given page in a sketch book, where all the details are drawn to a larger scale and dimensioned. These books are kept in their proper order in a bookcase, so as to be readily available.

The cross-sections of all cables are marked on the Ordnance maps and the numbers of houses inserted where known, so that a new consumer can be located on the map and measurements taken of the length of service line and any extension of main required.

For new work, or alterations, the mains engineer writes up, preferably in a carbon copy-book, the particulars, such as section and number of cables, polarity of service, method of installation, number and size of boxes, &c., and gives it to the foreman in charge, together with a tracing from the Ordnance map showing the route to be taken, and also includes in the instructions a job number for cost-keeping. On the completion of the work this is returned by the foreman to the engineer, who notes on it any alteration from the original design, signs it and passes it on to the draughtsman, who enters the particulars on his maps, together with the measurements and sections he has taken during the progress of the work. The sheet is then handed on to the costing clerk, who checks from it the actual orders received for material bearing the particular job number, and if the material given out tallies with the work shown on the sheet the latter may then be destroyed. The clerk should also work out the cost of labour per yard of trench opened, and should enter up the date at which the work was done and the names of the foreman, jointers, &c., employed on it. The costs books are stored and the outsides dated, and if the date of the completion of all work be entered on the Ordnance maps, the particulars of any work can readily be referred to in the costs book bearing that date.

If the meter department keeps the "balancing" cards for a three-wire or multiphase system, the instructions sheets must pass through that department before going to the costing clerk, so that a record may be kept of the polarity of the new services.

To ensure the return of all the sheets issued, the mains engineer enters the number and title of each job in a book when issuing the sheets, and checks their return by this book. The highest accuracy should be aimed at, and hardly any detail is too unimportant to note. A knowledge of the number, size and position of pipes and other works in a street is frequently required, and it is thus useful to keep in a special book drawings showing sections of streets, or parts of them, which the undertaking has had occasion to open up when laying cables. One of the most difficult of a mains engineer's duties on a large supply system is to allocate all the time and material to their proper accounts. Thus, some of the work has to be allocated to capital account, and this must again be subdivided into mains

* G. G. L. Preece, "Electric Cables for Collieries," "Iron and Coal Trades Review," 1906.

† A. T. Snell, "Electric Motive Power." For detailed information on safety cables and mining work generally the reader is referred to this book in "The Electrician" Series.

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extensions proper and services; then, in the maintenance account, renewals of cable must be distinguished from ordinary up-keep, chiefly on account of the income tax charges. There are also public lighting capital and maintenance accounts, and other work the cost of which is recoverable from consumers or other authorities, and probably sub-divisions of some of these.

Thus, even on everyday extension work involving services, the time and material has to be analysed and allocated to two different accounts.

The foreman in charge of a job should be the only person to issue orders for materials for that job, and should mark them all with the job number. The return of all unused or scrap material to the stores should be done through him, and his returning notes also numbered, the storekeeper having instructions to refuse all material returned unaccompanied by an order. These orders come back to the mains engineer from the stores, and are signed and allocated by him. Similarly, the foreman numbers the time sheets of the men, which are then allocated by the mains engineer. Charges for cartage are similarly dealt with, so that it will be abundantly clear (on an extensive network at least) that great care must be given to the booking up of costs if accurate and instructive figures for future guidance are to be obtained. The method of arriving at the proper tariffs to impose on a public supply system depends essentially on the correct allocation of all expenditure.

(To be continued.)

THE DESIGN OF OIL-BREAK SWITCHES.*

BY FRITZ DEHLER.

In high-tension electrical work the oil-break switch has found a large field of usefulness. The present article contains some notes relating to details of construction employed by a well-known German firm, who were early in the field as pioneers in the manufacture. The point which is kept constantly in view is the advantage to be derived from that form of design which places the live contacts at the bottom of the vessel containing the oil, the cables being connected up through openings arranged at the bottom of the case containing the switch. This plan was first suggested when it was proposed to combine the switch with replaceable fuses. Obviously this would be awkward and even dangerous if the contacts were arranged at the top, whereas on the other system the fuses can be mounted inside the cover, which is free from any live contacts. Therefore, as soon as the switch is opened and the cover raised, it is possible to set to work at once on replacing a fuse. An ammeter can also be combined with the switchwork and mounted on the same base, the whole constituting a complete substitute for a motor panel on the switchboard. It can also be combined with a minimum cut-out, which is mounted on the top of the cover, and keeps the switch closed so long as current passes. A further design includes an automatic maximum cut-out, which is likely to be useful on 10,000 volts; oil switches, combined with fuses, are possibly suitable for 5,000 volts, but for higher voltages they could only be used to control very small areas, and even in those cases only very small currents could be carried by the fuse.

One form of design is shown in Fig. 1. This could be mounted on a pedestal, or, as is often found convenient, a number of these could be mounted side by side round the room, each switch being placed in a separate cellular compartment. This switch consists of three parts, the portion *a* to the bottom of which live contacts are connected by means of suitable insulators, the portion *b* which contains the switchwork proper, and the cover *c*. The bolts holding the porcelain insulators at the bottom, end at the knife contacts *d*, which receive the spring contacts of the movable switchwork. This latter consists of a framework *e*, which is capable of vertical motion, and carries the contact springs mounted on insulators. The switch is worked from the outside by a lever, which can be moved through 180 deg., and is connected to the inside mechanism by a series of links. The releasing magnets *f*, which constitute the maximum cut-out, are immediately opposite the armatures *h*, when the switch is closed; if the current should exceed a certain limit, the armature is attracted and causes the releasing mechanism to open the switch. An opening is arranged in the cover, through which it is possible for anyone to see from the outside whether the switch is on or off by means of an indicator worked by *i*. At *k* two safety valves are placed.

These switches are suitable both for mining work and also for central stations, 68 of them being installed in the municipal works at Cologne, the whole being arranged in separate cellular compartments. Other methods of mounting the switches are used, the choice depending naturally on the circumstances of the case.

It is quite likely that automatic cut-outs in combination with oil

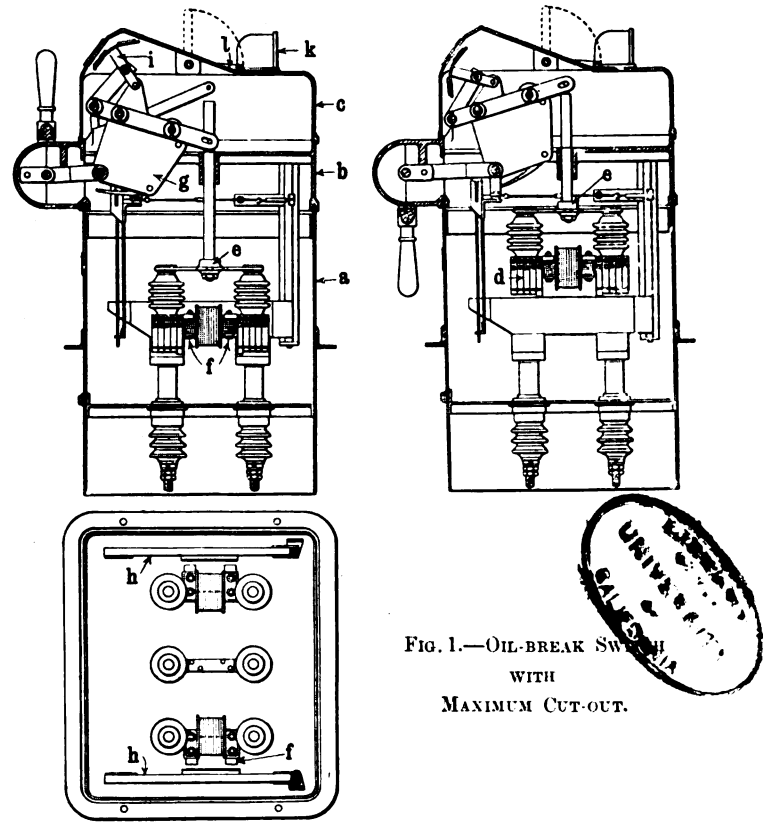

FIG. 1.—OIL-BREAK SWITCH WITH MAXIMUM CUT-OUT.

switches will be in greater demand in the future, and will be used in place of fuses. The advantage of such a combination lies partly in the fact that the circuit can be re-closed immediately, if desired, without the loss of time involved in replacing a fuse and partly also

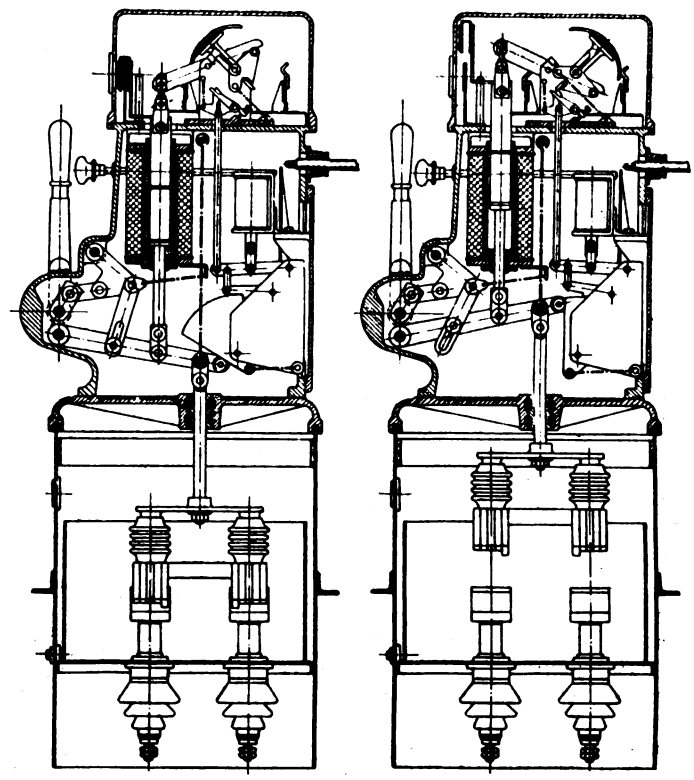

FIG. 2.—OIL-BREAK SWITCH FOR REMOTE CONTROL, SHOWN BOTH OPEN AND CLOSED.

in the consideration that it operates with much greater certainty with a double break, whereas a fuse merely blows on the one pole. Moreover a fuse requires a somewhat uncertain length of time in

* Abstract of an article in the "Elektrotechnische Zeitschrift."

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order to break the circuit, and this may or may not be an advantage. The oil switches with direct maximum cut-out should be so designed that, if replaced on a continuous short-circuit, the switch automatically opens again at once, irrespective of the position of the hand-operated lever. All types can, of course, be combined with minimum cut-outs, which are specially to be recommended for use with high-tension motors as a safeguard against an accidental stoppage.

Another type of switch is one that is suitable for operation from a distance, drawings of which are shown in Fig. 2, the contacts being arranged, as before, at the bottom, and all the parts connected with the moving cores of the operating coils being in an easily accessible position at the top. The contacts being made at the bottom, it is convenient to arrange a small doorway in the lower half of the pedestal, by means of which access to the interior is possible. This arrangement is adopted in the Gutehoffnung mine at Oberhausen, where 16 switches are used, which can be automatically connected and disconnected, all the connections being made below the switch case. Very similar arrangements are made in the central station at Dortmund, where 44 switches are arranged in two rows for 5,000 and 10,000 volts. In this case, on the switchboard gallery there are two panels, to which the connections for the remote control of these switches are made, the transformers being placed on the floor below. In this way the connections are taken direct from the transformers to the bottom of the switches, with a consequent saving of space and of unnecessary and possibly dangerous lengths of cable-runs. In fact, the advantages of the arrangement by which the contacts are made at the bottom of the oil-containing case are so great that for all types of work requiring switches of this sort this form of design may well be adopted.

THE CHAMBERS LIQUID MICROPHONE.

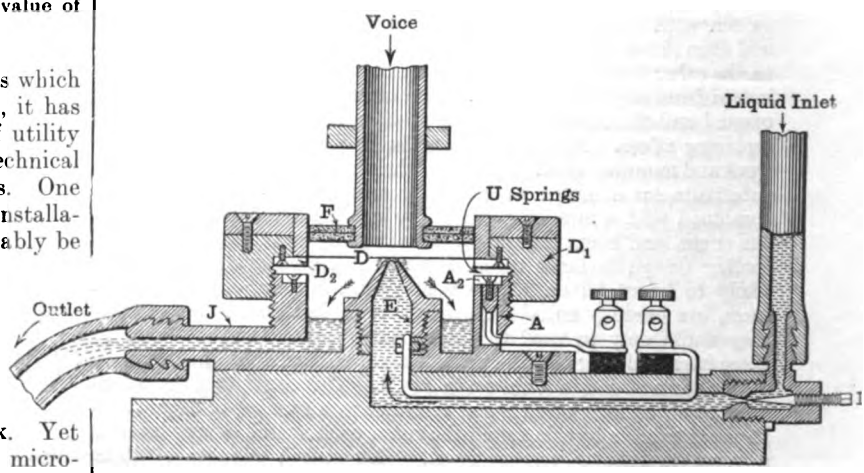
BY F. J. CHAMBERS.

Summary.—The author, after expressing some interesting views upon wireless telephony in general, proceeds to describe a novel form of transmitter. The H.F. current is led through an electrolytic path of small dimensions, so arranged that its resistance is varied considerably by the vibrations of a diaphragm, the liquid being maintained in a state of continuous flow. The advantages include absorption of energy, faithful speech reproduction, and constant normal resistance with facilities for adapting this to suit requirements. Models have proved capable of taking energies up to the value of 500 watts. Practical results are described.

After prolonged investigation of the elemental factors which go to make up a Hertzian wave telephone equipment, it has come to be the opinion of the writer that the field of utility open to this class of communication is divided, by technical and commercial considerations, into two distinct parts. One of these depends on the short distance robust form of installation, cheap to manufacture, and which can unquestionably be put into the hands of the unskilled person; and the other requires the use of more complicated forms of apparatus, for long distances, which need the attention of trained operators. Even the most sanguine inventor will admit that neither of these has as yet been evolved in really practical form, though most has been done in regard to short-distance work. Yet in this case the customary combination of the carbon microphone, which controls small energies, with large initial generating power, strikes the technical mind as being scientifically incongruous, and seems to suggest that the true solution of the problem lies in combining the carbon transmitter with what has yet to be discovered, namely, a generator of electric oscillations with the required properties, which deals with energies of the same order as the microphone; or, still further, a "generator microphone." Although the writer is at present working in the latter direction also, it is the immediate object of this article to describe one form of variable resistance instrument which, it is hoped, will eventually supply a need in the second or long-distance form of station.

In order that the wireless telephone for skilled operation may become of commercial value, it must be able to compete on reasonably favourable terms with the small power telegraph. It should have, let us say, a working range of a hundred miles at least. To effect this, if the controlling factor be a variable resistance instrument, it must be capable of dealing with an energy of the order of some hundreds of watts, and the range of control actuated by the voice must be wide. For wireless work it must be constant in its action, *i.e.*, it must impose a load on the circuit which varies only by reason of the influence of the sound waves. In dealing with large currents it is the practice of many workers to use a solid form of variable resistance instrument, such as a carbon microphone or combination of microphones, in which the destructive heating, due to the absorbed energy, is combated by some form of artificial cooling, water or a hydrocarbon being employed. The resistance of the microphonic contact, however, is well known to be of indifferent constancy, and it is principally for this reason that microphones are so frequently "burnt out," so that, in the present instrument, the writer has preferred to pass the oscillatory current through an electrolytic path, which has a constricted portion of high resistance, one or more dimensions of which is varied by the excursions of a vibrator actuated by the voice. In order to absorb the considerable energy necessary, this variable electrolytic resistance is kept in a state of continuous flow, so that a cold supply is constantly replacing the liquid heated by the current. It is clear that a change in the dimensions of the constricted portion of the liquid will, in general, produce a change of the velocity of the liquid along the constricted part of its path, and consequently, even when the resistance of portion is altered positively by change of volume, it will also be further altered indirectly by the resulting change in the velocity of the liquid. These two changes must be arranged to act in unison, for in some cases the temperature coefficient of an electrolyte is as high as 2 per cent. for 1°C. variation. Experimental work, extending over some 12 months, has determined that the most practical form of instrument is that embodied in the figure. Many varieties of valve were tried, including several forms of vibrator appended to a diaphragm, but tests showed that it is most advantageous to employ the diaphragm itself as one boundary of the constricted portion.

The figure shows, in cross section, a complete instrument.



CHAMBER'S LIQUID MICROPHONE.

A metallic diaphragm, D, is mounted upon a ring ebonite holder, D_1 in contact with a metal ring, D_2, secured to the latter. The underside of the holder is turned out, and a female thread chased upon the inner side. The ring is screwed upon A, the body of the apparatus, by means of this thread. Inverted U springs serve the double purpose of taking up the backlash in this thread and making electrical connection between the diaphragm and a second ring, A_2, secured to the ebonite body; from this ring a lead is taken out through the wall of the body to one terminal. The diaphragm thus forms one electrode, and the other is shown at E, a tubular piece of metal with an upper nipple. The liquid supply is led through a fine adjustment valve, I, to the centre of the lower electrode, passing through the latter and the constricted portion between the diaphragm and its lip, and is collected in an annular reservoir formed in the body of the vessel, A, from which it

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passes by an outlet pipe, J. The lower electrode is connected by a lead passing out through the body of the vessel to another terminal. The flow of liquid is controlled by the fine adjustment valve, I, and the distance between the diaphragm and the lower electrode is adjusted by revolving the diaphragm holder. A speaking tube concentrates the sound waves upon the diaphragm, and F is a disc of felt which confines these, whilst allowing the holder to be revolved.

The head of liquid was fixed by experiment at from 3 ft. to 4 ft., and a shallow supply tank, of large capacity, is arranged accordingly. As the instrument is primarily intended to be used with high-frequency currents it is unnecessary to make provision for electrolytic decomposition, and it is obvious that the liquid must not be raised to boiling point. In practice, the velocity of flow is adjusted so that the liquid is withdrawn from the influence of the normal current at a temperature not exceeding 80°C., thus a safety margin of 20°C. is left for variations. When the microphone is installed in a wireless station, the energy in the antenna is approximately measured, and the speed of flow arranged to correspond with that portion which is to be allotted to the microphone. The resistance of the instrument is then adjusted by trial and varying the conductivity of the electrolyte, to suit the other electrical characteristics of the circuit. These two are permanent, leaving only the diaphragm adjustment which has been found easy of operation by the aid of a permanently installed hot wire instrument. The constancy of these is remarkable, an experimental instrument has repeatedly been left overnight with the liquid turned off, and found to be in perfect adjustment next morning directly the flow was started. It is possible to use very thin diaphragms of large diameter, for the liquid is a most efficient damping agency for the tendency of the diaphragm to swing in its own period. The speech reproduction is exceedingly good, and resembles a voice speaking in a space surrounded by thick curtains; there does not appear to be any trace of the metallic sounds so prevalent in most large current microphones. In order to get an idea of the range of variation the instrument was tested against a Bell telephone transmitter of equal resistance with a single dry cell in circuit, and the comparison was favourable to the liquid microphone. The flow during this test was measured, with the instrument in working adjustment, and shewed the latter to be capable of absorbing an energy of more than 250 watts. This has since been surpassed, and the latest model gives every indication of reaching 500 watts.

Tests have been carried out under peculiarly unfavourable circumstances with a type of generator which produced a hiss representing, probably, a 10 to 20 per cent. variation, and, though the hiss was preponderant over the speech, light tapping with a wisp of thin paper was loudly reproduced. It is hoped that there will shortly be an opportunity for testing this instrument in combination with an arc form of "silent generator," when good results will be expected.

The development of the invention is not yet mature, and further simplifications and capability are expected, but sufficient experience has been gained to permit of the construction of reliable instruments by those who regard the wireless telephone for skilled operation with favour.

ELECTRIC TRACTION IN THE ST. CLAIR TUNNEL.*

Summary.—A detailed account is here given of the operation of the single-phase installation in the St. Clair Tunnel of the Grand Trunk Railway, the cost of power under electric working, the maintenance of the equipment and the features of the power station plant being described.

The St. Clair tunnel of the Grand Trunk Railway has been electrically operated since May 18, 1908, and the severest requirements of the service are said to have been met very successfully by the single-phase system. The equipment † was furnished by the Westinghouse Electric & Manufacturing Co. The length of the tunnel from portal to portal is 6,032 ft. The open tunnel approach on the Port Huron side is slightly over 2,500 ft. in length, while that on the Sarnia side is nearly 3,300 ft. in length. The total distance between the American and Canadian summits is 12,000 ft., or about 2¼ miles.

The specifications for the electrification of the tunnel service stipulated that the installation should be capable of hauling a 1,000-ton train through the tunnel from terminal to terminal in 15 minutes, that in doing so the maximum speed should not exceed 25 miles per hour and that the minimum speed when ascending a 2 per cent. grade should not be less than 10 miles per hour.

The single-phase system was chosen for this work on the score of economy in operation. Preliminary figures showed the first costs for the two systems to be about equal if no battery were installed. The estimates, including batteries, were slightly favourable to the direct-current system. However, the increased first cost with a battery would have been large in either case because of the nature of the load with frequent high peaks and short intervals during which charging could be done. The guaranteed efficiencies of the two systems without batteries indicated a considerable saving in the cost of power by the use of the alternating-current system. The distribution losses and the use of current for rheostatic control lowered the relative efficiency of the direct-current system. Preliminary guaranteed figures for the power consumption for one locomotive trip hauling a 1,000-ton train through the tunnel were 141 kw.-hours for the single-phase system. In practice, considerably better figures of performance than those guaranteed have been obtained.

The electrical equipment includes six three-motor locomotive units fed with 3,300-volt, 25-cycle current generated in a steam turbine station and distributed by a catenary supported copper wire.

Operating Statistics.—The St. Clair Tunnel Co. have furnished some comparative figures for steam and electrical operation which are of interest, indicating as they do in a general way the relation between important items of operating costs. These data refer to two years' operation—one before and one after electrification. Although the amount of traffic handled during these two years was not identical, the service performed was sufficiently similar for purposes of approximate comparison of figures.

The cost of coal with electrical operation was 39 per cent. of the cost of coal under steam operation. A part of this saving is due to the greater economy of the electrical system so far as coal consumption is concerned, while another large part of the saving is due to the fact that it was necessary to burn anthracite coal in the steam locomotives that formerly operated through the tunnel, while ordinary coal or even slack is used for the power plant.

The total service charges, including all items that are charged by the railway company against locomotive service, but not including fixed charges, indicate that this charge under the electrical operation is about 60 per cent. of the charge under steam operation. If, however, the fixed charges, including both interest and depreciation on equipment, are added in each case, it is found that the total charge for locomotive service under electrical operation is approximately 84½ per cent. of the charge under steam operation.

If a comparison be made of fuel costs under steam operation with the cost of electrical energy delivered at the trolley under electrical operation, it is found that, disregarding fixed charges, the cost of power delivered to the locomotives under electrical operation is 39 per cent. of the cost of the fuel under steam operation. If, however, the fixed charge (and depreciation) due to the initial investment for the electrical generating plant and distributing system be added to the charge for electricity delivered at the locomotive, this charge then practically equals fuel cost under steam operation. This indicates that the saving is effected in other items than that of cost of power delivered to the two locomotives in the form of electrical energy in one case and of fuel in the other. One of the large items in this saving is in the maintenance and repairs to locomotives, which for the years under comparison indicates the electrical cost to be about 55 per cent. of the steam cost. Other items chargeable to steam operation, such as the coaling of locomotives, water supply, &c., do not appear at all in the charges for electric locomotives.

Locomotive Maintenance.—Three locomotives are available for use in the tunnel and switching service. At present the entire traffic is handled by two locomotives, each of which consists of two half units. The half-units are duplicates in every respect, and are equipped with the multiple-unit system of control. Each half unit is mounted on three axles driven through gears by three single-phase motors with a normal rating of 250 H.P. Inasmuch as the motors have a very liberal overload rating it is possible to develop 2,000 H.P. with two half units. In a test made on a half unit using a dynamometer car it was found that a single half unit would develop a 43,000 lb. draw-bar pull before slipping the wheels. The locomo-

* Abstract of an article in the "Electric Railway Journal."

† An illustrated description of the installation appeared in THE ELECTRICIAN, Nov. 27, 1908.

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tives have a maximum speed of 35 miles per hour, but they are never called upon to operate faster than 25 miles per hour to handle the full number of trains.

An annunciator system has been installed in the inspection shed in connection with the 3,300-volt trolley wire to provide against accidents. Ordinarily the section of trolley wire inside the shed is disconnected from the trolley line outside. When current is desired to move or to test a car a hook switch installed about 10 ft. above the floor at one end of the building is closed to connect the interior and exterior trolley wires. Within the box of this switch an earth connection is provided so that when the knife of the switch is pulled open, to cut the shed trolley wire off from the line, the trolley wire within the car house automatically is earthed. An annunciator bell rings at 15 second intervals to warn the men while the 3,300-volt trolley is alive.

A regular programme of inspection is followed, and each half unit is kept in the inspection shed for 12 hours every three days. In addition to this short inspection each half unit is kept in for more thorough care for 24 hours once every 24 days. Thus the units are in service 80 per cent. of the time, which is considerably more than is possible with steam locomotives. The shed staff includes a foreman, two day and one night inspectors, one wiper and one overhead linesman whose services are also available for trolley work.

It has been found necessary to turn the locomotive tyres once every 12 months. This is on account of flange wear rather than hollowing of the tread. The flange wear is attributed to the low centre of gravity of the unit. Once every 30 days each locomotive is turned around so that the flange wear may be evenly distributed. The motor or journal bearings have given no trouble. The armature of each of the three motors drives its axle through a pinion with 16 teeth and a gear with 85 teeth. The life of these pinions is from 50,000 miles to 60,000 miles and some have run 64,000 miles. None of the gears has yet been renewed after two years' service. Whenever a pinion has run more than 30,000 miles, and the wheels are removed for any purpose, a new pinion is put on so that the wheels may not have to be removed unnecessarily.

The standard Westinghouse galvanised sheet-steel pantograph shoe is used, one on each half unit. The average life of these shoes is about 3,000 miles. The shoe is adjusted to have a pressure against the wire of 7½ lb. in the winter and 5 lb. in the summer. These low contact pressures are made possible by the limited speed of 25 miles per hour at which the trains operate. Shoes with copper wearing surfaces were tried with the idea that they would not wear the wire, but as no apparent advantage was realised and as their life was much shorter than that of the galvanised steel shoes, the trial was abandoned. The steel shoes apparently do not wear the wire so much as the copper shoes. This is attributed to the reduction in friction when dissimilar metals are used. A spring balance is used when adjusting the pantograph tension. Such adjustments are needed very infrequently, but if any undue flashing is noted during operation the tension is inspected and usually it is found that the pantograph spring has become weak or that the joints in the pantograph are stiff.

Operation.—When the electric locomotives were first put into service classes of instruction for the men who had been operating the steam locomotives were held every afternoon for two months. The men are enthusiastic over the change to electric operation. The locomotive crews are made up of two men, an engineer and an assistant. The assistant spends his time in looking over the electrical apparatus in the cabs of the two half units while they are in operation, and when not thus engaged he rides in the rear half unit. Formerly two brakemen were required for each train passing through the tunnel. The smoothness with which the trains are handled has now made it safe to operate with but one brakeman.

A round trip through the tunnel, including the terminal switching when a train is handled in either direction, requires a run of about 10 miles. The freight trains are made up so as not to exceed 1,000 tons each, and all cars are inspected before passage through the tunnel. The average mileage for each locomotive is in the neighbourhood of 2,700 miles per month. The maximum monthly mileage is 3,540 miles.

An indicating ammeter in each locomotive cab serves to assist in keeping the demand on the power station within a safe maximume The locomotive engineers are required not to let the motors of on. half unit exceed a maximum of 3,500 amperes. There are 17 running positions on the controllers. The first, second and third notches are only for switching, coupling up a train and other purposes where slow speeds are desired. The fourth to the 20th notches, inclusive, are running notches, and the controller can be left on any of these, according to the speed that is desired. The engineers become very adept at gauging the amount of power required when starting trains of various loads. When using the ammeter it becomes possible to accelerate the train and to notch up the controller as the current tends to drop. If a train will not start on 3,000 amperes, or less, per half unit the crew is instructed to look for trouble in the air-brake system.

Trolley Maintenance.—The trolley circuits for the entire electrified zone are normally all in one electrical section. Switches are provided at each tunnel incline for cutting off the yards from the tunnel section, if such sectionalisation should ever be needed. Since operation was started there have been practically no electrical troubles or mechanical defects in the trolley circuits. At one time a high brake wheel on an especially large car earthed the trolley wire in the tunnel and opened the breaker, but the trolley wire itself was not damaged enough to interfere with the continued operation of the same train after the brake staff had been bent out of the way. Apart from three of the porcelain spool insulators that were cracked when installed, the trolley wire insulation and suspension have given no trouble.

Within the tunnel the messenger cables are insulated from the conductor wires. The messengers are carried on porcelain spools and the trolley wires are supported from the messengers by special wood break hangers 3 in. square and 15 in. long. The effective insulating length of these hangers is about 5 in. If a porcelain insulator breaks down and allows the messenger cable to earth on the tunnel shell, then the wood break hangers are put under electrical stress and the weakest one begins to smoke. As stated above, three such breakages have occurred. In each instance the smoking wood insulator was noted in time so that repairs were made before service was interrupted. A tunnel patrolman is always on duty inspecting the tracks.

The pantograph shoes are lubricated with a mixture of cheap grease and graphite. This lubricant distributes itself over the trolley wires and so coats them with grease that ice has never yet formed to a thickness sufficient to interfere with regular operation.

Connections between the power station switches and the conductors and the track return in the tunnel are made through lead-covered cables for the feeder and bare copper return cables. The cables pass from the power station in underground ducts for a distance of about 150 ft. to a shaft leading down to the tunnel bore. An extra lead-covered cable, with end bells ready for quick connection at both ends, is available in case the feeder cable gets damaged.

Westinghouse gravity type lightning arresters with metal arcing points are used for protection of the trolley and messenger wires in the electrical zone outside the tunnel. The metal arcing points of these arresters, which are mounted on the steel catenary bridges, afforded a convenient perch for birds, and until precautionary measures were taken the breakers not infrequently were opened by short circuits caused by the birds alighting on the arcing points. The bodies of the birds would carbonise and afford a path to earth for the current, so that the fuse stick would not fall and disconnect the arrester. The circuit-breaker at the power house would thus open, and the lightning arrester would weaken and let the heavy insulator fall. This has been effectively provided against by adding a perch for the birds directly above the metal arcing points, an ordinary two-wire porcelain cleat being supported from one end only by a small metal bracket.

Telephones.—In installing the telephone circuit, cable was used throughout, and no part of the line is carried on poles, the object being to avoid any mechanical interference with the service. So far the telephone has given uninterrupted service.

Power Station.—The generating station is located in Port Huron on the St. Clair River front, about 150 ft. distant from the line of the tunnel. The boiler house equipment includes four Babcock & Wilcox boilers. The tubes are arranged 21 wide in order to secure quick steaming, and three drums provide a large hot-water storage capacity to assist in maintaining steam pressure under excessive demands. Underfeed stokers are used, and on account of the great variations in the load a fan 11 ft. deep by 3 ft. 5 in. wide, driven by an enclosed vertical engine, is used to accelerate quickly the fires of each group of boilers.

While no trains are in the tunnel the load on the station is about 400 kw.; but when a freight train passes into the tunnel and starts to climb the incline a peak load amounting to about 2,000 kw. is suddenly thrown on the turbine. This overload makes a heavy demand for steam, and it is necessary for the boilers to be forced immediately or their reserve capacity would be exhausted and the pressure fall below a good operating point.

The interaction of the various parts of the steam supply when excessive load comes on the turbine is as follows: Attached to the supply line is a pressure line extending to a valve located in the boiler room. The diaphragm in this valve is under two pressures. On one side is the 200 lb. pressure of the live steam main and on the

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other side is the 125 lb. pressure of the auxiliary main. A balance lever serves to keep the valve in equilibrium. When the heavy demand comes on the steam line to the turbine, and the pressure in that line falls, the valve is thrown out of balance and its movement opens the throttle of the engines which drives the forced-draft fan. Normally a difference in pressure of 4 lb. will operate this valve. As the load on the turbine continues to draw heavily on the boilers the steam pressure falls and the valve feeds more steam into the fan engine until the fan is driven at full speed. With the coming on of the load the fuel is also fed more rapidly, the stoker control valves being driven through a system of belts operating from the flywheel of the fan engine.

When the control valve for the fan engine was first installed the high-pressure tap was made from the main steam header in the boiler house. The valve then lacked sensitiveness, and so to improve the service the live steam tap was made at a point in the steam line close to the turbine throttle. Thus the valve is affected by the additional drop in pressure caused by the increased load and the resistance of the header and turbine connections. In addition to making the valve more sensitive this change in location of the pressure tap has reduced the temperature in the valve. Formerly the value diaphragms lasted only two or three weeks, but since the longer pressure line has been used the life of the diaphragms has been increased to three or four months.

A separately fired Foster superheater is installed between the two batteries of boilers. This superheater can raise 36,000 lb. of steam per hour at 200 lb. per square inch pressure to a final temperature of 587°F., which corresponds to a superheat of 200 deg. The grates are hand-fired and the temperature of the steam is controlled automatically by means of a thermo-couple in the steam outlet of the superheater. This thermo-couple is connected to a relay with a large solenoid which opens and closes the valves to a hydraulic piston. These valves move dampers in the air ducts and thus regulate the draught. In practical operation the regulating devices have been found to control the temperature very closely, notwithstanding the great variation in load to which the power plant is subjected. The superheater is of especial value because on periods of normal and low load the piping and turbine are kept highly heated by it, and thus initial condensation is greatly reduced at the time of the sudden demands.

The two Westinghouse-Parsons turbo-generators which comprise the main units of this plant are three-phase machines, but by the specifications are required to furnish their full-rated load of 1,250 kw. from a single phase. Each of the turbine units is capable of handling the entire load and so one machine always is held in reserve. Each turbine regularly handles peaks of from 2,000 kw. to 2,300 kw. single phase, which last for four of five minutes at intervals of about 15 minutes. This phase also carries the lighting load. The other phases carry the load of the pumping and auxiliary apparatus, amounting to 200 kw. With normal traffic through the tunnel the daily output of the plant is about 10,000 kw.-hours. The maximum output for one day was 12,000 kw.-hours and the highest peak load 2,750 kw. This plant has been in continuous service without any interruption in supply since April, 1908.

The main generators are cooled by means of air drawn through the coils by vanes mounted on the rotor. The supply of air for this cooling service as originally installed was all taken from out of doors. An independent supply duct serves each turbine. The ducts are short, and so air is taken into the turbine generator at practically the outdoor temperature. Formerly difficulty was experienced in severe weather because of frost accumulating on the air intake screens and cutting down the circulation. To provide against this condition an opening was cut through the side of each duct. Now, in cold weather, the turbine cooling air is taken from the basement. The circulation of this air through the turbine generator also serves to warm the building.

Each turbo-generator set was at first used on alternate days, but now the load is shifted from one machine to the other twice a week, because of the stresses set up in a turbine when it is warming or cooling. A Tirrill voltage regulator set is a very essential part of the regulating equipment of the plant. This set is connected with the locomotive phase of the generator only and maintains it practically constant at 3,300 volts. When a heavy train goes through the tunnel and a maximum load comes on the railway phase, the other two phases get considerably out of balance, and so, to keep the voltage on the lighting supply constant, all the lighting transformers are connected with the locomotive phase. The smaller pump motors, machine shop and other motors are all of the three-phase induction type operating directly across the 3,300-volt line, and so they are not unduly affected by the locomotive phase being out of balance with the two unloaded phases.

On account of the widely variable nature of the load it is necessary to keep an especially careful watch over the turbine governors and emergency valves. A systematic method of testing these safety devices is followed. Whenever a turbine unit is shut down, and the load is changed from one to the other twice a week, the emergency valve tripping device is given a service test. The engineer moves the governor rod so that the speed of the turbine is increased, meanwhile watching the frequency indicator and noting at what frequency the emergency valve closes. The valve is set to open at 10 per cent. above normal speed, and it is thus put to an actual test twice each week.

ELECTRIC DRIVE IN TEXTILE MILLS.*

BY A. MILMOW.

Summary.—The author first discusses the comparative cost of the power plant in a textile mill fitted with electric drive and in one where a mechanical drive is adopted. He then considers the cost of operation, mentioning the various advantages of the electric drive.

It is the purpose of this Paper to deal especially with the employment of electric power, derived from hydroelectric systems of distribution, for the operation of textile mills, and to treat the subject from a broad, general viewpoint, with particular reference to its commercial aspects, and especially in comparison with the old forms of steam drive.

First Cost.—The references which follow will be to new mills especially equipped for electric drive, insofar as first cost is considered, and not to mills already equipped with steam power. The figures are based on a plant of 25,000 spindles on moderately fine work, requiring a power equipment of about 1,000 H.P., a group drive throughout and 2,300-volt motors being used. Details of the cost of the various items of the installation for electric drive and for mechanical drive are tabulated by the author, and show the total cost of the power plant for steam drive to be about £16 per horse-power and for a similar electric equipment about £7 per horse-power, or a saving of £9 per horse-power where the electric drive is used. All the costs are included in these estimates, though it is quite usual for advocates of steam drive to take for its first cost only the costs of engines, boilers, piping, &c., neglecting such important items as chimneys, belt-ways, condenser reservoirs and other items essential to steam drive, but not required where a mill is electrically driven. This difference in cost should enter into the cost of power, taking the interest and depreciation at 12 per cent., the lowest possible figure. However, it is obvious that it this same amount of money were expended in producing textile machinery the earnings would certainly exceed the 6 per cent. included in this figure as an interest charge.

Cost of Operation.—The cost of steam power in a textile mill is very difficult to determine, since, owing to the very wide variation of power, only a very thorough and detailed set of indications will give a fair average of the amount of power. Moreover, to obtain perfectly accurate results such tests should extend over a long period, embracing all the seasons of the year, as there are many variable quantities involved, such as the temperature of the mill, the humidity of the air and even the nature of the cotton staple. These factors cause an extreme variation of power during, say, a year's period of as much as 20 per cent.

On account of using the same boilers for power and for other purposes it is difficult to obtain accurate figures on the cost of dye-house, heating and slasher operation in a steam-driven mill. In electrically-driven mills it has been possible to segregate these costs. The cost of heating a 10,000 spindle mill is, for the climate of the Piedmont region, about £50 per year, and as this size mill will use about 500 H.P., the cost of heating may be taken as about 2s. per horse-power per year. This figure is for a boiler of just sufficient capacity for the work. Similarly, the cost of slashing is found to be 6s. per horse-power per year. Of course, this figure varies with the class of work, but it applies to work using an average of about No. 30 yarn. The figure commonly taken in estimating steam horse-power cost is about 16s. per horse-power per year, which is entirely too high. For these reasons it is very difficult to determine any accurate cost of the steam power on the horse-power-year basis. When a mill is changed to electric drive, the opportunity of improving speed, &c., is usually taken advantage of, and the mill is generally reorganised to an extent that precludes the possibility of a direct comparison. It has been found, however, that where the machinery in a converted mill has been kept intact and the speed kept constant, and where accurate records of engine indications prior to the change have been kept (which is rarely done), a saving in the power required is effected,

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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though most mills when making this change take the opportunity afforded of improving the production in one or more ways and thus increase the power required.

Assuming the price of electricity to be £5 per horse-power per year for 11 hours per day, 306 days per year, and assuming a saving at equal production of 15 per cent. in power (which I consider conservative), the cost at which steam power must be generated to equal the price of electric power will be £4. 5s. From this must be deducted the fixed charges on the difference in first cost, which we may take at 12 per cent. on £9, or 22s. per horse-power per year, leaving £3. 3s. plus 8s., which will be required for the heating and slashing operations of the mill, or a total of £3. 11s. as the figure at which steam power must be generated to be equal in cost to electric power at £5 per horse-power; and in this figure there must be included the cost of oil, waste, labour, fuel, ash removal, coal handling, superintendence and, most important of all, the item or repairs, which is frequently omitted entirely in making estimates of steam power cost. If it were possible to attain this figure with a steam drive, a power only very inferior to electric drive would have then been obtained.

Production.—Hydroelectric power offers many advantages in operation, due to the readiness with which parts of a mill may be run so that the maximum possible output may be obtained. In equipping a mill for electric drive it is usual to provide one or more motors for each process of the work so that in case the demand on any department is increased, it is possible to work over-time on that particular department; whilst, on account of the inefficiency of the steam engine at light loads and often because of the very small part of its capacity that is required, it would be impossible to run with a steam drive.

In mills using automatic looms they are frequently left in operation at the noon hour, when they will run until some threads break, when the loom automatically stops itself and remains stopped until the weaver returns. Many continue in operation without interruption. In some cases looms are left in operation after shutting down time until the loom stops itself, which often does not occur until all the filling yarn is exhausted. These hours in the aggregate sum up a very respectable total in the course of the year.

The textile industry in the south is at a growing stage and few if any mills are left complete as first installed, especially among the larger mills. In the days before electric power was available this necessitated a steam plant entirely too large for the first installation, so a plan was resorted to of installing one-half of an engine and operating this as a simple engine, with the ultimate intention of adding a cylinder for compounding when the mill should be increased. This arrangement necessitated the investment of a great deal of money in a steam plant, and resulted in very high costs for power when using only a simple engine. With electric drive the system is perfectly flexible. Only the investment for the work actually installed is demanded at the outset, and the full output and efficiency are secured from the beginning.

An interesting application illustrating the flexibility of electric drive has recently been made and is being quite generally followed. In this case a mill was built with a capital of £20,000 and with an equipment of 5,000 spindles for the production of yarns. It was the intention to operate this mill day and night and the promotion of the mill was based on this idea. It was found, however, that for the spinning frames, which require women and girls to operate them, sufficiently satisfactory labour could not be obtained to operate during the night run, so that the management found itself in a position of being able to offer to its stockholders a production based only on the actual money employed, or £20,000. Through their own initiative they then took advantage of the opportunity offered by electric drive and added to their equipment an amount of spinning machinery equal to that already installed. This operated with the rest of the equipment during the day time, and all preparatory machinery, for which only men are employed, is operated day and night, thus giving material to the double number of spinning frames during the day. This resulted in a production equal to that of a mill of 10,000 spindles costing £40,000, while the total cost of the mill was only £24,000. This arrangement has, simply by the proper use of electric power, saved the mill an additional burden of investment of £16,000, the interest and depreciation on which would more than eliminate the entire power bill.

It has been found that in practically every mill that has been converted from mechanical to electric drive, an increase in production has been obtained. This is almost always the case, and it is not usually taken account of by investigators of power costs. Among the uninformed there is a quite general opinion that the converted mill takes to operate it electrically as much as or more power than it previously did with steam. On account of the increased production with the electric drive this is true in a great many cases; but in many other cases it is uncertain, as no accurate records of steam indications have been taken or kept. The explanation of this increase in power is simply that the production has been increased. At the time the motors are installed the speeds of the mill are readjusted and nearly always increased, the power is applied more directly to the work with less chance of slippage of belts and, above all, the speed with the motor drive is much more constant.

The Paper includes 50 curves taken with a delicate recording tachometer, and showing the improved drive with electric motors. In the territory of the larger hydroelectric systems the total number of mills operated consume a large amount of power. Each mill comprised in the group uses a relatively small proportion of the power furnished by the system. It is therefore possible to throw off or on many motors, or, indeed, many of the entire mills without disturbing the speed of the system. This is not the case in a mechanically-driven mill, where even a small part of the machinery represents a good percentage of the total load of the engine.

In a converted mill, driven from a hydroelectric station, one of two results are always brought about. If the original production is maintained the amount of power necessary is reduced. This should not in all cases be regarded as of paramount importance, the most vital advantage being an increased product from the mill, which it has been shown can be obtained through electric drive. This has actually been obtained in nearly every case that has come under my observation. In mills only very roughly converted, where surplus power is taken, and where the old uneconomical arrangement is left intact so that the steam drive may be used when the electric power is temporarily shut off, all carefully kept records show that an increase of production of from 2 to 10 per cent. is obtained. In new mills especially constructed for electric drive the higher of these figures should obtain. This increase is brought about by two things. First, proper balancing of the work, and next, the application of motive power directly to the work it is to drive, and the fact that this motive power has a constant speed value, both instantaneously and continuously.

The importance of production may be shown in a general way as follows: The capital value of a mill's product per annum is about equal to its capital stock. The cost of manufacture, with many variations for the class of work, may be taken proportionately about as follows: Cotton, 60 per cent.; power, 4 per cent; all other costs, 36 per cent.; and the power cost is from 3 to 6 per cent. of the total market value of the product. Thus, assuming the cost of a 5,000 spindle mill as £20,000, its product in a year will be worth, roughly, £20,000 and its power bills, say, £1,000. If the product of this mill could be increased 10 per cent. the gross value of this increase of product would be £2,000, of which the only cost would be cotton and power and some labour. The most costly operations of labour are paid by the day and effect no increase. Allowing, however, for some increased labour cost we have as the total cost of this extra production: Cotton 60 per cent., power 4 per cent., and labour 3 per cent., or a total of 67 per cent., and a net profit of £660 per year, or two-thirds of the total cost of the power, thus nearly eliminating the power bill. On account of the steadiness of the speed of the electric drive the machinery will suffer less deterioration than if run at even lower speeds with the steam drive.

General.—In hydro-electric systems of distribution to cotton mills it is found to be impracticable to place a sub-station for each consumer, especially to meet the conditions which we have in Piedmont, Carolina, where several mills of small or moderate size are installed in one town. This is on account of the large first cost of a sub-station reducing the pressure from 100,000 volts, and also on account of the difficulty of running the high-tension mains through cities and towns. On account of the high cost of transmitting power at low voltage any distance, both as to the initial investment and power loss, it was found necessary to adopt 2,200-volt motors in mills where the general practice had been to use motors of 550, 400 and even as low as 220 volts. At first considerable prejudice existed among the mill owners and the underwriters against the use of high voltage motors, but some years of experience have demonstrated their superiority in every way. The first cost is about equal to that of the lower voltage motors. Their efficiency is equal and the slip is also equal or somewhat less.

In many of the older low voltage installations, for the sake of economy, open wire is run in the mill. The cost of installing it in conduit would be excessive on account of its size. And also on account of the size of the wires, and the very extensive system of feeders, it is only a matter of time until open wiring becomes disarranged, due to its being swept to remove the lint and dirt which it accumulates. Another serious feature of this system is the frequent and necessary employment of fuses to protect smaller branches.

Probably 90 per cent. of the motors burned out in the mills under my charge have been burned out by the failure of one of the three

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fuses of the three-phase circuit, leaving the motor operating on a single phase. On account of increases to the mill equipment, or bad initial calculations, the wiring loss in the mill often runs up to very high figures with the lower voltages. In one mill in my experience, with a 220-volt distribution about 500 ft. long, the total wiring loss reaches 15 per cent., and this after the mill management had at a considerable cost added feeders from time to time as the mill was enlarged.

In mills using 2,200-volt motors, the wiring is run in iron or steel conduit, and consists of three-wire insulated cables with lead sheaths. The loss in this system is reduced to practically nothing, the cost is low, and complete protection is afforded by means of automatic oil switches. The size of the wires is very small, and the whole system takes up less space in a mill and is no more conspicuous than water and sprinkler pipes. As the conduit is earthed the liability to accident is practically eliminated.

SHOULD THE 1870 TRAMWAYS ACT BE REVISED?*

BY F. COUTTS.

Within the last forty years nothing of public importance and interest has made greater strides than the mode of travelling, and, perhaps, amongst the many varieties of transport, tramways stand out prominent as having undergone the greatest changes and improvements; so much so that the Act of Parliament made in 1870 to guide the laying down and working of street railways, however excellently it may have suited the requirements then, has now become so obsolete as to render it only fit to be included in the list of Parliamentary Acts which have now ceased to serve in a proper way the purpose which led to their being enacted. In addition to the improved methods of conveyance, we must keep in mind that there is a great deal more hustle in daily life now than there was forty years ago, and legislation, like everything else, must be brought up to date, so as to allow business to be carried through and completed in a month's time which forty years ago might reasonably have been held to be quite good enough had it been possible to carry out in three months. It is therefore necessary that the method of obtaining Parliamentary powers to build a tramway be greatly simplified and so save both time and money, and in many cases induce promoters to come forward for powers to construct a tramway in a thinly populated district, who at present, with the heavy expenditure staring them in the face, would never dream of making the attempt.

The period allowed for purchasing, although perhaps ample at the time of the passing of the 1870 Act, with only horse haulage in vogue, and a correspondingly small capital cost to be considered, is much too short for the present system of electric traction, with costly cars, its necessarily heavy and expensive permanent way construction, and overhead and feeders in addition. Although in several instances a longer period than 21 years has been allowed, this has invariably been dearly bought from the local authorities, as in return they have bargained either for money payment or its equivalent. It would, therefore, be well that instead of 21 years, 42 years be substituted, and thus a reasonable time given to the promoters to recoup themselves. Clause 5, which compels promoters to have the support of two-thirds of the local authorities in whose district the proposed route is to be laid, should, without doubt, be cut out, and the same with Clause 9, which prevents a tramway being laid where less than 9 ft. 6 in. intervenes between the footpath and the nearest rail if one-third of the owners or occupiers object. This might well be left to the discretion of the Board of Trade, and thus throw it out of the power of obstinate individuals to compel a tramway undertaking to possibly put in a short stretch of single or interlacing line. But it is not on those points that I wish to dwell so much as those of more interest to us tramway officials who, after powers have been obtained and the lines built, are responsible for the safe and economical working of the systems.

I think some consideration should be given to the question of upkeep. Who should bear the cost of the permanent way repair and renewal? In the horse car days undoubtedly the tram horses were the greatest users of the portion of the highway occupied with the tramway, but now the cars wear nothing but the rails, and considering that tramway owners have been put to the heavy expense of laying substantial track, where in many cases previous to their coming along there were only very indifferent macadam roads, they should be relieved of some portion of the burden of upkeep, for, while tramway owners have steadily been giving additional privileges to the public in the shape of a more frequent service, reduced fares, better roads, &c., those bodies representing the public have given nothing in return, but have been guilty of squeezing the last drop of juice out of the orange wherever an opportunity presented itself, such as charging a price for power entirely outside anything that is reasonable or honest; asking subscriptions to rebuild bridges that on account of the increase in numbers of fast-going vehicles it had become necessary to rebuild, although their building was of no benefit to the tramway company, but rather in some cases to help a motor company running in opposition to the trams, and who use the same roads, but in no way contribute, directly or indirectly, a single penny to their upkeep. Of course, we always hear the old cry from the local authorities, that in face of the tram track being laid, the roads cost them as much as ever to keep up, but we know that this is all humbug, and that although the rate has not been reduced, the money is now spent on other roads; but if the roads of 25 to 30 years ago could be placed side by side with the roads of to-day there would be no comparison, and any large horse contractor could tell that he can, wherever a tramway track is laid, increase his load by at least 25 per cent., and is thus enabled to cut down the charge per ton for carriage on all kinds of material, in this way benefiting, more or less, all ratepayers; and perhaps some such arrangement might be come to as the latter part of Clause 13 of the Tramways (Scotland) Act of 1861 suggests. For while the tramways in this Act were really what we might now term cartways, yet the present tramways fulfil to a large extent the same purpose. The part of the clause referred to reads as follows:—"And the expense of maintaining, managing, and repairing the tramways shall be defrayed by the trustees out of the funds and revenues under their management, or by the person or company by whom the same is laid down, or jointly by the trustees and such person or company, as may be agreed upon."

While criticising the clauses that want to be cut out or recast, there are also a few that might be inserted in the interest of the travelling public's safety, and instead of leaving them to the local authorities, might it not be advantageous to all that they be made compulsory? For instance, all vehicles travelling on roads where tramways are laid to carry lights both front and rear, also that slow-going traffic be compelled, where width of road will permit, to keep clear of tramway track, and so enable, not only tramway cars to travel freely, but other fast traffic.

Should this meeting come to a decision that steps should be taken to have the 1870 Act revised, I would suggest that without further delay a committee be appointed to go very fully into it and bring forward to the Association, with as little delay as possible, a scheme to be followed up to interest the various Members of Parliament into the need for such a change. It will undoubtedly be a stiff job to get it revised, as so many of the local authorities now own their own tramways, and look upon them as a sort of providentially-sent spring to be drawn upon in every conceivable way, to bolster up other less fortunately managed branches of municipal ventures; for although in nearly all cases it would come to the same thing in the end if the ratepayers were taxed to their legitimate amount for the upkeep of the roads, loss on lighting station, &c., and either receive a contribution from the tramways department to the rates or a longer ride for their penny, yet those municipal undertakings must of needs, through sympathy (as was done in the case of compulsory running powers), stand by those municipalities and local authorities who, in many instances, knowing they themselves could not carry out successfully, from various reasons, a tramway scheme to profit, have handed over the concession to some pushing company who are willing to take a sporting risk.

* Paper read before the Tramways and Light Railways Association, slightly abbreviated.

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Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON

(ONLY ADDRESS.)

Tel.: Holborn **6363** (Two Lines). *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."

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With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fifty-first issue of the Supplement will be published (Gratis) with the next number of "THE ELECTRICIAN."

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SAFETY IN TRAIN LIGHTING.

Train lighting is one of those specialised subjects that do not receive much attention in the technical world. This is rather to be expected, for the field of train illumination is so very much smaller than that of public electricity supply for light and power. Nevertheless the subject is important, and we may certainly say that to the travelling public it is very important indeed.

First, there is the question of adequate and steady illumination. Not so very many years ago railway travelling after dusk was a most monotonous procedure, as reading was only possible at considerable risk of damaging the eyesight. Since those days there has been a very marked change for the better, and passengers can now read with comparative comfort. There is, however, a further point which we wish to emphasise more particularly on the present occasion, namely, that of safety. In raising this question we have no wish to be in any sense alarmist. Considering the vast number of train miles run every year it will be admitted that railway travelling is now extraordinarily safe. Nevertheless, so long as the human element is present in railway working, accidents certainly will occur from time to time, and in such cases it is most important that the illuminant should be of such a character as not to give rise to fire. A

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railway accident in itself is bad enough, but the horror is increased tenfold if a fire occurs.

In this connection it can be said, without fear of contradiction, that electricity is very much ahead of its rivals, and that it is in fact the only safe illuminant. This point is being much more fully appreciated on the Continent than in this country. Thus, in a recent issue of the "Neue Freie Presse" of Vienna, it is pointed out that a number of railway accidents have taken place recently at Marburg, Herlishein, Trenton, Missouri, Uhersko, on the Canadian Pacific Railway and elsewhere, and that in such cases, as a sequel to the accident, the gas used for illumination has caused a fire to break out, thus sacrificing the lives of passengers who would otherwise have escaped. At a meeting of the Council of the Austrian State Railways recently the Ministry were requested to introduce a modern illuminant for lighting railway stock, and the representatives of the Administration informed the meeting that it was their intention to introduce incandescent gas lighting. At the next meeting this decision led Mr. MAXIME KRASSNY to move the following resolution :—"The Ministry for Railways is requested to discontinue the use of gas for lighting passenger trains, and to use exclusively electric lighting for all future passenger cars as well as for those at present on order."

In the discussion that ensued Dr. ELLENBEGEN mentioned that in Italy gas was being completely eliminated, even oil being used in preference. There were still approximately 1,400 cars lighted with gas on the Italian railways, but a portion of these were being converted to electric lighting, and the others were to be converted in the near future. The representative of the Government, in replying, stated that the Administration were doing everything in their power to improve the lighting, having regard to the means at their disposal. A series of tests which had lately been completed showed that, taking into consideration recent improvements, electric train lighting possessed economical advantages. As a result of these tests they had decided not only to convert old cars to the electric system, but that the same system should be used for the new cars to be supplied in 1911 ; and if further results were in any way favourable to electric lighting the use of this system would be greatly extended in future. As a result of the discussion a resolution was adopted practically in the form moved by Mr. KRASSNY.

In all such matters, of course, the question of cost is of some importance, but where safety is concerned cost should not be permitted to have an undue influence. In the present case, however, there is not much to choose between the cost of running electric light and incandescent gas for train lighting. The introduction of the metal filament lamp has, naturally, placed the electrical method at some further advantage, though it is rather in the improvement of the illumination than in the reduction of the running cost. In electric train lighting equipments the running cost is largely due to the initial outlay. The cost of producing the energy is negligible, and therefore it does not matter whether the lamps are efficient or inefficient. On the other hand, with metal filament lamps the battery can be smaller than would otherwise be the case, and consequently there is a gain in part of the equipment, and there is a marked advantage in the better illumination that can be given. In any case, the difference in cost between the two systems appears to be comparatively small, and therefore there is every reason for train lighting to be considered from the point of view of safety in this country as on the Continent, and that without delay. Questions involving the safety of the general public on railways come under the control of the Board of Trade, and, considering the present position of the whole question, we do not think it would be out of place for the Board of Trade to take some action in the matter without waiting for a disaster, with its attendant sacrifice of human life, when public opinion will doubtless force such action to be taken.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. And 10 per cent. for abroad or for foreign books.)

Electricity. By H. M. HOBART. (London : Constable & Co.) Pp. xix. + 207. 6s. net.

Mr. Hobart's latest contribution to electrical literature would, in the ordinary course of events, be exceedingly difficult to review. But, happily, the task is somewhat lightened by the author's habit of providing a preface in which, besides discoursing on things in general, he tells us his reasons for writing the book and the methods by which he hopes to carry out his ideas. Having read the preface, we know what we ought to expect, and having been introduced to the ideal in the preface are able, in its light, to criticise the reality.

Mr. Hobart's wishes in the teaching of elementary electricity, or rather electrical engineering, to break away from old methods and to produce a book in which "friction machines, electric eels, frog's legs, pith balls, lodestones, sealing wax, cats' skins, the electrophorus, the aurora borealis, St. Elmo's fire and Benjamin Franklin's kite" are omitted as being "rarely of importance to the present generation of students of electrical engineering." It is a worthy conception, and one which, if fully carried out, should do much towards the cleansing of elementary electrical engineering from the barnacles now too closely clinging to it, always provided that general knowledge is not too much curtailed.

Turning to detail, we are met by the difficulty that we cannot view the first few chapters through the glasses of those for whom they are primarily intended. Mr. Hobart would, in fact, be well advised to get some first year Finsbury student to give his opinion on the question; it would be more useful, in some respects, than ours.

Our first criticism is, starting at the beginning, on the title. It is too wide ; for the book is certainly not essentially on, or mainly about, electricity, as the term is generally understood, but is rather devoted to electrical engineering matters. Though Mr. Hobart tells us that the word "electricity" is commonly used when "electrical energy" is meant and that he has followed usage, yet since this book is presumably intended for budding electrical engineers, it would have been better to have been more guarded in his nomenclature. The eradication of good habits and the acquirement of bad are both too easy.

Again, Mr. Hobart, as a necessary consequence of his nomenclature, refers to the B.T.U. as a measure of the quantity of electricity. Of course, Mr. Hobart does not mean anything of the kind, but this unnecessary looseness of expression on the part of the teacher will inevitably lead to looseness of thought on the part of the student. Such looseness of thought is already too rife among electrical engineers, as is evident by

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the frequency with which one sees such expressions as "steam consumption per kilowatt."

Mr. Hobart continues to urge the claims of the "kelvin," that is, the kilowatt-hour. There is certainly much to be said in favour of reducing electrical, thermal and other energy calculations to such a quantity, but we are a little doubtful if the nomenclature will be generally adopted. Names are convenient, but they give us more to remember; whereas a term, such as "kw. hr.," of which the meaning is self-evident, has a great advantage. The term "B.T.U." is also available, but doubtless seems far removed from mechanics. There is much less reason for the adoption of the name "siemens" (which will remind older readers of resistance) to denote the watt hour.

Mr. Hobart, like most authors, is fond of his own ideas, and perhaps this accounts for some rather odd minor details. It is a well known rule in literature that an abbreviated word is followed by a full stop. This is more or less rational and certainly convenient. In the book before us this rule has been brushed on one side, and thus we have such expressions as ats (ampere turns) per cm length, and rings of 4 sq cm cross-section with a one mm airgap and flux measured in cgs units. In this country decimal points are indicated by stops and multiples of thousands by commas, whereas on the Continent decimal points are always indicated by commas. Each method may be equally good in its place, but we fail to see why Mr. Hobart should adopt Continental practice in this respect any more than Continental writers should adopt our method. Thus "1 000 000 grams" has an odd appearance, and to be told that the specific heat of water is 1,044 at 200 deg. is risky for the elementary student. Surely the aim of an author should be to make the reading of his book easy, not confusing.

The book, as it stands, may be divided, and indeed falls naturally, for critical purposes into two portions; in the first of these the author deals with elementary questions including conductors, energy, Ohm's law and the magnetic field, and is in parts rather laboured. The chapter on the magnetic field deals with fields due to currents, and goes minutely into the variation of the strength of field as the distance from the conductor or conductors is varied. What may be described as the second part of the book deals with conductors moving in a magnetic field, "alternating electricity," inductance, the magnetic circuit and insulating materials. Here there is much that will repay study, though, since anything mathematical is taken for granted, the treatment is often "sketchy," more particularly in alternating currents. Naturally, this remark does not apply to such a subject as insulating materials, of which a very good account is given in brief.

We cannot really recommend the first part of the book, in spite of the many excellent curves and useful tables which are contained therein. The author's argument in working up to his conclusions is not close enough for the elementary student, and the introduction of practical details about metal filament lamps, for instance, is not, we think, very wise. The second part of the book, however, forms an excellent introduction to the study of electrical design. The argument is not hurried, and the reason for many operations which are decidedly obscure to most students is well explained.

The most valuable feature of the book is that the point of view is very different from that of the ordinary text book. Thus the magnetic field due to currents is dealt with graphically and arithmetically in detail. But, as much is taken for granted, we think it is rather a book for the teacher than for the average student. The average teacher would benefit, because it would enable him to put things differently from the stereotyped method, and the matter could then be administered discreetly with much advantage.

Electrical Installations of Electric Light, Power, Traction and Industrial Electrical Machinery. By RANKIN KENNEDY. Vol. III. (London: The Caxton Publishing Co.) Pp. 244. 7s. 6d. net.

Vol. III. of this work is devoted to Gearing, Turbines, Steam, Gas and Oil Engines, Switchboard Wiring and Accessories. The portion on Gearing is simple and practical as regards belts and couplings, but might with advantage have dealt more fully with toothed and worm gearing, which is now of much greater importance in connection with electrical work. Turning to motive power, the preliminary remarks are useful, and include an exposure of the fallacy of the proposals for liquid air as a motive agent. Wind and water turbines are briefly dealt with, and steam turbines fairly fully, the De Laval, Parsons and Zoelly forms being described, but not the Curtis type. Of high-speed steam engines the Willans, Westinghouse, Belliss and Mather & Platt engines are considered, but the author is of the opinion that the days of such engines are numbered. Gas and oil engines receive a considerable amount of attention, as the author thinks that "the next generation of engineers in all likelihood will abandon steam in electrical generating altogether." He tells us little, however, as to the reliability of gas and oil engines and of producers, nor does he warn us of the restricted sources and control of the oil supply.

Among the general remarks which the author is fond of sandwiching in between his technical descriptions are some sensible ones about the importance of the thorough mechanical training of the electrical engineer, especially as regards engines. We may also agree with his remark that "the great mistake in our technical schools is the attempt to teach too much, giving a very scanty training in many subjects, instead of a thorough training in a few correlated subjects," except that we would rather say that the fault lies in cramming students with descriptive knowledge of details rather than teaching them the essentials and principles by which they can readily realise the action of any actual machine and evolve improvements themselves. It is the examination and syllabus system which is chiefly responsible for this. The sections dealing with Motor Wiring and Switchboards call for little comment; but wiring might have been more fully dealt with, notably as regards fittings and Continental wiring. A brief description of mining machinery closes the volume. The frontispiece is a dissected diagram of the author's form of salient pole two-phase motor.

IMPROVING THE PORTABILITY OF THE WESTON NORMAL CELL.

BY HENRY TINSLEY.

One of the greatest difficulties experienced in making standard cadmium cells for commercial use is that of making them sufficiently robust, so that the chemicals do not become displaced during transit to the customer or when being sent to and from the standardising laboratory. This is of special importance in the case of cells which are destined for a tropical country, as in this case the risk of disturbance is very much increased by the heat and inevitable jarring during transit.

The recommendation of the National Physical Laboratory to ensure that the chemicals shall retain their proper respective positions is to crystalise some of the cadmium sulphate solution so as to form a crystalline plug after the cell has been set up. This crystalline plug is so arranged as to form just below the constriction shown in Fig. 1, the constriction acting as a further safeguard by preventing the plug sliding up or down the tube.

The writer has made hundreds of cells of this type and despatched to different parts of the world, including places as far away as China and South America, and apparently such cells arrive in good condition.

Special care has, however, to be taken in forming the crystalline plug for cells that have to go to hot climates; usually it has to be made very thick so that the solution of the crystals at the higher temperature abroad will not be sufficient to allow the plug to shift or the crystals to separate and crumble. A further disadvantage is that the thicker plug considerably increases the internal resistance of the cell, and though this may ultimately fall to about the right resistance, it is an uncertain factor and as such should be avoided if possible.

The writer has tried many ways of overcoming this diffi-

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culty by placing a mechanical plug over the solid chemicals, such as perforated discs of mica and porcelain, a plug of glass wool, asbestos pads, &c., none of which appear quite so satisfactory as the method described below :—

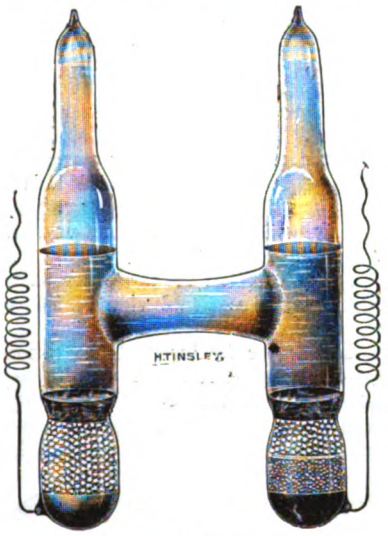
The essentials of such a screen or plug are that :

1. It must not introduce any deleterious matter into the cell, such as may cause the cell to change.

2. It must not increase the internal resistance of the cell appreciably.

3. It must be strong enough to be placed firmly in position and hold the heavy chemicals securely against sudden jars.

When the separate limbs have been filled with their amalgam, mercury and respective chemicals, small rings of cork are made tightly fitting the inside of the glass limbs, the centre hole of these rings being kept as large as possible. Some pure unbleached linen is now carefully freed from its dressing by washing and boiling till no sign of chemical matter can be detected. This is then dried and cut into discs, the same size as the outside diameter of the rings. These discs are then sewn to the bottom of the cork rings, forming miniature drumheads which can be inserted as plugs on the surface of the layered chemicals. These drumheads are now forced firmly on the solid matter and will hold the chemicals in position against even violent handling. In a tropical climate, however, some solid crystals of $CdSO_4$ are sure to be taken up in solution, and the chemicals in the drumhead may become loose, so that it is as well to add a few crystals of $CdSO_4$ *above* it to allow for this.



PORTABLE WESTON CELL.

The constriction in the glass limbs is retained as in the N.P.L. pattern cell, as this acts as a guide to the height of the chemicals, also being an advantage for binding the platinum wires against slipping during the mounting and manufacture of the cell.

Cells set up in this way do not appear to be materially affected in the E.M.F. by the linen screen, and as this at once becomes impregnated with solution, its resistance is kept low, the linen only being very thin, much thinner than a glass wool or asbestos plug would be, besides affording a fairly free passage for solution as the limbs of the cell expand or contract.

The table given below will clearly show how much more uniform in internal resistance cells made in this way are, besides having the great advantage of allowing immediate sealing after construction and a simpler form of tube being used.

New type of cells with diaphragm.			Cells with constriction and crystal plug.		
No. of cell.	Volts.	Internal resistance.	No. of cell.	Volts.	Internal resistance.
195	1·0185	700	77	1·0184	2,600
196	1·0184	700	144	1·0183	1,000
197	1·0184	800	147	1·0184	1,200
198	1·0184	700	163	1·0184	1,000
199	1·0184	800	177	1·0184	2,200

THE BRUSSELS INTERNATIONAL EXHIBITION.—IV.

THE ELECTRICAL AND ENGINEERING EXHIBITS.

The French electric motor makers appear to be keenly alive to the importance of the individual drive for practically every class of industrial machinery. In the International Machinery Hall will be found numerous interesting examples of the electric drive in the textile trades. Messrs. H. Duesberg, of Bossons, exhibit a number of cotton carding engines, each gear driven from 2 H.P. continuous-current motors. They also show several examples of opening machines, each operated by its own motor. The Panhard Levassor Co. show a large band saw operated by a 60 H.P. continuous-current motor which is placed below the floor level and which is connected to the machine by belts. In the French industrial section, which is reached from the machinery hall by ascending a staircase, are the exhibits of the principal electrical manufacturing firms. The Société Alsacienne Belfort make a good show of three-phase turbo-generators and a quantity of typical motor-operated mining machinery. On the stand of the General Electric Co., of Nancy, is an interesting 12,000 volt solenoid operated switch capable of dealing with 5,000 kw. Messrs. Berthoud Borel, of Lyons, exhibit specimens of high-tension and extra-high-tension cables and also X-ray apparatus. The Société Ateliers de Construction du Nord, of Jumet, show specimens of generating plant and controlling apparatus employed on a 150,000 H.P. high-tension plant. In the section devoted to the metal exhibits are to be seen many fine examples of French steel work. The Société des Acieries de Longwy, amongst a quantity of steel products, exhibit the steel frame of a 16-pole direct-current dynamo, which weighs 16 tons. Messrs. Paul Girod also show a 9 ton field frame, 14 ft. 6 in. internal diameter. In the same section may be seen a number of useful products of the electric furnace, particularly of the Héroult furnace, in which examples of aluminium in practically every conceivable form are shown. A particularly interesting item on this stand is a tank some 8 ft. in diameter by 5 ft. 6 in. deep, made up of welded aluminium plate. Adjoining this exhibit is an interesting model of the Rhone Valley hydro-electric plant, which has a capacity of 330,000 H.P., and operates under a 220 ft. fall. The model shows the situation of the dam at an extremely rugged portion of the valley and it also shows the location of the forebay, draught tubes and tail race. Immediately surmounting the crest of the steep side of the valley is a large transformer house where the pressure is raised for the transmission line. Just above the model is a large wall map of France on which are shown the positions of the principal generating and sub-stations of the company operating this extensive system. The principal transmission line is one of 72 miles from Grenoble to the steel centres at St. Etienne. The company has in view a scheme for the transmission of energy from Grenoble to Paris, but up to the present time nothing further has been done towards carrying this project into operation.

The Belgian exhibits of electrical apparatus include a 125,000 volt transformer plant of the Société de Constructions Electrique de Charleroi. The same company also exhibit specimens of suspended insulators for extra high tension and special line work. This exhibit is placed in the Belgian Industrial Hall and immediately adjoins the principal British section.

There is a good show of German machine tools, all of which are electrically operated, and the cranes which span the main machinery exhibit are of considerable interest, particularly one by Messrs. Stuckenholtz, which has been designed specially for use in steel works for lifting steel ingots out of the soaking pits. Actual examples of these pits have been installed on the stand and the crane is shown at different times of the day lifting weights up to 20 tons. The exhibits of lighter electrical apparatus in the German section include a good display of insulators, both for ordinary electrical work and also for extra high voltage transmission lines by the Hermsdorf Porcelain Works.

In the British section of the Exhibition there is no moving machinery shown, but the textile industries occupy a large proportion of the space with attractive displays of cotton and woollen goods. They take the shape of tableaux arranged in a darkened portion of the building, which is effectively lighted by electric lamps. These tableaux form one of the most interesting and attractive sections of the British exhibit. The Bradford Chamber of Commerce have got together a series which depict the stages of manufacture of woollen goods from the raw material to the finished product. The tableaux illustrating mechanical processes have been carefully prepared, and they show wool combing, spinning, weaving and dyeing. An illustration of the wool combing tableaux is shown in Fig. 1. The setting is made up of a couple of circular wool combing machines which are connected by belt to an overhead shafting. In the illustration it will be noticed that the effect of the interior of the wool combing

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shed is given, but this has been obtained by the use of a suitable background. The two figures in the foreground are wax, and the other figures are painted on the background. The machines themselves are of a slightly smaller pattern than those used in a woollen mill, but they are of a type which is now extensively operated by electricity in Bradford and the surrounding district. But for the fact that there was no motive power circuit laid into the British section we understand that these interesting machines would have been shown in operation. Engineers visiting the Exhibition who are

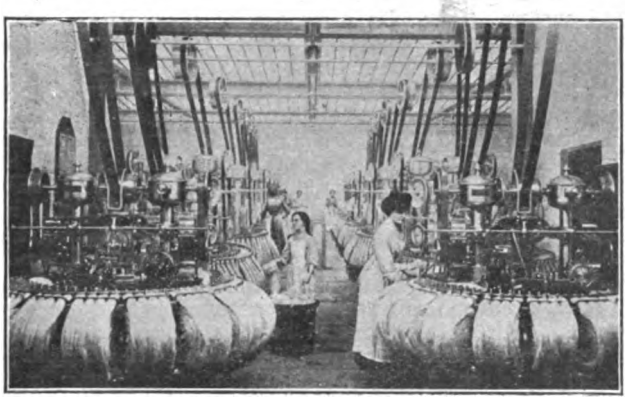

Fig. 1.—One of the Tableaux in the British Section showing the Wool Combing Process as employed in the Bradford Woollen Mills.

not familiar with the various processes of wool preparation should make a point of seeing these tableaux.

An interesting British exhibit in the Industrial Machinery Hall is that of the Underfeed Stoker Co., who are showing their class B and class E type stokers on stand No. M.54. In addition, they have one of their air heaters on view, this device having been developed for heating the air supplied in the furnaces of either water-tube or Lancashire boilers. Fig. 2 shows the application of this heater to a standard Babcock & Wilcox boiler. The heater itself is made up of a number of semi-circular flat units, which are placed horizontally or vertically in the main flue of the boiler. The hot gases pass between these units and raise the plates to a high temperature. There is an enclosed space or tunnel left between each plate to admit of the passage of air, and this is drawn or forced in by means of a fan. It will be seen from the illustration that the heater can be conveniently placed at a point where the hot gases from the grate, after passing through the boiler tubes, impinge on the heater discs. The fan forces the air through the heater round suitable ducts to the grate at the front of the boiler. The heater can be supplied to a single boiler, or a large pattern heater can be inserted in the main flue, and air can be delivered from this to a whole battery of boilers.

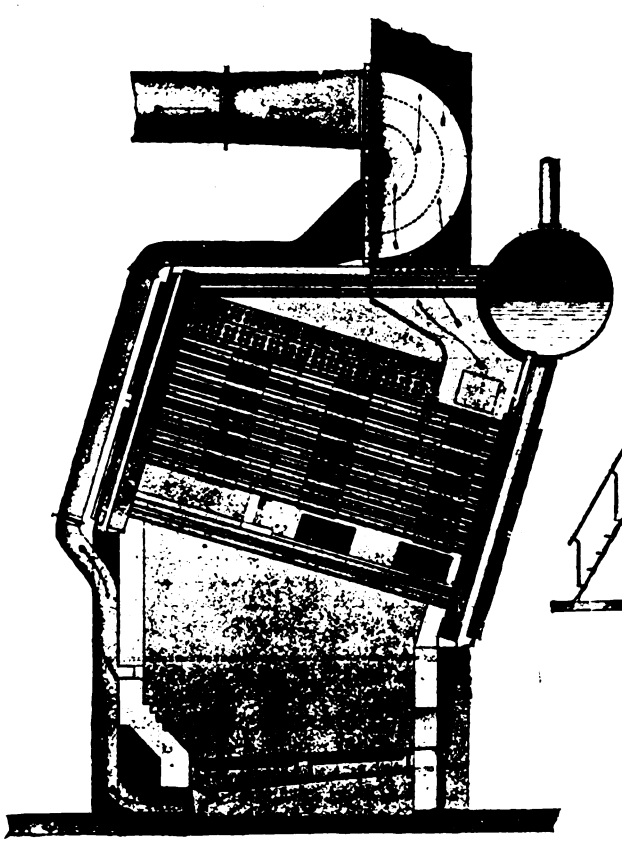

Fig. 2.—General View of Air Heater applied to Babcock Boilers.

In the German section Messrs. R. Wolf make two distinct exhibits

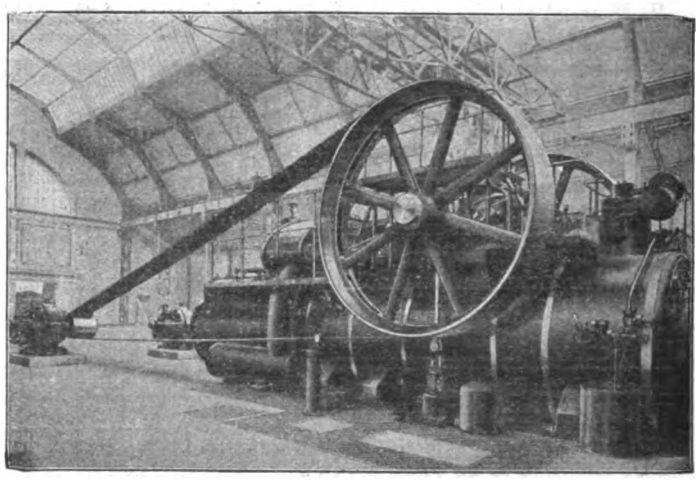

Fig. 3.—650 h.p. Wolf Locomobile in Power House of the German Section.

of their well-known locomobile. One is in the Machinery Hall, and comprises a 100 h.p. compound condensing h.p. locomobile, a 15 h.p. high-pressure locomobile and a portable locomobile. This exhibit has been made to attract attention to the value of the Wolf locomobile for agricultural work or similar service where a temporary power plant is required. Several patterns of agricultural machinery are introduced into the exhibit, including centrifugal and plunger type pumps. The second portion of the exhibit is in the power house adjoining the Machinery Hall, where a 650 h.p. Wolf locomobile is in daily operation driving two 200 kw. direct-current generators by belt from the main flywheels. Fig. 3 is a general view of this exhibit taken previous to the erection of the other units in the power house. Fig. 4 illustrates a sectional view of this particular locomobile, and an inspection of this will make clear the position of the superheater, the feed water heater and the automatic sprinkler stoker. The locomobile runs at 170 revs. per min., and each dynamo is driven by an 18 in. belt. We have dealt very fully with the Wolf locomobile in previous issues, but we may recall here the remarkable efficiency of these self-contained steam plants. Recent tests by

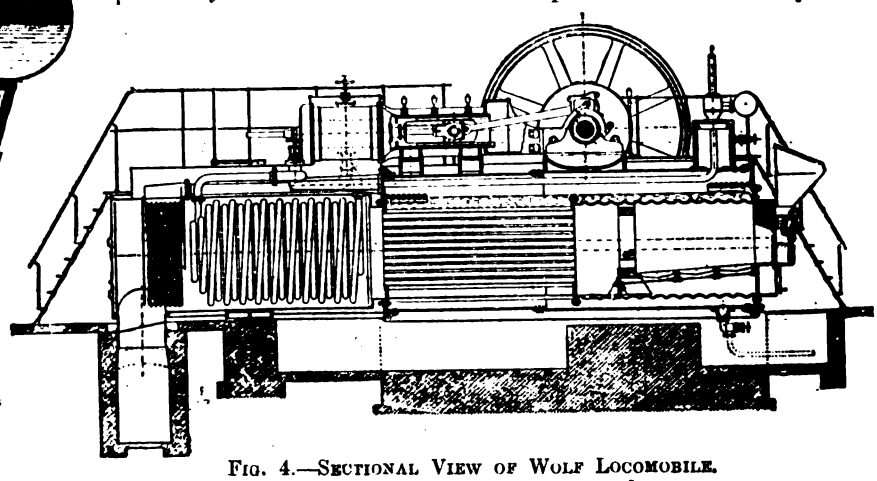

Fig. 4.—Sectional View of Wolf Locomobile.

Prof. Burstall on a 150 h.p. locomobile showed a steam consumption of 8·81 lb. per brake horse-power-hour, and a coal consumption of 1·05 lb. per brake horse-power-hour. These figures are exceptional, and illustrate the amount of care taken in the design and construction of these machines. It is interesting to recall the fact that the 650 h.p. plant in the power house of the German section was in position and running some month or six weeks before the exhibition was due to open, and various exhibitors could therefore be supplied with light and power. In a pamphlet issued by the company it is stated that there are 3,000 men employed at their Magdeburg works, and that upwards of 4,000 superheated locomobiles have been built with an aggregate horse-power of 350,000.

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CORRESPONDENCE.

STREET LIGHTING CONTRACTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of July 8th you reprint a Paper in which Mr. Jacques Abady deals with the above subject and, in particular, gives his reasons for advocating a specification based upon the light emitted, rather than upon the energy consumed, by the lamps installed. That this proposal is a distinct step in the right direction will, I think, be admitted by all who have studied the question, and the Westminster City Council are to be congratulated upon having issued their recent lighting specification upon this basis.

Whether, however, the particular specification proposed by Mr. Abady is altogether satisfactory seems open to doubt. As regards the adoption of candle-power, instead of illumination, as the basis of comparison, I am inclined to agree with the author, in that the former is undoubtedly better understood by the lay mind and, for this reason, to be preferred in a case of this kind. At the same time I cannot agree with Mr. Abady when he speaks of illumination measurements as introducing "all kinds of difficulties and problems (as to the behaviour of light rays with respect to surfaces and view point) about which photometrists themselves are not agreed." This might have been the case 10 or even five years ago, but is certainly not so to-day. The author appears further to have overlooked the fact that the illumination in foot-candles is what is actually measured by all forms of photometer, and that the candle-power has to be subsequently *calculated* from this.

In this connection I notice that the photometer is specified to be one "working on the law of inverse squares." What this clause is intended to convey does not seem at all clear, unless it is that the adjustment of illumination is to be made by sliding the standard lamp to and fro until balance has been obtained. I hardly think however, that this can be the intention, seeing that this particular method of adjustment has been abandoned in nearly all modern photometers intended for street work.

Probably the most important, and in my opinion the least satisfactory, part of Mr. Abady's proposal is the definition of the candle-power called for as the mean of two measurements at 20 deg. and 50 deg. respectively with the horizontal. The author points out that the aim in the design of a street lamp should be to provide a maximum of light at angles of 10 deg. or 20 deg. with the horizontal and a *minimum* below 40 deg. By assigning equal importance to the candle-power at 50 deg. and at 20 deg. (as is the case with the proposed specification) encouragement is given to a distribution of light which is distinctly bad from the street lighting point of view.

To overcome this very serious drawback I would venture to suggest that, instead of angles of 20 deg. and 50 deg. with the horizontal, 15 deg. and 25 deg. should be selected. Or, if it was feared that such a proposal might lead to the entire neglect of the illumination near the vertical (which I do not for a moment think likely), the 20 deg. rays might be given a preponderating influence on the result by adding the candle-power of the 50 deg. ray to that of the 20 deg. ray doubled or even trebled and taking the mean.

A comparison of polar curves 11 and 13 in Mr. Abady's Paper illustrates, I think, the unsatisfactory nature of his proposed definition of candle-power. The former is cited by the author as "a bad example" of light distribution and the latter as a particularly good one, and yet, judged by their 20 deg. and 50 deg. ordinates, the "bad example" is quite as good, if not better than, the other.

It seems a little doubtful whether it can be regarded as satisfactory to take any arbitrary angles, owing to the fact that, at some points, the polar curve of light distribution is so steep that a small change in the angle makes a very serious difference in the candle-power. This is well seen in Mr. Abady's digaram No. 12 (10-ampere flame arc) in which, at 20 deg. with the horizontal, an error of only ± 4 deg. in the measurement of the angle makes a difference of nearly 50 per cent. in the candle-power.

There is one other matter to which I should like to allude, as it seems so far to have escaped attention, and that is as to how far it is possible to speak of the "candle-power" of a lamp fitted in a dioptric lantern or provided with a curved reflector.

The whole notion of candle-power is bound up with the conception of the light emanating from a point, and consequently obeying the law of inverse squares. That this law is quite inapplicable to lamps provided with lenses or mirrors will be at once obvious if the extreme case of a parabolic mirror, such as that fitted to a searchlight or to an acetylene motor headlight, be considered.

To speak of the "candle-power" of such a lamp would be quite meaningless, and all that could be said would be that at a given distance from it a certain illumination was produced. I have not personally carried out any tests in this direction, and it would be interesting to inquire how far such considerations applied to some of the modern street lanterns.—I am, &c.,

Westminster, July 11. KENELM EDGCUMBE.

THE CRADLE DYNAMOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The article by Messrs. Davies and Shaw in your issue of this morning is of considerable interest, and I am glad to see that the cradle method, which, in my opinion, is by far the best of all the devices for the measurement of power, hitherto designed, is again brought into prominence. As, however, the authors refer somewhat specially to my own form of what I call a regenerative dynamometer brake, perhaps you will permit me to deal with some of their criticisms.

The mounting of the machine under test upon a cradle, instead of direct coupling it to a permanently suspended machine, as in my own form, was carefully considered by me before adopting the latter arrangement, and rejected for two principal reasons, one being that the mounting of every fresh machine meant jarring the suspension, and the other that unless the axis of the machine under test coincided exactly with that of suspension, any resultant side pull due to the driving belt or other cause would be a cause of error. In brief, the mounting of a machine on a cradle to obtain the best results require a number of adjustments which are much better done once for all upon a machine kept for the purpose, than repeated at every fresh test with machines of different sizes, weights, &c. Coming next to the question of knife edges *v.* ball bearings, my brake was originally tried with the latter, and found to be insufficiently sensitive. It must be remembered that the generator was a heavy machine of 8 kw. capacity. The addition of the knife edges immediately increased the sensitiveness considerably so that a difference of about 0·02 of a lb. ft. can be detected with a range up to nearly 80 lb. ft. It is hardly necessary, however, to argue this point, as no one would think of putting the beam of a testing machine, or of a chemical balance, on ball bearings, and no injury of any kind has been found to the knife edges of this brake after seven years' hard use.

The arrangement of my first brake was, however, needlessly complicated by these changes from ball bearings to knife edges, &c., and two years ago I had another constructed in which the generator was mounted on knife edges as before, and the whole arrangement mounted on a portable stand which could be readily brought up and directly coupled by means of a simple flexible coupling to any machine to be tested. This device has been found most convenient, and I propose to send you a description of it with a complete analysis of the iron, friction and other losses of a machine obtained with it. Incidentally, it may be mentioned that these tests have shown the hysteresis loss to be proportional to $B^{1.54}$ and the eddy current loss to B^2. It is possible, however, that Messrs. Davies and Shaw's value for the hysteresis exponent is not wrong as it must be remembered that we are here concerned with rotating rather than alternating fields.

Finally, as to the authors' remark that the cradle dynamometer has not met with a large measure of success, I fancy

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that this has simply been because it has not been commercially available. I understand, however, that the National Physical Laboratory have been constructing a large brake on the lines of my later form, and I am quite certain that when its advantages are realised it will become the standard method for accurate work, and indeed for commercial testing in works. In this belief I have recently arranged with Mr. R. W. Paul to have the portable form put on the market in various sizes. —I am, &c.,

Reigate, July 8. CHARLES V. DRYSDALE.

FISCAL POLICY AND THE ELECTRICAL INDUSTRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to the Free Trade statement "that imports of goods can only be paid for by exports of goods": this is quite correct amongst those who live on trading only. If Smith (Britisher) and Brown (foreigner) trade only with each other and have no other means of subsistence, it is obvious that trade in value must be quite equal, or one or the other would come to grief. But let us suppose Smith is a lucky man; his grandfather some 50 years ago made money and left him an income of £200 a year invested in a railway in Brown's country, this income being quite outside the trading question. Smith hears that motor cars, pianos, &c., are made very cheaply abroad, and writes to Brown not to send the £200, but to send instead that amount in motor cars, pianos, jewelry, &c., for his family to use, as they are cheaper than he can make them at home. Under these circumstances the balance of money would remain equal. Our workers would lose profits and wages to the extent of £200 (less the value of raw material). Where do British traders and workmen stand in this case? Jones makes a fortune of £50,000, say, in China or South Africa. He wants an investment for his money, and puts it into the construction of railways in the United States (to the advantage of the American workmen), and gets his £2,000 per annum for his investment. But this money is not sent home in cash, because someone else has ordered £2,000 worth of electrical machinery in the States which have to be paid for, so the balance of exchange is equal. But the British workman does not come in at all. He sees the foreigner reap the benefit both of the capital and the interest. And this is being repeated in every country. Thousands of wealthy people who have made fortunes abroad, in the Cape, Australia, India and on the Continent returning home and investing in the same manner as Jones.

Now, the Inland Revenue Report (some five years back) tells us that our British annual income from foreign investments is 63 millions a year. The returns during the past few years must have largely increased, but are not available. And this (together with Jones's money) goes to pay for our foreign manufactured goods bought abroad. No cash is sent over, but goods. And the sum is adjusted by bankers' bills. Therefore, the cash balances show no difference. Now, this sum of 63 millions per annum is interest on foreign investments, is the interest on the sum (according to good authorities) of £2,000,000,000 we made during that marvelously prosperous period from 1850 to 1880 before referred to, statistics showing but few foreign investments before that time.

The fact that imported goods are partly paid for by taxed exports must also injure our trade. Suppose a 25 per cent. tax is levied on our manufactured goods sent abroad, we should have to send over 25 per cent. less goods than the foreigner sends us, in order to make the balance of trade equal, because we have to pay the duty, against nothing paid by the foreigner.

The only people who gain directly by the admission of untaxed manufactured goods are people living on money invested abroad and pensioners. But these peoples' families and relatives, are in as awkward a position regarding employment as others. The working man in the first instance loses his wages and consequently cannot go to the butcher, grocer and draper, and cannot pay his rent. And so every one loses all round. The grocer cannot do much business, so he cannot consult his lawyer, and the lawyer loses some of his practice and has to reduce his staff. The doctor loses because his patients, having but little money, have to go to the charitable hospital. The landlord loses his rent, and will have to reduce his expenses and economise all round. Everyone losing indirectly under free manufactured imports. The following is an interesting quotation: "Berlin, April 16th, 1910.—The Conservative and Protectionist 'Kreuzzeitung' indulges in a pæan of triumph on the decay of Britain and flourishing progress of Germany. Taxation in England in 1908 amounted to 95·80 marks per head, in Germany to 48·17. Emigrants leave Britain by the hundred thousand, German emigrants are counted by tens of thousands. The Germans have in the savings banks nearly four times as much as the Britons. The abundance of capital in England, says the journal, is another sign of decay. Money is dear in countries like Germany and America, with their rapidly and powerfully growing industries, and cheap in decadent countries like France and Great Britain, whose industry is unable to absorb accumulative capital. The journal says that the explanation of these evils is largely to be found in Free Trade and the depopulation of the countryside."—I am, &c.,

Ealing, July 11. BENNETT FITCH.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: If your readers will examine Mr. Hookham's note in this week's issue I think they will find a logical fallacy underlying his first letter rather more clearly expressed. He says: "If, by a duty, you stop goods from coming in, you will stop the goods that used to pay for them from going out; that is to say, that *the employment you give on the one hand you take away on the other.*" This involves the unwarrantable assumption that exports and imports of similar selling price represent the same amount of labour.

Selling price naturally divides itself into three items: (1) material cost, (2) labour, (3) profit. Even supposing, which is not strictly true, that imports and exports balance each other on paper, it is surely evident that the country that is getting the largest proportion of items (2) and (3) is getting the best of the bargain. It seems to me, therefore, that the deductions that Mr. Hookham draws from the crude "imports pay for exports" theory are not proved.

On the other hand, in considering the effect of Protection on employment, he has overlooked the primary object of scientific tariffs—*i.e.*, the exchange of our manufactures for the other nation's raw material—and refers only to their secondary effect on home prices. It seems to me that the answer to his "challenge" lies in the fact that the tariffs will be graded in proportion to the "labour value" of the goods.—I am, &c.,

Norwich, July 12. S. E. GLENDENNING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of July 8th contains more nutshell arguments from Mr. Hookham. In his letter the reasoning is lucid in the extreme:—

1. Imports are paid for by exports.
2. Stop the imports and you stop the exports.
3. What employment you give for the home market you take away from the export trade.

So far Mr. Hookham. But why stop there? Why does he not continue thus:—

4. Conversely, increase the imports and you must increase the exports to pay for them.
5. Buy only imported goods, and so compel foreign nations to buy our goods in exchange.
6. Eventually have every country importing all its consumption and exporting all its production, and thus attaining an almost indecent pitch of prosperity.

Mr. Hookham stops at No. 3 because he can detect the utter nonsense of 4, 5 and 6. But they are the logical sequence from his own arguments.

The truth is, of course, that there are more things in Protection and Free Trade than are dreamed of in Mr. Hookham's philosophy. It is by no means so simple a question as he appears to think, and it cannot be disposed of off hand by any "nutshell" argument. All sensible people realise that

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roughly, the total selling prices of exports are equal to the total buying prices of imports. What is not so clearly realised is that the value of the *labour* in equal values of different commodities is by no means a fixed quantity. By exporting highly manufactured goods and importing (say) raw cotton in exchange, we ensure a great gain of employment to the country. On the other hand, an export of coal balanced by an import of watches means a serious loss of employment. A tariff is an instrument whereby encouragement is given to the right sort of exchange, while the wrong sort is penalised, and the fines thus imposed are added to the country's public funds.

The total *value* of imports (and, therefore, exports) is no true index to a country's prosperity, any more than turnover is a criterion of sound business. In each case it is essential that the transactions shall be profitable. The shipping industry seems to be the only one directly affected by such a question, and even here gross tonnage is of more importance than gross value, with which it is only indirectly related. An intelligent tariff does not seek to curtail imports or to restrict trade. It seeks to encourage the profitable transaction at the expense of the unprofitable. It aims at ensuring an equality of conditions with those of other nations, so that labour, where economically advantageous, may be purchased in the country rather than abroad.

An intelligent tariff will, therefore, increase employment because (1) it will foster manufacturing for home consumption, (2) it will encourage payment for imports by *manufactured* articles. Mineral wealth, agriculture and human activity are the sole exportable resources of any country. We *must* have imports. Let us pay for them with the work of the men now starving under a policy of foreign preference.

Mr. Hookham's first letter contained a challenge to anyone to show him how his arguments were unsound. I did so. His second letter issued a new and wider challenge. I have met it. It is now for Mr. Hookham to reply. No doubt he will again entirely shift his ground, and then claim a victory.—I am, &c.,

London, July 11. MUDRÉTZ.

PARLIAMENTARY INTELLIGENCE.

NORTH-EAST LONDON RAILWAY BILL.

On Thursday last week this Bill, which had already passed through all the stages in the House of Commons, came before a select Committee of the House of Lords, presided over by the Earl of Donoughmore.

After hearing Mr. Freeman, K.C. (who opposed the Bill on behalf of the G.E.R. Co.), the chairman intimated that the committee considered the preamble not proved, that the petitioners against the Bill had been unreasonably and vexatiously subjected to expense, and that, therefore they were entitled to recover their expenses from the promoters.

Mr. FREEMAN asked the committee not to allow the withdrawal of the Bill, but to order the promoters to proceed, and, if they failed to do so, to reject the bill. In 1905 the North-East London Railway Co. were granted powers to construct a line, partly in tubes and partly above ground, from the City to Waltham Abbey. Parliament made it a condition of the passing of that Act that within a specified period the promoters were to satisfy the Board of Trade that they had raised a certain amount of the construction capital. The promoters had failed to comply, even though they were given four extensions of time. Meanwhile the line had been blocked and the district hung up, the Great Eastern Co. being unable to carry out various works they would otherwise have carried out. A further extension of time was asked for by the promoters this year.

MINES ACCIDENTS (RESCUE AND AID) BILL.

This Bill was read a second time in the House of Commons last week.

Mr. MASTERMAN, who replied to criticisms of the Bill, said it was not suggested that they should fix on some particular type of apparatus and insist that it should be provided in all mines. Nor was it proposed that they should interfere with the responsibility of the management. If any Treasury grants were to be made they should go to the advancement of scientific knowledge through experiments. The Commissioners would not interfere with the mine management, but would see that some form of rescue apparatus was provided at the mine or in the immediate neighbourhood. They would have to see also that there were men trained to use the apparatus. The proposed Orders would be laid on the table, and if neither House of Parliament objected they would become law. The masters would provide the apparatus, and the men would have to provide men trained in its use. At every mine where an explosion had occurred in the last ten years messengers had been hastily despatched for rescue apparatus which very often had been of no use because of the distance it had had to be brought and because nobody knew how to use it. At Whitehaven the apparatus did not arrive until 17 hours after the disaster. There were two sets, one from Newcastle and the other from Lancashire. The first was without the necessary liquid air, and the second without the electric light. If this apparatus could have been used within half an hour of the disaster, by men trained in its use and knowing the pit, it was likely that there would have been a smaller loss of life.

WIRELESSS TELEGRAPHY ON SHIPS.

In the House of Commons on Wednesday Sir E. SASSOON obtained leave to introduce a bill to render the installation of wireless telegraphy on passenger ships compulsory. He said experience had shown the value of that marvellous invention for the preservation of human life and property, and he did not anticipate that shipowners would grudge the cost. It would be an obligation such as Parliament had imposed upon railway companies in the use of brakes. From such inquiry as he had made the expense of installation would not be more than £200. The main item of expense would be that of an expert operator, and in these days of diffusion of technical knowledge for small vessels that expense might be avoided or reduced by simplification of apparatus and by utilising the services of the engineer or junior engineer. The increased demand that would follow the passing of the bill would tend to reduce the cost of the apparatus, and there would be compensation in reductions in premiums for insurance. The cost of assistance to the steamer "Trieste" would have been reduced by the use of wireless telegraphy. In New Zealand the Government authorities had power to enforce such an obligation upon vessels; that was also the case in France, and a like proposal was before the Italian Parliament. The bill, which would come into operation in 12 months from its passing, would make it unlawful under a penalty of £1,000 for a vessel carrying passengers and crew to the number of 50 to leave port without having installed an apparatus for transmitting and receiving messages over a distance of 100 miles. The company installing would be under obligation to receive and transmit messages, and the Board of Trade would be required to frame regulations. Coastwise vessels would be exempted.

Mr. T. GIBSON BOWLES, who opposed the introduction of the bill, thought there was great danger that in its operation the measure would do more harm than good. Large steamers had to a great extent wireless telegraphy installed. To small steamers the expense would be a matter of great importance; not every tramp steamer could bear the expense of £200. There would be in addition the expense of carrying two men to work the apparatus, for one man could not be on continuous duty, and the engineer had his work in the engine room to attend to. Nothing had hampered English shipping more in the past than the manner in which it had been regulated. The system had done nothing but mischief, and had ruined hundreds of shipowners. It was proposed to institute a further set of regulations to be carried out by the Department which had oppressed and strangled shipping as much as they could. It was no use installing wireless telegraphy on board ships unless they had a sufficient number of stations on land to receive the messages. Between this country and New York there were many stations, but they were under the control of the Post Office, and, like everything else under the control of a public Department, they were hundreds of years behind the times. They were so bad as to be almost useless, and there was no hope of any improvement. Regarding other parts of the world, when they got to Australia and India there was scarcely a station to be found, so that passenger ships had to go many thousands of miles without being able to use wireless telegraphy.

The bill was read a first time.

LONDON ELECTRIC SUPPLY BILL.

The Select Committee of the House of Commons on this Bill met on Tuesday, under the chairmanship of Mr. Brunner.

The Bill, which is promoted by the Board of Trade, constitutes London County Council the purchasing authority of the undertakings of the Kensington & Knightsbridge and Notting Hill Electric Lighting Cos., the St. James' & Pall Mall Electric Light Co., the Westminster Supply Corpn., and the Central Electric Supply Co. The Bill complements the Electric Supply Act of 1908.

There was no opposition, and the Committee found the preamble of the Bill proved.

RHONDDA URBAN DISTRICT COUNCIL (TRAMWAYS EXTENSION, &c.) BILL.

On Tuesday a Select Committee of the House of Lords (presided over by Lord Donoughmore) passed the preamble of this Bill, which authorises certain extensions of the system, including a line to Maerdy. The Taff Vale Rly. Co. opposed, on the ground of competition, but, after hearing the evidence, the Committee allowed the Bill to proceed.

Telephone Time Limit.—In reply to a protest by the Bradford Master Builders' Association, the National Telephone Co. state that the time limit of 3 minutes for local calls applies to junction lines only. It is not new, but it has not been enforced in the past and this has resulted in dislocation of the service. The company has the right to disconnect any call at the expiration of three minutes, but the right is not exercised except in the cases of trunk and junction calls.

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LEGAL INTELLIGENCE.

Attorney-General ex rel. India Rubber, Gutta Percha & Telegraph Works Co. v. West Ham Corporation.

On Tuesday, Mr. Justice Neville commenced the hearing of this action for a declaration that large overdrafts obtained by defendants from the London and County Bank in respect of their electricity undertaking were unauthorised and illegal and that the Corporation were not entitled to levy a rate for paying off such overdrafts or interest thereon. An order was also asked for to compel the bank to refund the interest already paid to them in respect of the alleged illegal overdrafts.

Sir Alfred Cripps, K.C., M.P., Mr. MacMorran, K.C., and Mr. Joshua Schofield appeared for plaintiffs; Mr. Danckwerts, K.C., Mr. C. Morten, K.C., and Mr. Tomlin for defendants; and Mr. Buckmaster, K.C., and Mr. Methold for the Bank.

In opening the case, Sir ALFRED CRIPPS said some crucial points were raised as to what was illegal and improper on the part of a Corporation when dealing with its borrowing powers. It was alleged that defendants had expended large sums in respect of their electricity undertaking without any statutory authority. Having exhausted their authorised or statutory borrowing powers, they had, without any legal authority, obtained an overdraft from their bankers. The total commitments at one time under that head amounted to £150,000, not one penny of which was authorised either by statute or by the L.G. Board. If a Corporation was to be allowed to borrow on an overdraft after they had exhausted their statutory borrowing powers, all restrictions imposed by Parliament to ensure fair trading would be absolutely valueless. When it was found in March, 1908, that there was a deficiency of £44,000, instead of it being met as the Act contemplated, illegal borrowing was resorted to. The Corporation had purported to use their general statutory borrowing powers as security for obtaining advances for their electrical undertaking. That was, he submitted, wholly illegal and improper. Further, provisions for sinking fund had not been complied with. The sinking fund, which had amounted to £90,000, instead of being invested in outside securities, as it should have been, was set off against the overdraft obtained from the bank. Such a way of dealing with local funds could not possibly be justified. The Corporation had chosen a London Bank of high standing, but they could choose their own bank, and supposing that they had chosen a bank less stable there was no telling what might have become of all their money. The money they had raised under their statutory powers might have been lost altogether. He could not conceive any more improper use of their financial powers than in using their sinking fund in order to obtain an improper overdraft instead of investing it in a legal and authorised manner. It was intended that that fund should be invested for the benefit of future ratepayers. The Electric Lighting Act of 1882 showed how the expenses of a local authority for electric light were to be met. It provided that any expense incurred by a local authority under the Act (including expense of obtaining powers or of meeting opposition to obtaining such powers) might be defrayed out of the local rate as defined in a schedule to the Act. The local authority might cause such rates to be levied as might be necessary to defray such expenses. Sec. 8 of that Act provided that the local authority might from time to time borrow money on such security and subject to such consent as was mentioned in the schedule. Such borrowing was subject to the same restrictions as borrowing under the Public Health Act, 1875, but it was not alleged with regard to the borrowing in question in the present action that the Act of 1875 was complied with or that any sanction was obtained from the L.G. Board. It was important to notice that any deficiency of income of any one year not met out of the reserve fund should be payable out of the local rate. It was clearly the intention of the Legislature that the Corporation was to carry out its electric light undertaking on a fair and proper business basis. If there was a deficiency in any particular year the ratepayers were to bear it. The ratepayers of that year would then be in a position to see how the electricity undertaking was being carried out for them by the Corporation. What happened was that a continuing deficiency from year to year which ultimately amounted to nearly £50,000 (at all events over £44,000) was never met or answered out of the local rates. Instead of which there was illegal borrowing by overdraft at the bank. Plaintiffs believed that there was at present outstanding a deficiency on revenue account of over £44,000, and that amount had been secured by illegal borrowing. Corporations were under a statutory obligation to pay their debts year by year, and if there was any deficiency to pay the debt out of the local rates, the debt was the ratepayers', and it was required that they should pay their way as they went along, because if not they had a debt that was a burden upon future ratepayers with which they were not concerned and ought not to be called upon to bear. Persons who, for the time being, had the benefit of that electricity undertaking should also make up any deficiency (if any) and not leave it as a charge against future ratepayers. So far as current expenses and revenue was concerned, the Corporation had no power to borrow. The West Ham Corporation Act, 1893, gave the Corporation power to purchase electrical fittings incidental to their supply, but it was important to bear in mind that any expense incurred by the Corporation under the sections of that Act was to be deemed an expense incurred under the Electric Lighting Act of 1882 where not otherwise provided for. Sec. 52 of their provisional order of 1892 gave the Corporation power to borrow, but only power to borrow in accordance with that section. It could only be done as a charge on the local rates with the sanction of the L.G. Board. He did not find that those powers were ever exercised or purported to have been exercised in respect of the amounts of which plaintiffs complained. There was a slight difference between the parties as to the figures in the accounts, but he thought it would appear that the accounts up to March 31, 1908, showed that the electric lighting account had been overdrawn to the amount of £44,952. 12s. There were other sums amounting to £90,000 odd, and at that time the Corporation had got an overdraft without authority of £148,671 odd. According to the bank they had lent nearly £150,000, which was wholly illegal.

His LORDSHIP asked how were the electric undertaking accounts kept. Were they balanced each year?

Sir A. CRIPPS said they were made up each year to March 31.

His LORDSHIP said then he could know whether there was a profit or loss. The accounts so far had not shown that. All they had shown was that the Corporation had overdrawn the electric lighting account. It was important, as it might be that there was sufficient to pay off the overdraft each year.

Sir A. CRIPPS said he did not think that his lordship would find that was so. What he would find was that after the matter had been considered by the Finance committee a communication was made to the bank with reference to this overdraft, the amount of which was very large indeed.

Mr. Justice NEVILLE said that from remarks that had fallen from Mr. Danckwerts he gathered that the parties were not really agreed as to the facts. Under these circumstances was it possible to proceed with the case until the accounts of the Council had been taken?

Sir ALFRED CRIPPS thought so. There would be sufficient to explain what the course of dealing with the funds had been, which would enable his lordship to determine the principal question.

Mr. DANCKWERTS suggested that it might be more convenient to take the accounts first, but his Lordship said that if Sir Alfred thought there was a question to be determined first he must hear the case.

Sir ALFRED contended that it made no difference whether the loan was for a limited time or continuous, for if the overdraft was renewed from time to time the Corporation were working upon what plaintiffs said was an illegal overdraft. Dealing with the correspondence, counsel submitted that it showed the overdraft was being used for revenue purposes. He submitted that the Corporation could not borrow in the way the correspondence showed they had borrowed. They could not borrow generally under their powers to borrow. They must borrow for a specific purpose, and having obtained power to borrow for that specific purpose they could not use the money for another purpose. Further, he submitted that, without putting themselves in a position to raise money by permanent loan; they could not raise it by overdraft. According to the minutes of the bank the overdraft was for the general purposes of the Corporation. They showed that the whole position was brought to the notice of the bank and the bank was cognisant of all that was going on.

His LORDSHIP put the case of where the Corporation had been authorised to borrow but were advised by their broker that the state of the money market made it inexpedient to borrow at that time, and consequently went to the bank and asked for a temporary overdraft. That, he suggested, would be legitimate.

Sir ALFRED thought not, unless as a temporary expedient. His case was that what the Corporation had done was not done by way of temporary expedient, but by way of a continuous overdraft. You could not, as against illegal borrowing, take advantage of the Consolidated Loans Fund. A great part of the overdraft was for expenditure that had not been sanctioned. Whether or not the Corporation could be entitled to borrow in anticipation of obtaining powers to do so, there could be no authority for setting the balance of the loans fund against unauthorised borrowings. Here, in the words of the reported case, the Corporation had not merely a temporary borrowing but a normal floating debt, and the whole of the authorities were to the effect that such a debt was illegal. Speaking broadly, on the authorities, his contention was that the Corporation had no power to arrange for an overdraft, apart from the consolidated fund, except for purely temporary purposes, and that the pooling of the accounts was absolutely illegal and could not be justified. The present case practically related entirely to the electric lighting account, and it would not in evidence be necessary to go into the other accounts in anything like detail, but it would be necessary to refer to them for showing how the accounts of the Corporation were kept and the general impropriety.

Mr. LEON KEEN, C.A., said that he had investigated the accounts of the Corporation for three years—from April 1, 1905, to March 31, 1908. For the quarter ending March 31, 1908, it appeared that on the electrical fund revenue account there was an overdraft of £44,952. 12s. and that the capital on the electrical account was overdrawn to the amount of £92,452. 4s. 4d. Those figures appeared in the published accounts of the Corporation. Some £1,500 odd was deducted from the £92,452, but, in his opinion, it ought not to have been, as it was money for a special purpose and should have been carried to a special account. The revenue account included all the expenses relating to the generation and supply of electricity. It represented the expenses over the revenue obtained from the supply of current. Of that, £4,669 was for expenses incurred in 1906 and was charged to net revenue account in 1908. Stores in hand, £22,000 odd, was only another way of saying that the Corporation had borrowed from the bank to pay for those stores. The same thing applied to the motors. They were paid for out of the overdraft. The electrical accounts always showed an overdraft on revenue. The lowest was £28,000, and from 1907 it had always been over £40,000. The £92,000 overdraft of electric lighting capital account was an amount

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that had been accumulating. It started at £12,000 and went up gradually, until in 1908 it reached £92,000. In cross-examination, witness said that he was given access to all books and accounts he desired to examine. There was nothing in the books to show that they were otherwise than well kept. The Corporation s accounts were audited by an eminent firm of independent chartered accountants throughout the period in question.

In reply to Mr. BUCKMASTER, K.C. (for the Bank), Witness said that in his examination of the books and papers of the Bank he saw nothing that would enable him to say that the Bank ever knew the source from which the moneys paid into the Corporation s general account came from or the purpose for which the money was drawn out of it.

The case was proceeding when we went to press.

Steam Regenerative Accumulator Patent.

The Solicitor-General (Sir Rufus Isaacs) recently gave judgment in the appeal from the decision of the Chief Examiner of Patents, ordering that the patent applied for by D. B. Morison in regard to improvements in the apparatus for the utilisation of intermittent supplies of exhaust steam (No. 22,025 of 1907) be sealed. In the course of his judgment the Solicitor-General said the opponents (the Société d'Exploitation des Appareils Rateau) sought the insertion of a specific reference to specification No. 3,608 of 1901, or for an amendment (by way of disclaimer) of applicant's specification, on the ground that the 1901 patent was a master patent for steam regenerative accumulators for receiving exhaust steam at irregular intervals from engines running intermittently and delivering this steam with regularity either to an ordinary condenser or to an auxiliary engine interposed between the main engine and a condenser. Applicant's first claim was for "the combination of a water heating thermal storage apparatus with a high and with a low pressure engine, and with an automatic regulating valve so arranged that, when the exhaust steam from the high pressure engine was in excess of that normally desired for the working of the low pressure engine, a part or the whole of the steam is caused by the valve to pass into the said apparatus, and be therein utilised, as far as the temperatures may practically permit, to heat water, which is thereafter, in whole or in part, withdrawn from the apparatus at an exit temperature higher than its admission temperature, and when there is no such excess the valve remains full open, and an uninterrupted passage is established from the high pressure engine direct through the valve to the low pressure engine."

Applicant's claim was for a combination including the use of an automatic regulating valve which did not form part of the invention of the opponents, and upon the true construction of applicant's claim it appeared to him that it was limited to the combination including the automatic valve, and that from the title and the description in the body of the specification his claim related to the improvements in the apparatus for use in connection with the utilisation of intermittent supplies of exhaust steam, and did not cover the use of steam regenerative accumulators for such purposes. The point of the invention was the use of the automatic valve in combination, thus providing a regularisation of the steam supply to the turbine, and his claim was therefore for a specific limited improvement only. For the applicant it was contended that the first claim of the opponents' specification should be construed by reference to the whole of the claim, the description, and the total specification, and that so considered it amounted to a claim for a specific apparatus, and must be limited to the specific apparatus described by him in his claim, and he was of opinion that this contention was correct. It was clear to him that the opponent's claim must be limited to the invention and the improvements described in the specification and claimed in the first claim, and having come to the conclusion that the opponents' claim must be limited to the specific improvement described, it was apparent that the opponents had not a master patent, and therefore a specific reference should not be inserted in applicant's specification. Sir Rufus Isaacs also held that, although it was not necessary to deal with it in detail the specifications of Jurisch (No. 1,488 of 1880), and of Duff (No. 16,985 of 1896) were sufficient to displace the contention of the opponents that the placing of steam regenerative accumulators for the purpose, and in the manner indicated in the opponents' specification was novel. He was, therefore, of opinion that the Chief Examiner's decision was correct, and that the appeal must be dismissed with 10 guineas costs.

Settle v. Sheerness & District Electric Power & Traction Co. and Queenborough Wharf Co.

The Court of Appeal (Lord Justice Vaughan Williams and Lord Justice Buckley) on Saturday heard an interlocutory appeal by plaintiff against an order of Mr. Justice Bucknill, restraining Queenborough Wharf Co. from producing to plaintiff certain letters written by the secretary of the Sheerness Co. to their co-defendants.

Plaintiff had the use of a house at the wharf of the Queenborough Co., and the Sheerness Co. supplied electricity (through uninsulated wires which passed over plaintiff's house) to the Wharf Co.'s cranes. The house had a flat roof, and one of plaintiff's workmen, who went on to the roof, touched the live wire and was killed. The dead man's relatives, who took proceedings against plaintiff, had to be compensated, and plaintiff was bringing an action for an indemnity. After the issue of the writ the secretary of the Sheerness Co. wrote the letters in question, and the Queenborough Co. disclosed them in an affidavit of documents without claiming privilege.

After argument, the Court dissolved the injunction, but declined to make any order for the production of the letters, holding that they had no bearing on the issue.

Marine Electric Propulsion Patents.

On 7th inst. the Comptroller-General of Patents (Mr. R. Temple Franks) had before him a question as to whether the specification of an invention by the Hon. C. A. Parsons as to the use of electric apparatus in the propulsion of ocean-going vessels infringed a patent of Mr. W. P. Durtnall, embodying his inventions of 1905. The Durtnall patent, it was claimed, was a method of so combining a high-speed engine, an electric installation of dynamo and motor and a propeller that the engine, or prime mover, could be run at its most economical speed, while driving the propeller much slower, and so raising the efficiency of the latter in relation to the power used and the speed of the vessel, without any undue loss of power in transmission. That combination involved the use of a polyphase motor, and in the Parsons specification of 1909, embodying an arrangement with a similar object, a polyphase motor is also included. Mr. Durtnall contended that his invention was the first attempt to utilise the polyphase principle in that specific manner, but ultimately Mr. Durtnall agreed that he would be quite satisfied if the specification of the Parsons patent included a reference to his own so far as the polyphase principle was concerned.

The Comptroller reserved his decision.

Compensation for Colliery Accident.

In the Hamilton Sheriff Court, Sheriff Thomson has delivered judgment in an action brought against Archibald Russell (Ltd.) by the representatives of the late John Wallace, miner, who was killed in defendants' colliery.

In giving judgment, the Sheriff said on Dec. 8, 1909, deceased was requested by his brother (an oversman in the pit where the accident occurred) to give assistance to men at work in a chamber which was being prepared for an electric motor. Deceased assisted in the removal of some hutches, and after they had been removed he was seen, perhaps a minute before the accident occurred, leaning against a prop in the chamber. On the opposite side of the prop a coil of electric cable was hanging: the cable was not at the time fully connected up, but the voltage of the circuit was high enough to be fatal to a person who should receive a shock from it. Three lamps had been connected with the cables but two had been removed and the remaining one was employed in lighting the chamber. The holders of the two lamps which had been removed were left on the cable, and anyone would receive a shock who put his fingers on those. A notice was posted up in the mine warning unauthorised persons not to touch cables or other electrical apparatus. Deceased had no authority to touch these things. A minute later deceased was heard to give a cry of pain, and he immediately collapsed and fell against the iron plate which was only a few inches away. He had a coil of the cable in his hand at the time. He expired at once, and the cause of death was electric shock from the cable. When his brother heard his cry he instinctively removed the coil of cable from the prop and threw it on the ground, and current was switched off. The doctor who was sent for found life extinct, and discovered on the breast of deceased a mark as of a burn of recent origin, but he could not say whether the burn was due to electric shock. The cable was in perfect condition when put in a few days before. After the accident it was found damaged to some extent, and denuded in some places of its insulation. The oversman had power, in cases of emergency, to put ordinary miners to other work, and the oversman (David Wallace) considered it a case of emergency which justified his putting deceased to work in the chamber. He (the Sheriff) found that under the circumstances the death of deceased was due to an accident arising out of and in the course of his employment, and that pursuers were entitled to compensation, which he assessed at £300.

North-Western Electricity & Power Gas Co.—In the Manchester County Court on Monday Judge Parry had before him a petition by the trustees and executors of the will of J. H. Gartside for the compulsory winding-up of this company. It was, however, announced that since the matter was previously before the Court the parties had come to terms, under which the petition would be withdrawn, the Company undertaking to pay the taxed costs. The petitioners thought there was a chance of the Company being resuscitated, and wished to give them every possible facility. Judge Parry confirmed the agreement.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An important Italian firm manufacturing electric motors and transformers require a competent works manager to supervise about 1,000 men. Applicants must be certified engineers of Italian nationality, and have already filled a similar position in a manufacturing firm. See an advertisement.

A large manufacturing Company require a first-class foreman for their winding department. See an advertisement.

The committee of the Tottenham Polytechnic invite applications from teachers of electrical engineering to prepare students for the City and Guilds examinations. The teacher will be required to attend on two evenings a week from 7:30 to 9:30. Fee 12s. 6d. per evening. Forms of application from Mr. J. W. Tomlinson, the

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Polytechnic, South Tottenham, to whom applications by 21st inst. See advertisement.

Applications are invited for the positions of assistant in the mechanical and electrical engineering department of the Municipal Technical School, Halifax (at a commencing salary of £160 per annum), and lecturer in mathematics (specialist in practical mathematics), at a commencing salary of £150 per annum. Forms of application (to be returned not later than July 28) may be obtained from the Secretary of the Education Offices, Mr. W. H. Ostler, Halifax. See also an advertisment.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

Bombay Corporation require an executive engineer with knowledge of all branches of municipal engineering, including lighting and electricity. Minimum monthly salary R.1,200 (£80), maximum R. 2,000 (£133. 6s. 8d.). Applications to Mr. G. Midgley Taylor, Caxton House, Westminster, S.W., by July 31.

A professor of pure and applied chemistry is required at the Municipal Technical Institute, Belfast. Salary £350, increasing to £400. Particulars from the Principal. Applications by noon July 20.

On Wednesday the Birmingham Electrical Supply committee had before them the applications (322) for the position of secretary to the electric supply department at a salary of £600 per annum.

A sub-committee had selected 11 candidates, and four of these were before the committee on Wednesday, when Mr. Howard Foulds, secretary of the Electrical Standardizing, Testing and Training Institution, was appointed. The other three candidates selected for interview were Messrs. W. E. Foden (assistant sec. Manchester electricity department), W. T. Green (chief clerk Leeds electrical supply department), and E. J. Jennings (sec. Marylebone (London) electric supply department).

Colchester Council have appointed Mr. W. Frisby, who has been for the past three months in charge of the electricity department, borough electrical engineer at a salary of £250, rising by £10 yearly to £300.

Mr. A. L. Gardener, late rolling stock superintendent of the Wolverhampton district tramways and of the Burton & Ashby Light Railway Co., has been appointed tramway superintendent of the Isle of Thanet Electric Tramways & Lighting Co.

Watford Council have appointed Mr. G. D. Vickers, of Birmingham, assistant electrical engineer. Mr. W. Jessop (Eastbourne) and Mr. R. B. Craig (Bermondsey) were also interviewed by the Council.

Mr. A. E. Bolter, assistant secretary of the G.W. Railway Co., has been promoted to the position of secretary, on the retirement of Mr. G. K. Mills.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

University of Glasgow.—The next session will commence on Oct. 17 and end on March 23, 1911. In the departments of engineering, mining and naval architecture students usually spend the summer months in practical work, thus receiving their training on the Sandwich system. Prospectus of the course for the degrees of B.Sc. and D.Sc. in engineering and syllabus of classes may be obtained from the Assistant Clerk, Matriculation Office, The University, Glasgow.

University of Manchester.—The new session commences on Oct. 4. New and enlarged engineering laboratories have been erected. Prospectuses, giving particulars of the lectures, laboratory and drawing courses in engineering and physics, &c., may be obtained from the Registrar.

BRITISH AND COLONIAL.

Aldershot.—The Council have applied for sanction to a loan of £2,300 for the electricity department.

Association of Engineers-in-Charge.—On Saturday last about 60 members of this association visited the works of Messrs. Davey, Paxman & Co., at Colchester, the visitors having been previously entertained to luncheon by the firm at the Liverpool-street Station Hotel.

The visitors arrived at the works about 3 p.m., and were shown round the establishment by Mr. William Paxman and members of the staff. Much interest was taken in a tandem compound steam engine of the Paxman-Lentz type, fitted with positive valve gear, developing some 450 I.H.P., which was shown under steam; also in the firm's economic boilers, a large number of which were seen in course of construction in the boiler shop. (An order for five of these boilers has been received for the new Essex County Asylum at Colchester.) Other engines seen in course of erection or running included a 30 in. by 60 in. coupled winding engine with 12 ft. drum, gas engines, benzine engines, high-speed vertical steam engines, and horizontal slide-valve engines of various types.

After the tour through the various shops, which occupied nearly three hours, tea was provided in the large fitting shop.

Australasia.—The "Australian Mining Standard" states that Hay (N.S.W.) Council have let a contract for the electric lighting of the town and for the electric pumping of water and sewage for 15 years, after which period the Council may purchase the plant at a valuation.

An Order in Council was recently passed to authorise the South Gippsland (Victoria) Creamery & Butter Co. to supply electricity for lighting the town of Yarram Yarram.

The report of the directors of the Mount Lyell Mining & Railway Co. (Tasmania) for the year ended March last states that the requirements of the township of Queenstown of electric light provided by the company have much increased, and the transmission line has been improved during the year. On the termination of the original agreement a new one has been entered into with the municipal Council.

The electric lighting of the town of Glenelg by the Adelaide Electric Supply Co. was inaugurated on May 12.

The official opening of the Malvern–Prahran tramway took place on May 30. The capital expenditure by the Tramway Trust is £72,000. St. Kilda, Prahran and Malvern Councils have applied for authority to construct a line along Dandenong-road.

Additional generating plant of 2,000 H.P. has recently been put in at the Waipori (N.Z.) hydro-electric works. The demand in hand will take 750 H.P. of the new plant.

At the opening of the State Parliament last week the Governor (Sir Thomas Gibson Carmichael) referred to the appointment of a Royal Commission to consider the future of the Melbourne cable tramways and the proposed electrification of the suburban railways.

Battersea (London).—An extension of the feeder cable is to be carried out at a cost of £1,061.

Beckenham.—At the last meeting of the Council the resident electrical engineer (Mr. J. E. Tapper) reported that the present free wiring contractors were willing to continue the existing contracts for such period as the Council might require up to the limit imposed by the balance of "free wiring" capital in hand, and it was recommended that their offer be accepted.

The Electricity committee also recommended that the Council apply for sanction to a loan of £6,000. (Mains and services, £5,000, and meters £1,000.)

In the course of the discussion, Mr. Dykes called attention to the question of free wiring, and said that the returns regarding free wiring customers connected during the past year deserved careful attention. He was not then concerned as to whether free wiring was paying as a whole or not, but members should examine the figures. There were 27 consumers, and the average cost per lamp was 23s. 4d., while the average receipt from the sale of current had gone down to 3s. 9d. Some time ago the average receipts were 7s. 9½d. per lamp, but they had gradually fallen to 3s. 9d., while at the same time the cost of connecting up those installations was increasing. One consumer with 10 lamps cost £15.7s.8d. or 30s. a light. The return they got for that was 15s. 10d. That was not business. They ought to get a definite return for each lamp wired. Another consumer with 20 lamps cost £24. 8s. 10d. and the return was £4. 17s. 6d., or 4s. 10d. per lamp. A third consumer with 20 lamps cost the Council practically the same, but the receipts were £2. 3s. 9d., or only 2s. 1d. per lamp. There was no justification for such an expenditure, and the receipts did not pay their standing charges. He urged the Council to do what Poplar had done and get a proper return for their outlay.

Bradford.—The Electricity committee recommend that, as from July 1, the following charges be made for electric current:—

Private house consumers may elect to be charged on the basis of a fixed charge of 15 per cent. per annum on ratable value, plus ½d. per unit

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for energy consumed, this charge to include meter rent. In the case of arc lamps, a flat rate of 3½d. per unit to be charged for energy supplied through separate meter, these meters being regarded as sub-meters and so charged. Where arc and incandescent lamps are supplied through one meter, the existing flat rate of 4d. per unit to be charged.

In the case of power, heating and cooking, in the existing rate applicable to private consumers, the maximum demand to be reduced from not exceeding 10 to not exceeding 5 kw., and in the rate for large power stations the maximum demand to be reduced from exceeding 10 to exceeding 5 kw. The scale of discounts to be altered as follows:—Exceeding 10 and not exceeding 20 kw. 2½ per cent.; 20-30, 5 per cent.; 30-40, 7½; 40-50, 10; 50-75, 15; 75-100, 20; 100-150, 25; over 150, 30. In cases not covered by this scale the discount not to exceed the maximum discount already in force. In the case of all future connections as regards all classes of consumers, a minimum charge of £1 per half-year (inclusive of meter rent), to be enforced, whether energy to that amount is used or not, the existing provision as to minimum charge being rescinded.

The charges are based on the average price of coal consumed at the electricity works remaining at 9s. per ton, the price per unit charged consumers to be increased or reduced by 2½ per cent. for every 1s. or portion of 1s. the average price of coal is advanced or reduced, no increase or reduction if the average price of coal does not exceed 10s. per ton or fall below 8s. per ton.

On Tuesday when the recommendations were submitted to the Corporation, Mr. PALIN inquired whether the committee had taken into consideration the desirability of selling electricity at a more favourable rate in Thornbury, Laisterdyke and Tyersal, in order to compete with the outside gas companies.

The CHAIRMAN (Ald. G. H. Robinson) said the committee already supplied some part of Tong, and they would be pleased to lay mains to compete with the gas company in Thornbury if the Finance committee thought it wise. It was possible for a shopkeeper, if he consumed electricity long enough, to get it at 1½d. a unit for lighting. Shopkeepers as a rule were unprofitable consumers because they were short-hour consumers.

The recommendations were adopted.

Camborne.—The Urban Electric Supply Co., which has entered into a contract with the Dolcoath Mine (Ltd.) for the supply of electrical energy for power and lighting, has notified the Council that it will apply for a provisional order or make arrangements for taking a transfer of the Camborne Electric Lighting Order of 1899.

Cardiff.—The Council are negotiating in regard to the supply of electricity in Llandaff and Dinas Powis, but the subject has been deferred pending a report from the Parliamentary committee as to the extension of the city boundaries.

Carlisle.—A discussion took place at the Council meeting on Tuesday as to the appropriation of the profit (£3,050) on the electricity undertaking, and eventually it was agreed to allocate £1,000 to relief of rates and £1,000 to reserve, carrying forward the remainder.

Chatham.—Owing to the extended use of metal filament lamps, the Kent Electric Power Co. propose to discontinue the maximum demand system, and to adopt a new scale of charges.

Consular Service.—On the 7th inst. a meeting was held at the House of Commons to consider the present position of the British Consular Service and the possibility of its improvement. The notice convening the meeting stated that as a result of a preliminary consideration of the question by a special sub-committee of the London Chamber of Commerce, the following general propositions had been agreed to as a basis of possible recommendations:—

(1) That as far as practicable the British Consular Service should be confined to British subjects, whether paid or unpaid.

(2) That as regards certain important countries (*e.g.*, Germany, Russia, Scandinavia), where there are now a considerable number of foreigners acting as British Consuls or Vice-Consuls, such countries be divided into districts with a British subject in charge.

(3) That the status of British Consuls generally should be raised (*a*) by examinations, (*b*) by adequate remuneration for their services, (*c*) by giving greater encouragement to young men to qualify themselves for the Consular services.

Mr. McKinnon Wood, who was present, was understood to have assured the meeting that the Foreign Office would be willing to consider the appointment of paid consuls where it was thought the circumstances justified the expenditure.

Crewe.—The Council have been asked to extend the electric supply mains to the new garden city at Wistaston.

Crewkerne.—Messrs. J. & A. Purves propose to apply for a provisional order forthis district.

Dromore (Ireland).—Mr. Pegg, of Belfast, has been authorised to prepare a report on electricity supply.

Eccles.—The Council have received sanction of the L. G. Board to a loan of £3,234. 3s. 10d. for extensions of the electricity undertaking.

Electric Cables under the Clyde.—The Clyde Valley Electrical Power Co. have recently laid six new electric cables under the Clyde at Yoker.

The cables in the river bed have been damaged by passing vessels, and only a few weeks ago one was rendered unworkable from that cause. The company have dredged the river from the Yoker side to the Renfrew side at the railway pier to a depth of 30 ft. below the low water mark, and at this part the new cables have been laid. Three of them are for conveying current at extra high tension (11,000 volts) while the other three are relays. With the placing of the cables at a greater depth it is expected that they will be more immune from damage than formerly.

Electricity in Mining.—At the meeting last week of the Mond Nickel Co., Sir A. Mond, M.P., said they had erected a hydro-electric power station to supply electric power for the mines and smelting works at their Victoria Mines. The plant was running satisfactorily. In order to comply with the charter of the Ontario Government with regard to way-leaves, &c., they formed a Canadian company (the Lorne Power Co.) the shares of which were mainly held by their company.

Faversham.—The electrical engineer (Mr. G. Somerville) has reported that during the past year a saving of 9,800 units on public lighting had been effected by the conversion of 48 Nernst lamps to metal filament, and recommends that the remaining 53 Nernst lamps be converted during the current year. The recommendation has been adopted.

Grangemouth.—The Scottish Electric Power Co. are laying cables in this district, and hope to be able to supply energy by Aug. 15.

Hammersmith (London).—For some time past negotiations have been in progress with the Inland Revenue authorities with a view to obtaining an alteration in the basis of assessment of the profits of the electricity undertaking for income tax.

Up to 1904-5 it was the practice to allow from the gross profits a fixed sum of £2,500 to cover depreciation in machinery and plant. This was considered insufficient, and claim was made for a larger allowance. Ultimately it was arranged to allow each year fixed percentages on the capital outlay on mains and machinery of 3 per cent. and 5 per cent. respectively. No income tax has been paid since 1904-5, but for the three years ended March, 1908, £1,920. 5s. 4d. had been set aside to meet the liability. On the basis now arranged, the income tax payable in respect of these years will be £1,298. 14s., or £621. 11s. 4d. less than the amount provided.

India.—H.H. the Nizam has sanctioned a scheme for the supply of electricity in a part of the city of Hyderabad.

Callenders Co. are to supply and lay the mains and Messrs. Osler & Co. to do the wiring in private houses. The generating plant is to be erected at the Mint, and the use of the same engines for driving the electrical and the coin manufacturing plant is expected to result in economy. Supply of current will probably commence by the end of August.

Lahore Municipality propose to erect and equip electricity supply works at a cost of about 5,00,000 rupees, for lighting the Civil Lines at Lahore.

Japan British Exhibition Awards.—The Superior Jury of the Japan-British Exhibition has completed the examination of the awards, numbering between 5,000 and 6,000. The distribution is to be made in the Congress Hall of the White City to-day (Friday), at 3:30 p.m., when H.R.H. Prince Arthur of Connaught will preside. The prizes will be distributed by the Duke of Norfolk to the Japanese Exhibitors, and by Baron Oura to the British Exhibitors. It is notable that the awards are ready for distribution during the actual progress of the Exhibition.

Leicester.—The Gas and Electric Light committee have abandoned their intention to appeal against the recent decision of Mr. Justice Neville declaring wiring work and the supply of electrical fittings, &c., by the Corporation to be ultra vires.

Light Railways.—The Llanelly and District Light Railways (revival and extension of time) Order has been submitted to the Board of Trade for confirmation. Objections by July 27.

Liverpool.—A sub-committee of the Tramways committee has reported against the proposal to run express electric tramcars.

Macclesfield.—The Council have received two notices of intention to apply for provisional electric lighting orders.

Malvern.—The Council, on the recommendation of the engineer (Mr. W. J. Rendell Baker), has decided to cancel the present maximum demand system (2½ units for each 8 c.p. lamp wired), which has resulted, since the higher candle-power metallic came into vogue, in a greater percentage of the consumption being charged upon the higher rate. The engineer's recommendation was for a flat rate of 6d. per unit, less 5 per cent. for cash in 28 days, with increased discounts for larger consumers. The Council, however, decided to give the system a trial at a universal rate of 6d. per unit, less 5 per cent., representing practically 5 per cent. reduction to all consumers.

Marylebone (London).—The Electric Supply committee recommend the Council to enter into agreements with Mr. A. Hugh Seabrook, general manager, Mr. C. Jennings, secretary and accountant, Mr. Richardson, station superintendent, Mr. Smyth, mains superinten-

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dent, and Mr. Holmes, sales manager of the electricity supply department, on the following terms:—

(1) That there shall be an advancing salary for four years. (2) That each officer shall be bound to serve the Council during this period, but that he may be dismissed on payment of six months' salary, or without compensation in the case of misconduct or of illness lasting beyond six months. (3) That 6 per cent. out of the profits on the first £10,000 net profits in any year and 9 per cent. on anything beyond £10,000 shall be allotted proportionately among the officers affected as extra remuneration. This will only be paid in the event of a growth in the sales at the rate of 500,000 units a year, and a diminution in the average price of 5 per cent. each year. The Council will keep absolute control as to reducing prices.

It is proposed that Mr. Seabrook be granted an annual increase of salary of £50, plus 2 per cent. on profits up to £10,000, and 3 per cent. on profits beyond. The other officers are recommended for annual advances of £25, plus 1 per cent. on profits up to £10,000 and 1½ per cent. on profits beyond.

Municipal Telephony.—The accounts of the Portsmouth municipal telephone department for the year ended March 31 show total income of £11,721 (against 11,285 in 1908-9), including £9,123 for exchange rentals, £194 for private rentals, £470 for local tolls, £351 for public telephones, £80 P.O. royalty and £94 terminal fees from the National Telephone Co., also £1,340 trunk and terminal fees and £60 for interest.

The working expenditure was £7,028, and included £948 for line repairs, £124 for line reconnections, £1,246 for instrument and exchange repairs, £793 salaries and office wages, £1,396 operators' wages, £1,030 royalties and P.O. commission, £278 terminal fees to National Telephone Co., £611 rent, rates and taxes, and £165 for wayleaves. The gross profit was £3,293, and after taking credit for amount brought forward and paying interest (£1,463), instalment of principal (£1,465) and income tax (£36), the balance (£530) was transferred to reserve. The capital expended is £53,154, an increase of £772. There are 2,556 telephones working, exclusive of junction lines. There are 1,953 subscribers' lines (decrease 39), 627 extension and other lines (increase 50) and 10 exchanges (as in 1908-9).

Oldham.—It is probable that the Council will apply for a provisional order for Royton, as there seems to be a fair demand for electricity supply in that district. At present the Lancashire Electric Power Co. have authority to supply for power, but not for lighting.

Osrams in Glasgow.—Unquestionably one of the finest examples of street illumination by metal filament lamps, is to be found in Glasgow, where, by their highly successful trials, "Osram" lamps are in favour for the lighting of important positions. A walk down Queen-street—a wide and busy thoroughfare—will convince even the most sceptical that the metal filament lamp has more than secured its position in the field of "public illuminants." Its economies have all along been appreciated, and now the fragility of its filament is no longer a nightmare, it supplies the most fitting of all weapons with which to fight the gas bogies—Let there be war to the death!

The remarkable results in Queen-street are obtained by means of 30 Osram lamps—16 100-watt and 14 55-watt, all for 260 volts. These are arranged on 23 posts and have been installed since April 1, burning just over 400 hours up to date. None of the lamps have failed, and the candle-power has in no way diminished. This installation furnishes yet another proof of the strength of the Osram filament now supplied. Queen-street is a main thoroughfare, and heavy traffic passes up and down unceasingly morning, noon and night.

Pacific Cable Board.—Mr. A. S. Baxendale, general manager of the Pacific Cable Board, is in Canada formally taking over the land telegraph line across the Dominion which has been leased from the Canadian Pacific Railway Co. The staff of operators at the different stations on the line are to be appointed and controlled by the Board.

Penmaenmawr.—The L.G. Board have sanctioned, without local inquiry, a loan of £550 for the electric lighting of the promenade.

Personal.—Mr. J. W. Saaler, of Bruce Peebles & Co. was married on the 12th inst. at St. Margaret's Church, Westminster, to Miss Frances R. Knott, of Southsea. Mr. and Mrs. Saaler sail on Saturday by the R.M.S. "Saxon" for South Africa, where Mr. Saaler is taking up a position for his firm in Johannesburg, and we are sure has the good wishes of many friends.

The members of the South-Eastern district of the Institution of Municipal Engineers have elected Mr. Henry C. Adams, consulting municipal engineer, as their chairman for the second year in succession.

Provisional Electric Lighting Orders.—The Board of Trade have issued their report respecting the applications to and proceedings of the Board under the Electric Lighting Acts, 1882 to 1902, during the past year.

Of the 25 applications 14 were made by local authorities and 11 by companies or persons; 20 orders were granted. In three cases (Ballyclare, Brumby and Frodingham, and Templemore) the Board were not satisfied that an undertaking could be established without involving the Councils of the districts in a loss. The Frimley Council did not proceed with their application, and owing to a technicality Messrs. R. A. Lister & Co. were unable to proceed with their application for Brixham and Totnes. In the case of Runcorn the Parish of Weston was allotted to the Castner-Kellner Alkali Co. and the urban district and the remainder of the rural district were given to Messrs. G. H. Cox and H. J. Falk. The local authorities of Ardrossan and Smethwick refused to give their consent to the applications for orders for those districts, but after holding local inquiries the Board dispensed with their consent and granted orders.

Provisional Order Revocation.—The Board of Trade have revoked the Heswall Electric Lighting Order, 1908, as from July 2.

Salisbury.—The local Electric Light Co. intimate that they propose to apply for a provisional order to extend their area of supply so as to include the whole of the borough.

Sevenoaks.—The Council have referred to a committee a report from Messrs. Mordey & Dawbarn on the question of electricity supply.

The report states that, judging from somewhat similar residential districts, in the third year of working the consumption by private consumers would reach about 60,000 units. At 6d. per unit, the cost to the consumer would not be more than that of gas at 3s. 2d. per 1,000 for the same standard of illumination. If an electric supply scheme should be adopted, street lighting should be included, because the revenue derived from it would cover the entire working cost of the first year, leaving capital charges only to be met by revenue from private consumers, thus avoiding the risk of any serious charge on the rates during the initial stages of the undertaking. In their estimate Messrs. Mordey & Dawbarn have allowed for distributing cables aggregating about 4¼ miles. The estimated initial outlay is as follows:—Power station site, building and plant (including two petroleum engines and dynamos, each of 60 kw. capacity, one being spare, and a battery of accumulators), £5,427; distributing cables for private lighting, with 200 service connections, £4,918; distributing cables for street lighting (including assumed purchase of pillars and lanterns from the Gas Co.) £5,623; total £15,968. If the Board of Trade allowed overhead wires in the outlying portions of the district the capital outlay would be reduced. On the first year's working there would be a deficit of £345, assuming the sale of 20,000 units for private lighting and an income of £1,058 from street lighting (303 lamps), and in the second year there would be a profit of £181.

Sheffield.—The Tramways committee have decided to make a further trial with the latest method of Thermit rail joints. The cost of the joints is put at 29s. each.

Application is to be made for power to borrow £2,500 for purchasing motors to be let on hire. Extensions of mains are to be carried out at an estimated cost of £1,144.

South African Trade.—The British Trade Commissioner for South Africa (Mr. R. Sothern Holland) writes, regarding the information bureau which has been established at Cape Town, that considerable interest is being taken by manufacturers in the development of the bureau, and he asks that copies of catalogues, &c., may be furnished him for the purpose of filing.

Stafford.—The salary of the electrical engineer, Mr. R. E. Meade, has been increased by £25 a year.

Taunton.—The Council are about to advertise for a successor to Mr. E. B. Thornhill (borough electrical engineer), at a salary of £200 a year.

Tonbridge.—The Council have applied for sanction to a loan of £1,441 for extensions of the electricity undertaking.

Torquay.—The Council has granted a honorarium of 100 guineas to the Borough Surveyor for his services in connection with the erection of a new power station. A sum, equal to three months' salary, is to be given to the widow of the late electrical engineer (Mr. P. Storey), while Mr. Keenan is to be granted £25 for extra services rendered by him during the illness of Mr. Storey.

Victorian Institute of Electrical Engineers.—At the annual meeting of the Electrical Association of Victoria it was unanimously resolved that the title of the association be changed to the Victorian Institute of Electrical Engineers.

The Papers to be read during 1910 include the following: "New Safety Regulations Concerning the Production and Utilisation of Electricity," by J. D. Gillan; "Ball Bearings," by J. D. Wearn; "Consulting Engineers at Home and Abroad," by W. F. Marshall; "Radio-active Material," by T. C. Baddeley; "Arc Lighting," by H. G. Such; "The Electrification of Melbourne Cable Tramways," by G. S. Morrison; "Electro-Thermometry," by E. B. Brown; "Electricity Recording Meters," by W. H. Alabaster and N. A. Wheaton; "Lubricants," by F. A. McCarty.

In his presidential address Mr. A. H. Jackson referred to the progress made in connection with electric traction in the cities of the various States. The Melbourne tramways would probably be electrified with the suburban railway lines. The address also dealt with the progress in the manufacture of metal filament lamps, the utilisation of refuse, brown coal and water-power in Victoria in the generation of electricity.

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Wallasey.—A new tramway route, between Wheatland-lane and Wallasey Village (about 3½ miles of double track) was opened for traffic on Friday last.

Walsall.—On Monday the Corporation unanimously adopted a recommendation of the Electricity committee to put down additional generating plant at the electricity station, and to extend the mains to Birchills, Bescot and Bloxwich, at a toal cost of £23,225.

The committee also reported that they had considered an offer of a power company to supply the Corporation with electricity in bulk, but they were of opinion that such a course offered no advantage.

Mr. SLATER stated that the company's offer had commended itself to certain members of the Council who were not enamoured of municipal trading, as the company were prepared to supply the Council with current at ¾d. per unit. When the offer was scrutinised, however, it was found that a considerable loss of current occurred in the process of conversion, and the actual payment would be at the rate of about 0·94d. per unit. In addition, considerable capital outlay would have to be incurred to enable the current to be distributed, and when all the charges were met the committee calculated that the actual cost would be 1·77d. per unit. An important consideration was that if the Corporation took a supply in bulk from the company, practically the whole of their generating plant would become useless, which would entail a loss of about £37,500. That would have to be met by a call upon the ratepayers, and it was very probable the L.G. Board would insist on them making good the deficiency by three annual payments, which would mean an addition to the rates of no less than 1s. in the £. Dealing with the merits of their scheme he said that the Council were originally asked to sanction an outlay of £35,000, but as a result of a searching enquiry by a L.G.B. inspector the scheme was withdrawn for further consideration. The result had been that a proposal to build a new generating station had been abandoned and a saving of about £8,000 effected. With the new plant the committee would be in a position to supply current to manufacturers on more reasonable terms and on a system more suitable for manufacturing purposes. It was also proposed to lay mains into districts where there was a likelihood that manufacturers would find electric supply advantageous.

Wednesbury.—The L.G. Board have sanctioned a loan of £2,095 for extensions of the electricity undertaking.

West Ham.—The Thames Ironworks Co. have provisionally agreed to take the whole of their supply for power and lighting from the Corporation for a further period of three or five years.

The total income of the tramways undertaking for the year ended March 31 was £125,694, from which £3,111 is to be deducted in respect of receipts due to other authorities in connection with through running. Total expenditure was £87,561, less £1,188 for through running. The net profit (£5,737) is to be carried to reserve and renewals fund, which now amounts to £39,293.

Whitchurch.—The surveyor has been requested to collect information regarding electricity supply for the Lighting committee.

Whitehaven.—An inquiry was held here last week into the Council's application for sanction to borrow £5,293 for extensions of the electricity undertaking.

The TOWN CLERK said the loan was required for additional plant to meet the demand for electric light and for mains extensions. The Council was advised that the additional plant would enable them to reduce the cost of production. For plant £2,993 was required and £2,300 for main extensions.

The INSPECTOR (Mr. H. R. Hooper) observed that the works costs were considerably more than double what they ought to be. Their financial position was not half so bad as it appeared, and there was no reason why in a few years time they should not be in a fairly good position. He urged the necessity of improved and more reliable plant, and emphasised the necessity of pushing the undertaking.

Wimbledon.—The Council has received sanction to borrow £3,400 for mains, £1,600 for house services and £1,600 for meters.

Wireless Telegraph Note.—The Board of Trade has been approached by the Associated Chambers of Commerce urging the compulsory installation of wireless telegraphy on all passenger ships for oversea traffic. The Board has replied that, while they appreciate the importance of this question, in view of the large number of passenger vessels which have been and are being voluntarily fitted with wireless telegraph apparatus, they consider that compulsory legislation at the present moment would be premature.

Wolverhampton.—The Corporation have decided to put down water-softening apparatus at the electricity works, to renew the economisers, &c., at a cost of £1,450.

Worcester.—Mr. Parker has given notice that he will move at the next meeting of the Council that, in order to increase the use of electricity the Electricity Department be allowed to act as agents for manufacturers in the sale of heating and cooking apparatus and motors on commission (but not to undertake the sale of fittings or lamps, or the wiring of houses), on the distinct understanding that the Council are not to be liable for the price of the goods sold.

York.—An unopposed inquiry was held last week into an application for sanction to borrow £2,475 for the electricity undertaking.

The city electrical engineer (Mr. J. W. Hame) said that £1,100 was wanted for services, £800 for motors and £575 for meters.

The inspector (Mr. H. Ross Hooper) said it would be well to avoid borrowing for meters if they could. The loan for meters would only be allowed for five years. The undertaking was rather handicapped, and it would be to the advantage of everyone to stop borrowing those small sums.

Siemens Institute Annual Sports.—The annual sports of the Siemens Institute, Stafford, have come to be looked upon as one of the most important athletic gatherings in the Midlands. The grounds, the property of the firm, provide both a grass and cinder track. The fifth anniversary takes place on Saturday, Aug. 20, under M.C.A.A. laws and regulations. In addition to a full list of members' events, there are included in the programme the following open items: 10 miles walking handicap, 1 mile flat handicap, 1 mile cycle handicap, 3 miles cycle handicap, obstacle race and Boy Scouts' relay race (full dress). All athletes, especially those from other firms, will be very welcome, and can obtain further information from the general secretary (Mr. F. E. Read), Siemens Institute, Stafford.

Annual Outing.—The employés of Robertson Electric Lamps, Ltd.' had their annual outing on Saturday last at Margate. The party, consisting of the male and female employés at the Brook Green Works and their friends, numbered over 700, and were conveyed from Addison-road (from whence, by the way, you can get to anywhere) by special train direct to the famous Isle of Thanet holiday and health resort. The weather was heavy and dull during the morning, but fortunately brightened up in the afternoon. No fixed programme was arranged for the morning, the party spending their time in their own way. Lunch was served in one of the hotels on the Marine Parade, after which drives into the country in brakes engaged for the party formed not the least appreciated part of the day's enjoyment. The whole of the arrangements for the large party were well carried through, more particularly the facilities, for those who could not join the "special," to travel by ordinary train, and the management committee are to be congratulated on the complete success of their efforts. And Margate offers many attractions for a large party.

Electra House Flower Show.—The second annual show of the Electra House Rose and Sweet Pea Society (which is affiliated with the National Sweet Pea Society) was held in the large meeting hall of Electra House, Finsbury-pavement, London, on Tuesday, and, notwithstanding the vagaries of the weather this season, the exhibitors (who are all members of the staffs of the Associated Telegraph Companies) made a very attractive display.

126 exhibits were staged, compared with 43 last year. Roses were the chief sufferers from the weather, but, this notwithstanding, there were some fine examples amongst the exhibits. The chief honours in the rose classes were carried off by Messrs. Hale, Hardie, De Merrall, Hibberdine, E. A. Roberts and Lindford. In the sweet pea section there were some really charming blooms, and keen competition resulted. Capt. Pattison secured the two best prizes, but it was agreed that the chief honours rested with Dr. Curtis, whose exhibits were the subject of warm appreciation from the judge (Mr. W. A. Billey, J.P., F.R.H.S.). Messrs. Hardie and Hibberdine each obtained a first prize in the sweet pea section. Amongst hardy cut flowers Mr. H. C. Woodcock was first, and Mr. H. F. Porter came out first in violas, beside achieving considerable success in other sections. In the awards, the silver medal presented by the N.S.P. Society for the best bunch of sweet peas went to Dr. Curtis, Mr. Porter securing the same Society's certificate for second best. The "Electra" trophy for the member scoring the highest number of points went to Dr. Curtis with 54 points. Lady Denison-Pender presented the trophy and the Sweet Pea Society's medal and the certificate. The exhibition proved a complete success, and great credit is due to the secretary for the excellent arrangement of the exhibits. The President of the Society is Mr. J. C. Denison-Pender, and the visitors included Sir John Wolfe Barry, Sir John and Lady Denison-Pender, Sir James Pender, Sir Albert Cappel, Sir W. R. Brooke, Mr. J. G. Griffiths, Hon. A. G. Brodrick and Mr. T. W. Stratford-Andrews.

FOREIGN.

Argentina.—The "Review of the River Plate" says the National Government have sanctioned the expenditure by Santa Fé municipality of $39,285 (gold) in the erection and equipment of electricity works for lighting and power purposes in the port.

During the centenary celebrations at La Plata about 40,000 incandescent electric lamps were used for the illuminations.

Austria-Hungary.—A concession has been granted to the Aktiengesellschaft Triester Kleinbahnen (Trieste) for the construction of a light electric railway from Opcina to Sesana.

Bolivia.—A report from the Belgian Legation at La Paz states that there is every prospect that greater use will in future be made of

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the abundant waterfalls and rivers in Bolivia for the generation of electric power.

Canary Islands.—The old steam tramway between Las Palmas and Puerto de la Luz, 3½ miles in length, is being electrified by a Madrid company, who have bought the concession.

China.—Consul F. E. Wilkinson (Newchwang) writes that inquiries have convinced him that there is a demand in South Manchuria for electrical goods, as in most of the large towns electric light and telephone installations are either already in existence or are contemplated. In almost every case, however, contracts are in Japanese hands.

Acting Vice-Consul Paton states that a new engine, boiler and dynamo have been ordered from the U.K. for *Mukden* (Manchuria) electricity works. The lamps used by the company are of German make. The number of lamps connected to the *Dairen* electricity supply mains is 16,000. There is a supply of power of 1,500 kw., of which the electric tramway requires 400. The present plant is unable to meet the demands upon it, and is being increased by 2,000 kw. this year. The new plant consists of American engines and generators and British boilers, rotary converters and steam condensers. The Dairen tramway system was completed and opened in September last. There are 14 miles of track. Of the cars 40 came from the U.K. and 10 from Japan, the rails from the U.K., and the motors, wires and poles from Germany. An extension of 3½ miles may be made this year.

Constantinople.—It is reported that eight offers were received for the concession for the electric lighting of Constantinople and the suburbs from the following syndicates:—

Union Ottomane, consisting of the Deutsche Bank and the Constantinople tramway group, Fouquiau & Warnant (acting for a French group), "Westinghouse" group, Cie Francaise d' Eclairage Electrique, Swiss Electrical Synd., Giros & Louchard (representing a group of French and Swiss electricians), Ganz & Co., and Schneider & Cie.

After examination by a commission of the financial standing of the various tenderers, an exhibit of their schemes will be held at the Prefecture of the City during eight days, which the public may inspect. Subsequently a technical commission (appointed by the Minister of Public Works) will examine the schemes, and within one month will send in their report indicating the most favourable tender, and also which three schemes should receive the prize of £T250. The work of installation will have to be carried out within 18 months.

Costa Rica.—The report of Consul F. N. Fox says imports to Costa Rica during 1909 from the United Kingdom and the British colonies included electrical supplies £2,453 (increase £2,356 compared with 1908) and railway material £2,260 (increase £2,005). The Guacimal hydro-electric power plant of the Abangarez Goldfields is in course of erection and will be completed early in 1911. The Costa Rica Electric Light & Traction Co. have completed and opened an extension of the San José tramways to Guadalupe, and the hydro-electric power plant at El Brazil, 9 miles west of San José, which is eventually to develop 5,000 H.P., is under construction.

Exhibition.—It is announced that the international electric railway exhibition, which was to have been opened next month at St. Petersburg, is postponed until 28th (15th O.S.) April, 1911, in order to adapt it to the 75th anniversary of the Russian railways. The exhibition will remain open three months. Inquiries to the Committee of Organisation, St. Petersburg.

France.—Vice-Consul Beresford (Cherbourg) states that it has at last been decided to convert the steam tramways to electric traction. It is also proposed to extend the tramway from Querqueville to Landemer, which will prove a great boon in opening up a charming summer resort.

The report of Consul C. Clipperton, of Rouen, for 1909 states that the Cie. Centrale de Chemin de Fer et de Tramways have applied to the Prefecture at Rouen for sanction to build at Grand-Quevilly (a suburb of Rouen) a large electrical generating plant for supply of light and power to various towns and manufacturing centres within a radius of 20/25 miles.

Holland.—The Watergraafsmeer communal authorities have decided to borrow £2,917 for extensions of their electricity undertaking.

Iceland.—A company has been formed in Norway to utilise the water power of the Gullfoss and Sog Falls for the generation of electrical energy.

Italy.—The Minister of Posts and Telegraphs has brought forward a Bill for the construction of a large number of new telephone lines for intercommunication throughout the country, at an estimated cost of £29,600, of which £2,400 is to be set apart for apparatus and material for experiments in multiple telephony and in combined telephony and telegraphy.

The Public Works Department are about to spend £17,200 upon electric cranes for the new port on the river Tiber, near the Rome-Pisa railway line. (Only firms on the Government list are usually allowed to tender.)

The report of Consul Maclean (*Sicily*) for 1909 states that new iron and steel works will be erected at Palermo by the Soc. Anon. Ferri e Metalli during the present year.

The power required in the works will be 12,000 H.P., and all the accessory machinery will be driven by electric power. A Belgian company with £200,000 capital was formed in Brussels in August last to construct and work a tramway from Palermo to Mondello.

Consul-General Keene (*Genoa*) states that the electric tramways (which are owned by a company) ran 7,951,810 car-miles during 1909 and carried 61,152,935 passengers. The total receipts were £320,786 and the gross profits £108,829. There are 94 miles of tramways, and the companies employ 1,555 persons.

Consul Guattari (*Savona*) says the Italian State Railways Department have decided to extend the electrification of the Savona–San Guiseppe railway as far as Ceva, and that the total length of the electric line will be 28 miles.

A 30 years' concession for the construction and working of an electric tramway from Savona to Vado has been granted by the Consiglio Provinciale of Genoa to a local committee interested in the formation of a company, with a capital of about £32,000, to carry out the work. It is expected that the line will be completed by the end of 1911.

Vice-Consul E. Antione (*Turin*) states that tramways owned and worked by two companies represent a total length of about 65 miles.

Liberia (West Africa).—There is little to record of an electrical character from this independent negro Republic, and that little is chiefly of a negative character, but a few extracts from Vice-Consul M. Y. H. Park's report may be of interest as indicating the undeveloped condition of the country.

There are no local telegraph or telephone systems yet. Direct cable communication with Europe was established by German cable, via Teneriffe, on March 21, 1910. There are no railways, and all transport is done by native carriers. There are no roads, but the interior is intersected by numerous tracks, some of them barely a foot wide. Rubber is the principal industry, but it is as yet in its infancy. Scientific instruments, machinery and mining tools and "Faulkner's telephone, &c., materials" may be imported duty free.

Mozambique.—Consul Maugham states, in his report on the province of Mozambique for 1909, that Germany is the more successful competitor in the supply of machinery and electrical and telegraph material, owing to well undertaken local representation not enjoyed by most British manufacturers in those branches.

In regard to electrical apparatus and railway and telegraph material, Mr. Maugham is satisfied that the outlay of the various departments of the administration of the province for local use would repay a system of combined representation of manufacturers. At present there is no such thing as serious British competition, while Continental manufacturers are so keenly represented that the bulk of the orders is without difficulty obtained for them. The rule in inviting tenders is to invite a number of local agents to send in estimates, and very frequently an order is given at once, without formality, and, naturally, goes to the local business house whose representative can produce the goods at the shortest notice and at the same time give evidence of possessing an intelligent knowledge of the requirements of the moment. Mr. Maugham offers to furnish further information on the subject to British manufacturers. Imports at Lourenço Marques in 1908 included electric and telegraph material £1,543, compared with £1,320 in 1907 and £1,918 in 1906. Of this total Germany supplied £679 and the U.K. £647.

Peru.—The report of Consul-General L. J. Jerome for 1908-9 says the Peruvian Telephone Co. has spent £50,000 during the last two years in changing its service in Lima from overhead to underground, and that the common battery system has been adopted. The average subscription in Lima is £7. 10s. and the number of subscribers in the city is 1,600. The total telephone system connecting the various sections of the country may be taken at 3,000 miles.

The effect of the service of electric tramways running between Callao and Lima has proved very great. Mercantile houses which formerly maintained considerable branch establishments at Callao have removed to Lima. In the evenings the tramcars are crowded.

Acting Vice-Consul Rowlands at Mollendo says there is a general tendency to increase the use of electricity for power and lighting in Arequipa and in the mines. The Societe Electrique de Arequipa, which was formed about five years ago and is under Peruvian management, is working hard to secure an increased demand for electricity for public and domestic purposes. There has been a movement towards replacing the existing horse tramways at Arequipa by electric tramways, but, although a quantity of material arrived in January, 1909, work has not yet been commenced.

Portugal.—Vice-Consul P. dos Santos says the municipalities of Faro and Loulé are "sanctioning the construction on their own account of electric cars for passengers and goods," and "they are trying to furnish the two chief towns of Faro and Loulé with electric light."

Spain.—The following items of news are forwarded by the British Consuls in Spain:—

Consul Arthur Keyser (*Seville*) writes that electricity is being introduced to lighten labour on farms, more especially for the turning

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of the heavy wheels which draw the water supply from wells. The German electricity company continues to enjoy a monopoly of providing electric power for Seville, and has obtained control of the power from La Hidrö Electrica del Guadiaro. Imports at Seville in 1909 included dynamos 85 tons (British 3 tons) compared with 195 tons (British 2 tons) in 1908.

Vice-Consul W. J. Smith (*Algeciras*) writes that an English firm has set up a new electric lighting installation and competition is proving a great benefit to the town.

Vice-Consul R. E. Carr (*Cordoba*) states that serious efforts are being made to induce foreign capitalists to construct electric tramways, and the local authorities are making a broad street into the heart of the city to accommodate tramways.

Switzerland.—A concession has been granted to Messrs. Isler, Cathrein & Roemer for the construction and working of a narrow-gauge electric railway from Brigue via Riederalp and Eggishorn to the Aletsch Glacier, at an estimated cost of 3,850,000 fr. (£154,000). A concession has also been granted to Messrs. Baumgartner, Beusch, Bohl, Hardegger, Kuhn & Looser for a similar line from Buchs to Nesslau, the estimated cost of which is 5,100,000 fr. (£204,000).

Turkey.—The report of Consul H. E. Satow (Palestine) says the construction of an electric tramroad at Jaffa has been mooted, but nothing has been done so far to carry it out.

Consular Agent Knesevich states that at Gaza there is talk of granting a concession for an electric tramway from the eastern side of Gaza to the sea shore, and plans have been drawn up.

Consul Devey (Damascus) says the electrical plant in the Kadem workshop of the Hejaz Railway was installed in Jan., 1909, and repairs have been made to upwards of 20 engines, and about 200 wagons and carriages. The average monthly takings on the electric tramways were £980 (compared with £820 and £790 in 1908 and 1907 respectively). Some small extensions are about to be made, and the question of securing land for extensions to Muzzel Kassab and to Duma (6 miles north of Damascus) is under discussion. In Dec., 1909, the record receipts of £700 for electric lighting were reached. Nearly 1,300 houses are now lighted electrically, the average number of lamps being 10 per house. The power supply to the Hejaz workshops produces £1,280 per annum, and electric power for four or five other workshops has been applied for.

Vice-Consul E. C. D. Rawlins (Adana) says a concession is offered for electric tramways and the supply of electricity for lighting in Adana, and that similar schemes might be worked out for Tarsus and Mersina.

A company called the Popular Cartagena is being formed, with a capital of 500,000 pesetas (£18,500), for the erection of an electric power station of 450 kw. capacity for supply of continuous current for lighting and power in Cartagena.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Acton.—The district auditor (Mr. Sutherland Wilkinson) has reported to the Council on the accounts for the year ended March 31.

The report states that a great improvement has been made in the financial position of the electricity undertaking. The deficit on the net revenue account at March 31, 1909, was £4,943. 17s. 10d., which was met by a transfer from the district fund, while the deficit at March 31, 1910, was only £675. 1s. 2d. The improved result was accounted for (1) by a reduction in expenditure of some £1,492. chiefly in cost of generation and distribution, and (2) by an increase in income of £2,913. chiefly due to increased sales of current and to a charge being made for hire of meters not previouslay mde. The expenditure chargeable on net revenue account increased by £137.

Barnstaple.—The capital expended on the electricity department at March 31 was £32,185, an increase of £456.

Income from the sale of current was £4,157 and total receipts £4,412. Expenses were £3,000 and gross profit £1,412. After paying interest (£892), instalments of principal (£974), and interest on overdraft (£106), there was a deficit of £560 on the year. 236,382 units were sold (against 221,059 in 1908-9), including 157,142 to private consumers (against 126,887), and 79,240 for public lighting (against 94,172). There are 30 arc and 174 Osram lamps for public lighting, and the total maximum supply demanded was 248 kw.

Birkenhead.—The income of the Electricity department for the year ended March 31 was £21,410, including £20,459 from the sale of current.

Expenses were £8,927, and after paying interest (£4,343), sinking fund (£3,809), &c., and contributing £1,000 to relief of rates the balance (£2,963) was placed to renewals fund. The capital expended is £157,479, an increase of £6,789.

The income of the tramways department was £56,817, including £55,759 for traffic receipts. Working expenses were £33,757, and after allowing for bad debts., &c., the balance was £22,683. Interest on capital and on amount applied to redemption of debt, &c., absorbed £11,768, and sinking fund £9,317. The balance profit (including £780 returned for income tax over-paid) was £2,357. 6s. 11d., which has been placed to renewals fund. The capital expended is £366,419, an increase of £2,990 during the year.

Doncaster.—It was reported to the Corporation last week that the profit on the electricity department during the past year was £1,222, which has been carried to renewal fund; but on the tramways there was a deficit of £134. 14s. 10d., against £1,477 in 1908-9.

ELECTRICITY SUPPLY TABLES AND DATA.

This Valuable Set of Tables and Engineering Data relating to Electricity Supply and to Electric Traction on Railways and Tramways in the United Kingdom, the Colonies, and some important places abroad, is now ready, and can be obtained complete in handy book form, price 6s. 6d. post free, or on very hard paper for rough or constant use, price 8s. 6d. post free. A complete Index is included.

Ilford.—During the year ended March 31 the profit on the electricity department was £1,562, against a deficit of £300 in 1908-9.

The improved result is mainly due to a saving in coal effected by the use of chain grate stokers.

The chairman of the Electricity committee (Coun. PHILPOT), said the gross profit amounted to £12,865, or over 8 per cent. on the capital. They had now a reserve fund of £8,000, and they had repaid £30,000 of the capital. The private lighting demand had gone up by 93,000 units in spite of the extended use of metal filament lamps, and they had also supplied 26,000 more units for power. There had been a falling off in the current supplied to the tramways.

Maidstone.—The accounts of the electricity supply department for the year ended March 31 show total income £13,281, against £13,308 in 1908-9.

The working expenses were £7,625 (against £7,364), and the gross profit was £5,657 (against £5,944). After paying interest (£2,313) and sinking fund (£3,294) there was a deficit of £102. There was an increase in the receipts from the sale of current for public and private lighting, and the drop in the total receipts was due to decreased consumption by the light railways department. The capital expended is now £81,010, an increase of £2,231 during the year.

Sheffield.—During the year ended March 25 the municipal tramways department carried 78,620,798 passengers and 7,459,911 car-miles were run. The income was £299,154 and the gross profit £117,637. After meeting all charges the net balance on the year's working was £39,252, of which £12,192 is to be applied to relief of rates, £21,605 placed to renewals fund, £2,000 to special purposes fund and £3,453 to accumulated surplus fund. The capital expenditure is £1,203,326.

At the meeting of the Corporation on Wednesday, Ald. Bennett in submitting the accounts of the electricity department for the past year, said that it was a matter for regret that more satisfactory accounts could not be presented, but there was not the slightest doubt that the adoption of metal filament lamps had been a set-back which they, along with every other electricity undertaking in the kingdom, had suffered from. If it had not been for the loss on that account, there would have been a profit of £4,808, instead of a deficiency of over £2,000. They hoped that next year there would be no loss. In reply to questions, he said that if they had not had to meet the interest and sinking fund on unproductive capital, there would have been a profit of £9,060 or £10,060. The lighting and heating accounts had not been kept separately, but the matter should have attention.

Southport.—The borough electrical engineer (Mr. A. S. Black) reports that there was a net profit of £1,475 on the past year's working of the electricity department, despite the decrease of £3,100 in revenue owing to the extended use of metal filament lamps.

Wimbledon.—The accounts of the electricity department for the year ended March were presented to the Council last week by the chairman of the Electric Light committee (Councillor D. Stuart).

Mr. Stuart said it was gratifying to again have a surplus, which amounted to £1,986. 3s. 5d., against £2,510 in 1908-9. Receipts from sale of current by meter were £23,499, and the total income was £28,920. Total expenses were £12,827 (1·392d. per unit, against 1·502d.) and gross profit was £16,093. After paying interest (£5,943), sinking fund (£742) and instalments of principal (£7,422), the net profit was £1,986 odd. 3,052,933 units were generated and 2,211,933 sold; 1,709,513 units were sold to private consumers (at an average price of 3·291d. per unit) and 502,420 supplied to public lamps (at 2·519d.). There are 91 arcs and 1,136 metal filament lamps for public lighting. Consumers numbered 3,252 in Wimbledon and 625 in Merton, and the total lamps connected were equivalent to 183,028 35-watt (including 3,567 for street lighting). The total maximum supply demanded was 1,344 kw. The existing debt was £168,999. 18s. 4d., an increase of £1,524. The gross earnings were 17·1 per cent., and the net earnings 9·52 per cent. The reserve fund stood at 7·56 per cent., and if the £2,024 standing to suspense account is added it would be 8·77 per cent. of the existing debt. Generating expenses were going down, but there was a slight increase in the cost of distribution. The total cost of generation was 0·830d. per unit, against 1·035d.

Wolverhampton.—At the Corporation meeting on Monday the chairman of the Electricity committee (Mr. Gough Allen) moved the adoption of the annual report and accounts.

He said that it was by far the best report they had issued. They had made a gross profit of £20,059, against £15,891 in 1909; and the net profit was £8,297, against £3,411. Twelve months ago the committee reported that the undertaking had been adversely affected by trade depression and the use of metal filament lamps. There had since been great improvement, and the large increase in the current sold seemed to show that trade depression was passing away. The cost of generating had gone down, and the undertaking was in a sounder position than ever.

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TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is NOW READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

BELFAST Harbour Commissioners invite tenders for supply and delivery into the Alexandra Graving Dock engine house, Belfast, of of 3¼ miles of 7/18 paper insulated lead-covered h.t. cable, served with jute, and suitable for 3,000 volt continuous current; also ½ mile 7/18 rubber insulated cable to sample. Specification, forms of tender, &c., from the harbour engineer, Mr. W. Redfern Kelly, M.Inst.C.E. Tenders to the secretary, Mr. W. A. Currie, Harbour Office, Belfast, by 27th inst. See also an advertisement.

BELFAST Harbour Commissioners also invite tenders for the construction, delivery and erection at their electric light station of an independent surface condensing plant, with oil separator, &c. Specification and form of tender, &c., from the harbour engineer, Mr. W. Redfern Kelly, M.I.C.E., and tenders addressed to the secretary, Mr. W. A. Currie, Harbour Office, Belfast, must be in by Wednesday, July 27. See also an advertisement.

Tenders are invited up to Sept. 7 for supply of battery material and glassware to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Official Secretary in Great Britain of the Commonwealth of Australia, 72, Victoria-street, London, S.W. See also an advertisement.

LONDON County Council want tenders by 11 a.m. July 26, for supply of 4,800 steel tyres for driving wheels, and 1,600 steel tyres for pony wheels for tramcars. Forms of tender, &c., from the Chief Officer.

LONDON County Council also want tenders by 11 a.m., July 19 for the roadwork and platelaying required for the construction of tramways in Battersea Bridge-road and Beaufort-street, Chelsea, on the underground conduit system, and for paving work. Specifications, &c., from the Chief Engineer, Spring-gardens, S.W.

WALTHAMSTOW Council want tenders by noon July 22 for supply and fixing of a railway weighbridge at the siding adjoining the electricity works, also for car bodies, trucks and electrical and magnetic brake equipments for six double-deck roof-covered tramcars. Specifications, &c., from the Electrical and Tramways Engineer, Priory-avenue, Walthamstow.

WHITEHAVEN Corporation want tenders by July 16 for supply of a 35 kw. single field d.c. automatic converter to convert from 420 to 220 volts d.c., and two sprinkler type mechanical stokers for Babcock boilers. Specifications from Borough Electrical Engineer.

LEITH Corporation require tenders by noon July 25 for supply and erection of 500 kw. mixed pressure turbine and d.-c. generator, condensing plant and cooling tower. Specification, &c., from the Burgh Electrical Engineer.

MORECAMBE Corporation want tenders by July 28 for feeder pillars and arc lamp carbons. Specifications, &c., from the Borough Electrical Engineer.

CHELMSFORD Education committee want tenders by Aug. 31 for electric light wiring at Trinity-road school. Forms, &c., from Mr. W. H. Pertwee, London-road, Chelmsford.

SALFORD Corporation require tenders by noon July 18 for a borehole pumping plant for their electricity works, Pendleton. Particulars from the Borough Electrical Engineer.

MANCHESTER Tramways committee want tenders by 10 a.m. July 19 for supply of h.d. copper trolley wire. Specification, &c., from Mr. J. M. McElroy, 55, Piccadilly, Manchester.

BARNET Guardians want tenders by July 26 for supply of dynamos, motors, battery, wiring work, &c. Tender forms from the clerk.

Tenders are invited up to Aug. 2 for the supply and delivery of 1,820 private letter box fronts to the Postmaster-General's Department in the States of VICTORIA, QUEENSLAND, SOUTH AUSTRALIA and WESTERN AUSTRALIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to July 27 for supply of a pneumatic tube service to the Postmaster-General's Department at ADELAIDE (S. Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, MELBOURNE (Victoria), will receive tenders until 3 p.m. Aug. 30 for supply of electrical sundries, insulators, wire and sulphate of magnesia. Local representation necessary. Further particulars from 72, Victoria-street, London, S.W.

The TRANSVAAL Administration of Posts and Telegraphs require tenders for supply of 2 miles of 64-conductor switchboard cable. Further information from 72, Victoria-street, London, S.W. Tenders to Pretoria by July 27.

Firms having agents in Canada whom they can instruct by cable will be in a position to tender for portion of a contract for the supply and erection of an electrically-driven centrifugal pump and automatic starter required by the City Corporation of Moose Jaw, Saskatchewan, Canada. Plans and specifications are to be seen at the office of the City Engineer, Moose Jaw, and tenders are to be sent by 8 p.m. on July 18 to Mr. W. F. Heal, the city clerk. Plans and specifications are also to be seen at 62, Church-street, Toronto; B33, Board of Trade-buildings, Montreal; and Room 424, Building Exchange-building, Winnipeg. The other portion of this contract (B) is for supply and erection of a complete air lift system.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The Société Nationale des Chemins de fer Vicinaux, BRUSSELS, want tenders by July 20 for underground cables, and by July 27 for the equipment of a transformer station.

The Ministerio de Fomento, MADRID, will receive tenders until July 30 for the construction of an electric (or steam) strategic railway from Requena to Alcaráz, via Casas Ibáñez and Albacete. The contract is open to Spanish firms only.

TENDERS RECEIVED AND ACCEPTED.

L.C.C. are recommended by the Fire Brigade committee to accept the following tenders for wiring and fitting fire brigade stations for electric lighting:—

G. Weston & Sons (lowest), for Woolwich station £185. (Five tenders received; highest £270. Chief engineer's estimate £170.)

W. J. Fryer & Co. (lowest), for Kingsland station, £164. 18s. 6d. (Five tenders; highest £221. Chief engineer's estimate £182.)

Tilley Bros. (lowest), for Lewisham station, £160. 18s. (Five tenders; highest £234. Chief engineer's estimate £189.)

West Bromwich Corporation are recommended to accept the tender of the British Insulated & Helsby Cables for supply and laying of paper insulated lead-covered feeder and pilot cables.

The following firms also tendered: Callender's Cable & Construction Co., Lahmeyer Electrical Co., W. T. Henley's Telegraph Works Co., W. T. Glover & Co., Western Electric Co., Siemens Bros. & Co. and Johnson & Phillips.

Stretford Council has accepted the following tenders:—

British Westinghouse Co., three-wire booster (£859) and safety attachment (£51); Worthington Pump Co., condensing plant (£1,180); James Hodgkinson, one pair coking stokers (£132. 10s.); E. Green & Sons, additional economiser tubes (£110).

Sheffield Council has accepted the following tenders:—

J. Spencer (Ltd.), 26 No. 1 tramway poles with fittings, £6. 11s. 6d. each, and seven No. 2 ditto, without fittings, £8. 14s. 3d.; Hadfield's Steel Foundry Co., points and crossings for Shoreham street tramway depot, £954. 10s.

Erith Council have accepted the tender of Fraser & Chalmers for a 1,000 kw. Rateau impulse turbo-alternator at £4,305, and for a Lancashire boiler at £1,200; and that of the British Westinghouse

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Co. for a stator at £264. There were seven tenders for the turbo-alternator and twelve for the boiler.

Stockport Council have accepted the following tenders :—

Consolidated Electric Works & Appliances Co., 30, tramcar destinator screens; Mitchell's Emery Wheel Co., grinding machine; Ferranti Limited, meters.

Hammersmith (London) Electricity committee have accepted, after testing the specimen prepayment meters submitted by seven firms and considering the Engineer's report upon them, the tender of Ferranti Ltd. at £3 for all sizes and for 110 and 220 volt circuit.

Nine firms submitted tenders to the Council for the supply of one 200 kw. transformer :—

British Electric Transformer Co. (*accepted*), £159. Spagnoletti (Ltd.) £168, General Electric Co. £171, British Thomson-Houston Co. £175, British Westinghouse Co. £190, Johnson & Phillips £190, Lahmeyer Electric Co. (oil cooled, not to specification) £172. 10s., Union Electric Co. £118. 10s., Ferranti (Ltd.) £128. 10s.

Messrs. Jens Orten-Böving & Co. have received an order from the British North American Pulp Co. for six Francis turbines of 1,600 H.P. each, and 1,800 H.P. for overload for their Ocean Falls plant in British Columbia.

Herne Bay Council have accepted the following tenders :—

Harpin & Co., 900 ft. second hand strip cable for suspending incandescent lamps, 7d. per foot; Siemens Bros. & Co., cable for lighting pier pavilion, £60; Union Electric Co., 10 flame lamps, £60.

Bolton Council have accepted the tender of the Brockie-Pell Arc Lamp for the supply of single-phase transformers for 12 months in sizes up to 15 k.v.a.

Bolton Corporation have also placed an order with Ed. Bennis & Co. for two sprinkler stokers and self-cleaning compressed air furnaces for a new Lancashire boiler at their electricity works.

Croydon Corporation have accepted the tender of Johnson & Phillips for wiring the extensions at the Borough Hospital for £349. There were 26 tenders, varying from that of the accepted to £785.

Walsall Council has accepted the tender of Herbert Morris & Bastert for an overhead hand-power travelling crane and gantrey at Darwall-street sub-station.

Spennymoor Council have accepted the tender of the Northern Counties Electricity Supply Co. for lighting 302 public lamps at 52s. each per annum.

Tonbridge Council have accepted the tender of Galloways (Ltd.) for a Lancashire boiler, economiser extensions and pipework at £574.

The Bastian Meter Co. have secured the contract for the supply of meters at Bolton,

Brandon Council have accepted the tender of F. Reid, Ferens & Co. for electric lamps and fittings for the hospital and lodge at £33.

Canterbury Council have accepted the tender of G. E. Dashwood for electrical work for six months.

Brighton Council have accepted the tender of Siemens Bros. & Co. for 250 yds. of 1 sq. in. cable at £416.

Belfast Guardians have accepted the tender of Wm. Dowling for erection of a power house at £1,200.

Coalville Council have accepted the tender of Blythe Bros. for the erection of electric fire bells at £66.

Browett, Lindley & Co. recently received an order for two 325 B.H.P. engines for the Mount Elliott Copper Mines, Queensland.

Reading Council have accepted the tender of W. H. Baughan & Co. for wiring work at the library at £84.

Launceston (Tasmania) Tramways committee have accepted the tender of the Brush Co. for tramcar trucks, £1,122; the Australian General Electric Co. for motor equipments, £3,206, and Hadfield's Steel Foundry Co. for points and crossings, £2,120.

Electrically-driven Motor Vans.—At the meeting of London County Council on Tuesday the Fire Brigade committee submitted a report on the tenders received for the supply of three electrically-driven motor (escape) vans. The tenders were :—

Electric Vehicle Co., £825 each; Merryweather & Sons, £947. 16s. 8d. each (including £91 for Tudor batteries and £280 for spares); "Cedes" Electric Traction Co., £1,044. 18s. 11d. each (including £380. 9s. 3d. for spares); H. Simonis & Co., £1,046 each; Crompton & Co., £1,048 each (including £66 for Tudor batteries).

Up to the present, the report states, no electrically-driven appliances have been purchased for use by the London Fire Brigade, although such appliances have for some time past been in successful operation in the principal cities of Europe. The first cost of electrically-driven was somewhat higher than that of petrol-driven appliances, but the wear and tear were less, and this was to be expected if new batteries were provided from time to time. The chassis and motors should last much longer than those of petrol-driven appliances. Having carefully considered the tenders, the committee were of opinion that the interests of the Council would be best served by the acceptance of the tender of "Cedes" Electric Traction Co., owing to the special type of vehicle offered by the company and the wide experience possessed by it in that class of work. The company proposed to sublet the supply of the chassis and wheel motors to the Austrian Daimler Motor Co., and the supply of the batteries to the Tudor Accumulator Co. The committee recommended that three vehicles be obtained from the "Cedes" Co., but consideration of the matter was postponed.

Ship Lighting.—Messrs. W. C. Martin & Co., Glasgow, have received orders from Messrs. Swan, Hunter & Wigham Richardson to supply and fit electrical installations for the two new steamers building for the Cunard Company. The installations will have a large number of lights and motors, and will be fitted similar to the equipment supplied by the same firm for the "Mauretania." Messrs. Martin & Co. have also contracted to supply the electric installation for the new Anchor Liner "Cameronia," and several of the new steamers recently ordered for the British India Steam Navigation Co., two steamers for the Harrison Line of Liverpool, a large passenger liner for Italian owners and other vessels, making a total of electrical plant in hand of over 2,000 H.P.

"Nesdrum" Boilers and the Admiralty.—Messrs. Richardsons, Westgarth & Co., Middlesbrough, have received intimation from the Admiralty that their name has been placed on the Admiralty list of approved water-tube boiler makers.

Commonwealth Tenders.—The Public Works Department (N.S.W.) have accepted the tender of Standard-Waygood (Ltd.) for supply of an electric goods lift for the General Post Office, Sydney.

The Postmaster-General's Department (N.S.W.) have accepted the tenders of the Western Electric Co. for supply and erection at Sydney telephone exchange of two incoming junction sections of common battery switchboard at £2,050; F. Zwicker & Co. for 26,000 porcelain insulators at 3½d. each; and Jas. Paton & Co. for 4,000 porcelain insulators at 3d. each.

BUSINESS NOTICES.

Owing to the rapid increase in their business as lift manufacturers, Messrs. Smith, Major & Stevens have found their Battersea premises inadequate, and are taking new works, which are now in course of erection at Northamptan.

It is hoped that the new works, which will be equipped on up-to-date principles, will be ready for occupation in the autumn. A portion of the staff and a number of workmen will be retained in London, where they and their predecessors have been established for 140 years.

Mr. C. M. Ferguson notifies us that the agreement under which Messrs. J. Gordon & Co., 81, Knightrider-street, London, E.C., acted as selling agents for his sectional steam superheater has expired, and arrangements have been made for all future business connected with the superheater to be carried on at 11, Queen Victoria-street, E.C., under Mr. Ferguson's personal supervision.

Messrs. W. F. Dennis & Co. have been appointed sole agents in the United Kingdom for the Karlsbader Kaolin Industrie Gesellschaft (of Merkelsgrün Austria), manufacturers of telephone, telegraph and high tension porcelain insulators and other porcelain goods for electrical purposes.

Messrs. A. Hirst & Son (Ltd.), makers of the Crescent coal cutters and coal drills have settled down in their newly erected works in Meadow-lane, Dewsbury. The premises are constructed to allow of considerable expansion when necessary.

The change had to be made on account of the increasing demand for the firm's specialities, and at present there are numerous orders in hand for Crescent coal cutters.

Sale by Auction.—Messrs. Horne & Co., 35, Old Queen-street, Westminster, S.W., will sell by public auction at the Royal Arsenal, Woolwich, on Thursday, July 21, at 11 a.m., unserviceable and obsolete stores, including quantities of iron and steel, brass, copper, gunmetal, lead and antimony, zinc, &c., some cable drums, lathes and machine tools, electric light fittings, telegraph and electrical instruments, &c. The flots may be viewed at the Royal Arsenal, Woolwich, on Monday, Tuesday and Wednesday, previous to and on morning of sale. Catalogues from the War Office, Whitehall; the Ordnance Office, Tower; and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Plant for Sale.—Two gas driven alternator sets of 250 kw. each are advertised for sale.

Agent Wanted.—A German firm manufacturing watertight electrical appliances requires an agent to sell goods on commission.

Patents Development.—The owners of British Patent No. 23,378 (1907), for "Improvements in the manufacture of electric resistances," desire to sell their patent rights or to grant licences. Applications to Messrs. Day, Davies & Hunt, 321, High Holborn, London, W.C.

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The owner of Patent No. 16,729/1906, relating to "Dynamo electric generators," desires to arrange by licence or otherwise for manufacture and for the commercial development of the patent. Address Messrs. Herbt. Haddan & Co., 31 and 32, Bedford-street, Strand, London, W.C.

The proprietor of letters patent No. 28,542/1907, relating to "Electrical induction furnaces," desires to enter into arrangements for exploiting same. Communications to Messrs. J. E. Evans-Jackson & Co., 19 and 20, Holborn Viaduct, London, E.C.

The proprietors of patent No. 5,203/1907, relating to "Brush carriers of electric machines," and No. 17,698/1907, relating to "Commutators and brush carriers of electric machines," desire to enter into negotiations for the grant of licences to manufacture under royalty. Applications to Messrs. Carpmael & Co., 24, Southampton-buildings, London, W.C.

"Green Book of London Society."—From Messrs. J. Whitaker & Sons, London, we have to acknowledge receipt of a copy of this book, which forms a directory of the court, society and political and official world of the United Kingdom. Besides giving a quantity of information on matters affecting literature, art, science, sport, the drama and many other subjects, those who have occasion to refer to works of reference of this nature will find the book so well arranged that the information it gives can be turned up with facility. There is included a list of foreign titles borne by British subjects—in fact, much of the information here available is that which is omitted from many other books of a like nature. The published price of the "Green Book" is 5s. net.

The Holiday Season.—Our readers are reminded that the Great Central Railway (Publicity Dept., 216, Marylebone-road, London, N.W.) have ready their A B C Programme of holiday arrangements, which can be obtained free by request. Much information concerning the numerous holiday and rest resorts on the company's extensive system, for which specially low fares are quoted, are set out in the programme.

CATALOGUES, &c.

"Freezor" Electric Fans.—We have received from the General Electric Co. a copy of their new catalogue dealing with this seasonable subject. It is prefaced by a general description of these apparatus which is followed by details, electrical, mechanical and financial, of the various types of desk, ceiling and exhaust fans, as well as of that very useful apparatus the "Bandy" punkah. The fans are made in all sizes and are also designed to suit all pockets.

Models.—Two catalogues are to hand from Messrs. Bassett, Lowke (Ltd.), which deal with model aeroplanes and small aeroplane motors, and model yachts and electrically operated model torpedo boats, warships, Atlantic liners, &c. Some of the latter are most elaborate and are listed as high as £45. All the models are to scale.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during June, 1910, and (*b*) during the current year from Jan. 1 to June 30, with the increases or decreases compared with the corresponding periods of 1909:—

Electrical machinery (*a*) £46,350 (increase £4,806), (*b*) £279,432 (increase £46,665); telegraph and telephone cables (*a*) £11,168 (decrease £10,437), (*b*) £72,447 (increase £9,772); telegraph and telephone apparatus (*a*) £14,424 (decrease £3,310), (*b*) £89,102 (decrease £3,753); other electrical wires and cables, rubber insulated (*a*) £30,323 (increase £23,113), (*b*) £99,315 (increase £70,279); with other insulations (*a*) £1,738 (decrease £6,693), (*b*) £14,575 (decrease £39,233); carbons (*a*) £10,173 (decrease £693), (*b*) £68,033 (increase £2,346); glow lamps (*a*) £41,755 (increase £9,751), (*b*) £269,565 (increase £52,327); arc lamps and electric searchlights (*a*) £252 (decrease £29), (*b*) £1,801 (decrease £7,025); parts of arc lamps and searchlights (other than carbons) £5,395 (decrease £86), (*b*) £35,643 (increase £7,916); primary and secondary batteries (*a*) £3,233 (decrease £97), (*b*) £20,571 (decrease £3,962). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (*a*) £128,295 (increase £11,726), (*b*) £720,827 (increase £86,289).

Exports.—The exports of electrical machinery, material, &c. (*a*) during June, 1910, and (*b*) during the current year from Jan. 1 to June 30, and the increases and decreases compared with the corresponding periods of 1909, are as follows:—

Electrical machinery (*a*) £150,710 (increase £22,863), (*b*) £719,423 (increase £11,762); telegraph and telephone cables (*a*) £29,773 (increase £18,624), (*b*) £900,094 (increase £701,666); telegraph and telephone apparatus (*a*) £16,104 (decrease £12,813), (*b*) £81,967 (decrease £41,527); other electrical wires and cables, rubber insulated (*a*) £26,983 (increase £10,366), (*b*) £199,363 (increase £72,586); with other insulations (*a*) £30,987 (decrease £11,857), (*b*) £144,496 (decrease £3,143); carbons (*a*) £1,249 (increase £410), (*b*) £8,662 (increase £4,462); glow lamps (*a*) £11,322 (increase £5,701), (*b*) £62,817 (increase £27,597); arc lamps and searchlights (*a*) £1,654 (increase £554), (*b*) £9,420 (decrease £125); parts of arc lamps and searchlights (other than carbons) (*a*) £1,028 (decrease £122), (*b*) £6,739 (decrease £1,711); primary and secondary batteries (*a*) £11,849 (increase £1,552), (*b*) £53,166 (decrease £3,332). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire (*a*) £168,166 (increase £21,623), (*b*) £1,692,794 (increase £807,158).

BANKRUPTCIES, LIQUIDATIONS, &c.

Frank Sheppard, electrician, 4, Haslett-road, Kensington, London, has been adjudicated bankrupt.

A receiving order has been made against Ernest Albt. Thorn, electrical engineer, &c., 22, Mossbury-road, Clapham Junction, London, S.W. First meeting of creditors July 21 at 132, York-road, London, S.E. Public examination Aug. 4 at the Court House, Wandsworth, S.W.

An application for the discharge of Geo. K. Spivey, formerly electrical engineer, Market-place, Wakefield, and Bradford-road, Batley Carr, will be heard on Aug. 9 at the Court House, Wakefield.

A dividend is to be paid to creditors of Alan McAlpin (trading as McAlpin & Co.), electrical engineer and contractor, 44, Cank-street, Leicester, and Cumbergate, Peterborough. Claims to Mr. L. V. Wykes, 24, Friar-lane, Leicester, by July 25.

A meeting will be held on Aug. 9 at Broad-street House, London, E.C., to receive an account of the winding up of the Britannia Electric Lamp Works (1905), Ltd.

The Alliance Electrical Co. (Ltd.) is being wound up voluntarily for purposes of reconstruction. Mr. H. Marriott is liquidator. The liquidation is solely for the purpose of a re-arrangement of capital, and all creditors will be paid in the ordinary course at the company's offices, 23, Grafton-street, London, W.

Deed of Assignment.—A dividend is to be paid under a deed of assignment executed by W. P. Theerman (trading as W. P. Theerman & Co.), electrical engineer, 263, Oxford-street, Manchester. Claims to Mr. G. E. Cor field, Balfour House, Finsbury-pavement, London, E.C., or to Mr. P. Gregson, 44, Brown-street, Manchester, by July 16.

COMPANIES' MEETINGS AND REPORTS.

Electric Construction Co. (Ltd.)

The seventeenth annual general meeting of this company was held yesterday (Thursday), under the presidency of Mr. Walter S. B. McLaren, M.P.

The SECRETARY (Mr. David Willock) having read the notice convening the meeting and the auditors' report,

The CHAIRMAN said: Gentlemen, the accounts we submitto-day, while not so favourable as we anticipated at this time last year, are not unsatisfactory having regard to the conditions which have prevailed. I told you at our last general meeting that volume of business was the crux of the situation, and I am sorry to say that our hopes of maintaining the larger output of last year have not been fulfilled. However, there are not wanting many indications that the effect of the introduction of metal filament lamps is now passing away, and this, coupled with the general improvement in trade, justifies us in expecting a greater demand for electrical machinery during the present year. While, however, we have suffered like the rest of the trade from a diminution in the volume of business, I feel confident that we have not suffered more proportionately than our competitors, and, judging from our balance-sheet as compared with theirs, I should say we have suffered less. It is a pleasure to be able to assure you that the work we turn out gives complete satisfaction to our customers, many of whom come to us over and over again, because they know that our work is absolutely reliable. We send machinery to all parts of the world, and have orders from Government Departments under the most severe specifications and tests that can be devised. We do not shrink from these, for we can hold our own against any other manufacturer, both in excellence of design and perfection of work. You will readily realise that any diminution in orders is at once reflected in the manufacturing profit, because, as I have told you more than once, we cannot look for any further reduction of importance in our standing charges. These continue, however, to receive the closest attention, and a moderate saving was effected during the past year. While sympathising very fully with the ordinary shareholders in the absence of a dividend (and those of us on this side of the table are among the greatest sufferers), I must congratulate them upon the strong financial position of the Company, and I think you will recognise that to have strengthened our position as we have done during such troublous times proves the wisdom of the policy pursued by the Board. We have now no loans of any kind, our realisable assets are many times greater than our current liabilities, and we are in a position to pay prompt cash for all that we buy, and so command the best prices and discounts which prevail. Moreover, we have been able to redeem on favourable terms £40,000 of our second mortgage debenture stock, and an annual sum of £1,800, hitherto paid as interest,

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will become available for dividends. The stock will be kept alive for the purpose of re-issue, if required, but the board do not at present foresee any necessity for this. Out of the surplus arising from the redemption we have placed £10,000 to the credit of general reserve fund, and we have a further substantial amount at the credit of a suspense account. In 1908 an action was brought against the company by a German firm for alleged infringement of a patent. The board obtained the advice of one or two leading experts, and were advised that there was no subject matter for a patent in the plaintiffs' specification. Being desirous, however, of avoiding litigation, the board entered into negotiations with the plaintiffs for a licence, but as reasonable terms could not be obtained the action was allowed to proceed. After extraordinary delay on the part of the plaintiffs, the case came before Mr. Justice Parker at the end of January of this year, and judgment, with costs, was given in favour of this company on all the issues. An appeal, however, has been lodged by the plaintiffs, which it is expected will be heard towards the end of this month. Pending the conclusion of this litigation, the board have, as I have already said, credited a sum to a suspense account. The items in the profit and loss account being all strictly comparable with those of last year, it is not necessray for me to go through them in detail. I may draw your attention, however, to a saving in debenture interest of £825 (which, as I have told you, will be increased to £1,800 this year) and also to a reduction of £597 in general charges. I now move the adoption of the report and accounts.

The MANAGING DIRECTOR (Mr. James Gray) briefly seconded the resolution, which was carried unanimously.

The retiring directors (Sir James Pender, Bart., and Mr. Philip Edward Beacheroft) and the retiring auditors were then re elected, and the proceedings terminated.

Chili Telephone Co. (Ltd.)

The twenty-first ordinary general meeting was held yesterday (Thursday) under the presidency of Mr. GEORGE KEITH.

The SECRETARY (Mr. Edmund Petley) having read the notice convening the meeting and the auditor's report,

The CHAIRMAN said: The report shows that our business in Chili has continued its general progress during the past year. The improvement shown has been due principally to the general commercial activity in the large centres of Santiago and Valparaiso, where the bulk of our business lies, and in a lesser degree to the year's good harvest and the general prosperity in the Central and Southern agricultural districts, while in the districts of Iquique and Serena little or no progress has been made in consequence of the depressed state of the nitrate and mining industries. The value of the currency, in which our revenue is collected, remained throughout the year low and practically steady at an average rate of exchange of 10½d. As a result the currency revenue in Chili shows an increase for the year of 8 per cent., while the working expenditure comes out at 70 per cent. of the revenue or 2 per cent. more than it did last year. The increase in the rate of working expenses was due to the higher price of materials and to the advancing cost of living, which involved an increase in salaries and wages. The income in Chili, when converted into sterling, shows an increase for the year of £2,713, and interest on investments and the year's cash balances is £453 more. Taking transfer fees into account, the gross income amounts to £41,685, or £3,171 more than last year. The total charge against income amounts to £3,415, or an increase of £228. The balance profit was £38,270, which, after providing the interim dividend of 3 per cent. paid in January and £20,504 for the reserve, enables the Board to recommend the payment of the usual final dividend of 5 per cent., making with the interim payment a total distribution for the year of 8 per cent., free of income tax, the same as last year, and to increase the balance carried forward by £166 to £2,987. After providing £737 for difference of exchange and £2,766 for replacements of plant, the reserve account shows an increase of £17,000, as against which £7,179 has been expended on new additions to the property and carried to the capital expenditure account. The stock account shows an increase of £4,286, due principally to the requirements of the underground work in course of construction, and investments are £5,956 more, bringing up the total cash reserve invested in outside securities to £35,774. As regards their property in Chili, besides the ordinary extensions, due to joining up new subscribers, 19 new offices have been opened during the year in the small towns of the Central and Southern districts. The trunk lines have also been increased and extended to meet the growing requirements for inter-town communication. The work of placing the wires underground in Santiago has been very much advanced during the year. Some of the cables have been laid and the subscribers' lines transferred to them, which is gradually relieving the congestion of overhead wires in the centre of the city. They were considering the advisability of capitalising a part of the reserve which has been invested in the business and of distributing it to the shareholders as fully paid-up shares, in order to put the issued capital of the Company more on a par with the value of the property. I now move the adoption of the report and accounts.

Mr. FRANK W. JONES seconded the motion, which, after a brief discussion, was carried, several shareholders congratulating the board upon the strong position of the Company, the proposal of the directors to divide a portion of the reserve amongst the shareholders being warmly approved.

A resolution approving the final dividend of 5s. per share was then carried unanimously, and, the retiring director and auditors having been re-elected, a hearty vote of thanks to the chairman and directors, proposed by Sir Alexander Henderson, brought the proceedings to a close.

CHILIAN ELECTRIC TRAMWAY & LIGHT CO. (LTD.)—At the meeting last week (Mr. L. Breitmeyer said the company's operations in Santiago during the past year showed a substantial improvement compared with 1908. The tramways had carried 7,000,000 more passengers and the receipts had improved by £54,000. The lighting and power department showed an increased profit of £34,000. They had placed £32,000 to reserve after paying the dividend on the 5 per cent. preference stock.

CITY & SOUTH LONDON RAILWAY CO.—The directors' report for half-year ended June 30, states that the receipts amounted to £88,832. 7s. 2d., and the cost of working was £42,212. 13s. 11d., leaving £46,619. 13s. 3d. profit. Inclusive of balance brought forward, net revenue account shows an aggregate of £47,331. 19s. 4d. After making provision for debenture stock interest, rent charge, and transfering £1,500 to renewal fund, a balance remains of £31,185. 12s. 5d., out of which the directors recommend the full dividend of 5 per cent. per annum on the preference stocks, and a dividend at the rate of 1¼ per cent. per annum upon the consolidated ordinary stock for the half-year, leaving £1,634. 9s. 5d. to be carried forward. The number of passengers (exclusive of season ticket holders) carried was 11,497,140 (compared with 11,227,179 in the corresponding half of 1909. The increasing competition of the tramways remains unabated, and the electrifying of the Brighton Co.'s line from London Bridge to Victoria has not tended to increase the City & South London Co.'s receipts between London Bridge and Clapham. The admissions to the Anglo-Japanese Exhibition at Shepherd's Bush have been adversely affected by current events, and the interchange traffic between the tubes and other railways has consequently fallen below expectations. The directors regret, therefore, that owing to these causes, to increases in wages bill and in coal and other stores, and to some exceptional repairs, they have no alternative but to recommend a diminished rate of dividend on the ordinary stock. The erection of the emergency staircase at the Brighton Co.'s end of the subway at London Bridge is completed. The Bill promoted by the Metropolitan Railway Co. to authorise the construction of a low level subway at Moorgate-street to connect the stations of the Metropolitan, G.N. and City and City & South London Railways has passed through committee in both Houses of Parliament. The contract for the construction of the high level subway between the Bank station of the Company and that of the Central London has been placed, and the work will proceed without delay.

GENERAL ELECTRIC CO. (LTD.)—For the year ended March 31 the net trading profits and income from investments, &c., were £95,461. 12s. 6d.; deducting depreciation and debenture interest (£27,057. 8s. 10d.) the balance was £68,404. 3s. 8d. Preference dividend absorbed £12,500, leaving £55,904. 3s. 8d. The directors recommend that this be appropriated as follows: Provision for managing directors' and employés' bonus £5,590. 8s. 4d., dividend on ordinary shares of 5 per cent. for the year £19,395, reserve £22,000, leaving £8,918. 15s. 4d. to be carried forward. This brings the reserve to £158,488. The result of the trading for the year has been satisfactory, and the factories at Witton, Salford, Birmingham and London have been well employed. The switchgear arc lamp and small motor departments have been removed from Salford to Witton. Peel Works, Salford, are now entirely devoted to the manufacture of telephone and telegraph apparatus. The directors have thought it desirable to carry on these departments as a subsidiary company, and part of the assets of these works now appears under investments.

GRINDELL-MATTHEWS WIRELESS TELEPHONE SYND. (LTD.)—At the statutory meeting on Wednesday, Sir J. Clifton Robinson said, having regard to the exceptional character of the undertaking, and with a view to conserving the interests of the shareholders, it had not been deemed desirable to issue more shares than were necessary for providing funds for their immediate requirements. Negotiations were in progress for the sale of certain foreign rights of the syndicate. Representatives of several public bodies had come over from the Continent, to have the telephone explained to them, and he had been informed that their experts had expressed themselves satisfied with the demonstration. The board proposed to make it a condition of the acquisition of any of the company's foreign rights that the purchaser should subscribe for a holding in the present syndicate, thus maintaining an interest in it. They had just completed their works on the Bristol Channel.

MADRAS ELECTRIC SUPPLY CORPN. (LTD.)—In the report for 1909 the board express regret at the death of Sir Ralph D. R. Moor, one of the directors. The construction contract is now practically completed, although the plant has not yet been officially taken over from the contractors. Tramway supply commenced on Jan. 12 last. The board have placed the whole of the working costs up to Dec. 31 last (less receipts) to a suspense account, which will be written off by instalments out of future profits. On April 3, when the supply from the permanent plant commenced, the equivalent of 5,200 8 c.p. lamps was connected to the mains, and at Dec. 31 the equivalent number was 29,057, with 4,562 more awaiting connection, and at the date of the last report (June 16) the number had increased to 40,981, with 5,105 awaiting connection. The tramway demand is equivalent to 16,666 lamps. The licences applied for by the company to enable a supply of electricity to be made to the Port Trust at Madras and to Fort St. George have been granted, and supply has commenced. Applications are frequently being received for extensions of mains for supply of current to new consumers. In order to meet the outlays required for such extensions, to pay off the loan from the bankers and to provide an adequate working capital, the directors propose to make an issue of £100,000 of 6 per cent. first mortgage debentures, which will shortly be offered to the shareholders.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—The directors' report for the year ended March 31 states that the gross receipts in the River

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Plate were £336,422. 4s. 3d., against £287,064. 11s. 8d. for 1908-9. Deducting expenses in Argentina and London, debenture interest, preference dividend and interim ordinary dividend, and adding interest, &c., there remains £95,557. 18s. 3d., added to £5,138. 1s. 5d. brought forward, making £100,695. 19s. 8d. After making the proposed appropriations, the directors recommend a final ordinary dividend of 5 per cent., making 8 per cent. for the year (tax free), and that the balance of £4,633. 9s. 8d. be carried forward. The steady and satisfactory increase of the business necessitates the introduction of further capital, and it is therefore proposed forthwith to make a fresh issue of 40,000 ordinary shares to the ordinary shareholders at par. For this purpose an increase in the nominal capital will be required, and a resolution to that effect will be submitted at the forthcoming meeting.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

G. W. CLARKE & CO. (LIVERPOOL) (LTD.) (110,604)—Reg. July 5 capital £1,000 in £1 shares (250 deferred), to take over as a going concern the branch business of electrical engineers carried on by the Walsall Electrical Co. in Liverpool, to acquire from G. W. Clarke the benefit of certain licences and inventions relating to appliances and devices for indicating and recording temperature and otherwise. Private company. First directors, E. B. Barron (chairman) and G. W. Clarke.

CONTRAFLO CONDENSER & KINETIC AIR PUMP CO. (LTD.)—Reg. June 18, capital £80,000 in £1 shares, to carry on the business of inventors, dealers in patents, engineers, founders, mechanicians, &c., to acquire invention relating to the manufacture, production, treatment, application and use of boilers, engines, condensing, pumping and cooling plant, &c., and to adopt certain agreements, &c. First directors D. B. Morrison and C. W. Milne. Reg. office, 3 and 5, Crown Court, Old Broad-street, London, E.C.

DRILLS (LTD.) (110,603)—Reg. July 5, capital 2,000 in £1 shares, to carry on the business of engineers, founders, manufacturers and patentees of electric and other drills, and to adopt an agreement between R. S. Crawford and J. Scott for the acquisition of electric mining drill and other electrically driven percussive tools, instruments, &c., and patents in respect thereof. Private company. First directors, R. S. Crawford and J. Scott (provisional).

ELECTRIC FURNACES & SMELTERS (LTD.) (110,576)—Reg. July 4, capital £5,000 in £1 shares, to carry on the business of smelters, refiners, treaters and amalgamators of ores and other metalliferous and mineral substances, manufacturers of electrical or other furnaces for smelting, &c. Private company. Reg. office, 110, Cannon-street, London, E.C.

ENGINEERS' STANDARDISED PUBLICATIONS ASSOCIATION (LTD.) (110,652)—Reg. July 7, capital £2,000 in £1 shares, to take over the business of agents for the classification and distribution of manufacturers' trade circulars and price lists of engineering requisites carried on by F. Samuel and J. D. B. Innes as the Engineers' Standardised Publications Association. Private company. First directors, F. Samuel, J. D. B. Innes and J. C. Butler.

HIGH-SPEED PRINTING TELEGRAPH CO. (LTD.) (110,630)—Reg. July 6, capital £2,000 in £1 shares, to carry on the business indicated by the title. Private company. R. Warner, of 10, Walbrook, London, E.C., is the first secretary.

NOKES & CANNON (LTD.) (110,444.)—Reg. June 28, capital £2,000 in £1 shares, to carry on the business of engineers, founders, smiths, machinists, &c., and to adopt an agreement with E. S. Nokes and J. J. Cannon for the acquisition of the business of mechanical and electrical engineers formerly carried on by E. S. Nokes at Leicester as Clerk & Nokes. Private company. First directors, E. S. Nokes and J. J. Cannon. Reg. office, Canning-street, Leicester.

PHŒNIX ILLUMINATED ADVERTISING SYND. (LTD.) (110,420.)—Reg. June 27, capital £2,000 in £1 shares, to carry on the business of advertisers, advertising agents, manufacturers of advertising appliances, suppliers of electricity, &c. Private company.

THOMAS BRITTAN (LTD.) (110,549.)—Reg. July 1, capital £500 in £1 shares, to take over the business of telegraph, telephone and electrical instrument manufacturers and telegraph engineers carried on by W. T. Brittan and T. E. Want as Thomas Brittan. Private company. First directors, W. T. Brittan, T. E. Want and E. W. Cairns. Reg. office, 34, Risinghill-street, Pentonville, London, N.

WITTON, JAMES (LTD.)—(110,693)—Reg. July 8, capital £6,000 in £1 shares (2,000 preference), to carry on the business of manufacturers of and dealers in electrical driving equipments for printing, textile and paper-making machinery, electric blowers, flexible couplings, &c., and to adopt agreements with the General Electric Co. and H. V. James. Private company. First directors, H. V. James, A. H. Railing and A. I. S. Baron. Reg. office, 71, Queen Victoria-street, London, E.C.

STATUTORY RETURNS.

CHISLEHURST ELECTRIC SUPPLY CO. (LTD.)—In return to May 2 capital is £15,000 in £5 shares. All shares taken up and paid for in full. Mortgages and charges, £10,000.

DOWSING RADIANT HEAT CO. (LTD.)—According to return dated Nov. 5 capital is £12,000 in £1 shares. All shares taken up. £1 per share called up on 6,970, 5s. per share on 5, and nil on 25. £6,971. 5s. paid. 5,000 shares considered as fully paid. Mortgages and charges, £9,971 debenture stock.

ELECTRIC SIGN & GENERAL ADVERTISING CO. (LTD.)—Return to March 30 gives capital as £5,000 in £1 shares. 2,000 shares taken up. £1,000 paid. £1,000 considered as paid. Mortgages and charges, nil.

GUILDFORD ELECTRICITY SUPPLY CO. (LTD.)—According to return to April 13 capital is £55,000 in 25,000 preference shares of £1 each and 6,000 ordinary shares of £5 each. 15,976 preference and 2,802 ordinary shares taken up. £29,988 paid, including £2 on two ordinary shares forfeited. Mortgages and charges, £25,000. (165 preference shares have been allotted for cash since date of above return.)

METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)—In return to March 22 capital is £1,500,000 in 200,000 ordinary and 100,000 preference shares of £5 each. 200,000 ordinary and 76,121 preference shares taken up. £5 per share called up on 195,936 ordinary and 76,121 preference. £1,360,285 paid. Mortgages and charges, £483,000.

A. REYROLLE & CO. (LTD.)—Return to April 5 gives capital as £40,000 in £1 shares (20,000 preference). 17,500 ordinary and 19,019 preference shares taken up. £1 per share called up on 10,500 ordinary and 19,019 preference. £29,519 paid. £7,000 considered as paid on 7,000 ordinary. Mortgages and charges, £14,400.

MORTGAGES AND CHARGES.

MORRIS & LISTER (LTD.)—Particulars of £3,000 debentures, created by resolutions of June 2 and 21, 1910, filed pursuant to sec. 93 (3) of Companies (Consolidation) Act, 1908, whole amount being now issued. Property charged, company's undertaking and property, including uncalled capital. No trustees.

SUNBEAM LAMP CO. (LTD.)—Issue on June 30 of £6,250 debentures, part of a series of which particulars have already been filed.

TELEGRAPH & TELEPHONE INSTRUMENTS (LTD.)—Particulars of £600 debentures, created June 20, have been filed; amount of present issue £500. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

RECEIVERSHIP.

MAXIM ELECTRICAL CO. (LTD.)—Notice of appointment of H. J. Morland, of 3, Frederick's-place, Old Jewry, E.C., as receiver, on June 4, under powers contained in indentures dated March 9, April 2 and Oct. 29, 1908, has been filed.

CITY NOTES.

MEMORANDA (July 14).—Bank rate 3 per cent. (since June 9, 1910). Price of silver, 25d. per oz. Consols 81⅛—82⅛ for money; 82—82⅛ for account. Consols Pay Day, Aug. 4; Stock and Shares Continuation Days, July 26 and Aug. 10; Ticket Days, July 27 and Aug. 11; Pay Days, July 28 and Aug. 12; Mining Shares Carry Over Day, July 25.

PRICES OF METALS (London).—*Copper*, cash, 53¾; three months, 54. *Lead*, English, 12⅞—13⅛; foreign, 12⅜. *Spelter*, 22⅜. *Tin*, English, 147—149; foreign cash, 148⅜; three months, 149⅞. *Iron*, Cleveland, cash, 48/9½, three months, 49/7.

BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared the usual interim dividends upon the 4½ per cent. preference and the 6 per cent. second preference shares (less tax) for the half-year to June 30, and also an interim dividend on the ordinary shares at the rate of 5 per cent. per annum (less tax) for the same period.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares of 6s. per share, less tax.

DIRECT UNITED STATES CABLE CO. (LTD.)—The Board has resolved to recommend a final dividend of 4s. per share, together with a bonus of 2s. per share (both tax free), such dividend and bonus to be payable on and after the 30th inst., and making, with the three interim dividends already paid, a total distribution of 4½ per cent. for the year ended June 30, after placing £5,000 to reserve and carrying forward about £4,783. The transfer books will be closed from the 12th to the 26th inst. inclusive.

PARA ELECTRIC RAILWAYS & LIGHTING CO. (LTD.)—The directors announce a dividend on the ordinary shares at the rate of 8 per cent. for the half-year ended May 31. The reconstruction of the old mule tramways and certain improvements to the lighting system were completed in 1908 by the contractors, Messrs. J. G. White & Co., of London, and in 1909 the company purchased a majority of the shares in the other electric supply company in Para. The gross receipts for 1909 were £225,917 (against £205,311 in 1908); the operating expenses £120,310 (against £152,637); and the surplus was £60,590 (against £16,214). The first half of the current year shows cabled net earnings of £62,360, representing an increase over a similar period in 1909 of £18,253.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed July 27 a special settling day in, and have granted a quotation to 30,000 £1 fully paid vendors' preferred ordinary and 90,000 £1 fully paid vendors' deferred ordinary shares of the *National Telewriter Co. (Ltd.)* The committee have also ordered £1,000,000 4½ per cent. first and general mortgage 30-year bonds (issued in Amsterdam) of the *New York Telephone Co.*

TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)—The transfer books will be closed from 11th to 19th inst., inclusive, preparatory to payment of an interim dividend of 12s. per share.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	July 1	226	— 2	26	5,690	+ 108
Anglo-Argentine	„ 8	46,132	+ 7,031	27	1,194,139	+ 134,903
Ayr Corporation	„ 9	419	+ 43	8	2,567	+ 105
Baker St. & Waterloo Ry.	„ 9	3,450	+ 85	1	3,450	+ 85
Barnsley	„ 1	157	— 1	26	4,433	+ 141
Barrow	„ 1	325	+ 74	26	6,493	+ 876
Bath Electric Trams, Ltd.	„ 6	842	— 19	27	20,722	+ 1,423
Birmingham Corporation	„ 9	6,753	— 2,345	14	96,381	— 1,246
Birmingham & Midland	June 24	869	+ 40	25	20,775	+ 415
Blackburn Corporation	July 6	1,012	— 118	‡15	16,011	— 918
Blackpool and Fleetwood	..	..	..	..	..	..
Bolton Corporation	„ 10	2,504	+ 158	15	34,274	— 827
Bombay	June 10	2,624	+ 195	23	62,994	+ 4,370
Bournemouth Corporation	July 6	2,037	+ 444	14	23,227	— 4
Bradford Corporation	„ 9	5,239	+ 274	15	73,252	+ 1,480
Brighton Corporation	„ 10	1,025	+ 59	§14	13,399	— 445
Bristol Trams & Carriage	„ 8	6,203	+ 233	1	6,203	+ 233
Burnley Corporation	„ 9	1,221	— 38	1	1,221	— 38
Burton Corporation	„ 10	279	+ 3	14	3,824	— 40
Bury Corporation	„ 10	1,254	+ 56	§14	17,173	— 498
Calcutta Tramways Co.	„ 9	₹52,172	— ₹644	1	₹52,172	— ₹644
Camborne-Redruth	„ 9	156	+ 32	27	3,285	— 119
Cardiff Corporation	„ 2	2,273	+ 47	14	29,670	+ 246
Cavehill	„ 1	94	— 8	26	2,172	+ 173
Central London Railway	„ 9	6,026	+ 418	1	6,026	+ 418
Charing C., Euston & H'stead	„ 9	3,710	— 280	1	3,710	— 280
Chatham & Dist. Lt. Rys.	„ 7	822	+ 38	27	21,851	+ 1,095
City & South London Rly.	„ 10	3,125	— 66	1	3,125	— 66
City of Birmingham	„ 1	2,901	— 16	26	74,091	+ 3,382
Colchester Corporation	..	..	..	..	..	..
Cork Electric Trams Co.	„ 7	531	— 92	27	12,780	+ 1,653
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	„ 1	411	+ 99	26	10,717	+ 1,326
Dover Corporation	„ 2	218	+ 11	13	2,708	— 2
Dublin & Lucan Railway	„ 8	163	— 17	1	163	— 17
Dublin United	„ 8	5,631	— 18	1	5,681	— 18
Dudley-Stourbridge	„ 1	812	+ 26	26	19,407	— 596
Dundee Corporation	„ 6	1,235	+ 21	§7	9,129	+ 168
East Ham Council	„ 9	1,050	+ 6	¶14	14,909	+ 334
Exeter Corporation	„ 8	341	+ 4	14	4,513	— 671
Gateshead & Dist. Trams	„ 1	981	+ 43	26	25,258	— 233
Glasgow Corporation	„ 9	17,857	+ 1,138	6	104,843	+ 7,705
Glossop Trams	„ 9	116	— 7	27	3,012	— 151
Gloucester Corpn.	„ 6	294	— 8	1	294	— 8
Gravesend-Northfleet	„ 1	218	+ 1	26	5,140	+ 112
Great Northern & City Rly.	„ 9	1,351	+ 15	1	135	+ 15
Gt. Northern, Piccadilly, &c.	„ 9	5,900	+ 225	§1	5,900	+ 225
Greenock & Port Glasgow	„ 1	723	— 24	25	15,527	+ 2,074
Hartlepool Tramways	„ 1	230	+ 21	26	5,900	+ 288
Hastings Elec. Trams Co.	„ 7	1,175	— 90	1	1,175	— 90
Hong Kong	„ 9	$9,153	+ $965	1	$9,153	+ $965
Huddersfield Corpn.	„ 9	1,733	+ 129	14	25,109	+ 1,088
Hull Corporation	„ 9	2,738	+ 142	14	38,405	+ 2,404
Ilford District Council	„ 9	571	+ 27	14	7,681	+ 310
Ilkeston District Council	„ 6	131	— 10	14	1,781	— 92
Ipswich Corporation	„ 9	443	+ 11	14	5,776	+ 160
Isle of Thanet Co.	„ 9	1,126	+ 141	¶39	16,170	+ 629
Jarrow	„ 1	123	— 1	26	3,104	+ 190
Keighley Corporation	„ 7	165	— 14	14	2,499	+ 59
Kidderminster & District	„ 1	117	— 8	26	2,539	+ 76
Kilmarnock Corporation	..	..	..	..	..	..
Lanarkshire Trams Co.	„ 7	1,405	— 138	27	37,087	+ 3,920
Lancashire United	„ 6	1,339	— 784	27	34,584	— 533
Leamington	„ 1	210	— 11	26	4,036	— 103
Leeds Corporation	„ 9	7,020	— 270	14	101,046	+ 2,916
Leicester Corporation	„ 9	2,317	+ 71	1	2,317	+ 71
Leith Corporation	„ 9	709	+ 1	8	5,112	+ 188
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	„ 2	11,675	+ 376	26	287,068	+ 11,364
Liverpool Overhead Rly.	„ 10	1,457	+ 14	2	2,871	— 111
Llandudno&ColwynBayRy.	..	..	..	..	..	..
London County Council	June 25	43,207	+ 3,378	¶12	519,424	+ 74,634
London United	July 9	6,500	— 488	27	166,971	+ 9,520
Lowestoft	„ 9	203	— 3	41	6,352	+ 231
Maidstone Corporation	..	..	..	..	..	..
Manchester Corporation	„ 9	16,271	— 1,124	14	222,098	+ 3,289
Mersey Railway	„ 9	1,833	— 60	1	1,833	— 60
Merthyr	„ 1	235	+ 17	26	5,213	— 203
Metropolitan Dist. Railway	„ 9	11,221	+ 830	1	11,221	+ 830
Metropolitan Elec. Trams	„ 1	7,550	+ 1,257	26	183,333	+ 35,733
Middleton	„ 1	330	— 24	26	7,947	— 543
Nelson Corporation	„ 9	144	+ 4	§14	2,039	+ 2
Newcastle-on-Tyne Corp.	„ 9	3,795	+ 85	¶14	57,332	— 490
Newport (Mon.)	„ 9	704	+ 28	15	10,256	+ 341
Northampton Corporation	„ 8	501	— 5	§14	6,994	+ 3
Oldham, Ashton & Hyde	„ 1	563	..	25	14,187	— 62
Oldham Corporation	„ 10	1,905	+ 85	15	28,511	— 1,010
Perth (N.B.) Corporation	„ 6	177	+ 15	§7	1,272	+ 85
Perth (W.A.) Elec. Trams	„ 8	1,439	+ 174	27	41,744	+ 3,180
Peterborough	„ 1	123	+ 4	25	2,786	— 9
Portsmouth Corporation	„ 9	2,211	— 16	14	28,842	— 1,121
Potteries	„ 1	1,842	— 5	26	45,214	— 427
Preston Corporation	„ 6	727	— 52	14	10,240	— 293
Rotherham Corporation	„ 7	616	+ 121	14	8,629	+ 65
Rothesay	„ 1	291	— 87	25	3,230	— 30
Salford Corporation	„ 11	4,974	— 100	†15	63,471	+ 83
Sheerness	„ 1	54	+ 8	26	1,174	— 25
Sheffield Corporation	„ 10	6,076	+ 577	¶15	91,576	+ 5,215
Singapore Trams	„ 9	$10,224	+ $646	1	$10,224	+ $ 646
South Metropolitan	„ 1	833	+ 19	26	23,675	+ 1,260
South Staffs	„ 1	832	+ 19	26	21,322	+ 36
Southend Corporation	„ 6	683	+ 108	14	7,525	+ 817
Southport Tramways	„ 1	341	— 66	25	7,127	+ 217
Stalyb'dge, Hyde, &c., Jt. Bd.	„ 9	742	— 5	¶14	10,203	— 1,062
Sunderland Corporation	„ 10	1,178	— 26	15	16,426	— 357
Sunderland District	„ 6	454	— 19	35	14,188	— 1,896
Swansea Trams	„ 1	1,155	+ 149	26	25,870	+ 3,050
Swindon Corporation	„ 6	123	+ 1	1	123	+ 1
Taunton	„ 1	43	+ 2	25	1,055	+ 116
Tynemouth and District	„ 1	319	— 1	26	5,407	+ 584
Tyneside Trams Co.	„ 6	379	— 82	1	379	— 82
Wallasey District Council	„ 9	1,027	— 36	§14	13,275	— 458
Walsall Corporation	„ 9	529	+ 20	27	14,324	+ 685
Warrington Corporation	..	..	..	..	..	..
West Ham Corporation	June 30	2,510	+ 241	13	32,196	+ 173
Weston-super-Mare	July 1	215	— 1	26	2,211	— 21
Wolverhampton Co.	„ 1	454	+ 54	26	10,762	+ 200
Wolverhampton Corpn.	„ 6	1,255	+ 473	14	13,132	+ 1,997
Worcester	„ 1	310	— 9	26	6,876	+ 172
Wrexham	„ 1	92	— 6	26	2,475	+ 20
Yorkshire W.R. Trams	„ 10	1,219	+ 79	28	34,195	..
Yorkshire Woollen District	„ 1	944	+ 40	26	25,063	+ 2,279

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed., July 13	Rate per cent. Yielded.	Dividend Due.	Business Week to July 13 High-est.	Business Week to July 13 Low-est.
		Electricity Supply.		£ s. d.			
10	6/0	Boarnemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9½	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼—10⅝	5 13 0	Feb, Aug	..	..
St.	4½%	†Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	102½	102
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼—7⅝	6 9 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7 —7½	4 13 6	Mar, Sept	7⅛	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¼—4	6 5 0	Feb, Aug	3⅜	3⅛
5	2/3	Do. 4½ per Cent. Pref.	4¼—4⅜	4 17 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	96 —98	4 1 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101¼—103½	4 7 0	..	102	..
5	2/3	†Do. City Undertaking 4½% Cum. Pref.	3⅜—4⅛	5 9 3	Jan, July	3⅜	..
5	2/6	Chelsea Electric Supply Ord.	3½—4⅛	5 4 6	March	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11¼—11⅞	5 19 0	Feb, Aug	11⅞	11⅝
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼—12⅛	4 16 0	Jan, July	12⅛	11⅞
St.	5%	†Do. 5 per Cent. Deb. Stock (red.)	119 —123	4 1 6	June, Dec	..	..
St.	4½%	†Do. 4½ per Cent. 2nd Deb. Stock (red.)	99½—102½	4 7 6	Jan, July	102	101
5	..	County of Durham Elec. P. D. Ord.	1⅛—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2⅛—3⅛	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7⅛—8	6 0 0	Feb, Aug	7⅞	7½
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅛—11⅛	5 6 6	Mar, Sept	10⅜	10⅛
St.	4½%	†Do. 4½ per Cent. Deb Stock (red.)	103½—105½	4 4 6	Jan, July	105⅛	..
St.	4½%	Do. Second Deb. Stock	99 —102	4 9 0	May, Nov	100⅛	100
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4⅜	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7¼	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	5¼—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94⅛—95⅛	4 3 6	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 —100	4 0 0	April, Oct	..	..
St.	3½%	Kent Elec. Power Co.	83 —87	5 3 6	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅛—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5 —5½	5 14 0	Mar, Sept	5⅜	5⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	92	..
5	2/6	Metropolitan Electric Sup. Ord.	3⅛—3⅞	6 9 0	April, Oct	..	..
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4 —4⅛	5 0 0	Jan, July	4⅛	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock 1st Mort.	102 —105	4 5 0	June, Dec	104⅛	..
St.	3½%	†Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	†Midland Elec. Corp. for P. D. 1st Mort. Deb.	95 —97	4 12 6	June, Dec	..	..
5	4/0	Newcastle Elec. Supply Ord.	3¾—4⅛	4 11 6	Feb, Aug	..	..
5	5%	Do. 5 per cent. non Cum. Pref.	4¼—4½	5 2 6	Feb, Aug	..	..
100	4½%	†Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	100 —102	4 18 0	..	..	..
10	6/0	†Notting Hill Electric Ord.	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅛—8½	5 9 6	Feb, Aug	8⅛	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7⅛	4 15 0	Feb, Aug	7⅛	..
St.	3½%	†Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3⅛	6 11 0	April	..	..
St.	5%	†Do 5 % 1st Mort. Stock (red.)	99 —102	4 18 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	½—⅝	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	½—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	2⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8⅜—8⅝	5 12 6	Mar, Sept	8⅝	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	96 —98	4 2 0	Jan, July	97½	96½
1	..	Bath Elec. Trams Pref. Ord.	¾—⅞	..	April	..	..
1	0/6	†Do. 5 per Cent. Cum. Pref.	⅞—1⅛	6 12 9	Jan, July	..	..
St.	4½%	†Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	†B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	80⅞	80½
10	6%	Bristol Tramways & Carriage Ord.	6¾—7	8 11 6	Feb, Aug	..	..
10	4%	†Dc. Cum. Pref. (fully paid)	7¼—7⅜	5 3 0	..	..	..
St.	4%	†Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¾ —1⅛	..	June, Dec	¾	¾
10	..	Do. 6 per Cent. Cum. Pref.	2¼—3	10 0 0	Feb, Aug	3	2⅞
St.	5%	Do. 5 per Cent. Perpetual Debs	88 —92	5 8 6	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 —73	6 3 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	66 —68	4 9 0	Feb, Aug	66	65½
St.	4%	Do. 4 per Cent. Pref. Stock	86 —83	4 11 0	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.	101 —103	3 17 6	Jan, July	..	..
St.	4%	†Charing X, Euston & Hmpstd Per. Deb Stk.	93 —95	4 5 0	Jan, July	94½	93½
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	29½—30½	3 15 0	Feb, Aug	31½	29½
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 —101	3 19 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	Gt. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	93 —95	4 5 0	Jan, July	94½	..
5	..	Hastings & District Elec. Trams, 6% C. P.	¼ —1½	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	†Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅝—1⅛	4 14 0	Mar, Sept.	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	64 —69	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10⅛	5 18 9	Feb, Aug	..	..
St.	5%	†Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	†Do. 4 per Cent. 1st Mort. Deb. Stock	67 —71	5 12 6	Jan, July	69½	67½
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	¾—⅞	..	..	⅞	..
1	..	Do. Deferred	⅛—¼	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—½	5 0 0	Feb, Aug	½	⅜
St.	4½%	†Do. 4½ per Cent. Deb. Stock	96 —99	4 11 0	Jan, July	99	93
St.	1%	Metropolitan Railway Consolidated	40 —40½	2 9 6	Feb, Aug	40⅜	40
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	67½	66½
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90⅛	89½
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	86½	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	87½	86½
St.	3½%	Do. 3½ per Cent. Debenture Stock	92 —94	3 14 6	Jan, July	..	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption. †Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shre	Last Divi-dend	NAME.	Price Wed. July 13	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to July 13 Highest	Lowest
		Electric Railways and Tramways—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	91 —93	3 15 0	Jan, July	92½	
St.	..	Metropolitan District Railway Ord.	21½—22	..	Feb, Aug	21¾	21½
St.	..	Do. Extension Pref. (5 per Cent.)	68 —70	..	Feb, Aug	..	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 6	Feb, Aug	72½	72⅜
St.	3%	†Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	..	..
St.	4%	†Do. 4 per Cent. Midland Rent-charge	99 —102	3 18 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	..	..
St.	6%	†Do. 6 per Cent. Perp. Deb. Stock	140 —142	4 4 6	Jan, July	141½	..
St.	4%	†Do. 4 per Cent. Ditto	94 —96	4 3 6	Jan, July	95¼	..
1	4½d.	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—⅝	..	..	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoup5	35 —37	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds	101½—102½	4 17 6	..	102½	102⅛
..	4½%	Do. 4½% Bonds Ex coup. 5	86 —88	5 2 0	..	87½	87
..	4%	Do. 4 per Cent. 1st Power Ho. Dbs. ..	98 —100	4 0 0	..	99¼	99
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—¾	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	..	..	..	..
St.	4½	†Do. 4½ per Cent. 1st Debs.	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	†Ancho Cable Co. 4½ % Deb. Stock	99½—101½	4 8 6	..	..	..
1	..	Aron Electricity Meter Ord.	½—⅝	..	..	..	..
1	1/9⅗	†Do. 6% Cum. Pf. .... xd and arrears	23/32—27/32	6 16 3	April, Oct	..	..
1	3/2⅗	Babcock & Wilcox Ord.	5½—5¾	5 8 0	April, Oct	5⅝	5 9/16
1	0/7⅕	Do. Pref.	1 7/16—1 9/16	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7	7 3 0	July, Feb	6⅝	..
5	3/0	Do. 6 per Cent. Pref.	5¾—6¼	4 16 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.)..	101 —104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	5/16—9/16	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	99 —101	5 19 0	..	100¼	100
St.	4%	†Do. 4 per Cent. Mort. Deb. Stock	59 —61	3 5 6	Jan, July	59¼	58
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	†Do. Perpetual 2nd Deb. Stock	23 —27	16 12 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9½—10¼	6 8 0	Jan, July	9¾	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	4⅞—5¼	4 15 0	Jan, July	4⅞	..
St.	4½%	†Do. 4½ per Cent. 1st Mort Debs. (red.)..	100½—102½	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.	2⅝—2⅞	5 8 9	May, Nov	2 11/16	2 21/32
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	106 —109	4 3 6	Feb. Aug	..	..
..	0/7⅕	Chadburn's (Ship) Telegraph Ord.	1 1/16—1 3/16	5 19 0	March ..	..	..
1	0/7⅕	Consolidated Electrical Co.	⅜—½	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.	13/16—15/16	5 12 9	April, Oct	13/16	..
1	0/7⅕	Do. 6 per cent. Cum. Pref.	27/32—31/32	6 8 0	April, Oct	..	..
3	3/0	*Crompton & Co (Nos. 1 to 85,000)	¼—¾	15 0 0	Jan, July	..	..
100	5%	†Do. 5 per Cent. 1st Mort. Debs. (red.)..	84 —87	5 15 0	Jan, July	..	..
1	0/7⅕	Davis & Timmins	⅞—1⅛	..	Mar, Sept	..	..
5	1/2⅗	Dick, Kerr & Co. Ord.	1 1/16—1 3/16	5 0 0	Sept.	..	..
5	0/7⅕	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	Sept	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	1/16—3/16	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1¼	9 3 0	Feb. Aug	1/16	..
St.	4%	†Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	3/16—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1¾	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)..	76 —79	5 14 0	Jan, July	..	..
2	..	Electric Construction Co.	¼—½	..	Jan, July	..	..
2	2/9⅗	Do. 7 per Cent. Cum. Pref.	1⅜—1⅝	8 12 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs ..	61 —66	6 1 0	Jan, July	..	..
10	5/0	†General Electric (1900) 5% Cum. Pref. ..	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	11⅞—12⅜	6 1 0	Feb, Aug	12¼	..
5	2/3	Do. 4½ per Cent. Pref.	4⅞—5¼	4 5 9	Feb, Aug	5⅛	5 3/32
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	103½—105½	4 5 6	Mar, Sept	..	..
10	5/0	†India Rubber, Gut. Per., &c., Works	14½—15¼	6 10 6	Feb, Aug	14⅝	14½
10	5/0	†Do 5 per Cent. Cum. Pref.	10¼—10¾	4 14 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	..	..
1	..	National Elec. Construction Co.	¼—½	..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	5/16—7/16	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	9/16—1 1/16	..	May, Nov	..	..
St.	4½%	†Do. 4½ per Cent. Perp. Deb. Stock	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	30/0	Telegraph Construction & Maintenance..	33½—35½	5 18 6	Mar, July	34½	33
100	4%	†Do. 4 per Cent. Deb. Bonds (1909)	99 —101	3 19 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2 —2⅛	4 9 3	..	2 1/16	2
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1½	4 0 0	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	109 —112	4 9 3	..	110½	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	103½	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	103½—105½	4 15 6	..	105	104½
10	10%	J. G. White & Co. 6% Cum. Pref	11½—12½	8 0 0	..	..	..
1	..	Willans & Robinson Ord.	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1¼—1¾	10 13 6	Apr. Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3⅞	..	June, Dec	..	..
100	20/2	†Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan. July	96¼	9 ½
St.	15/0	Anglo-American	64 —66	5 7 6	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	106½—108½	5 11 6	F,My,Ag,N	107¾	106½
St.	25/0	Do. Deferred	25⅛—25⅝	4 17 6	F,My,Ag,N	25 5/16	23⅛
St.	4%	†Commercial Cable 4 per Cent. Deb. Stk...	84 —86	4 13 0	Jn,Ap,Jy,O	85½	84
10	6/0	Cuba Submarine Ord.	8¼—9	6 13 6	Feb, Aug	8⅜	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 15 0	Feb, Aug	16½	..
5	2/0	Direct Spanish Ord.	3⅛—3⅜	5 15 0	April, Oct	3 3/16	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7¾—8¼	6 1 6	April, Oct	8⅛	..
50	4½%	†Do. 4½ per Cent. Deb.	99 —101	4 19 0	Jan, July	..	..
20	4/0	Direct United States Cable	14½—15	5 13 6	Ja,Ap,Jy,O	15⅛	14½
100	4½%	†Direct West India Cable 4½%Rg.Db.(rd.).	98 —100	5 0 0	June, Dec	..	..
St.	65/0	Eastern Ordinary	133 —136	5 3 6	Ja,My,Jy,O	134½	133⅛
St.	17/6	Do. 3½ per Cent. Pref. Stock	84 —86	4 1 6	Ja,My,Jy,O	84½	84
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	101½—103½	3 16 6	May, Nov	103⅛	..
St.	6/6	Eastern Extension	12⅞—13⅛	5 10 0	Ja, Ap,Jy,O	13	12⅞
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101½	3 18 6	May, Nov	..	..
10	5/0	G.N (of Copenhagen), Ex Coupon 79	30¼—31¼	5 14 3	Jan, July	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	51	53½
100	5%	Mackay Companies Common	88 —92	5 9 0	Ja,Ap,Jy,O	..	..
100	4%	Do Preference	77 —81	4 19 0	Ja,Ap,Jy,O	78½	..
1	..	Marconi's Wireless Teleg. Co.	11/16—13/16	..	April	23/32	23/32
100	4%	†Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	96 —98	3 18 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 12 9	May	..	..
100	4%	†Do. 4 per Cent. Debs.	96 —98	3 18 0	Jan, July	96¼	..
10	..	West India & Panama	⅝—⅞	..	May, Nov	11/16	21/32
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9	6 12 6	May, Nov	8¾	8 9/16
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	†Do. 5 per Cent. Debs.	99 —101	4 19 0	Jan, July	100	..
10	3/0	†Western Telegraph	13⅝—14⅛	4 18 0	Mr,Jn,O,D	14 1/16	13 13/16
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	99 —101	4 19 0	June, Dec	..	..
—	4%	Western Union Telegraph, $1,000 4% Bds	101 —104	3 16 6	—	101½	101
..	4½%	Do. $1,000 4½% Fdg. & Rl. Est.Gd.Bnds	99 —102	..	..	..	..

Shre	Last Divi-dend	NAME.	Price Wed., July 13	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to July 13 Highest	Lowest
		Telephones.					
100	2$	†Amer. Telephn. & Telegh. Cap. St.	136 —138	5 16 6	..	..	..
..	4%	†Do. Coll. Trust $1,000 4 per Cent. Bds.	91 —93	4 6 0	Jan. July	93⅛	..
St.	4%	Do. 4% Cons. Bonds 1936	103 —105	3 16 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
5	3/0	Chili Telephone	8 5/16—8 9/16	4 8 3	August ..	8 17/32	8½
1	0/7⅕	Monte Video Telephone Ord.	⅞—1	7 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	25/32—29/32	5 13 9	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106½—108	5 11 0	Feb, Aug	108	107
St.	6%	Do. Def. Stock	127 —129	4 13 0	Feb, Aug	128¼	127
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10⅛—10⅞	5 10 0	Feb, Aug	10 5/16	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10⅛—10⅝	5 10 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5 1/16—5 11/16	4 7 6	Feb, Aug	..	..
St.	3½%	†Do. Deb. Stock 3½ per Cent. (red.)	96 —98	3 12 0	June, Dec	97⅛	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.)	98 —100	4 0 0	Jan, July	98⅜	97½
..	4½%	New York Telephone Co. 30 yr. Bnds.	97½—98½	4 11 6	..	..	..
1	1/0	Oriental	1 5/16—1 11/16	4 15 0	April, Oct	..	..
1	0/7⅕	Do 6 per Cent. Cum. Pref.	1 5/16—1 7/16	4 11 6	April, Oct	1 9/32	1 3/16
St.	4%	†Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	86	..
St.	4½%	†Telephone Co. of Egypt 4½%Db.Stk.(red.)	98 —100	4 10 0	Jan, July	..	..
5	3/0	United River Plate	7⅜—7⅝	5 5 0	July	7	7½
5	2/6	†Do. 5 per Cent. Cum. Pref.	5 1/16—5 5/16	4 14 9	June, Dec	7 3/16	..
St.	4½%	†Do. 4½ Deb. St. Red.	101 —103	4 12 6	Jan. July	..	..
		Financial, Investment, &c.					
5	3/0	†Elec. & Gen. Investment 6% Cum. Pref...	2⅞—3¼	9 4 6	Jan, July	..	..
10	5/9	†Globe Telegraph & Trust	10¼—10¾	5 8 3	Sp,DcMrJu	10 11/16	10 9/16
10	3/0	†Do. 6 per Cent. Pref.	12⅝—13⅜	4 6 3	Sp,DcMrJu	13¼	13
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 10 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	†Anglo-Argentine 5% Cum. 1st Pref.	4⅜—4⅝	5 8 0	April, Oct	4 9/16	4½
5	2/6	†Do. 5% Cum. 2nd Pref.	4¼—4½	5 9 0	Jan, July	..	..
St.	4%	†Do. 4% Deb. Stock	89½—91	4 8 0	June, Dec	90⅜	89½
St.	4½%	†Do. 4½% Deb. Stock	93½—96½	4 13 6	..	95¼	94½
St.	5%	†Auckland Elec. Trams. 5% Deb. (red.)	103 —105	4 15 3	Jan, July	105	104
5	4/6	Brisbane Electric Trams. Invest. Ord	6½—7	4 8 0	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 1/16—5 5/16	4 13 9	May, Nov	..	..
St.	4½%	†Do. 4½ per Cent. Db. Prov. Certs.	99 —102	4 8 6	Jan, July	102	..
St.	8%	British Columbia El.. Rly. Df. Ord.	141 —146	5 10 0	Mar, Sept	141	..
St.	6%	Do. Pref. Ord. Stock	124 —128	4 13 6	May, Nov	126⅞	124½
St.	5%	Do. 5% Cum. Perp. Pref. Stock	110 —113	4 8 3	Jan, July	112½	112
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	102 —105	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	103 —105	4 0 0	..	104⅜	104
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99 —102	4 18 0	Mar, Sept	100½	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	97 —100	6 0 0	Feb, Aug	..	..
5	2/6	Calcutta Tramways (1 to 137,610)	4⅛—4⅜	4 7 6	Mar, Sept	..	..
100	2/6	†Do. 5 per Cent. Cum. Pref.	4⅜—4⅝	5 2 6	Jan, July	..	..
1	4½%	†Do. 4½% 1st Deb. Stock (red)	96 —99	4 11 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	¼—½	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 9/16—5 13/16	4 9 6	F,My,A,N	5 13/16	5 11/16
St.	4%	†Do. 4 per Cent. Deb. Stock	97 —100	4 0 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	95 —98	5 2 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	78 —81	6 3 6	June, Dec	..	..
1	5%	†Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94½—97½	5 2 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	1/16—3/16	..	..	1/16	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	92 —96	5 3 6	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7⅕	Lisbon Elec. Trams. Ord.	1 1/16—1 3/16	5 4 0	July	..	..
100	0/7⅕	Do. 6 per Cent. Cum. Pref.	1 1/32—1 3/32	5 5 3	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	97½—101½	4 18 6	Jan, July	..	..
St.	5%	†Madras Elec. Trams. 5% Deb. Stk.	95 —98	5 2 0	Jan, July	..	..
100	5%	†Manoas Trams and Lt. Co. 5% Debs	86½—88	5 14 0	..	..	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	98 —100	5 2 0	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	124 —126	4 15 0	..	125⅜	125¾
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	97½—98½	6 1 6	..	93¼	97½
St.	6%	†Do. 6% 50 yr. Mort. Bds.	97½—98½	6 1 6	..	99	97¼
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	102 —104	4 6 6	Feb, Aug	103½	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	101 —103	4 7 6	..	102¼	..
1	0/6	Perth Elec. Trams Ord.	9/16—13/16	5 15 5	May	..	..
St.	5%	†Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	..	..
5	3/0	†Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅝—5⅞	5 2 6	..	5 11/16	..
St.	4½%	†Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	94	92½
100	$1	Rio Janeiro Tram, Lt. & P. Co.	93 —95	4 4 6	..	97⅛	96¼
..	5%	†Do. 30 yr. Gold Bnds.	97 —98	4 2 0	..	88¼	87¼
100	5%	Do. 50 yr. Mt. Bnds	87 —88	5 14 0	..		
..	$2½	†Sao Paulo Tramway, Light & Power Co. $100 Stock	144 —146	6 19 0	..	145¾	145
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	100½—102½	4 18 0	June, Dec	102	101⅛
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅝—5⅞	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 9 0	..	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stk. (red)	92½—94½	4 15 0	Jan, July	93½	93
..	5%	†Do. 5 per Cent. 2nd Mort. Deb. Stock..	96 —98	5 2 0	..	..	..
5	4/9	Calcutta Elec. Supply Ord.	6¼—6¾	6 4 0	April, Oct	6⅝	..
100	7/2½	†Canadian Gen. Elec. Co. Com. St.	104 —108	6 7 6	..	107	105⅜
100	$3½	Do. 7% Cm. Pf. Stock	122 —125	5 12 0	..	124¼	121¼
100	5%	†Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co. of Ontario	85 —88	5 12 6	..	86¼	86½
St.	5%	†Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	1/16—3/16	..	..	..	..
1	0/7⅕	Do. 6 per Cent. Cum. Pref.	⅛—¼	8 0 0	April, Oct	⅛	..
..	5%	†Kaministiquia Power Co.5% Gold Bnds..	100 —102	4 18 0	..	101½	..
5	..	Madras E. S. Corp. Ord.	2⅞—3⅛	..	..	..	..
St.	..	Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
St.	5%	†Do. 5% 1st Mortg. Deb. Stock	90 —92	5 7 6	..	..	..
500	5%	†Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84½—85½	5 17 0	..	85½	85
St.	$1	Mexican Lt. & Power Co. Com. St.	78 —80	5 12 0	..	79½	78½
St.	$3½	Do. 7% Cum. Pref. St.	101 —103	6 17 6	..	103½	101½
500	5%	Do. 5% 1st Mort. Gold Bnds.	93 —94	5 6 0	..	94	93
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	133 —137	5 2 0	F,My,A,N	134	..
St.	£9	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	2 7/32	2⅛
St.	6%	Do. 6 per Cent. non-Cum. Pref. Stk.	105 —115	5 5 0	May	1 5/32	..
St.	5%	†Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
5	3/0	Rosario Ele . Co. Ord.	8½—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
5	3/0	Do 2nd Pref.	8⅜—8⅞	6 14 6	..	..	..
100	$1	Shawinigan, Water & Power Co. Ca	99 —101	4 9 0	..	101½	99½
..	5%	†Do. 5 per Cent. Bds.	105 —107	4 13 6	Jan, July	106½	..
St.	4½%	Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102½	102
St.	4½%	Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	..	..
..	6d.	Victoria Falls Power Co. Pref. (1 to 808,000)	½—⅞	5 6 6	Jan, July	23/32	..
1	..	Do. (808,081 to 1,700,000)	11/16—13/16	..	..	..	—

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,679. [No. 15. Vol. LXV.] FRIDAY, JULY 22, 1910. PRICE SIXPENCE (by post, 6d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

A Clearing House for Goods in London.

WE do not doubt that the man in the street, when he receives a parcel, or a box of goods, has but the faintest idea of the amount of labour that has generally been spent upon directing that parcel, or box, to its destination. It is only necessary to look at a map of London on which the goods stations and goods depots of one kind and another are marked to realise what a large area is taken up in the process of sorting. This large area postulates a very inefficient process. A small sorting establishment is easy in its manipulation, but the larger the depot the greater the difficulty in this direction. The chief trouble is that the difficulty of working does not increase merely in the same proportion as the number of parcels handled, but increases in a considerably greater ratio, just like the handling of calls in a telephone exchange. Consequently any difficulty which now exists will not be diminished, if our present system be maintained, but will be much intensified as time goes on. So far the method adopted seems to be the most primitive, consisting simply of manual sorting, and no amelioration can be expected so long as this method is retained.

IN another column we give an account of the solution proposed by Messrs. A. W. GATTIE and A. G. SEAMAN. The broad principle of belt conveyors is quite familiar, but such a principle does not go far enough. It is almost necessary that the belt conveyors should be endowed with some form of discrimination if an effective system is to be evolved. The ingenious devices of Messrs. GATTIE and SEAMAN appear to meet the need in this respect, so that it becomes only necessary to set a form of controller where the parcel is dispatched, and the parcel will then travel to the required point on the sorting floor, where all parcels for the same destination would thus be collected. An examination of the scheme shows that what is required is quite feasible in principle, and we therefore hope that a serious attempt will be made to prove its claims in practice. Mr. GATTIE is ambitious in coming forward with the suggestion to have a huge clearing house for goods for the whole of London. Such a scheme is magnificent in conception, but we may, perhaps, be pardoned for saying that we should like to see something on a smaller scale first. Everyone who has had experience in engineering matters knows that difficulties are almost certain to arise in the operation of entirely new plant. These difficulties may be merely matters of detail, but nevertheless they give trouble, and it is more easy to eliminate them on a small scale than on a large one. We would therefore suggest that in the first instance Messrs. GATTIE and SEAMAN should make a large size model to demonstrate the working of the system, after which we hope that financial support will be sufficient to enable a clearing house to be erected in one of the provincial towns where most valuable experience would be gained in proving the feasibility of the London scheme proposed by Mr. GATTIE.

Electrical Progress in St. Marylebone.

WE are glad to see by the report and accounts issued last week that the Marylebone undertaking has now turned the corner and is making a substantial profit after meeting all capital charges. A year ago a modest estimate was made that the year just closed would show a net profit of £1,341, but the actual result has been a net profit of £8,482, compared with the debit balance of £3,930 which was the result of the previous year's working. This result must be very gratifying to all concerned. The improved position is, no doubt, due to many causes, and among the economies which are most noticeable we may mention that although there was an increased output of 1,775,598

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units, or 19·7 per cent., yet the total expenditure was £1,368 less than in the previous year. The costs per unit sold have now fallen below 1d., being actualiy 0·961d. In the report reference is made to the bonus scheme in operation at the works as being a fruitful source of economy on the generation account. We have no details of the particular scheme employed, but we do not doubt that much can be done by making economies personally advantageous. Moreover what is true of the stoker and driver is true in a more limited sense of the superior officers; and doubtless for this reason the Electricity Committee have recommended, provided the output increases by at least 500,000 units per annum and the cost per unit diminishes by 5 per cent., that 6 per cent. of the first £10,000 of the profits and 9 per cent. on anything beyond this sum should be distri buted among the chief officers. Since the success of an undertaking of this kind is so essentially dependent on the efforts of the responsible officers, it is only fair that when good progress is made the staff should benefit, and few of us are free from the very human feeling that reward is an incentive.

We need scarcely remind our readers that the Marylebone undertaking is severely handicapped by heavy capital charges; in fact, this item in the total costs amounts to 1·42d. per unit sold, so that it is something of an achievement to have reduced the selling price to an average of 3·66d. Moreover, the load factor is distinctly poor, being 15·7 per cent., though this is a considerable advance on 13·6 per cent., which was the figure in 1907-8. Reference is made in the report to the sales department, which has been the object of considerable criticism at times. We are glad to see it stated that the policy of the Council is not to take work out of the hands of private contractors, and that in some cases the Council's staff has been withdrawn as soon as it has been found that a contractor was already dealing effectively with the work in hand. It is also stated that a fair profit has been obtained on the work carried out, and that no attempt is made to compete unfairly with private enterprise. In regard to hire and hire-purchase, not very much has been done up to the present, but the progress that is being made is stated to be satisfactory. Certainly, whatever opinions may be held in regard to wiring by municipalities, there can be very little question as to the importance of carrying on a business of hiring out plant if electricity supply is to meet effectively the very keen competition by gas. Mr. Seabrook has some hard work before him, but we do not doubt that now the undertaking has turned the corner the progress in successive years will be very rapid.

Tramway Development in London.

Ten years ago London was justly the laughing-stock of many provincial towns, for it was only just then begining to possess electrically-driven tramways, and, in certain districts, still relied mainly upon obsolete horse-worked cars for travelling from place to place. The reasons for this regrettable state of things were many and complicated. There existed persons who thought the old methods were good enough; there were also those who wished to see the new system introduced, but who wished to make as much as possible out of the change; while a third class opposed for the sake of opposing. Restrictive legislation, too, was a large factor in the case, for no company could be expected to spend money on drastic changes when the life of their undertaking had but a few years to run. Owing to more favourable conditions, the London United Tramways Co. just ten years ago opened an electrically-worked section from Hammersmith and Shepherd's Bush to Acton, using the same route over which the old horse tram company had worked. By degrees, with great expenditure of capital and in spite of regrettable tac'ics by the local authorities concerned, the same company gradually extended their borders along the principal trunk roads in west and south-west London, and even out into the surrounding country. Some years after, the Metropolitan Electric Tramways Co., in conjunction with the Middlesex County Council, laid down several miles of line in the northern suburbs, also extending outside the county boundaries into the neighbouring districts. The authority, however, which has done most towards helping the development of electric traction in London is undoubtedly the London County Council. After acquiring the rights of the existing horse tramway companies both in south and north London, this authority opened their first electrically-worked section in 1904. Though we have from time to time found it necessary to criticise certain actions of the Council, both financial and engineering, with regard to their tramway system, we have never had anything but praise for the general way in which they have carried out their policy in spite of opposition, not only emanating from interested local authorities (chiefly from the borough councils as the road authorities) but from within the Council itself.

At the meeting of the Council on Tuesday last it was proposed to constuct another 22½ miles of track. The completion and setting to work of these extensions will practically complete a network of lines extending over almost the whole of outer London and even into the suburbs and country districts beyond, not wholly owned by the Council but working in connection with their system. There are now 113½ miles of electrically worked lines in operation, as well as 19 miles on which horses are still used. The total weekly income from the whole system is £56,700. The number of cars employed is 1,200, while 250 more are in course of construction. The number of passengers carried during the past 12 months was 451,000,000, practically 150,000,000 more than were carried three years ago. The system is, in fact, still spreading, though not at so rapid a rate as was once the case, and when it is complete there will be at least 150 miles of electric tramways in operation within the county, capable of carrying about 15,000,000 passengers per week.

London may be behindhand in taking up new things, but not the most convinced provincial can now say that she is backward in tramway matters. The problems that have to be faced are not the same as those met with in Liverpool or in Manchester. Unless extensive rebuilding is to take place many London streets will always be quite unsuitable for tramway working, while, in others, for many reasons, cars could not be admitted. To have a line laid down either in Fleet-street or Piccadilly would

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be unthinkable. Nevertheless, there has been plenty of room for development in outer areas, and it cannot be denied that the County Council has seized its opportunity in these districts. On certain details of policy it has perhaps laid itself open to criticism, but in spite of this it has provided London with a tramway system of which we may well be proud.

Personal.—We understand that Mr. J. H. Rider is resigning his position as chief electrical engineer to the London County Council, and is joining Messrs. H. Eckstein & Co., at Johannesburg, in September, his position being an advisory one in regard to the large amount of engineering plant in use by the company. Mr. Rider's many friends will congratulate him on his new appointment, but will be sincerely sorry that his work should be so far removed from the metropolis.

The Late Mr. Harry W. Cox.—It will be seen that a proposal is made in our correspondence columns that a fund should be provided for further assisting the wife and family of Mr. H. W. Cox, the X-Ray enthusiast, whose lamented death was recorded in our last issue. A question was asked in Parliament on Monday as to whether Mrs. Cox would be recommended for a Civil List Pension. The Prime Minister said it was impossible to make any statement at the present time, but he would consider any representations that were made to him.

Sir Wm. Crookes and the Order of Merit.—An announcement in "The Times" states that Sir William Crookes wishes to thank his numerous friends who have congratulated him on receiving the Order of Merit. He hopes they will excuse his delay in replying personally to each, as their gratifying letters have arrived in such overwhelming numbers that many weeks must elapse before he will be able to clear up arrears of correspondence.

Wireless Telegraph Developments.—The isolation of the Austrian Lloyd liner "Trieste," consequent upon that vessel not being equipped with wireless telegraph apparatus, has called particular attention to the necessity for all vessels carrying passengers being provided with facilities for wireless intercommunication with ships at sea and with stations on shore. All the principal legislatures of the world are considering the subject of the compulsory equipment of passenger vessels, and these proceedings tend to show that the system is making a great advance. Amongst the manufacturing companies which will benefit by this general demand will be the parent company over which Mr. Marconi presides, and the manufacturing side of that undertaking should take a very prominent place in this development. Recently published statements show that a number of important equipments have been placed in the company's hands for execution. Already most of the important steamship lines have adopted wireless, and of these a large proportion are equipped with Marconi apparatus having a range of from 100 to 300 nautical miles. The effect upon marine insurance rates is so considerable as to prove a great inducement to steamship owners to adopt this modern and extremely useful means of intercommunication. There is full evidence that these installations will serve the purpose we have always contended they would serve, that of feeding the submarine cable and land line services of the world, and from this point of view a wider interest even than that of the development of wireless telegraphy is concerned. In other directions the development of wireless telegraphy is proceeding. There have been a number of instances recorded of wireless telegraphic communication being successfully carried on between stations erected on the surface and temporarily erected stations in mines and other underground situations. We recorded a case only the other day at the Chislehurst caves, and now we read in the Berlin "Tageblatt" of some interesting experiments made by Dr. Löwy and Dr. Leimbach in the potash mines at Dienenburg. These investigators made a series of trials and succeeded with very simple apparatus in exchanging signals at long distances and through several levels of the mines. These signals proved so satisfactory that it is thought much greater depths can be dealt with and that this branch of wireless telegraphic development is a very promising one. It should provide another source of revenue to manufacturers of all systems of wireless operation.

New London-Paris Telephone Cable.—Some interesting preliminary experiments were made on this new telephone cable last week by a party of engineers, at the invitation of Major W. A. J. O'Meara, Engineer-in-Chief of the Post Office. It will be remembered that the cable was recently laid from Dover to Cape Grisnez, and as the use of Pupin coils was really an experiment (no cable so long as this having yet been laid on this principle), the new cable was in general construction made of precisely the same type as the old cable, viz., each core, per naut, consisted of 160 lb. of copper and 300 lb. of gutta percha; so that if the new cable proved a failure owing to the breaking down of the loading coils, it would be a simple matter to cut out these coils, which are spaced 1 naut apart, and thus obtain a cable as good as the old one, the cutting out of the coils costing a few hundred pounds only. The coils each have an inductance of a little over 100 millihenries. The object of the experiments was to compare the old and the new cables. With this object the cables were looped at the French end (Cape Grisnez) and observations made at the English end (Abbotts Cliff) by speaking through the looped cable, the speaker being in one room and the listener in another room, lengths of "standard cable" being added on until the limit was reached at which speech became uncommercial. The following results were obtained :—

Observer.	Old Cable. Added length of standard cable.	New Cable. Added length of standard cable.	Gain by new cable.
W. Judd	26 miles symmetrical	40 miles symmetrical	14
J. E. Kingsbury	26 „ „	40 „ „	14
W. Duddell	24 „ „	40 „ „	16
		*50 „ „	...
		*55 miles at one end	...
W. R. Cooper	24 „ „	48 „ symmetrical	24

* As breakdown limit of hearing.

By "symmetrical" is meant that the "standard cable" length was split up, half being connected to each end of the telephone cable. It will be seen that the mean gain by the new cable was 17 miles of standard cable. Taking a mean figure, 21 miles of standard cable was the length that could be spoken through when joined up at each end. This means that conversation can be carried on at a place over 450 miles distant from Dover in England to a place equally distant from Calais on the French side, if aerial land-lines are used weighing 800 lb. to the mile, such as are in use between Glasgow and London. The following are details of typical trunk circuits from London to some of the more important provincial towns.

Typical trunk circuit.	Standard cable equivalents. Existing, which include several short underground sections.	Standard cable equivalents. If sections of underground cable were replaced by open wires.	Loss due to requirements of local authorities in regard to underground.
London-Liverpool	12·5	7·077	5·423
London-Newcastle	14·97	10·95	4·02
London-Dublin	28·01	*26·128	1·882
London-Glasgow	15·5	13·158	2·342

* Includes 13·7 standard cable miles for submarine cable.

Some of the observers noticed a very marked improvement, as regards clearness of speech, in the new cable over the old cable when the cable alone was in circuit.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repairs.
Assab—Perim	July 8, 1909	—
Malta—Tripoli	April 20, 1910	—
Madagascar—Reunion	May 12, 1910	July 18, 1910
Reunion—Mauritius	May 20, 1910	—
Latakia—Palura	May 26, 1910	—
Obock—Djibouti	June 24, 1910	—
Falmouth—Bilbao	July 4, 1910	July 11, 1910

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Starting Device for a Squirrel-cage Rotor.—According to the "Electrical World," it is proposed in a patent issued to Mr. S. R. Bergman to improve the starting torque of a squirrel-cage induction motor by providing two end-rings in parallel, one of low and the other of relatively high resistance. A laminated iron ring mounted on the rotor shaft is so arranged that it can be shifted to or from the low-resistance end-ring and in this way vary the reactance of this circuit. When starting, the reactance of the low-resistance circuit is a maximum, and more current will be carried by the high-resistance ring than by the low-resistance ring, thus reducing the total current and increasing the torque.

Railway Engineers on Electric Traction.—At the International Railway Congress which concluded its sittings at Berne last Saturday the modern development of railway operation received attention in four reports. Mr. George Gibbs, the reporter for America, dealt with electric traction on existing steam railroads. He said that all first costs of conversion of steam roads to electric working must be dealt with separately, experience being in such cases no guide. He presented tables showing that the Long Island line operated its electric sections at a cost of 9d. per car-mile, against steam traction costs of 1s. 2d. An interesting report brought up by Dr. Gleichmann dealt with the preliminary work necessary before the introduction of electric operation on German main railway lines. The reporter stated that when it was a question of introducing electric traction on large connected systems an alternating system would be preferred. The Swiss Federal railways, it was stated, were also contemplating the adoption of electric traction on their international lines. The Austrian State railways were reported to have the subject of main line electrification under consideration, the proposal being to convert 2,690 miles of line, within range of available water powers, on the single-phase system. The discussion on these reports seemed to indicate that at no distant date long lengths of Continental main lines would be converted to electric work, and the single-phase system would be generally employed, the power being generated by hydro-electric plants. In Great Britain, with cheap coal and but little available water power, the subject of main line electrification was not likely to receive serious consideration at present. It would involve, in the opinion of the speakers, an enormous capital expenditure without any adequate return. For the operation of traffic in dense centres of population the advantages of electrical working were apparent enough, but main line traffic was on an entirely different basis.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. J. Rezelman contributes an article on "Analysis of Leakage Reactance."

Last week a meeting of consulting engineers was held, when the desirability of forming an association for the protection of the interests of consulting engineers was considered, and it was definitely decided to form such an association. A strong committee, consisting of civil, electrical and gas engineers was elected to carry the scheme to completion.

We give an account of the system which Messrs. A. W. Gattie and A. G. Seaman propose to employ for the mechanical sorting of parcels and goods, the object being to centralise such operations and to reduce them to the simplest possible character.

At the meeting of London County Council last week the Finance Committee submitted an interesting report on the life of electric generating plant and the periods to be allowed for repayment of loans.

The Council have been recommended by the Highways Committee to obtain sanction for the construction of 10 additional tramway routes, equal to about 22 miles of single line, at an estimated cost of £462,470.

Hampstead (London) Council have authorised the conversion of 802 additional gas lamps to incandescent electric lighting.

Messrs. Mordey & Dawbarn have prepared a report on the Torquay tramways, in which they express the opinion that the present Dolter system could be improved so as to give satisfaction.

Hackney (London) Council have decided to extend their feeder and distributing cables at an estimated cost of £18,364. In order to encourage the use of electricity for cooking and heating and other domestic purposes, a revised scale of charging, somewhat similar to that in use in Marylebone, is to be adopted.

At a conference of representatives of the Urban District Councils of England and Wales a resolution calling attention to the present unsatisfactory state of the law with regard to the assessment of tramways was passed, and the Local Government Board was urged to introduce a bill providing for the assessment of all tramways or railways running through or along the public streets at a full net annual value.

An inquiry was held last week at Dundalk by the electrical adviser to the Board of Trade, Mr. A. P. Trotter, into the objections made to the electricity supply scheme of the Council.

Keen competition, the scarcity of contracts and the general depression in business has adversely affected the past year's financial result of Messrs. Crompton & Co. The directors, however, report that the outlook gives some sign of improvement, and economies that are being effected will, it is hoped, and anticipated, improve the general situation.

At a meeting of the Telegraph Construction and Maintenance Co. on Tuesday it was announced that Lord Selborne had accepted the position of chairman.

Legal.—Mr. Justice Neville last week commenced the hearing of an action brought by the Attorney-General (on the relation of the India Rubber, Gutta Percha & Telegraph Works Co.) against West Ham Corporation for a declaration that overdrafts obtained by the defendants from their bankers in respect of their electricity undertaking were illegal, and that the Corporation were not entitled to levy a rate for paying off the overdrafts or interest thereon, and an order was also asked for to compel the bank to refund the interest already paid in respect of the alleged illegal overdrafts. The hearing of the case was concluded on Tuesday, and judgment was reserved, but the bank agreed to refund £7,000, money paid to them as interest.

An important Factory Act suit was argued before the bench of magistrates at Houghton-le-Spring last week, the Newcastle-on-Tyne Electric Supply Co. being summoned for employing a person to carry out work at their electricity generating station who was not "competent" for such employment. The prosecution was undertaken by the Director of Public Prosecutions, and the case for both parties was skilfully argued by Mr. H. S. Mundahl and Mr. W. S. Burton.

Companies' Meetings and Reports.—The directors' reports of the Mexican Light & Power Co. and the Mexico Tramways Co. give particulars of the progress made with their hydro-electric transmission schemes during the past year.

INSTITUTIONS AND SOCIETIES

Lectures on Law Relating to Engineering.—The Council of the Junior Institution of Engineers, in conjunction with the Council of the Society of Engineers, have arranged for a course of six fortnightly lectures on "The Law Relating to Engineering," to be delivered by Mr. L. W. J. Costello, M.A., LL.B. (Cantab). The lecture will be given on October 10th next.

ARRANGEMENTS FOR THE WEEK.

INSTITUTION OF MECHANICAL ENGINEERS.

TUESDAY, July 26th.

10 a.m. Joint Meeting with the American Society of Mechanical Engineers at the Birmingham and Midland Institute. Reception by the Right Hon. Lord Mayor of Birmingham. The reception will be followed by the reading and discussion of Papers of mechanical interest.

WEDNESDAY, July 27th.

10 a.m. Meeting at the Birmingham and Midland Institute. Papers of mechanical interest will be read and discussed.

FRIDAY, July 29th.

10 a.m. Meeting at the Institution of Civil Engineers, Great George-street, London, S.W. Papers on "Electrification of Suburban Railways," by Mr. F. W. Carter; "Cost of Electrically Propelled Suburban Trains," by Mr. H. M. Hobart; "Economies of Railway Electrification," by Mr. W. B. Potter; "Electrification of Trunk Lines," by Mr. L. R. Pomeroy; and "Electrification of Railways," by Mr. G. Westinghouse.

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CLEARING HOUSE FOR GOODS IN LONDON.

Summary.—An account is given of the means proposed by Messrs. A. W. Gattie and A. G. Seaman for the handling of goods and parcels mechanically. The means adopted consist essentially of two moving belts and an electric controller which ensures the goods being transferred from any one point to any other desired point. In conclusion, brief details are given of the "clearing house" which Mr. Gattie proposes for handling all the goods and parcels that require sorting in London to reach their destination.

In our issue of July 1 we gave a brief account of a lecture by Mr. A. W. Gattie before the London Chamber of Commerce, in which he advocated the establishment of a "clearing house," where all bales, crates and parcels would be sorted and whole loads shunted, the handling being effected almost wholly by mechanical means. There is no question that an enormous amount of delay occurs, and much labour is involved, in the primitive method that still holds, and must continue to hold, unless mechanical means are developed, for the sorting of parcels and goods and sending them on a fresh stage of their journey, inevitably for another sorting before their destination is reached.

Mr. Gattie pointed out that the present system of having large goods stations for the sorting of goods is an unsatisfactory way of carrying out this work on account of the very unwieldy nature of the goods stations themselves, this feature defeating their purpose as places of exchange. The primary object of a goods station is to provide a meeting place where vehicles can exchange their loads from rail to rail or road to rail, and *vice versa*, but at existing goods stations vehicles are frequently compelled to remain a good distance apart. Platforms are sometimes 1,200 ft. long, and, owing to lack of design, it is impossible for two vehicles, transferring a load from one to the other, to come near to each other, their average distance apart being 600 ft. Thus, there is a good deal of carting by means of hand trucks over quite considerable distances, and these have to be manipulated over areas which are very congested.

The result of having several separate goods stations is that many vans are to be found in the streets more or less empty, and it is a common thing for vans to wait a long time to pick up their loads, either at railway goods yards or at business premises, owing to the fact that the parcels must be submitted to sorting before they are delivered to the vans. A goods clearing house would avoid all this, because the sorting would be done at the clearing house instead of at many separate establishments. Consequently, if a van called for parcels at any premises these would be delivered to the van irrespective of destination, and much time would be saved. There would also be a corresponding improvement in the congested state of London traffic.

The adoption of such a system would bring benefits to the railway companies, for, apart from the freeing of valuable sites now occupied by goods stations and the saving of time and expense in handling goods, the rolling stock could be put to more efficient use. A great part of the time of goods rolling-stock at the present time is taken up in loading and unloading, and in the marshalling of trains, &c. Mr. Gattie states that according to an analysis of the Board of Trade figures the average mobility of a laden wagon is only 6 minutes in 24 hours, *i.e.*, it is on the move doing useful work for only 31 hours during the year. A lot of this wasted time could be saved if the goods trains could be run into a clearing house where the goods would be mechanically sorted to a large extent.

General Scheme.—At present we do not wish so much to deal with the obvious advantages, but with the mechanical means proposed by Messrs. Gattie and Seaman. In what follows we shall deal chiefly with the principles, not with the details that will be necessary in practice. Briefly, the problem is to transfer a parcel, bale or load of goods from any given position to any other given position in the clearing house. Suppose we have the arrangement shown in Fig. 1 in which there are a number of isolated divisional floors on the same level indicated at D_1, ... D_5, and each of these is divided up into bays. Every alternate divisional floor D_1, D_3, D_5, is surrounded by a moving platform or "belt," B_1, B_3, B_5, moving constantly in the same direction, as indicated by the arrows. Further, round the whole building or floor is another moving platform or "belt" which moves constantly in the direction of the arrow round the whole floor, and every part of this platform comes in close proximity to each divisional moving platform in turn. The arrival of goods trains and vans may be imagined to be below this whole structure; the contents of any van or railway goods wagon being hoisted bodily into one of the bays through a suitable well, the choice of the bay being governed by the convenience of the moment. Suppose that a batch of parcels has been delivered at M by one of the cranes, and each item has to be sorted and transferred to one of the various points of the main floor A, from whence they are despatched to their various destinations. It may be desired, for example, that all parcels, or goods of any sort, for Croydon shall be brought to the point N. Now it is clear that four transfers will suffice to bring a parcel from M to N. All that is necessary is, first, to transfer the parcel or bale to the divisional belt B_5, thence to transfer it to the main belt when the two are in proximity, next to transfer from the main belt to the divisional belt B_1, and finally to the point N. Hand manipulation in this way would not be much of an advance, and we have therefore to consider the mechanical method of doing the transfers. This may, naturally, be sub-

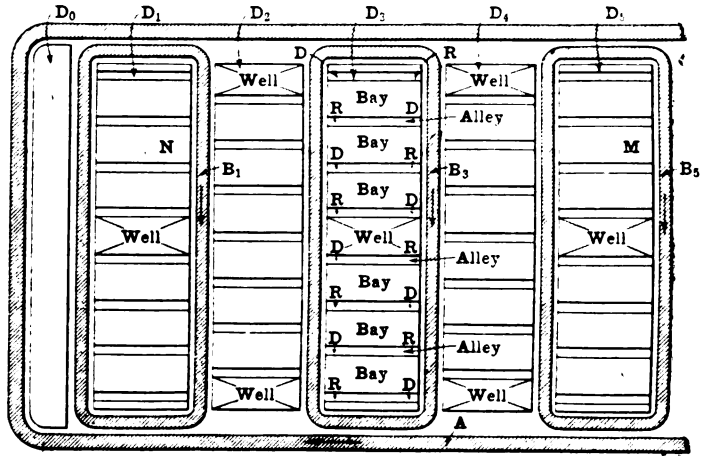

FIG. 1.—DIAGRAM OF FLOOR WORKED BY BELTS.
$D_0 \ldots D_5$, Divisional Floors; B_1, B_3, B_5, Divisional Belts; A, Main Belt; R = Receiving Point; D = Dispatching Point.

divided into the means of effecting the actual transfer and the means of assuring that the transfer from one platform to another shall take place at the exact moment desired. These we shall consider separately.

Means of Transfer.—In order to render the operations definite, the moving platforms consist of a series of trucks, or "truckers," as Messrs. Gattie and Seaman call them. Each parcel is placed on an iron tray, and this tray is transferred as a carrier whenever a transfer is made from a floor to a trucker or from a trucker in one platform to a trucker in the other platform. The tray is mounted on ball-bearing castors so that it will move easily in any direction. In a large clearing house the top of each trucker in the sorting hall would be, say, 5 ft. long and 4 ft. broad, and each tray would be the same size and designed to carry 5 cwt.; but shunters (*i.e.*, shunting trays) would be much larger and would carry 10 tons, and would be manipulated in the same way. Under the conditions assumed, each tray would be brought into a definite position at the point M, and would be transferred at the right moment to an equally definite position on an empty trucker of the belt B_5, later transferred to a trucker of main belt A, then to the belt B_1, and finally transferred to the floor D_1 at N. Now, since the trucker is moving continuously at, say, 3 miles per hour, the motion given to the tray must be in such a direction as will enable it to assume the speed of the plat-

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form, and must also be transverse. Thus an oblique motion is necessary. This motion is obtained by having transfer rollers whose upper surface is slightly below the under surface of the tray. These rollers can be magnetised, and if a steel tray is above them when so magnetised they become attracted by the bottom of the tray, and thus any motion of the rollers is transmitted to the tray. Fig. 2 shows the arrangement of transfer rollers on a trucker seen in plan, and Fig. 3 is an end elevation of a trucker. These do not necessarily show the construction that would be adopted, but they serve to show the principle. It will be seen by Fig. 3 that the motion of the trucker causes a vertical spindle to rotate, carrying a bevel

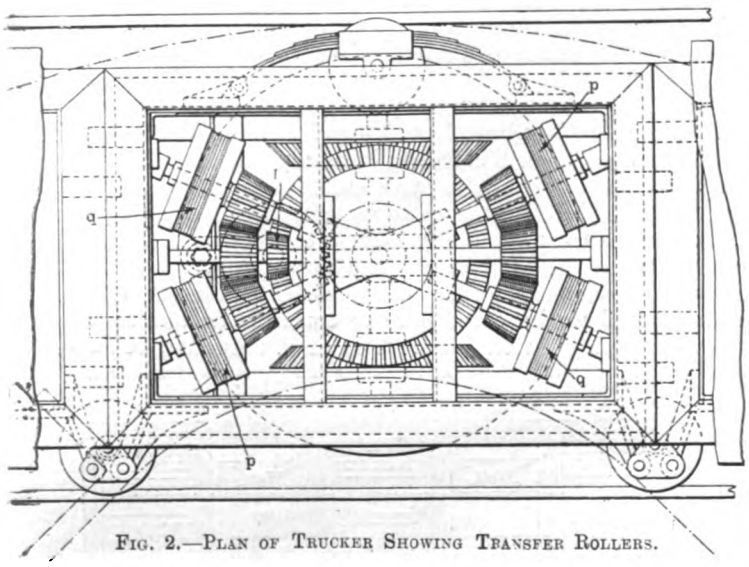

FIG. 2.—PLAN OF TRUCKER SHOWING TRANSFER ROLLERS.

wheel which gears with a pinion *n* (Fig. 2); and the spindle on which this is mounted drives the two pairs of transfer rollers *p.p* and *q.q*. This drive is coupled up through the medium of an electric clutch. The two rollers of either pair are excited in series, but only one pair would be in use at one time (although both would be rotating), the choice depending on the direction of motion of the trucker to give the necessary oblique motion. At the dispatching point M only one pair of rollers is required, and these are worked, also through an electric clutch, by shafting in the bay so as to run at the same speed as those on the trucker.

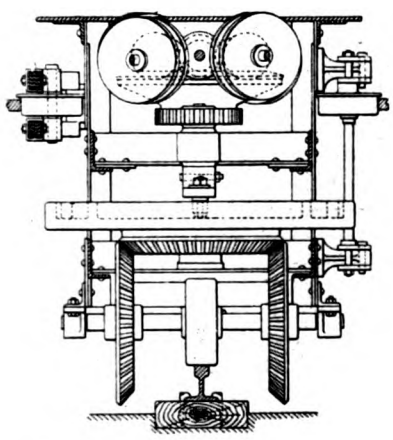

FIG. 3.—ELEVATION OF TRUCKER.

The transfer is, of course, complicated by the motion of the trucker. Thus in Fig. 4, if AB is the transverse velocity, BC the velocity of the trucker, then AC is the resultant velocity to be given to the tray. If the dispatch bay and the trucker are as shown diagrammatically in Fig. 4, the motion of the latter being shown by the arrow, then the rollers in the bay must be placed obliquely, as shown, and the rotation must be towards the trucker. On the other hand, the rollers used on the trucker must be those giving motion in opposition to the motion of the trucker itself, though the other component must still be in a direction away from the dispatch bay. For landing the tray the obliquity of the rollers would be reversed. Actually, it is not a case of uniform motion of the tray, because a certain acceleration at starting and deceleration at the finish must be allowed. Consequently, what takes place is that the rollers on both dispatch bay and trucker are clutched and energised at the same moment, and rotate while the trucker is passing over a certain distance, but the speed of the rollers is brought up gradually at the beginning and reduced gradually at the end of this travel by means of a cam arrangement, or some equivalent. The trucker is provided with wiping contacts, so that when these contacts are made the rollers are electrically in series and will work together if the other conditions permit.

Since the main belt runs at 6 miles per hour, *i.e.*, at double the speed of the divisional belt, the transfer from a divisional trucker to a main trucker, or *vice versa*, is made in the same way and under the same conditions, the relative motion being the same.

The Control.—It will now be seen that the automatic operation reduces itself to the closing of electric circuits at the desired moment. This is effected by a species of controller, or what is better termed a "register". It must be remembered that each bay and each trucker are provided with a number

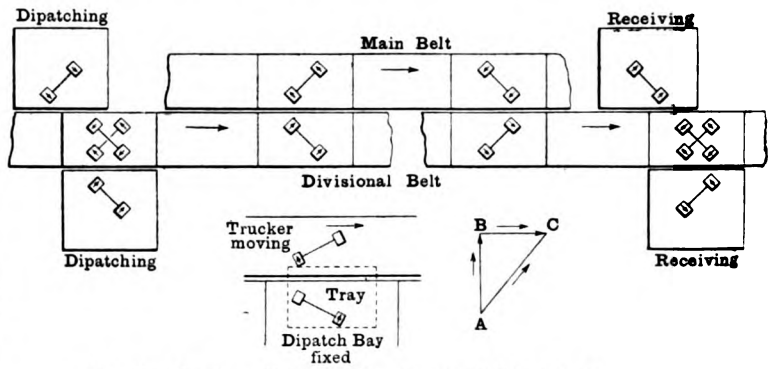

FIG. 4.—DIAGRAM SHOWING DIRECTION OF MOTION OF TRANSFER ROLLERS.

of rubbing contacts. Suppose, now, that each trucker while in its engaged position, *i.e.*, having a load on board, carries a register which moves one step forward each time a trucker makes contact with a bay. Then it is clear that by setting the register back to a suitable number, say, 5 from zero, the trucker will travel to the fifth bay before the register is brought back to zero, and if the connections for this position are suitably arranged, a transfer will take place at the bay following the fifth.

It is impracticable, however, for registers to be set by hand on each moving trucker, and therefore registers are provided at each dispatch point, and the setting of these is automatically transferred to the registers on the truckers. This is possible by connecting the registers in series.

Before going further, it will be well to indicate the form of a register in greater detail. In principle, it may be described as a ratchet wheel operated by an electromagnet, according to well-known methods, as shown in Fig. 5. Let the wheel carry an insulating arm, A, which passes through two springs, S, forcing them apart. This may be taken as the zero position of the register. If it is moved round, the springs are in contact and a circuit can be completed through them. Let the wheel carry 20 teeth and suppose it is set forward 7 teeth from zero. This setting may be done by hand or by a series of impulses by passing continuous current through the electromagnet V intermittently, each impulse causing the register to move on by one tooth. Suppose this register to be at the dispatch point. There is a similar register on each trucker. The register on the trucker and that at the dispatch point are

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so connected up that when the trucker makes rubbing contact with the dispatch bay they are in series with each other and with a source of alternating current of low frequency, such as 5 per second. In the case of the dispatch register the circuit is made through the spring contacts S, but in the trucker register this is not so. Assuming that the trucker register is at zero, as soon as the trucker makes rubbing contact both registers will move round rapidly until the dispatch register has come round to zero when the circuit will be broken by the springs S being forced apart. In other words, both registers will have travelled round 13 teeth, but whereas the dispatch register will have returned to zero the trucker register will still have to move through 7 teeth before its zero is reached. Since 7 was the original setting given to the dispatch register, we see that this setting has been transferred to the trucker register, and that it will have to make 7 contacts (*e.g.*, at 7 bays) before it gets to zero. It will be noticed that the trucker register is at 13, whereas the dispatch register was at 7, that is the complementary number, and it follows that a transfer so made must always give the complementary setting.

Since there are two moving platforms, it is necessary to have double registers, the component parts of which may be called the bay register and the belt register. The bay register is for counting the number of bays passed, and the belt register for counting the number of divisional belts passed en route. Suppose, for instance, that the dispatch point M is in the fifth bay of D_5 from the end of the divisional floor in the direction of travel of the divisional

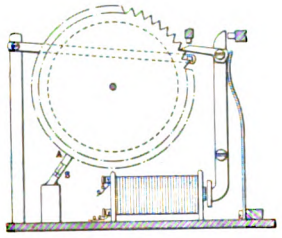

FIG. 5.—DIAGRAM OF REGISTER.

platform, then four bays must be passed before the main platform is reached, and the dispatcher therefore sets his register at 4. As there is one bay belt to be passed after the main belt has received the transfer before re-transferring to belt B_1, the main register is set at 1. If the point N is at the eighth bay, reached by travelling on the belt B_1 after being transferred from the main belt, the bay register must be set to pass six bays round the floor D_1. Hence, to take account of both floors, D_1 and D_5, the belt register is set at 7+4 or 11. The dispatcher therefore sets his combined register at 11 and 1 in circuit with the transfer roller control. If a loaded trucker passes nothing happens, but if a light trucker passes (*i.e.*, with its register at zero) then the settings of the bay and belt registers are transferred and the tray also. After leaving the dispatch bay the trucker makes contact at each bay, the contacts being short and connected to a source of continuous current. Therefore, at each bay the bay register moves forward one step, and after the four bays have been passed a transfer will occur to the main belt when any empty main trucker overtakes it and comes alongside. At the same time the setting of the main register is transferred by the action of alternating current as before through another circuit. Then, for the time being, the bay register is out of action. The main belt continues until the divisional belt B_3 has been passed, at which point the belt register moves on one, and having come to zero, a transfer to the belt B_1 is possible when the trucker reaches that part of the floor and overtakes a free trucker of belt B_1. When this transfer takes place the residue of the bay register is again transferred to the register of the new trucker by an alternating-current circuit, and the load travels round the divisional floor D_1 until the point N is reached.

It is well to notice that there is a point in which this description is not quite accurate. Since in transferring a register the complementary number results, it follows that after the first transfer from the dispatching point the bay register would show 11 points to run and the main register one point to run. But when the transfer to the main belt takes place there would be 7 on the bay register and 1 on the main register to be transferred. The transfer will, therefore, result in the numbers 13 and 19 (supposing the belt register wheel also to have 20 teeth). Consequently this second transfer does not give us what is required on the main register, but this difficulty is easily avoided by the dispatcher setting his register at 19 instead of 1. The complementary number on the bay register does not matter because it does not come into use again until after a third transfer, when the number 7 again results. In

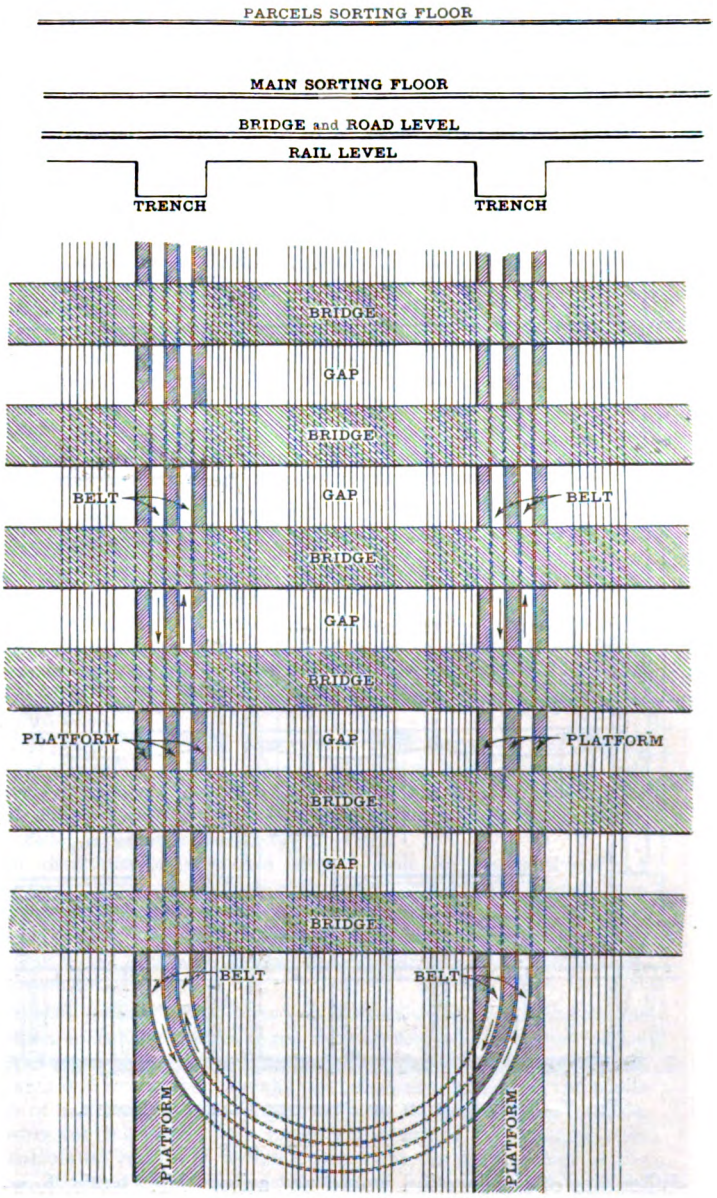

FIG. 6.—DIAGRAM SHOWING MEANS OF INGRESS AND EGRESS BY ROADS AND RAILWAYS, ALSO SHUNTING TRENCH.

practice this would all be arranged automatically by having a set number for every delivery point, and the same number would apply for dispatching from any point by setting the dispatching registers to suitable false zeros.

It may be mentioned that if the trucker in a divisional belt does not come in contact with a free trucker in the main belt, the loaded trucker merely travels round the floor, returning to the same point when a further opportunity occurs. The trucker is found to travel right round the divisional floor because its failure to transfer on to the main belt keeps its discharging circuits open.

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The trays which arrive at the delivery points proceed very slowly to the dispatching points by the tray alleys. These alleys are operated by live rollers which can be brought to a standstill, and re-started at will by the operator. It is while trays are thus slowly proceeding between bays from receiving points to dispatching points that they are unloaded of the goods they have brought and reloaded with goods they are required to take away. These alleys are marked in Fig. 1, and it will be noticed that one end of each is used for receiving (marked R) and the other end for dispatching (marked D), so that the circulation of goods and trays is very simple. The large shunting platform in the sub-basement of the building is a large edition of those in the sorting hall.

Details of the Clearing House.—The system described is applicable in a general way to any establishment in which a large amount of sorting is carried on, though it is obvious that in the case of small parcels the machinery might be much less elaborate, because the weight per parcel would be small and

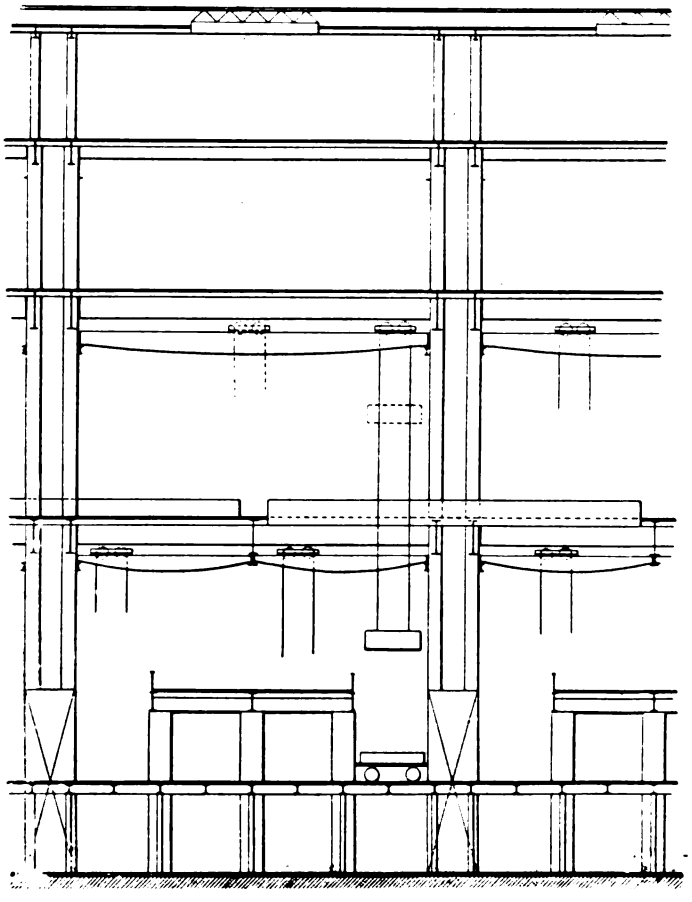

FIG. 7.—PART SECTION OF PROPOSED CLEARING HOUSE.

difficulties of acceleration would not arise. Mr. Gattie, however, is ambitious in his ideas, and therefore he discusses the possibility of handling all London goods (except, for the moment, coal and cattle) in a single building, which, by analogy with the method followed by bankers, he calls a goods clearing house. For this purpose he would erect one huge building, through the centre of which Clerkenwell-road would run. This building would be 1,144 ft. long by 440 ft. broad, and from crypt to roof 180 ft. high, with five water towers 208 ft. high.

All the railway lines would be connected with this building by means of three underground lines, 28 berths being laid in the basement of the building, as indicated in Fig. 6, which is a diagram showing the general lay out. The lowest level in the building is the crypt, where loads are retained, if necessary, pending the arrival of the appropriate train, and accommodation is provided here for 1,000 loads. Each of these loads is immediately available without the disturbance of any other load; this feature being a marked advantage on the system of any existing goods station.

Above the railway berths, and running at right angles to them is a series of 12 bridges, each 44 ft. wide, affording access for road vehicles.

The method adopted would be to provide vehicles, both railway and road vans, with detachable containers. These would be hoisted by means of cranes as soon as the vehicle came into position, and the contents would be distributed by means of the automatic apparatus, or, if required, the container would be transferred immediately on to another railway line. Shunting would be avoided by what Mr. Gattie terms "trenching." The loads would be hoisted by cranes and lowered into the trench furnished with two moving platforms moving in opposite directions, so that loads deposited by a crane at one point would be conveyed to any other point, and thus placed beneath any other crane in the building. This trench with its moving platforms would cross under the railway sidings at each end of the building, as indicated in Fig. 6.

Fig. 7 shows part of a longitudinal section of the clearing house. The building is supported by structures of four steel columns, each 4 ft. in diameter. The lowest level is the crypt, to which reference has already been made; above this are the railway tracks. Above these again are seen the road bridges (in section) surmounted by a series of travelling cranes. Above the bridges comes the first floor, which is the great sorting hall, where the heavy goods (*i.e.*, up to 5 cwt.) would be sorted. This floor is similar to that shown in Fig. 1. But there are 48 bays to each divisional floor, and the number of divisional floors is six. It will be noticed that the bays are staggered so as to utilise the belt to the best advantage. The divisional floors are 88 ft. by 440 ft., and are provided with wells through which the goods are hoisted. The system of cranes would deliver from the railway tracks to the roadways or vice versa, or to this heavy sorting floor. From this floor the small parcels are transported by belts to the floor above, which is reserved for this lighter sorting work. The top floor contains offices, workshops and other accommodation, and as the roof covers 10 acres it is fitting that such an area should be laid out as a garden. The cost of the whole scheme, including 2 miles of tunnels for railway approaches, is estimated at 54 millions sterling.

In concluding our description of this interesting scheme we may mention that the design of the proposed plant for handling the goods has been examined by Sir William Preece, who states that, in his opinion, the proposal is sound in principle, and states further: "We also think that the mechanical and electrical arrangements are practical in conception, although probably some modification in detail will be found advisable after experience of working has been obtained." Messrs. Waygood have also expressed themselves satisfied with the practicability of the scheme.

Hydro-electric Extensions in Canada.—The "Canadian Electrical News" in a recent issue gives particulars of the proposed second power station of the Shawinigan Water & Power Co. This station will be situated near the present generating plant at Shawinigan Falls, on the St. Maurice River, about 85 miles from Montreal, and will be designed for a capacity of 75,000 H.P., as against 55,000 H.P. in the case of the existing station. It is stated that the Company's transmission lines, which are of aluminium carried on wooden poles, are at present the most extensive in Canada, exceeding a total of 400 miles. For transmission to Montreal the current, which is generated at 2,200 volts, is stepped up to 50,000 volts; 3,000 H.P. is supplied to the Montreal street railways, and 15,000 H.P. to the Montreal Light, Heat & Power Co. It is of interest to mention that the Shawinigan Company supply 25,000 H.P. of water-power (undeveloped) to the Northern Aluminium Co., and 14,000 H.P. of water-power to the Belgo-Canadian Pulp & Paper Co. The greater part of the above power is obtained at a second dam about a mile up the river.

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RECENT ADVANCES IN PYROMETRY.*

BY R. S. WHIPPLE.

Summary.—The author discusses gas thermometry, resistance thermometry, thermo-electric pyrometry and radiation pyrometry, describing recent developments in each subject. He finally refers to the question of standardisation, and suggests that the national physical laboratories in each country should supply small quantities of pure metals for the determination of fixed temperatures.

The science of pyrometry has made such strides during the last few years that it may be helpful to consider briefly the work that has been carried out within comparatively recent years. As pyrometric methods are being so largely used in all industries, it is well to examine the present position of the fundamentals on which the science of pyrometry is now based.

Gas Thermometry.—Referring first to the gas thermometer, the final reference in all thermometry, a great deal of work had recently been devoted to the extension of the gas thermometer scale. Holborn, at the Physikalisch-Technische Reichsanstalt, by means of a bulb of pure iridium, has been able to extend the temperature measurements with his gas thermometer to 1,600°C. This thermometer scale, which is now generally used as the basis of high temperature measurements, is officially stated to have a probable error of 2 or 3 deg. between 300 and 1,150 deg., and of 10 deg. between 1,150 and 1,600 deg. The great difficulty in gas thermometry is to find a material of which a bulb may be made which will hold an expanding gas without loss or change through a long range of temperatures and yet will permit of accurate measurements of the pressure-volume relations within the bulb. Day and Clement overcame this great difficulty by arranging that the bulb should be surrounded by nitrogen at the same pressure as that inside the bulb. This checked any tendency of the gas to diffuse through the walls of the bulb and at the same time prevented any deformation of the bulb due to internal pressure. A further important advantage was the fact that much greater pressures could be employed. In this way it was possible to make the instrument three times more sensitive than any other gas thermometer. It is interesting to note that Dr. Day believes that in the future porcelain bulbs will no longer be used in gas thermometry, partly because of the uncertainty in determining their coefficient of expansion and partly owing to their porosity. In the last report of the National Physical Laboratory it is stated that Dr. Harker, in order to measure extremely high temperatures, proposes to make a gas thermometer bulb of some of the rare earths, such as those used in making Nernst filaments. If this project is carried out a great deal of light may be thrown on high temperature gas thermometry; but the difficulties to be contended with are very great.

Resistance Thermometry.—There is not any striking advance to report in this branch of thermometry. A valuable Paper by Dr. Harker on the "High Temperature Standards of the National Physical Laboratory"† gives the results of a series of comparisons made between the resistance and thermo-junction standards and the nitrogen gas thermometer up to 1,000°C. These results entirely justify the use of Callendar's parabolic formula up to 1,000°C. Waidner and Burgess‡ have since confirmed Harker's results in an investigation of the behaviour of resistance thermometers made of platinum wires of varying degrees of purity.

In the construction of resistance thermometers some improvements have been introduced, the most important being that due to Dr. Haagn,§ who suggested to Messrs. Heraeus the construction of a thermometer in quartz, the wire being wound on a rod of quartz and protected by a very thin tube of quartz fused over it. This thermometer can be made as small as 25 mm. long and 3 mm. in diameter, and yet be comparatively robust. By this arrangement the wire is protected from the injurious effect of gases and mechanical strain; it also very quickly attains the temperature of the surrounding medium. It is, however, handicapped by the drawback that quartz devitrifies if exposed for any length of time to temperatures as high as 1,000°C.

Two new methods of winding the thermometer coils for avoiding strain on the wires are shown in the Paper by Waidner and Burgess previously referred to; one in which, by means of a modified form of mica frame, a flexible mounting is given to the wire, and the other, due to Northrup, in which stouter wires in the form of a spiral without any support are employed. Prof. Callendar has also designed some very sensitive resistance thermometers for medical work. In America the Leeds & Northrup Co. have lately introduced a recorder for use with resistance thermometers, and also a direct-reading instrument or ratiometer.

Thermo-electric Pyrometry.—In this branch of the subject most workers appear to have devoted their efforts to: (*a*) Increasing the purity of the metals employed in the platinum thermo-couples; (*b*) producing cheaper or base metal couples, the large increase in the price of platinum having produced a demand for such couples; (*c*) improving the methods of measurement with thermo-couples.

(*a*) Great steps have been made comparatively recently in the production of pure and homogeneous metals for standard thermo-couples, the firms of Johnson, Matthey & Co., of London, and Heraeus, of Hanau, having sunk a considerable amount of capital in large ingots of pure platinum, platinum 10 per cent. rhodium, and platinum 10 per cent. iridium, for this purpose. In the case of a sample supplied for thermo-couples to the National Physical Laboratory by Messrs. Johnson, Matthey & Co. the analysis of the platinum-rhodium alloy was as follows: Platinum = 89·9, rhodium = 8·98, both being directly determined and no trace of any other metal being discovered.

The ingots owned by Messrs. Johnson, Matthey & Co. have been found to be exceptionally homogeneous, and Messrs. Heraeus have now been able to repeat their standard of purity for some time. So that, as a result of the work of these two firms, it is possible to obtain a second thermo-couple similar to one previously obtained, and that may be used without introducing any serious error on the same galvanometer or recorder.

It has been known for some time that platinum thermo-couples deteriorate in an atmosphere of hydrogen, but it has not been possible to account for a large number of the failures. In the Paper by White* it was shown that the main source of error in thermo-elements is in homogeneity, by the removal of which, in most cases, far greater accuracy may be attained than has hitherto been realised. It was also shown that the iridium slowly sublimes from the platinum-iridium side of a couple and enters into combination with the platinum side, thus slowly reducing the E.M.F. given by the couple. This sublimation has been found to commence at 900°C. and to become serious at 1,200°C.

Iron has undoubtedly a disastrous effect on platinum, and the destruction of large numbers of couples may be put down to this cause. Annealing a low-reading thermo-couple to a temperature of 1,200°C. will frequently restore it to its original E.M.F. When the use of contaminated elements is necessary, fair accuracy can still be obtained if the defective couples are frequently compared with standard ones.

(*b*) A large number of wires have been suggested for making cheaper thermo-elements. Onnes and Clay have employed gold and silver elements for very low temperatures with success, this couple showing itself at −253°C., as read on a hydrogen thermometer, to be twice as sensitive as constantan-steel.

The most satisfactory base metal couple for temperatures not exceeding 700°C. is undoubtedly copper-constantan (constantan = 60 per cent. copper, 40 per cent. nickel), and this couple has been used in several scientific researches. Amongst other couples may be mentioned iron-constantan, iron-nickel, iron-nickel chromium, copper-nickel.

A useful book by Prof. Pécheux† has lately been published on the thermo-couple. In this he urges the adoption of the copper-nickel couple for use up to temperatures of 900°C., and he also shows that although it is impossible to make one parabolic formula fit the whole range of usefulness of the couple, yet with the aid of three formulæ covering varying parts of the range, the observed results agree with the calculated results to within 1 deg. over the greater part of the scale. My own experience shows that it is extremely difficult to obtain homogeneous wires, and therefore, for accurate results, it is necessary to calibrate every individual couple, and even then the calibration may be found to have seriously altered if, by any chance, the couple has been overheated or perhaps over-annealed.

For accurate work it is customary to maintain the cold junction of a thermo-couple at 0°C., but not infrequently, in what may be called semi-scientific work, it is not easy to control the cold junction temperature. Although it has been customary to halve the difference between the temperature of the head of the thermometer and 0°C. and to add this quantity to the obtained hot junction temperature, provided the cold junction correction does not exceed 50°C., yet this is incorrect, as the relation of the E.M.F. to temperature is not a straight line. This has been fully discussed by C. Offenhaus and

* Abstract of a Paper read before the Birmingham Metallurgical Society.

† Phil. Trans. Roy. Soc., A, Vol. CCIII., pp. 343-384.

‡ Bulletin of the Bureau of Standards, Vol. VI., No. 2.

§ "Report of the Physikalisch-Technische Reichsanstalt," 1906.

* W. P. White, "The Constancy of Thermo-elements" ("Physical Review," Vol. XXIII., December, 1906).

† "Le Pyromètre Thermo-électrique pour la Mesure des Températures élevées," par H. Pécheux, Gauthier-Villars, Paris.

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Ernst N. Fischer,* who show that the correction depends on both the hot and cold junction temperatures and the particular couple. Briefly, they show that the true temperature of the hot junction is not, starting with the needle at zero (the cold junction having the temperature of the room), the temperature which corresponds to the millivolt reading, but is found by adding the number of millivolts which corresponds to the temperature of the cold junction to the millivolt reading.

(c) For accurate work the conditions imposed upon a potentiometer for use with thermo-electric couples are very exacting, and may be grouped as follows: (1) If possible, temperatures up to 1,600°C. must be read to 0·1°C. with a platinum, platinum-rhodium element, 0·1°C. corresponding to about $\frac{1}{1000000}$th of a volt. (2) The potentiometer coils must be unaffected by leakage from external circuits. (This is important where, as is now generally the case, the thermo-couple is being used in a furnace which is electrically heated by heating coils the P.D. in which may be 100 volts or more, any leakage to the potentiometer coils introducing serious errors.) (3) Manipulation must be simple in order that quickly altering temperatures may be followed.

To meet the above conditions various potentiometers have been designed, amongst the most important being those designed by Dr. White,† Dr. Harker‡ and the Cambridge Scientific Instrument Co.§ The instrument designed by Dr. White differs from the other two in that no bridge wire is employed, the rapidity of action being obtained by switches and a direct-reading galvanometer. In the instrument designed by Dr. Harker and also in that designed by the Cambridge Scientific Instrument Co. the bridge wires are kept as short as possible, being placed in series with a continuous coil of many sections. In the former instrument these sections are introduced by means of connectors and mercury cups, in the latter by a switch and contacts. The maximum E.M.F.s that can be measured are 21 and 30 millivolts respectively, and the minimum, by estimation, 1 microvolt.

Several recorders of various types have been introduced for use with thermo-couples; amongst others must be mentioned those by Pellin, Siemens & Halske, W. H. Bristol and the Cambridge Scientific Instrument Co.

In connection with the last-mentioned instrument some experiments have lately been tried with a view to increasing the stability of zero. It has been found that a phosphor-bronze wire reduces the creep from half to one-third that which would be given by the same wire rolled as a strip.

Radiation Pyrometry.—The last few years have witnessed great progress in this, the latest, branch of pyrometry. The temperature of a hot body may be estimated either from the visible light emitted or from the thermal effects of the longer infra-red waves. The intensity of the light emitted by a hot body varies enormously with the temperature, and therefore at the first glance one would assume that the easiest way to a temperature would be photometrically to compare the light emitted by the hot body with that emitted by a second hot body at a definite temperature; but, unfortunately, all bodies at the same temperature do not emit the same amount of light. Kirchoff first propounded the idea of a "black-body" as being a body which would absorb all radiation falling upon it and would neither reflect nor transmit it. He also showed that the radiation from such a body is a function of the temperature alone. Wien and Lummer were the first to make a scientifically so-called "black-body" furnace, although this was much improved by Lummer and Kurlbaum in 1898 by the addition of electrical heating. It may be noticed in passing that very often furnaces employed in industrial operations closely approach black-body conditions.

It is found that the apparent temperature of any material when away from black-body conditions always bears a fixed relationship to its true temperature, this apparent temperature being called its "black-body" temperature. It is thus very important to know the relationship between the radiation emitted and the temperature, and a great deal of mathematical and practical work has been devoted to this object. Stefan was the first to state that the energy radiated was proportional to the fourth power of the absolute temperature. Boltzmann later propounded the same law from thermo-dynamic reasoning, assuming the existence of light pressure. This law has since become known as the Stefan-Boltzmann radiation law—$E = K(T^4 - T_0^4)$. When the radiation from an incandescent body passes through a non-absorbing prism it is spread out as a spectrum and the energy corresponding to the different wave-lengths may be determined by means of a bolometer. Such experiments have shown that the greater part of the energy is found in the infra-red part of the spectrum. It is also found that if the particular wave-length having maximum energy for a given temperature of the radiating body were determined, and if the temperature were then raised, the wave-length of maximum energy was displaced towards the shorter wave-lengths. This displacement with change of temperature is illustrated by the now well-known energy curve of Lummer and Pringsheim.*

Wien found that as the temperature of a hot body is changed the wave-length having the maximum energy will be changed, so that the product of the wave-length λm and the corresponding absolute temperature T is a constant. If T increases, λ shifts towards the shorter wave-lengths. Combining the above relation with the Stefan-Boltzmann law, he was led to the constant $E_{max.}T^{-5} = \text{constant}$, in which $E_{max.}$ indicates the energy corresponding to the wave-length of the maximum energy and T is the absolute temperature of the radiating source. Planck has also propounded a formula which represents the results for certain regions of the spectrum and for certain temperatures somewhat better than the Wien formula, the calculated values agreeing extremely well with the observed.†

A basis on which to found radiation measurements being thus obtained, it has been a comparatively easy matter to design instruments for measuring the radiation. The first satisfactory radiation pyrometers were photometric—that is to say, they were arranged to match the luminous radiation obtained from an incandescent body against that obtained from a standard lamp. The Chatelier, as modified by Féry, and the Wanner pyrometers are the most successful photometric pyrometers. In both cases mono-chromatic light is matched against that obtained from a lamp, in the former from an amyl-acetate flame, in the latter from an electric incandescent lamp. A considerable amount of light is lost in the optical system of the Wanner, thus preventing temperature measurements below 900°C., and for that reason, as well as for the openness of scale of the Féry pyrometer, the latter is to be preferred. Féry has recently modified this instrument by the addition of extra neutral tinted glasses, so that the range is largely extended. The instrument as now arranged is particularly suitable for determining the temperature of incandescent lamp filaments, the electric arc, &c. On the other hand, the instrument is not so portable as the Wanner. The Holborn-Kurlbaum pyrometer has proved itself a useful tool in the hands of the observers at the Reichsanstalt and at the Bureau of Standards. The only instruments using the total radiation from a hot body are the Féry and Thwing pyrometers. Féry's first model consisted of a lens (preferably fluorite) which focussed the radiation received on to a small thermo-electric couple, the E.M.F. generated actuating a sensitive galvanometer. Unfortunately, the lens absorbed a considerable quantity of the radiation, especially at the low temperatures where a great part of the energy exists in the form of long wave-lengths, and the pyrometer was, therefore, only suitable for high temperatures. Féry afterwards modified the instrument by substituting a concave mirror to focus the radiation instead of the lens, and this largely increased both the range and the sensibility of the instrument. Its sensibility has since been further increased by the substitution of a more sensitive and efficient thermo-couple, the greater E.M.F. obtained enabling pivoted galvanometers to be employed in place of the more delicately suspended instruments. By employing a comparatively delicate galvanometer it is possible to determine temperatures with this instrument below the boiling point of water.

Féry has since introduced a third form of this pyrometer, in which the radiation is concentrated on to a small bi-metallic spiral, carrying an aluminium pointer. As the temperature of this spiral increases it unwraps itself, moving the pointer over a scale. This simple form is being found useful in works where it is desirable to avoid the complication of a galvanometer.

Some interesting tests were recently made at the National Physical Laboratory on the absorption of the receiving mirrors in these instruments, and it was found that they reflected about 96 per cent. of the total radiation falling upon them. It was also found that a slight film of oxide on the gilded surface of the mirrors made no serious difference to the amount of radiation reflected, as the greater part of the energy exists in the form of long wave-lengths which the tarnished mirrors reflect without difficulty.

Thwing‡ lately has introduced a pyrometer in which the radiation is reflected on to a thermo-couple by a deep conical mirror, a series of diaphragms being arranged in a tube so that a fixed cone of rays always falls on the mirror.

As previously stated, optical pyrometers are calibrated in terms of the radiation emitted by a black body, but the temperature as measured by them will depend on the nature of the hot body under observation. It is, therefore, necessary to know the "black-body

* Electrochem. and Met. Ind., New York, pp. 362-365, September, 1908.
† "Physical Review," Vol. XXV., No. 5, November, 1907.
‡ "Phil. Mag.," July, 1903.
§ THE ELECTRICIAN, January 31, 1908.

* "Ver. d. Deutsch Phys. Ges., I., 217, 1899.
† Rubens and Kurlbaum, "Ber. d. K. Akad. d. Wiss.," Berlin, p. 929, 1900.
‡ "Journal of the Franklin Institute," May, 1908.

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temperatures" of a material at a given temperature in order to obtain the real temperature. A great deal of work has been done on this subject, more particularly on the black-body temperatures of platinum and molten copper. But it is much to be regretted that no authoritative work has yet been carried out on the black-body temperatures of molten iron and steel.

Standardisation.—The question of standardisation is of great importance to all users of pyrometers. The various national physical laboratories have apparatus capable of testing closely up the scale to 1,500°C., and have also one or two other points of reference up to the temperature of the arc. It is interesting to note that the tendency of recent workers is to adopt the melting points of pure metals as the standards of reference, several of the melting pionts being known to a high degree of accuracy. Unfortunately the metals cannot be obtained commercially sufficiently pure to guarantee an accuracy of 1°C. at the higher temperatures, but if an accuracy of 1 to 3 deg. is sufficient, then Kurlbaum's best materials will answer the requirements. It is hoped that in the near future the National Physical Laboratory, or some similar institution, will be able to supply small quantities of pure metals the melting points of which have been carefully studied.

The author finally gives a list of the most satisfactory standardisation points.

AN IMPROVED METHOD OF SORTING INCANDESCENT LAMPS.*

BY K. KEIL.

The sorting of lamps is a most important operation, seeing that nowadays lamps of 16, 25 and 32 c.p. are required for a series of very definite voltages, differing often by a single volt. This requires very careful work, and the following graphical solution is given as the outcome of a considerable experience in dealing with both metallic and carbon filaments, the test lamps having been taken quite at random from a very large stock.

The mean horizontal candle-power and the number of watts taken at different voltages are first determined, and plotted on a curve. Table I. gives figures for Osram lamps. The observed candle-power, as noted in column 3, satisfies the equation $y = a \cdot x^b$, where x is the voltage, y the candle-power, and a and b are constants. The calculated value of b is given in column 4. Thus if E_1 and E_2 are two voltages, and L_1 and L_2 the corresponding candle-power, we have

$$\left(\frac{E_1}{E_2}\right)^b = \frac{L_1}{L_2} \quad \text{and} \quad b = \frac{\log L_1 - \log L_2}{\log E_1 - \log E_2}.$$

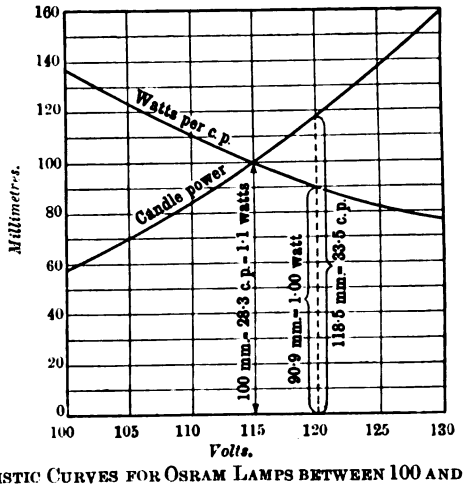
The small differences in the values of b are doubtless due to errors of observation, the mean value being probably correct. The mean value for 16 c.p. was found to be 3·88, for 32 c.p. it was 3·81, and for 50 c.p. it was 3·85, there being in these cases no great difference, and 3·85 can probably be taken as the nearest approximation. We may therefore assume that the candle-power of an Osram lamp varies as the 3·85th power of the voltage, and on the basis of this assumption the calculated candle-power is given in column 5, and curves can be constructed. From the observed values of the watts taken by the lamp at different voltages, it seems that the number of watts varied with the 1·59th power of the voltage. The observed values are given in column 6, and the calculated values in column 8. From this we see that there is a direct connection, which can be expressed in a formula, between the voltage and the candle-power, and also between the voltage and the watts taken by any particular lamp. Similarly there is also a connection between the voltage and the efficiency, as expressed in watts per candle-power, which may be formulated as follows, viz., the efficiency of an Osram lamp, expressed as watts per candle-power, varies inversely as the 2·26th power of the voltage. The figures for the Bergmann filament are slightly different; the candle-power is proportional to the 3·98th power of the voltage; the watts, taken by the lamp, to the 1·68th power, and the watts per candle-power inversely to the 2·3rd power. Thus the Bergmann and the Osram lamps give very similar results, and this is obviously due to the fact that essentially both consist of tungsten, and such small differences as can be noticed are doubtless due to slight variations in the method of manufacture.

With carbon filaments, things are rather different, and the exponential coefficient does not remain constant, as in the case of tungsten lamps. When dealing with the connection between the candle-power and voltage, the value of the exponent b varies from 7·87 to 4·23, and in the neighbourhood of the normal voltage its value is 6·3, which is about twice its value in the case of the metallic filament. The watts taken by the lamp vary as the 2·18th power of the voltage; in the case of the connection between the watts per candle-power and the voltage, the value of the exponent b varies from −5·72 to −2·05, its value at the normal voltage being −4·1. In Table II., all the values of b are collected together and arranged systematically. Here b_L is the exponent for the candle-power, b_A is the exponent for the total watts taken by the lamp, b_S is the exponent for the watts per candle-power.

* Abstract of an article in the "Elektrotechnische Zeitschrift," April 28, 1910.

Table I.

C.P.	Voltage.	Candle-power. Obs.	Exponent b.	Calc.	Total watts. Obs.	Exponent b.	Calc.	Watts per c.p. Obs.	b	Calc
1	2	3	4	5	6	7	8	9	10	11
25	60	2·2	3·64	2·31	11·4	1·56	11·3	5·18	...	4·90
	70	3·9	3·90	4·18	14·5	1·58	14·5	3·72	...	3·46
	80	6·6	4·05	6·99	17·9	1·60	17·9	2·71	...	2·56
	90	10·6	4·20	10·8	21·6	1·61	21·6	2·04	..	2·00
	100	16·5	4·06	16·5	25·6	1·49	25·5	1·55	...	1·55
	110	24·3	3·86	23·8	29·5	1·63	29·7	1·21	...	1·25
	120	34·0	3·53	33·2	34·0	1·39	34·1	1·00	...	1·03
	130	45·5	3·78	45·2	38·4	1·82	38·7	0·84	...	0·86
	140	60·2	3·84	60·2	43·5	1·61	43·6	0·72	...	0·73
	150	78·5	3·82	78·5	48·6	1·75	48·6	0·62	..	0·60
	160	99·0	3·98	100·7	54·4	1·56	53·9	0·55	...	0·54
	170	126·0		127·1	59·8	1·40	59·3	0·48	...	0·47
	180				64·8		65·0	0·43	...	0·41
		Mean = 3·88			Mean = 1·58			Mean = (-2·30)		



CHARACTERISTIC CURVES FOR OSRAM LAMPS BETWEEN 100 AND 130 VOLTS.

These figures can be regarded as characteristic of the various lamps. A simple calculation shows that the resistance of the lamps can be deduced from the figures already given. Thus, in the case of the Osram lamp, the resistance varies as the 0·41th power of the voltage, in the Bergmann lamp it varies as the 0·32th power, and in the carbon filament it varies inversely as the 0·1th power.

The question now arises as to how these figures are to be used in the sorting of lamps. Let us suppose that we are dealing with a batch of Osram lamps to be run at voltages between 100 and 130. Here all the measurements can probably be conveniently made at 115 volts, and it is an advantage to use, as a standard, a lamp which has been calibrated at 115 volts. For all Osram lamps, with voltages between 100 and 130, the appended curves will be used. Let us suppose a lamp to have been tested at 115 volts, and its candle-power has been found to be 28·3, and its total watts 31·1. Its efficiency is therefore 1·1 watts per candle-power. In the curve the ordinate at 115 volts corresponds to 1·1 watts per candle-power. This ordinate measures 100 mm. But the lamp in question is intended to be run at an efficiency of 1 watt per candle-power, and to this the corresponding ordinate will be $\frac{1 \cdot 0}{1 \cdot 1} \times 100$ mm., *i.e.*, 90·9 mm. It is therefore necessary to find the point on the "watts per candle-power" curve which has an ordinate of this length. The corresponding abscissa will give the voltage at which the lamp must be burnt, which is in this case 120·2 volts. In order to find the candle-power of the lamp, the ordinate of the "candle-power curve" corresponding to this voltage must be found and measured on a proper scale. At 115 volts the candle-power was 28·3, so that 28·3 candle-power corresponds to an ordinate of 100 mm. The ordinate on the "candle-power curve" corresponding to 120·2 volts

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Table II.

C.P.	Osram lamp.			Bergmann lamp.			C.P.	Carbon lamp.		
	b_L	b_A	b_S	b_L	b_A	b^S		b_L	b_A	b_S
25	3·88	1·58	−2·3	3·93	1·68	−2·25	16	7·13 to 5·56	2·16	(−4·89) to (−3·52)
32	3·81	1·59	−2·22	3·92	1·69	−2·23	25	8·45 „ 3·20	2·21	(−6·35) „ (−0·78)
50	3·85	1·59	−2·26	4·09	1·67	−2·42	32	8·03 „ 3·92	2·18	(−5·91) „ (−1·84)
Mean :	3·85	1·59	−2·26	3·98	1·6	−2·3	Mean :	7·87 to 4·23	2·18	(−5·72) to (−2·05)

measures 118·5 mm., and the value of the candle-power at this voltage will therefore be $\frac{118·5}{100} \times 28·3$, *i.e.*, 33·5 c.p. The lamp in question may therefore be taken as giving 32 c.p. at 120 volts.

It may appear at first sight as though the proposed method was likely to be rather wearisome. A little practice is sufficient to prove that it can be worked very quickly, and that it allows a much more exact sorting of the lamps than has been hitherto possible. Lamps are often labelled as giving 25 c.p. at a given voltage, whereas they are found in practice to give 30 c.p. and even more; sometimes, on the other hand, they give less than their nominal candle-power. Cases of this kind would be impossible if the proposed method were properly applied.

THE WIRING OF THE NEW BUILDING OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

The step taken by the Council of the Institution of Electrical Engineers to provide the Institution with a home of its own by taking over the building of the Royal College of Physicians and Surgeons on the Victoria Embankment has already been dealt with in these columns. The work of reconstruction of the interior of the building has proceeded apace, and it is hoped that by the time the 1910-1911 session opens the whole of the business of the Institution will be conducted in the new quarters. The original building was wired for electric light, but as this installation was carried out some quarter of a century ago it was found quite unsuitable for the present purposes of the altered building. The work of remodelling has, therefore, included the complete re-arrangement of the electrical circuits and the provision of a supply of energy for both lighting and power purposes.

The consulting engineers for the re-wiring of the premises are Messrs. Handcock & Dykes, who were instructed to prepare a complete specification which would bring the installation entirely up to date. From a perusal of this specification it is evident that the consultants have done their utmost to bring the installation into line with modern wiring developments, and from an inspection of the work we can confirm the high standard aimed at in the specification. The specification gave the contractors practically a free hand to choose from among the various recognised systems of wiring. After consideration the contractors decided to use screwed steel barrel for all the main wires and tinned brass tubes for sub-distribution purposes as being most suitable for the carrying of the circuits round the old walls of the building. With the exception of the basement, the whole of the wiring is concealed, and this system of tubing was found to be very adaptable to the process of sinking below the level of the plaster; at the same time, by the adoption of a scheme of easy bends in the tubing, drawboxes were dispensed with and the insulated wires could be pulled through between the switch and the light points after all decorative work was completed. The whole of the sub-circuit wiring has been installed upon this plan, with the result that there is not a single draw-through box at any point in this portion of the installation. The contractors for the entire installation were Messrs. Drake & Gorham, Ltd.

The tinned brass tube or Kalkos system of wiring was described in THE ELECTRICIAN "Industrial Supplement" for October, 1907, and since its introduction at that time it has been installed in many large and important buildings. We may recall here the main features of the system, namely, the brass tubes heavily tinned inside and out, the sweating up of all switch, ceiling and bracket boxes and the novel adjustable ring in all the boxes, by means of which the level of the particular accessory, either switch, ceiling rose, or wall plug can be altered to suit the requirements of either flush or surface wiring. The general principle of the system remains the same, and its application has been considerably amplified in accordance with the greater experience obtained with its practical application.

The supply of energy for the new Institution building is being given by the Savoy Hotel (Ltd.), whose power-house is immediately adjoining, at a pressure of 100 volts, two-wire, the service being in duplicate. The cables enter the building at two distinct points, and comprise, in each case, two pairs of 19/12 lead-covered V.I.R. mains coupled up to the service at the point P (Fig. 1) in the basement. One

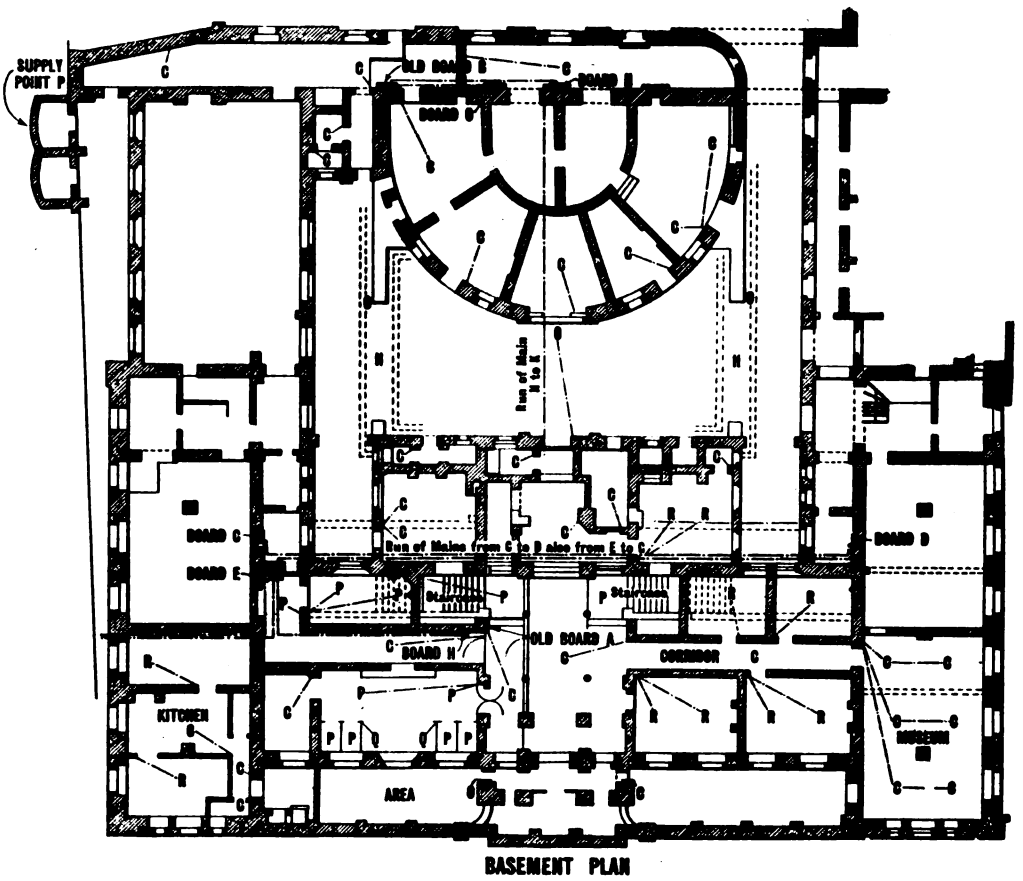

FIG. 1.—PLAN SHOWING RUNS.
C=ceiling light, H=holophane reflector, P=plain pendant.

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pair has been disconnected from the existing fuseboard at B and extended by means of a new pair of cables through a 75-ampere cast-iron switch fuse to a new circuit fuseboard at N. The other pair has been run into a new board at the point C to supply a portion of the circuits of the Royal College of Physicians, and also into a board at E from which a supply is given to the front portion of the Institution building. The board at N is three-way, and controls the circuit to the lantern room, lecture hall and the corridor at back of the lecture hall. The board at E is seven-way, and controls the circuits for the tea and smoking rooms, lecture lantern, basement corridor, first floor west and east, and two circuits for the cornice lighting in the lecture hall. The working current of the N board fuses is 25 amperes, and the fuses on board E work at 51 amperes in the case of five circuits and 25 amperes in the case of two circuits. The risers from these main circuit boards to the distribution boards have been run in screwed steel conduit of heavy gauge, and the cables are V.I.R. taped and braided.

The lay-out of the principal circuits in the building is shown in the diagrams (Figs. 1, 2 and 3). A reference to these will indicate the positions of the incoming cables, the main circuit boards and the principal distribution boards. Ample provision has been made for adequate and appropriate illumination of the various rooms, and wall sockets have been included at a number of convenient points in almost every room, but more particularly in the library.

Special circuits have been run for the lecture hall table lantern and to the lantern room overlooking the lecture hall. In the tea and smoking rooms three experimental wiring points have been provided, and these terminate in special cast-iron boxes sunk into the wall. Each box contains two single-pole enclosed switch fuses and two heavy pillar terminals with fly nuts to which temporary leads can be quickly connected. The boxes are fitted with plate glass and polished hardwood fronts which match the surrounding panelling.

Separate power circuits have been run to supply energy to a motor for the service lift from the basement to the tea-room. A pair of 7/18 mains has also been run in heavy gauge steel screwed conduit to a motor starter and regulating switch with no-volt release, and thence to a motor driving a 42 in. horizontal discharge ventilating fan. This latter has a capacity of 10,000 cubic ft. of air per minute against $\frac{1}{4}$ in. water pressure, and is employed for extracting the air from the lecture hall. The motor for this fan develops 1 H.P. and the speed is 300 revs. per min.

We were given an opportunity of inspecting the installationwhen the work of running the brass tubes was in progress. We were then shown how they had been planned out so that wires could be drawn from point to point without the use of draw-in boxes. Despite the fact that the wires travel round several bends this method was uniformly applied throughout. Photographs were taken at the time of installation, and Figs. 4, 5, 6, 7 and 8 serve to illustrate the manner in which the work was done. A minimum of tube is required, and also the smallest possible amount of cutting away of the walls and plaster.

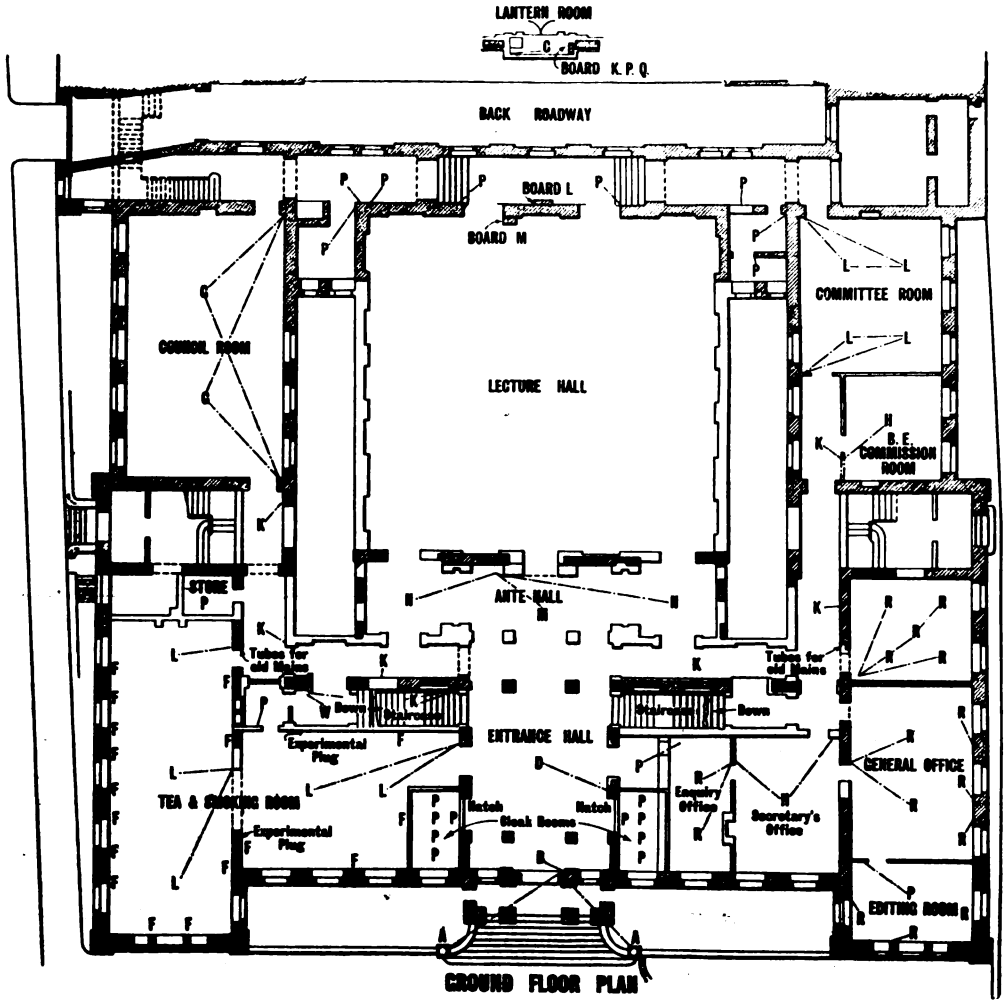

FIG. 2.—PLAN OF GROUND FLOOR SHOWING POINTS.
F=bracket, L=three-light electrolier, R=pendant.

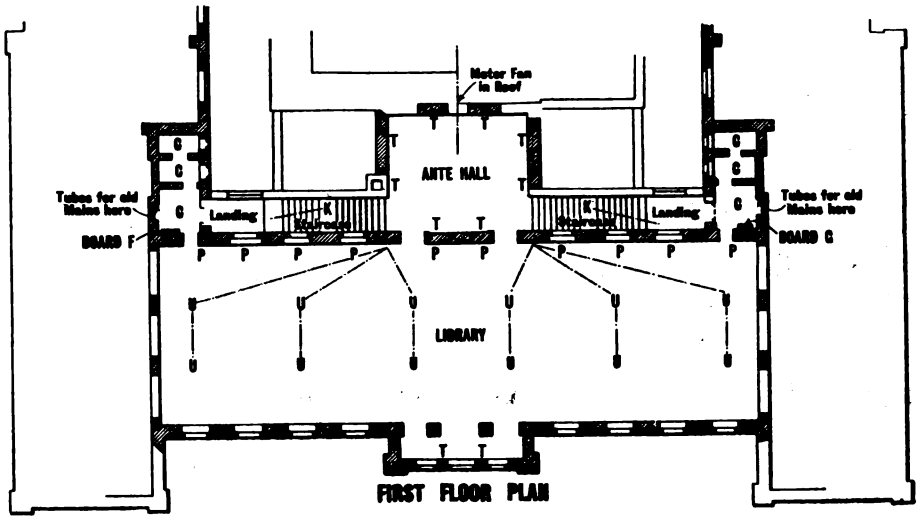

FIG. 3.—PLAN OF FIRST FLOOR SHOWING POINTS.
T=bracket, U=three-light bowl fitting.

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The standard Kalkos boxes admit of the entry and exit of wires from any point on the side of the box, and also through the bottom of the box. The tubes in every case are sweated into special inlet and outlet pieces, which are bell-shaped and, therefore, avoid sharp bends. They also dispense with the

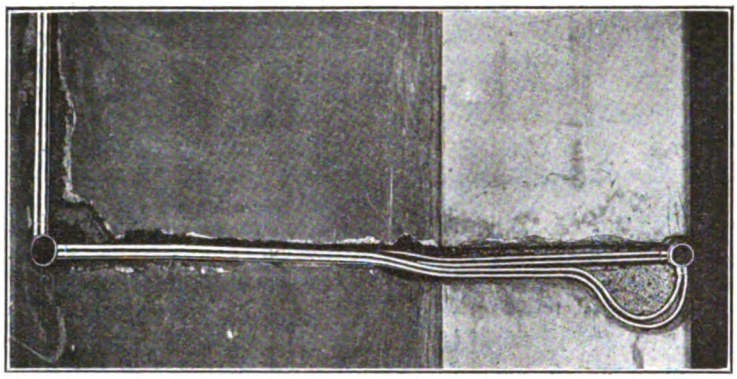

FIG. 4.—EXAMPLE OF TUBE WORK AT SIDE OF DOOR. The feed wires enter the right hand box from the hole in the wall near the centre of the picture. The outgoing wires pass round the easy bends to the next box.

necessity for insulating bushes. This is one of the important features of the system, and contributes largely to the ease with which wires can be drawn in round a number of

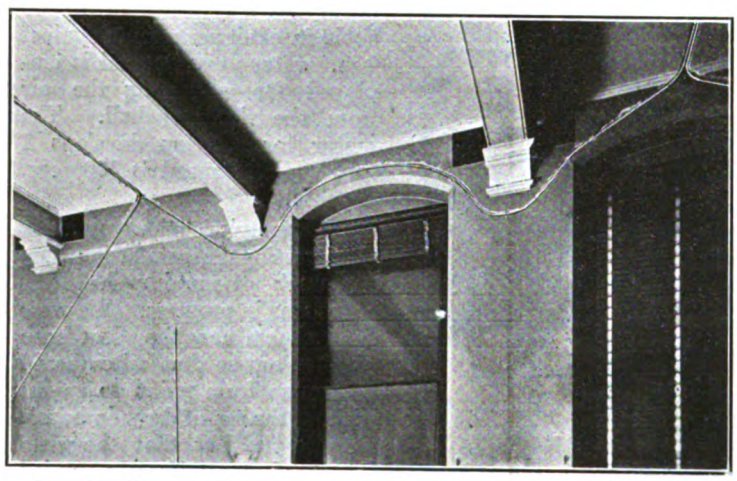

FIG. 5.—TYPICAL ILLUSTRATION OF THE EASY BENDS IN TUBES BY CUTTING CHASES IN THE WALL ROUND BEAMS, WINDOW FRAMES, &C. The wires are drawn in after the tubes have been plastered over.

bends from one switchbox to another or from a switchbox to a ceiling box.

The whole of the tubing for the sub-wiring of the Institution

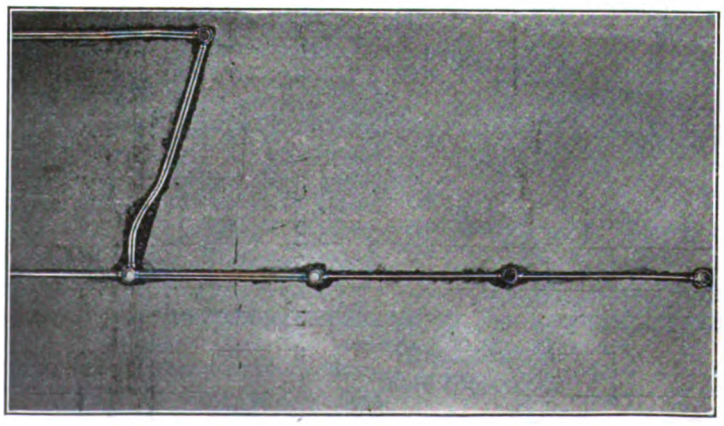

FIG. 6.—AN EXAMPLE OF CEILING WORK TAKEN FROM BELOW.

building was first erected, the plastering was carried out, and subsequently the wires were drawn in. There are no joints in the wiring, the looping-in system having been adopted throughout. This is according to specification, though, of course, it does not apply where flexibles or fittings wires require to be linked up to the wiring circuits. With fittings wires an ordinary soldered joint is made, and with flexibles the connection is effected with porcelain insulated connectors.

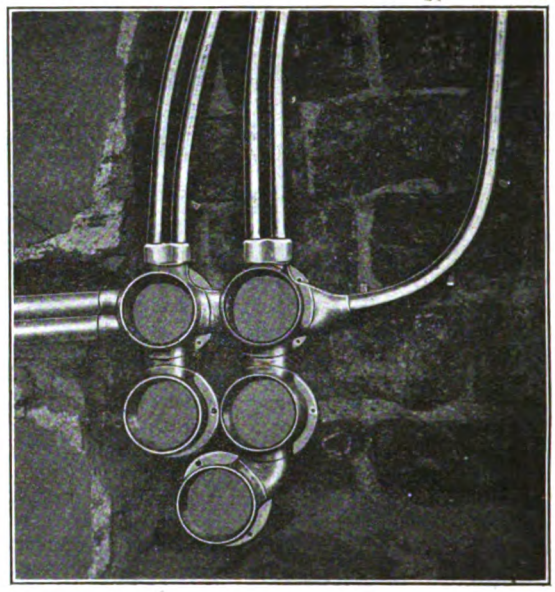

FIG. 7.—EXAMPLE OF CLOSE GROUPING OF SWITCH BOXES. The incoming leads enter by the two tubes on the left, are looped into the different switches and out again to the lights by the other five tubes.

In addition to the ordinary wiring system, circuits have been run for the Magneta clocks, which have been fitted in all the important rooms. Fifteen clocks have been installed, including the master clock, and these are principally of the open face wall type. In the secretary's office there is a magnetic timepiece on the fire mantel. The Sun Electrical Co. are the originators of the Kalkos system and manufacturers and suppliers of the tubes and fittings. They have supplied the whole of the Kalkos tubing and fittings for the new Institution building, and the actual erection has been carried out by Messrs. Drake & Gorham, Ltd.

Our thanks are due to Mr. P. H. Wigg, of Messrs. Drake & Gorham, Ltd., for his kind assistance in the preparation

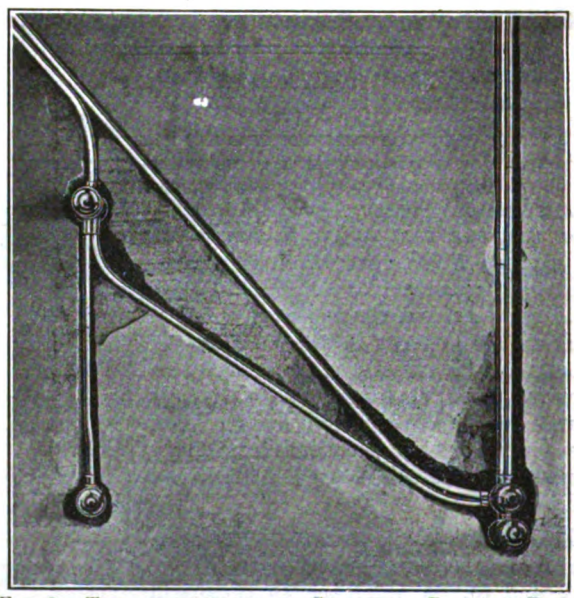

FIG. 8.—TYPICAL GROUPING OF SWITCH OR BRACKET BOXES. When the photograph was taken each box was temporarily sealed with a plasterer's cap.

of this article. The greatest credit is due to his firm, as contractors, for the very excellent manner in which the work has been carried out.

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THE MECHANICAL MEASUREMENT OF THE WORK OF HYSTERESIS OF IRON IN A ROTATING FIELD.

BY G. VALLAURI.

Summary.—After reviewing the work of other investigators of this subject, the author gives his own results, which are in substantial agreement with those of previous observers. The angle of lag between the magnetising force and the intensity of magnetisation was also determined.

The dissipation of energy termed hysteresis which occurs in iron when subjected to a state of variable magnetisation has been chiefly studied for the case of an alternating magnetic field, the direction of which keeps constant. Although this occurs in practice, as, for example, in the case of the cores of static transformers, yet this simple condition does not always obtain, the direction of the magnetisation changing as well as its intensity. It becomes necessary, therefore, to obtain data of the loss which occurs in iron when subjected to a rotating magnetic field.

The existence of hysteresis in a rotating field ought to reveal itself by the presence of a couple tending to oppose the rotation of the field, or, what is equivalent, if we represent the intensity of magnetisation and the magnetising force by vectors **I** and **H** respectively, the vector **I** will lag behind the vector **H** by an angle of lag ϵ. The couple per unit of volume will be

$$\mathbf{H}\,\mathbf{I}\sin\epsilon,$$

and the work done per cycle becomes

$$w_r = \int_{\delta}^{2\pi} \mathbf{H}\,\mathbf{I}\sin\epsilon\, da.$$

For an isotropic material where **H** **I** and ϵ are constant, this reduces to

$$w_r = 2\pi \mathbf{H}\,\mathbf{I}\sin\epsilon.$$

The Molecular Hypothesis and Rotary Hysteresis.—It was at first considered an argument against Ewing's molecular theory of magnetism that rotary hysteresis vanished in fields of very great intensity. This, however, is not the case, and the molecular theory is really supported by the observation. Consider a body of iron subjected to an alternating magnetic field. During the period when the magnetising force passes through its zero value the molecules, which, by their grouping under the action of the magnetising force, produce the phenomena of magnetisation, have an opportunity of re-forming themselves into groups and chains. These groups are, however, broken up as the magnetising force increases again and a loss of energy occurs.

With rotating magnetising force, however, this is not the case, as the molecules are always under the action of this force, and have no opportunity for re-forming their arrangements. No energy will, therefore, be lost, and the direction of magnetisation will always coincide with that of magnetising force.

Previous Researches.—F. G. Baily measured the couple acting on a small bundle of iron or steel discs in a rotating field, calculating the eddy currents on the basis of a hypothetical distribution of the flux in the discs. The induction was carried up to a value of $\mathbf{B} = 20{,}000$. The same iron was also tested with alternating magnetisation. For rotating magnetisation the loss reached a maximum at $\mathbf{B} = 16{,}000$ and then rapidly decreased.

Grau and Hiecke tested a single disc in a manner similar to that of Baily, and found a maximum at $\mathbf{B} = 13{,}000$. They maintained from theoretical considerations that the maximum rotating hysteresis occurred for a value of $\mathbf{B} = 2/\pi$, the saturation value, and was equal to the maximum alternating hysteresis. For low inductions they considered that the rotating hysteresis should be twice the alternating.

Beattie and Clinker, also experimenting on a single disc hung by a torsion wire in a rotating field, found a maximum loss at $\mathbf{B} = 16{,}000$, falling to zero at $\mathbf{B} = 24{,}000$. Beattie also experimented on nickel and cobalt and obtained similar results to those with iron.

Martens revolved discs of iron in the earth's field, and measured the angle of lag ϵ, which he found to be greater the softer the iron.

Dina experimented on a ring made up of iron wire, causing it to rotate in the field of a dynamo and measuring the heating. He found the rotating hysteresis to be greater than the alternating for values of **B** up to 10,000 and less from 10,000 to 18,000, but the differences do not reach 10 per cent. These results are supported by tests made by Bloch.

Schenkel rotated iron discs in a fixed magnetic field and obtained a maximum loss at $\mathbf{B} = 16{,}000$, reducing to about 8 per cent. of the value at $\mathbf{B} = 23{,}000$.

Bauwens measured the angle of lag ϵ in a dynamo running idle by finding the position of the brushes for which there was no P.D. between them. He found increased as **B** was raised up to the value of 11,000.

Wecker, rotating metal rings in the interior of a solenoid, obtained values of the hysteresis greater than the alternating values, but never by more than 20 per cent.

Hermann, using a ring-shaped stamping wound with wire traversed by polyphase currents, and measuring the loss by means of a wattmeter, could detect no difference between the rotating and alternating hysteresis.

Weiss and Planer, using a rotating field created by powerful electromagnets in which was suspended a disc of soft iron, obtained values of the rotating hysteresis greater than the alternating hysteresis for values of **B** up to 15,000. The rotating hysteresis was a maximum at $\mathbf{B} = 16{,}000$, and diminished to zero at 21,500. Steel and nickel behaved similarly.

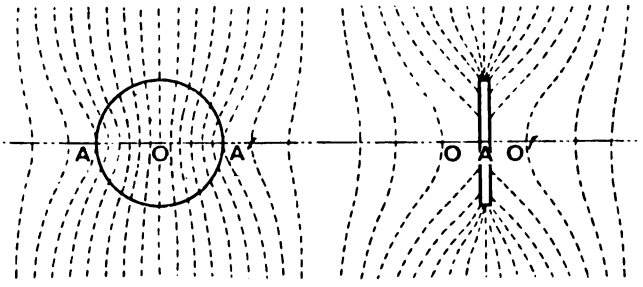

FIG. 1.

Vallauri carried out tests on an iron tube magnetised by two orthogonal fields, measuring the values of **I** and ϵ, and deducing the value of the rotating hysteresis $w_r = \int_{\delta}^{2\pi} \mathbf{H}\,\mathbf{I}\sin\epsilon\, da$. The rotating hysteresis was a maximum at $\mathbf{B} = 13{,}200$.

Summarising these results it will be seen that those of Bloch, Dina, Wecker and Hermann differ from those of the other experimenters, in that in their experiments the hysteresis measured is not in general a pure rotating hysteresis, but is a mixture of alternating and rotating and from the form and dimensions of the tests it will be seen that the first must in general prevail, so that the net result will not be far different from the case of a pure alternating hysteresis.

The other experiments give fairly concordant results, although to these measurements some objections may be made. They are somewhat handicapped in most cases by the smallness of the samples tested, which requires very delicate measurements of the couple

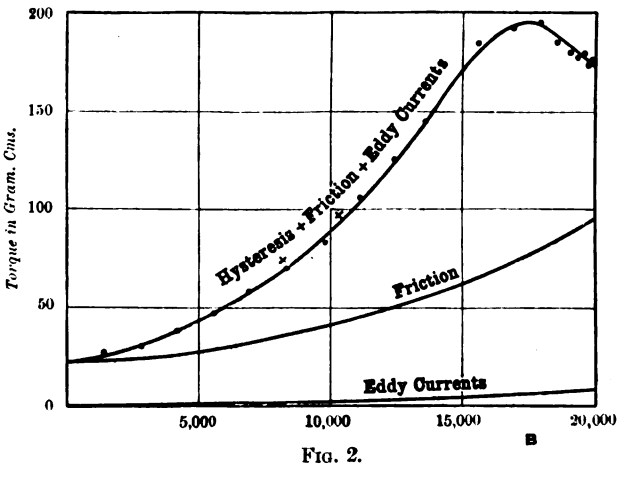

FIG. 2.

Revs. per min., 208.

and renders uncertain the measurements of the induction **B**. They also require high values of the velocity of rotation and consequently large losses due to eddy currents.

In practically all these experiments it is, moreover, doubtful whether the field in the specimen was uniform or whether it was not really of the shape shown in Fig. 1, in view of the distances between the test specimen and the polar extremities which were purposely made large in order to diminish the magnetic attractions.

The Author's Experiments.—In these tests a horse-shoe magnet of considerable size (area of cores 28·3 cm.²) was mounted on the end of the shaft of a 1·5 H.P. direct-current motor, and the magnet was fitted with suitably shaped pole-shoes formed so as to embrace a cylindrical space of 8·15 cm. diameter, in which was arranged the specimen consisting of a number of iron armature stampings of various diameters from 7·5 cm. to 8 cm. These discs had a thick-

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ness of 0·332 mm. and were insulated from one another by paper. The total quantity of iron in the specimen was about 70 cc.

Owing to the magnetic attractions due to slight and unavoidable defects in the centring of the specimen, it was found necessary in the final tests to employ a diameter of specimen of only 7·6 cm. and to support the end of the shaft which carried these in a small bearing fixed to the magnet frame. This, of course, is open to the objection that it introduces a friction couple which has to be allowed for.

The couple acting on the specimen was balanced by means of a pair of adjustable weights sliding on a bar.

The flux passing through the specimen for different values of the magnetising current was measured ballistically by means of a coil of thin wire wound on a diameter of the specimen. This was used in conjunction with a ballistic galvanometer of long period of swing. Substantially the same values were obtained whether the magnet was rotated through 180 deg. or its exciting current was reversed.

It was also possible, by causing the search coil to assume successive angular positions, to investigate the distribution of flux in the gap so as to see whether the hysteresis was purely a rotating one. If this is to be so the distribution of flux density normal to the surface of the specimen must follow a sine curve. The form factors of three different measurements made by means of the search coil were 1·14, 1·14 and 1·13, as against 1·11 for the sinusoidal case.

It was further ascertained that even at velocities considerably greater than those actually employed the couple due to the movement of the air set up by the rotation of the magnet system was quite negligible, so that no error is anticipated on this score.

Measurements of the couple acting on the specimen were made for both directions of rotation and include in each set about 20 values

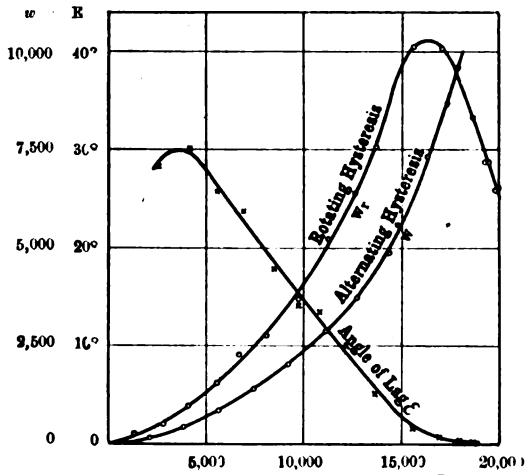

FIG. 3.

for inductions varying from a minimum of 1,300 to a maximum of 20,000. Between two measurements the current was cut off for a time so as to keep the temperature conditions constant. Although it was found that even after running for a quarter of an hour at 312 revs. per min. and B = 20,000, the heating of the bearing was scarcely sensible and the specimen was quite cool. Before taking a reading the current was reversed several times and measurements taken with increasing or decreasing currents were found to present no systematic differences.

Measurements were taken at speeds of 104, 208 and 312 revs. per min., and the mean values given refer to a speed of 208 revs. per min. Notwithstanding the presence of friction and eddy current effects the curve shows a well-marked maximum corresponding to the point of maximum hysteresis.

Separation of Effects of Hysteresis and Friction from Total Couple.—The separation of the eddy current losses was accomplished by taking measurements at the three speeds given. Subtracting the couple exerted at 104 revs. per min. from that at 312 revs. per min., and assuming the proportionality of the eddy current loss to the square of the frequency, the mean couple at 208 revs. per min. due to eddy currents only was obtained. From this was deduced the value of the coefficient β which had to be inserted in the equation

$$w = 2\beta\delta^2 n^2 B^2,$$

where w is the loss, δ the thickness of the laminations and n the frequency, the factor 2 being introduced to take account of the fact that eddy current loss is twice as great for a revolving flux as for an alternating one.

This gave a value of $\beta = 0{\cdot}000228$, which agrees well with Epstein's figure of 0·000224. Using this figure the curve of eddy current torque given in Fig. 2 has been drawn.

The torque due to friction has been separated by means of tests made on the starting friction with the magnet system stationary. This was observed with various values of the flux density. The running friction was also measured with the field magnet revolving but deenergised. The starting friction was thus found to be equal to 1·52 times the running value, and it is assumed that this relation holds good right throughout the series.

The friction was found to follow a relation of the form $y = a + bB^2$, which is to be expected, as the load on the bearing was made up of two parts, viz., the weight of the specimen and the force due to defective centring in the magnetic field. Knowing the values of both the eddy current and friction torques, that due to hysteresis is found by subtraction.

From the results has been drawn the curve in Fig. 3, which gives the hysteresis loss at different values of the flux density B, and which shows a well-marked maximum value of 10,400 ergs for B = 16,000, falling to 6,300 for B = 20,000.

Comparison with Alternating Hysteresis.—Tests were made on 60 rings 11 cm. × 8 cm. diameter, punched out of the same sheet as the specimens, wound with wire and tested ballistically in the ordinary way. The relation w_r'/w_a', which for low values of B is equal to or slightly over 2, becomes unity at B = 17,800 and steadily decreases towards zero.

The Angle of Lag.—For the expression given earlier in the Paper, viz.—

$$w_r' = 2\pi H I \sin\epsilon,$$

we may without any serious error write

$$w_r = \tfrac{1}{2} H B \sin\epsilon,$$

and from the values of w_r obtained from the tests ϵ may be calculated. It is found to have a maximum value at about B = 4,000, and tends to a zero value at saturation.

The angle of lag was also observed experimentally by placing a search coil on a diameter of the specimen and arranging a contact breaker to connect the terminals of the coil to a ballistic galvanometer at a definite point in every revolution of the magnet. The contact maker having been adjusted for a maximum deflection the direction of rotation was reversed, and the angle through which the search coil had to be revolved to give again a maximum was equal to twice the angle of lag ϵ. This, again, gave a maximum at about B = 4,000.

ASSOCIATION OF CONSULTING ENGINEERS.

On Wednesday of last week, a meeting, presided over by Sir William Preece, K.C.B., F.R.S., was held at Caxton Hall to consider the desirability of forming an Association of Consulting Engineers, the object of the Association being to improve the status of the profession and to place it on a more satisfactory basis than hitherto.

Invitations had been issued to a number of consulting engineers, at the instance of a Provisional Committee, and the invitation was signed on behalf of this Committee by the following members:—

Representing Civil Engineering: Messrs. W. T. Douglass, E. L. Mansergh, Midgley Taylor and Henry Rofe.

Representing Electrical and Mechanical Engineering: Messrs. B. M. Jenkin, W. M. Mordey, Llewellyn Preece and James Swinburne.

Representing Gas Engineers: Messrs. C. G. Hunt and E. H. Stevenson.

Mr. A. H. Dykes, as hon. secretary of the Provisional Committee, read letters of regret at their inability to attend the meeting from Messrs. Charles Bright, E. M. Lacey, C. Hunt, H. Humphreys, W. H. Patchell, C. P. Sparks, W. T. Douglass, H. Rofe and J. F. C. Snell, all of whom expressed themselves as being heartily in sympathy with the objects of the meeting.

Mr. MIDGLEY TAYLOR, who presided at the opening of the meeting pending the arrival of Sir William Preece, who was detained, said that the object of calling the meeting was to form an Association of Consulting Engineers. The subject had been before several consulting engineers for the past two years, or more, and as some initial step had to be taken, the members who originally took the subject up formed themselves into a Provisional Committee and had held a large number of meetings, with the result that the present meeting had been called to confirm, or otherwise, the action taken by the Committee in the past. The object of the meeting was to see whether the general idea of the formation of the Association met with the approval of consulting engineers in this country. Everyone knew that quite recently the Institution of Civil Engineers had helped the consulting engineer to the best of their ability by form-

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ing rules for professional conduct, and he was sure that every engineer would feel that that was a step in the right direction. He had no doubt that from the point of view of the Council of the Institution of Civil Engineers they (the Council) had gone as far as that body could go. He thought the membership of the Institution was something approaching 10,000; probably the regular consulting engineers in this country were not 5 per cent. of that body, and therefore the self-appointed Committee considered that the Council of the Institution could not, in the very nature of things, give all the protection that was desirable for the consulting engineer. He wished to emphasise the point that the Committee had not been working in any antagonism to the Institution of Civil Engineers, but had been endeavouring to go one better than was possible for that body. He felt that the public wanted protecting. At the present time, if municipal authorities erected works, even of large magnitude, they were not compelled to employ a qualified man to advise them, and there was nothing to prevent an absolutely unqualified man going to the particular authority, touting for the work and being employed. Under those circumstances he felt they should endeavour to form an Association such as would not only protect themselves, but would also protect the various public bodies and persons in this country who were anxious to get a properly qualified man to advise them on engineering works. He felt that those unqualified men who endeavoured to take the work out of one's hands, even after the appointment had been made, should not have the standing that would belong to the members of a body such as it was proposed to form. The Committee hoped that the meeting would result in the formation of the Association, but at the same time they wanted to have an open expression of opinion from everyone, whether they were favourable or otherwise. He then called upon Mr. James Swinburne (who had interested himself in the movement from the very beginning) to propose the formation of the Association.

Mr. JAMES SWINBURNE formally proposed that the Association be formed at once, but he first wished to say that the self appointed Committee had met with many difficulties. First, there was an idea that there was some antagonism between the proposed Association of Consulting Engineers and the Institution of Civil Engineers and other institutions. The only thing that a body like the Civil Engineers could do was to frame rules of etiquette which were very good things in themselves, but which really limited the powers of the genuine consulting engineer rather than helped him. It was, therefore, necessary that consulting engineers should work in sympathy with the Institution of Civil Engineers and other institutions, and that they should, in addition, form an association themselves, not for the purpose of technical papers but purely to guard the interests of consulting engineers as such, and of the public in so far as the latter were bound up with the interests of the consulting engineer. The great difficulty in forming an association was that people were apt to split over small differences of opinion. He therefore asked the meeting to look at the matter as broadly as possible, and not to consider whether any particular rule interfered with their own ideas. He also urged the older members of the consulting profession not to stand aloof because they were in a position sufficiently independent not to be affected by the malpractices of those who were not genuine consulting engineers. By lending their names to the movement they would be helping the younger consultant, who was the man to be looked after. As to the rules that had been circulated, the idea was not to adopt them immediately. All they could do was to say whether they were going to have an Association of Consulting Engineers or not. If they were, then they had to appoint something—a temporary committee or something of that sort—to which the details of formation and rules of the Association could be handed over for consideration to be finally approved by the members of the Association. In the case of this first meeting it was obviously impossible to make the list of invitations as complete as the Committee would desire. It was hoped that any who had not yet been communicated with, would understand that the Association was intended to cover the broadest possible field consistent with its objects, and that those corporate members of the Institution of Civil Engineers who were practising purely as consulting engineers, would, by sending in their names, assist the Secretary in compiling his list of membership for submission to the Committee.

The motion having been seconded by Mr. E. L. Mansergh, a general discussion took place.

Mr. E. H. STEVENSON remarked that he only wished such an Association had been started 20 or 30 years ago, and although it might not now affect the older members like himself, it would be of very great assistance to the younger consulting engineers. Mr. Robert Hammond dwelt upon the importance of such an Association from the public point of view. Although a private company was quite at liberty to have work carried out in any way that might seem desirable, in the case of municipal work it became highly desirable that public money should be spent only under the guidance of properly qualified engineers. A good deal of the discussion turned upon the question of the name of the Association. Thus, Mr. A. H. Preece, whilst expressing on behalf of his firm entire accord with the step that had been taken, thought that a committee might be sufficient without any formal Association. On the other hand Mr. Swinburne, Mr. Midgley Taylor, Mr. Lowcock, Mr. Hammond and others, were strongly in favour of an Association with a Council, owing to the fact that such a body would carry more weight with Government officials, Courts of Law and the general public. Mr. W. M. Mordey saw no objection to the formation of an Association from the point of view of adding to the already long list of societies, because its functions would be very different from those of the ordinary society. He was of opinion that a great deal depended upon the selection of a suitable name, and he thought it would be best to call the society an Association.

There was also some discussion as to whether the term "consulting engineer" was altogether the best to be adopted in the name of the Association. Mr. Druitt Halpin thought it was undesirable, but other speakers thought it was difficult to substitute any other term. Mr. A. P. I. Cotterell asked whether the Institution of Civil Engineers were in favour of the scheme, as otherwise the Association might come in conflict with the Institution sooner or later, which would be highly undesirable. In reply to this question Mr. A. H. Dykes said that he had received a letter of a most sympathetic nature from the Secretary of the Institution of Civil Engineers.

The formation of the Association was also supported briefly by Mr. Campbell Swinton, Mr. B. M. Jenkin and Mr. H. W. Handcock.

Sir WILLIAM PREECE, who had arrived during the discussion and had taken the chair, said he was entirely in sympathy with the movement. Most of the discussion had been on the question of the name which was not very important at the moment. He assured them of the sympathy of the Institution of Civil Engineers, and he was sure that the Committee of the Association would be received heartily by the Council in the discussion of any points that might arise. What they wanted was to band themselves together as brothers in a similar profession with a very strong committee and strong chairman. He then put the resolution, that the Association be formed, to the meeting, and declared it to be carried unanimously.

The Chairman then read the list of names of the suggested Committee, the names being as follows:—

As representing *Civil Engineering:* Baldwin Latham, S. R. Lowcock, E. L. Mansergh, Henry Rofe and Midgley Taylor.

Electrical and Mechanical Engineering: Messrs. Robert Hammond, B. M. Jenkin, W. M. Mordey, W. H. Patchell, Sir Wm. Preece, J. F. C. Snell, James Swinburne.

Gas Engineering: Messrs. C. Hunt, E. H. Stevenson and Henry Woodall.

No further names being forthcoming, the Committee were elected as above, with power to add to their number, to take what steps they considered desirable for the formation of the Association, and to formulate rules to be submitted to a general meeting to be called in the autumn.

Mr. B. M. JENKIN explained the lines on which a code of rules had been drawn up by the Provisional Committee, and placed them formally at the disposal of the new Committee. The Committee drew up a set of rules which they handed to the Institution of Civil Engineers for consideration. There was a proposal at that time that the Institution might distinguish in their list of members between those acting as consultants and others, but the Council were not prepared to do so. The object of the rules was to define what a consulting engineer was, and one of the objects of the Association was to make all consultants join together and work together along definite professional lines. That was extremely difficult, as one could only define a consulting engineer by saying what he could or could not do, but it was hoped that the rules would define pretty clearly what he might or might not do, and would be a help to young consultants as to what their professional conduct should be, and teach the public what a consulting engineer is. The idea was to print the rules with a list of members, so that anyone who wished to obtain a consulting engineer could consult the register. The rules were not complete, or in their final form, but were issued primarily with a view to discussion later.

Mr. JAMES SWINBURNE proposed the election of Mr. A. H. Dykes as honorary secretary, reminding the meeting that the success of the matter was entirely due to him, and this was seconded and carried unanimously.

Mr. DYKES responded briefly in accepting the position, and the meeting terminated with a vote of thanks to Sir Wm. Preece for presiding.

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Amongst those who accepted the invitation to the meeting or who wrote that, whilst unable to be present, they were in sympathy with the movement, were: J. S. Alford (Messrs. Chatterton & Alford), Walter Beer, W. I. E. Binnie (Messrs. Sir Alexander Binnie, Son & Deacon), Charles Bright, F. Broadbent (Messrs. Wilkinson & Broadbent), H. R. J. Burstall, H. R. Carr, A. P. I. Cotterell, A. T. Coode (Messrs. Coode, Son & Matthews), W. R. Cooper, Martin Deacon, A. L. Dearlove (Messrs. Clark, Forde & Taylor), R. A. Dawbarn, W. T. Douglass, A. H. Dykes, S. Moore-Ede, Tom Ekin, Percy Griffith, Robert Hammond, Robert Hammond, jun., H. W. Handcock, K. P. Hawksley (Messrs. T. & C. Hawksley), G. W. S. Hawes, H. M. Hobart, H. H. Humphreys, C. Hunt, F. H. Jones, B. M. Jenkin and J. M. Kennedy (Messrs. Kennedy & Jenkin), Baldwin Latham, E. M. Lacey, S. R. Lowcock, E. L. Mansergh and W. L. Mansergh, John May, J. C. Mellis, C. H. Merz (Messrs. Merz & McLellan), E. W. Monkhouse, William M. Mordey, W. H. Patchell, A. F. Phillips, Sir William Preece, A. H. Preece, Llewellyn Preece, Henry Rofe, Henry Rofe, jun., A. M. Sillar, A. T. Snell, J. F. C. Snell, E. J. Silcock, C. P. Sparks, E. H. Stevenson, James Swinburne, A. A. C. Swinton, Midgley Taylor (Messrs. Taylor, Son & Santo Crimp), W. C. Unwin, Robert Weekes, Henry Woodall (Messrs. Corbet Woodall & Son), A. Valon, G. A. Yourdi.

The honorary secretary of the Association is Mr. A. H. Dykes, of 1, Victoria-street, Westminster, S.W.

STANDARDISATION OF FUSES.

We give below an account of the discussion that took place at the meeting of the Birmingham local section of the Institution of Electrical Engineers when Mr. H. W. Kefford read his Paper on the above subject. An abstract of this Paper appeared in our issue of May 27th.

Mr. J. F. Crowley thought it was desirable that fuses should be so standardised that it was impossible for one of the wrong capacity to be put in circuit. He took exception to one point in the Paper. The author, in treating of the minimum limiting current of a fuse, had referred to four hours as a practical time to allow. He thought that this should be increased to six hours or even more. He would also like a better definition of the short-circuit test. The capacity of the circuit and also its inductance must be taken into account. Possibly one reason for the somewhat chaotic state of the fuse question was that cut-outs were extensively used instead of fuses. For small currents he thought that fuses were the correct thing.

Mr. A. E. Gott took objection to the statement in the Paper that fuse selection was decided on considerations of ornamentation. There was no doubt, he thought, that they were getting nearer and nearer to the solution of a perfect fuse, but they had not reached finality yet. The overloads allowed by the author on his fuses before they blew seemed rather too small. A fuse should not be expected to save plants from overloads which if continued would injure them; its proper function was to save them from destruction under abnormal conditions. Where small margins of operation were required, the right thing was to use circuit-breakers, which could be set for any desired overload or time limit. These were more reliable and dissipated less power. Short fuses under certain conditions of the circuit failed to cut off the current, and so supply authorities had insisted on definite lengths for certain currents and voltages. The P.D. loss over such a fuse was the price of real safety. The economical fuse of the future would probably be a fraction of an inch in length, but with a mechanical means for increasing the gap at the moment of fusion. Nothing had been said in the Paper about the porcelain which formed the body of the fuse. As a general rule this was of bad quality, and it would probably pay manufacturers to go to some trouble to get a suitable variety for the purpose. The author had stated that the limiting current was a perfectly definite quantity but the speaker disagreed with that, because the effects of a draught had not been taken into account. With some types of fuses the opening of a door would considerably affect the limiting current.

Mr. Lindsay Foster said that he had found the use of asbestos-covered wire for fuses made the explosion when a fuse blew much less violent. As to regulations for the interchangeability of fuses, these would be of great value; but the day for them had not as yet arrived.

Dr. Kloss referred to the question of the supply company fixing a definite minimum length between the poles of a fuse. This was all very well with the old type of fuse, which when it blew produced an arc, but it was not right that such restrictions should be made to apply to fuses in which there was no arc produced. He would like to take the opportunity of pointing out again how important it was in drafting specifications not to stick to certain words which had been in use in past times, but always to specify what was required—the object and not the means. If the object only were specified, the designer was left freedom to develop new ideas.

Mr. Shaw asked up to what size the fuses were made so that they could not be tampered with by an incompetent man. With larger currents it was generally the case that the man in attendance was not incompetent.

Mr. A. M. Taylor thought that in the case of a fuse connected to 'bus bars, with a large amount of power behind, the rush of current was far greater than indicated by the instruments. He had made some rough calculations of the rate at which the temperature of a fuse would rise on short-circuit with definite currents flowing, and he had come to the conclusion that it was not possible for a fuse to blow in the short interval of time frequently observed, unless the rush of current was very great indeed. This, he believed, was the reason for some of the alarming things which Mr. Kefford had shown in the photographs.

The Chairman (Mr. R. K. Morcom) remarked that, once things became standardised, one got authorities laying down limits, and they generally laid them down as inconveniently as possible. He believed that any standardising of fuses would lead to even more tampering with circuits than at present.

Dr. D. K. Morris, in a written communication, said that the author gave at the end of his Paper a suggested basis for a specification for standard fuses. As a device for opening a circuit on overload through the heating effect of such overloads, the fuse had until recently been the only apparatus available. It was interesting, however, to notice the remarkable way in which the thermally operated time element circuit-breaker now met all the requirements of the author's specification. In addition, the circuit was always ready for immediate closing without the delay in replacing and re-wiring a fuse.

Mr. Kefford, in reply, thought that Mr. Taylor had arrived at such remarkable results owing to his having neglected to take into account the rise in resistance of the copper with the temperature, which would greatly decrease the time taken to blow the fuse and bring the results of calculation and observation into line. As for the question of standardisation, if the time had not then arrived he really did not know when it would. With regard to Mr. Shaw's inquiry, the gauge rings could be easily altered if one had the key. To the ordinary user there was, however, nothing to show that it was not a part of the fitting. Competent mechanics would, no doubt, find all sorts of dodges for changing it, but would have to answer for it afterwards.

ACTINIFEROUS RADIO-ACTIVE EARTHS.

[Communicated.]

The researches in the laboratory of M. and Mdme. Curie at Paris, which led to the discovery of radium and polonium, have had several other interesting results, scientific and practical. Amongst the latter are the so-called actiniferous earths of permanent activity, which have been the subject of prolonged clinical experiments by the French pathologists. These "earths" are constituted from the bye-products of the process involved in the separation and extraction of uranium, and form the residue of the ores used for that purpose, their activity being due to that remarkable element actinium, discovered by Becquerel, of which so little is known. It has been known for some time that the curative effects of the "mud baths" of Bohemia are due to their radio-active properties, although prior to the discovery of radium and radio-activity the cause was unknown, or ascribed to chemical agency. Unfortunately, the potency of these earths or muds disappears when they are exported, and this was ascribed to some obscure change in their chemical constitution, by which the volatile beneficient elements in them became dissipated. Now, however, it is known that the existence of the radio-active emanations which give these earths their pathological value is limited to a definite period, and, therefore, the earths must be used when fairly fresh, *in situ*, or, in other words, during the life of the emanations.

The actiniferous earths, the residue of the uranium extraction, are, however, not subject to these objections; not only have the French pathologists shown that they may be utilised with success for all purposes where natural mud baths are employed, but for other cases and with more varied application; and, lastly, they can be transported without loss of their radio-active properties—indeed, their radio-activity is permanent. This apparent paradox is due, firstly, to the misuse of the word "radio-active," which term, originally applied by Becquerel to the activity of certain elements, has since been associated more largely with radium and its action of dissipating its atomic energy, which is, however, not strictly permanent; and, secondly, to the fact that these residues owe their so-called radio-activity principally to quite another element, namely, actinium. The ores from which uranium is extracted are, in contradistinction to the source of radium, minerals other than pitch-blende, and others not containing silicates. On analysis, the residues are found to consist of oxide of iron, alumina, phosphoric acid combined with iron and aluminium, oxide of uranium, oxide of manganese, carbonates and sulphates of sodium, oxide of silicon, sulphate of lead, carbonate of calcium, and, finally, the "radio-active" elements actinium, polonium and radium. The last is, however, present in such small traces that it is quite negligible, whilst polonium disintegrates so rapidly that its effect may also be considered nil. But the new element actinium, to the life of which no period has at present been set, is the radio-active factor of

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importance in these residues, or earths, which owe practically all their activity to its presence, and have, therefore, been named "actiniferous."

The comparison of the radio-activity of actinium and radium is interesting. The French method is to take the spherical activity of uranium as the standard, and with this equal to unity, it is calculated that the approximate activities of radium and actinium are 2,000,000 and 20,000,000 respectively, whilst that of the actiniferous earths is 0·15, and from this it is estimated that the earths contain $\frac{1}{3000000}$th of their weight of actinium.

Radium, as is well known, gives off three kinds of "rays," which have been called the *alpha*, *beta* and *gamma* rays. The *alpha* rays are small particles shot off at a very high velocity, which find a difficulty in penetrating metals, except very thin aluminium and natural organic substances. The *beta* rays are particles about one thousand times as small as the *alpha* rays, having a velocity from three to 10 times as great, and are capable of penetrating metals more easily. The *gamma* rays are vibratory, similar to X-rays, and are still more penetrative. Actinium gives off three kinds of rays like radium, and these, for purposes of convenience, have been called *alpha*, *beta* and *gamma*; the first two are corpuscular, and the third vibratory, but, so far as is known, the resemblance is a relative one only. It has been found possible, however, to arrange a table of the breaking down of actinium, which shows an interesting similarity to that of the radium group.

	Half life.		Radiation.
Actinium	?	.....	inactive.
Radio-actinium	19·5 days	.....	alpha
Actinium X	10·2 „	.....	„
Emanations	3·9 weeks	.....	„
Actinium A	36 months	.....	beta
Actinium B	2·15 „	.....	alpha
Actinium C	5·1 „	.....	beta, gamma

This table shows that actinium differs from radium in two important respects, namely, that the *alpha* rays are given off in large quantities, whilst the *beta* rays are quite uniform, whereas in radium they are divided into *beta* soft, *beta* medium and *beta* hard.

The actiniferous earths present several other points of interest besides those of the purely physical aspect, in which there is a large field for investigation, and these may be referred to briefly. For instance, on the biological side, whilst their *alpha* and *beta* rays are known to affect adversely vital organisms when applied in large doses locally, if the dosage is spread over a large area the harmful effect is said to be eliminated. The emanation, also, may be employed for prolonged effects to any vital organism without any apparent injurious action. On the therapeutical side there is much to be said. The presence of the emanation permits of *a priori* investigations along the same lines as those employed for the applications of mud baths, with more successful results in view on account of the actiniferous origin of the emanation, its constancy, the coexistence therewith of *alpha*, *beta* and *gamma* rays, the large proportion of the *alpha* rays, and finally, the fact that these earths are 50 times more radio-active than the natural earths, or mud baths. Further, in comparison with the applications of radium salts, the actiniferous earths present several advantages. The former, although they have much larger spherical activities (varying from 500,000 downwards according to the form of applicator or screen employed) are confined to a more or less limited part of the body. The earths, however, being applied in the form of a soft paste, may be spread over as large a surface as desired for direct application, or they may be suspended in water and the patient can be subjected to a radio-active bath. Now, whilst the activity is only 0·15, which implies that a centigramme spread over a square centimetre has a spherical radiation of 0·15, if this figure be multiplied by the area of the surface over which the earths are spread (and more than a centigramme may be applied per unit area), it is possible to obtain a much stronger dosage of radiation than with a radium applicator, although the specific activity is so much weaker. In consequence of the local action being mild, the applications may be prolonged—in fact, from several hours to several days, without (it is claimed) harmful results. It has been shown by experiments of the French doctors that the actiniferous earths have no antiseptic action which might tend to neutralise their vital effects on the tissues, nor do they act like a caustic or a poison. In fact, although microbes are not killed in their presence, the stimulating action they set up tends to dissipate infection. It is hardly within the province of this article to deal with the pathological aspect of these new earths, but reference may be made to the researches in Paris, which have shown excellent results in the treatment of rheumatism, neuritis, gout, eczema, rheumatoid arthritis, gonacoccal rheumatism, &c. It is, of course, well known that vibratory massage will stimulate the muscles to resume their normal healthy state in diseases of this description, and it would almost seem as if the mild, but prolonged bombardment of the cellular tissue by the corpuscles thrown off from the actinium, produced a whipping or vibratory effect of an extremely beneficient nature. The earths are applied by coating the affected parts with a layer, sterilised if necessary, and covering this with oiled silk to preserve the moisture and thus to ensure the production of emanations. If the earths become too dry they may be moistened with water, and they can be used over and over again because the activity is permanent. The duration and frequency of the applications depend, of course, on the nature of the case. Another method of application is by baths. This is necessary when the indication is general rather than local. About 250 grammes of earth are usually used for a bath of about 50 gallons, the temperature being 37°C. and the application half an hour. If necessary, a local bath may be employed or even injections.

The study and applications of actiniferous earths are, however, only in their infancy. But sufficient has been done abroad, as shown by this brief record, to indicate that they have valuable scientific and therapeutical properties; and the investigation of actinium, having a radio-activity 10 times as great as radium, with the parallel researches in regard to its effect on the diseases of the human organism, will be watched with interest and sympathy.

MAGNETIC DISTURBANCES AT KEW.*

BY C. CHREE, SC.D., F.R.S.

A recent Paper† discussed the diurnal inequality of Kew magnetic declination derived from 209 of the most highly disturbed days of the 11 years 1890 to 1900. The present Paper discusses the corresponding phenomena for the same days in the other magnetic elements. The most prominent features of disturbed days are the irregular nature of magnetic changes and the frequency of large oscillations. These more obvious features have hitherto engrossed attention. It is found, however, that the irregular changes on disturbed days are accompanied by large regular diurnal changes, which are specially striking in vertical force. In declination and horizontal force the range of the regular diurnal inequality on disturbed days is in the average month of the year about double that on quiet days, but in vertical force the former range is fully four times the latter. Disturbance affects the type as well as the range of the diurnal inequality. The former influence is comparatively small in horizontal force and the component to geographical north, larger in declination and the component to geographical west, and largest of all in vertical force. On quiet days the characteristic feature of the vertical force inequality is the fall in the forenoon to the minimum about 11 a.m. and the rapid rise in the early afternoon. Disturbed days, however, approach to a type in which there is a minimum about 4 a.m.—near the principal barometric minimum for the day—and a maximum at from 4 p.m. to 6 p.m., according to the season. The day rise and the night fall are about equally rapid. On disturbed days the shorter period Fourier "waves" in the diurnal inequality for V become of reduced importance relative to the 24-hour wave, and this wave has its phase some four hours earlier than on quiet days. Vertical force inequalities from the disturbed days of the four sunspot maximum years, 1892–1895, show a considerably larger range than those from the whole 209 days, and their phase angles depart more from the phase angles for the quiet days of the 11 years.

The question of the seat of the forces to which the regular diurnal inequality is due turns largely on the vertical force phenomena, and it is thus clear that different results may be reached according to the extent to which the disturbance element enters into the data employed. Dr. Schuster, employing results from 1870, a year of exceptionally large sunspot frequency, and Dr. Fritsche, employing data from miscellaneous years, have reached notably different conclusions. The results of the present Paper emphasise the importance of securing as great uniformity as possible in the data from different stations. It is suggested that three sets of diurnal inequalities might be published, representing respectively quiet days, highly disturbed days and intermediate days. If the diurnal inequality is due, as Dr. Schuster concludes, to electric currents associated with the movements of the upper atmosphere, the increased conductivity of these regions due to increased ionisation may account for the increased amplitude of the regular diurnal inequality at sunspot maximum, or on days of magnetic disturbance. But it is not obvious how it can account for large differences in phase angles between quiet and disturbed days, or for the difference that manifests itself in the effects of

* Abstract (from the "Proceedings") of a Paper read before the Royal Society.

† "Phil. Trans.," A, Vol. CCVIII., p. 205.

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disturbance on different magnetic elements. It is possible that the variation with altitude in the electric conductivity of the air is altered, so that appreciable effects are experienced on disturbed days from electric currents in layers which are normally ineffective. Thus differences between the upper air movements at different heights might make their presence felt.

If magnetic storms were of approximately constant length—under 24 hours—and followed on the whole a similar course, then the existence of a regular diurnal inequality on disturbed days might mean that storms commenced more often at one hour of the day than another, and not that the forces modifying the nature of the phenomena were largely dependent on local time. Influences of this kind do not improbably have some effect. The time, however, during which magnetic conditions remain highly disturbed is very variable. Of the 209 days included in the Paper only 64 were days of isolated disturbance; the remaining 145 were all preceded or succeeded by days also classified as disturbed. There are several other reasons for concluding that the diurnal inequalities discussed in the Paper indicate in the main a true daily variation, independent of the stage that the magnetic disturbance has reached. An inspection of individual vertical force disturbances of short period showed that when these occurred in the late afternoon there was almost invariably a rise in the force, whereas if they occurred in the early morning there was a fall.

It was found, however, that the non-cyclic changes experienced on disturbed days did depend in a marked way on the stage reached by the disturbance. When a disturbance lasts for two days, or more, the usual phenomenon is for westerly declination, horizontal force and vertical force to fall during the first day and rise during the second. The fall on the first day predominates in the case of the horizontal force, the rise on the second day in the case of the vertical force.

In ion-emission theories of magnetic storms—such as that of Prof. Kr. Birkeland—the question of the height and extent of the hypothetical electric discharge turns largely on the vertical force phenomena. The fact that so large a proportion of the vertical force range during magnetic storms proves to represent a regular diurnal inequality seems not unlikely to prove a crucial test for such theories.

SOME NOTES ON A TRIP TO THE NORTH AMERICAN CONTINENT.*

BY MAJOR W. A. J. O'MEARA, C.M.G.

Summary.—The author gives an account of the various telephone and telegraph installations visited by him on his recent trip to the United States. Useful comparisons are drawn between American and English practice, especially as regards the commercial and engineering organisation.

The success of the American in engineering and commercial enterprises is widely acknowledged, and I therefore endeavoured to ascertain during my hurried journey through the United States and Canada to what this success could be fairly ascribed. I have no hesitation in stating that from September 16th, the day I investigated the organisation of the New England Telephone Co. in Boston, and the methods adopted by its officers in handling telephone propositions, to December 21st, that last day which I spent at the offices of the American Telephone & Telegraph Co. in New York with Mr. J. J. Carty, I was struck by nothing more than the broad-mindedness of the officials engaged in the telephone and telegraph industries of the New World, and the orderliness in the management of those undertakings behind the scenes of which I was, through generosity and kindliness, allowed to penetrate.

At the time that the first rudimentary telephone exchange was established in Boston, in the year 1877, the original telephone patents were acquired by the American Bell Telephone Co. This company, now known as the American Telephone & Telegraph Co., was in consequence put into a position to control the telephone situation throughout the United States, and has done so most successfully. At one time and another some 43 so-called Bell companies have been incorporated under separate boards of directors, and have carried on local service telephone exchanges under licence from the parent company; these licensee companies have at the same time provided the "short haul" trunk lines. The so-called "long distance" service, that is to say, the lines connecting the systems of the associated operating companies with one another, is owned and operated by the American Telephone & Telegraph Co., and in consequence the trunk line service as known to us is partly owned by the licensee companies and partly by the parent company. The American Telephone & Telegraph Co. also holds stock in the Western Electric Co., and exercises a very complete control over the policy of this concern. In consequence, the American Telephone & Telegraph Co. is further able to maintain its lead in the van of telephone progress by keeping closely in touch with the latest developments in the field of invention.

On the North American continent the telephone and telegraph systems are ranked among the engineering enterprises of the land, and it is therefore not surprising to find the prominent position which is accorded to the engineering department in the organisation of the American Telephone & Telegraph Co. In the words of Mr. Theodore Vail, the president of this company: "The engineering department takes all new ideas, suggestions and inventions, and studies, develops and passes comments upon them. It has under continuous observation and study all traffic methods and troubles, improving or remedying them. It studies all construction, future development and extension schemes, makes plans and specifications for the same, and gives, when desired, general supervision and advice."

Whilst I was in New York I had many opportunities of closely watching the working of the great deliberative machine so ably presided over by Mr. T. Vail, and so well managed by Mr. H. B. Thayer, one of the vice-presidents of the company. The first thing which naturally attracted attention was the complete absence of the huge files of correspondence so familiar to those who work in Government offices. The functions of the various departments of the American Telephone & Telegraph Co. are very clearly laid down, and since decentralisation exists in its completest form, the business of the company is transacted by the heads of departments in personal interviews with the president and vice-president. It is this procedure which accounts for the absence of the files of correspondence to which attention has been drawn, and to it is also due the fact that the staff attached to the offices of the president and vice-president are reduced to microscopical proportions. In the case of the American Telephone & Telegraph Co. I understand that about half a dozen stenographers comprise the whole of what would constitute the administrative section in a large British public department. Another point which came under my observation was the close personal relationship which exists between Mr. Carty and the chief engineer of the Western Electric Co., Mr. C. Scribner. When one considers the character of the problems which telephone and telegraph engineers have to handle nowadays it is not difficult to realise how great must be the advantages which cannot fail to result from the close personal intercourse of the chief engineers of the manufacturing and operating departments of the American Telephone & Telegraph Co.

Mr. Carty's mission is to provide for the handling of telephone traffic in an efficient manner, it naturally follows that one important sub-division of his department devotes itself to the study of traffic questions. A second sub-division deals with questions relating to equipment, &c., by means of which the traffic must be handled. The work of these two sub-divisions is closely associated, as the problems of the one interact on those of the other. In order to produce the highest efficiency with the greatest possible economy it is absolutely necessary to consider the traffic problems in relation to the design of equipment and vice versa. Mr. Carty put it well when he informed me that his responsibilities "covered the design of the guns and ammunition, and also the manner in which the ammunition was to be used and the guns fired." But he further impressed upon me the fact that his responsibilities did not end here. For, if a telephone undertaking is to be a commercial success, it is a further duty of the engineer to follow carefully every change in the commercial policy of the company with which he is associated, since matters relating to tariffs, concessions, &c., all in turn produce reactions both on the internal equipment and external plant, and such reactions often demand important modifications in the engineering plant to meet the altered traffic requirements arising from a change in policy.

In America a commercial department has been instituted for selling telephone service. Secondly, in order to enable the telephone companies to fulfil their part of the contract after the bargain for the service has been entered into, the necessary equipment and plant have to be designed, installed and maintained; the responsibility for this work is provided for by the plant department—*i.e.*, the engineering department as known in our service. Finally, when the equipment and plant are in position it necessarily follows that measures have to be adopted for bringing them into service, and the responsibility for this work is placed upon the traffic department. A feature of this organisation which struck me as admirable lies in the fact that the heads of these three departments have the same title, viz., that of superintendent—that is to say, they are on the same level as to rank, and thus human sentiment is very largely cared for. It is safe to say that with such an organisation business getting will be

* Abstract of an article in the "Post Office Electrical Engineers' Journal."

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much more effectively organised and carried on; the equipment and plant will be better designed and constructed, and maintained at lower cost, and the operating will be of higher quality and exhibit greater efficiency. The concentration of effort, the conserving of special skill, the co-ordination and co-operation within each functional department, will also tend naturally to the acquisition of the greatest efficiency in each department of work.

In my young days it was frequently impressed upon me that the best results would always follow if subordinates, however lowly in rank, were given an opportunity to do at least one thing on their own responsibility. This idea has been made a principal feature in the functional organisation in the form in which it has been introduced in America. I found that every effort is made to push responsibility down the line, and hence it is that in every grade officials know that there are always certain things in which no further authority than their own judgment is required for the execution of prescribed works. I could not help noticing the spirit of enthusiasm which is thus engendered, and I readily believe that this results in work of so superior an order that the cost of the mistakes which may be made from time to time is paid for many times over by the greatly increased output of work of every official in the great telephone organisation of the Bell interest. Such an arrangement also has the merit of developing the most useful attributes of man, and hence there is no lack of the proper material for filling the highest administrative posts.

Telephones.

It seems hardly necessary for me to say much on the technical side of telephone engineering. We know how thorough our American cousins are in all they put their hands to. Their success is entirely due, in my opinion, to the scientific spirit in which they approach a subject. No changes are introduced until a complete investigation into each aspect of the situation has first been made. A novelty has to be "tested out" and "proved in" before it has any chance of acceptance. So far as service by means of the multiple switchboard is concerned, not much room for improvement has been left for some years past. However, American telephone engineers have not been content to rest on their oars, and many improved features of a minor character have been introduced into the service; for example, the study of traffic conditions has resulted in the introduction of the ancillary jack, which provides for calls appearing at two or more positions, and thus facilitates team working.

The question of the location of the trunk exchanges has not been, I fear, as deeply studied by us as the importance of the subject demands. In the case of the multi-office urban areas it is as necessary to study the economics of the location of the trunk exchange as it is to determine the theoretical centre for a local exchange. The problem is certainly a somewhat complex one to deal with, since it is difficult to assess the relative values of the variable factors which are introduced by the necessity of providing trunk circuits which must serve as sections of channels of communication between several widely separated areas as well as serving as direct channels between closely associated areas. In the case of many cities where the arbitrary attitude of the local authorities has caused us to contemplate the substitution of underground cables for aerial conductors, a study of the transmission efficiencies of those circuits which are built up of many component parts in order to provide a means of communication between the more widely separated centres has certainly indicated the desirability of erecting such conductors on pole lines constructed on routes outside the jurisdiction of disobliging corporations. The American telephone engineers have had seriously to face this problem, since not only do the cities in the United States cover immense areas, but at times the city authorities impose serious restrictions in the construction of open lines. In those cases in which a large number of trunks has to be provided for use, partly for local purposes and partly for extension or through traffic, the location of the exchange is determined by the section of copper required within the city limits to provide for transmission efficiency of the standards adopted for the circuits which have to be installed—that is to say, the question of cost in relation to the transmission efficiency required to meet the various traffic conditions is the ruling factor in deciding whether the trunk exchange shall be located within the city limits or outside the same. At three of the centres visited by me, Buffalo, Chicago and Philadelphia, the "long-distance" exchanges were situated at some distance outside the boundaries of these cities.

As was to be expected, a very complete study has been made of "loading" problems, and practical trials are being made over "loaded" aerial circuits. Many difficulties have been successfully overcome, and during my stay in New York an opportunity was afforded me of talking with Chicago on a "loaded" aerial circuit. The distance is about 1,000 miles, and the conductors are 420 lb. copper to the mile. Even under the adverse atmospheric conditions which prevailed it was quite possible to understand my correspondent in Chicago.

Some very useful information was given me concerning the interferences caused to long-distance telephone circuits by the electrification of railways, and ingenious methods have been devised for partly eliminating the disturbing currents, but the additional apparatus which has to be introduced into loops for this purpose seriously reduces the efficiency of the circuits for telephone purposes. The invention of telephone repeaters has received considerable attention, and they have been installed in quite a number of circuits, but unfortunately I had no opportunity of making observations on any circuits so equipped.

Automatic and Semi-automatic Exchanges.

Perhaps of all the interesting questions which were discussed, the most important is that relating to the development of the automatic and semi-automatic equipments. It was my good fortune to see no less than five different types of switch equipment, designed to provide automatic and semi-automatic telephone service, and I also had the advantage of discussing the question of providing service by means of these new types of equipment, not only with those who advocate these systems, but also with those who are opponents of the automatic systems. A matter which has been much debated is that relating to the probable attitude of the public towards a service provided by means of full automatic systems. The question naturally arises whether the public will take kindly to the task of calling their correspondents when once the novelty of the apparatus has worn off. I think the non-committal answer of "wait and see" is the safest at the present moment. True, at the present time, some 200,000 full automatic stations are in operation in North America, and the advocates of the system point to this fact in support of their contention that the public prefer this system. On the other hand, the opponents of the system claim that it is the novelty of the thing which appeals to the public, and suggest that the users are also stock-holders in the operating companies, that the pleasure arising from a feeling of ownership in the plant is responsible for the enthusiasm, where such exists, and that as soon as the plant begins to age, and the service in consequence shows signs of deterioration, the present feeling of satisfaction will give place to one of disgust. The whole question certainly requires the serious consideration of telephone engineers in this country. We have yet to learn from actual experience whether the automatic and the semi-automatic equipments provide sufficient flexibility to cover the wide range of requirements of the British public, how far the mechanism is reliable in the care of such men as we can train to maintain it, and how the cost of first installation and the annual charges in respect of depreciation, maintenance and traffic operation compare as a whole with similar costs in respect of existing types of installation. Clearly, if the new designs of equipment on "testing out" actually "prove in," there can be no doubt as to the course we must be prepared to adopt.

Comparative Costs of Electric Traction Systems.—In a Paper recently read by Mr. F. Darlington on this subject the author stated that estimates prepared for the electrification of about 100 miles of single-track railway, with about 25 miles of side tracks and with heavy gradients to be climbed and very heavy and frequent trains to be handled, showed the total cost of direct-current transmission and distribution apparatus, including sub-stations, to be £476,200, and for single-phase alternating current with transformer stations £202,200. These figures are based on 1,500 volts with a third rail for direct current and 11,000 volts with an overhead trolley for single-phase current. The difference in cost of the two distribution systems is £274,000. However, the single-phase locomotives for the same railroad would be more costly than direct-current locomotives by about £74,900, but this amount is only about one-quarter of the difference in the cost of the transmission and distribution appliances. In discussing the Paper, Mr. L. R. Pomeroy said that the advocates of electric traction had been dwelling on only a small portion of the various elements involved in the cost of transportation and that the effectiveness of engineering recommendations was somewhat diminished by the fact that the advice given was not always disinterested. He remarked that the electrical achievements thus far made, while mainly confined to passenger traffic, had shed little light, except in special cases, on the larger problem of freight train operation.

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Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON

(ONLY ADDRESS.)

Tel.: Holborn **6363** (Two Lines). *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."

All Editorial communications to be addressed to THE EDITOR. Letters for insertion in "THE ELECTRICIAN," or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.

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With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fifty-first issue of the Supplement is published (Gratis) with the current number of "THE ELECTRICIAN."

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THE ASSOCIATION OF CONSULTING ENGINEERS.

For the last two years we have strongly advocated the formation of a society for protecting the interests of consulting engineers, and we have pointed out from time to time the futility of expecting any existing institution to carry out the work that is really necessary. An attempt to stop the unprofessional conduct that was bringing consulting engineering into disrepute was made some years ago by the Institution of Electrical Engineers, but it in no wise prevented the malpractices which the Institution had in view, and at the same time it weakened, if anything, the hands of those consulting engineers who wished to act in a truly professional spirit. Last year the Institution of Civil Engineers took the matter up, and adopted a certain code of rules, and this year the Institution of Electrical Engineers have taken further action by adopting identically the same rules as those of the parent Institution. But, however good the intention of such rules may be, it is impossible to expect bodies representing so many varied interests to legislate very effectively for one particular group, and that group by no means a large percentage of the whole.

In another column our readers will see that steps have now been taken to form an Association of Consulting Engineers. We heartily welcome this movement. For the last two years the matter has been under consideration, and, although it may seem that progress has been slow, there is every

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indication that a very good beginning has now been made. It will be noticed that the new Society is not restricted to the electrical profession. It embraces civil engineers (using the term in its more restricted sense) and gas engineers as well, so that a very large field of engineering is covered. Also, there need be no fear that the new Society is in any sense run by a clique, as the invitation to attend the meeting held last week was backed by names which were certain to carry weight, and a representative gathering was the result. The proceedings showed entire unanimity of opinion, and the committee that was elected to carry the matter forward cannot fail to bring the Society into prompt recognition.

It may be well to point out that the new Society is in no way antagonistic to existing societies, and that it does not propose to read technical Papers, or to add to that output of technical literature which many people feel to be already too large. This assurance will come as a relief to any of our readers who may have had such an idea. Primarily the object is to raise the standard of the profession of consulting engineering. We, therefore, hope that it will be supported by the goodwill of many who are not themselves consulting engineers. For example, there is the general public. Hitherto there has been no easy means of finding out who was, or who was not, a consulting engineer; much less was there any means of determining the qualifications of any engineer who styled himself a consultant. From the point of view of the public this was very unsatisfactory, and has doubtless led to the carrying out of a great deal of indifferent work, and has produced much dissatisfaction. As mentioned by Mr. MIDGLEY TAYLOR at the meeting last week, there is nothing to compel a municipal authority to employ a properly qualified man to advise them, even in works of large magnitude; and if such a man is appointed, attempts to dislodge him in favour of an engineer with doubtful qualifications, and who does not mind touting for the work, are not unknown. Nor is this the only way in which the public may suffer. If the programme of the new Society is carried out, the public will feel that some protection is provided, as the tendency will be to employ only those consulting engineers who are members of the Society; and the fact that they are members will be some guarantee of their qualifications and that they are guided by the recognised rules of professional conduct.

It is equally important, however, that other engineers should recognise that the new Society will aim at the greater well-being of all things connected with consulting engineering, and in this respect we hope very sincerely that manufacturers and contractors will support the new movement and recognise that it is really to their advantage. There have been many complaints in the past of consultants who were not properly qualified, or who did not scruple to take advantage of the contractor in an unfair way. The true consultant acts in a semi-judicial capacity, and sees that not only does his client receive what is specified, but that the contractor also obtains fair play. It is to be hoped that unfair episodes will end once for all with the formation of the new Society, and we, therefore, trust that manufacturers and contractors will give it their cordial support.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Radiation, Light and Illumination. By C. P. STEINMETZ. (New York: The McGraw Hill Book Co.) Pp. xii. + 788. $3 net.

In the volume now before us we have another instance of the protean character (if the allusion may be pardoned) of Prof. Steinmetz's work. To most of us the author is known principally in connection with his extensive mathematical investigations on alternate-current phenomena, and his practical applications of this theory to electrical machinery. Those, however, who have been privileged to visit his private laboratory at Schenectady know that the problems of light production have had a special fascination for Prof. Steinmetz for many years past, and some of his work in this direction, notably as regards the magnetite arc, has been followed here with interest.

In the volume now before us we have the substance of a series of 13 lectures delivered at Union University. Unfortunately, no verbatim report was made, and Prof. Steinmetz has been obliged to leave the editing in other hands, with the result that a number of small errors have crept in; but, even so, the book is most valuable as being the only treatise which deals in a comprehensive and original manner with a subject which becomes daily of greater interest and importance.

The first chapter, or lecture, deals with the nature and different forms of radiation in a simple and clear manner. In introducing the undulatory theory, however, its inception is ascribed to Euler, and no mention is made of Huyghens, Young or Fresnel. On the same page two beams of light of equal amplitude and coincident phase are stated to give twice, instead of four times, the intensity of one. In dealing with X-rays on pp. 15-17, they are spoken of as oscillations having a wave-length of about $0{\cdot}01 \times 10^{-6}$ cm., although the view now more generally accepted is that they consist of sharp individual pulses produced by electronic impact. On p. 16 the blank space between the *longest* electric and the *shortest* ultra-violet light is spoken of. In the second lecture, on the relation of bodies to radiation, simple physical explanations of refraction and dispersion are given by the wave theory, of emission and absorption spectra, of reflection, colour and fluorescence. The author speaks of the *actual* or *objective* colour of a body, and also its *subjective* colour when viewed by a coloured source. The terms *absolute* and *relative* colour would perhaps be better, reserving *subjective* colour for the effect on the observer, who might be colour blind. On p. 30 lamp black is instanced as a black body, but not platinum black. The term *albedo* is employed to denote the whiteness of a grey body, being a coefficient which is unity for a perfectly white and zero for a perfectly black surface. A very interesting lecture is devoted to the physiological effects of radiation, starting with a description of the eye and of Fechner's law. In common with other writers on the subject, however, the author does not differentiate between the functions of the pupil and the retina in connection with this law. The useful and injurious effects of various kinds of radiation on the eye and the body are remarkably well treated.

Incidentally, the mechanical equivalent of light is given as having a value of 0·01 watt per candle, which is probably far too low.

After a short lecture on the chemical and physical effects of radiation, the laws of temperature radiation are discussed in lecture V. The Stefan-Boltzmann law (spelt Stephan) is given with a coefficient of $5' \times 10^{-12}$ which is lower than that of Karlbaum ($5{\cdot}32 \times 10^{-12}$) and of Féry ($6{\cdot}3 \times 10^{-12}$). Wien's and Planck's laws are quoted, but full justice is not done to their utility as regard temperature measurement and luminous efficiency. The classification of elements according to their melting points and the periodic law is done in a very effective diagram; the use of the term vapour *tension* is, however, objectionable. Carbon as a radiator is fully dealt with, and interesting remarks are made on the peculiarities of carbon produced in flames from various combustibles.

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Lecture VI., on luminescence, is one of the most interesting in the book, as it deals largely with Prof. Steinmetz's work on arcs, mercury, carbon, magnetite, &c. Several most original experiments as to the non-reversibility of the arc are quoted, and incidentally the value of the old "exploring carbons" as a method of investigating the distribution of potential in the arc is completely exploded. The titanium arc is described as having a consumption of 0·25 watt or less per mean spherical candle, but little mention is made of the quartz mercury vapour lamp.

The chapter on flames as illuminants and arc lighting are both interesting, but one would like to have seen more about the Welsbach and other mantles. However, some good works already exist on this subject. Lecture IX., on the measurement of light and radiation, is somewhat disappointing, photometry being treated in a very sketchy fashion and radiation measurement hardly touched. It is satisfactory to find that Prof. Steinmetz advocates discrimination as the basis of heterochromatic photometry, but the "luminometer" he describes is a very crude instrument, and no mention is made of the use of an artificial pupil, which is such an important adjunct. Two very complete lectures are given on light flux and illumination, with most exact calculations as to the light distributed from and received with various sources. Finally, two excellent lectures are devoted to illumination and illuminating engineering and to physiological problems, which are in every way most interesting and instructive, especially in connection with the present discussions concerning glare.

Prof. Steinmetz's new work will doubtless be read with attention by all interested in this important subject, and we hope that it will soon reach a second edition, when he will be able to perfect it.

C. V. DRYSDALE.

Les Oscillations Electriques: Principes de la Télégraphie sans fil. By C. TISSOT. (Paris: Doin & Fils.) Pp. xii. + 454. Fr. 5.

This volume is one of the Encyclopédie Scientifique series. It deals with the physics, as distinct from the technology, of electrical oscillations. Mathematical argument and experimental fact are agreeably blended throughout the work, but the former predominates. In the first 50 pages the reader is introduced to the general theory and formulæ of simple harmonic and damped harmonic vibrations. Then the laws of ordinary alternating current are discussed. The study of high-frequency electricity begins with a chapter on the production of oscillations, and proceeds with an account, mainly historical, of the work of Hertz and others on the propagation of electrical waves along wires and through space. The physics here is thoroughly up to date; that of the spark is set out in considerable detail, but that of the arc is not so fully treated as it might have been with advantage. The remainder of the book is almost entirely mathematical, and may be described as a summary or abstract of Hertz's discussion of the radiation from an oscillator and of the theory of the oscillations in coupled circuits as given by Bjerknes, Oberbeck, Wien and Drude. This summary, though purely academical, should prove useful to technical men, as it is written with an eye to modern applications and is otherwise very good. It will be seen from this survey of the book that it fills a very apparent lacuna in French electrical literature.

W. H. E.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

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"Proceedings of the Royal Society." Vol. LXXXIV. No. A568. Series A—Mathematical and Physical Sciences. (London: Harrison & Sons.) 2s. 6d.

"Practical Electro-Plating." By G. Gentry. (London: Percival Marshall & Co.) 1s. net.

"The Steam-Engine and other Heat-Engines." By J. A. Ewing, F.R.S. 3rd edition. (Cambridge: University Press.) 15s.

ANALYSIS OF LEAKAGE REACTANCE.

BY J. REZELMAN.

Summary.—The author continues his investigations into the leakage of the windings of alternating-current machines. The expression for the permeance λ_k is considerably simplified and made much more general; the expression for the slot permeance, too, is slightly modified. The leakages of many machines have been carefully analysed and the results are here given. Bar windings also are dealt with.

In the Paper on "Leakage Reactance," recently published by the author, certain coefficients have been introduced, their values having been found by experiment.

These coefficients vary with the type of winding, and we shall see in the following that it is necessary to make certain corrections in order that the formulæ shall become general. For this purpose we will consider a two-phase winding, and utilise the well-known property of the independence of the phases.

1. *Permeance* λ_k.—It has already been shown that

$$\lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + C_q + q\log\left(\frac{\tau}{(q-1)t_1}\times B\right)\right\}$$

in which the first term—$\log\left(\frac{\pi z_1}{r_1}\right)$—relates to the flux between the tips of neighbouring teeth, the factor C_q to the flux between the teeth which are not adjacent, and the last term to the flux embracing all the slots per pole and phase; τ represents the extent of the integration, and B a factor taking account of the curvature subtended by the polar arc.

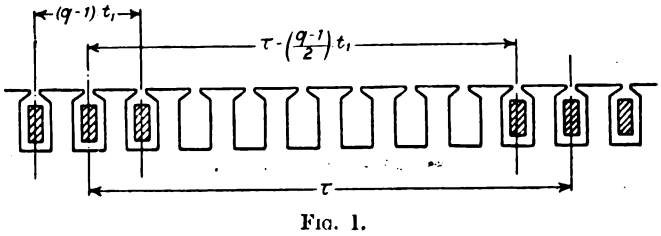

FIG. 1.

Let $\tau = Qt_1$ where Q = number of slots per pole; then the last term becomes $q \times \log\left(\frac{Q}{q-1}\times B\right)$. By inspection it is seen that the summation ought not to be carried over the whole polar arc; in fact, starting from $\tau - \frac{1}{2}(q-1)t_1$ (Fig. 1) the flux does not embrace most effectively all the slots per pole and phase.

We will integrate for a length $x = (Q - cq)t_1$ and have $\lambda_k = 0{\cdot}92\left\{\log\frac{\pi z_1}{r_1} + C_q + q\log\left(\frac{Q-cq}{q-1}\right)\right\}$, assuming that B = 1, that is to say, that the number of poles is very great.

To find the value of C, consider the case of a winding covering the whole polar arc ($q = Q$), in which case the last term $Q\log\left(\frac{Q-cQ}{Q-1}\right) = 0$; that is to say,

$$(Q - cQ)/(Q-1) = 1$$

and

$$c = 1/Q.$$

In general the last term will thus become: $q\log\left(\frac{Q - \frac{1}{Q}\times q}{q-1}\right)$, and we obtain for

$q = \frac{1}{2}Q$, that is, for one phase of a two-phase winding: $q\log\left(\frac{4q-1}{2q-2}\right)$.

$q = Q$, that is, for two phases in series of a two-phase winding: $q\log\frac{q-1}{q-1} = 0$.

$q = \frac{1}{3}Q$, that is, for one phase of a three-phase winding: $q\log\left(\frac{9q-1}{3q-3}\right)$.

$q = \frac{2}{3}Q$, that is, for two phases in series of a three-phase winding: $q\log\left(\frac{9q-4}{6q-6}\right)$.

It is well known that the permeance of one phase of a two-

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phase winding ($q=\frac{1}{2}Q$) is the same as that of the two phases in series ($q=Q$), it follows, then, that

$$C_q + q \log\left(\frac{4q-1}{2q-2}\right) = C_{2q}, \text{ and, for example, with } q=2:$$

$$C_2 + 2\log\left(\frac{4\times 2-1}{2\times 2-2}\right) = C_4, \text{ whence } C_4 = C_2 + 1{\cdot}09.$$

Now, the factor C only depends on the number of slots per pole and phase, and is zero for $q=2$, whence $C_4 = 1{\cdot}09$. Proceeding in this manner we have

$$C_4 + 4\log\left(\frac{4\times 4-1}{2\times 4-2}\right) = C_8, \text{ whence } C_8 = 1{\cdot}09 + 1{\cdot}59 = 2{\cdot}68,$$

and similarly

$$C_8 + 8\log\left(\frac{4\times 8-1}{2\times 8-2}\right) = C_{16}, \text{ whence } C_{16} = 2{\cdot}68 + 2{\cdot}76 = 5{\cdot}44.$$

The four values of C_2, C_4, C_8 and C_{16} enable us to plot the curve (Fig. 2), from which the values of C corresponding to intermediate values of q can be determined.

For a given type of winding the last term $q\log\left(\frac{Q-q\times 1/Q}{q-1}\right)$ has a value which, like C, only depends on the number of slots

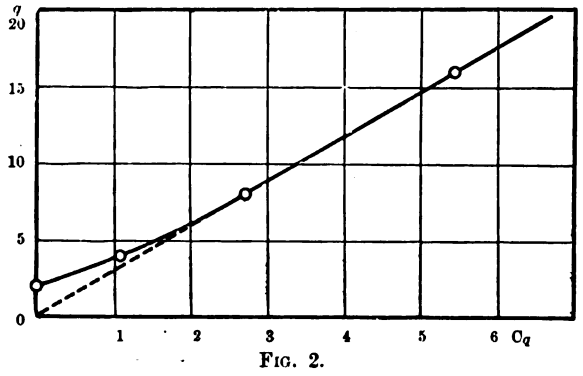

FIG. 2.

per pole and phase; we can thus combine these terms and write

$$D_q = C_q + q\log\left(\frac{Q-\frac{1}{Q}\times q}{q-1}\right).$$

We thus obtain, for a large number of poles,

$$\lambda_k = 0{\cdot}92\left\{\log\frac{\pi\times z_1}{r_1}\right) + D_q\right\}$$

where D_q has the values given below.

q.	Values of D_q for			
	$q=\frac{1}{2}Q$.	$q=Q$.	$q=\frac{1}{3}Q$.	$q=\frac{2}{3}Q$.
2	1·1	...	1·51	...
3	1·97	...	2·57	...
4	2·70	1·1	3·45	2·10
5	3·41	...	4·35	...
6	4·10	1·93	5·22	3·26
7	4·76	...	6·05	...
8	5·46	2·70	6·93	4·37
9	6·10	...	7·75	...
10	...	3·40	...	5·42
12	...	4·10	...	6·48
14	...	4·78	...	7·50
16	...	5·45	...	8·52
18	...	6·10	...	9·52

An examination of the above table shows that there is almost an exact proportionality between D_q and q, so that

$D_q = 0{\cdot}68\times q$ for a winding in which $q=\frac{1}{2}\times Q$.
$D_q = 0{\cdot}34\times q$ for a winding in which $q=Q$.
$D_q = 0{\cdot}875\times q$ for a winding in which $q=\frac{1}{3}\times Q$.
$D_q = 0{\cdot}545\times q$ for a winding in which $q=\frac{2}{3}\times Q$.

We have now to determine the augmentation of the permeance due to the curvature of the polar arc; we must thus add a term of the form $x_q\times q\log B$, where B is a factor depending upon the number of poles on the machine.

We write $x_q\times q$, being given that there is a contraction of the lines of force corresponding to C_q as well as to $q\times\log\left(\frac{Q-q}{q-1}\right)$; the coefficient x depends, therefore, on the number of slots per pole and phase. In addition, to fulfil the condition that the permeance of a winding $q=\frac{1}{2}Q$ is equal to that of a winding $q=Q$, it is necessary that $x_q\times q\times\log B = x_{2q}\times 2q\times\log B$, that is to say, $x_q = 2x_{2q}$.

By putting $x=1$ for a winding in which $q=\frac{1}{2}Q$, it follows that $x=0{\cdot}5$ for a winding $q=Q$. It being given that D_q varies in direct proportion to q for the same type of winding, we can take, with a very close degree of accuracy:

$x=1{\cdot}3$ for a winding $q=\frac{1}{3}Q$

and $x=0{\cdot}8$ for a winding $q=\frac{2}{3}Q$.

The complete formula thus becomes

$$q=\tfrac{1}{2}Q,\quad \lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + 0{\cdot}68q + 1\times q\log B\right\}$$
$$= 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + q\left(0{\cdot}68 + \log B\right)\right\}$$

$$q=Q,\quad \lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + 0{\cdot}34q + 0{\cdot}5q\log B\right\}$$
$$= 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{1}\right) + 0{\cdot}5q\left(0{\cdot}68 + \log B\right)\right\}$$

$$q=\tfrac{1}{3}Q,\quad \lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + 0{\cdot}875q + 1{\cdot}3q\log B\right)$$
$$= 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + 1{\cdot}3q\left(0{\cdot}68 + \log B\right)\right\}$$

$$q=\tfrac{2}{3}Q,\quad \lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + 0{\cdot}545q + 0{\cdot}8q\log B\right\}$$
$$= 0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right) + 0{\cdot}8q\left(0{\cdot}68 + \log B\right)\right\}$$

Applied to various machines on which λ_k has been determined by means of auxiliary coils, the following values of B were found:—

H.P.	p.	q.	Q.	B.	$(p+1)/p$.
220	1	5	15	1·9	2·0
220	1	10	15	1·96	2·0
4,500	2	4	12	1·545	1·5
4,500	2	8	12	1·6	1·5
175	3	6	12	1·36	1·33
175	3	12	12	1·36	1·33
175	4	3	9	1·23	1·25
175	4	6	9	1·24	1·25

It follows from the above table that the value $(p+1)/p$ can be taken for B.

2. *Permeance* λ_s.—In order to determine the accuracy of the formula $\lambda_s = 0{\cdot}46q_s\left(\log\frac{2l_s}{U_s} + A\right)$, experiments were carried out on the rotor coils of a turbo-alternator; the dimensions of these coils were in agreement with those normally met with in practice. Each coil consisted of 36 bars (1·7 × 21), arranged as in Fig. 3.

Table of Experiments.

Readings with a current of 10 amperes in coil.	Voltage measured on coil.					Current.	Freq.	Watts measured.	I^2R	$\frac{W}{I^2R}$
	a	b	c	d	$a+b+c+d$	I.	C.	W.		
a	6·4	4·0	2·6	1·6	15·2	10·0	50·0	7·5	4·9	1·53
$a+b$.....	10·3	9·35	6·0	3·6	30·0	...	...	18·75	9·25	2·03
$a+b+c$ ...	13·2	13·0	10·6	6·25	44·0	...	...	28·0	13·25	2·11
$a+b+c+a$	15·0	15·0	13·3	10·0	54·0	...	...	34·0	17·2	1·97
b	4·0	5·6	3·55	2·2	16·0	10·0	50·0	7·25	4·4	1·65
$b+c$.....	6·7	8·8	8·0	4·8	28·5	...	...	16·3	8·4	1·94
$b+c+d$ ...	8·5	11·0	10·6	8·5	39·0	...	...	23·75	11·85	2·01
c	2·8	3·6	4·6	2·8	13·5	10·0	50·0	6·0	3·95	1·52
$c+d$.....	4·35	5·6	7·3	6·3	24·5	...	...	12·5	7·45	1·68
d	1·8	2·2	2·8	3·7	10·0	10·0	50·0	5·15	3·5	1·48
$b+d$	5·75	7·5	6·2	5·8	...	...	...	...	...	...
$a+d$	8·2	6·4	5·4	5·35	...	10·0	50·0	...	...	...
$a-d$	4·65	1·85	0	1·85	...	...	...	...	...	...
$a+c$.....	8·8	7·45	7·0	4·3	...	10·0	50·0	...	...	...
$a-c$	3·55	0	1·6	0·75	...	...	...	...	...	...

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The wattmeter readings show that there are important additional losses; on making the corrections necessitated thereby, we obtain the following table:—

Coil.	Voltage.	Reactance.	Coil.	Voltage.	Reactance.
a	6·25	0·625	c	4·5	0·450
$a+b$	19·5	1·950	$c+d$	13·4	1·340
$a+b+c$	36·8	3·680	d	3·5	0·350
$a+b+c+d$	53·3	5·330	$d+b$	13·1	1·310
b	5·5	0·550	$a+d$	13·4	1·340
$b+c$	16·67	1·667	$a+c$	15·6	1·560
$b+c+d$	30·05	3·005			

The reactance

$$x_s=\frac{12\cdot5\times c\times w^2}{10^8}\times l_s\times\lambda_s=\frac{12\cdot5\times 50\times w^2}{10^8}\times l_s\times 0\cdot46\left(\log\frac{2l_s}{U_s}\times A\right)$$

$$=\frac{288w^2}{10^8}\times l_s\left(\log\frac{2l}{U_s}\times A\right).$$

l_s being the length of a half-turn and $c=50$, we have the lines of force through the coils themselves; A would probably have larger values with wire windings. In any case, it follows from the tables that the permeance varies sensibly according to the expression $\log\frac{2l_s}{U_s}$, and that it is essential in exact calculations that the circumference U_s should be introduced.

It would then be useless to use these experiments as a sole basis for determining the relationship between A, and at the same time R, and the dimensions of the coils; moreover, we shall see, from experiments made with this especial purpose on the stator of a three-phase 175 H.P. motor that the formula we have previously employed, is in perfect agreement with the nature of the actual phenomena.

Stator of a three-phase motor, 175 h.p., 8 poles, 50 cycles per second, 750 revs.; 3,000 volts between phases, the rotor being removed.

Coils in series.	l_s	U_s	$\frac{2l_s}{U_s}$	$\log\frac{2l_s}{U_s}$	w^2	$\frac{288w^2l_s}{10^8}$	$\frac{288w^2l_s}{10^8}\times\log\frac{2l_s}{U_s}$	x_s measured.	$\frac{288w^2l_s}{10^8}\times A$	A	R = x_s measured / x_s calc. (A = 0)
a	1,415	222	12·72	1·105	1,296	0·528	0·583	0·625	+0·040	+0·0758	1·070
$a+b$	1,353	299	9·05	0·956	5,184	2·020	1·935	1·950	+0·015	+0·0075	1·010
$a+b+c$	1,298	376	6·90	0·838	11,664	4·350	3·650	3·680	+0·030	+0·0069	1·001
$a+b+c+d$	1,235	453	5·45	0·735	20,746	7·380	5·420	5·330	−0·090	−0·0122	0·985
b	1,298	222	11·70	1·068	1,296	0·485	0·517	0·550	+0·033	+0·068	1·061
$b+c$	1,235	299	8·25	0·916	5,184	1·840	1·685	1·667	−0·012	−0·0065	0·990
$b+c+d$	1,180	376	6·30	0·799	11,664	3·950	3·150	3·005	−0·145	−0·0370	0·953
c	1,180	222	10·60	1·025	1,296	0·440	0·451	0·450	−0·001	−0·00227	0·997
$c+d$	1,119	299	7·50	0·874	5,184	1·670	1·460	1·360	−0·100	−0·0600	0·934
d	1,055	222	9·50	0·978	1,296	0·393	0·383	0·360	−0·023	−0·0585	0·940
$d+b$	1,180	376	6·30	0·799	5,184	1·760	1·405	1·310	−0·095	−0·0540	0·933
$a+d$	1,235	453	5·45	0·735	5,184	1·840	1·350	1·340	−0·01	−0·0054	0·992
$a+c$	1,298	376	6·90	0·838	5,184	1·935	1·620	1·560	−0·06	−0·0310	0·963

By taking the average value A = 0, the maximum deviation between the calculated and measured values only reaches ± 6 per cent., depending on the various shapes of the sections; it is

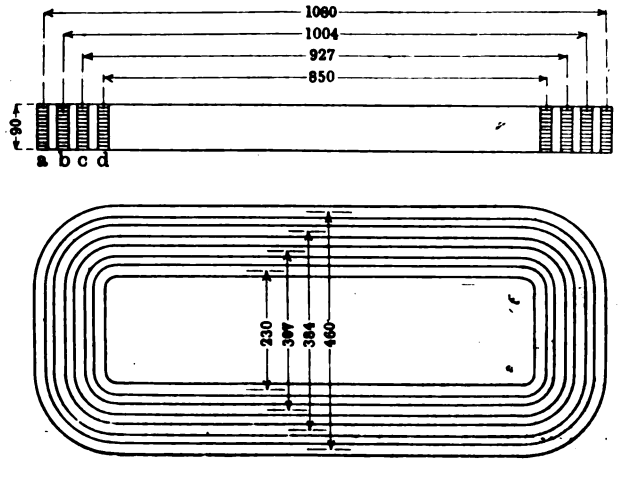

Fig. 3.

to be noted that a small error in the measurements will have a considerable effect upon the value of A, but only a small effect on the ratio $\frac{x \text{ measured}}{x_s \text{ calculated } (A=0)}$. In spite of great care the table shows that there are errors up to 5 per cent.; it is necessary that

(Line a.)		Line (a).		Line ($a+b$).
e_a	+	e_b	≷	e_{a+b}

that is to say, 6·4 + 4 ≷ 10·8;

similarly

(Line a.)		(Line b.)		(Line $a+b$.)
e_a+e_b	+	e_a+e_b	≷	e_a+e_b,

that is to say, 6·4 + 4 + 4 + 5·6 ≷ 10·8 + 9.35.

In addition, the flat copper impedes the free formation of

Dimensions.

$\phi_i=750$ mm. ..... $\tau=294$ mm.
$l=270-3\times7\cdot5$ mm. ..... $l_i=260$ mm.
72 slots (19 × 50) ..... $t_1=32\cdot7$ mm.
$S_n=23$ $p=4$ $q=3$.

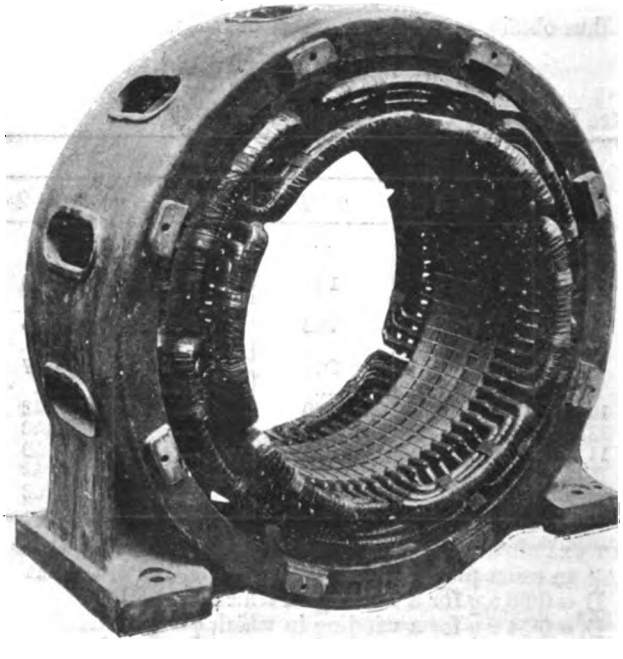

Fig. 4.

The stator of this motor is wound with consequent poles, there are thus four coils per phase; the 12 coils are arranged in two planes containing two coils of each phase (Fig. 4). It follows from this arrangement that the six coils in each plane can be connected in series and thus form a two-phase six-pole winding, with a split-phase winding, or winding per pole.

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The dimensions become

$\phi_s = 750$ mm. ..... $\tau = 392$ mm.
$l = 270 - 3 \times 7{\cdot}5$ mm. ..... $l_i = 260$ mm.
72 slots (19 × 50) mm. ..... $t_1 = 32{\cdot}7$ mm.
$S_s = 23$ p = 3 q = 6.

By a simple change in the connection of the coils we have thus transformed a winding per consequent pole into a winding per pole; the lengths of the outhang coils are the same for the two cases:

$l_s = 680$ mm., $l_{s_a} = 360$ mm, $l_{s_c} = 320$ mm.;

and also the periphery $U_{s_a} = 210$ mm. With the periphery U_{s_c} the values are not the same for the two cases.

In three-phase $U_{s_c} = 210$ mm., and in two phase $U_{s_c} = 470$ mm.

In order to separate the permeances λ_h, λ_s and λ_n experimentally, auxiliary coils were placed:—

1. Five wires in the slot opening of each of the three slots forming one coil, along the stator bore, the length of the slots of one pole;
2. 20 wires along l_i of one coil, in each of the two intervals.

Experiments.—Readings were taken:—

1. On one-phase of the three-phase winding.
2. On two phases in series of the three-phase winding.
3. In three-phase.
4. On one-phase of the two-phase winding.
5. On two phases in series of the two-phase winding.
6. On one coil separately, three slot coils, *a*, *b* and *c*.
7. On two slot coils, *a* and *b*.
8. On two slot coils, *b* and *c*.

Table of experiment.	Winding.	$e_{0-I.}$	$e_{I.-II.}$	Voltages on the auxiliary coils. e_h. Mea.	e_h. Red.	e_s. Mea.	e_s. Red.	I.	c.
I.	Phase 0 - I ...	101·3	109·0	2·24	41·2	2·33	32·1	10	51·5
II.	Phases I. and II. in series .	109·0	218·0	2·63	96·8	2·42	66·2	10	51·5
III.	Three-phase..	109·5	190 0	2·61	48·0	2·44	33·5	10	51·5
IV.	Straight coils	205·5	...	3·26	90·0	3·5	72·5	10	51·5
	Bent coils ...	207·5	...	...	...	...	...	10	51 5
V.	Straight coils	204·0	410·0	3·2	83·5	3·43	71 0	10	51·5
	Bent coils ...	206·0	...	...	...	...	...	10	51·5
VI.	Coils *a*, *b* and *c*	29·3	...	2·63	12·1	2·81	9·8	10	51·5
VII.	Coils *a* and *b*.	15·5	...	1·42	6·55	1·24	5·7	10	51·5
VIII.	Coils *b* and *c*..	14·1	...	1·32	6·08	1·03	4·73	10	51·5

Notes on the Test.—It is established that for a constant current of 10 amperes the voltage set up in the exterior auxiliary coils depends upon the winding traversed by the current.

1. One phase of three phase winding ..... 2·33 volts.
2. Two phases in series of three-phase winding 2·42 volts.
3. Three-phase ..... 2·44 volts.
4. One phase of two-phase winding..... 3·50 volts.
5. Two phases in series of two-phase winding 3·43 volts.
6. One coil separately ..... 2·84 volts.

It is also established that there is a slight positive mutual induction between the end coils of a three-phase winding, although wound per consequent poles. The chief point established consists in that the voltage induced in the exterior auxiliary coils, by one coil alone, is markedly greater than that induced by one phase of the three-phase winding.

The values l_i and U_s being the same in the two cases, this increase can only be put down to the absence of a demagnetising force, which thus proves experimentally the presence of an important negative mutual induction between the neighbouring coils of a consequent pole winding.

(To be continued.)

Hydro-Electric Development in Sweden.—According to the "Engineer," the Swedish Government intend to expend over a million sterling upon the establishment of an electric power station at the Porjus Falls, which are on the Stora Lule River, near the Gellivare iron district. Great hopes are entertained that a large industry will arise in the regions affected.

CORRESPONDENCE.

FISCAL POLICY AND THE ELECTRICAL INDUSTRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must once more remind Mr. Fitch that national prosperity depends not on the profits of employers but on the total production of wealth. I know how difficult it is for a manufacturer to realise this, but it must be realised if the subject is to be understood and usefully discussed. Also that, if there is a choice of producing for the home market or for a foreign market, the foreign market has the greater advantage for the working man. We, as the principal dumpers of the world, do our foreign trade at the lowest possible profit; and, consequently, in this trade, labour bears the greatest proportion to total value. In other words, the workman's share is larger as compared with the employer's.

For the rest, I am sure it would be better if your Tariff Reform correspondents would leave out of account the subject of my ignorance and want of intelligence and candour, as being of no general interest, and answer the simple question that I ask. It is, as I have said, fundamental; and if it is not answered Tariff Reform falls to the ground, notwithstanding the defects that they discover in me. Can they give the steps in the argument by which it is shown that Tariff Reform would increase employment, without assuming that imports are paid for with "golden sovereigns"? I gave the steps in the argument by which it is shown that Tariff Reform would reduce employment. This also remains unanswered. And that is how we stand at present—an argument for reduction; no argument for increase.—I am, &c.,

Birmingham, July 20. GEORGE HOOKHAM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall be glad if you will allow me a little space in which to reply to Mr. Bennett Fitch's letter in your issue of July 15th.

Mr. Fitch cites a hypothetical case. He asks us to suppose a case where "Smith's grandfather some 50 years ago made money and left him an income of £200 a year invested in a railway in Brown's country, this income being quite outside the trading question. Smith hears that motor cars, &c., are made very cheaply abroad, and writes to Brown not to send the £200, but to send instead that amount in motor cars, &c., as they are cheaper than he can make them at home. Under these circumstances the balance of money would remain equal. Our workers would lose profits and wages to the extent of £200 (less the value of raw material)."

Mr. Fitch's own words place him quite out of court as an economist, for it is the height of absurdity to claim that Smith's income can be regarded as being "quite outside the trading question." It is not, and cannot be, outside the question, for it implies the investment at a previous date of, say, £4,000 (which at 5 per cent. would bring in the £200 per annum) in the railway in Brown's country, which I will assume to be France. That £4,000 represents, directly or indirectly, British goods or British labour, and Smith's annual income of £200 is in the nature of the profit on the British labour expended. Mr. Fitch's case assumes that the motor car can be made more cheaply in France than here. Suppose Smith gets for his £200 a car which would have cost him here £250; what does it mean? Simply that Smith is £50 in pocket on the transaction, and this £50 he can spend in this country on other goods which will in turn find employment for British workers.

As a matter of fact, the purchase of the motor car is quite a separate transaction. Smith's grandfather employed British labour, and invested the proceeds in France, and Smith draws the profit; that is one complete transaction. Smith, having got his £200, can do what he likes with it, and, being a sensible man, he buys something which he needs in the cheapest market where he can get it. That is a second and quite separate transaction.

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Returns show that the goods which come into this country in payment of interest on our investments abroad are in an overwhelming proportion in the nature of raw materials, which, to quote the words of another of your correspondents, ensure a great gain of employment to the country.

Mr. Fitch is amusing when he quotes a German Protectionist newspaper to show that England is a decadent country. Judging from the Board of Trade returns for the present year we can afford to go on "decaying" at our present rate for quite a long time to come.

Mr. Glendenning, in his letter in your issue, says the primary object of scientific tariffs is the exchange of our manufactures for the other nation's raw material. But why adopt a tariff, "scientific" or otherwise, when we already attain that object by our Free Trade system?—I am, &c.,

Free Trade Union, Manchester, July 18. J. ANDERSON.

LIQUID MICROPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of July 15, 1910, a liquid microphone by Mr. F. J. Chambers is described. I think that Mr. Chambers is to be congratulated on his application of a liquid microphone to large currents as used in wireless telegraphy. I may mention that in the year 1879 I made and used a liquid microphone ("Nature," October, 1879, and the "Telegraphic Journal," November, 1879) in which the area and hence the resistance of a small column of a liquid conductor, either stationary or flowing, was controlled by the vibrations of a diaphragm attached to a glass valve which controlled the flow. Subsequently, in November, 1892, I constructed a liquid rheostat, which acted as a transmitter or microphone, in which a jet of conducting liquid flowing on to a platinum plate inclined at an acute angle to it was actuated by a vibrating diaphragm. When these liquid microphones were put into a telephone circuit the articulation was excellent, quite smooth and free from grating sounds. Experiments with the latter were shown at the Junior Science Club, Oxford, in 1892. I never experimented with currents of large value such as employed by Mr. Chambers, nor did I follow the matter up, as experts in telephonic work seemed to think that the employment of a liquid would render the apparatus unfit for practical telephony.—I am, &c.,

Lymington, July 18. F. J. JERVIS-SMITH.

SUGGESTED MEMORIAL TO THE LATE H. W. COX.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you open a fund for raising a memorial to the late H. W. Cox? When a naval or military man performs some heroic deed in war it is customary, I believe, for the commanding officer to refer to it in his report to the home authorities. When the man who has done the brave deed returns home he is perhaps decorated by his Sovereign with the Victoria Cross "For Valour." And when the warrior dies, it sometimes happens that a statue is erected to his memory by a grateful country.

Now, I know, Sir, that in such a civil profession as electrical engineering, whatever heroism a man may display, there is no such thing as being mentioned in despatches, or receiving a V.C. It is possible, however, to follow the example of a grateful country and raise a memorial to a man who has shown as much bravery as any sailor or soldier.

On these grounds I am asking you, Sir, to invite subscriptions from those who know and appreciate the work done by H. W. Cox.

I would suggest that the memorial consist of a sum of money to help to keep the wife and family of a man who has laid down his life for his fellow men. I am, &c.,

Faraday House, Southampton-row, London, W.C., July 18. CHRISTOPHER SILVER.

[We shall be pleased to accept subscriptions as suggested, and to hand them over to any committee authorised to act in the matter.—ED. *E.*]

LOANS FOR PLANT AND MACHINERY.

In a recent report to London County Council the Finance Committee state that they have considered the question of the periods (25 and 20 years) allowed for repayment of loans for engineering plant and machinery.

The report states that the particular instance on which the question was first raised was in connection with the machinery at Abbey Mills pumping station. That machinery was not comparable with the electric lighting plant and machinery for which 20 years are sanctioned in loans to metropolitan borough councils. It would, however, be not unreasonable to draw a comparison between the plant and machinery at the Council's electric generating station at Greenwich and the larger corresponding items installed by borough councils at their generating stations. The basis on which the respective periods of 20 and 25 years have been settled is mainly the estimated life of the work. In the case of loans to borough councils the terms of repayment are fixed strictly on that basis, and the periods sanctioned for various parts of the same work differ according to their estimated life as reported by the Council's officers, and in the case of plant and machinery 20 years are almost invariably allowed. The period of 25 years was adopted by the Council with the sanction of H.M. Treasury in 1893, with a view to simplifying the accounts by charging over a single period expenditure the repayment of which was then being spread over terms varying from 15 to 50 years, and the term of 25 years then represented approximately the equated period of the amounts made repayable over those varying terms. The 25 years' period was introduced before the commencement of expenditure by the Council on tramways, and in recent years the great bulk of the expenditure of the Council which was spread over 25 years was incurred for that purpose. The application of the term of 25 years to tramway expenditure was specially considered when that expenditure arose, and H.M. Treasury concurred in the term, "having regard to the permanently remunerative character of the undertaking which is being purchased, and on the understanding that, in future, renewals will be charged to the revenue derivable from the tramways." The Treasury approved the period of 25 years also for the estimated cost of conversion from horse to electric traction, including the cost of equipment, "on condition that renewals of appliances and equipment were charged to revenue during the period allowed for the repayment of the primary outlay thereon."

It should be stated that "renewals," in the sense in which it was used by the Treasury, means not only renewals within the loan period, but also the supply of new plant and machinery, when necessary, after the expiration of the loan period.

It has been represented to us (proceeds the report) that these considerations apply precisely to any loan sanctioned by the Council for electricity purposes of the borough council, and that, speaking generally, the principle of some extended period for repayment is justified. In support of this it has been urged that electricity mains, at the beginning of an undertaking, are lightly loaded, that the machinery and plant are but little used, and that yet the undertaking has to bear at once the full debt charges, though its earning power is at first very limited. We would point out, however, that this has been met in the case of several borough councils by allowing them to postpone the commencement of repayment up to three years in respect of loans for the initial cost of electricity installations and for the initial cost of large extensions. During the period of postponement no charge falls on the undertaking for repayment, but only for interest on the borrowed money. The Council has not sought this relief in respect of any of its own expenditure on electrical machinery, and it appears to them that this argument does not affect the question of the period of repayment. Up to 1906 electric lighting loans were granted for an all-round term of 42 years, subject to the condition that if any renewal were necessary during the currency of the term the cost of such renewal should constitute a maintenance charge, and should not be made the subject of a fresh loan. Since the introduction of the 20 years' term that condition has been dropped, and borough councils are allowed to borrow for renewals or replacements, provided that any loan outstanding on the replaced plant is paid off. With one or two exceptions, none of the metropolitan borough councils which have borrowed for periods admittedly in excess of the life of the work, has provided a reserve fund for renewals calculated on a basis sufficient to provide new plant at the expiration of its probable life. The Council urges the borough councils to make provision for the renewal of electric lighting machinery by way of an adequate reserve fund for renewals, but it cannot insist upon such a fund being established and properly maintained, though up to the present the Council has not granted any loan for renewals, except where the original loan is wholly repaid. On the other hand, the Council does not borrow for replacements at all. In the case of the tramways a renewals fund has been established, which is calculated to provide the whole cost of any replacements. So far as the plant and machinery at Greenwich generating station are concerned, the tramways renewals fund ($\frac{3}{4}$d. per car-mile) is based on the following estimated lives: Machinery, &c., 25 years; boilers, &c., 20 years; sundry small items, 10 years. The 20 years' period allowed to borough councils covers all items of machinery, plant and boilers, and the initial cost of small items as well. The Council, further, repays the whole of its debt on plant and machinery, on the system of equal instalments of principal, and if the amount of the annual instalment of principal required to repay a given amount of debt in 25 years were set aside to a sinking fund to repay the debt on the annuity system, the amount of the debt would be provided at the end of 19 years; in other words, the repayment of the debt in 25 years on the instalment system is equivalent to repayment on the annuity system in 19 years. The borough councils can elect to repay their loans on either the instalment or the annuity system. The committee submit that if a borough

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council elects to repay its debt on the annuity system, it is not badly treated compared with the Council if it has to repay in 20 years, whilst the Council repays on the instalment system in 25 years.

The representations which were made to the committee were not to challenge the propriety of the term of 25 years which the Council adopted for the repayment of its own expenditure, but to urge that the period of 20 years allowed to borough councils should be extended to 25 years; but the committee state that they are of opinion that, in the circumstances, the Council would not be justified in extending the period of repayment of loans of the borough councils beyond the estimated life of the works. The term of 20 years was the subject of very careful consideration, and was adopted on the advice of Prof. Sir Alex. Kennedy and the Council's chief engineer. Moreover, the term of 20 years allowed by the Council in sanctioning loans by borough councils compared favourably with the terms allowed by the L.G. Board for electrical machinery. The Board does not allow an equated period.

Having, therefore, carefully considered the whole matter, we have (says the committee) come to the conclusion that the borough councils are not hardly treated as compared with the Council's own position in regard to loans of the kind in question, but that, taking all things into consideration, the Council applies to its own undertaking a stricter rule than it is able to apply to the local undertakings. We are not prepared to recommend any modification of the present practice.

THE METALITE LAMP.

The future before the metal filament lamp in this country and the colonies should be a particularly rosy one. Central station engineers have got over the shock which they received at the time of the introduction of this form of lamp, and are now urging its use upon all their consumers. This action in itself will create an enormous demand, and with the co-operation of electrical contractors and allied trade houses there should be no difficulty in maintaining a brisk business in metal lamps for many years to come.

It is something of a consolation to find that British enterprise is well to the front in these matters. While we may have been slack in the early development of the metal lamp, we have made up a lot of leeway and should now be able to go ahead successfully. The Bryant Trading Synd., as our readers are well aware, has been associated with incandescent lamp making since the earliest days of electrical industry. They have been making metal filament lamps for a number of years, but have been anxious to perfect a type which would give every satisfaction to the public, who, after all, must be the best judges of the merits of electricity consuming devices of every description.

We were given a recent opportunity of inspecting the Horsell-road factory, where the British Metalite lamp is turned out in large quantities, and the works afforded ample testimony of the existence of a flourishing business. The productive equipment is the best that inventive genius and constructive skill can provide, and the girl operators—women seem peculiarly adapted for this class of work—are extremely deft in the carrying out of their delicate duties.

Special attention has been paid to the exhausting plant, including the latest pattern of rotary mercury pumps, which are used in connection with McLeod gauges and an auxiliary reciprocating vacuum pump. The process of mounting the filaments is also interesting. The ends of the filaments are severally welded by electrical means to the radial supports projecting from the lower part of the lamp stem, the looped ends of the filaments resting upon specially shaped springs.

While the actual manufacture of complete lamps at Horsell-road is an important section of the company's operations, an extensive business in metal filaments is being conducted. These filaments are prepared in large quantities and exported to all parts of the world. Extreme care is taken in the packing and the methods adopted for different sizes of filament have, we understand, proved extremely satisfactory. We are informed that, despite a 45 per cent. tariff, a tremendous business in the supply of Metalite filaments to the United States of America is being carried on. This in itself is a mark of appreciation of which the company may well be proud.

It is claimed for the Metalite lamp that it has an average light duration of 2,000 hours, that it will successfully resist vibration, and that with an 8 c.p. lamp 40 hours illumination can be provided at a cost of a penny. We were shown some 200 volt 25 c.p. lamps in ordinary pear-shaped bulbs which looked very businesslike, and which we understand are turned out in very large quantities.

P.O. Telegraphs Flower Show.—The Postmaster-General, Mr. Herbt. Samuel, and Mrs. Samuel (who awarded the prizes) on Wednesday visited the Central Telegraph Office Amateur Gardening Association's exhibition at St. Martin's-le-Grand, London. The controller of telegraphs (Mr. J. Newlands) and the deputy controller (Mr. J. Willshire) were also present. The exhibits included cacti, roses, sweet peas, violas and vegetables.

LEGAL INTELLIGENCE.

Attorney-General (ex rel. India Rubber, Gutta Percha & Telegraph Works Co.) v. West Ham Corporation.

Mr. Justice Neville continued the hearing of this action in the High Court since our last report.

At the close of plaintiffs' evidence, Mr. MacMorran summed up the case for plaintiffs. He said the electricity undertaking of the Corporation was a separate trading concern, and that being so the Corporation were required to keep and publish separate accounts in respect of it. It had been proved that the Corporation had overdrawn both the capital and revenue accounts. On the face of it, therefore, there was something that called for an explanation. He found that the overdraft both of capital and revenue was not covered by any sanction to borrow or any statutory authority.

His LORDSHIP: With regard to the electricity supply there was not.

Mr. MACMORRAN said they had to proceed upon that state of things. The Corporation kept separate accounts of their different undertakings, and the result as regards the electricity account was as he had stated. It had been suggested that there might be some power to borrow with regard to the capital account, but it could not be suggested with regard to the revenue account, for these the Corporation had to provide for the expenses out of the district rate. It could not be said that there was a sanction for this overdraft because there was enough money to meet it out of the general district rate, for the money had not been so applied. The money was represented by motors, fittings, &c. In other words, they had borrowed money from the bank to buy motors and fittings, and by doing so they had contracted an illegal debt.

Mr. Justice NEVILLE: Assume the borrowing for electricity was ultra vires, you had to consider what was the result. You could not restrain them borrowing without the sanction of the L.G. Board that which was already borrowed. He supposed all that could be done was to restrain further borrowing.

Mr. MACMORRAN said if it was an illegal borrowing then it was an illegal debt. It was not merely ultra vires, but it was a thing that was illegal for them to do. That being so, the Corporation had no power to apply any money in their hands for payment of such a debt.

Mr. Justice NEVILLE: But supposing they had done it.

Mr. MACMORRAN submitted that in that case they would have to repay. It might have to go further and make some persons personally responsible. With regard to the interest on the money there could be no question that if it was borrowed without express sanction the interest ought not to be paid.

Mr. Justice NEVILLE: Assuming you are entitled to an injunction, what do you say as to the rest of the relief?

Mr. MACMORRAN said that if originally illegal no subsequent act in paying off the money could legalise it.

Mr. Justice NEVILLE said he saw some difficulty in the form any order ought to take. The only way the Corporation could put themselves right was by levying a rate for the purpose, and he was not sure that they could legally levy a rate.

Mr. MACMORRAN pointed out that the Corporation had sources of revenue other than the rates. It was sufficient for plaintiffs that the debt was illegally incurred, whatever the consequences might be that followed from it. He submitted that the money must be put back somehow. If the bank gave that loan with the knowledge that it was illegal, then the bank was liable. From the way the accounts had been kept it was clear that the bank had had notice that there was a large overdraft in respect of the electricity account.

On Friday Mr. DANCKWERTS opened the case for the defendant Corporation. He submitted that the case was founded upon mere technicalities, and the Attorney-General had disregarded the substance of things. Plaintiffs' accountant had admitted that there had been nothing in the nature of dishonest dealings and the overdraft at the bank had been treated by the drawing of cheques in favour of the lawful creditors of the Corporation. What had really happened was that by arrangement the Corporation had got the bank to pay its creditors. They had done nothing more than for the sake of convenience to transfer the debt from one creditor to another, and that, he submitted, they were perfectly entitled to do. The Corporation were advised that during the period under discussion—the period during which this overdraft was created—it would be inexpedient to go to the stock markets to raise money. They suffered in that respect and also in consequence of the extraordinary delay on the part of the L.G. Board in giving their sanction for raising certain loans. Under those circumstances what was the Corporation to do? Their affairs could not be allowed to stand still and creditors had to be paid. The only practical thing for them to do was to go to the bank and get them to pay the creditors. With regard to the Consolidated Loans Fund, he submitted the Corporation had the right to lend themselves the money pending the sanction they were expecting to get from the L.G. Board daily or even hourly. He should ask the Court to say that the Corporation in no way deserved castigation, and that technicalities could be pressed too far. No harm had been done. The action was supposed to be taken in the interests of the ratepayers, but it would have just the reverse result, as that action was unnecessary and expensive, and had been started by people who could not hope to benefit by it.

Mr. PATTERSON, borough treasurer, answering Mr. Danckwerts, gave details of the method of keeping the Corporation's accounts and the application of the overdraft.

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In cross-examination by Sir ALFRED CRIPPS, he said that in 1906 the authorised loan was £94,026. It was true that at that time they were negotiating with the bank for borrowing £200,000, and that was partly for the electricity and partly for the education account. When the letter was written to the bank on Jan. 23, 1906, the total sanction obtained for loans amounted to £94,026. They had no other sanction, but they had borrowing powers outside the sanctions. The Board of Education required £26,093. Their borrowing powers were not exhausted at that time. Of the money the Corporation was then getting from the bank, part was spent on electricity supply, but witness did not know the exact amount they set off against the general district fund which was overdrawn on the electricity account. There was always a substantial working balance left over from the district rate. It was looked upon as a working balance for the whole of the accounts of the Corporation. For the year ended March 31, 1909, the estimated charge on the district fund for the electrical undertaking worked out at £116,669 odd. The Corporation had included in the general rates sums for the payment off of the overdraft.

Do you think it is right for any purpose to mix up the district fund account with the borough fund account?—Theoretically no, practically yes. Properly they could not have taken any part of the borough fund for electrical purposes. In March, 1910, the overdraft for electricity supply was: revenue account £35,000 odd, capital account £57,000 odd. Substantially, since 1903 up to 1907 the rates had been 10s. in the £. He denied that their real difficulty in raising money was that their rates were so high. They were paying the bank 4 per cent. for the borrowed money, and they were crediting the loan account with 4 per cent. The interest on the consolidated loan fund was 1½ per cent. below bank rate, at that time the bank rate was 3 per cent., so that they were paying on the consolidated loan fund 1½ up to March, 1908. He did not know that the relators in that case were paying £7,000 a year in rates, but he knew that they were very large ratepayers.

This concluded the evidence for the Corporation, and Mr. BUCKMASTER, K.C., opened the case for the bank. He said the money obtained from them had been used for the purpose of keeping the electrical undertaking going, and it was in evidence that the electrical undertaking could not have gone on without that money being raised. There was no evidence that the bank knew the way the money was being expended. The statement to the bank was that it was necessary to keep things on foot, to pay the people who had done the work and the people who had supplied the goods. Either the Corporation had to pay these expenses or the creditors had to go unpaid. He submitted that these were debts legally incurred for a lawful undertaking. The debt to the bank was incurred by the Corporation for its authorised undertaking, and was honestly incurred in pursuance of a lawful undertaking. It was necessary for the continuance of the undertaking that the creditors should be paid, and to the bank whose money had paid them the money must be refunded. It could not be right that the ratepayers should enjoy this undertaking financed by the money of the bank, and then leave the bank unpaid. In conclusion, he contended that all the bank had done was to lend a sum for which they knew the Corporation had borrowing powers, and they could not be held responsible if the Corporation had applied the monies for purposes for which they had no borrowing powers.

Sir ALFRED CRIPPS replied on the whole case. He said that he had consulted with Mr. Buckmaster, and for the present was willing to leave the case against the bank where it was. His lordship would understand that what plaintiffs were anxious for was a declaration that the course of conduct of the Corporation was ultra vires.

In the course of the reply terms were arranged as regards the bank. It was agreed that upon payment by the bank to the Corporation of £7,000 in respect of the interest paid to the bank on the balance of the overdraft, and on the bank agreeing to pay plaintiffs' costs as between party and party, including the indemnity costs, all proceedings against the bank should be stayed. The £7,000 was to be paid to the credit of the Corporation at once.

Mr. BUCKMASTER desired to point out that, though the bank had come to that agreement for the purpose of saving embarrassing inquiries, they in no way admitted any liability.

At the conclusion of the reply his lordship reserved judgment.

Reid Newfoundland Co. v. Anglo-American Telegraph Co.

On Friday the Judicial Committee of the Privy Council delivered their reserved judgment in this appeal from a judgment of the Supreme Court of Newfoundland.

Lord MACNAGHTEN, in delivering judgment, said the Supreme Court had restrained appellants (the railway company) from erecting, maintaining or operating a line of telegraph upon their own land for the efficient working of their own railway. The result depended on the construction of an agreement of Aug. 11, 1888, made between the Newfoundland Railway Co., its receiver and manager and the Anglo-American Telegraph Co. By that contract the railway company agreed that the telegraph company should have (for 27½ years from November 1, 1888) the exclusive right to build, erect, maintain and operate upon and along the lands forming the roadways of the southern division of the railway company's line between St. John's and Harbour Grace and between Harbour Grace and Carbonear, as many telegraph lines for the business of the telegraph company as the telegraph company might deem necessary, and a special wire for the use of the railway company (their servants and agents, and successors and assigns) for use in the management, operation and control of their railway, with all necessary posts, wires, &c. By another clause in the agreement the railway company agreed not to transmit commercial messages over the special wire, except for the benefit and account of the telegraph company; and the telegraph company agreed to build and erect with good and suitable materials, &c., and to maintain in good working order and operate at least two lines of telegraph wire from the railway station at Harbour Grace to the railway station at Carbonear, one of such wires to be for the use of the telegraph company, the other to be a wire (called the "special wire") for the special and exclusive use of the railway company. The contract was one between a railway company seeking its profits by serving the public as railway managers and concerned with telegraphs so far as necessary for the safety of the railway and the efficiency of its working, and on the other hand a telegraph company seeking its profits by supplying telegraphic convenience to the public. The question that arose in the former case between the parties was as to the extent of the right of the railway company to use the special wire provided for its use, whether that use was limited to the purposes of the railway as it existed in 1888 (the date of the contract) or whether it extended to the purposes of the railway as afterwards developed.

On that occasion the view of the Court in the Colony was affirmed, and it was held that the right of using the wire was limited to the purposes of the railway as it existed at the date of the contract. That decision appeared to have been felt by the railway company as placing it in a difficulty, and it proposed to meet that difficulty in a way which had given rise to the present litigation. The railway company proposed to lay telegraph lines of their own along their own lands for working their railway. That was what was objected to by plaintiffs in the present suit, and that objection prevailed in the Court of the Colony. Their Lordships had to say whether that objection was well founded. The argument on behalf of the telegraph company was largely based upon the use of the words "exclusive right" in the clause cited. It was necessary, therefore, to see what the "exclusive right" referred to was. It was not an "exclusive right" of entry, for the railway company remained in possession, and must do so in order to work its railway, which it was under an obligation to do. The exclusive right granted was to enter for the purpose of erecting, maintaining and operating telegraph lines for the business of the telegraph company. In their Lordships' opinion that exclusive privilege of erecting and working telegraph lines for the business of the telegraph company did not exclude the right of the railway company to erect and work telegraph lines on its own property for the purposes of its railway business. Their Lordships were of opinion that the railway company was not shown to have exceeded its rights. They would humbly advise his Majesty that the judgment and decree of the Colonial Court should be set aside, and the suit dismissed with costs in the Court below. Respondents would pay the costs of the appeal.

G. Freeman & Sons v. Middleton Electric Traction Co. (Ltd.)

At Manchester Assizes last week Mr. Justice Hamilton tried an action for the recovery from defendant company of sums amounting in the aggregate to £1,699, in respect of extra work done in connection with the construction of a tramway from Rochdale through Castleton to Middleton.

For plaintiffs it was stated that they obtained from defendants the tender for the construction of the tramway for £38,761 in 1901. It was agreed that payment was to be made for certain extra work not contemplated in the contract. In due time the work was completed, and the final certificate of the engineer (Mr. Stephen Sellon) was given. The Middleton Electric Traction Co. was a subsidiary company of the British Electric Traction Co. A Mr. Angus, who had since died, was appointed resident engineer in the case of the Middleton and Rochdale tramway, and in that capacity had given orders for extras, and it was in regard to these orders that the action arose. The total amount of the extras ordered was stated to be £6,843.

Defendants pleaded that Mr. Angus was not authorised, within the meaning of the contract between the parties, to give orders, and they also claimed that some of the work in respect of which the action arose was work contemplated in the original contract. They admitted that they had declined to submit the case to arbitration.

Mr. SELLON, in the course of his evidence, said that during the construction of the tramway he had been on the job some 20 or 30 times, and he did not sanction the appointment of Mr. Angus as resident engineer.

In giving judgment, his LORDSHIP said Mr. Angus was never anything but a resident engineer, the deputy of Mr. Sellon appointed to assist him, and not to relieve him of any of his duties under the contract. There was no evidence to satisfy him that Mr. Angus was the engineer to give orders in writing under the clause of the agreement which dealt with those matters. He therefore gave judgment for defendants. He did not think plaintiffs had been very well treated, but he had come to the conclusion that if he said judgment would be without costs it would only be because he was sorry for plaintiffs. That seemed to be an insufficient judicial reason, and therefore he gave defendants their costs. He refused to grant a stay of execution.

Collins v. Bradford Corporation.

At the West Riding Assizes (Leeds) on Tuesday, before Mr. Justice Grantham and a special jury, a carter named Mark Collins sought to recover damages from Bradford Corporation owing to the alleged negligence of defendants' servants. The claim arose out of a tramcar accident in Leeds-road, Bradford, on Sept. 15, 1909. Plaintiff was taking a cartload of bricks down the street when he saw a tramcar coming at high speed. As there was another cart in front of him, he could not pull to the left, so he whipped his horse and directed the cart to the right in an effort to avoid an accident. The tramcar, however, caught the cart, and threw him into the road.

Medical evidence was called to say that Collins would never be able to work again.

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The defence was that the finger of the controller had become electrically fused, that that was an unusual accident, for which the Corporation could not be held responsible, and that plaintiff was guilty of contributory negligence.

Mr. C. J. SPENCER, manager of Bradford tramways, said he had never before known a controller stick in the way that did. Undoubtedly it was due to fusing, but what caused that he was unable to say.

After hearing the evidence the jury returned a verdict for plaintiffs for £350, for which judgment was given with costs.

Factory Act Prosecution.

At Houghton-le-Spring on Thursday last week the Newcastle-upon-Tyne Electric Supply Co. was summoned on two charges under the Factory and Workshops Act.

Mr. H. S. Mundahl appeared for the prosecution and Mr. W. S. Burton represented the company.

Mr. BURTON took a preliminary objection that the particular summons with which they were concerned did not disclose an offence.

Mr. MUNDAHL replied that the information was that a certain man died by reason of defendant company having neglected to observe the regulations made in pursuance of the act by permitting an unskilled man, not being an authorised or competent man, to undertake certain work.

Mr. BURTON said that the particular summons did not set up an offence, and was most misleading.

Mr. MUNDAHL said defendant company was the owner of works for generating, transforming and distributing electricity at Philadelphia, and on April 15 they had occasion to employ a joiner (Liddell) in a kind of passage between the switchboard and wall of the works building. There was about 3 ft. between the wall and the board, and on the morning in question Liddell went with an electrical engineer named Archbold to do something in connection with the conductors. Archbold was to refit a bush which had got loose, and for which Liddell had made a wedge. By some means Liddell came in contact with one or other of three conductors, and received a shock of about 3,000 volts, with the result that he was killed. There could be no doubt that Liddell met his death while he was engaged at work at the back of the switchboard, and that he was killed by an electric shock in consequence of coming into contact with some of the conductors conveying electricity at a very high pressure. Mr. Mundahl urged that Liddell was not a man of technical knowledge or experience as was adequate to avoid danger. Liddell was employed by Mr. Wardroper, and was permitted by the company or their officials to go into the place referred to, and to be exposed to danger where practical knowledge or experience was required in order to avoid danger. It might be that Liddell was handing something to the electrician—they did not know exactly what had happened; but what the prosecution urged was that deceased was permitted to engage in work where technical knowledge or experience was required to avoid danger. It might be said that the conductors were insulated, and that certain precautions were taken to render them as harmless as possible; but, insulation or not, the man was killed, and he submitted that an offence had been committed by defendants having failed to take adequate steps to prevent deceased from engaging in the work referred to.

Mr. BURTON: My point is that Liddell was a competent joiner, was 31 years of age, a man with full possession of his faculties, and, to that extent, on April 15, he was electrically competent, and therefore filled all the requirements of the act. He contended that deceased was electrically competent by knowledge imparted to him by persons at the works and warnings given him.

Mr. MUNDAHL said the only question for the bench was: Was the deceased competent, a competent man where technical knowledge or experience was required in order to adequately avoid danger.

Mr. BURTON said it was for the prosecution to show that the man was not competent. That had not been proved, and, therefore, prima facie, the prosecution had not made out a case in respect of that summons.

Mr. GEO. WARDROPER, contractor, Penshaw, said deceased was a competent man as a joiner, and had been employed at the Philadelphia power station for three weeks.

Mr. F. F. PYLE, engineer-in-charge of the station, said Liddell had to get permission from witness before he could work at the western switch chamber where the fatality occurred. The "passage" was not exactly a passage, but was the inside of the chamber. One-half the chamber was occupied by the switchboard. Liddell was under the charge of Archbold. Liddell was doing work in the western chamber similar to what he had done in the eastern chamber, the chambers being alike. Witness told Liddell he must not touch the insulated conductors. The conductors were distinctly painted yellow. Witness told deceased that they were "alive," and that a cut of a chisel or any sharp tool might cut through the insulation.

Mr. P. H. ARCHBOLD, with whom deceased was working, said Liddell handed him a wedge to complete a job.

Mr. MUNDAHL: You thought it necessary that this man should be warned?—Yes.

Unless he was warned there was danger?—Yes.

If he had the technical experience and knowledge of a competent man, why was it necessary to warn him?—He might have forgotten.

Mr. MUNDAHL: The warning suggests that the man had no knowledge.

Mr. BURTON: My friend puts it to you (witness) that there was danger. I suggest it was nothing more than a risk, and that apparently the insulation was sound?—That is so.

Mr. J. CUSWORTH, chief engineer of the operative department of the Newcastle Electricity Supply Co., said the switchboard was of the latest type, and the insulation of the conductors the best that could be used. All that Liddell required to know was that the conductors were alive, and that there was risk if he came in contact with them with tools. If they were unable to employ a joiner in such circumstances as Liddell was employed there would be unreasonable and serious interference with their business, as they supplied collieries with electricity night and day.

Mr. BURTON asked the bench to find, in the first place, that Liddell was competent, and that, in the second place, the company had done all that was reasonably necessary to provide against the man meeting with any sort of accident. He submitted the company was clearly justified in employing Liddell, having regard to all the circumstances.

The bench consulted, and the chairman (Mr. R. Richardson) said the magistrates found that the man was not competent for the work he had to do, and they, therefore, fined the company £10 and costs.

Mr. MUNDAHL said they had brought the case to get a definition of the word "competent" for the public benefit, and did not ask for costs.

Mr. BURTON said he might be instructed to take the decision to a higher court, and the magistrates thereupon, in the event of an appeal, fixed the recognisances at £100.

Mr. MUNDAHL said he would not proceed with the second summons.

Metropolitan Rly. Co. v. G.W. Rly. Cy.

On Wednesday the Railway and Canal Commissioners (Mr. Justice A. T. Lawrence, Mr. Gathorne-Hardy and Sir J. Woodhouse) sat to hear a dispute between the Metropolitan and Great Western Railway Co.s as to the basis on which the latter were to pay the former for adapting their line for electric traction.

Mr. Balfour Browne, K.C., and Mr. G. A. Thomas appeared for the Metropolitan Railway Co., and Sir A. Cripps, K.C., Mr. Simon, K.C., and Mr. W. S. Kennedy represented the G.W. Railway Co.

Mr. BALFOUR BROWNE said the G.W. Co. had running powers over the Metropolitan Co.'s system from Bishop's-road to the City, and paid a minimum of £15,000 a year for the privilege. In 1893 the Metropolitan Co. obtained an act empowering them to substitute electric for steam traction. It was provided that if the company should at any time require the Great Western Co. to substitute electric traction for steam locomotives for working their trains over the system of the Metropolitan Railway Co. the question as to how the cost, or any part of it, should be borne should be referred to arbitration. The Metropolitan Co. gave the Great Western Co. notice to substitute electric traction for steam locomotives, and by agreement the Metropolitan Co. supplied the necessary electric traction. The question for the court was as to the amount of the remuneration the Metropolitan Co. were to receive for those services. He submitted that they should receive the actual cost of supplying the traction, with a reasonable sum for profit.

Sir A. CRIPPS, for the G.W. Co., contended that the question which had to be referred to arbitration was not the cost incurred by the Metropolitan Co., but the cost thrown on the G.W. Co. by the demand of the former. The payment, he said, should be based on the actual saving of cost to the G.W. Co. That company could not be called upon to bear a greater cost in connection with electric traction than they had originally undertaken in connection with steam locomotion.

The court held that the arbitration clause of the Act of 1898 was passed for the protection of the G.W. Co., and that the cost to be borne by that company was on the basis of the cost they were put to for steam traction.

It was arranged that counsel should agree to the form in which the decision of the court should be drawn up and submit it to the court.

Witney Electric Supply Co. (Ltd.)—On Friday Mr. Justice Swinfen Eady made an order for the appointment of a receiver of this company, which was formed in 1899; in 1902 they created an issue of debentures. The interest was not in arrear, but the case was one of jeopardy (said counsel). The company was being carried on at a loss, and would not be able to pay the interest in December or to pay off the debentures that fell due in December.

PARLIAMENTARY INTELLIGENCE.

LEEDS CORPORATION BILL.

Last week the Committee on Unopposed Bills in the House of Commons considered this bill, which had already been through the House of Lords.

Mr. PRITCHARD, parliamentary agent, explained that the bill authorised the provision of omnibuses worked by electricity, and to carry out street improvements, &c. The vehicles it was proposed to run were trolley vehicles or trackless trams.

Mr. J. B. HAMILTON, general manager of the Leeds tramway undertaking, explained that the cars would be run on pretty much the same principle as ordinary trams, the difference being that the return current, instead of going through the rails would have to return by duplicate overhead wires. Those cars were successfully running on the Continent. The capital charge was about one-fifth of the ordinary trams, but the cost of working was much the same. They were very much lighter vehicles, and were intended for sparsely-populated districts. Where there were large centres of population it would be much preferable to have ordinary tramways. But these would serve sparsely-populated and distant parts of the city, whence they had had application for some means of communication, and where, because of the heavy initial cost, they had been unable to consider the question of ordinary tramcars. If those districts developed and there was sufficient traffic eventually for tramways, then

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the trolleys and wires would be utilised without alteration, but they would have to lay down lines.

Mr. PRITCHARD explained that in the Bradford bill the Corporation was taking practically similar powers with regard to trackless cars, and the Local Legislation committee which had considered the bill had agreed to the Board of Trade having power by Provisional Order to authorise additional routes or variation of the routes sanctioned in the bill if that became necessary. Leeds had followed the same course. It was so also with regard to the period of repayment. Leeds had in their bill originally 10 years for vehicles and 20 for equipment, but the Local Legislation committee said 15 years for both. So Leeds, while thinking their own proposals best, adopted those put into the Bradford bill.

The CHAIRMAN said he was of opinion that 10 years and 20 years was much sounder finance, and the committee agreed.

The bill was then ordered to be reported for third reading.

WIRELESS TELEGRAPHY AND THE COLONIES.

In the House of Commons on Wednesday Mr. SANDYS asked the Under-Secretary for the Colonies whether the recommendations of the conference, held in Melbourne in December, upon the establishment of wireless telegraphy between Australia, New Zealand, and the Pacific Islands, had been adopted by the Governments concerned.

In reply, COLONEL SEELY said he understood that the Australian and New Zealand Governments had taken steps to establish high power stations at Sydney and Doubtless Bay, but it had not yet been possible to carry out the recommendations of the conference with regard to the Pacific Islands. Of course they expected to hear from them when the work was completed or nearing completion; but the time had not yet come for a statement of that kind.

Mr. GIBSON BOWLES asked, in view of the great importance of an increase in those wireless telegraph stations in that hemisphere, whether the Government would do their best to secure the establishment there of as many stations as they could.

COLONEL SEELY said he could not give a pledge as to that. Of course it would be of great value, but he was afraid he could not make a statement now.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A sub-station attendant is required for the Stepney (London) electricity supply department. Applicants must have had experience with h.-t. three-phase a.-c. switchgear, converting plant and l.-t. three-wire d.-c. supply. Commencing salary 30s. Applications to the engineer and manager (Mr. W. C. P. Tapper), 27, Osborn-street, Whitechapel, E. See advertisement.

The governing body of the Northampton Polytechnic Institute London, invite early applications for the appointments of senior assistant in the electrical engineering department, to take charge of new electric generating station (salary 45s. per week); junior assistant in electrical engineering department, chiefly to take charge of producer plant (28s. per week); second lecture assistant in electrical engineering department (£80 per annum); and assistant lecturer and demonstrator in the mechanical engineering department (£120 per annum). The appointments will take effect after the summer vacation. Particulars from the office of the Institute or from the principal, Dr. R. Mullineux Walmsley. See advertisement.

Applications are invited for the positions of assistant in the mechanical and electrical engineering department of the Municipal Technical School, Halifax (at a commencing salary of £160 per annum), and lecturer in mathematics (specialist in practical mathematics), at a commencing salary of £150 per annum. Forms of application (to be returnednot later than July 28) from the Secretary of the Education Offices, Mr. W. H. Ostler, Halifax.

There is a vacancy in the civil and mechanical engineering department of the City and Guilds Central Technical College for an assistant who has had drawing office and workshop experience, and who has had sufficient college training to enable him to lecture in the subjects of "Strength of Materials," "Mechanism" and "Heat Engines." Commencing salary £150 a year. Applications to the Dean of the College, Exhibition-road, London, S.W. See advertisement.

An assistant lecturer in engineering is required at the Technical College, Derby. Commencing salarg £140. Particulars from the Registrar.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

A lecturer in technical engineering is required at Blackburn Municipal Technical School. Salary £120 to £140. Forms from the Director of Education. Applications by Aug. 13.

A Canadian publishing house advertise for an experienced editor for an electrical journal.

Bombay Corporation require an executive engineer with knowledge of all branches of municipal engineering, including lighting and electricity. Minimum monthly salary R.1,200 (£80), maximum R. 2,000 (£133. 6s. 8d.). Applications to Mr. G. Midgley Taylor, Caxton House, Westminster, S.W., by July 31.

Dr. W. Geoffrey Duffield, of Manchester University, has been appointed professor of physics at University College, Reading, in succession to Prof. G. J. Burch, M.A., D.Sc., resigned.

Mr. W. J. McDonald, late traffic superintendent of Colchester Corporation tramways, has been appointed traffic superintendent on the Burton & Ashby Light Railway.

Mr. H. P. J. Moseley, B.A., has been appointed lecturer and demonstrator in physics at the Victoria University, Manchester.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

A petition has been presented to His Majesty in Council by the City and Guilds of London Institute for the grant of a supplemental charter, and His Majesty has referred the petition to a committee of the Lords of the Council. All petitions for or against such grant should be sent to the Privy Council offices by July 30.

Northampton Polytechnic Institute (London).—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Monday, Oct. 3.

The courses in mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include specialisation in radio-telegraphy. The entrance examination takes place on Sept. 28 and 29. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in engineering at the University of London. There are full and part time courses in all branches of technical optics. Particulars as to fees, &c., can be obtained at the Institute, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

University of Manchester.—The session commences on Oct. 4. Complete theoretical and practical training is given in this university to students preparing for the higher positions in the electrical engineering profession. The subject may be taken as part of the courses preparing for the B.Sc. degree in both the honours schools of engineering and physics. The John Hopkinson laboratories and dynamo house are well equipped, and offer good facilities for educational and research work. Prospectuses from the Registrar.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

BRITISH AND COLONIAL.

Ashburton.—The Council will oppose an application for a provisional order by Purvis & Co.

Ashford.—The East Kent Electric Supply Co. will apply for a provisional order.

Ashton-under-Lyne.—The Council propose to expend £48,424 in extensions of the electricity undertaking.

Atherton.—The South Lancashire Tramways Co. has authorised the Council to use the tramway poles of the company for attaching overhead cables for the supply of electrical energy to consumers over the Atherton boundary in Bolton-road.

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Assessment of Tramways.—At the annual conference of Urban District Councils of England and Wales last week at Ilfracombe, the following resolution was adopted on the motion of Mr. W. Wood (clerk to Fleetwood Council):—

That in view of the unsatisfactory state of the law with regard to the assessment of street tramways, whereby the anomaly is presented of a tramway assessable to the general district rate at its full net value, and of an undertaking similar in construction and use, but constructed under the provisions of the Light Railways Acts, being only assessable at one-fourth of such value, this conference urges upon the Local Government Board the necessity for a Government bill being introduced at the earliest possible date providing for the assessment of all tramways or railways running through or along the public streets at their full net annual value for the purpose of all local rates.

Belfast.—The Corporation have adopted a report of the Tramways and Electricity committee, which recommended that powers be sought for the construction of eight additional tramway lines, &c., at a cost of £161,000.

Bradford-on-Avon.—The Western Electric Distributing Corpn. propose to apply for a provisional electric lighting order.

Dundalk.—The electrical adviser to the Board of Trade (Mr. A. P. Trotter) held an inquiry last week into the objections made to the electricity supply scheme of the Urban Council.

Mr. T. M. Healy, K.C., appeared in support of the scheme, Mr. Matheson, K.C., opposed on behalf of the Dundalk Gas Co., and Mr. Donaldson opposed on behalf of some ratepayers.

The objections to the scheme were that it provided for 9 miles of overhead wires, which crossed the strets at intervals, "to the danger of the public." There would be underground cables placed direct in the soil in the main thoroughfares, and it was contended that, owing to the nature of the soil, the gas pipes in nearly all the streets of the town would suffer from corrosion, and that if the electricity escaped it would set up electrolysis, to the detriment of the Gas Co. For the Council it was urged that they had adopted the specification of the Board of Trade, and that similar schemes were in operation elsewhere.

Edinburgh.—The Tramway committee have been asked to report on a communication received from the solicitors to a London syndicate who propose to obtain powers for constructing new electric tramways.

It was reported at a meeting of the Electric Light committee on Tuesday that the actual surplus for the year was £8,263, against an estimate of £2,020. It was agreed to defer proposals for the disposal of the surplus until they had reports from the engineers as to what the undertaking required. The convener (Judge Stevenson) proposed to alter the price of current, but it was agreed to adhere to the present price.

Exeter.—On Wednesday the Council decided on the recommendation of the Electric Lighting committee, to reduce the charge for electricity for power and heating by ½d. per unit and for traction by ¼d.

Falmouth.—The question of the acquisition of the local electricity works by the Council is to be considered.

Hackney (London).—The Electricity committee have decided to extend the feed and distributing system at a total cost of £18,364, and to extend the switchboard at a cost of £900.

The cables will be purchased under a current contract with the British Insulated & Helsby Cables, but tenders are to be invited for the switchboard.

The committee report that there is now so much practical heating and cooking apparatus on the market that it is worth while to cater strenuously for domestic heating and cooking business, and in order to stimulate this branch the committee have decided to modify the tariff, from Sept. 1 next, so that all supplies of current for domestic purposes other than lighting shall be supplied at 1d. per unit. A modified maximum demand system is to be tried, similar to that employed in Marylebone and Hampstead, and under this the following optional rate for supply of energy for lighting and other domestic purposes in premises which are lit solely by electricity is to be adopted: £2 per kw., equal to using electricity at the rate of 1 unit per hour and would give an illumination of 800 c.p. from metal filament lamps equal to 25 32-c.p. lamps per quarter, based on the rate at which the consumer desires to use the supply, payable quarterly in advance, and a charge for electrical energy used each quarter of 1d. per unit, with a discount at the rate of 10 per cent. of the rent to consumers who pay four quarters' rent in advance.

The mains are to be extended to Lingwood-road, Stamford-hill, and the showroom and offices at 306, Mare-street, are to be fitted up at an estimated cost of £550.

Hampstead (London).—An exhibition of heating and other electrical appliances is to be held in the Baths (Finchley-road) from Oct. 4 to 8 inclusive.

The Lighting committee have been authorised to convert 802 more gas lamps to incandescent electric lamps in addition to those already in hand.

Heston and Isleworth.—An inquiry was held here on Tuesday into the Council's application for a loan of £3,600 for extensions of the electricity supply undertaking

Japan-British Exhibition Awards.—The following awards have been made to exhibitors:—

Grand Prize.—Sir W. G. Armstrong, Whitworth & Co. (ordnance and machine tools); Vickers, Sons & Maxim (ordnance and naval models); Babcock & Wilcox (coal conveying plant); Thames Ironworks, Shipbuilding & Engineering Co. (collective exhibit); C. A. Parsons & Co. (steam turbines); Central London Railway Co. (working models); Dowsing Radiant Heat Co. (medical baths and heating appliances); Electromotors Limited (balancer set, motors, &c.); India Rubber, Gutta Percha & Telegraph Works Co. (telegraph apparatus and rubber goods); Osram Lamp Works (metal filament lamps and fittings); Western Electric Co. (telephones and cables); Chloride Electrical Storage Co. (cells and accessories); Brunner, Mond & Co. (pure alkali, &c.); United Alkali Co. (collective exhibit); Johnson, Matthey & Co. (collective exhibit).

Diploma of Honour.—Newtons Limited (d.c. generators and motors.

Gold Medal.—Hurst, Nelson & Co. (tramway rolling stock); John Thompson (dish-end boilers); W. R. Sykes' Interlocking Signal Co. (models of automatic signalling apparatus); Hans Renold Limited (steel driving chains); J. Hopkinson & Co. (safety boiler mountings and valves); E. Green & Son (fuel economiser); John Dugdill & Co. (moving and extending fittings); Maxim Lamp Works (flame and enclosed arc and metal filament lamps); Bertram Thomas (electric cooking appliances); Float Electric Co. (mining and small batteries.

Silver Medal.—T. & J. Jackson & Co. and Lambie, Wrigley & Co.

Leicester.—The Corporation have instructed Mr. James Swinburne to prepare a report upon the position of the electricity department and particularly as to the desirability of putting the Aylestone and Belgrave generating stations under one management.

London County Council.—On Tuesday it was agreed to sanction loans of £9,863 to Battersea and of £9,625 to Stepney for electricity purposes.

Invention.—Mr. A. Champion, an assistant in the electrical branch of the chief engineer's department, was permitted to take out full patent rights for his invention in connection with the construction of electric junction boxes and similar chambers for the prevention of gas and water accumulations.

Electrically-driven Escape Vans for Fire Brigade.—As reported in last week's ELECTRICIAN, the Fire Brigade committee brought up a recommendation for the purchase of three electrically-driven motor (escape) vans from the Cedes Electric Traction Co. for £2,957. 10s. 1d.

The chairman of the committee (Hon. H. Lygon), in submitting the recommendation, assured the Council that the Fire Brigade committee had taken the advice of experts in the matter. In order to soothe the heartburnings of those who objected to the contracts being given to a foreign firm, he could say that a great portion of the work would be done in England. The Cedes Electric Traction (Ltd.) is to be allowed to sublet to the Austrian Daimler Motor Co. the supply of chassis fitted with wheel motors, and to the Tudor Accumulator Co. the supply of the batteries.—The recommendation was adopted.

L.C.C. Tramways.—On Tuesday the Highways committee recommended County Council to apply for Parliamentary powers to construct a number of additional tramways (about 22 miles of single line) at an estimated cost of £462,470. The proposed lines are:—

(i.) Marble-arch to Cricklewood, via Edgware-road, Maida-vale, High road Kilburn and Shoot-up-hill. (ii.) Chalk Farm-road to Child's-hill, via Chalk Farm-road, Adelaide-road, Upper Avenue-road and Finchley-road. (iii.) Kilburn High-road to Upper Avenue-road, via Kilburn-priory, Alexandra-road, Hillgrove-road and Adelaide road. (iv.) Marylebone-road to Swiss Cottage, via Upper Baker-street, Park-road, Wellington-road and Finchley-road. (v.) Edgware-road to Upper Baker-street via Marylebone-road. (vi.) King's-road to junction of Fulham-road and Elm Park-gardens, via Beaufort-street and Fulham-road. (vii.) Fulham-road (Elm Park-gardens) to Brompton-road, via Fulham-road. (viii.) Diversion of South Lambeth-road tramways, via Archer-street and Bond-street. (ix.) Additional tracks on Dog Kennel-hill. (x.) Further extension westward of tramways in Tooley-street from Duke-street.

The conduit system will be used on all these routes except (iii.), on which the trolley system will be employed, and either the conduit or trolley will be adopted on the first route. Consideration of the report has been deferred for a week.

Light Railways.—The Light Railway Commissioners have decided to grant an order to Birmingham Corporation to construct and work railway No. 5, and by agreement with the Hales Owen Light Railway Co. to purchase so much of railway No. 1 (running through Hales Owen and Quinton to Balden-road) as lies jointly in the city and the Urban District of Oldbury, provided the Council will pass a special resolution applying for the Order, and will by resolution undertake to complete railway No. 5, so that it shall be ready for inspection by the Board of Trade at the same time as the other Hales Owen railways are inspected. Birmingham Tramways committee recommend their Council to pass these resolutions.

The Weston-super-Mare Light Railway Order (authorising the construction of a light railway connecting the Weston, Clevedon & Portishead Light Railway and the tramways of the Weston-super-Mare & District Electric Supply Co.) has been submitted to the Board of Trade for confirmation. Objections by Aug. 10.

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On Tuesday the Light Railway Commissioners held an inquiry into the application for an order to construct a funicular railway on the Malvern Hills, up the Rushy Valley to within 90 ft. of the top of the Worcestershire Beacon.

After hearing the evidence the Commissioners said that as the railway would be over common land the consent of the Board of Agriculture would be necessary, but, subject to that, they were prepared to grant an order for the construction of the line, as they felt that the balance of public opinion was in favour of it.

Llanelly.—A Board of Trade inquiry was held here last week into the objections made by owners of houses within 200 yards oft he site of the proposed generating station of the Llanelly & District Electric Light & Traction Co. As a result of the inquiry all objections were removed, and the contractor (Mr. G. Mercer) proceeded with the work.

Municipal Telephony.—At the meeting of the Hull Telephone committee on Tuesday it was reported that Mr. Bentham had put a question in the House of Commons to the Postmaster-General as to the future of municipal telephony, and in reply the Postmaster had stated that the taking over of the National Telephone Co.'s undertaking had been definitely settled. As to the question of the Hull municipality, that was quite another matter. In all probability they would be left in the position in which they were if it was the general desire.

Municipal Wiring.—On Saturday last Barnstaple Council adopted a recommendation of their Electric Light committee that further expenditure on an electrical exhibition was undesirable until satisfactory arrangements had been made for the proper display and supply of fittings, and further facilities afforded for wiring premises of prospective consumers.

Coun. J. T. WHITE said even opponents of municipal trading seemed to be forced to the conclusion that there was only one alternative, and that was for the Council to acquire wiring powers. They would have to consider some means for increasing the sale of electricity amongst private consumers.

Coun. BARRETT said an application for a provisional order to empower the Council to wire premises would cost about £100, and, having regard to the strong opposition which would no doubt be offered, it was doubtful if the order would be secured.

Newport (Mon.).—At the last meeting of the Council it was decided that £3,500. 5s. 10d., standing to the debit of the electricity capital account in respect of superseded plant, should be paid out of the electricity revenue account or out of the general district fund. It has also been decided to apply for sanction to borrow a similar sum repayable in three years.

Penzance.—Mr. W. T. Pressland, acting for the Penzance & District Electric Supply Co., has informed the Council that his company has made arrangements for a bulk supply of electricity from the Cornwall Electric Supply Co.'s station at Hayle, the necessity for a generating station in Penzance being thereby avoided. A supply of electricity would be available in Penzance by Dec. 31, 1911, and the Council were asked to agree to allow their provisional order to remain in force and to ask the Board to postpone its revocation, so that the works might be carried out. The matter was referred to the Electric Lighting committee.

Presentation.—At the Hylton-road electricity station (Sunderland) on Thursday evening last week Mr. Harry Webber, late works superintendent, was presented with a gold chronometer stop watch by the staff of the Corporation electricity department on his leaving to take up the position of borough electrical engineer at Keighley. The presentation was made by the borough electrical engineer and manager (Mr. Alfred S. Blackman), who, in a few well chosen words, eulogised the good qualities of Mr. Webber, and wished him success in his new sphere of duty. Mr. Windle (assistant engineer), Mr. Crowther and Mr. Donkin also spoke, and Mr. Webber suitably responded.

Preston, Chorley and Horwich Tramways.—There is a prospect of this tramway scheme, which has been before the public for some time, being carried out. The Anglo-Continental Industries (Ltd.) has agreed to finance it, provided some of the required capital is found locally.

Provisional Order Revocation.—The Board of Trade have revoked the Sutton-in-Ashfield Urban District Electric Lighting Order, 1904, as from July 12.

Rhyl.—The Electric Light committee offer to supply electric current to the L. & N.W. Railway for lighting and power at the local station at 5d. per unit up to 10,000 units per annum, and if this figure is exceeded the price will be 4d. per unit.

School Lighting.—Bath Education committee have decided to adopt electric lighting at the Long Acre Technical Institute.

On Wednesday the L.C.C. Education committee decided to instal electric lighting in an extension of a technical institute by direct employment of labour at a cost of £350, and alterations are also to be carried out to the existing installation at a cost of about £130.

London-road schools and the special instruction centre, Southend, are to be wired.

South Africa.—The annual report on the Central South African Railways for 1909 states that the purchases by the administration during the year included electrical material purchased in South Africa £4,006 and in Europe £3,158, machinery £389 and £2,600, waste £309 and £1,213, engine, carriage and waggon parts £222 and £34,889, pipes and fittings £1,654 and £1,752. Steel culvert pipes (all purchased in Europe) £6,492.

Stretford.—An unopposed inquiry was held last week into the application of the Council to borrow, amongst other sums, £2,150 for additional plant for the electricity works.

The Electrical Committee.—This committee met recently, and it was decided that the president, vice-president, hon. treasurer and hon. secretary should form a committee of management entrusted with power to call meetings when necessary and generally prepare the business for the committee. Those interested in the electrical industry are requested to communicate with the hon. secretary, Bank Buildings, Kingsway, London, W.C., with reference to any question that they may wish to bring before the committee. The president has been requested to make endeavours to form a Parliamentary party in the House of Commons, and he will welcome any suggestions as to the composition of that party which may be addressed to the hon. secretary.

Torquay.—At a private meeting of the Council on Wednesday a report prepared by Messrs. Mordey & Dawbarn on the local tramways was presented.

In their report Messrs. Mordey & Dawbarn state that, in their opinion, the present Dolter system could be improved and perfected so as to render it satisfactory, and also that another surface-contact system could be substituted if necessary. An offer has been made to replace the parts of the stud which had given trouble by a simplified and improved modification by Mr. E. A. Mitchell, who was engineer to the company when the system was put down. They were of opinion that the studs so modified would give greatly improved results, and would be more easily obtained. They understood Mr. Mitchell had offered to adopt his modification to the studs on a mile of track free of cost, on the condition that if satisfactory it should be applied to the whole line. The cost would be £590 per mile, or a total of about £6,500, considerably less than the £10,000 they understood the company was prepared to expend in putting up a trolley system and in removing the studs and making good the roadway. They thought the company should be strongly urged to adopt Mr. Mitchell's proposal.

The Tramway committee were authorised by the Council to take such further action as may be necessary or expedient to retain a surface-contact system.

Wealdstone.—The Harrow Electric Light & Power Co. propose to apply for a provisional order for Wealdstone, Harrow Weald, Pinner, and Great Stanmore.

Wireless Telegraphy.—The owners of the White Star Line have made a departure by putting into commission a training ship intended primarily for the training in wireless telegraph work of a number of young men for employment in the White Star and associated companies. The "Mersey," a sailing ship, has been equipped with Marconi apparatus. She sails from Liverpool on July 28 for Australia.

Workhouse Lighting.—The South Dublin Guardians have received sanction from the L.G. Board to borrow £3,000 for electric lighting plant.

Sports.—The annual sports of Croydon Corporation Tramways Athletic Club took place last week in fine weather and in the presence of nearly 6,000 spectators. The funds will show a considerable surplus for the benefit of local hospitals.

FOREIGN.

Germany.—H.M. representative in Baden reports that a supplementary estimate has been laid before the Baden Diet for the preliminary works in connection with the erection of hydro-electric works in the Murg Valley (Black Forest) above Forbach.

The electrical energy generated will be used by the State railway administration for lighting, for motive power at the railway stations, for the workshops, and at the harbour works at Mannheim. It is not proposed at present to utilise the power from this station for traction. The total cost of the works (with cables) is estimated at 26,784,000 marks (about £1,317,000), and the first half of the work is to be taken in hand at once.

Electrical Progress in Japan.—With "The Times" of Tuesday there appeared a special illustrated supplement giving a mass of information relating to the history, the physical characteristics and the scientific, industrial and educational progress of Japan.

It is stated that at the end of 1909 the electric light, power and traction enterprises numbered 879 (of which 111 were not in operation), with a

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capacity of 439,877 kw. (of which 247,963 kw. was not available), and the capital invested in these undertakings was 166,396,440 yen (£16,674,310), increases, compared with 1905, of 70 per cent. in the number of undertakings, 353 per cent. in plant capacity and 206 per cent. in capital. The first electricity supply undertaking was that of the Tokyo Electric Light Co., which started in 1887 with one generating set of Japanese make, and this was followed by Kobe, Osaka, Kyoto, Nagoya and Yokohama and other towns, and there are now few large cities or towns without electricity supply. Though an electric tramway was constructed in Tokyo in 1890, the earliest used for public traffic was opened in Kyoto in 1895. The first hydro-electric undertaking was commenced in 1891. The tramways in operation include 17 electric and 37 horse. The total capital invested in tramways is 89,037,000 yen (£9,089,194), and the length of the lines is over 550 miles. There are 186 electricity supply undertakings (55 not in operation), with 263,016 kw. of plant, and at December, 1908, there were 318,339 consumers with 1,230,876 lamps, besides 3,688 power consumers with 3,978 motors (17,093 H.P.). Of the total plant mentioned above (439,877 kw.) 254,437 kw. is (or will be) operated by water-power and 185,440 kw. by steam, gas or other power. The motors in use in metalliferous mines in 1908 were 562 (19,842 H.P.) and in non-metalliferous mines 299 (10,461 H.P.). Although the manufacture of electrical machinery in Japan is of recent origin, it has grown rapidly, and almost all kinds of general machines, tools, wires, cables, lamps and other materials can now be obtained from works in the country, and insulators can now be manufactured for currents of the highest voltage. There are more than 50 establishments engaged in the electro-chemical industries. The first telegraph line for public use was between Tokyo and Yokohama, and was constructed by Mr. W. H. Stone, an Englishman, who is still in the Government Telegraph Department. There are now 3,933 public telegraph offices. The domestic telegrams transmitted in 1909 were some 25,140,000, the telegraph revenue in 1908 was 8,153,900 yen (£832,377), and the expenditure 5,830,400 yen (£595,187) At the end of 1909 there were 424 telephone exchanges and 932 telephone offices, and 95,271 subscribers connected, besides applicants amounting to nearly half that number awaiting connection. Telephone revenue and expenditure in 1908 were 5,262,000 yen (£537,163) and 1,835,000 yen (£187,323) respectively. Japan is an adherent to the International Wireless Convention. The system used during the late war was the work of two Japanese inventors. The use of wireless telegraphy was until quite recently confined to the army and navy, but messages from foreign steamers are now received at the coast stations for transmission to the Japanese telegraph system. The steep gradients of the railways and the presence of a large number of tunnels suggest the advisability of using electric power on the railways, and the available water-power is abundant. A special committee was appointed in 1909 to consider this subject.

Russia.—Vice-Consul D. Young reports that a Belgian company, which constructed and controls the electric lighting and tramway undertakings in Sevastopol, has obtained a concession for the construction of an electric tramway, &c., at Simpheropol, the chief town of the Crimea.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Hastings.—The total income of the electricity department for the year ended March 31 was £17,627 (11·08 per cent. on capital expended), against £16,848 (10·78 per cent.) in 1909.

Receipts from the sale of current by meter were £13,125 and from public lighting £3,750, meter rental, &c., making up the balance. Expenditure was £9,704, leaving a gross profit of £7,923 (against £7,334) to meet interest (£5,168), sinking fund (£5,621), &c. The net deficit was £2,919 (against £3,801), which the borough electrical engineer (Mr. R. F. Ferguson) states is due in a great measure to the fact that people will not wire their houses for the supply and no new buildings are being erected. Mr. Ferguson also considers that the excision of the clause from the Electric Lighting Act, 1909, conferring wiring powers, &c., on local authorities handicaps the department (which is working under a provisional order), as he has received numbers of applications for houses to be wired under some such system. Metal filament lamps have also caused a drop in the number of units sold. 846,546 units were generated (against 870,323); 569,848 were sold to private consumers (against 616,269) and 162,066 were supplied to the public lamps (against 139,103). There are 1,067 consumers (against 1,001); there are 115 lamps for public lighting (against 113) and the total maximum supply demanded was 530 kw. (against 591 kw.).

Ilford.—At the meeting of the Council last week the chairman of the Tramways committee (Mr. R. Stroud, J.P.) presented the report and accounts of the tramways department for the year ended March.

The total income was £27,580, and included £25,709 from traffic receipts. Total expenditure was £18,523 and gross profit £9,058. Interest required £4,364 and instalments of principal repaid £4,211, and after crediting the account with £557 (received from the electricity department for instalment and interest on machinery used wholly for the generation of electricity by the electricity department) there was a net balance of £1,040, which has been placed to reserve and depreciation. Capital expenditure is £148,274 and loan repayments £25,591. 7,274,398 passengers were carried and 666,344 car-miles run. 976,513 units of current were consumed (1·36 per car-mile) and the percentage of working expenses to receipts was 67·2.

Marylebone (London).—The accounts of the electricity department for the year ended March 31 were presented to and approved by the Council at their last meeting.

Receipts from the sale of current by meter were £152,868, from public lighting £4,998, and meter rental £5,859, the total income being £164,092. The cost of generation was £22,367, distribution £6,273, rents, rates and taxes £4,628, management expenses £7,760, and with legal and special expenses the total expenses were £42,052, leaving a gross profit of £122,040. After paying interest and sinking fund charges, &c. (£113,733) there was a balance of £8,482 on the year's working. After meeting sundry expenses incidental to change of pressure and other small items, the net balance (£6,369) was carried forward. 13,910,922 units were generated, 10,033,457 units were sold to private consumers by meter (against 8,843,089 in 1909) and 743,002 (against 157,772) to the public lamps (87 arcs and 2,179 incandescents). The total maximum supply demanded was 7,824 kw.

The report of the electric supply committee states that the total capital expended is £2,037,276, an increase of £12,874 during the year; but the net liability on loans account is £1,955,590. The committee do not anticipate the necessity, apart from special circumstances, for raising further capital other than relatively small amounts (about £5,000 a year) for service lines, meters, &c., for new consumers, and short extensions of the network. The increase in the number of units sold was unprecedented, and was due chiefly to important additions to the consumers' roll. Generation expenses were £43,273, against £44,606 in previous year, a decrease of £1,333, although the output increased by 19·7 per cent. Costs per unit sold were 0·961d. (against 1·19d.) The work of installing electric lamps for public lighting made rapid progress during the year, and 2,179 lamps had been dealt with at March 31, the saving to the rates amounting to £1,630 per annum. Work has been commenced on the remaining 1,100 lamps.

In moving the adoption of the report and accounts, Ald. Debenham gave particulars of the bonus scheme (referred to in our last issue), and said this scheme had already been in operation at the generating station, and had been found very satisfactory. As the result they had economised to the extent of £15,000. He considered that the electricity report was extremely satisfactory under all the circumstances, especially considering the short time the Council had had control of the undertaking. The cost of generating and distribution had decreased, and would continue to decrease. They had steadily reduced the prices charged, and they hoped to still further reduce them.

South Shields.—The borough electrical engineer (Mr. J. H. Cawthra) has issued his report (with accounts, diagrams, &c.) for the year ended March 31.

Capital expended is £184,627, an increase of £2,363 on the year. Total revenue was £25,071 (against £25,559), including £14,590 from private consumers (1,448,803 units at average of 2·42d. per unit, against £14,188, or 1,245,722 units at average of 2·73d. in 1908-9), £3,656 from public lighting (548,217 units at 1·26d., against £3,649, or 547,704 units at 1·28d.); £6,261 from tramways department (1,078,981 units at 1·39d., against £7,107, or 1,235,082 units at 1·38d.); and £564 from the Jarrow Tramways Co. (90,295 units at 1·5d., against £616, or 98,531 units at 1·5d.). Working expenses were £13,430, leaving a gross profit of £11,641 to meet interest on loans (£5,246) and sinking fund (£6,501), leaving a deficit of £106, which, together with the loss of £103 on Holborn Quay, makes a total deficit of £209 on the year's working (against a profit of £1,209 in 1909). The works costs were 0·63d. (against 0·62d.) and the total costs (including interest and sinking fund) 1·85d. (against 1·81d.). The equivalent of 133,703 35-watt lamps is connected (against 99,481), and the total horse-power of motors is 2,540, against 1,184. There are 1,474 private consumers (against 1,366), and for public lighting there are 94 arcs and 484 incandescents (as in 1909). The maximum supply demanded was 1,760 kw. (against 1,653 kw.) and the load-factor 20·53 per cent. (against 21·59 per cent.).

Mr. Cawthra attributes the deficit to the effect of metal filament lamps upon the revenue, and points out that in 1908 (when there were only 1,313 private consumers) the lighting output was 4,515,495 and last year (with 1,474 consumers) the output dropped to 1,380,881 units; the revenue from private lighting in 1908 was £14,300, against £12,412 last year. The revenue per 35-watt lamp equivalent was 2s. 8d. last year, against 3s. 7d. in 1908-9.

Accompanying the report is an interesting table, showing the number and classification of power consumers.

Stepney (London).—The total capital expended on the electricity undertaking at March 31 last was £356,259, an increase of £36,281 on the year.

Income from sale of current for private lighting, power and heating was £42,454 (against £37,852) and from public lighting £6,199 (against £6,013). After allowing for irrecoverables and adding miscellaneous receipts, &c., the total income was £52,266, against £46,934. Expenses of generation (including £12,290 for fuel, steam and electricity purchased in bulk) were £21,298, and total expenditure was £31,450 (against £28,748), leaving gross profit £20,816 (against £18,186). After paying interest (£10,850) and providing for repayment of debt (£7,955) and other items there was a net balance of £1,515 (against £1,808). The units sold for private lighting were 3,027,894 (increase 191,826), for power and heat 3,388,215 (increase 829,630), for public lighting 1,165,372, and bulk supply 427,693 (increase 118,253) a total of 8,009,174 (increase 1,175,309). The total lamps connected during the year were equal to 74,134 30-watt lamps (against 65,550); there are 484 arcs and 122 incan-

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descents for public lighting (as in 1909), and the maximum supply demanded was 3,669 kw. (against 3,248 kw.). The works cost per unit sold was 0·669d. (against 0·692d.), the total cost (including interest and sinking fund) was 1·445d. (against 1·505d.), and the average income for the total supply was 1·458d. per unit (against 1·540d.).

In the report of the engineer and manager (Mr. W. C. P. Tapper) it is stated that the outstanding feature of the year's operations was the opening of the Council's Limehouse station (on Oct. 27, 1909) by the Hon. Harry and Mrs. Lawson. The station was started and actually supplying current within 13 months from the commencement of the work on the site. An unusual feature in connection with the starting of the station, and one which added greatly to the difficulty of the work, was that it involved the removal from the Whitechapel station of boilers and turbo-generators to the extent of 2,000 kw., half of which was transferred during 1909, and the remainder is now in course of removal. In order to enable the transfer to be effected without endangering the supply, energy had, during the year, been purchased in bulk from Poplar Council to the extent of 1,027,429 units. This bulk supply is interesting as being the first case of "linking-up" under the London Electric Supply Act, 1908. Whilst the net profit is no measure of the success of an undertaking conducted primarily for the benefit of the ratepayers of the borough, it is satisfactory to be able to show, after meeting all expenses and loan charges out of revenue, a surplus of £1,515, notwithstanding that the average income per unit is only 1·458d. —the lowest in London. In his report for the year 1907-08, Mr. Tapper pointed out that, owing to the charges on unproductive capital at Limehouse station, a call upon the reserve fund might be anticipated for the first year or two after that station started working. As, however, the percentage yield of gross profit has proved to be as high as 6·16 on the capital expended—the additions during the year being averaged, it has not been necessary to call upon reserve to meet any of the increased capital charges. A large proportion of the expenditure (viz.: £1,073. 14s. 5d.) on removal of plant and machinery from Whitechapel to Limehouse was incurred during the past year, and a sum has to be written off capital expenditure, in respect of various plant and material rendered useless by the removal. This to date of accounts amounted to £1,262. 11s. 5d., and these items have been charged to reserve. The whole balance of the somewhat heavy preliminary expenses incurred at Limehouse has also been charged to reserve, in order to wipe the item out of the capital account. The value of the plant transferred to Limehouse during the year was £10,240. 0s. 3d. Most satisfactory increases would be noted in the maximum load, units generated and sold, and in lamps connected. The increase in units sold for power and heating was in advance of last year's record, whilst the private lighting units were still being influenced by the adoption of the metal filament lamps. Although the increase in total units sold was greater than in any previous year, the increase in units supplied to feeders was less than that of the previous year. That was due to the reduction effected in distribution losses by the running of the Limehouse station. The total additional lamps connected during the year was greater than that for any previous year, and there again the progress in power connections was very satisfactory. The private lighting connections show signs of recovering from the set-back received from the introduction of metal filament lamps, and the large increase in bulk supply connections was accounted for by the decision of the Port of London authority to take, during the summer months, current from the Council for the whole of their property in Stepney. The total connections (in 30-watt lamp equivalents) at March 31 last was 385,265, viz., private lighting 129,659, power and heat 226,325, public lighting 9,558, and bulk supply 19,723. Of the total of 149,382 lamps connected for private lighting and bulk supply, no less than 30,000 are connected on the "restricted supply" system. In other words, a total of 900 kw. is connected and excluded from the maximum load, and for which no provision has to be made in capital expenditure, apart from service costs and meters. With reference to the average costs per unit sold, a considerable reduction may be anticipated for the current year, when the necessary arrangements will be completed for obtaining coal in barge "alongside" at the Limehouse station, and the condensing plant put into commission. The cost of repairs and maintenance keeps at a reasonably low figure, partly due to economy effected by the annual overhaul of the machines being carried out by the Council's own staff, and partly due, also, to the remarkable freedom from serious faults on the distributing mains.

Salford.—The report of the general manager of the municipal tramways (Mr. G. W. Holford) for the year ended March states that the gross capital expenditure is £719,348.

Traffic revenue was £237,502 and total receipts £242,960. Working expenses were £152,002, and after paying interest (£24,101), sinking fund (£21,726) and rent to outside authorities (£25,958) there was a net balance of £19,172, of which £17,000 was voted to relief of rates and £2,172 carried to depreciation and renewals. 5,647,428 car-miles were run and 45,940,775 passengers carried; 9,094,699 units of current were used, or 1·63 per car-mile. The percentage of working expenses to receipts was 64, the average total revenue per car-mile was 10·33d. and the average fare per passenger 1·24d.

West Ham.—The gross receipts of the tramways for the year ended March were £127,066, against £115,813 for 1908-9. The net profit is £7,000, compared with £5,923.

Since the linking up of part of the system with that of the London County Council at Bow Bridge, the average receipts in West Ham have been about £250 a week more than those for the corresponding weeks of last year.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

London County Council invite tenders for the wiring and fitting for electric lighting of the second section of the central car repair depot, Woolwich-road. Specifications, &c., from the Clerk of the Council, County Hall, Spring-gardens, S.W. Tenders by 11 a.m. Tuesday, Aug. 30. See also an advertisement.

Tenders are invited up to Sept. 7 for supply of battery material and glassware to the Postmaster-General's Department in Queensland. Tender forms and specifications from the Official Secretary in Great Britain of the Commonwealth of Australia, 72, Victoria-street, London, S.W. See also an advertisement.

Dublin Corporation invite tenders for 12 months' supply of machinery oils for their electricity works. Specifications, &c., from the town clerk, Mr. Henry Campbell, City Hall, Dublin, where tenders (addressed to the Chairman of the Supplies committee) must be in by Friday, 29th inst. See also an advertisement.

Newport (Mon.) Electricity and Tramways committee invite tenders for supply of carbon filament electric lamps, radiator lamps (British made), flame arc lamp carbons for Excello and Oliver type lamps, and a.-c. and d.-c. two-rate and prepayment meters, during the ensuing 12 months. Specification and schedule from the borough electrical engineer and tramway manager, Mr. H. Collings Bishop, M.I.E.E. Tenders to the Town Clerk, Town Hall, Newport, Mon., by first post Aug. 15. See also an advertisement.

Belfast Harbour Commissioners invite tenders for supply and delivery into the Alexandra Graving Dock engine house, Belfast, of of 3¼ miles of 7/18 paper insulated lead-covered h.t. cable, served with jute, and suitable for 3,000 volt continuous current: also ½ mile 7/18 rubber insulated cable to sample. Specification, forms of tender, &c., from the harbour engineer, Mr. W. Redfern Kelly, M.Inst.C.E. Tenders to the secretary, Mr. W. A. Currie, Harbour Office, Belfast, by 27th inst.

Belfast Harbour Commissioners also invite tenders for the construction, delivery and erection at their electric light station of an independent surface condensing plant, with oil separator, &c. Specification and form of tender, &c., from the harbour engineer, Mr. W. Redfern Kelly, M.I.C.E., and tenders addressed to the secretary, Mr. W. A. Currie, Harbour Office, Belfast, by July 27.

London County Council want tenders by 11 a.m. July 26, for supply of 4,800 steel tyres for driving wheels, and 1,600 steel tyres for pony wheels for tramcars. Forms of tender, &c., from the Chief Officer.

The Secretary of State for India requires tenders by 2 p.m. Aug. 3 for supply of overhead floating staging and electrically-driven water supply pumps. Conditions, &c., from the Director-General of Stores, India Office.

Chorlton Guardians want tenders by July 26 for the re-plating, &c., of an accumulator at the Cottage Homes, Styal, Cheshire. Specifications, &c., from Mr. F. W. Page, 14, St. Ann's-square, Manchester.

Morecambe Corporation want tenders by July 28 for feeder pillars and arc lamp carbons. Specifications, &c., from the Borough Electrical Engineer.

Chelmsford Education committee want tenders by Aug. 31 for electric light wiring at Trinity-road school. Forms, &c., from Mr. W. H. Pertwee, London-road, Chelmsford.

Manchester Electricity committee want tenders by noon Aug. 2 for supply and erection of induced draught plant at Bloom-street generating station. Specifications, &c., from Mr. F. E. Hughes, Town Hall, Manchester.

The Deputy Postmaster-General, Brisbane, will receive tenders until noon Sept. 7 for supply of glass cells, corks and tubes and porous cups for batteries, battery material, chemicals, &c. Specifications, &c., from the High Commissioner for the Australian Commonwealth, London. Local representation is necessary.

The Deputy Postmaster-General, Melbourne (Victoria), will receive tenders until 3 p.m. Aug. 30 for supply of electrical sundries, insulators, wire and sulphate of magnesia. Local representation necessary. Further particulars from 72, Victoria-street, London, S.W.

The Transvaal Administration of Posts and Telegraphs require tenders for supply of 2 miles of 64-conductor switchboard cable. Further information from 72, Victoria-street, London, S.W. Tenders to Pretoria by July 27.

Invercargill (N.Z.) Borough Council require tenders for construction of 8 miles of electric tramway, including overhead equipment, supply of power house plant, &c., and eight motor cars. Tender forms, &c. (on deposit of £1) from the Town Clerk.

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The Italian State Railways Administration, 16, Via Ludovici, ROME, want tenders by Aug. 22 for supply of 584.000 common carbons for arc lamps. Only firms on list kept by administration are generally allowed to tender. Local representation is practically necessary.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The Maire of BOURGES (Cher, France) will receive tenders until Aug. 4 for supply of 24 three-phase asynchronous motors.

Tenders will be received at the District Offices, TOLNA (Hungary), on Aug. 16 for erection and equipment of an electric power station.

The French Government Telegraph Department, PARIS, will receive tenders until July 28 for supply of 505 tons of various sizes of g.i. wire, and until July 30 for supply of bronze and copper wire and 2,090,000 porcelain or glass insulators.

TENDERS RECEIVED AND ACCEPTED.

London County Council have accepted the following tenders :—

Brush Electrical Engineering Co. (lowest tender) for supply of 250 bogie truck double-deck roof-covered car bodies, £94,375. (Six tenders received, highest £143,750.)

Heenan & Froude (lowest) for 250 swing bolster trucks, £28,750. (Five tenders ; highest £34,000.)

British Westinghouse Co. (lowest), 250 electrical equipments, £83,812. 10s. (Three tenders ; highest £86,187. 10s.)

British Westinghouse Co., 250 sets of magnetic brake equipments, £14,250 (same price as existing contracts).

Dick, Kerr & Co. (lowest), alteration of superstructure of Battersea Bridge, £6,843. 17s. (Thirteen tenders ; highest £11,759. 7s. 5d. Chief engineer's estimate, £6,995.)

Western Electric Co. (lowest), low-tension cables, cable boxes, &c., for central car repair depot, £948. 14s. 2d. (Seven tenders ; highest £1,053. 4s. 6d. Chief officer's estimate £980.)

Maritime & General Improvement Co., insulating varnishes for electrical purposes, £105.

The L.C.C. Education committee have accepted the tender of the Central Motor Engineering Co. (at £175. 12s. 6d.) for wiring St. Mark's-road School, Kensington, and also for wiring the Haverstock Hill (St. Pancras) School at £240. 14s. 6d.

The Metropolitan Asylums Board has placed the following orders :

Speedy, Eynon & Co., extensions to internal telephones at N.E. Hospital, £29 ; United Electric Car Co., alteration to fittings of ambulance tramcar for small-pox hospitals, £22. 15s.

West Ham Education committee received 25 tenders for wiring three schools. The contract for the Clarkson-street school was let to Newbald & Co. (who will use the Stannos system) at £153. 10s., and Weston & Sons secured the order for the other two schools (which will be wired on the Simplex system) at £136. 11s. and £115. 13s. respectively. In each case the lowest tender was accepted.

Barnes Council have placed an order with Siemens Bros. & Co. to lay and joint the Boileau Arms and Clifford-avenue feeders at 4½d. per yard.

Twickenham Council have accepted the tender of Stuart & Moore for supply of three additional fire alarm posts and connecting same to existing indicators on the fire alarm switchboard for £74. 15s.

Lowestoft Council have accepted the tender of the Standard Cable Co. (at £326) for supply of cable.

Darlington Council have placed an order with the Gilbert Arc Lamp Co. for 56 arc lamps at £5. 16s. each.

Newport (Mon.) Corporation have accepted the following tenders :

General Electric Co., l.t., h.t. and e.h.t. switchboards for Llanarth-street and Corporation-road generating station, £3,063 ; Balcke & Co., cooling tower, £681 ; and Babcock & Wilcox, superheaters for six boilers, £915 ; Albion Clay Co., four-way ducts for electric cables 3s. 11½d. (less 2½ per cent.) per yard. There were 14 tenders for the switchboard contract, and the lowest tender was accepted.

Carlisle Council have accepted the tender of Pratchitt Bros. for pipework at the electricity works.

Sunderland Electricity and Lighting committee have accepted the following tenders :—

W. T. Henley's Telegraph Works Co., v.i.r. cable for stock and lead-covered cable ; British Insulated & Helsby Cables, service boxes ; J. Thompson & Co., wood troughing ; W. G. Farrow, pavement boxes for stock ; Electric & General Stores, well glasses, lanterns, wall brackets and post brackets ; Crompton & Co., Oliver Arc Lamp (Ltd.) and General Electric Co., carbons ; Sunderland Forge & Eng. Co., bearings and shaftings for converting steam-driven dynamo at Hylton-road works into motor-generators.

Worsley Council have accepted the tender of Allman & Co. for wiring the Town Hall.

Storage Batteries Contracts.—With the present low prices ruling, owing to the depreciated market values of lead, the public are doing exceedingly well in placing their orders for storage batteries. The D.P. Battery Co., of Bakewell, seem to be sharing in the contracts obtainable, and amongst numerous orders they are installing a second large battery at Letchworth for the First Garden City (Ltd.), and they have recently supplied three light and power batteries to the Midland Railway Co., the Melbourne Electric Light & Power Co. and Blackpool Co-operative Society.

The firm are also shipping five batteries to India, China, New Zealand and the Argentine, and they have even been able to ship to the United States, in spite of the tariff.

In reference to the recent meeting of mining engineers in London, where a statement was made that storage batteries entailed the attention of a highly skilled engineer, whilst such services are admittedly desirable in the case of a large central station installation, it is estimated that in fully 95 per cent. of small installations batteries are in use without skilled attention with excellent results.

BUSINESS NOTICES.

Owing to the greatly increased volume of their speedometer and motor accessory business, Messrs. S. Smith & Son have established a telephone exchange at 9, Strand, London, W.C., so that their customers may be switched through to the correct department without delay. The firm's new numbers are Gerrard 9,201 (3 lines).

Messrs. Hogan & Wardrop have removed from Gloucester Mansions, Charing Cross-road, to 2, Gresham-buildings, Basinghall-street, E.C., London.

The increased facilities will enable the firm to carry larger stocks of their fans and small motors, as well as a full range of the various switchgear manufactured by the Midland Electric Manufacturing Co. Cryselco incandescent electric lamps and the manufactures of the Electrical Conduit & Fittings Co., of Walsall, will also be stocked. The new telephone number of the firm is London Wall 723.

Mr. Walter H. Derriman, B.Sc., A.C.G.I., A.I.E.E., fellow of the Chartered Institute of Patent Agents, has entered into partnership with Messrs. Dicker & Pollak, chartered patent agents, 37, Furnival-street, Holborn, E.C., and the style of the firm has been changed to Dicker, Pollak & Derriman. Mr. Derriman is taking charge of the firm's electrical business.

We are informed that Messrs. James Gordon & Co., 81, Knightrider-street, London, E.C., makers of sectional superheaters, are placing on the market a new patented sectional superheater, which, it is claimed, has many advantages over existing designs.

Plant for Sale.—Two gas driven alternator sets of 250 kw. each are advertised for sale.

Patent Development.—The owners of British Patent No. 23,778 (1907), for "Improvements in the manufacture of electric resistances," desire to sell their patent rights or to grant licences. Applications to Messrs. Day, Davies & Hunt, 321, High Holborn, London, W.C.

The owners of Heys' patents (communicated by Scott, Varley & Anderson), Nos. 1,863/1900, 1,864/1900, and 5,257/1900, relating to "Coils for electrical purposes," desire to grant a licence or to enter into arrangements for manufacturing the patented articles in the United Kingdom. Applications to Messrs. W. E. Heys & Son, 51, Deansgate-arcade, Manchester.

The proprietor of patent No. 18,408/1906, for "Improvements in electric insulators for h.-t. conductors," desires to enter into arrangements for exploiting same in this country. Communications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, London, W.C.

The "Journal."—Part 202 of the "Journal" of the Institution of Electrical Engineers is now ready, price 5s. Particulars of contents are given in an advertisement.

Another Osram Innovation.—In several previous issues we have furnished particulars in regard to the extraordinary length of time that certain Osram lamps have been in use for street lighting in various parts of the country, and in this connection it is interesting to record that occasionally the metal caps have been found to become actually eaten away through prolonged exposure to the elements before the filaments had failed. We learn from the manufacturers that on this account they have decided in future to supply high candle-power Osram lamps with practically indestructible plated copper caps instead of brass as heretofore.

Electricity Supply in Marylebone.—We have received from the general manager of the Marylebone electric supply department two pamphlets dealing with the conduct of electricity supply in his area. The first gives a concise, clear account of the two methods of charging employed—the "maximum demand" and the "telephone" systems—either of which may be adopted at the option of the consumer. The tariffs in force for lighting, heat and power are given, accom-

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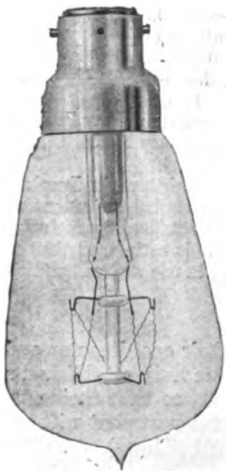
panied by numerical examples which should make the whole matter clear to the non-electrical person. The second pamphlet contains a number of illustrations showing various electric power applications, and should prove of great use to the borough canvassers.



Siemens' "Onewatt" Lamps.—We are informed by Messrs. Siemens Bros. Dynamo Works that they are now placing on the market a range of "One-watt" lamps, suitable for use on 20, 24, 25 and 30 volts and of either 10 or 16 candle-power. These lamps are being supplied with bell-shaped bulb at 2s. and with spherical bulb at 2s. 3d. They should be specially suitable for houses where transformers are used or for train lighting. The accompanying photograph shows one of these lamps, the scale being one-half.

Holiday Arrangements.—For the coming August Bank Holiday the Great Central Railway Co. announce that they have prepared a special programme of excursion arrangements to all parts of their system, and that copies of this programme can be obtained at Marylebone station, at any of the G.C.R. Agencies, or free by post from the Publicity Department, 216, Marylebone-road, London, N.W.

CATALOGUES, &c.

ELECTRO-MEDICAL INSTRUMENTS.—We have received from Messrs. Siemens Bros. & Co. three pamphlets dealing with their large range of electro-medical apparatus. The first of these has been specially produced for the forthcoming British Medical Association Annual Exhibition, which is to take place next week in London, and contains illustrated particulars of many pieces of apparatus. The second pamphlet deals with X-ray tubes and their accessories, and the third with radium salts and radio-active earths. Much useful information to medical men is contained in each of these booklets.

FORTITER THREE-PHASE MOTOR STARTERS.—The Union Electric Co. have issued a catalogue dealing with their well-known make of three-phase motor starters. A perusal of this shows that in it are described some new designs of starter, notably a star mesh switch designed for starting motors with short-circuited rotors. These are fitted with a quick make-and-break device, as well as with a ratchet which prevents them from being operated in the wrong direction.

DUDDELL OSCILLOGRAPH.—We have received from the Cambridge Scientific Instrument Co. a copy of a pamphlet describing recent improvements that have been made in their well-known Duddell oscillograph. A full description, both theoretical and practical, is given, and attention is also paid to the auxiliary apparatus which must be used with this instrument. Some interesting records that have been obtained with this instrument are also given. We understand from the company that they have just received two orders for complete Duddell oscillograph outfits for use on 50,000-volt circuits. One of these orders is from a firm in Tokyo, and the other from a large firm of cable manufacturers in Australia. The company are good enough to point out that probably these orders are the result of the notes we published on this instrument some time ago. We only hope this is the case.

"EXCELLO" LAMPS.—In a list recently issued by the Union Electric Co. an endeavour has been made to summarise in convenient form all the available information relating to the excellent "Excello" arc lamp. These lamps are being made in the same designs and types as hitherto, but attention may be drawn to two patterns which are fitted with a device for automatically cutting out the lamp should it, from any cause, fail to continue burning. Some new types of reflectors and covers are also illustrated. The same company send us a pamphlet giving details of a special lamp designed for cinematograph work.

ALIOTH MACHINES AND TRANSFORMERS.—Mr. J. Stottner forwards his latest price list of electrical material. This is a well-illustrated pamphlet containing details of the machines made by the Alioth Co. of Basle.

BANKRUPTCIES, LIQUIDATIONS, &c.

Ernest Albt. Thorn, electrical engineer, &c., 22, Mossbury-road, Clapham Junction, London, S.W., has been adjudicated bankrupt.

Neville Kaye & Co., Ltd. (electrical and general engineers), is being wound up voluntarily.

The trustee (Mr. E. F. Gardner, 144, Commercial-street, Newport, Mon.) in the bankruptcy of Geo. Sutcliffe (trading as Geo. Sutcliffe & Co.), electrical engineer, 22, George-street, Abertillery, Mon., has been released.

The trustee (Mr. C. J. Band, 8, High-street, Coventry) in the bankruptcy of Ernest Goodman (trading as E. Goodman & Co.), electrical engineer, 30, Hertford-street, Coventry, has been released.

A first and final dividend of 1s. 9¾d. is payable July 25 at 26, Baldwin-street, Bristol, to creditors of Robt. Edwd. Joy (trading as the Bristol Electrical Co.), 143, Cheltenham-road, Bristol.

A dividend is to be paid to creditors of Harry Graham, electrician, &c., Albion-street, Huddersfield. Claims to Mr. E. Netherwood, Cloth Hall-street, Huddersfield, or to Mr. G. W. Smith, 23, John William-street, Huddersfield, by July 29.

A dividend is to be paid to the creditors of Charlotte Rix (trading as Bridgewater & Wright), electrical engineer, 78, York-road, King's Cross, London, N. Claims to Mr. E. H. Hawkins, 4, Charterhouse-square, London, E.C., by July 29.

COMPANIES' MEETINGS AND REPORTS.

United River Plate Telephone Co. (Ltd.)

The twenty-fourth ordinary general meeting of this company was held on Tuesday, under the presidency of Sir IRVING COURTENAY.

The SECRETARY (Mr. David Smith) having read the notice calling the meeting, and the auditors' report,

The CHAIRMAN said: Gentlemen, the result of the year's working has been exceedingly satisfactory, and the company has made excellent progress during the year under review. Subscribers have increased, revenue has increased, the service, we believe, has improved and is improving. By the end of the year we expect all our principal exchanges in Buenos Aires will have been turned over from magneto to common battery working. The new common battery boards, several of which are now working, have been of the most material assistance to us. These changes, of course, necessitate a great deal of other work before the boards can come into use. For instance, existing overhead installations have to be taken down and new distributors connected to our underground plant; but, as far as possible, all this work has been proceeding contemporaneously, and the present year should see the bulk of it completed. Labour troubles (not our own), the rapid development of the demand for telephone facilities, and the Centenary celebrations (bringing as they have done many thousands of visitors into the capital of Argentina) have made the strain in our case exceptionally severe this year; but great as the strain was (on some days the rush of traffic rose to 127 per cent. above normal) our latest advices indicate that we got through without any serious hitch. We are also engaged in erecting a common battery board with a suitable building in Bahia Blanca, where, as I mentioned last year, we have put part of our plant underground; and as a like provision will require, before very long, to be made in Rosario, we have taken the opportunity, when installing a new sub-exchange in that city, to anticipate the conversion of the main exchange and this sub-exchange will be on the common battery system. Our exchange in Cordoba has also been growing, and will require reorganisation soon, and there also a new building will be necessary when we put in the new board. We have opened new exchanges in Florencio Varela and Monte Grande, two important and growing suburban towns to the south of Buenos Aires, and in Maipu on the Dolores Mar del Plata line. I mentioned last year that we were making arrangements for constructing a line to Mar del Plata, which has been described as the Brighton of Argentina. The authorities were anxious that this line should be ready for last season, and, in spite of many difficulties, our people completed this line of about 250 miles in what I should think is record time for such an undertaking. It was opened early in the season. The result has more than fulfilled our expectations. The Azul line, to which reference was also made in last year's report, has enabled us to tap an important district in the centre of the Province of Buenos Aires, and when we are in a position to carry this line right through to Bahia Blanca, as we hope to do before long, we will have an extension of which any company may be proud. Our private branch exchange business is growing rapidly, and is already a valuable adjunct to our business. During the year we have strengthened several of our older provincial lines, enabling them to withstand the violence of the severe storms which from time to time sweep over parts of the country, besides adding additional junction lines between the more important exchange centres.

It is our policy, wherever possible, to own the land and buildings in which our exchanges are situated. During the year we have purchased the premises at Brandzen and Lujan. We have secured a desirable plot of land in Mar del Plata, and we have purchased sites in General Belgrano and Bella Vista, as well as one for the new sub-exchange in Rosario. Suitable buildings for these exchanges are either in course of erection or will form part of the current year's programme. To provide for these various works, it is proposed to make a fresh issue of 40,000 ordinary shares, to be offered to the ordinary shareholders at par.

With regard to the accounts, there are few items calling for special mention. Share capital has been increased by £150,000 by the issue in September last. Sundry credit balances are a little higher, due to increased volume of business. Subscriptions paid in advance have increased by £2,700; the reserve fund is increased by the £25,000 added last year, and we propose to add a further £30,000 for the present year. The reserve fund, you will doubtless note with keen approval, is growing steadily, and in view of the growth of our business and capital the directors attach great importance to this. On the credit side we have

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spent £130,530 in capital expenditure. The special replacement account stands at £30,447. 18s. We have considered it wise in the past to write down this account as quickly as possible, and we have this year put aside £30,000 for the purpose, which practically clears the account. Our real estate is up by £16,000, representing new buildings and sites for exchanges, &c. The increase of £13,000 in sundry debtors represents, for the most part, payments made on account of the new boards in transit or in course of erection and not yet taken over by us from the contractors. The securities are nearly of the same amount as last year, and it will be a satisfaction to you to know that the market value of these investments is well over the figure in the balance-sheet. Stock of materials has risen considerably, but in connection with our new developments we have naturally to carry large quantities of materials of many and varied descriptions, as in our case we are a great distance from our suppliers. Bills receivable and cash at bankers are together some £11,000 better than last year. There has been a gratifying increase in receipts in the River Plate, and although the expenses abroad have also gone up, still the general result is an increase in the net profit for the year of £8,124. Our secretray, Mr. David Smith, has just returned from Buenos Aires, where he made himself thoroughly acquainted with the staff and the various departments of the business; a visit which will be of much benefit to the company. The directors recommend a final dividend of 5 per cent. on the ordinary share capital (making 8 per cent. for the year, tax free). I now move the adoption of the report and accounts and the dividend recommended therein.

Mr. GEORGE KEITH seconded the resolution.

Mr. MARTIN HERZHEIM said he had followed with much pleasure the statement made by the chairman. The satisfactory conditions on which the chairman had enlarged were chiefly due to two points: first, to the continued increase in the wealth and population and the industrial activity of the Argentine Republic, and, secondly, to the wisdom, care and scientific skill brought to bear upon the management of the company. The chairman, assisted by his colleagues, and by, he believed, their expert adviser, Sir John Gavey, gave time to the affairs of the company for which they could scarcely be sufficiently grateful to him.

After a short discussion, the motion was carried unanimously.

The re-election of Mr. Frederick Green as a director, and of the retiring auditors, was followed by a resolution increasing the capital of the company to £1,500,000 by the creation of 100,000 new shares of £5 each, which was unanimously approved.

The CHAIRMAN then said: I have a pleasant duty to perform—to move a resolution that a sincere vote of thanks be accorded to the Consultative Committee in the Argentine, as well as to Mr. Parker, the general manager, and his staff, and also to Mr. David Smith, our excellent secretary, and his staff in London.

Sir J. GAVEY seconded the motion, which was carried unanimously, and a cordial vote of thanks to the chairman and directors brought the proceedings to a close.

Telegraph Construction & Maintenance Co. (Ltd.)

A half-yearly general meeting of this company was held on Tuesday, under the presidency of Sir JAMES PENDER, Bart.

The SECRETARY (Mr. C. W. Clarke) read the notice convening the meeting.

The CHAIRMAN then said: Gentlemen, I have much pleasure in announcing that the Earl of Selborne has accepted the chairmanship of this company. I feel sure that you will all agree with me in thinking that we are very fortunate in getting so eminently suitable a chairman; he will certainly add great strength to our board. This important announcement quite justifies our summer meeting for once, otherwise it is usually a matter of embarrassment to your Directors that you should be called together at this time without there being any definite business to be laid before you. You will remember that the half-yearly meetings of this company were inaugurated in 1871 in accordance with a wish expressed by a few of the proprietors, that although no accounts could be rendered, a meeting should be held in order that they might hear a few words from the chairman with respect to the position of the company, and have the opportunity of asking questions. These interim meetings no doubt served a useful purpose in the early seventies, when there was a good deal of speculation in shares, and when they were very sensitive to all kinds of surmises and rumours. It has now, however, become a question which the proprietors may do well to consider whether they really care to continue these midsummer meetings. On the present occasion all I have to tell you is that we are very busy. There are details of our work which I might talk about, but every business man in this room knows that it is best not to talk about work which we have in prospect, or concerning any contract we may be expecting. This only incites our competitors to redouble their efforts. On the other hand, if we have secured a contract, it is best not to talk about it, as materials have to be bought, and it is only too easy to put prices up against ourselves by permitting the markets to know what our requirements are. With regard to the immediate past, the newspapers have informed you that during the last half-year we have laid the second longest cable in the world (3,144 miles), between La Plata and Ascension, the longest cable being the Vancouver–Fanning Island section of the Pacific cable, which we laid in 1902, the length being 3,458 miles; but the cable we have laid this year is heavier in the copper conductor, making it the biggest cable ever laid. Everything went well with this work (cheers), and it was successfully completed before the contract date, and well in time for the opening to take place on the occasion of the centenary of the Argentine Declaration of Independence. I have nothing further to announce, except that the interim dividend of 12s. per share (5 per cent.) will be posted to you to-day.

Mr. CROFT thought the shareholders will have heard the announcement just made with respect to the appointment to the board with great satisfaction. It is a great thing for a company of this kind to have such an eminent person as Lord Selborne at the head of affairs. This does not imply that the chair has not been well filled during what I may call the interregnum. You have carried out the duties of chairman in the most satisfactory manner, with the approval not only of your colleagues but of the company generally. With regard to what you have described as the midsummer meeting, you, as I understand, desire the opinion of the shareholders whether this is really necessary. I suppose it would require a vote of the company to do away with the second meeting; but, speaking for myself, I have always thought it unnecessary to hold this meeting, which, after all, is not a half-yearly, but only an interim meeting.

The CHAIRMAN thanked Mr. Croft very much for his remarks. The directors were specially glad to hear the opinion of the proprietors in reference to the interim meeting. He was obliged to Mr. Croft for his reference to the work done by the board and the staff, for which he was sure they would be grateful. The proceedings then terminated.

General Electric Co. (Ltd.)

At the meeting on Tuesday the CHAIRMAN (Mr. G. Byng), in moving the adoption of the report, said that the directors were glad to be able to report a good increase of profits—£95,000 against £78,000 last year. The board had decided to propose as hitherto a dividend of 5 per cent. on the ordinary shares. They were increasing their reserve fund by £22,000 and had commenced a new policy of carrying forward a substantial sum. These measures would considerably strengthen their financial position. Hitherto they had used their credit for their financial purposes, but in future they intended to invest part of their reserve in convertible securities, which they hoped would enable them to rely upon their own resources for the large sums they were sometimes called upon to employ in the business. The balance carried forward exceeded £8,000, enough to cover the full interest on their debentures. The directors were proud of the success which they had lately achieved in the production of telephone exchange equipments. The English telephone industry had in the past been in an ignominious position. They had been especially well fitted to produce telephones, and in the inception of that industry England was far ahead of any other country. Yet, that important industry had been strangled in its infancy, and for over 20 years the English and Colonial telephone companies had had to buy all their equipments and instruments from foreign makers. He was pleased to say that a change had at last been made by the British Post Office. They had been very far-sighted in insisting on getting English made apparatus in spite of deep-rooted prejudice, due mainly to mistaken notions in regard to the economical aspect of the question. The General Electric Co. especially had to thank the Government for much encouragement. The result had been most satisfactory to both parties. They had now completed the installation of one of the largest and most important telephone exchanges in the kingdom—every particle, every screw, being made at their Salford works—as well as, and he was assured, even better than, the foreign equipment which held the monopoly for 20 years. They had also nearing completion the installation of another Post Office exchange. Further, they had well in hand an exchange equipment for the Australian Commonwealth, and they had supplied similar plant to the Indian Government. Besides those exchange equipments, they had manufactured, and were manufacturingl, arge quantities of telephone apparatus for the British Post Office and the Colonies. Moreover, the apparatus was to designs prepared by the company. The prices at which the Post Office was now buying in England were far below the foreign prices paid formerly. For instance, instruments previously supplied by the foreigner were now produced in this country and sold at rates lower than the old prices by various percentages running up as high as 30 per cent. That would explain why they had devoted the whole of Peel Works to the manufacture of telephone apparatus, and they were carrying it on now as a subsidiary company called the Peel-Conner Telephone Works (Ltd.), under the able management of Mr. M. S. Conner. Their biggest enterprise, the Witton Engineering Works, had turned out very good work, and its excellent staff and workers had again increased the reputation of their products throughout the world. They had erected some big plants, not only at home, but in the Transvaal, Australia, India, the Argentine and the East. It was unfortunate that the prices ruling were still unremunerative. They had to rely less upon competitive prices than upon the excellence of their plant. They were keeping the flag flying over their carbon works, although they had not yet been able to show a profit in face of foreign competition. The advent of the flame lamp had helped them very much, and in the making of flame carbons they had succeeded in beating the quality of almost all their Continental competitors. They had been greatly encouraged by the policy pursued by the Admiralty, who had recognised the importance of a carbon factory in England. Their example was being followed by most Government Departments, but they had much to complain of in the action of many municipalities. They had increased their foreign depots and agencies in order to find outlets for their large factories. The preferential duties in Canada and Australia had been of very material benefit to them, and had helped in the employment of hundreds of workpeople throughout the year. The sale and influence of the Osram lamp had fulfilled the board's expectations. The wonderful efficiency of that great invention had reduced the cost of electric lighting to less than that of gas. Thousands of Osram lamps were in use to-day that had burned over 6,000 hours—a durability truly astonishing. They regretted to say, however, that their patent rights had been greatly infringed, and they had been compelled to take legal proceedings against infringers, both on the master patent as well as upon minor patents, of which there are many.

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CHATHAM & DISTRICT LIGHT RAILWAYS CO.—For the half-year ended June 30 the revenue was £21,601. 8s. 1d. and the expenses £12,703. 17s. 4d. Deducting rent of Rochester Corporation lines (£1,871. 16s.) and interest (£1,234), and adding amount forward (£298. 10s. 5d.), the balance is £6,090. 5s. 2d. The directors recommend payment of the 5 per cent. preference dividend (£2,940) and of dividend at the rate of 2 per cent. on the ordinary shares (£1,060), carrying forward £2,090. 5s. 2d. Traffic receipts show an increase of £1,242 over those for the corresponding period of last year, and there has been a saving of £117 in the expenses.

CROMPTON & CO. (LTD.)—The directors' report for the year ended March 31 states that competition for business has been keener than ever before, and orders have been difficult to obtain. With a view to keeping the works employed, a considerable amount of business has been taken at works cost, with the result that output has only fallen off to a comparatively small extent. The gross profit realised on trading has not been sufficient to pay administration and selling expenses, while the completing of a large contract in the East has entailed a heavy charge on the year's accounts. Litigation in connection with an order for pumping plant has involved the company in special legal expenses. The loss for the year, after making the usual full provision for depreciation and charging all repairs against revenue, amounts to £20,493. 2s. 10d., compared with a profit of £10,051. 10s. 4d. for the previous year. After providing for debenture interest and other charges shown in the net revenue account, and after deducting the balance brought forward, there remains a debit balance of £23,368. 18s. 9d. The guarantee of the Auxiliary Electric Co. in connection with the earnings of the Electric Supply Corpn. has now expired, and the final adjustment should shortly be arrived at. The directors have decided to write down the company's holding in the Electric Supply Corpn. to £4 per share, taking the necessary amount from the reserve fund for that purpose. The claim under the policy of insurance held by the Auxiliary Co. has been settled on terms which are considered favourable. During the financial year, expenditure on patents and experimental work has been considerably in excess of the average. This increase is in connection with an invention which is likely to prove of great value to the company. All such expenses have been charged against revenue, but £600, being the purchase price of a patent which it was important that the company should control, has been added to patents account. In view of the continued depression in the electrical manufacturing trade, the directors have taken steps to further reduce expenses, and with that view are arranging to move the headquarters of the sales department to the works, which it is estimated will effect considerable economies. Although there appears to be an improvement in the volume of the trade of the country, the slight increase in the demand for electrical machinery has not affected market prices. At the same time, the directors are of opinion that by the exercise of the most rigid economy a margin of profit can be earned, even on the basis of the present low prices. Since the close of the financial year an improvement is noticeable in the value of orders coming from colonial and foreign sources.

DIRECT UNITED STATES CABLE CO. (LTD.)—The report of the directors for the half-year ended June 30 states that the revenue (after deducting out-payments) amounted to £58,556. 0s. 5d., compared with £56,444. 18s. 1d. for the corresponding half-year of 1909. Working and other expenses for the same period (including income tax) amounted to £25,277. 6s., leaving £33,278. 14s. 5d. as the net profit, and making, with £6,859. 11s. 2d. brought forward, £40,138. 5s. 7d. For the corresponding period of 1909, the working expenses and other payments were £25,035. 17s. 3d. Three quarterly interim dividends of 4s. each per share (amounting to £36,426) have been paid, and a final dividend of 4s. per share is now proposed, together with a bonus of 2s. per share (both tax free), making with the three interim dividends 4½ per cent. for the year, a total distribution of £54,639. After transferring £5,000 to reserve, the balance of £4,783. 5s. 7d. is proposed to be carried forward. The reserve fund has been debited with £3,584, cost of cable maintenance, and after being credited with interest on the investments, profit on sale of securities and amount transferred from revenue, the balance now amounts to £533,024. 5s. 1d.

NATIONAL TELEPHONE CO. (LTD.)—The income accrued in respect of the business of the half-year ended June 30 amounted to £1,677,587. 17s., compared with £1,549,136. 2s. 9d. for the corresponding period of 1909, an increase of £128,451. 14s. 3d. Working expenses were £974,757. 7s. 2d., compared with £890,798. 2s. 5d., an increase of £83,959. 4s. 10d. The net result (after deducting P.O. royalties amounting to £161,529. 16s. 1d.) was a profit balance of £541,300. 13s. 8d., compared with £509,210. 10s. 10d. an increase of £32,090. 2s. 10d. The rentals carried forward for unexpired terms of running contracts amount to £1,482,179. 1s. 8d., compared with £1,366,283. 9s., being an increase of £115,895. 12s. 8d. Out of the available balance of £409,093. 14s. 1d. the board recommend payment for the half-year of a dividend at the rate of 6 per cent. per annum on the first and second preference shares, 5 per cent. per annum on the third preference shares, 6 per cent. per annum on the preferred stock, and 6 per cent. per annum on the deferred stock, less tax in all cases. The board also propose to transfer £175,000 to reserve and to carry forward the balance of £15,343. 14s. 1d. £216,873. 14s. was expended on capital account during the half-year in the erection of 16,236 additional exchange and private stations and in the construction of underground works.

NATIONAL TELEWRITER CO. (LTD.)—The first general meeting was held on Monday when the chairman (Sir Wm. P. Treloar) said the working capital, after payment of the purchase consideration, was £52,000. £12,554 had been expended on construction, instruments, exchange and plant. They encountered difficulties with regard to the delivery by the makers of the standard machine parts—difficulties which had delayed their operations. Contracts were placed in July, delivery to be made in November; but the parts tendered for approval did not pass the tests to which they were submitted, with the result that the period of manufacture was unexpectedly prolonged, and deliveries to enable them to assemble the various parts of their machines did not actually begin until January of this year. A competent staff for the assembling of the machine parts was at once engaged and trained; but the first complete instruments were not at the disposal of their contract department until March 1, 1910. They had now obtained orders for upwards of 100 instruments, and, in addition to orders which were pending, trials were being made with the company's instruments by railway companies, hotels and others. They believed the great usefulness of the Telewriter was bound soon to be made evident. They hoped shortly, with the sanction of the Post Office, to complete arrangements whereby messages could be sent through their exchange direct to the cable companies' offices. They had secured and equipped premises where private Telewriter boxes were installed for the use of members of the Stock Exchange, and other installations were in preparation. Until recently their operations had been practically confined to the Metropolis; but they looked forward with confidence to results to be obtained in the provinces. They had appointed agents in the principal provincial centres, and competent mechanics had been trained in their workshops to take over the maintenance of Telewriter installations. They contemplated the early opening of an exchange in the West-End of London.

PHOSPHOR BRONZE AMALGAMATION.—We understand that the London Phosphor Copper & Bronze Co. have acquired the entire assets and works of the Phosphor Bronze Co. (Ltd.) (in liquidation). The businesses have been amalgamated, and are being continued under the name of the Phosphor Bronze Co. (Ltd.), which has a capital of £100,000 and will take over all existing contracts. Mr. Walter Lester, proprietor of the London Phosphor Copper & Bronze Co. has been appointed managing director and chairman of the newly-formed company.

CITY NOTES.

MEMORANDA (July 21).—Bank rate 3 per cent. (since June 9, 1910). Price of silver, 25¼d. per oz. Consols 81¼—82 for money; 81⅜—82 for account. Consols Pay Day, Aug. 4; Stock and Shares Continuation Days, July 26 and Aug. 10; Ticket Days, July 27 and Aug. 11; Pay Days, July 28 and Aug. 12; Mining Shares Carry Over Day, July 25.

PRICES OF METALS (London).—*Copper*, cash, 53⅜; three months, 54⅛. *Lead*, English, 12¾—13; foreign, 12⅝. *Spelter*, 22⅜—22¾. *Tin*, English, 147—149; foreign cash, 148½; three months, 149⅜. *Iron*, Cleveland, cash, 48/11, three months, 49/7½.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The directors have resolved, after placing £5,000 to credit of the renewal fund, to declare an interim dividend for the quarter ended June 30 of 15s. per cent. on the ordinary stock and £1. 10s. per cent. on the preferred stock (less tax) payable 30th inst. After paying the foregoing dividends there will be a balance of £18,297 to be carried forward.

CENTRAL LONDON RAILWAY CO.—For the half-year ended June 30 a dividend of 3 per cent. per annum on the ordinary stock is recommended, and 4 per cent. per annum on the preferred. Provision is also made for the dividend on the deferred, payable at the end of the year, and £40,000 is carried forward. A year ago the dividends were at the same rate and £39,000 was carried forward.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The transfer books and register of members of this company will be closed from 27th inst. to Aug. 10 inclusive.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The directors have declared an interim dividend on the preference shares at the rate of 6 per cent. per annum (less tax) for the half-year ended June 30, and an interim dividend on the ordinary shares for the same period at the rate of 4 per cent. per annum (less tax), both payable on Aug. 2. The transfer books and register of members will be closed from 20th inst. to Aug. 2.

METALITE LIMITED.—We set out on another page an abridged prospectus of Metalite Limited. The capital is £500,000 in £1 shares of which 380,000 will be offered for subscription. The subscription list opens on Monday next, and will close on Friday, July 29, for London, and Saturday, July 30, for the country. The company has been formed to acquire as going concerns the "British Metalite" lamp and metallic filament manufacturing business in the United Kingdom of the Bryant Trading Synd., (Ltd.), and the business, patents, processes and goodwill of International Filaments, Limited. As regards price and efficiency, it is claimed for the "British Metalite" lamps that they are superior to any of the foreign productions sold in this country. The prospectus states that contracts at a substantial profit and exceeding fifteen million (15,000,000) filaments per annum for the next five years are already in hand and in course of execution, in addition to many large trade orders.

METROPOLITAN RAILWAY CO.—The directors recommend a dividend on the ordinary stock for the past half-year at the rate of 1½ per cent. per annum (against 1 per cent. last year), carrying forward about £6,000 (against £4,000), after placing £10,000 to electrical renewal and depreciation fund. The total receipts for the half-year were £391,488 and the expenses £194,019, leaving a profit of £197,468. The receipts show an increase of £12,001 and the expenses an increase of £776 over the corresponding half-year. The net revenue account, after providing for interest on debenture stocks and other fixed charges and placing £10,000 to electrical renewal and depreciation fund, showed a balance of £146,379.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—The directors have declared an interim dividend on the preference shares at the rate of 7 per cent. and on the ordinary shares at the rate of 10 per cent. for the half-year ended June 30. The share transfer books will be closed from July 23 to Aug. 5 inclusive.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	July 8	216	− 5	27	5,906	+ 103
Anglo-Argentine	„ 15	45,489	+ 10,166	28	1,239,628	+ 145,069
Ayr Corporation	„ 16	534	+ 67	9	3,102	+ 172
Baker St. & Waterloo Ry.	„ 16	3,120	+ 15	2	6,570	+ 100
Barnsley	„ 8	164	− 1	27	4,597	+ 140
Barrow	„ 8	304	+ 47	27	6,798	+ 922
Bath Electric Trams, Ltd.	„ 13	953	+ 56	28	21,676	+ 1,484
Birmingham Corporation	„ 16	6,745	+ 445	15	103,127	− 800
Birmingham & Midland	„ 1	864	+ 22	26	21,639	+ 438
Blackburn Corporation	„ 13	1,207	+ 104	‡16	17,218	− 809
Blackpool and Fleetwood	„ 16	1,307	+ 333	..	..	..
Bolton Corporation	„ 17	2,561	+ 126	16	36,837	− 700
Bombay	June 17	2,696	+ 190	24	65,690	+ 4,560
Bournemouth Corporation	July 13	3,900	+ 2,245	15	27,127	+ 2,241
Bradford Corporation	„ 16	5,567	+ 629	16	78,819	+ 2,109
Brighton Corporation	„ 17	1,056	+ 18	§15	14,455	− 426
Bristol Trams & Carriage	„ 15	6,456	+ 656	2	12,659	+ 889
Burnley Corporation	„ 16	1,313	+ 57	2	2,534	+ 19
Burton Corporation	„ 17	272	− 3	15	4,096	− 43
Bury Corporation	„ 17	1,242	+ 49	§15	18,415	− 449
Calcutta Tramways Co.	„ 16	₹3,922	+ ₹1,676	2	₹106,094	+ ₹1,032
Camborne-Redruth	„ 16	117	− 2	28	3,402	− 121
Cardiff Corporation	..	..	..	..	..	..
Cavehill	„ 8	104	+ 14	27	2,277	+ 188
Central London Railway	„ 16	5,673	+ 379	2	11,699	+ 797
Charing C., Euston & H'stead	„ 16	3,635	− 215	2	7,345	− 495
Chatham & Dist. Lt. Rys.	..	..	..	..	..	..
City & South London Rly.	„ 17	3,002	− 86	2	6,127	− 152
City of Birmingham	„ 8	2,850	− 1,536	27	76,938	+ 1,843
Colchester Corporation	„ 13	217	+ 17	..	..	..
Cork Electric Trams Co.	„ 14	581	+ 43	28	13,361	+ 1,696
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	„ 8	401	+ 57	27	11,118	+ 1,382
Dover Corporation	„ 9	242	+ 21	14	2,950	+ 18
Dublin & Lucan Railway	„ 15	185	+ 26	2	348	+ 1
Dublin United	„ 15	6,399	+ 717	2	12,904	+ 657
Dudley-Stourbridge	„ 8	800	− 62	27	20,207	− 659
Dundee Corporation	„ 13	1,236	+ 124	§8	10,366	+ 292
East Ham Council	„ 16	1,074	+ 48	¶15	15,982	+ 399
Exeter Corporation	„ 15	373	+ 36	15	5,521	− 634
Gateshead & Dist. Trams	„ 8	992	− 5	27	26,249	− 238
Glasgow Corporation	„ 16	18,392	+ 1,431	7	123,236	+ 8,488
Glossop Trams	„ 16	116	− 13	28	3,158	− 164
Gloucester Corpn.	„ 13	314	+ 12	1	608	+ 4
Gravesend-Northfleet	„ 8	227	− 12	27	5,366	+ 100
Great Northern & City Rly.	„ 16	1,327	+ 29	2	2,678	+ 44
Gt. Northern, Piccadilly, &c.	„ 16	5,435	+ 5	2	11,335	+ 230
Greenock & Port Glasgow	„ 8	831	+ 351	27	16,358	+ 2,425
Hartlepool Tramways	„ 8	286	+ 10	27	6,186	+ 298
Hastings Elec. Trams Co.	„ 14	1,175	− 11	2	2,350	− 101
Hong Kong	„ 16	$9,442	+ $1,733	2	$18,595	+ $2,748
Huddersfield Corpn.	„ 16	1,884	+ 259	15	26,991	+ 1,347
Hull Corporation	„ 16	2,704	+ 222	15	41,109	+ 2,627
Ilford District Council	„ 16	569	+ 73	15	8,250	+ 383
Ilkeston District Council	„ 13	133	− 2	15	1,915	− 93
Ipswich Corporation	„ 16	475	+ 16	15	6,251	+ 201
Isle of Thanet Co.	„ 16	1,231	+ 185	¶40	17,401	+ 814
Jarrow	„ 8	125	..	27	3,221	+ 190
Keighley Corporation	„ 14	199	+ 28	15	2,699	+ 88
Kidderminster & District	„ 8	131	− 6	27	2,670	+ 70
Kilmarnock Corporation	„ 16	163	+ 8	9	1,359	+ 13
Lanarkshire Trams Co.	„ 14	1,493	+ 157	28	38,580	+ 4,076
Lancashire United	„ 13	1,458	+ 111	28	36,044	− 448
*Leamington	„ 8	165	− 57	27	4,202	− 160
Leeds Corporation	„ 16	7,352	+ 485	15	108,399	+ 3,347
Leicester Corporation	..	..	..	..	..	..
Leith Corporation	„ 16	685	+ 17	9	5,798	+ 200
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	„ 9	11,481	− 285	27	298,549	+ 11,079
Liverpool Overhead Rly.	„ 17	1,447	+ 13	3	4,318	− 98
Llandudno&ColwynBayRy.	„ 15	463	+ 52	§32	6,448	+ 1
*London County Council	„ 6	42,376	+ 5,038	¶14	585,266	+ 83,727
London United	„ 16	7,338	+ 707	28	174,309	+ 10,227
Lowestoft	„ 16	240	+ 24	42	6,592	+ 304
Maidstone Corporation	„ 16	194	+ 4	15	2,606	− 240
Manchester Corporation	„ 16	16,132	+ 914	15	238,230	+ 4,272
Mersey Railway	„ 16	1,969	− 21	2	3,852	− 81
Merthyr	„ 8	215	− 19	27	5,427	− 222
Metropolitan Dist. Railway	„ 16	10,703	+ 619	2	21,924	+ 1,499
Metropolitan Elec. Trams	„ 8	7,546	+ 242	27	195,883	+ 35,976
Middleton	„ 8	318	− 55	27	8,265	− 599
Nelson Corporation	„ 16	168	+ 25	§15	2,207	+ 26
Newcastle-on-Tyne Corp.	„ 16	3,796	+ 53	¶15	61,129	− 437
Newport (Mon.)	„ 16	675	+ 59	16	10,051	+ 399
Northampton Corporation	„ 15	510	+ 13	§15	7,503	+ 16
Oldham, Ashton & Hyde	„ 8	551	− 49	27	14,738	− 110
Oldham Corporation	„ 17	1,969	+ 65	16	30,480	− 945
Perth (N.B.) Corporation	„ 13	173	+ 25	§8	1,446	+ 111
Perth (W.A.) Elec. Trams	„ 15	1,529	+ 149	28	43,273	+ 3,371
Peterborough	„ 8	204	− 29	27	2,990	− 37
Portsmouth Corporation	„ 16	2,283	+ 81	15	31,130	− 1,040
Potteries	„ 8	1,799	− 94	27	47,013	− 521
Preston Corporation	„ 13	763	+ 15	15	11,003	− 278
Rotherham Corporation	„ 14	629	+ 91	15	9,258	+ 156
Rothesay	„ 9	466	+ 30	27	3,696	..
Salford Corporation	„ 18	4,802	+ 199	†16	73,273	+ 256
Sheerness	„ 8	52	..	27	1,227	− 25
Sheffield Corporation	„ 17	5,985	+ 268	¶16	97,561	+ 5,483
Singapore Trams	„ 16	$10,170	+ $810	2	$20,394	+ $1456
South Metropolitan	„ 8	830	− 78	27	21,505	+ 1,185
South Staffs	„ 8	838	− 80	27	22,160	− 45
Southend Corporation	„ 13	726	+ 140	15	8,252	+ 957
Southport Tramways	„ 8	325	− 52	27	7,452	+ 165
Stalyb'dge,Hyde,&c., Jt.Bd.	„ 16	799	− 38	¶15	11,002	− 1,100
Sunderland Corporation	„ 17	1,202	− 88	16	17,628	− 445
Sunderland District	„ 13	406	− 35	37	15,377	− 1,148
Swansea Trams	„ 8	1,141	+ 117	27	28,032	+ 3,291
Swindon Corporation	..	..	..	..	..	..
Taunton	„ 8	43	..	27	1,098	+ 117
Tynemouth and District	„ 8	334	− 59	27	5,741	+ 525
Tyneside Trams Co.	„ 13	456	+ 11	2	835	− 70
Wallasey District Council	„ 16	1,107	+ 97	§15	14,381	− 361
Walsall Corporation	„ 16	533	+ 22	28	14,851	+ 707
Warrington Corporation	„ 14	412	+ 39	15	5,852	+ 39
*West Ham Corporation	„ 7	2,498	+ 34	14	34,694	+ 1,203
Weston-super-Mare	„ 7	257	− 10	27	2,468	− 31
Wolverhampton Co.	„ 8	448	+ 31	27	11,210	+ 230
Wolverhampton Corpn.	„ 13	1,044	+ 159	15	14,176	+ 2,156
*Worcester	„ 8	306	− 19	27	7,183	+ 153
Wrexham	„ 8	94	− 9	27	2,569	+ 10
Yorkshire W.R. Trams	„ 17	1,192	+ 8	29	35,387	..
Yorkshire Woollen District.	„ 8	960	+ 37	27	26,023	+ 2,316

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Shre	Last Dividend	NAME.	Price Wed., July 20	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to July 20 High-est.	Business Week to July 20 Low-est.
		Electricity Supply.					
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½—9¾	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10⅛—10⅜	5 13 0	Feb, Aug	..	..
10	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	102⅛	102
St.	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼—7½	6 9 0	March	7 1/16	..
5	3/6	Do. 7 per Cent. Pref.	7 —7⅛	4 13 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3½—4	6 5 0	Feb, Aug	3 1/16	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 14 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	99	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	99½—101¼	4 8 6	..	101⅛	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅜—4⅛	5 6 0	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜—4⅛	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	101	..
10	9/0	City of London Electric Lighting Ord.	11⅜—11⅝	5 17 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅞—12⅛	4 16 0	Jan, July	..	..
10	5%	Do. 5 per Cent. Deb. Stock (red.)	119 —123	4 1 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99½—102⅛	4 7 6	Jan, July	101⅛	..
St.	4%	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2⅜—3⅛	7 14 0	April, Oct	..	..
5	6/0	County of London Elec. Supply Ord.	7⅛—8	6 0 0	Feb, Aug	7⅛	7⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅜—11⅛	5 6 6	Mar, Sept	10⅞	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103⅛—103⅝	4 4 6	Jan, July	105⅛	..
St.	4½%	Do. Second Deb. Stock	99 —102	4 9 0	May, Nov	100⅝	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4⅜	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7⅛	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	5⅞—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94⅛—96⅛	4 3 6	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5 —5⅛	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	90 —92	4 7 0	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	3⅛—3⅜	6 13 6	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4 —4⅛	5 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95⅛—97½	4 12 6	June, Dec	..	..
5	4/0	Newcastle Elec. Supply Ord.	3⅛—4⅛	4 11 6	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛—4½	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅛—8⅜	5 9 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6⅝—7⅛	4 15 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2⅛—3⅛	6 11 0	April	..	..
St.	5%	Do 5 % 1st Mort. Stock (red.)	99 —102	4 18 0	..	101	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅛—¼	..	..	..	..
1	0/8⅛	Do. 7 per Cent. Cum. Pref.	1 —1⅛	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	⅛—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2⅛	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8⅜—8⅝	5 12 6	Mar, Sept	..	..
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4⅛—5⅛	4 3 6	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	†Baker St. & Waterloo 4% Perp. Deb. Stock	94 —96	4 3 6	Jan, July	95⅛	94⅛
1	..	Bath Elec. Trams Pref. Ord.	⅛—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	1/16—1/8	6 12 9	Jan, July	⅛	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6⅛—7	8 11 6	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	7⅛—7⅜	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	99 —100	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅛—1	..	June, Dec	⅛	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅛—3⅛	..	Feb, Aug	2⅛	2⅛
St.	5%	Do. 5 per Cent. Perpetual Debs.	87 —91	5 10 0	April, Oct	89⅛	89
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	68 —73	6 3 0	May, Nov	68⅛	..
St.	3%	Central London Ordinary Stock	66 —68	4 9 0	Feb, Aug	67⅛	66⅛
St.	4%	Do. 4 per Cent. Pref. Stock	86 —83	4 11 0	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	..	..
100	4%	†Do. 4 per Cent. Debs.	100 —102	3 18 0	Jan, July	101⅛	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb. Stk.	93 —95	4 5 0	Jan, July	94⅛	94
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4⅛—5	5 0 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	28 —29	3 17 6	Feb, Aug	31⅛	28
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 —101	3 19 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8⅛	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8⅛	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	93 —95	4 5 0	Jan, July	94⅛	94⅛
5	..	Hastings & District Elec. Trams, 6% C. P.	⅛—1⅛	..	Mar. Sept	1 1/16	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3⅛—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 —1⅛	4 9 0	Mar, Sept.	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	64 —69	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9 1/16—10 1/16	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 —71	5 12 6	Jan, July	69	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	21/32—23/32	..	..	11/16	..
1	..	Do. Deferred	1/16—⅛	..	April	1/16	..
1	0/6	Do. 5 per Cent. Cum. Pref.	29/32—15/16	5 0 0	Feb, Aug	15/16	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	96 —99	4 11 0	Jan, July	97⅛	93
St.	1%	Metropolitan Railway Consolidated	38⅛—39½	2 10 6	Feb, Aug	40 1/16	33⅛
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	57⅛	66
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	89⅛	..
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	87⅛	86⅛
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	86⅛	..
St.	3½%	†Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	91⅛	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption. †Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shre	Last Dividend	Name	Price Wed. July 20	Rate per Cent. Yielded. £ s. d.	Dividend Due	Business Week to July 20 Highest	Lowest
		Electric Railways and Tramways—*Continued.*					
St.	3½%	†Met. Rly. 3½ per Cent. "A" Deb. Stock	90 —92	3 15 6	Jan, July	91¼	–
St.	..	Metropolitan District Railway Ord.	21½—22	..	Feb, Aug	21⅛	21⅛
St.	..	Do. Extension Pref. (5 per Cent.)	67 —69	..	Feb, Aug	..	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	72 —74	4 14 6	Feb, Aug	78½	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	75½	73½
St.	4%	Do. 4 per Cent. Midland Rent-charge	99 —102	3 18 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	..	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	140 —142	4 4 6	Jan, July	141½	..
St.	4%	Do. 4 per Cent. Ditto	94 —96	4 3 6	Jan, July	95½	..
1	4½d.	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	¼—½	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	¼—½	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoup5	34 —36	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds	101½—102½	4 17 6	..	..	..
..	4½%	Do. 4½% Bonds with coup. 6	86 —88	5 2 0	..	87⅜	87⅜
..	4%	Do. 4 per Cent 1st Power Ho. Dbs.	98 —100	4 0 0	..	99½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	¼—¾	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¾—2¼	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	99½—101½	4 8 6	..	..	..
1	..	Aron Electricity Meter Ord.	½—⅝	..	..	..	..
1	1/9¾	Do. 6% Cum. Pf.	23/32—27/32	6 16 3	April, Oct	13/16	..
1	3/2½	Babcock & Wilcox Ord.	5⅜—5⅝	5 10 6	April, Oct	5⅝	5 17/32
1	0/7½	Do Pref.	1 7/16—1 9/16	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¾—7	7 3 0	July, Feb	6¾	..
5	3/0	Do. 6 per Cent. Pref.	5¾—6¼	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	5/16—9/16	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	99 —101	5 19 0	..	100¼	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	59 —61	3 5 6	Jan, July	60⅛	60
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	23 —27	16 12 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9½—10½	6 8 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5¼	4 15 0	Jan, July	5 1/16	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	100½—102½	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.	2⅜—2⅝	5 8 9	May, Nov	2 7/32	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	106 —109	4 3 6	Feb. Aug	..	..
..	0/7½	†Chadburn's (Ship) Telegraph Ord.	1 1/16—1 3/16	5 19 0	March ..	..	..
1	0/7½	Consolidated Electrical Co.	⅞—1	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.	13/16—15/16	5 12 9	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	27/32—31/32	6 8 0	April, Oct	..	..
3	3/0	•Crompton & Co (Nos. 1 to 85,000)	¾—1	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	84 —87	5 15 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¾—1¼	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	1 1/16—1 3/16	5 0 0	Sept.	1⅛	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	1/16—3/16	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1¼	9 3 0	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	3/16—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1¾	..	May, Nov	..	..
St.	4½%	†Do 4½ per cent. 1st Mort. Deb. (red.)	74 —77	5 15 6	Jan, July	..	..
2	..	Electric Construction Co.	¼—½	..	Jan, July	..	..
2	2/9¾	Do. 7 per Cent. Cum. Pref.	1⅜—1⅝	8 12 6	July	..	..
St.	4%	†Do. 4 per Cent. Perp. 1st Mort. Debs.	59 —61	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	11⅞—12⅜	6 1 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¾—5¼	4 5 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	103½—105½	4 5 6	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works	14½—15½	6 10 6	Feb, Aug	15	14½
10	5/0	Do 5 per Cent. Cum. Pref.	10½—10¾	4 14 0	..	10⅝	10½
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April, Oct	..	..
1	..	National Elec. Construction Co.	¼—½	..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	5/16—7/16	..	Nov	..	–
1	..	Do. 6 per Cent. Cum. Pref.	9/16—11/16	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	33 —35½	5 19 0	Mar, July	34⅜	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99 —101	3 19 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2 —2⅛	4 9 3	..	2 1/16	2
1	0/6	Do 5 per Cent. non-Cum. Preference	1⅛—1¼	4 0 0	..	1 3/16	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	103½—105½	4 15 6	..	..	..
10	10%	J. G. White & Co. 6% Cum. Pref	11¼—12	8 5 0	..	11½	..
1	..	Willans & Robinson Ord.	¼—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1¼—1¾	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3⅞	..	June, Dec	3⅜	3 7/16
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan, July	96¼	95
St.	15/0	Anglo-American	64 —66	5 7 6	F,My,Ag,N	64½	..
St.	30/0	Do. Preferred	106 —108	5 12 0	F,My,Ag,N	107⅞	107
St.	25/0	Do. Deferred	25 —25½	4 17 3	F,My,Ag,N	26 7/16	24⅞
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	83 —85	4 14 0	Jn,Ap,Jy,O	85⅛	83⅛
10	6/0	Cuba Submarine Ord.	8¾—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16¾—17¼	5 15 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3⅜—3⅝	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7¾—8¼	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	99 —101	4 19 0	Jan, July	..	..
20	4/0	Direct United States Cable	14½—15	5 13 6	Ja,Ap,Jy,O	14⅞	14⅞
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.)	98 —100	5 0 0	June, Dec	..	..
St.	25/0	†Eastern Ordinary	132 —135	5 4 0	Ja,My,Jy,O	134	132
St.	17/6	†Do. 3½ per Cent. Pref. Stock	84 —86	4 1 6	Ja,My,Jy,O	84½	83½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	102 —104	3 16 0	May, Nov	102½	..
St.	2/6	Eastern Extension	12⅜—12⅞	5 15 0	Ja, Ap, Jy,O	12⅝	12⅜
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	102⅜	102½
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101½	3 18 6	May, Nov	..	..
10	5/0	†G.N (of Copenhagen), with Coupon 80	30 —31	5 14 6	Jan, July	30⅛	30
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	54½	54
100	5%	Mackay Companies Common	85 —90	5 11 0	Ja,Ap,Jy,O	88¼	..
100	4%	Do. Preference	76 —80	5 0 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	11/16—13/16	..	April	..	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	96 —98	3 18 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅜—1⅝	3 12 9	May	..	..
100	4%	†Do. 4 per Cent. Debs.	96 — 98	3 18 0	Jan, July	..	..
10	..	West India & Panama	⅜—¾	..	May, Nov	11/16	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9	6 12 6	May, Nov	..	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	99 —101	4 19 0	Jan, July	..	..
10	3/0	Western Telegraph	13⅝—14½	4 18 0	Mr,Jn,O,D	14	13⅞
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	99 —101	4 19 0	June, Dec	..	..
–	1½%	Western Union Telegraph, $1,000 4% Bds	103 —106	3 15 3	–	..	..

Shre	Last Dividend	Name	Price Wed., July 20	Rate per Cent. Yielded. £ s. d.	Dividend Due	Business Week to July 20 Highest	Lowest
		Telephones.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	136 —138	5 16 6	..	136½	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	91 —93	4 6 0	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	103 —105	3 16 0	..	104	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
5	3/0	Chili Telephone	9 —9½	4 4 0	August ..	9	8½
1	0/7½	Monte Video Telephone Ord.	⅞—1	7 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	25/32—29/32	5 13 9	May, Nov	..	..
St.	6%	National Co. Pref. Stock	106½—108	5 11 0	Feb, Aug	107½	106½
St.	6%	Do. Def. Stock	126½—128½	4 13 3	Feb, Aug	127⅛	126½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10⅛—10⅞	5 10 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10⅛—10⅝	5 10 0	Feb, Aug	10⅛	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5 1/16—5 11/16	4 7 6	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	96 —98	3 12 0	June, Dec	97	96½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	98 —100	4 0 0	Jan, July	99½	98½
..	4½%	New York Telephone Co. 30 yr. Bnds.	98½—99½	4 10 6	..	99	98¼
1	1/0	Oriental	1 7/16—1 11/16	4 15 0	April, Oct	..	..
1	0/7½	Do 6 per Cent. Cum. Pref.	1 5/16—1 7/16	4 11 6	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	98 —100	4 10 0	Jan, July	..	..
5	3/0	United River Plate	7⅜—7⅝	5 5 0	July	7 9/16	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5 1/16—5 5/16	4 14 9	June, Dec	5 3/32	5⅛
St.	4½%	Do. 4½ Deb. St. Red.	101 —103	4 12 6	Jan. July	102½	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	2¾—3¼	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10¼—10¾	5 8 3	Sp,DcMrJu	10	10½
10	3/0	Do. 6 per Cent. Pref.	12⅞—13⅜	4 6 3	Sp,DcMrJu	13 3/16	13⅛
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 10 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4 5/16—4 9/16	5 10 0	April, Oct	4½	4⅜
5	2/6	Do. 5% Cum. 2nd Pref.	4 3/16—4 7/16	5 9 9	Jan, July	4 5/16	..
St.	4%	Do 4% Deb. Stock	90 —91½	4 7 6	June, Dec	91	90½
St.	4½%	Do. 4½% Deb. Stock	93½—96½	4 13 6	..	95	91½
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	103 —105	4 15 3	Jan, July	..	..
5	4/6	Brisbane Electric Trams. Invest. Ord	6¼—6¾	4 13 0	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5¼	4 15 0	May, Nov	5	4⅞
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	99 —102	4 8 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	140 —145	5 10 0	Mar, Sept	142½	141
St.	6%	Do. Pref. Ord. Stock	124 —128	4 13 6	May, Nov	126¾	126
St.	5%	†Do. 5% Cum. Perp. Pref. Stock	108 —111	4 10 0	Jan, July	110½	108½
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
100	4½%	†Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	103½—105½	4 0 0	..	104½	103½
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99 —102	4 18 0	Mar, Sept	100½	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	97 —100	6 0 0	Feb, Aug	..	..
5	2/6	Calcutta Tramways (1 to 137,610)	4 —4½	5 0 0	Mar, Sept	4⅛	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅝—4⅞	5 2 6	Jan, July	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red)	96 —99	4 11 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	¼—½	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5 5/16—5 11/16	4 9 6	F,My,A,N	5 17/32	..
St.	4%	Do 4 per Cent. Deb. Stock	97 —100	4 0 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	95 —98	5 2 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	78 —81	6 3 6	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	94½—97½	5 2 6	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	1/32—5/32	..	..	1/16	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	92 —96	5 3 6	Jan, July	94	..
5	6%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	Lisbon Elec. Trams. Ord.	1⅛—1¼	4 8 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 16 0	Jan, July	1 3/16	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	97½—101½	4 18 6	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	95 —98	5 2 0	Jan, July	..	..
100	5%	Manaos Trams and Lt. Co. 5% Debs	86½—88	5 14 0	..	87	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	98 —100	5 2 0	Feb, Aug	..	..
100	$1½	†Mexico Trams Co. Com. St.	122½—124½	4 15 6	..	123½	..
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds	97½—98½	6 1 6	..	98½	98
St.	6%	Do. 6% 50 yr. Mort. Bds.	97½—98½	6 1 6	..	98⅛	97½
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	102 —104	4 6 0	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	..	..
1	0/6	†Perth Elec. Trams Ord.	11/16—13/16	5 15 6	May	11/16	..
St.	5%	Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅜—5⅞	5 2 6	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	..	..
100	$1	†Rio Janeiro Tram, Lt. & P. Co.	92 —94	4 5 6	..	93½	92
..	5%	Do. 30 yr. Gold Bnds.	97½—98½	4 1 6	..	98¼	97
100	5%	Do. 50 yr. Mt. Bnds	87½—88½	5 13 0	..	88¼	87
..	$2½	†Sao Paulo Tramway, Light & Power Co. $100 Stock	144½—146½	6 18 6	..	145½	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	100½—102½	4 18 0	June, Dec	101½	101
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	101 —103	4 7 6	Feb, Aug	102½	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅜—5⅞	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 9 0	..	..	..
St.	4½%	Do 4½ per Cent. Deb. Stk. (red)	92½—94½	4 15 0	Jan, July	93½	..
..	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock	96 —98	5 2 0	..	98½	..
5	4/9	Calcutta Elec. Supply Ord.	6½—6¾	6 4 0	April, Oct	6⅝	..
100	7/2½	Canadian Gen. Elec. Co. Com. St.	104 —108	6 7 6	..	105	105
100	$3½	Do. 7% Cm. Pf. Stock	122 —125	5 12 0	..	123½	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co. of Ontario	85 —88	5 12 6	..	86½	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	1/16—3/16	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅛—¼	8 0 0	April, Oct	..	..
..	5%	Kaministiquia Power Co.5% Gold Bnds.	100 —102	4 18 0	..	..	..
5	..	Madras E. S. Corp. Ord.	2⅞—3⅛	..	..	..	..
St.	..	Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock	90 —92	5 7 6	..	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	84½—85½	5 17 6	..	85½	8
St.	$1	†Mexican Lt. & Power Co. Com. St.	77 —79	5 1 0	..	79	7
St.	$3½	Do. 7% Cum. Pref. St.	101½—103½	6 15 3	..	103½	10
500	5%	Do. 5% 1st Mort. Gold Bnds.	93½—94½	5 5 3	..	94½	9
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	133 —137	5 2 0	F,My,A,N	135	..
St.	£9	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	..	..
St.	6%	Do. 6 per Cent. non-Cum. Pref. Stk.	105 —115	5 5 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
5	3/0	Rosario Ele. Co. Ord.	8½—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
5	3/0	Do 2nd Pref.	8⅛—8⅝	6 14 6	..	..	..
100	$1	†Shawinigan Water& Power Co.Ca	96 —98½	4 2 0	..	99	9
..	5%	Do. 5 per Cent. Bds.	105 —107	4 13 6	Jan, July	107	10
St.	4½%	Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102½	10
St.	4½%	Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	..	..
..	6d.	Victoria Falls Power Co. Pref.(1 to 808,000)	½—⅞	5 6 6	Jan, July	..	..

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Patent No. 13285/07.

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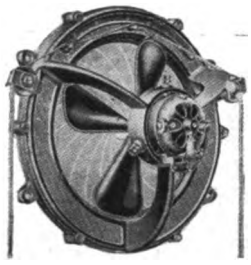
SIEMENS

PORTHOLE FANS



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A.C. Motor Starters.

IN these days of the wide application of motors to all kinds of industrial work, care has to be taken that the plant employed is in all cases suitable for the work it has to do. This condition is highly essential where starters are concerned, for they may be called upon to operate in textile factories, saw mills or other dusty places. They must therefore be suitably protected and must be so arranged that they can be worked wholly from the outside.

Mr. George Ellison, of Birmingham, has designed a series of starters with totally-enclosed covers and fitted with an inspection window and conduit caps. The arrangement of the double handle, with pointer and position marked on the cover, renders the operation of the starters most convenient, and there is no destructive burning of the contacts. The starters are fitted with a small external lever for tripping the retaining hook by hand, and as the starter arm has spring return to the "off" position, quick break action is obtained for stopping the motor. With this type of total enclosure, it is claimed that, it is impossible to touch live parts or terminals, and as the starters have no-voltage and overload releases the Home Office Rules and Regulations are entirely complied with. These starters are fitted with a patent combination of one no-volt coil connected across one of the stator phases and one overload coil connected in the rotor of slip ring motors (if the motor is not fitted with brush lifting and short-circuiting device for the slip rings), or in the stator circuit if the motor is of the "squirrel cage" type. This patent combination of one no-volt and one overload coil is, Mr. Ellison thinks, the only practical solution of the problem of protection for polyphase motors against failure of the supply on all or any one phase of the circuit.

The standard overload release is adjustable between 90 per cent. of the normal full load and 60 per cent. overload. As the overload coil is not in circuit until the running position is attained, it can be set for small overloads.

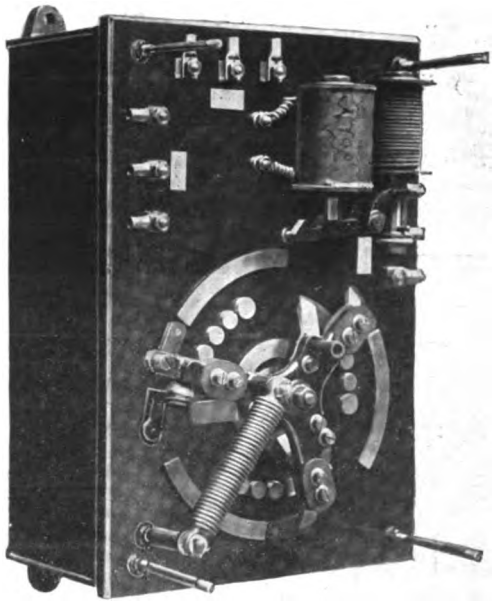

Fig. 1.—Double Automatic Release Starter controlling Stator and Rotor Circuits.

Of course, if the starting load is heavy and the operator puts the starter over to the running position too quickly, the overload release may operate if set for a small overload, and prevent the starter arm holding in the running position; the overload release will then have to be set for a heavier overload, or a patent adjustable time lag must be fitted. These retarders or time lags are particularly

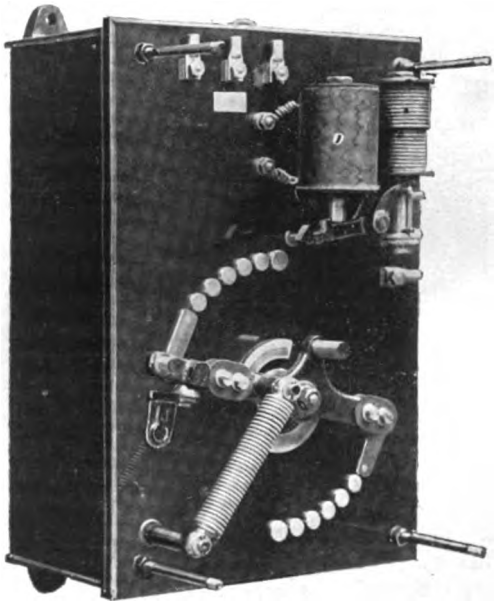

Fig. 2.—Double Automatic Release Starter.

recommended as an excellent addition to these starters where the conditions of service are such that the starting load is heavy or the running load a fluctuating one, subject to heavy peaks. The no-volt release can be utilised for stopping the motor at a distance by means of emergency switches so arranged that the no-volt coil circuit is opened

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when it is desired to stop the motor. Totally enclosed starters of this type, with overload and no-voltage release, can be supplied for almost all types of alternating-current motors.

Fig. 1 shows a type of double automatic release starters which control the stator as well as the rotor circuits, so that a separate switch and fuses are not necessary. The overload coil being connected in the rotor circuit and the no-voltage coil across one of the stator phases, protection is given against overload and against no voltage on all or any one phase. If the motor has brush lifting and short-circuiting device for slip rings, the overload release can be suitably arranged to allow for this. The starters are suitable for three-phase and two-phase three-wire slip-ring motors, and for two-phase four-wire motors if one lead is taken direct to motor, the other three through the starter. In the type "B" double automatic release starters the rotor circuit only is controlled, so that a separate switch and fuses or circuit-breaker are required for controlling the stator circuits of the motor. The overload coil being connected in the rotor circuit and the no-voltage coil across one of the stator phases, protection is given against overload and against no voltage on all or any one phase. These starters are only suitable for motors that are not fitted with brush-lifting and short-circuiting devices for the slip rings.

Type "C" double automatic release starters are fitted with resistances for reducing the current taken from the line on starting squirrel-cage motor. They are suitable for starting against light load; the resistances (one minute rating) being proportioned to pass about twice full load current on the first contact, good makes of squirrel-cage motors will develop about half torque with this current. As the overload coil is only in circuit in the "full on" or running position it can be set for small overloads, if a certain amount of care is exercised in starting up. However, as the operator is not always able to judge whether the motor is sufficiently up to speed, the release (if set for small overloads) may operate and prevent the starter arm holding when the running position is attained. For this reason a time lag is an excellent addition, especially in cases where the running load is a fluctuating one, subject to heavy peaks. These starters control the three phases of the circuit; a separate switch and fuses or circuit-breaker is not required.

Fig. 2 shows the "D" type double automatic release starters. These are fitted with resistances for reducing the current taken from the line on starting up squirrel-cage motors. They are suitable for starting against light load, the resistances (one minute rating) being proportioned to pass about twice full load current on the first contact; good makes of squirrel cage motors will develop about half torque with this current. As the overload coil is only in circuit in the "full on" or running position it can be set for small overloads, if a certain amount of care is exercised in starting up. However, as the operator is not always able to judge whether the motor is sufficiently up to speed, the release (if set for small overloads) may operate, and prevent the starter arm holding when the running position is attained. For this reason a time lag is an excellent addition, especially where the running load is a fluctuating one, subject to heavy peaks. These starters control only two wires of the two-phase circuit, and a separate switch is required. However, for two-phase three-wire circuits, the starters can be arranged to control all three wires, thus avoiding the necessity of a separate switch.

These starters are, we understand, now being used extensively in the Midland factories, one firm having already over 800 H.P. installed. Mr. Ellison points out that his starters are quite "fool-proof," and should be eminently suitable for use where female labour is employed. This is an ungallant remark!

Electrical Operation of a Gas Works.

According to the "Light Railway and Tramway Journal," the new works, at Landy, of the Paris Gas Co., have been completed recently, and have been equipped with the most modern electrical appliances by the French Thomson-Houston Co.

These works are composed of three principal parts, each 25 ft. wide. The central part is 150 ft. long and 160 ft. wide. It contains the boilers, and on either side of it is a machinery hall, 150 ft. long by 50 ft. wide. There are two chimney stacks for the boiler furnaces. Fuel is brought in and the ashes are removed by means of a conveyor, the pipe work being in a basement under the floor level.

The two machinery halls are quite identical in equipment, save that in one of them foundations have been provided for a converter set, in case the works should be connected up to a source supplying alternating current, and that in the other hall there has been installed a booster for the battery of accumulators. Each generating set comprises a horizontal compound tandem steam engine of 650 H.P. indicated, direct-coupled to a continuous-current dynamo, of the compound excitation type, of 400 kw., 250 volts, 125 revs. per min. The flywheel is so fixed that the regulator prevents, in case of the sudden suppression of the full load, the number of revolutions from exceeding more than 5 per cent. above the normal. Under all conditions of load the relation between the extreme values of the angular speed during a revolution does not exceed $\frac{1}{150}$th of the average speed during such revolution. The switchboard in each hall consists of two superimposed series of panels, the lower being on the floor level and the upper level with a metal bridge or gallery. There are six panels in the lower and 12 panels in the upper board. These are fitted with the usual switches, circuit-breakers, and measuring, &c., instruments. Each hall is equipped with two generating sets and a motor generator, consisting of a continuous-current shunt-wound motor running at 600 revs. per min. and giving 125 H.P. at 250 volts, and a direct-coupled dynamo with two commutators, which can be grouped in series or in parallel, and each capable of furnishing normally a current of 1,200 amperes.

The current is transmitted to the different parts of the gas works by 10 overhead lines. No. 1 feeder serves the coke department, No. 2 the purifying house, Nos. 3, 4, 5 and 6 serve the distilling house, No. 1, and Nos. 7, 8, 9 and 10 the distilling house No. 2. All the feeders are doubled near the front of the building, and run into each of the two works, so that they can be connected up by means of the feeder panels, corresponding to the two series of 'bus-bars, in such a way that any of the feeders can be served by either of the works. Special connections also allow of the putting in parallel of the 'bus-bars of works No. 1 with those of works No. 2. The outer feeders are all of copper cables.

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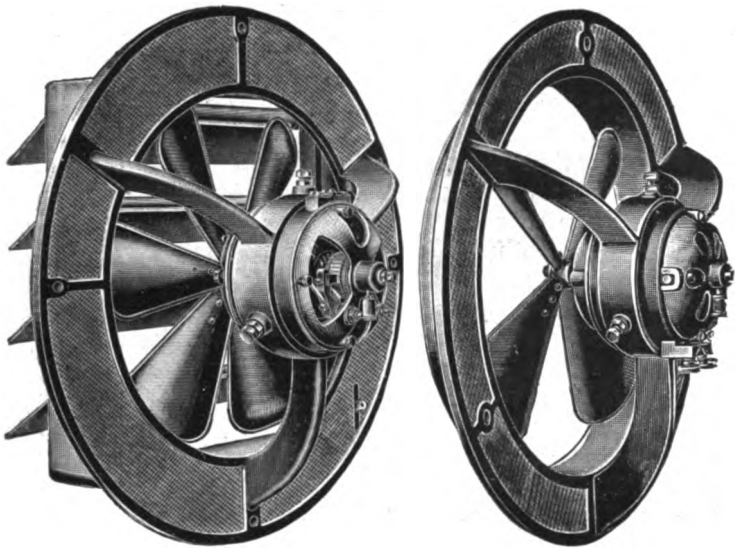
Inside the works the feeders are rubber insulated, and are carried to panels with circuit-breakers for each group of motors in such a fashion that they can instantly cut out any motor or group of motors in case of necessity.

Siemens Porthole Fans.

MESSRS. Siemens Bros. Dynamo Works are now manufacturing porthole fans for continuous, single-phase and three-phase current. These are normally arranged for a clockwise direction of rotation, though they can be arranged for running the other way or for reversing, if required. They can also be supplied with vertical shafts.

Fans fitted with continuous-current motors are made in nine sizes with a blade diameter varying from 10 in. to 32 in. and can be provided with either a protected or totally enclosed type of motor depending on the situation.



Figs. 1 and 2.—Examples of Siemens Porthole Fans.

Fig. 1 shows a standard type of porthole fan which can be fitted with any variety of motor, while Fig. 2 shows another type which is fitted with a venetian shutter that can be closed or opened as desired.

Porthole fans can also be fitted with single-phase or three-phase motors in similar sizes to those mentioned above in the case of continuous current. Single phase fans can, if desired, be run off the three-phase supply, while speed regulating devices are also provided when required. In the case of three-phase motors a throw-over switch is used for starting.

Asbestos Woven Net Resistances.

THIS is essentially an age of details, and it is therefore not surprising to find that great care is being taken in the perfection of each part of an apparatus so that the resulting whole may be as efficient as possible. In applying these remarks there is no direction in which they can be better turned than to the material used in building up the resistances required for motor starters and controllers. The material used for this purpose shows a great variety, and the most important are nickeline, constantan, rheostatine, excelsior, and others. There are very many different ways of making units for rheostats, the most common form adopted for the older types of motor starters and controllers, is resistance wire wound in spirals. Following is a description of a type of rheostat made by C. Schniewindt, of Neuenrade, which, it is claimed, has many advantages in comparison to the spirals just mentioned. The resistance is made by weaving asbestos threads and wires together, and the number of different forms this type of resistance can take is very large, and it can be applied to numerous purposes.

The following are claimed to be the advantages of this system: Small space required, convenient and cheap to mount, excellent insulation, and unbreakable through vibrations.

To illustrate the great adaptability in making up units to complete rheostats, let us follow the construction of a starting resistance for a 3 H.P. continuous-current motor for 110 volts arranged to start at full load. The starter is to be fitted with asbestos woven net resistances, an existing net 6 in. square being used for this purpose. The net has 25 wires, each with a diameter of 0·45 mm., and there are eight branch connections arranged in a geometrical row. One of these nets is sufficient for a starter for starting a ½ H.P. continuous-current motor for 110 volts at full load. Each resistance net weighs 45 grammes. By connecting

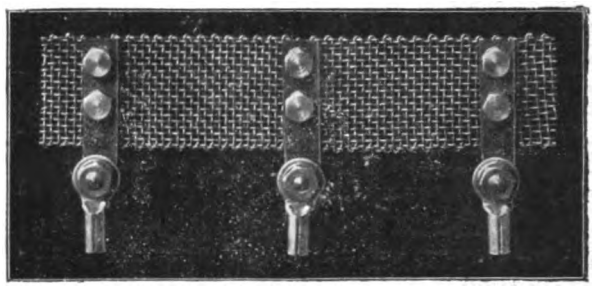


Fig. 1.—Asbestos Woven Resistance, showing Method of fixing Terminals.

six resistance nets as required for a ½ H.P. continuous-current motor in parallel, we get the total starting resistance for a 3 H.P. motor. Four resistance nets connected up in a similar manner are sufficient for a 2 H.P. motor. By this means the manufacturing process of motor starters, &c., becomes very cheap and simple, because one can easily use the same case for any number of motors of different sizes by connecting up resistance nets as required.

Compared with wire spirals the mounting of resistance nets is also very much simplified. The six nets for the 3 H.P. motor starter are built up together, one or two holes being punched in the sides of each resistance net. The portion free from wires is reserved for fixing purposes. They are then strung up on two or four bolts with a gap of about ¼ in. left between the adjacent nets. These gaps are packed up with strips of asbestos which are just as wide as the fixing portion at the sides of the resistance nets. Over the sides of the top and bottom nets there are narrow strips of iron, about ¾ in. wide, or the same width as the fixing portion of the nets, by which all the resistance nets are pressed together. It is also advisable to place a strip of mica between each iron strip and the first and last resistance nets, also to insulate the wire connections between each net with glass beads as illustrated in Fig. 1.

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The bolts mentioned are also used for attaching the complete resistance to the contact plate.

In the case of spiral coils an insulating plate is used at the top and bottom for fixing the spirals. Another piece of insulating material is passed through the centre in order to prevent the spirals bending and touching one another when the load is on; this might happen owing to any vibration. These end pieces and intermediate pieces are a disadvantage of this design, because slate is mostly used which cracks easily when drilling large holes. The intermediate pieces also prevent the circulation of air, apart from the fact that this construction is more expensive and elaborate than that with asbestos woven net resistances with less bolts and holes. With spiral resistances the resistance steps cannot be arranged in such a manner that the motor can start without jerks, because the only point where proper branch connections to the contacts can be attached to is at the top end of each spiral. For the last steps of the starter it is, however, necessary to have an accurate and fine graduation, the resistance on the last step, for instance, should be less than that of the armature

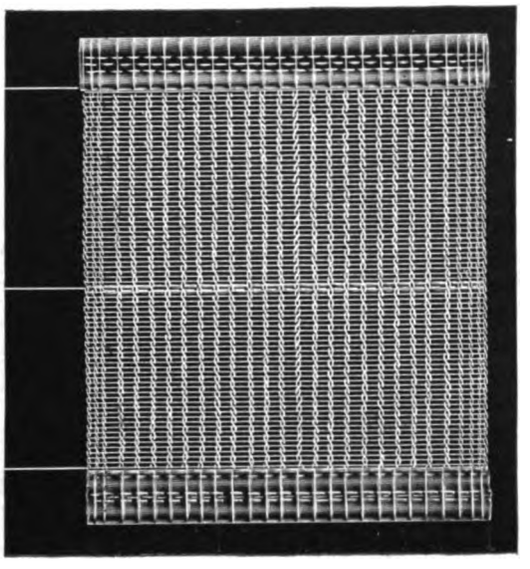

Fig. 3.

if the motor requires to be fully started without causing an appreciable rush of current. With resistance nets the disadvantage mentioned is not known, because one can obtain the required steps with great accuracy.

This comparison further shows that cheap labour can be employed for mounting and fixing this type of resistance, whereas spiral resistances can only be made up and connected by skilled and trained men, spiral wires of different sizes being used, the connecting up of which necessitates skilled and neat workmanship.

Numerous tests for ascertaining the temperature rise of asbestos woven net resistances have proved the astonishing rapidity with which the resistance nets cool after the current is switched off, this is a very important matter for apparatus for frequent starting. The permissible load, especially on starters, can therefore be comparatively high, provided the construction of the case will permit the circulation of air. The net resistances are also totally unaffected by continual heating and cooling, are thus suitable for changeable or any atmosphere.

The great stability of the resistance nets is a great advantage for resistances used in connection with shunt regulators, &c., the very thin wires required do not in the least reduce the rigidity.

Thin resistance wires wound in spirals are easily deformed, and it has often been found that this has caused damage to the regulator.

Other common designs for resistances consist, for instance, of porcelain cylinders with grooves threaded on, or rods with porcelain reels, but the advantages are all on the side of net resistances the mounting of which is much cheaper than that with other types of resistances.

The fact that asbestos units are unbreakable is a great advantage for crane and tramway controllers, which are subjected to violent vibrations.

Numerous experiments and tests have proved that these asbestos woven nets form the most suitable heating elements for the convector type of electric heaters, possessing many

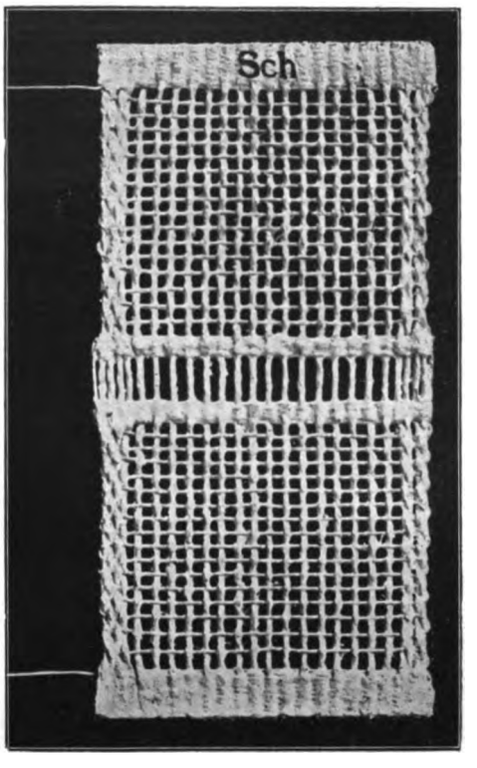

Fig. 4.

similar advantages as in the case of resistances. The radiator nets are installed in parallel, the number used being according to the heating capacity required. There is practically no self-induction, and the nets cannot be destroyed by vibration, and owing to the fact that they are manufactured only with the best materials, they will work with every satisfaction and without the slightest deterioration in heating capacity, for a long number of years, thus proving them to be the most economical and reliable heating elements. Further advantages of these heating nets are the small amount of space the units take up when assembled, and the remarkable lightness they possess, which makes them the most suitable heating elements adaptable for the light semi-portable electric heaters which are at present in demand. The accompanying illustrations show examples of asbestos woven net resistances.

OSRAM·LAMPS

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Electrically-Driven Pumps in Mines.

THE more the miner goes towards the centre of the earth, the greater are the risks he runs of encountering large quantities of water. The economical removal of this water is therefore one of the greatest problems of mining work. To do this the low efficiency pumping engine, the slow running reciprocating pump and electrically-driven high pressure centrifugal pump have all been used.

While the two first kinds of pump have the disadvantage of small reliability it was further always impossible to use steam driven pumps underground to any great extent, owing to the warming of the shaft, large condensing losses, and the great space required by the steam machinery and piping. It is for these reasons that the electrically-driven pump has come so much to the fore for mining work.

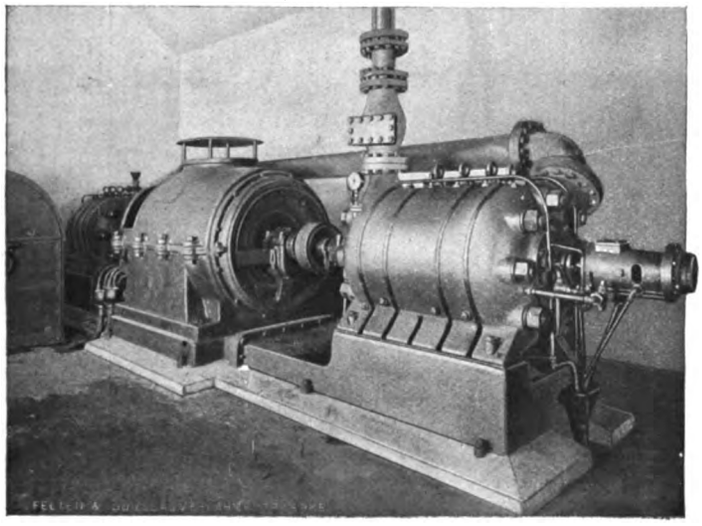

Fig. 1.—Pump Installation at the Antonienhutte.

A firm which has had a good deal to do with the development of this class of machinery is the Felten & Guilleaume-Lahmeyerwerke A.G. who, as long ago as 1897, erected an electrically-driven pump for unwatering purposes in the Zollverein mine at Caternberg in Westphalia. This pump was operated by a slow running 320 H.P. three-phase motor. Soon after a large number of similar electrically-driven pumps were supplied to several other mines.

A further step forward was made when so-called express pumps were adopted, running at about 300 revs. per min. These had the advantages of taking up a small space, and making it, therefore, possible to take them right down into the mine. It should, however, be noted that this speed was not very suitable for large pumps. The high speed high pressure centrifugal pump direct coupled to an electric motor was the first possible, and almost ideal, solution of the unwatering problem in mines. Along with the adoption of this class of plant may be seen the development of modern machinery for high speed work, and the attempt to reduce the amount of material used, especially in the moving parts, for large outputs. Where the use of electrical energy is possible, and the water does not make a continuous use of the pump necessary, electrically-driven high-pressure centrifugal pumps are mostly employed at the present time. On account of the high speed and the direct coupling between the pump and the motor a very compact combined arrangement is obtained, so that a cheap pump chamber in the mine itself can be erected. The transport of material down the shaft and along the stulms is quite easy, while the erection underground is very much simplified when compared with that of the slow speed machine. Finally a simple and cheap operation, on account of the small wear in moving parts, is obtained with such machinery.

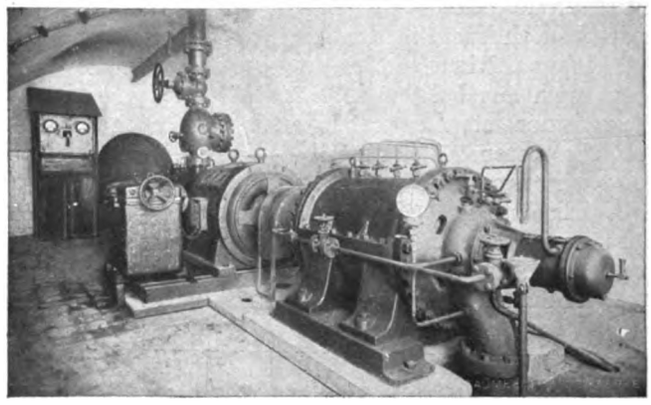

Fig. 2.—One of the Turbine Pumps at the Velsen Mine.

Fig. 1 shows the underground installation at Antonienhütte. This consists of two high pressure centrifugal pumps, which each deliver 6 cubic meters of water per minute to a height of 500 m., they are coupled to a three-phase motor with a capacity of 1,000 H.P. when running at 1,230 revs. per min. The working voltage of the motor, which is fitted with a short circuiting and brush lifting arrangement, is 2,000 volts. On account of the small dimensions of the shaft it was necessary to build the stator in two parts. A liquid starter is used in connection with this set.

Fig. 2 shows an underground pumping installation at the Royal Velsen mines. It consists of two six-stage turbine pumps direct coupled to an electric motor. By means of this installation about 2 cubic metres of water can be delivered to a height of 475 metres per minute. The motor is of the short-circuited type, and has a capacity of 350 H.P., when running at 1,500 revs. per min. The voltage is 5,000

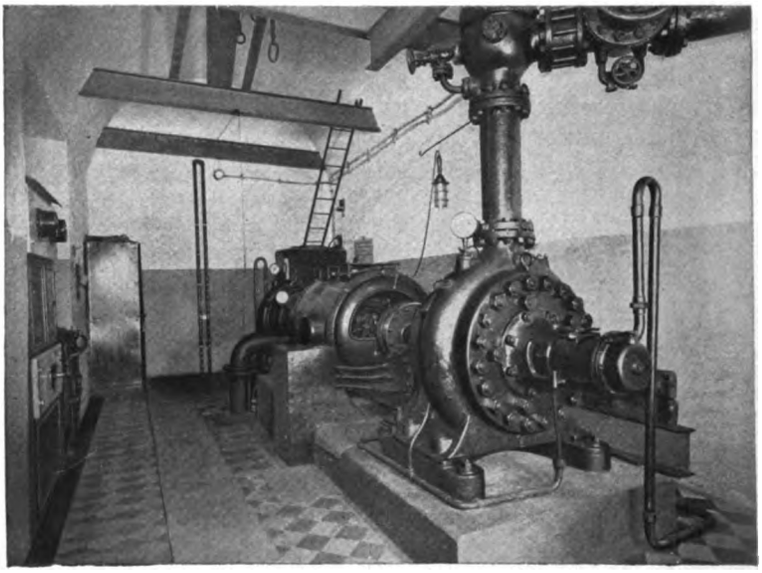

Fig 3.—Electrically-driven Unwatering Plant at Mont Cenis.

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and the starting is effected by means of a transformer arrangement, which can be seen in the illustration. Attention may be called to the small dimensions and weight of the driving motor. Its greatest length is 1,450 mm., the maximum width 1,150 mm., its greatest height from the

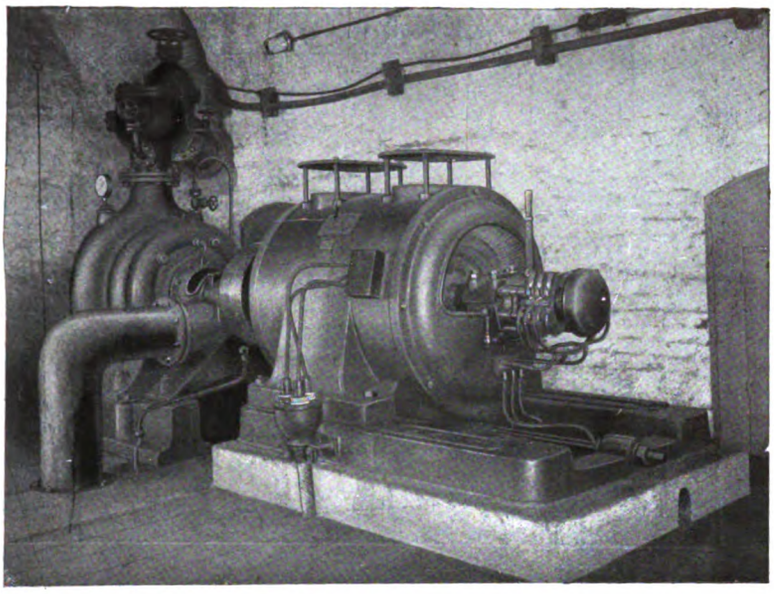

Fig. 4.—Pumps at the Massener Tiefbau Mine.

rails being 1,210 mm. The total weight of the motor is just over 3 tons. If these figures are compared with a slow running electric motor or a steam engine of the same output, the advantages of fast running electric working for unwatering purposes are manifest, while attention may also be called to the greater ease in bringing the material down the shaft and the small space taken up.

Fig. 3 shows an unwatering plant installed at the stone works at Mont Cenis. It consists of an asynchronous three-phase motor with a continuous output of 450 H.P. when

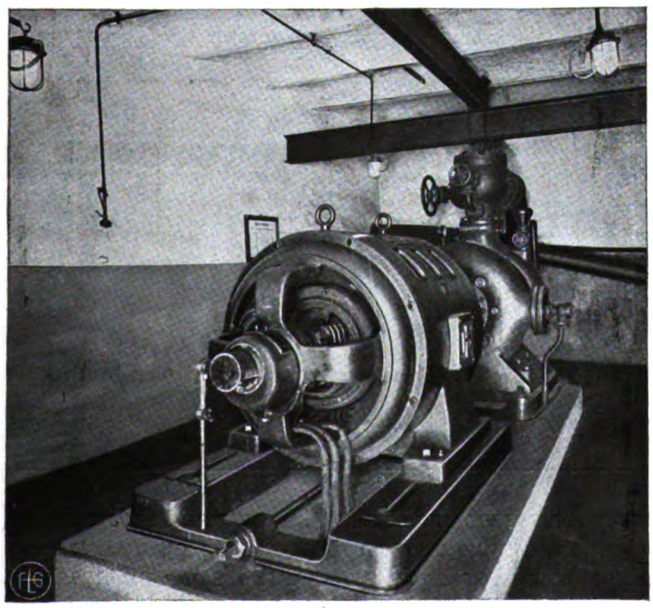

Fig. 5.—Pumping Installation driven by Three-phase Motors.

running at 1,475 revs. per min., the terminal voltage being 2,000. A liquid starter is used for the operation of this motor. Another asynchronous motor fitted with slip rings for a working voltage of 200 is shown in Fig. 4. This set is installed for unwatering purposes in the Massener Tiefbau mine, and when running at 1,475 revs. per min. and exerting horse-power of 470 can raise 5½ cubic metres of water a minute to a height of 267·5 metres. The construction of the two motors is similar to the standard construction of the Lahmeyer Co., adapted to high speed motors for large outputs and contains no special peculiarities. The diameter of both motors is 595 mm., so that the speed

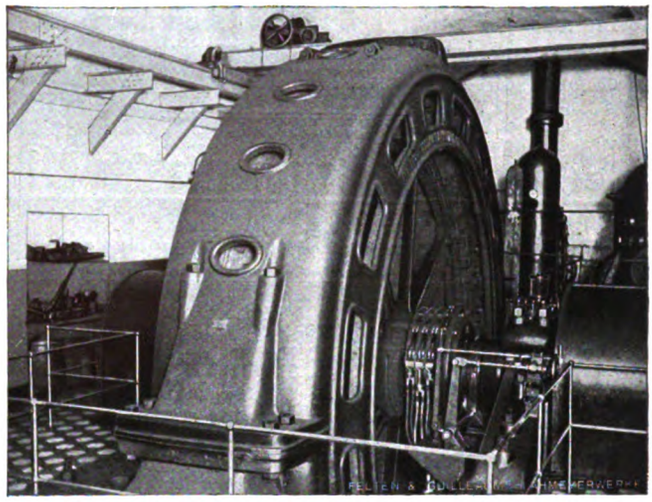

Fig. 6.—Slow-speed 2,500-volt Pump Motor.

of the armature works out at 46 meters per second. In order to move the motor in an axial direction, sliding rails are provided along which a motor can be shifted by means of a screw worked by a hand lever. Mention may be made of the plant at the Wildberg mine, which consists of two continuous current shunt wound motors, each with an output of 175 H.P. Their speed can be regulated between 416 and 715 revs. per min. They drive two high-pressure centrifugal pumps, and deliver 1·5 cubic metres to a height of 230 metres, running at the lower speed, and to the height of 316 metres at the higher speed.

In connection with the construction of these motors, it may be noticed that the armature iron is 250 mm. wide, and has a diameter of 480 mm., so that its peripheral speed when running at 715 revs. per min. is about 43 metres per second. The diameter of the commutator is kept as small as possible owing to the high speed, and being 250 mm., the peripheral speed works out at 22 metres a second. The commutator is secured by two shrunk rings, such as are used on the commutators of turbo-generators. For ventilation purposes a fan is placed on the motor to the opposite side of the com-

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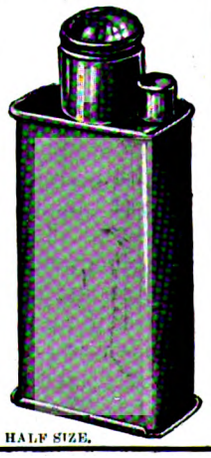

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mutator on all the Lahmeyer Co.'s high-speed three-phase motors, as shown in Fig. 5.

In mines, where the unwatering operations have to be continuous and the water dealt with is very large, a suitable efficiency is obtained by the use of slow running reciprocating pumps such as is shown in Fig. 6. The pump is of the double reciprocating type, and delivers 180 cubic metres a minute to a height of 620 metres. The driving motor is of the three-phase type fitted with slip rings and short circuiting arrangements. It is worked off a voltage of 2,500, the frequency being 50 and 75 revs. per min. At this speed the capacity of the motor is 1,300 H.P.

Portable Instruments for Direct and Alternating Currents.

MESSRS. Nalder Bros. & Thompson, of 34, Queen-street, London, E.C., have recently placed upon the market a complete line of portable standard instruments, suitable for continuous and alternating currents. These instruments are of the dynamometer type, and are fitted with air damping to render them dead beat. They have been carefully designed with a view

Fig. 1.—Portable Standard Voltmeter.

to giving great accuracy on either continuous or alternating-current circuits. The instruments have been thoroughly tested under all the varying conditions met with in practice, and give the most satisfactory results.

Instruments of this type comprise ammeters, voltmeters and wattmeters, they are fitted in portable polished wood cases with strap handle, lock and key, the cases being protected with rubber feet (which ensure that no sudden jar shall be received whilst the instrument is in use) and are arranged with anti-parallax mirror. The pointers are of the edgewise pattern, and the scales are very finely and accurately divided, so that observations can be taken with a considerable degree of accuracy. It will be noticed that the instruments are supplied with a zero adjustment, so that in the event of any slight variation in the zero it can be set quickly and easily.

One of the features of these instruments is that they can be made multi-range, thus the portable standard voltmeter illustrated, shows ranges of 15, 150 and 600 volts (*see* Fig. 1.) The ammeters are wound self-contained for currents up to 50 amperes, beyond which portable series transformers are supplied. The wattmeters are arranged self-contained for pressures up to 300 volts, and currents up to 50 amperes. For pressures over 300 and up to 650 volts, an external resistance box is used and for currents above 50 amperes portable series transformers, as in the case of the ammeters. For high tension circuits potential and series transformers are employed.

Fig. 2 illustrates the portable standard wattmeter, the instrument described is self-contained for circuit voltage up to 150 volts and not exceeding 20 amperes. Another

Fig. 2.—Portable Standard Wattmeter.

instrument suitable for continuous and alternating currents, and constructed on the dynamometer principle, is the lamp-testing wattmeter, shown in Fig. 3. This instrument is arranged for two voltages, say, 100 or 200 volts, and with a two-way switch key which, when placed on the contact corresponding to the voltage required, is depressed and an indication on the instrument obtained, the instrument reading directly the actual watts consumed. The instrument is fitted in polished wood case with strap handle, and one side carries the lamp-holder and fuse, and is equipped with a length of flexible wire fitted to a plug,

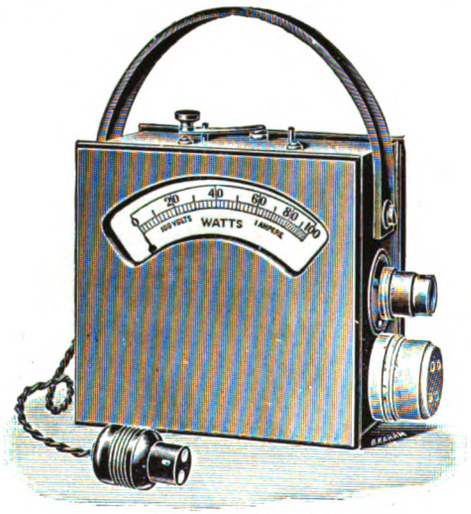

Fig. 3.—Lamp Testing Wattmeter.

which can be inserted into the standard lamp-holders. The dynamometer type of dead-beat instrument is also made in switchboard pattern case, black enamelled and nickel or copper finish.

In the construction of their instruments, we understand, Messrs. Nalder Bros. & Thompson make a very strong point of the fact that they use only English material, and strictly exclude everything of foreign origin, excepting, of course, such material as is not obtainable in this country.

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High-Tension Switchgear for Mines.

IN view of the necessity for switchgear which is absolutely safe for use in coal mines, and which complies with the Home Office Regulations, the Union Electric Co. has now designed an improved oil-break switch, which embodies the principal features of the Union exclusive designs in oil-break switches with automatic features and oil-break switches combined with fuses. This switch is the result of many experiments and tests carried out under actual working conditions and extending over a long period. The terminals of the incoming and outgoing cables are arranged in a special manner, the terminals being protected by either cast or wrought-iron enclosures. In addition to securing absolute protection for the cables against mechanical damage, the design lends itself to exceedingly simple methods of building up the switch units to form complete switches and distribution boards, with other advantages, such as ease of erection in connecting up and effective operation. There is also a very simple method of re-setting the overload release.

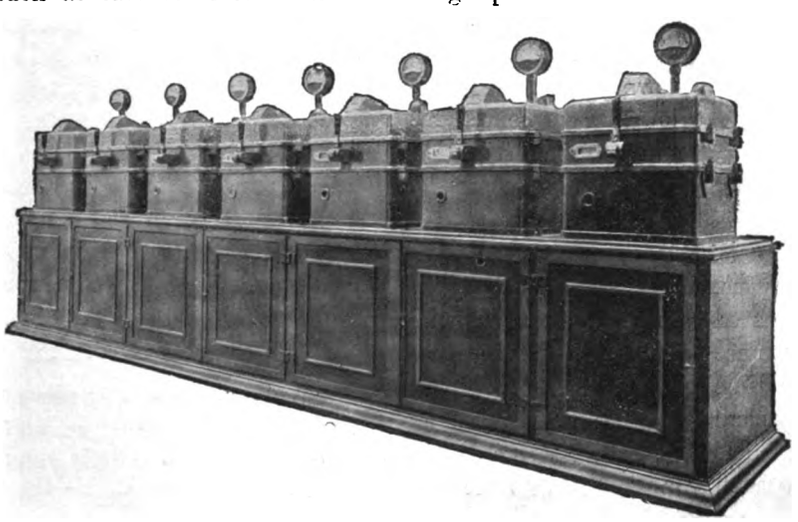

Fig. 1.—Mining Switchboard.

These switches are made in two designs, one for mounting on an angle-iron framework or stonework cells and the other for fixing to floors. In the latter type, on the assumption that the switch will be placed with its back against a wall or against the 'bus-bar enclosure, an opening is provided in the sheet-iron casing at the back. The space under the switch is accessible from the front, which is fitted with a detachable panel provided with a lock. Externally the switch consists of three parts: the lower case or oil tank, in the bottom of which are fitted the contacts and terminals; a centre casting on which is mounted the switch mechanism; and the cover enclosing the whole apparatus. This cover is provided with a special form of relief valve with flame-proof cap. It is, therefore, possible for the whole of the moving parts of the switch to be removed for inspection without disturbing any of the cable connections. The switch is fitted with two overload releases with the release coils immersed in oil, therefore the expense and extra complication in the connections incurred by the use of current transformers are obviated. The moving element of the switch is operated in the usual manner by a hand lever with independent release gear to prevent the switch being put in against an overload. An indicating arrangement, showing the position of the switch, is fixed in a conspicuous position on the case. There is also fitted a contact device for operating red and green signal lamps. The overload releases are adjusted by a key, and a scale with movable pointer shows the exact value in amperes at which the release will come into operation.

In connection with the overload release the switch can be fitted with a simple mechanical time element with adjustable time lag. This can be arranged to release the trip mechanism in from 2 to 7 seconds, the period not being dependent upon the value of the overload. This possesses great advantages in cases where several switches are in use in connection with one another and with the main supply, as the elements can be arranged to trip the switches in a certain predetermined sequence. To secure absolute safety against damage in the case of short-circuits provision is made to ensure an instantaneous trip when the overload reaches the value of approximately four times that of the maximum releasing overload for which the switch is intended. This combination of definite time lag for ordinary overloads and instantaneous release on short-circuits possesses advantages which will be appreciated by all engineers. In connection with the time element a second dial is provided with a pointer which indicates how often an overload has occurred which has passed off before the time limit has expired, and therefore without tripping the switch.

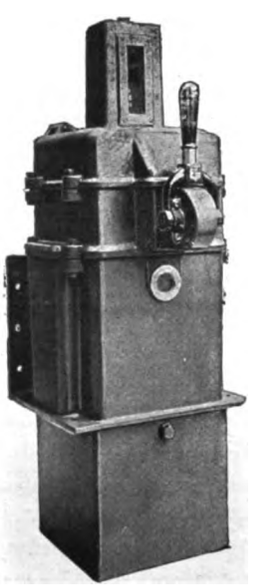

Fig. 2.—Union Mining Switch Unit.

A no-volt release attachment can be provided, and the coils wound for pressures up to 600 volts. In the case of high-tension circuits, suitable pressure transformers are required in connection, and in these cases the terminals of the no-volt coil are brought to the outside of the case by means of a water-tight receptacle with plug. Where ammeters are supplied with the switches their current transformers are arranged within the switch cases and oil immersed.

For use in situations where the space available is very limited, the Union Electric Co. have designed an extremely compact switch suitable for pressures up to 3,000 volts. This is an oil-break switch with cast-iron flame-proof enclosure. It is provided with automatic overload releases on two phases, the release coils being adjustable from the outside of case. Suitable indicating devices are also provided to show the position of the switch. As the terminals for the incoming and outgoing cables are arranged in a special manner, the switches may be assembled upon a framework to form a complete distributing switchboard.

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THE ELECTRICIAN INDUSTRIAL SUPPLEMENT

ISSUED MONTHLY — "THE ELECTRICIAN"

Telegraphic Address: "ELECTRICIAN NEWSPAPER LONDON" Telephone No. 949 HOLBORN.

All communications should be addressed to the Editor, "The Electrician" Industrial Supplement, 1, 2 and 3, Salisbury Court, Fleet Street, London, E.C.

Copy for Text or Advertisement pages for next issue, publishing on **August 19th, 1910,** *should reach the above address by Tuesday,* **August 9th, 1910.**

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

Conservation Problems.

There are not wanting those among us, though, unfortunately, they are not treated as they deserve, who point out that we are wasting our national and natural resources, and that a time will come, unless we speedily mend our ways, when we shall be bankrupt in this way at any rate. Anyone who has considered this subject at all will agree that there is much truth in these contentions. Not only do we waste what we have got, as can be easily gathered any day in manufacturing districts, but we take no thought for the future or consider any proposals for preventing the total loss of our natural resources. Coal, perhaps our most valuable commodity, is wasted in large quantities every day, while much is recklessly shipped abroad. It should not be forgotten in this connection that while the supplies of coal are large they are not unlimited, and that once the present deposits are worked out, which may not occur for years, but certainly will occur in time, this country will be in a difficult position. Much of our prosperity has been and is dependent on our coal supply, and every means should be therefore taken carefully to preserve it to our own use. The absence of water power in these islands makes this warning all the more necessary.

But even where water power is available it is altogether a wrong policy to waste it. Even that supply is not illimitable, and to make it continuously available requires careful handling. Indeed, Mr. L. Stillwell, president of the American Institute of Electrical Engineers, in a recent address, pointed out that great care must be taken in order that the water power shall not fall off. He contends that government control should be exercised over such falls as are not appropriated and should determine how and when they may be utilised. If this is not done the water power will speedily be exhausted and the country's natural assets will be that much the poorer. There are certain difficulties in determining how power users should be taxed, but the benefits which the general public must derive therefrom far outweigh these. It is time that this matter was taken up strongly, and that we as engineers should demand that some control be placed over the use of our coal supplies, which are, after all, national property.

The Extension of Supply from Continuous-current Stations.

In designing anything of an engineering nature which is to be used by the general public, the factor which is by far the hardest to determine is that of expansion. It is exceedingly difficult to determine whether a certain width of road will be adequate for the traffic 25 years hence or whether the passengers that will depart from a certain station 10 years hence will be able to use the present platforms without overcrowding. In the same way electrical engineers are faced with the problem of the expanding area of the towns they have to supply. Fifteen years ago a system of low-tension continuous current seemed quite the right thing to use for providing the town with light. But to-day with a large power load and an ever-widening area the problem of how best to meet the demands on the stations is a stiff one. One way to overcome it is to lay down high-tension plant to supply the outlying areas and to continue to employ the older machines for the district nearer home. This solution is in many ways good, except for the difficulty of knowing just where to leave off supplying the continuous current direct from the generating station and to start supplying it through sub-stations. This can be overcome by "feeding back" into the nearer area from the sub-stations—that is, instead of separating up the whole area into two sections, to keep it as one, but to feed the outer part from three-phase plant. This rather obvious solution has, of course, been often employed both in this country and abroad.

In a recent issue of the "Elektrotechnischer Anzeiger," Mr. W. Fuhrmann describes a somewhat different solution. He proposes the use of three-wire dynamos. These are provided with slip rings as well as commutators, so that alternating energy can be tapped off and stepped up for transmission to the outlying districts. The exact idea of this arrangement is not very evident, and it has the disadvantages that frequency troubles are sure to arise, for either the alternating current will be too low a frequency or the continuous current will tend to fluctuate. The old arrangement is not ideal, but it seems to be the best that can be devised.

Sub-Station Economy.

In this country among a certain class of engineers the sub-station is looked upon as a place to which aspiring students may be relegated on leaving college. It is doubtless felt that if they can stand sub-station work they can stand anything. It is a sort of cleansing by fire. The wages bill for a sub-station is therefore not high, but the arrangement does not

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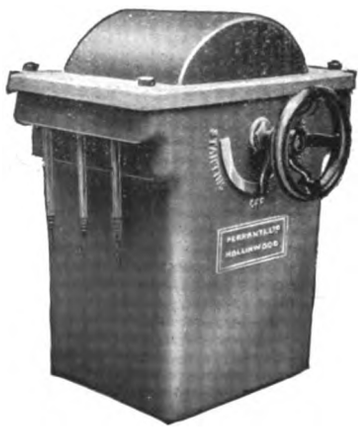

THREE-PHASE AUTO-TRANSFORMER STARTERS. TtotALLY-ENCLOSED. 245

make for great efficiency. If economy is to be practised on the wages account of a sub-station it must be effected by adding to rather than detracting from the duties of the attendant. Instead of allowing him to browse on penny dreadfuls during the whole of his shift, there is no reason, if the station be of the traction type, why he should not be employed on some traffic work, such as checking tickets or analysing reports. Similar work might be done in a lighting or power station. In this way a special man for this work would be saved, while the student would be acquiring useful knowledge instead of wasting his time. In dealing with this question the "Electrical World" states that in analysing the probable cost of operating a sub-station of, say, 500 kw. capacity in railway service, it appears that a good load factor is quite as important in relation to a low unit expense as in an ordinary generating plant. A recently completed sub-station of this capacity cost £4,400, including land, or £8. 16s. per kilowatt. Under reasonably favourable operating conditions the ratio of the average output to the normal capacity of the installation might be 30 per cent., giving a total yearly delivery of 1,315,000 kw.-hours at the continuous-current 'bus bars. Taking interest at 6 per cent., insurance and taxes 1 per cent. each, and depreciation 5 per cent., the fixed charges would reach £572 per year, or about 0·11d. per kilowatt-hour. In this installation three men are required, with wages totalling roughly 32s. per day. The labour cost, then, may be taken at about £564 per year, and allowing £156 for repairs and £80 for supplies, the total operating expenses reach £80. The total cost of handling the yearly service of the sub-station thus may be estimated at 0·26d. per unit of energy delivered to the continuous-current feeders.

These figures seem to show that the economy in operation is already as high as may be expected, but that something can be saved by careful design and on the wages account.

Electric Drive in the Machine Shop. The motor has for so long now been recognised as the proper machine to drive the tools and other apparatus used in an engineering shop that it is not surprising to find that useful information has been obtained on the best ways to arrange and drive the machinery, and that figures have been arrived at on which future work may be based. Perhaps the most important result of the general use of the motor is that machine-shop driving has become much more flexible than was formerly possible. Lathes or other machines can be placed conveniently for the work they have to do instead of having to be arranged with reference to the main shafting. The withdrawal of forests of belts allows greater facilities for handling materials both at the tools themselves and between them. The use of overhead cranes can be made much more extended, and as these will also be motor driven the use of ropes and other archaic plant is avoided. Further, a breakdown can much less seldom shut down the whole plant, while any breakdowns can be easily attributed to the proper quarter.

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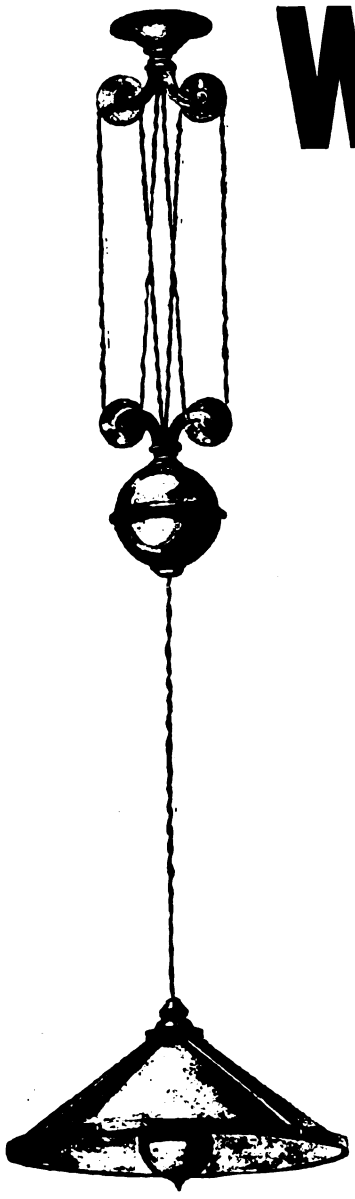

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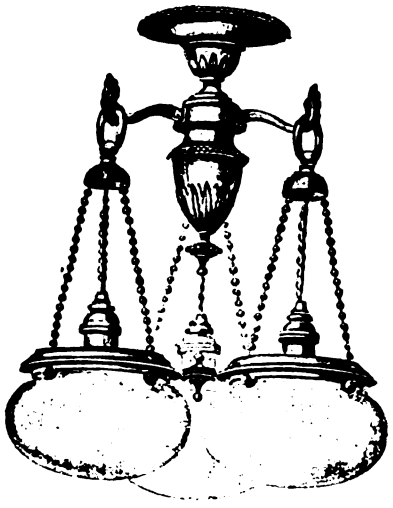

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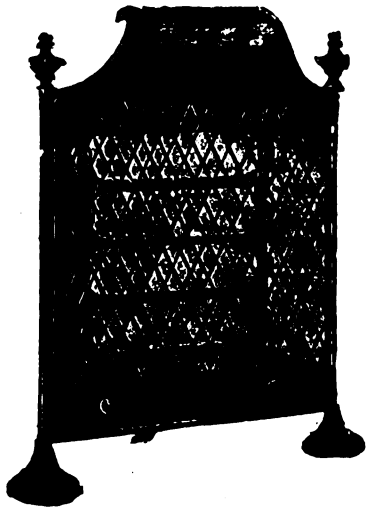

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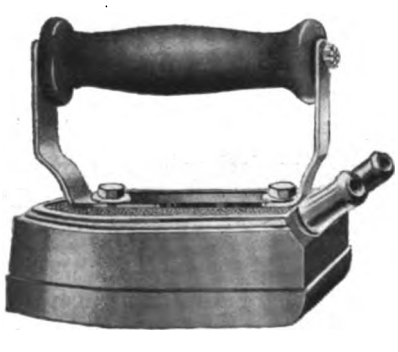

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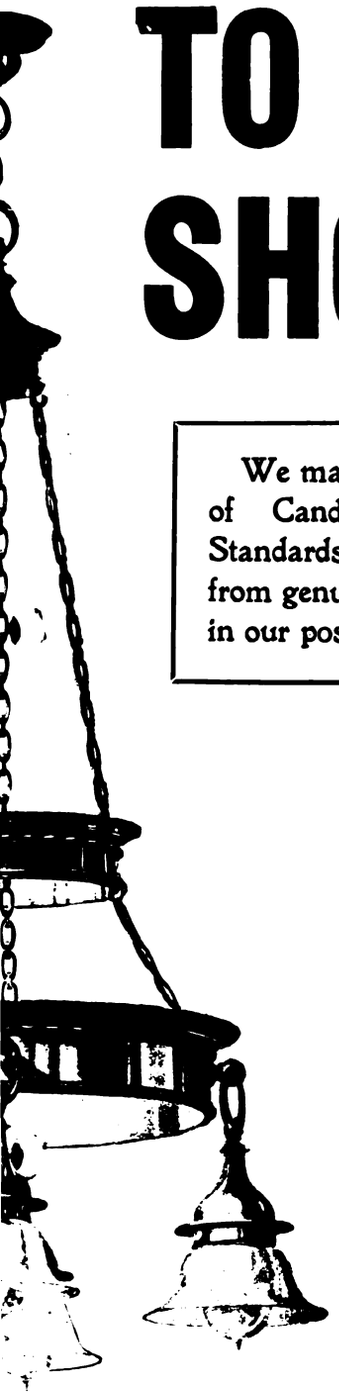

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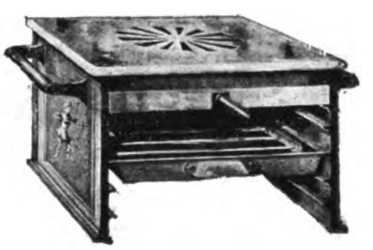

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The London Showrooms of the General Electric Co.

THERE has been much talk of the decentralisation of showrooms, of the opening of shops in the main streets of both large and small towns, and the supply to the public direct by the central station engineer of every kind of electricity consuming device. As a result of these recommendations one might expect to find a tendency on the part of the large wholesale electrical houses to curtail the expenditure of their showrooms and the display of electrical apparatus. It appears that how-

Fig. 1.—A G.E.C. Pendant.

ever desirable it may be to appeal directly to the buying public in electrical matters, both trade and domestic, the large wholesale showroom is still a necessity.

A showroom to be successful must be arranged with the utmost care to admit of comfortable inspection of the apparatus and to avoid undue clashing of the various articles on view; the latter more particularly applies to the display of electrical fittings. An attractive well-balanced showroom will always bring business and good business at that. The Queen Victoria-street showrooms of the General Electric Co. may be said to attain to a high standard in the matters of selection, adornment and classified grouping of electrical apparatus. The company's familiar premises have been recently undergoing a process of enlargement, and many improvements have been effected though none appear to be so extensive or modern as those carried out in the showrooms. Of these latter there are two, one on the ground floor and the other on the first floor, and they are each sub-divided into sections which contain some special group of fittings or apparatus.

At this juncture we may remark that the General Electric Co. has a special department for the design of electric fittings of every description. Not only does this department deal with the ordinary patterns of fittings from which a large number will be struck off, but also it acts in an advisory capacity where designs in some special style are

Fig. 2.—G.E.C. Radiator.

required. For instance, the majority of our great public buildings are constructed in accordance with the plans of a special architect. In the illumination of these buildings it is impossible to introduce standard patterns of fittings such as might be met with in the large showroom of the General Electric Co. The matters of the design and style of the fittings for each particular building must be submitted to an expert, who will only adopt a particular form and grouping as a result of close study of the requirements

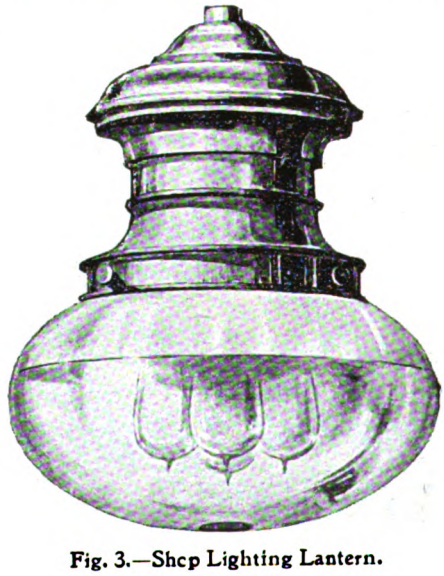

Fig. 3.—Shop Lighting Lantern.

of each individual case. The General Electric Co. has been and is regularly entrusted with important work of this character, and one has only to inspect its showrooms and turn over the pages of its fittings list to be at once impressed with the beauty and variety which are everywhere apparent in the results achieved.

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A feature of the first floor showroom from a popular point of view is a special room set apart for the display of French fittings. It is interesting to note that the company's designs and manufactures in this direction are of such consistently good quality that they can successfully compete with the French models. Our attention was particularly directed to the real gilt patterns which are undoubtedly handsome and highly ornamental. Candle brackets which are replicas of the Grand Fontainebleau and Louis XIII., XIV., XV., and XVI. models were specially

Fig. 4.—G.E.C. Milk Heater.

noticeable. These fittings have all been appropriately grouped, and can be severally or collectively turned on for display purposes.

Another portion of the first floor showroom is devoted to a special line of crystal fittings, which, we understand, are in considerable demand at the present time. With these fittings very pretty lighting effects can be obtained, more especially with Osram lamps. The crystals screen the source of illumination from direct contact with the eye and at the same time act as useful light diffusers. These fittings are mainly suitable for suspension from the ceiling, and the majority of the designs shown are of this pattern.

In the same showroom there is a tasteful display of adjustable pendants, such as are now very popular for diningroom and bedroom use. The diningroom patterns are now usually surrounded with an annular shade which screens the direct light of the lamps from the eye but at the

Fig. 5.—Two-light Bracket.

same time admits of upward reflection to the ceiling, from which the light is thrown down into the room. Practically every taste and every pocket are catered for in this group of fittings; for instance, a flat furnished upon a modest scale can be provided with its tasteful pendant appropriately to harmonise with the surrounding decorations. These moderate priced fittings are in large demand and can be seen to the best possible advantage in the showroom.

Practically the only remaining corner in the first floor showroom is occupied with an important trade section. Electric signs and flashers of every conceivable pattern have been erected on the walls and special circuits are run to the lamps so that each sign can be shown under both day and night conditions. From the point of view of an electrical contractor, who has no special showroom, but who is anxious to do business with a local tradesman, this portion of the showroom is of great value. If he can persuade tradespeople to make a journey to Queen Victoria-street—not a very difficult matter—he can then make a selection from a large variety of signs. In this same corner has been arranged many of the new pattern lanterns for holding one or more Osram lamps. These lanterns are taking the place of the small arc lamp for the lighting of shop windows both inside and out, and also for the illumination of small spaces. They are displayed in a great

Fig. 6.—G.E.C. Glassware Electrolier.

variety of types from the humble pattern containing a single 50 c.p. Osram lamp to the more ambitious variety, with half-a-dozen 50 c.p. lamps or a single 500 c.p. lamp. These lanterns can also be turned on severally or collectively to give an idea of the illuminating effect.

In this same section may be demonstrated the practical value of "strip-lite," a form of G.E.C. reflecting tubular lamp which is most effective for shop windows, show cases, jewellers' display cases, museums and picture galleries. In its most recent form this reflected lighting system has a central double holder carrying two lamps, which are both partly surrounded by an adjustable reflector. This pattern of illuminant is of small size, being narrow and long, and therefore admirably adapted for attachment to ledges, beadings, shelves, &c.

The showroom on the ground floor is rather larger than the one upstairs, and contains such fittings as electroliers,

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floor standards and special brackets. The electroliers and ceiling fittings are displayed in the centre of the room, and many of these are of very massive character. For instance, there is a particularly fine specimen in the shape of a bronze ceiling fitting, of which 400 were supplied to the Victoria and Albert Museum. This particular type is provided with a large bronze ring which is worked out of a single sheet of metal. A somewhat lighter pattern, but of similar design, which was supplied to the Victorian Government Strand building, is also on view.

This showroom is triangular in shape, and one of the longer sides is divided off into a number of compartments in each of which distinctive styles of fittings are displayed. There is a special bay for Dutch fittings, which contains many beautiful designs, and this will bear close inspection by buyers interested in these particular patterns. The range of floor standards in this room is very complete, and includes both the heavier and lighter designs. The radiator has received careful attention, and the General Electric Co. cater very widely for the radiator purchasing customer. There is a vast difference in price between the severe and the highly ornate in luminous radiators, and although the latter consumes not a watt less energy than the former the amount of work put in to its repoussé front or its richly chased sides is evidently worth paying for. The man who is blessed with an abundance of this world's goods and who is able to furnish various rooms in his house in accordance with particular styles can harmonise both the electric fittings and the electric radiator, not forgetting also the switches, bell pushes and wall plugs, with the adornments of the room. This class of customer is well catered for by the General Electric Co., and can have his every need satisfied.

A considerable portion of the ground floor showroom is devoted to a practical display of electric cooking apparatus. Here the latest patterns of G.E.C. ovens, hot plates, irons,

Fig. 7.—View of General Fittings Showroom at the General Electric Co.'s Head Office, 67, Queen Victoria Street, E.C.

fittings displayed are shown in polished brass, oxidised copper, oxidised silver, gilt and brass. Nearly the whole of one side of the showroom is occupied by a fine display of shades, so that a customer, after making a selection of a particular type of fitting, can choose a suitable series of shades. As in the case of the fittings in the showroom on the first floor, the ground floor showroom has been carefully wired so that any type of fitting selected can be immediately put in circuit.

Before we touch upon the electric cooking appliances which are given a special place in the showroom, we may say a word at this point on the subject of radiators. Most business men are familiar with the two-light or four-light luminous radiator which furnish heat upon hygienic lines in many modern commercial houses. For use in the home this welcome heater must present a less severe appearance than its office prototype. The production of an ornamental shaving water heaters, kettles, saucepans, steamers and numerous other forms of electric heating apparatus are on view. Practical demonstrations of the facility for quickly obtaining heat in cooking utensils, are regularly given, and consequently the prospective buyer is given an opportunity of judging of the suitability of the apparatus for his or her purpose. The attractive feature of this exhibit is an inexpensive oven which will cook a dinner for six or eight people at a cost of a few pence. Another interesting piece of apparatus is a toaster, which can be used on the breakfast table. The growing popularity of electric heating apparatus may be gathered from the fact that the company has supplied over 2,000 electric irons during the present season. One of the ovens on show is also fitted with a patent indicator which shows at what particular heating the oven is being used. It indicates whether the current has been left on or off.

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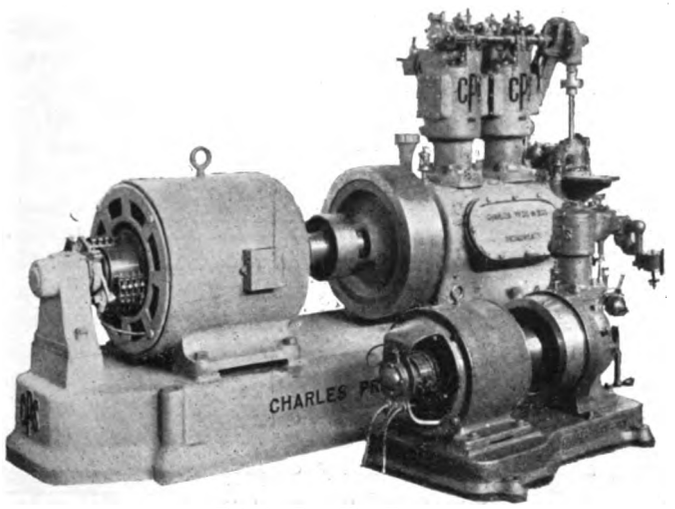
Price's Two-Cylinder Paraffin-Electric Set.

AN interesting paraffin-electric set made by Messrs. Chas. Price & Son, of Manchester, consists of a two-cylinder engine of 19 B.H.P. direct coupled to a 9·9 kw. shunt-wound dynamo. The engine is built to run on cheap petroleum oil (6d. to 6½d. per gallon), a perfectly clear and odourless exhaust being obtained when using fuel of this quality.

The crank shaft and valve operating mechanism is situated above the cylinder, the valve tappets being adjustable for wear; while the valves are contained in cast-iron cases and held in position by forged clips. The cams are hardened, and operate the valve rocking lever through the medium of hardened rollers running on hardened pins; half compression gear is fitted to ease the starting. Ignition is effected by means of a high-tension magneto, with a supplementary system consisting of a synchronised coil and accumulator. Lubrication is forced through the crank-shaft bearings by



Price's Paraffin Engine.

a rotary pump operated by the vertical shaft at front of engine. Emergency "sight-feed" lubricators are also fitted.

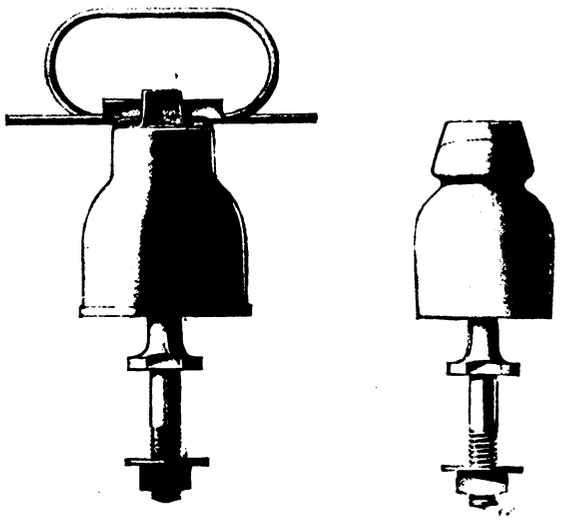
Cooling water is supplied by a gear pattern pump, and the system is arranged to clear itself through one cock in frosty weather. The governor is adjustable, and is specially sensitive to meet the narrow speed variation necessary on this class of work. Special arrangements have been made at the flywheel end of the crank shaft to avoid any wastage of oil, and the consequent throwing out of the same from flywheel rim. All bearings have been arranged to avoid oil leakage, and the plant is exceptionally cleanly in working. A large inspection door is fitted to the crank case, through which the connecting rod big end and also crank-shaft bearings can be adjusted for wear when necessary.

The generator has a capacity of 9·9 kw., and supplies current at a pressure of 100 to 156 volts. The plant is, therefore, adapted for accumulator charging or lighting direct. A noteworthy point about the dynamo is the separate commutator end bearing, which leaves the brushes fully accessible. The plant is exceptionally steady in running and almost noiseless, making it suitable for installing in the basement of a building where an outside power house is not available. Using fuel at 6½d. per gallon, the total cost per electrical unit is approximately 1⅞d. The net weight of the plant is 2½ tons.

Siemens Iron Telegraph Poles.

MESSRS. Siemens Bros. & Co. are well-known as pioneers in all branches of electrical work, but in spite of this it will doubtless come as a surprise to many to hear that they manufactured telegraph poles so long ago as 1863. In this year they first introduced their iron tubular poles, many of which have and are being used all over the world.

The taper form of tube has remained unaltered to the present day, but various modifications have been made in the design of the bases and in the joint for securing the wrought iron tube to the socket. Cast-iron is used for the base of the pole, as this metal is much less affected by the corrosive action of the earth than wrought iron. The advantages claimed for the Siemens pole are: great strength combined with light weight and low cost, small surface exposed to wind pressure, portability, compactness for shipping purposes, neat appearance, facility in erection



Figs. 1 and 2.—Standard Types of Siemens Telegraph Insulators.

and durability—a truly impressive list. Poles erected on lines over 40 years ago are, Messrs. Siemens inform us, still in use. In countries where wood is subjected to the ravages of white ants, or other boring insects, iron poles have been adopted universally.

Siemens poles have in fact been employed on the following lines: Transandine, Pacific and European, Central and South American, Indo-European, Central Persian, and on Government and other lines in South Africa, Uganda, Nigeria, Egypt, Australia, India, Argentina, Brazil, Chili, Peru, Uruguay, Mexico, China, &c.

The original type of Siemens pole consists of a tapered wrought-iron upper tube, a cast-iron base tube, a wrought-iron buckled foot-plate stamped to shape, and a lightning rod. The wrought-iron upper tube was placed in a socket formed in the top of the cast-iron base, and cement was run into the small annular space between the two. Four lugs were provided at the bottom of the base to which the buckled plate was bolted. A boss, with a conical hole in the centre, was welded into the top of the wrought-iron taper tube for the reception of the lightning rod, which consisted of a short iron rod, tapered at the end. A metal disc placed at the bottom of the socket provided a smooth surface for the wrought-iron tube to rest upon and to receive the cement. This also assisted in the important purpose of affording a good metallic connection between

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the upper tube and the base, so that the pole itself might form an efficient lightning conductor. Three small wooden wedges were supplied likewise, to centre the tube in its socket whilst the joint was being cemented. The buckled plate was dipped into boiling coal tar, and the cast-iron base and wrought-iron upper tube were dipped, whilst hot, into hot drying oil to preserve them from rust.

An important improvement in the method of securing the wrought-iron tube in its socket was designed and patented a few years ago. With this form of joint, cement is entirely dispensed with and the joint is made by means of a clamping ring. The ring is made of malleable iron or steel, is of wedge shape and is cut through on one side so that a small space is left between the two edges. On its outer surface a coarse screw thread is formed and a corresponding screw thread is cast inside the top of the socket of the base tube. When the pole is being erected, the ring is placed over the lower end of the wrought-iron tube and pushed up for some little distance; the tube is then placed in the socket and the ring screwed down with a special spanner provided for the purpose, when, owing to its wedge shape, it closes tightly on the tube and is held securely in the socket. The lower end of the socket is so shaped that the bottom of the wrought-iron tube is wedged into it. This joint can be made very quickly and easily, and the only tool or appliance that is necessary is the screw ring spanner.

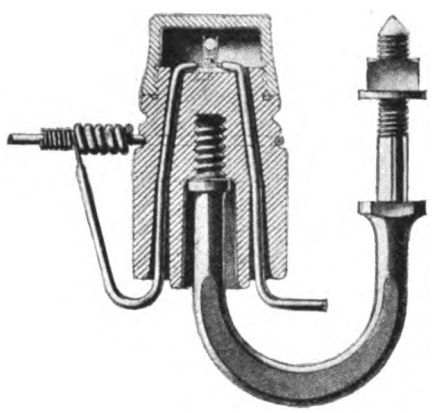

Fig. 3.—Insulator for Outside Work.

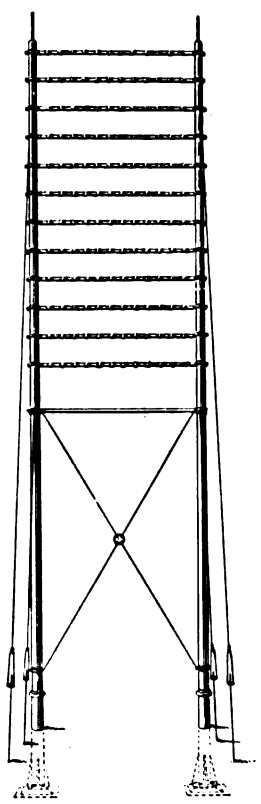

Fig. 4.—Typical Iron Pole Structure.

Another form of joint, known as the "Conical joint" or the "1872 joint," is so constructed that the wrought-iron tube fits directly into the socket of the base tube. For this purpose the socket is slightly tapered and a corresponding taper is formed on the lower end of the wrought-iron tube, so that they fit well together and make a perfectly rigid joint. This is a very convenient joint for the smaller sizes of poles.

Another modification consisted in the formation of a round flange with strengthening ribs on the bottom of the cast-iron base tube, so that the base tube might be used alone or might have a buckled plate attached if necessary. The type was introduced to meet cases where, on the same line, both very stiff and very soft soil would be found, and where it would be convenient to use the same type of pole throughout. In the one case it is obviously desirable to dig, or drill, as small a hole as possible, and, as a small base would be amply sufficient to support the pole, the flanged base tube could be used without a buckled plate, whilst in the other case, where there would be no difficulty in excavation, a large base would be necessary, and could be provided by the addition of the buckled plate.

In another type of pole the same feature as regards the bottom flange on the base tube as in the last type is retained and, in addition, the depth of the socket for the reception of the wrought-iron tube extends to the bottom of the base. The joint is always made with the screw-ring. This form affords, it is claimed, great strength to the lower part of the pole, as the wrought-iron tube so reinforces the cast-iron base that it cannot break. This type is, therefore, particularly recommended for high poles and for telephone poles which are to carry a large number of wires, especially when erected in towns, as, if the pole be overloaded or subjected to any exceptional strain, it would, at the worst, only be badly bent, whereas, with a pole in which the wrought-iron upper tube was supported above the ground level in a cast-iron base, the base might possibly break.

The pile pole consists of a cast-iron base pile which is driven into the ground by means of a rammer. The pile is in the form of a hollow tube with a solid point, and, in the act of driving, the rammer is placed in the tube, and the blows fall on the top of the solid point a wooden disc being provided to deaden the impact between the two metals. This form of base possesses several considerable advantages, viz.: the line can be erected with considerable rapidity, as two men can drive about 40 piles per day in ordinary soil. In driving, the soil is consolidated around the pile, and the upper portion of the pole can be fixed and the wires run immediately, there being no necessity to wait until the earth has settled, as in the case of poles inserted into a hole which has been dug for them, and the loose earth rammed down afterwards. No digging tools are required, the only tool necessary being the rammer. These piles are specially useful in rocky ground, as although they cannot, of course, be driven into rock, a small hole of suitable size can be formed by means of a special rock chisel or jumper, and the pile secured therein, whilst in the case of a pole with a large base, a considerable quantity of rock would have to be excavated. For ordinary telegraph lines, to carry several wires, the poles are usually constructed with a cast-iron intermediate tube bolted to the pile by four bolts, and provided with a socket to hold the wrought-iron upper tube.

The wrought-iron tube may be secured in the socket by the cemented joint, the malleable iron screw-ring joint, or, in the small sizes, by the conical joint. For light lines, to carry, say, one or two telegraph or four telephone wires, Messrs. Siemens have supplied very large numbers of pile poles which weigh about 110 lb. This pole has no cast-iron intermediate tube, the socket for the reception of the wrought-iron tube being in the pile itself. The wrought iron tube may be secured in the socket by the malleable iron screw-ring or the conical joint. This light pole has been used very largely for constructing lines in recently explored parts of Africa, as its two parts of about equal weight are just adapted for transport by native carriers. Larger poles are also supplied with the wrought-iron tube fixed directly in the pile, as described above.

In connection with the pile pole, Messrs. Siemens have lately introduced the patent steady plate which consists of a hollow boss with wings projecting from its periphery. The pile is placed in the centre of the boss and is driven into the ground until a circumferential ring, cast on the pile, comes in contact with the top surface of the plate, when, the driving being continued, the plate is forced into the ground with the pile, until its upper surface is an inch or so below the ground level. In this position the plate, being of comparatively

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large surface, affords considerable additional stability to the pole when the ground is of a soft nature. In hard ground the steady plate is not necessary.

In a slightly modified form these patent plates have been supplied in considerable quantities for a district where the soil is of sun-baked bog, comparatively hard on the surface, but very soft below. A deep, tapered wrought-iron plate with two wings, called a " bog " plate, fits over the lower part of the pile and is driven into the ground with it, the position of the wings being in the direction of the line, and a second plate, called a " ground " plate, which is placed on the pile above the bog plate is also driven down until its upper surface is level with the surface of the ground, or a few inches of the soil may be removed and the ground plate buried a little below the surface. The bog plate and ground plate may also be used separately.

Fig. 4 shows a typical iron pole structure designed to carry 72 pairs of telephone wires, the height from the ground to the lowest wire being 19 ft. The structure is composed of wrought-iron poles built in sections and fixed to cast-iron bases. The bracket for the insulators are made of two channel irons, bolted back to back, and the insulators themselves are spaced 8 in. apart. Figs. 1, 2 and 3 show types of insulators which are used in connection with these poles, that shown in Fig. 3 is intended for outside stations and is designed to protect a portion of the insulated leading-in wire from moisture and consequent surface leakage. In this form the live wire is bound to the body of the insulator, the removable part consisting of a porcelain cap being screwed on to the body, and the joint being made by an indiarubber band.

New G.E.C. Controller.

THE controller shown in the accompanying illustration has been designed and is now manufactured at the Witton Works of the General Electric Co. The aim of the designer has been to produce an article thoroughly sound mechanically as well as electrically, with all parts

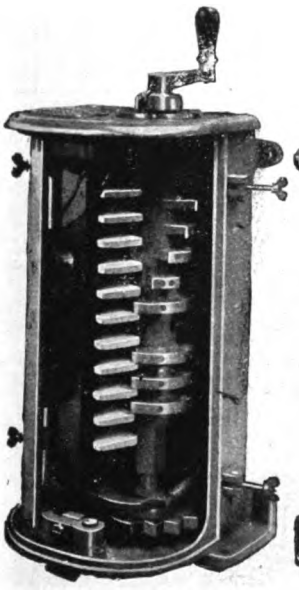

Fig. 1.—G.E.C. Controller with Cover removed.

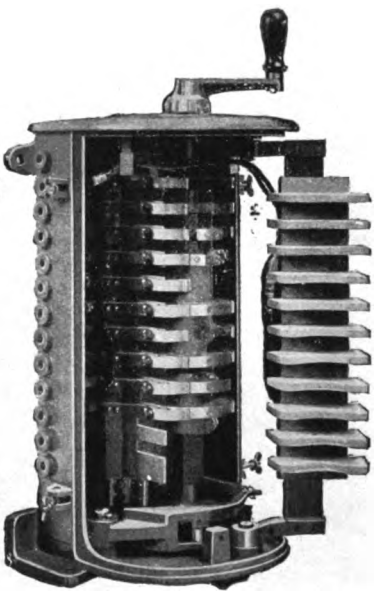

Fig. 2.—The same Controller with Blow-out Coil and Sparking Divisions swung out.

accessible, and which can at the same time be easily dismantled and reassembled.

The first illustration shows the controller in the working position with only the cover removed. Attention may be called to the large blow-out coil, the extra heavy uralite sparking divisions and the strong panel and cam wheel. Fig. 2 shows the controller with the blow-out coil and sparking divisions swung out. These swing quite clear from the controller and leave absolutely every part and every screw easily accessible for either inspection or repair. This illustration also shows the special ebonite clamps, which are provided to hold the blow-out coil leads in position. These, it may be mentioned, are in many controllers left unsupported, forming a constant source of trouble. Attention is also drawn to the ease with which the controller can be wired up. The terminals are directly opposite the cable entry holes, and are provided with sweaters of the same external diameter as the cable. Fig. 3 shows the component parts of the dismantled controller.

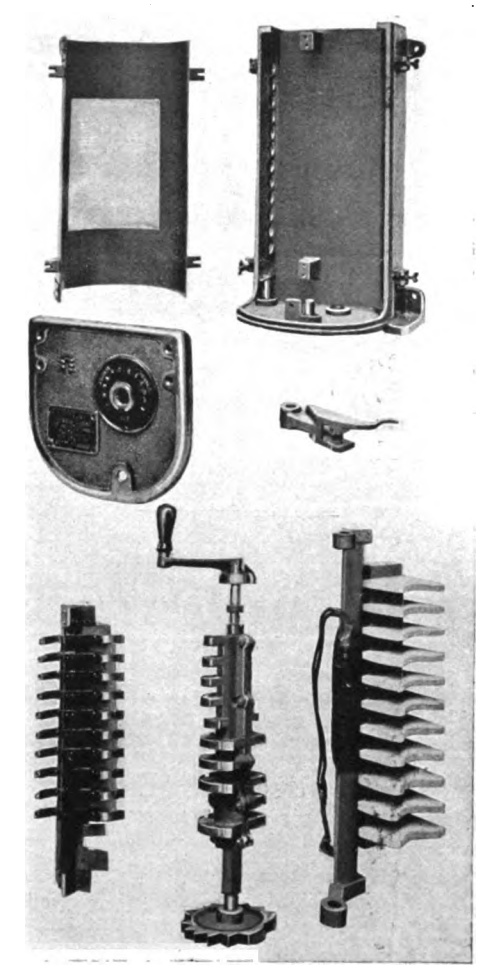

Fig. 3.—Component Parts of the G.E.C. Controller.

The case is made of cast iron and is machined where necessary. It is provided with a sheet-iron cover, held on with the usual fly nut fastening. On the back of the carcass, near top and bottom, two projections with V-shaped machined slots will be noticed. These carry the finger system, which consists of a square mild steel bar, fitting into the V-shaped slots of the above-mentioned projections, and is fixed to same with two screws at each end. This bar is micanised all over except at the extreme ends, and the finger carriers, which are wrought-iron stampings, are clamped to the micanised part. They carry on their upper end the contact fingers and on the lower cable terminals. The spark shield between the finger bar and drum is also attached to the finger bar by means of small angle pieces, which clamp under the fixing screws at both ends. Each

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finger can be removed separately without taking the finger bar out of the controller.

The drum consists of four castings clamped to a micanised square mild-steel shaft, not less than two sets of screws secured with lock nuts being used on each pair of castings. The castings have projections which are turned true when in place on the shaft. The interchangeable copper contact segments are screwed to these projections.

The two ends of the square shaft are turned round. To the lower end the cam wheel is keyed. This is very strong, as is also the panel, which can be seen above the cover in the illustration. It is most important that an ample factor of safety be allowed in these two parts, and also in the panel spring, as the safe working of the controller, and therefore of the motor and what it drives, entirely depends on these parts. The handle, as will be seen, is cup-shaped to prevent rain water from filtering through the bearing of the shaft, should the controller be used in the open. Provision is also made to prevent the handle being taken away in any but the "off" position. The top plate is of cast iron with polished brass fittings.

The pole-piece, which carries the amply dimensioned blow-out coil, has fitted to its face, and reaching over the whole length of the drum, a heavy piece of fireproof insulating material. The sparking shields of uralite are cemented into slots in this piece, no screws being employed, and therefore a breakdown to earth due to the splitting of one of the uralite pieces is made practically impossible.

The controller is suitable for motors up to a capacity of 50 B.H.P. on 500-volt circuits, or for a maximum current of 75 amperes on lower voltages. It can be supplied with the leading-in holes for the cables arranged either on the left or the right-hand side.

A Formosan Power Scheme.

AS is well known, great developments have recently taken place as regards hydro-electrical installations in Japan, and it will, therefore, be of interest to describe a scheme which has been carried out by the Allgemeine Elektricitäts Gesellschaft at Ronokei, in the neighbouring island of Formosa. This station is used for supplying power to sugar factories as well as the other electrical requirements of the town of Takao. The island of Formosa, which lies just off the south of Japan, contains a number of sugar plantations, which are, however, to be found principally towards the middle and south of the island. This industry has been established a very long time, but the methods used have been very primitive, and the production has, therefore, been small. Lately, however, more modern ideas have been introduced, and sugar is now the principal production of Formosa.

Tainan is a town of 60,000 inhabitants in the south of Formosa, from which the power plant is a distance of about 25 miles. The water used for driving the turbines is collected in a large catchment area, and is brought down to the station through four large and two small pipe lines, as shown in Fig. 1. Fig. 2 shows the interior of the station, where at the present time there are four main generating sets and two exciting sets at work. In a bay opening off the generator room are placed the transformers, switchboards and high-tension apparatus. Each main three-phase generator has a power factor of 0·8, an output of 400 kw. and a frequency of 60 when running at 600 revs. a minute. The overload capacity is 25 per cent. for two hours, and the temperature rise, after working on full load for eight hours, does not exceed 40°C.

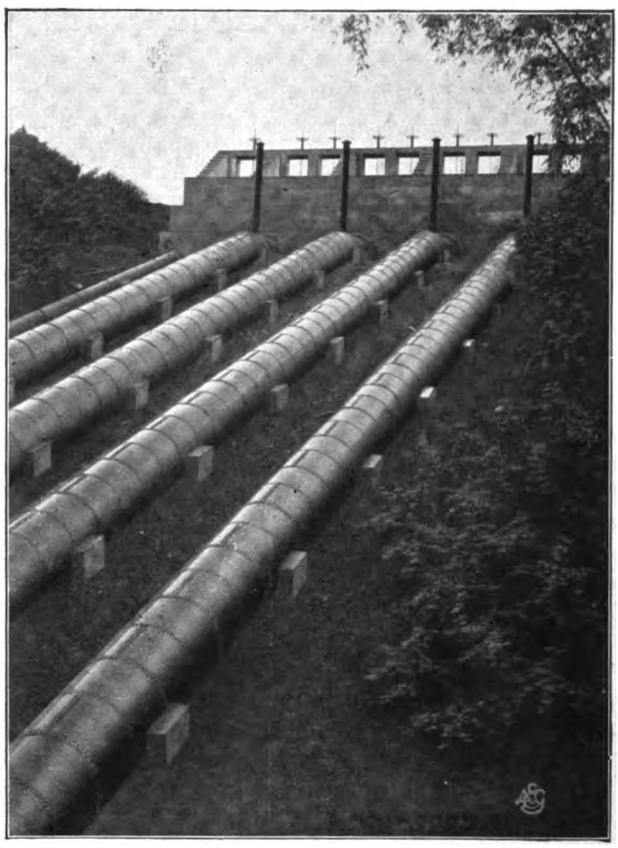

Fig. 1.—General View of the Ronokei Pipe Line.

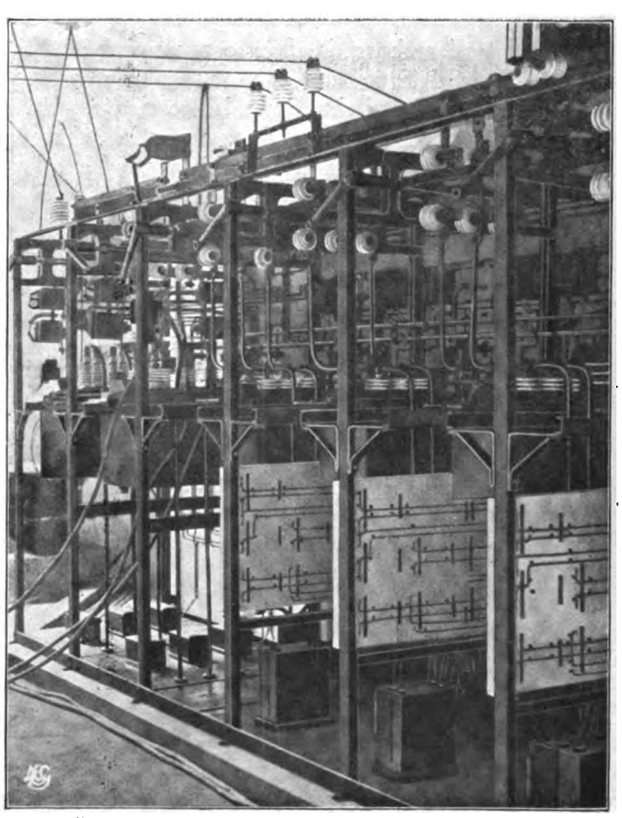

Fig. 2.—View of the Back of the Switchboard.

The generators are connected to the turbines, which are of the Francis type, by means of elastic couplings. The turbines are fitted with pressure regulators which work by

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oil, and each has an output of 600 H.P. when the fall is 70 ft. Their speed is 600 revs. per min., and their efficiency 80 per cent. when running with the throttle three-quarters opened. Each exciting set consists of a compound-wound continuous-current generator direct coupled to a Francis turbine, and delivering current at a constant voltage. Each continuous-current generator has an output of 50 kw. at 125 volts when running at 750 revs. per min. The overload capacity and temperature rise are the same as those given above for the main generators. The energy from the main generators has its pressure stepped-up to 3,300 volts for transmission. Six single continuous oil-cooled transformers, arranged in two groups, are used for this purpose, while two transformers of the same size are kept as reserves. On the low-tension side the group of transformers is connected up in mesh, while on the high-tension side the connection is in star form. The overload capacity of these sets is 35 per cent. for two hours. Each transformer is designed for over 22,000 volts, and is operated from above. The transformers are built up in cells, from which they can be drawn out for overhauling and repair. The general arrangement and construction of the switchgear is shown in Fig. 2. The switchboard consists of four generator panels,

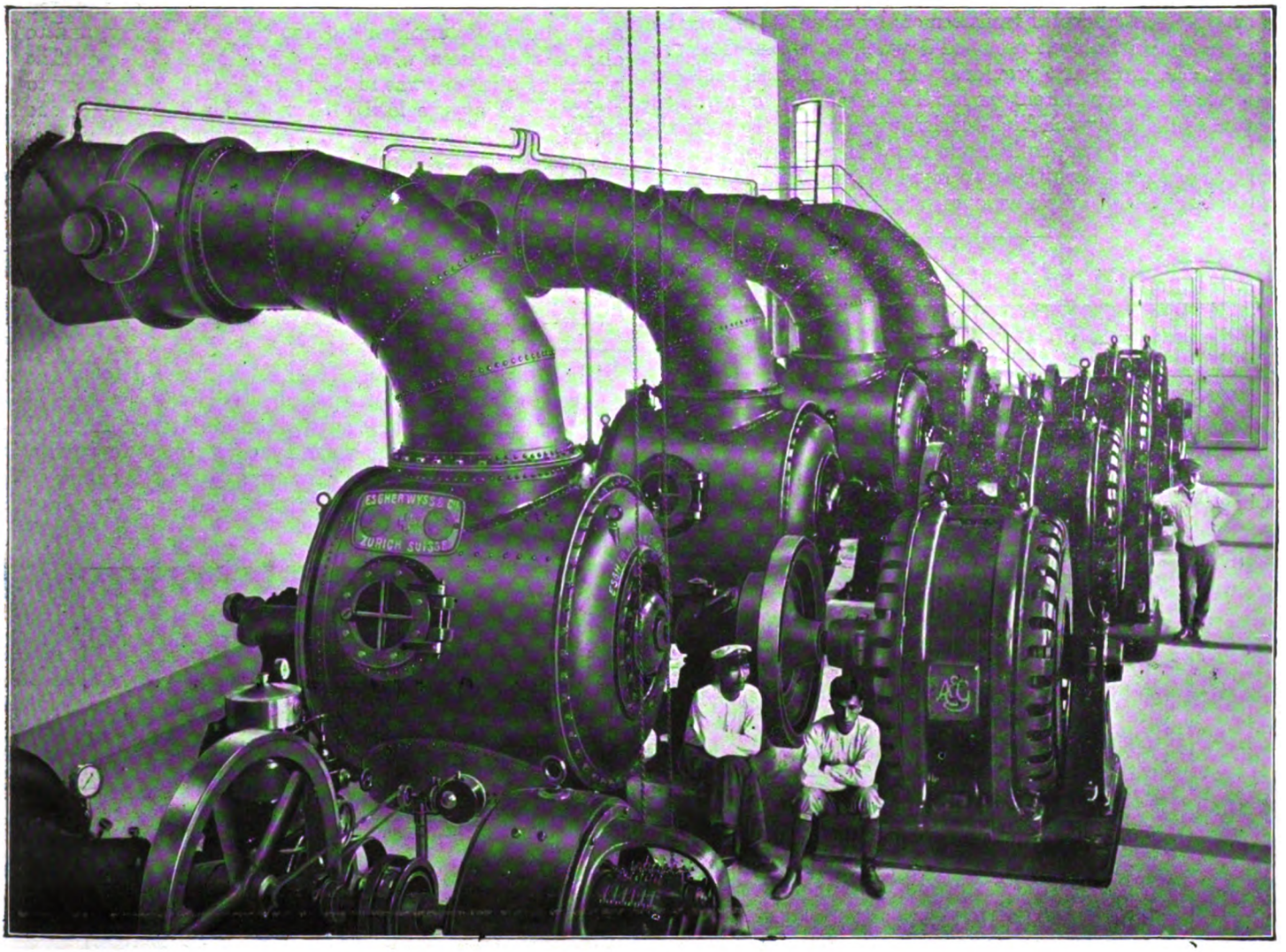

Fig. 3.—View of the Turbine Room at the Ronokei Station.

an exciting panel for the two exciting sets and two transformer panels. The overhead transmission lines consist of three stranded copper wires 0·03 mm. in area, which are fixed on wooden masts. High-tension insulators of the Delta form are being used.

At Nashiko there is a distributing station, and the overhead wire is here branched off into two lines, one of which supplies Tainan and the other Takao. Starting switches and lightning protectors are installed in this station. Each

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of the two sub-stations is equipped with four 250 kw. single-phase oil-cooled transformers by means of which the high-tension voltage is stepped-down 2,400 volts. Reserve transformers are also provided. In these sub-stations there is the necessary switchgear for the distributing circuits, as well as lightning and high-tension protectors. This installation is of interest, as it shows how the modern inhabitant of Japan recognises the way in which modern engineering can be applied to the development of his country.

Battery Plant at Messrs. Rowntree & Co.'s Works.

THE services of accumulator plant for the purpose of voltage regulation and economy in working have received much recognition, and among the latest examples of this class of work may be noted a large battery and automatic reversible booster at Messrs. Rowntree & Co.'s cocoa works at York. Messrs. Rowntree & Co.'s works contain two separate generating stations, the original steam-driven plant (having an output of 2,450 amperes at 230 volts) being supplemented by a gas-driven plant situated in another part of the works, 110 yards distant, with an output of 1,600 amperes. The two stations have separate sets of 'bus-bars connected by a 2·8 sq. in. cable. The gas station usually supplies about 1,200 amperes to the steam side, but occasionally the steam supplies current to the gas station board.

Amongst the reasons in favour of the installation of a battery, the following were perhaps some of the more important:—Much importance was attached to a steady line voltage. It was thought advisable to prevent the sudden stoppage, from any cause, of any generating set interfering with the supply of current.

These requirements could only be met by the installation of a battery and automatic reversible booster. The battery was designed to supply all the peaks of the load above the predetermined outputs of the machines, and to absorb the excess when the demand falls below. The second requirement was met by arranging for the battery to assist in taking the load of any set in the event of one stopping until another be started up. The regulation of the booster is affected by balanced coils, one coil (A) being energised by a fixed percentage of the total output of the station, the other coil (B) being a shunt across the main 'bus-bars and acting in opposition to A. Thus an increase in the demand on the station tends to strengthen A, and the battery discharges. Any falling off in the demand tends to weaken A, which is then overpowered by B, and the battery charges.

The battery consists of 112 D.P. cells capable of a discharge of 800 amperes for one hour, with a final pressure of 193 volts. The positive plates are of the "Planté" pattern, $\frac{1}{2}$ in. thick, being solidly constructed to sustain heavy rates of charge and discharge without buckling or disintegration of the active material. The negative plates

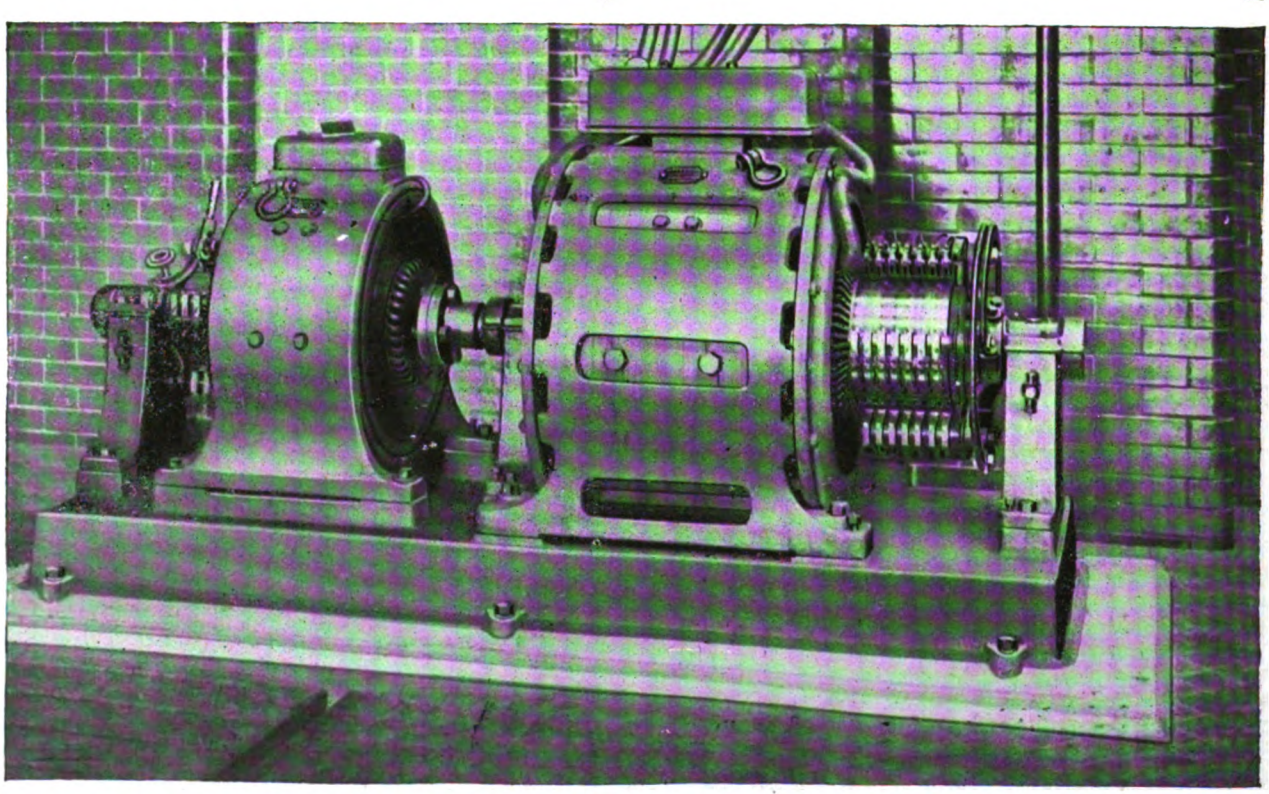

Fig. 1.—Reversible Booster Set at Messrs. Rowntree's Works.

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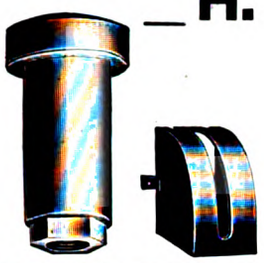

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are of the "Sponge" type, being proof against shrinkage or loss of the active material. The cells are burnt up throughout, the inter-row connections consisting of copper rod $1\frac{1}{16}$ in. in diameter. The booster and switchgear is of

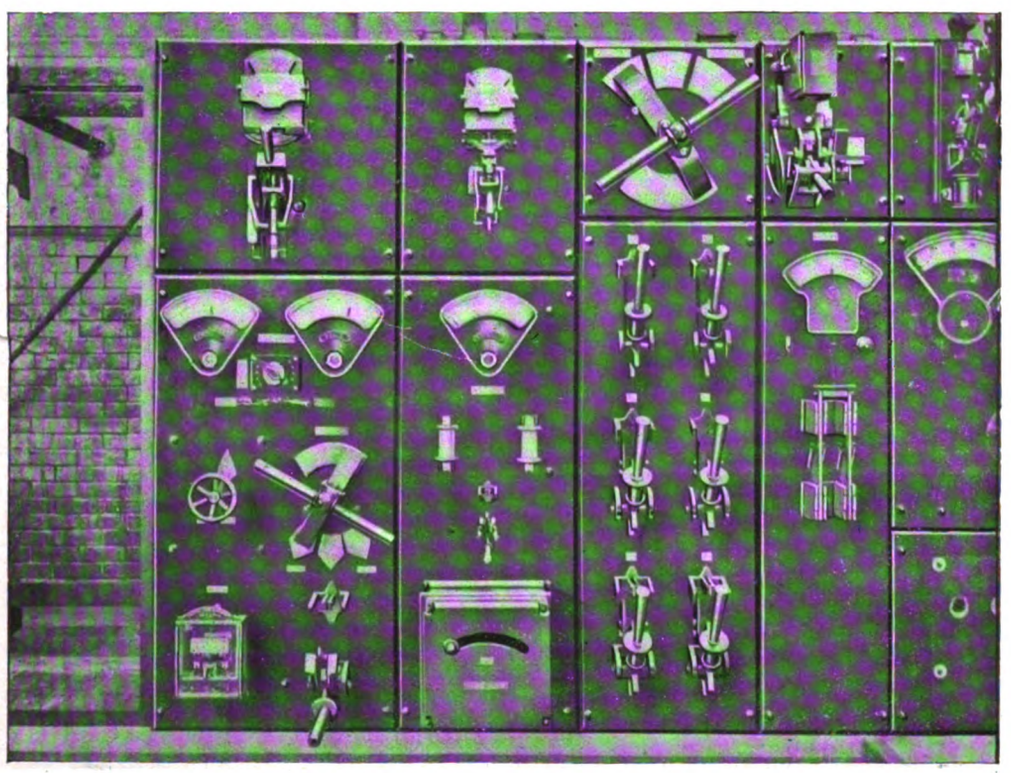

Fig. 2.—Switchboard at Messrs. Rowntree's Works.

Messrs. Crompton & Co.'s manufacture. The whole of the contract was carried out by the D.P. Battery Co., of Bakewell.

Electrical Progress.

IN this article we propose to call special attention to the progress which has been made during each preceding month by electrical manufacturers in their own special lines. This progress can best be gauged by reference to selections from their latest catalogues and price sheets, and we shall, therefore, give short notes on the subject matter of such catalogues and lists as are sent us, and which indicate either that new equipment has been designed or that modifications have been made in well-known apparatus.

Power Plant.

Motor Starters.—Mr. Geo. Ellison has recently issued a pamphlet giving full details of the starters made by him for alternating-current work. Their design has been very carefully worked out, and, thinking the subject may be of general interest, we give a detailed account of this apparatus on p. 70 of our present issue.

Accumulators in Power Working.—The application of accumulator batteries to power work is certainly a feature of modern electrical engineering. The batteries have been so strengthened as to render them capable of withstanding fairly large fluctuations in demand during discharge, and they are therefore being widely used for levelling up peaks, thereby saving a certain outlay on generating plant. One of the latest of these installations has been carried out by the D.P. Battery Co. at Messrs. Rowntree & Co.'s works at York. This is described in detail on p. 90 of this issue.

B.T.-H. Motors.—The British Thomson-Houston have just designed a new type of continuous-current motor, which is capable of working in all sorts of awkward positions. To make this possible a number of different types have been made, both open, semi and wholly enclosed and dust and flame-proof. These motors can be wound for all pressures and are manufactured in a variety of sizes.

Instruments.

Elliott Instruments.—The catholicity of Messrs. Elliott's work is well indicated in some pamphlets recently issued by them. They deal with instruments of all kinds both electrical and mechanical, as well as with portable transformers, keys and switches.

Siemens' Instruments.—Messrs. Siemens Bros. & Co.'s latest catalogue on this subject deals with precision type wattmeters and current and pressure transformers. A glance through it shows that Messrs. Siemens are still keeping up that high standard which they long ago set themselves.

OSRAM-LAMPS

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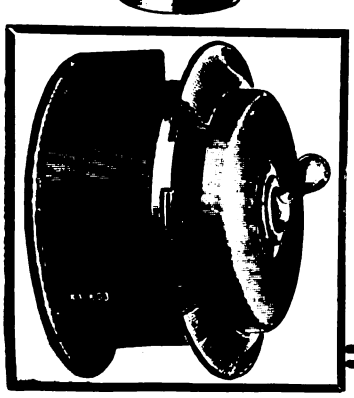

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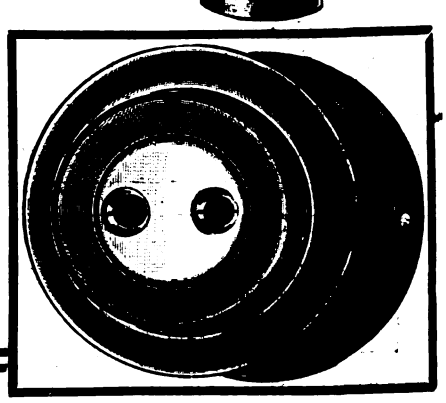

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Printed and Published by GEORGE TUCKER, at the Editorial, Printing and Publishing Offices, 1, 2 and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, JULY 22, 1910.

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THE ELECTRICIAN:

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ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,680. [No. 16. Vol. LXV.] FRIDAY, JULY 29, 1910. PRICE SIXPENCE (by post, 6d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Trackless Trolley Systems.

ALTHOUGH the trackless trolley system is not making any very great headway in this country, it seems to be quite an acknowledged thing for municipalities to send deputations to the Continent to investigate what is there being done in this direction. Doubtless such an investigation provides agreeable relaxation, but we doubt if there is very much more to learn than has been disclosed on previous occasions. The principle, however, that every municipality should be independent is evidently one that will continue to be followed. The latest deputation is from Bradford, and the report of the tour has now been issued. Vienna, Milan, Mülhausen and other towns were visited, but the trackless trolley was only investigated at the towns just mentioned. The system at Mülhausen is well known, and has often been cited as providing satisfactory proof that the trackless trolley is of commercial value. At Vienna the Mercedes-Stoll system is in use, and it is interesting to learn that the cost per omnibus-mile is only 4·52d. There is, however, no conductor on these vehicles, the entrance being at the forward end, so as to enable the driver to attend to tickets as well as to drive the vehicle; and there are seats for only 12 to 15 persons. The overhead construction costs £700 to £800 per mile. These figures sound encouraging, but it does not necessarily follow that the same results would be obtained in this country, because our ideals are apt to be higher. The deputation formed the opinion that 20-passenger cars at Bradford would cost about the same in running as 60-passenger tramcars, or 7·25d. per car-mile. The "Filovia" system seems to be working under particularly favourable conditions in Italy, for the service is so far appreciated that the Government is making a grant of £60 per annum per mile of route where this system is in use and where the district is not served by other means of transport. Perhaps the chief difficulty in this country is that we are not so easily satisfied as our neighbours.

Reflection in Illumination.

THERE is probably no subject in which the laws are more simple than in illumination, and equally no subject in which the laws are so frequently forgotten. The effect of reflection in illumination is a case in point. In purely scientific work it has long been realised that, for example, the loss by enclosing a source of light in a glass globe is not given simply by the coefficient of absorption of the glass. Since light is reflected as well as absorbed by the glass, the result is to increase the internal illumination of the glass, and thus the net diminution by the globe is less than might be expected from the coefficient of absorption of the glass. A similar problem was considered by Dr. W. E. SUMPNER in a Paper read before the Illuminating Engineering Society last April in regard to the Ulbricht globe for photometry. It was pointed out that if the reflecting power of the globe's surface is, say, 90 per cent., the brightness is about ten times what it would have been if merely due to the source of light. This means that 90 per cent. of the illumination in such a case is independent of the position of the source of light. As pointed out by Mr. MCALLISTER in an article of which we give an abstract elsewhere, similar principles apply to the illumination of rooms. Of course in such cases the conditions are much more complex. The reflecting power does not approach 90 per cent., or even 80 per cent., if we except a whitewashed ceiling, and thus the variations in illumination of the walls are much greater. Nevertheless the rôle of reflection in room illumination is very considerable and is sometimes brought home, even to the lay mind when the choice has fallen on a dark, though possibly artistic wall paper, and a room that was sufficiently illuminated

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previously is converted into one that is comparatively dismal in appearance.

The Post Office and the Telephone.

If the business men of these isles ever give a thought to the matter, they must be looking forward with something the reverse of pleasant expectation to the state of things which will most probably exist when the National Telephone Co.'s system has been taken over by the Post Office in 1911. The present examples of Post Office administration are such as to make any other addition to that department's excursions into trading concerns absolutely undesirable. We have all had experience of them. We are not surprised, therefore, at a trenchant criticism of Post Office administration, principally in its application to the telephone system, by Mr. H. Laws Webb, in a letter published in last Wednesday's issue of "The Times Engineering Supplement." We recommend its perusal to every engineer (and even more so to the public), and are glad that it has been printed in a paper that will ensure its general recognition. Mr. Webb points out that while the engineering department of the Post Office is always on the look-out for something new and is ready to adapt new things to the work in hand, their efforts are stunted in higher quarters with the present undesirable results.

It may be pointed out that in the Post Office the engineering department has too little power, while the administration suffers greatly from the system of political control and from the subservience of the whole of the work to the fads of the Postmaster-General for the time being. It seems to us that to take the control of all the Post Office work out of the political atmosphere, by which it is at present surrounded, must be the first step towards any ultimate reformation of the whole. If a Government department is to trade it must work in a more or less business-like manner, or disaster will be the result. Further, it must be free from any pressure that can be brought to bear on it politically by its servants, and it must be administered by a man who is familiar with his work. Though at the present time each department of the Post Office is controlled by an expert chief, in practice he is often over-ruled by an inexpert politician, while the whole system of employment in Government departments leads to general inefficiency and wire-pulling. The public in general should be grateful to Mr. Laws Webb for bringing this question so forcibly to their notice. There can be no doubt that, if example be followed, telephone administration under the Post Office will become more and more inefficient. Cannot some way be found of working the system in a business-like fashion, or, at least, of keeping it free from the red-tape which at present seems the necessary concomitant of every Government operation? We are afraid not, and, unless the public take the matter in hand very quickly, another going concern will be gone beyond recall.

The Association of Consulting Engineers.

We are glad to see that the decision to form an Association of Consulting Engineers has met with general approval, though, as is only natural, there has been a certain amount of criticism, not always to the point. Thus the "Manchester Guardian" states that most of those present at the meeting were agreed upon corporate membership of the Institution of Civil Engineers being a necessary preliminary to membership in the new Association, and our contemporary goes on to say that this is not a very desirable course, particularly as the Institution is somewhat out of sympathy with the younger generation of engineers and particularly with those of the Manchester district, rather to the disadvantage of those same engineers we should think. We may say without fear of contradiction that this particular point was not discussed at the meeting in question, so that no opinion on the subject was expressed. The draft rules that had been prepared by the provisional committee were not put forward for discussion, but were left over for much more detailed consideration than would have been possible at a preliminary general meeting. It is also rather curious to notice the opinion that is held in some quarters as to the meaning of the term "civil engineer." It has certainly come to have a restricted meaning, but surely it is understood that the Institution of Civil Engineers is an institution of engineers who are not in the military service. Consequently, the Institution embraces all classes of engineer, and it is quite erroneous to suppose that the electrical, the mechanical, or gas engineer is merely received on sufferance into the membership of the Institution of Civil Engineers and is not a civil engineer. As to the particular rule in question, we think there is much to be said in its favour, because it ensures a breadth of training, but we are equally of the opinion that the council of the new Association will find it necessary to have full power to put such a rule on one side whenever it is deemed desirable.

The Late Harry W. Cox.—We have received a donation of £1. 1s. from "Dare Quam Accipere," which we propose to hand over to the fund which has been created by Alderman W. Treloar, on behalf of Mrs. Cox and her children. We invite those of our readers who are disposed to contribute to this deserving memorial to a brave man to forward their contributions to Alderman W. Treloar at 68-70, Ludgate-hill, London, E.C., or we will ourselves receive subscriptions to be handed over to Sir William Treloar.

The Electrolytic Disinfecting Plant at Poplar.—The demand for the electrolytically made disinfecting fluid whose manufacture has often been referred to in these columns seems, judging from the report of the medical officer of health, Dr. F. W. Alexander, to have been greater than ever in Poplar during the past 12 months. The year's output from seven depôts was 27,216 gallons, the maximum taken in any one month being 4,326 gallons in August and the minimum 658 gallons in December. The cost of material used in manufacturing this amount was as follows:—

Electricity, 4,781 units at 1½d. per unit	£29	17	7½
Chloride of magnesium, 2 tons 18 cwt. 11 lb.	11	16	1
Salt, 4½ tons	7	5	0
Caustic soda	3	2	6
Water	1	1	0
Total	£53	2	2½

Since the plant has been installed (a period of about four years), nearly 90,000 gallons have been manufactured at a cost for electricity and materials of under £175.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910

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Clearing House for Goods in London.—We regret to find that an error was made in our last issue in stating the cost of the clearing house scheme for London. This should have been £6,000,000, which would be sufficient to provide 2 miles of tunnels as well as the building and other parts of the complete scheme.

Searchlights in the Panama Canal Zone.—According to the "Electrical Review and Western Electrician," barges filled with stone and sand are now unloaded at the Gatun Docks by means of searchlights. There are one single and two duplex cableways for unloading sand and rock, and one searchlight for each cable has been placed on the tail towers, casting a light along the cables, on the barges at the dock and over the storage piles. The searchlights are 18 in. standard Navy projectors, and are operated by a motor-generator which converts current supplied at 600 volts from the power plant to current at 125 volts for the lamps. The lights are controlled from the head or operating towers. In addition to the searchlights, strings of flame arc lamps have been stretched from the head towers to the tail towers, four lamps for each tower. These lamps form their arc at the apex of an acute angle made by the carbons, and therefore throw a light equally in all directions. On this account, although they are strung below the level of the cables, they illuminate them as well as the storage piles beneath.

Wireless Telegraphy in German Fisheries.—The United States Consul at Hennburg, states that three Cuxhaven steam trawlers are now equipped with wireless telegraph apparatus, and that the service is so satisfactory that efforts are being made to increase it. The most marked advantages resulting from the use of the wireless telegraph in this business are the ability of captains to communicate with each other at sea as to their respective catches, and the transmission of similar reports to Cuxhaven a number of hours before the return of the ships to port. Thus vessels of the same fleet which have found poor fishing are sometimes able to join other vessels more fortunately located, in time to return with good catches. All the vessels are then able to inform the managers of the public markets respecting the quantities of fish to be placed on sale, in such manner that, in the event of unusual catches, arrangements can be made in advance for distributing supplies in the least possible time. The receipt and transmission of hydrographic intelligence and reporting of breakdowns in engines or other accidents of navigation are also features of importance.

Electricity in Mining.—The 1909 report of Mr. J. B. Atkinson (H.M. Inspector of Mines for Newcastle District) states that the total quantity of coal cut by electric coal cutters in the district (which comprises Cumberland, North Durham and Northumberland) was 468,067 tons and by compressed air 767,114 tons; the electric coal cutters in use were 45, and compressed air 178. Of the 83 fatal accidents (compared with 100 in previous year) none are attributed to electricity; of 382 separate non-fatal accidents reported to the inspector (compared with 430) four are described as electric and of 15,643 non-fatal accidents disabling for more than seven days (against 13,398) only two are ascribed to electricity. The total estimated number of shots fired was 8,664,979 and the quantity of explosives was 4,681,137 lb. The shots fired by electricity were 2,294,372, the remainder being by fuzes and squibs. No electric lamps were in use. The lamps in use were 56,892, of which 38,091 burned colza, or colza and petroleum, the remainder using petroleum, volatile spirit and "other illuminants." There were no prosecutions against mine owners. In 16,972 lamps the method of locking was magnetic and in the remainder lead rivets, screws or other means.

Obituary.—GEORGE FLETT.—We regret to have to record the death of Mr. George Flett, which occurred as the result of a motor car accident at Birmingham on Wednesday last. The deceased, with two other directors of the Metropolitan Amalgamated Railway Carriage & Wagon Co., was proceeding from the works to the New-street station when a child ran into the roadway close to the car. The driver, in swerving out of the way, ran into the curb, with the result that the car was overturned. Mr. Flett, who was next the driver, received fatal internal injuries, while the other occupants were badly shaken and the child will probably not recover. Mr. Flett's position in the electrical engineering profession is well known to our readers. He was managing director of Messrs. Dick, Kerr & Co., and has done much in assisting the progress of manufacturing electrical work. As the announcement of Mr. Flett's death has come to hand at the moment of going to press, we are now only able to refer to his work in this brief manner. We hope, however, to place on record our appreciation of Mr. Flett's activities in our next issue.

Luminous Efficiency of the Firefly.—In a recent issue of the "Bulletin of the Bureau of Standards," Messrs. H. E. Ives and W. W. Coblentz describe an investigation of the light emitted by the common firefly. The spectrophotometric curve of the firefly, as compared with a carbon glow lamp, was obtained by comparison of the photographic densities of the negatives from the firefly and the glow lamp. From the known distribution of radiant energy in the carbon glow lamp, and by means of the spectrophotemetric relationship, the distribution of radiant energy of the firefly was derived. The light was found to consist of an unsymmetrical structureless band in the yellow green of the spectrum, with a maximum at 0·57μ, and extending to 0·51μ and 0·67μ. The luminous efficiency of the firefly is calculated by the authors as 96·5 per cent., as compared with 0·4 per cent. for the carbon glow lamp, and about 4 per cent. for the most efficient artificial illuminant. This value is obtained on the assumption that there is no infra-red radiation, other than that due to the natural body heat. They state that there are reasons for believing that the light emitted is due to a physiological-chemical reaction, not necessarily accompanied by heat waves of low frequency such as occur in a purely thermal (low temperature) radiation. But even if heat waves of low frequency are generated in the photogenic cells, they could not pass out into space on account of the opacity of the outer integument, the chitinous layer, of the insect, which probably can transmit radiation to wave lengths as great as 1·5μ. Now, from present knowledge of emission and absorption, and from the fact that the emission band in the visible spectrum stops abruptly at 0·7μ, it appears highly improbable that there is appreciable radiation between 0·7 and 1·5μ; hence the assumption of no infra-red radiation cannot seriously affect the results.

Science at the Japan-British Exhibition.—An interesting display of scientific apparatus, maps, specimens and statistics are to be found in that part of the Japan-British Exhibition which lies between the Shepherd's Bush and Wood-lane entrances. Oceanography, astronomy, anthropology, metrology, physics, geography, chemistry, geology and mathematics are all represented, and an inspection of the various exhibits will not be without its educational value to those visitors who can tear themselves away from the joys of the "Witching Waves." The principal exhibitors in the electricity and magnetism section are the Wheatstone Laboratory, King's College, London, from which several historical pieces of apparatus used by Wheatstone and Clerk Maxwell are shown; the Cambridge Scientific Instrument Co., who are showing standard cells and resistances, a Callendar-Griffiths bridge, oil bath oscillograph and twisted strip ammeter; and Mr. R. W. Paul, who is showing selections of the various instruments designed by Dr. Sumpner and Mr. Campbell, including the reflecting alternate-current dynamometer, vibration galvanometer and mutual inductance standard. Dr. C. V. Drysdale has lent some instruments designed in accordance with the results of researches which have recently been published in THE ELECTRICIAN, including a double wattmeter, phase-shifting transformer and direct and alternate-current potentiometer. In this connection, Mr. R. W. Paul has lent a compensated standard resistance coil and a universal standardising bridge, and Messrs. Nalder Bros. & Co. a plug permeameter. Mr. B. S. Cohen is also

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showing specimens of the apparatus which he has designed for telephone work.

Telephones on Trains—It is stated that the London, Brighton & South Coast Railway intend to fit the "Southern Belle" express with the Kramer system so that passengers can transmit telephone messages when the train is in motion. The system appears to depend essentially upon induction between a coil of wire on the train and the wires alongside the railway.

St. Marylebone Undertaking.—In our last issue we commented on the progress of this undertaking, but we fear that our note was a little ambiguous in regard to the capital charges. The 1·42d. per unit there mentioned refers only to the compensation paid to the company, or what may be termed "dead capital." The total capital charges (including special charges) reach the high figure of 2·52d.

The Maley Brake.—We have received a pamphlet from the Electro-Mechanical Brake Co., of West Bromwich, replying to a Paper read before the Institution of Electrical Engineers by Mr. A. Gerrard, describing tests which were to the disadvantage of the Maley brake as compared with the modified Westinghouse brake used at Glasgow. The pamphlet states (1) that the tests made by Mr. Gerrard were rough and not sufficiently accurate to make comparisons of any value: (2) that a brake can only be tested by accurate tests on ordinary greasy rails; (3) that the tests on the Maley brake were made unknown to, and without the experience of, the patentee, whereas the tests made on the Westinghouse brake were carried out after many months of experience; (4) that the Maley brake was tested with insufficient and improperly graduated resistance; (5) that the name of the Maley brake was suppressed, although the brake was fully illustrated; and (6) that Mr. Gerrard omitted tests made in the presence of the patentee showing better results than those obtained by Mr. Gerrard in his private tests. It is stated that the former included very satisfactory stops on a greased rail, a condition under which the tests on the Westinghouse brake were not recorded. A good deal of detailed criticism is given of Mr. Gerrard's tests, and the independent tests made at Leeds are compared with the Glasgow tests. In conclusion, many figures are given showing the total brake power, efficiency, relative amount of braking done through the wheels, relative motor output, and braking force on the rails for the two forms of brake. It is impossible to deal briefly with such data, and we would therefore advise our readers who are interested in the subject to write to the company for a copy of the pamphlet.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Dr. C. V. Drysdale contributes an article on "The Testing of Transformer Regulation."

Mr. J. Rezelman concludes his article on the "Analysis of Reactance."

We give a description of the plant laid down by the Anglo-Newfoundland Development Co. for the manufacture of paper from wood pulp, the paper being used for the printing of the "Daily Mail" and other papers of the Amalgamated Newspaper Co. of London.

We give an abstract of the report describing the year's work at the Reichsanstalt.

A report by Messrs. Mordey & Dawbarn has been issued on the working of the Dolter surface contact system at Torquay.

A report by a deputation of the Bradford Corporation has been issued as the result of a visit to certain Continental towns in which trackless trolley systems are in use.

In the hall of the Institution of Civil Engineers to-day (Friday) there will be a meeting of the members of the Institution of Mechanical Engineers, and a series of Papers dealing exclusively with the electrification of railways will be read.

Barnstaple Council have met with a curious experience in connection with their efforts to popularise the consumption of electrical energy for various domestic purposes. It has been found impossible so far to get a firm of contractors who will take up the supply of electric fittings and wiring of premises on lines similar to those of the gas company.

In the course of an inquiry before Mr. H. Ross Hooper at Aston to obtain permission for the Corporation to borrow £23,105 for electricity purposes, the Board of Trade Inspector congratulated the Electricity Committee on the eminently satisfactory profits of the undertaking.

The great usefulness of wireless telegraphy at sea has been further exemplified in the case of the missing Dr. Crippen and Miss Le Neve, whose whereabouts appear to have been located by its means.

The service which wireless telegraphy can render in the event of such catastrophes as a ship on fire was demonstrated off the American coast, where it was the direct means of saving 205 souls.

An unusual accident occurred at a colliery at Blaydon, where a deputy foreman named Barrett met his death while attending to the telephone, due to contact between the telephone line and a main cable whose insulation had become damaged by contact with a steam pipe.

Legal.—At Birmingham a point was raised as to the operation of the Employers' Liability Act. A firm of electrical manufacturers was summoned for having left machinery unfenced. The defence was that the guard had been left off the machine by a fellow-workman of plaintiff's. It was pointed out that the defendants were not exempt on this ground unless they had secured a conviction against the delinquent workman, and an adjournment was granted.

Companies Meetings and Reports.—Many points of interest were referred to in the speech of the chairman of the National Telephone Co. at the meeting of shareholdersyesterday (Thursday).

The meeting of the stockholders of the City & South London Railway was interesting, apart from the statement of the chairman, from a proposal made by Col. Perry that the name of the company should be changed to the "North & South London Railway." The result of the past year's working shows a large increase in season tickets but a poor response to the directors' considerable reduction of fares.

A line of London railway which would probably greatly benefit from electrification is the East London Railway, which forms a very useful link between the Metropolitan and the Metropolitan District, and some other railways in the East End of London, running from Shoreditch to New Cross. Lord Claud Hamilton made an interesting statement at the meeting on Tuesday, and foreshadowed a possible arrangement with some of our large contracting electrical firms on the basis of easy payments.

Mr. F. L. Rawson, presiding at a meeting of the British North Western Synd. (Ltd.) referred to an option the syndicate had obtained for practically the whole of the water-power of the Dettifoss Falls, Iceland, equal to 720,000 H.P.

At the meeting of shareholders of the Direct United States Cable Co. the chairman stated that, so far as that company was concerned, there was no truth in the statements that have been industriously circulated as to modified arrangements or working agreements with a large telephone company in the United States. The revenue to the company shows steady improvement.

INSTITUTIONS AND SOCIETIES

Institution of Civil Engineers.—It is announced that H.M. the King has been graciously pleased to become the patron of the Institution of Civil Engineers. His Majesty, as Prince of Wales, was an honorary member for 17 years before his accession.

Royal Meteorological Society.—H.M. the King has also graciously consented to become the patron of the Royal Meteorological Society.

ARRANGEMENTS FOR THE WEEK.

INSTITUTION OF MECHANICAL ENGINEERS.

FRIDAY, July 29th (to-day).

10 a.m. Meeting at the Institution of Civil Engineers, Great George-street, London, S.W. Papers on "Electrification of Suburban Railways," by Mr. F. W. Carter; "Cost of Electrically Propelled Suburban Trains," by Mr. H. M. Hobart; "Economies of Railway Electrification," by Mr. W. B. Potter; "Electrification of Trunk Lines," by Mr. L. R. Pomeroy; and "Electrification of Railways," by Mr. G. Westinghouse.

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LIVERPOOL CORPORATION TRAMWAYS.

Among the large electric tramway undertakings of this country that of the Liverpool Corporation takes a prominent position; and as this municipality terminates its financial year at an earlier date—viz., December 31st—than most other local authorities, we propose to take its tramway accounts first for analysis.

Both as regards the number of passengers and total receipts a decrease is shown for the year 1909 compared with the figures for the previous year. This decrease, although only 0·3 per cent., represents 394,943 fewer passengers and £1,873 less revenue, so that it is satisfactory to record an increase in the net profit, which latter amounted to £82,354, whilst the sum contributed in relief of the rates (£27,451) is £2,593 in excess of the sum set aside for this purpose in 1908. This result has only been possible owing to a decrease of £6,867 in the operating costs, brought about by economies in the management of the undertaking.

As showing the flourishing condition of these tramways, it may be mentioned that since the undertaking came into the possession of the Corporation £234,971 has been contributed in relief of rates and £717,851 has been set aside for the redemption of debt, whilst £228,677 has been paid in rates and taxes since 1897 and £502,713 set aside for reserve, renewal and depreciation funds.

The traffic receipts for the past year amounted to £561,271, or 11·27d. per car-mile, compared with 11·04d. in 1908, the revenue per car-mile being the highest yet recorded. The number of passengers was 121,532,940, a smaller total than in any year since 1904, whilst 11,952,373 car-miles were run (*i.e.*, fewer than in the preceding five years). The total number of units used was 22,747,990, equivalent to 1·87 units per car-mile, the energy being purchased from the electricity department at an average cost of 1·09d. per unit.

Mr. C. W. Mallins mentions in his annual report that the policy of the Committee in deciding to undertake their own insurance against third party risks has so far operated very successfully, the first 19½ months working showing a credit balance of £11,694.

We have on a previous occasion referred to the success attending the experimental first class tramway cars. In these, inside passengers only are charged higher fares, outside passengers paying the ordinary fares. We may mention, however, that the average earnings per car-mile of these first-class cars has increased from 5·26d. to 10·92d.; and a further experimental quarter-hourly service of first-class cars is to be established on the Croxteth-road route.

In regard to the division of passengers over the various stages, the large majority of passengers pay a penny fare—viz., 89·7 per cent. of the total; whilst 9·7 per cent. purchase 2d. tickets. (It may be here noted that ½d. and 1½d. fares are not in force.) As indicating the density of the tramway traffic at various points in the city, it is interesting to notice that 5,882 cars arrive at and leave the pierhead every day in the busy season, whilst at several important junctions between 3,000 and 4,000 cars cross daily. The total number of cars owned by the Corporation is 531.

The plough type of lifeguard continues to do good service at Liverpool, as may be judged from the fact that 38 persons who had been knocked down or who had fallen in front of the cars were pushed clear of the track without serious injury. There was also a decrease of 50 per cent. in the number of fatal accidents during 1909, the ratio of fatalities to the number of passengers carried being 1 in 30,383,235. Thirty-two fatal accidents were recorded in the city during the year, caused by vehicles other than tramcars.

The number of articles left on the cars amounted to 30,176, an increase of 1,930, or 6·8 per cent. over the number in the previous year; and 45·6 per cent. of the articles were unclaimed.

We give below an analysis of the cost of working for the year 1909, the cost per car-mile for the previous year being also included to facilitate comparison.

		Per car-mile. 1909.	1908.
Traffic Expenses.			
Superintendence	£4,709	0·09d.	0·10d.
Wages of motormen and conductors	101,070	2·03d.	2·00d.
Wages of other traffic employés	13,634	0·27d.	0·29d.
Cleaning and oiling cars	13,810	0·28d.	0·27d.
Cleaning, salting and sanding track	2,780	0·06d.	0·04d.
Fuel, light and water for depôts, &c.	2,166	0·04d.	0·04d.
Ticket check	6,738	0·13d.	0·13d.
Uniforms, &c.	2,871	0·06d.	0·08d.
Lighting routes and miscellaneous	3,107	0·06d.	0·04d.
Total Traffic Expenses	£150,885	3·02d.	2·99d.
General Expenses.			
Salaries	£8,323	0·17d.	—
Superannuation	414	0·01d.	—
Auditors' fees	100		
Store expenses	976	0·02d.	—
Rates and taxes	29,640	0·60d.	—
Advertising, printing and stationery	1,139	0·02d.	—
Fuel, light, cleaning offices, &c.	883	0·02d.	—
Law charges	57	—	—
Compensation (including £12,000 transferred to compensation fund account	12,193	0·24d.	—
Insurance	1,115	0·02d.	—
Miscellaneous	3,777	0·08d.	—
Total General Expenses	£58,617	1·18d.	1·13d.
Repairs and Maintenance.			
Permanent way	£29,089	0·58d.	0·59d.
Electrical equipment of line	5,677	0·12d.	0·14d.
Buildings and fixtures	1,589	0·03d.	0·04d.
Workshop tools	501	0·01d.	0·01d.
Cars	44,367	0·89d.	0·88d.
Other rolling stock and miscellaneous	371	0·01d.	—
Total Repairs and Maintenance	£81,594	1·64d.	1·66d.
Power Expenses (cost of current and contribution to fuel guarantee fund)	£103,219	2·07d.	2·09d.
Rental of leased lines	£5,891	0·12d.	0·11d.
Total Working Expenses	£400,206	8·03d.	7·98d.
Interest	£50,919	1·02d.	2·15d.
Sinking fund	59,249	1·19d.	
TOTAL EXPENSES (including capital charges)	**£510,374**	**10·15d.**	**10·13d.**
REVENUE.			
Traffic receipts	£561,271	11·27d.	11·04d.
Advertising	7,643	0·15d.	0·55d.
Miscellaneous	5,652	0·11d.	
Interest	18,162	0·36d.	
TOTAL REVENUE	**£592,728**	**11·89d.**	**11·59d.**
Surplus	£82,354	1·65d.	1·46d.
This surplus was allocated as follows:—			
Contribution in aid of general rate	£27,451	0·55d.	0·49d.
Reserve, renewal and depreciation account	54,903	1·11d.	0·97d.

The capital expenditure during the year amounted to £39,095, bringing the total expenditure to £1,969,697. The outlay during last year was mainly occasioned by extension of the permanent way, this accounting for £26,737, whilst £6,213 was spent on cars and £5,628 on land and buildings. The details of the capital expenditure, therefore, differ only to a small extent from the figures given in our analysis of the previous year's accounts (THE ELECTRICIAN, July 16, 1909).

RECENT ARRANGEMENTS FOR THE PARALLEL RUNNING OF ELECTRIC MACHINES.*

BY W. WOLF.

Summary.—In the present article this important question is discussed. The author deals with the methods employed by the leading firms on the Continent, both for the parallel running and synchronising of electric machines.

In order to run electrical machines in parallel satisfactorily special arrangements are necessary, unless they have a dropping characteristic, like shunt machines; for those units having a rising characteristic produce a greater E.M.F. with increasing current, and, therefore, gradually take over the whole of the load and drive the other

* Abstracted from the "Elektrotechnik und Maschinenbau."

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machines as motors. The following article deals with some methods (which are all patented) of obviating this difficulty.

The use of steam and explosion engines for driving the generators direct presents great difficulties, due to resonance between the prime mover and the network. However, the transmission of the pulsations to the generator can be overcome by the use of elastic couplings. With machines having different speed regulation and self-induction, such as two machines driven by a turbine and a reciprocating engine, although it is possible to run them in parallel under normal conditions, yet when a short-circuit occurs, the turbo-generator may be seriously damaged before the circuit-breaker operates. This is obviated by the A.E.G. by fitting a counter-compound winding to the turbo and connecting a choking coil in parallel. Normally this compound winding takes but little current, but with a sudden overload the greater part of the current flows through it owing to the self-induction of the choking coil, and thus the field strength is diminished, and the turbo is prevented from taking its share of the overload until the circuit-breaker operates.

The arrangement of the Lahmeyerwerke is to divide the windings into the same number of parts as there are machines to be driven in parallel and to connect them in such a way that each circuit consists of one part of each of the divided windings.

Although simple shunt machines will run satisfactorily in parallel, those with series compensating windings are not stable. For this case Parsons connects two points of the compensating windings together by an equalising connection. If the E.M.F. of one machine is momentarily greater than that of the other, due to an increase in speed, a part of the armature current of the first machine flows through the connection into the compensating winding of the other machine, whereby the magnetising component of the compensating winding of the first machine is smaller than the demagnetising component of the armature reaction, and the E.M.F. of this machine is decreased. In this way the parallel running is stable. The same method can also be applied to compound machines, or they can be supplied with counter-compound windings.

Synchronous generators have a considerable voltage drop, especially on inductive loads. To compound them the excitation is usually

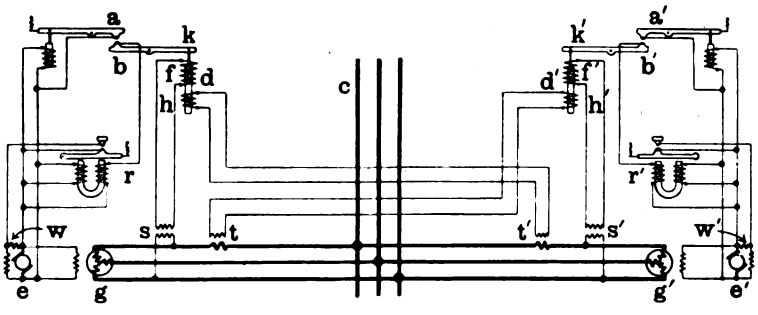

Fig. 1.

through an automatic regulator in such a way that by regulation of the excitation voltage the generator voltage remains constant for a given load and increases with increasing load. This method is desirable when the voltage of some point distant from the station is to be kept constant, and, therefore, the generator voltage must be increased with the load to compensate for the line drop.

As will be seen from the figure, this is accomplished by the use of the well-known Tirrill regulator, which is adapted for this case by exciting the series coil of the regulator for the one machine by means of the current flowing in the other. By choice of the phase in which the current transformer is placed or of the resistances or choking coils or condensers which are connected in series with the series or shunt windings, any desired distribution of watt or wattless load may be obtained.

The Siemens-Schuckertwerke use a differential method for the automatic distribution of the load, in which a relay for each machine is excited in opposite directions by some part of the total current and the current of the single generator. This method is not satisfactory, owing to the difficulty of adjusting the relays.

This trouble is overcome in the methods shown in Figs. 2 to 4. In these the relays are magnetised by single coils in which currents proportional to the out-of-balance currents flow. Of course, the relays must be so arranged that they do not only depend on the strength of the out-of-balance currents, but also on their direction with direct current or on their phase with alternating current.

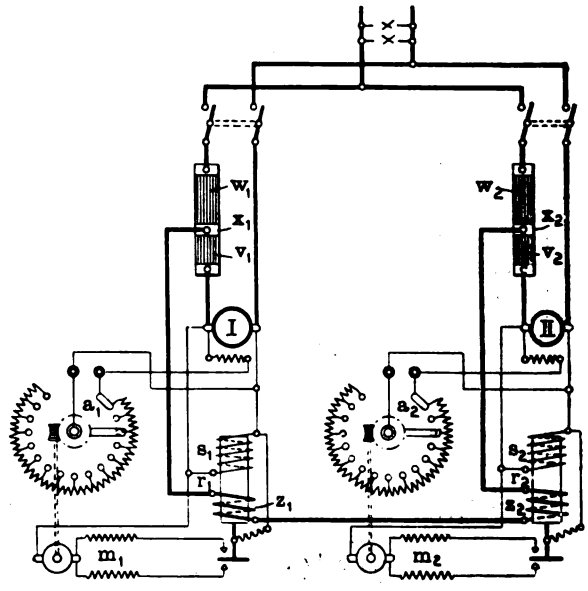

Fig. 2.

made dependent on the load. The A.E.G. effect this compounding by the use of condensers, connected either in the circuit of each generator or in the common leads. If the generator is inductively loaded the current produces a pressure drop in the machine and a rise in the condenser. By varying the capacity of the condenser or the ratio of the series transformer, this drop and rise can be made equal. Also the rise can be made greater or smaller than the drop, corresponding to over or under-compounding. The compounding will be approximately correct even if the phase of the current varies. In this way the generator and condenser work together like a direct-current compound machine. The A.E.G. turn the compounding arrangement into a counter-compound effect in order to meet the overloads in a more efficient way. The rectifier or another part of the compounding device is fed by two series transformers, of which one is connected for compounding and the other for counter-compounding. In normal running only the first is in circuit and the other cut out, while when a short-circuit occurs an automatic switch reverses these connections.

Instead of operating the switch, however, by means of the alternating current of the machine the exciting current can be used when it varies with the former, as, for example, when a rectifier is employed. The magnets of the switch have simpler construction, smaller dimensions and more accurate working when they are fed by direct current. Each generator must be controlled in the above way and the automatic switches can be either entirely independent of each other or completely or partly dependent.

In Fig. 1 is shown a device for the automatic distribution of the load on two direct-current, single or three-phase generators running in parallel and independent of each other. They are each excited

In order to make the relays work in this way a permanent excitation is provided of such a strength that these differential currents can never reverse the direction of the total excitation, so that obviously the displacements of the relay are dependent on the direction or phase of the current. Since only one current coil is used for the out-of-balance currents and the differential action is produced by fixed, not too sensitive, arrangements outside the relays, a considerable simplification in the working and maintenance of the apparatus is obtained, and the use of a large number of turns of wire is avoided, which to a large extent counteract each other.

Fig. 2 shows this method in the simplest form for only two direct-current machines. I and II are the armatures of the two generators, which are provided with automatic regulators a_1 and a_2 for the shunt excitation. The regulators are in this example variable resistance switches, and are driven in either direction by the auxiliary motors m_1, m_2, the relays r_1, r_2 serving to reverse them. A resistance is connected in the main circuit of each generator, and these are divided into the parts v_1, w_1 and v_2, w_2. The series coils z_1, z_2, which work in opposite directions on the relays r_1 and r_2, are connected to the dividing points x_1 and x_2. The permanent excitation is produced by the shunt coils s_1 and s_2.

The resistances v_1, w_1 and v_2, w_2 can be so arranged that the points x_1 and x_2 are equipotential for normal load distribution. As long as this condition holds no current flows through the coils z_1 and z_2. But if the generator I should take a larger part of the load than desired the out-of-balance current flows from x_1 to x_2, and excites the relay r_1 in the direction for lower and r_2 in the direction for higher voltage, so that the automatic regulator comes into operation, and the desired load distribution is restored.

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The more general form is shown in Fig. 3, for any number of generators in parallel. In this case all the series coils are excited in the same direction. Each generator has now two resistances in parallel, which are each divided into two parts, t_1 and u_1, and v_1 and w_1, &c. The points y_1, y_2, y_3 are connected together, so that the total current is divided in a given ratio between the portions w_1, w_2, w_3, which must correspond to the normal load distribution of the generators. In this case no current flows along the connection between y_1, y_2 and y_3. The dividing points are so arranged also that normally no current flows in the coils z_1, z_2, z_3. But if generator I takes too much of the load the voltage drop in the part u_1 is greater than in the parallel parts w_1, w_2, w_3, and so a current flows from x_1 to y_1, and the relay lowers the voltage of generator I. In this method the series coils z_1, z_2, z_3 are excited in the same direction on their relays; the differential action is obtained by the difference in voltage drop in the parallel resistances of each generator.

Lastly, a device for the automatic regulation of the wattless load of two three-phase generators in parallel is shown in Fig. 4. The two generators I and II are again provided with relays r_1 and r_2, which vary their excitation. Instead of the variable resistance regulator used before a quick-acting regulator is employed, in which resistances q_1 and q_2 are periodically short-circuited by the contacts c_1 and c_2. The duration of the short-circuit is determined by the position of the relays r_1 and r_2. The relays are again provided with shunt coils s_1 and s_2 connected to one phase of the network, and these have comparatively large ohmic resistances p_1 and p_2 in series to reduce the self-induction in comparison to the total resistance. Without these relays the network voltage would produce fields in

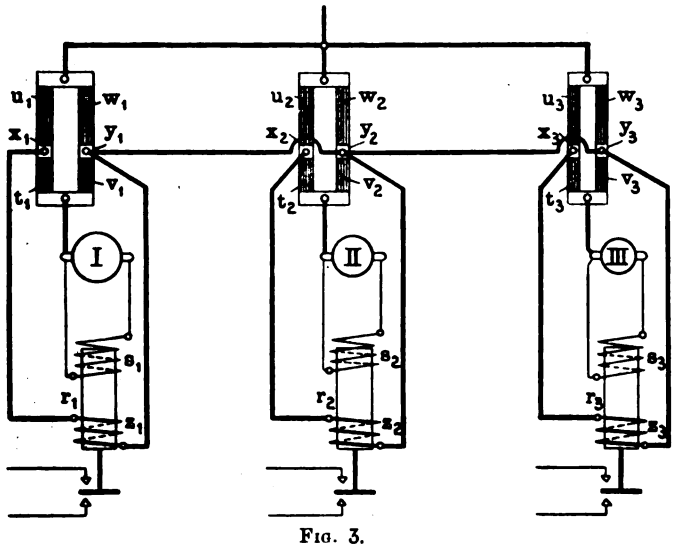

Fig. 3.

the relays, which would defeat the purpose of the latter. The series coils z_1 and z_2 are connected in opposite directions with the series transformers f_1 and f_2. These are also connected in series, so that a current always flows in them. If the two transformers are properly related to each other, for any currents flowing in their connections the tapping points are equipotential, provided that the currents are in phase. In this case the coils z_1 and z_2 connected to these tappings have no current. But this immediately alters as soon as a shifting of phase due to a wattless out-of-balance current occurs, in which case the coils z_1 and z_2 receive currents in the proper direction to make the relays produce a proportionate distribution of the wattless load.

These relations are shown more clearly in the diagram (Fig. 5), in which e_1, e_2 and e_3 denote the phase voltage, s the ampere-turns of the coils s_1 and s_2 connected between phases e_1 and e_3 (*see* Fig. 4), their inductance being neglected, i_I and i_{II} the generator currents corresponding to phase e_2. With a non-inductive load, i_I and i_{II} do not coincide with e_2 when an out-of-balance current is present, but i_I will lead and i_{II} lag, so that the vectorial difference z works the relay, z being a measure of the phase difference between i_I and i_{II}.

If the currents are alike in phase, the out-of-balance currents do not act on the relays if the vectors for the series and shunt windings are perpendicular to each other with proper distribution of the wattless current. If the currents are not only unlike in phase but also unequal, the out-of-balance current is not perpendicular to the voltage e_2 (Fig. 6). Resolving z into its horizontal and vertical components h and v and combining z with s, Fig. 7 shows the comparatively small effect of h.

The above method becomes very complicated when the various units which are to be run in parallel are situated in different stations, owing to the large number of connecting leads and to the fact that the regulation of each machine has to be dependent on the main station. The Siemens-Schuckertwerke employ a method for overcoming this difficulty, in which the series coil of the relay is fed by a series transformer in the circuit of its own machine, and the shunt coil is connected through an adjustable phase converter. In this way the regulation of each machine can be adjusted by hand according to the power factor of its own load.

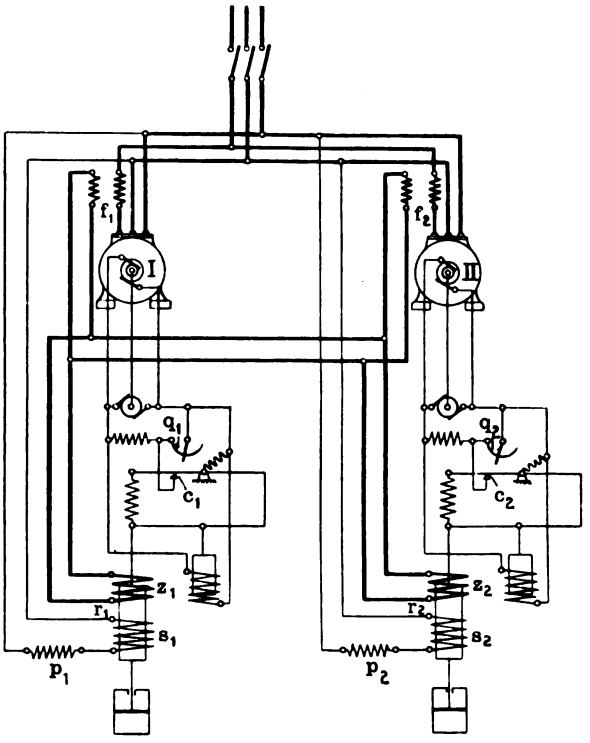

Fig. 4.

The firm of Voigt & Haeffner employ a method of synchronising three-phase generators in which three relays are used instead of the ordinary three lamps. Two of the relays are set up opposite each other with a swinging arm in between them. When one relay is excited this arm is pulled towards it, and makes a contact in a circuit, which consists of an auxiliary source of direct current and a coil which accomplishes the automatic regulation of the machine for the "too fast" condition. When the other relay is excited the arm

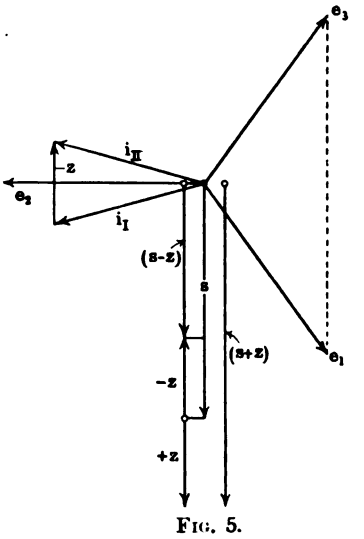

Fig. 5.

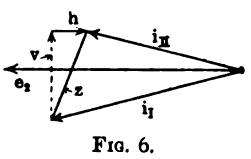

Fig. 6.

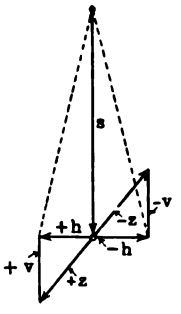

Fig. 7

moves the other way and makes contact in a similar circuit for the "too slow" condition. On the third relay being excited the circuits of both the other relays are broken simultaneously. When the arm is attracted towards the first relay it remains in that position as long as the relay is excited, even if the second relay is excited afterwards, because its distance from the second relay is greater than that from the first.

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Now suppose the relays are excited in the order "first, second, third," the arm is attracted towards the first relay and makes contact for the regulation of the machine to reduce the speed. The second relay is then excited, but does not pull the arm over, and the third breaks the contact of the other two. This cycle is repeated, so that contact is made practically continuously in the regulation circuit on the "too fast" side, until the speed of the machine has been reduced to the correct value, when the cycle stops and the machine can be switched in. In the same way if the order of the relays is "second, first, third" the contact is made on the "too slow" side, and the speed of the machine is increased to the proper value. A lamp is placed in parallel with each of the regulating coils, so that the operations may be seen. When they are both dark the machine can be switched in.

THE WORK OF THE PHYSIKALISCH-TECHNISCHE REICHSANSTALT IN 1909.

The recognition of the good influence that may be exerted on a nation's affairs by the establishment of an institution, in which scientific research is carried on and to which questions requiring an expert answer by unbiased authority may be referred, was certainly a step forward on the road of progress. Four great powers have now each their own institution, but doubtless the most famous of them is the Physikalisch-Technische Reichsanstalt at Charlottenburg. Both the testing and research work carried on there are excellent and the annual report indicates the present position of physical science in no uncertain way. We, therefore, in what follows give some details of the electrical work done there during the past year, abstracting our account from the "Zeitschrift für Instrumentenkunde."

Electricity.—General.—The measurements made on electrical standards consisted partly of those periodical tests carried out in the Reichsanstalt itself and partly of tests made in conjunction with the other national physical laboratories, in accordance with the conference held in London in 1908. Also the proposal made in the spring of 1909 for the interworking of the German, English, French and American laboratories required that certain further researches and preparations should be undertaken.

Resistance Measurements.—For testing the manganin standards used in Section I. the mean value, 1·001745 ohms, determined during the last 12 years was employed. On this assumption small permanent variations of the order of one $\frac{1}{100000}$th compared with those of the year before were obtained. In order to verify again this mean value, four manganin coils were tested against the mercury standards No. XI. and XIV., which since they were last measured in March, 1905, have remained full of mercury. The value thus determined agreed with the figure given above within $\frac{1}{1000000}$ths, from which it appears that mercury standards kept filled for a time remain quite as constant as a manganin resistance. For this reason standards XI. and XIV. will not again be filled, as the errors which are connected with such refilling will thus be avoided. The erection of new mercury standards will, however, be undertaken. The following table, extending over 16 years, shows that the average value, obtained from mercury standards XI., XIV., 106, 114 and 131, is practically constant, taking into account the observation error in the case of the mercury standard. There, therefore, appears to be no reason why the average value should be altered.

Table I.

	Int. ohms at 18°C.	Difference in 10^{-6} ohms.
November, 1893	1·001737	−2
January, 1895	37	−2
June, 1897	44	+5
March, 1903	48	+9
February, 1904	36	−3
March, 1905	34	−5
September, 1909	36	−3
	1·001739	

Opportunity was taken to determine from these measurements the values of a large number of manganin resistances between the temperatures of 12° C. and 26° C. The mercury resistance thermometer, which is made of quartz, and used in connection with calorimetric measurements, seems to retain its constancy of resistance quite well. Two similar 1-ohm resistances have therefore been constructed, which will be used as sub-standards in connection with the mercury and manganin standards.

In order to determine the effect of dampness on the 1-ohm manganin standards used in section I. three other 1-ohm resistances, which had first been carefully tested against the average value, were in July, 1909, permanently enclosed in an atmosphere of 50 per cent. humidity. A test on these coils after about three months showed that their value had varied about $\frac{1}{1000000}$th. This alteration is, however, within the limits of observational error. The year under notice was unsuitable for these observations, for specially dry weather, which might have had a great influence on the results, was waited for in vain. The observations so far obtained show that for corresponding coils alterations in humidity have no appreciable influence.

Silver Voltameter.—On account of certain earlier measurements on the silver voltameter, it seemed desirable (a special incentive being some work carried on in America in this direction) to discover whether the silver solution was influenced by the presence of organic substances. During some of the earlier measurements the anode was covered with raw silk, though at other times it was left bare. It may, therefore, be presumed that any small differences obtained between the two sets of readings would be due in the first instance to the use of an organic substance. This was, however, not the case when the relative measurements were carried out under the same conditions with and without silk. The mean difference between the values obtained in two cases was about half of $\frac{1}{100000}$th, while the mean observational error is about 12 times that amount.

Standard Cells.—Researches which were made on mercurous sulphate showed that when fresh preparations were used for making up standard cells, after being kept for several months in a dry place, the E.M.F. altered and became some 10,000ths of a volt too high. Further observations on this point show that when the freshly-prepared substance is stored under cadmium sulphate or in a vacuum no alteration in its conditions occurs, so that perhaps the oxygen of the air exerts a chemical action on the dry salt.

With the discovery of this phenomenon the last disturbing feature in the behaviour of the mercurous sulphate seems to have been found. It was already possible to obtain with accuracy preparations of the same E.M.F., but now their behaviour may be regarded as remaining permanently the same.

Thus it is now possible to begin the long-planned making of a great stock of standard cells, which will allow the practical unit of E.M.F. in the Reichsanstalt to be represented. For this purpose, the necessary chemicals—cadmium, cadmium sulphate, sulphuric acid, mercurous nitrate and nitric acid—were obtained as pure as possible from C. A. F. Kurlbaum, in Berlin, and then received a thorough testing in the chemical laboratory, in order that any harmful impurities might be rejected. Besides determining the purity of the substances by analysis the cadmium sulphate was re-crystallised twice and the mercurous nitrate once. Five preparations of mercurous sulphate were treated by the procedure described above, using solutions of sulphuric acid and mercurous nitrate of different strengths, and afterwards washed with water and concentrated cadimum sulphate. They were then preserved under concentrated cadmium sulphate solution. The cadmium amalgam was 12·5 per cent. strength and was prepared by melting.

The cells were of the well-known H-shape, with the form of leg used by the English National Physical Laboratory. By this means the electrodes covered with the salt could be kept in their places and the portability of the cells is thereby increased. After they have been filled, the cells were left open for some weeks to accelerate the welding together of the crystals, and were then sealed up. For storage and measurement they were placed in a large box for protection against the heat. Five groups of cells, corresponding to the five sets of mercury sulphate mentioned above were prepared, 67 cells in all, which, shortly after they had been put together, agreed within some $\frac{1}{10000}$ths of a volt.

Determination of the Absolute Ohm.—The idea of determining the absolute ohm by Lorenz's method was provisionally given up. Instead, attempts were made to determine it by geometric means and by absolute electric measurements of inductive coils. Afterwards it was determined by Wien's direct method and by the round-about way of comparing with a standard air condenser.

Heavy Current Laboratory.—After giving a list of the number and type of the various instruments tested during the year the report deals with the behaviour of electricity meters on variable loads. From theoretical data it was found that the readings of meters under such conditions were not falsified by the inertia of the moving system. This statement has been experimentally verified. During the past year a large number of continuous-current meters, in which the moving armature turns in the field of a permanent magnet and is in shunt across a resistance in which the main current flows, have been systematically tested. Such meters often do not fulfil the condi-

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tions that require that the readings shall remain constant during a long period of load, but show inaccuracies or become gradually slower and slower as time goes on. This phenomenon is a natural result of the meter construction. For the potential drop in meters is very small (at full load only 1 to 1½ volts) and the armature voltage is small, so that small alterations in the contact resistance between commutators and brushes give rise to the above-mentioned inaccuracies.

J. Busch, in an article which appeared in the "Elektrotechnische Zeitschrift," Vol. XXX., p. 180, stated, as a result of observations and tests, that these inaccuracies were due to mercury vapour. This is specially important, as mercury vapour is very prevalent in those laboratories in which the behaviour of the meters is tested. From his tests it appears that so long as the brushes and commutators of the magnet motor meters do not come in contact with the mercury vapour the meters are very suitable for use. Mercury vapour causes a slowing up of the meter which increases as the load decreases. As these results did not agree with the experience at the Reichsanstalt, tests were undertaken on three new ampere-hour meters, which were designated I., II. and III. respectively. I. and II. were loaded continuously with their full current, and their inaccuracies at $\frac{1}{5}$, $\frac{3}{5}$ and full-load were measured at intervals of a week. I. was enclosed in a closed air-tight zinc box, while II., which hung close to it, was fitted with a protective covering.

During two months continuous using I. exhibited from the beginning inaccuracies, and at $\frac{1}{5}$ of full-load gave results varying up to 10 per cent., in spite of the fact that any effects due to mercury vapour were excluded. II., on the contrary, showed a falling off of 3 per cent. only during the first 14 days, and then remained constant, while removal of the protecting cap did not alter its readings. After it had been running for 10 weeks a small cup of mercury was placed in the meter, which was then again closed in. As the current warmed up the interior of the meter, the mercury vapour was given off at a fairly quick rate, so that the silver commutator became covered with a gray amalgam. In spite of this the meter ran for another eight weeks without showing any noteworthy alterations in its readings. As similar tests of meter III. gave the same results, it appears that the results obtained by Busch must be attributed to other influences.

Mercury Rectifiers.—The current which flows through the rectifier in the "unrectified" direction was accurately measured by its dependence on the form and loading of the rectifier. The results will be published. Six 10-ampere three-phase rectifiers were connected in parallel and were used for charging a large accumulator battery during the night, so that in the daytime as many batteries as possible were at disposal and the rotary transformer, which had hitherto been used for charging could be employed for other purposes.

Work on the Electrometer.—Researches on the electrometer were continued. As the electrometer is used, in the first instance, for alternating-current measurements a method was devised to find out whether the constants determined for the quadrants with continuous current held good for any desired phase alterations of the needle and quadrant voltages. It was found that this was the case with sufficient accuracy in all the cases undertaken. The results have been published, and at the same time the faults due to the capacity currents that flow through the electrometer section were discussed.

Researches are now being undertaken to obtain with more accuracy the values of the electrometer constants. In the general formula, where the discharge is proportional to

$$a_0v_0^2+a_1v_1^2+a_2v_2^2+b_0v_1v_2+b_1v_0v_1+b_2v_0v_2+\ldots,$$

v being the needle charge and v_1 and v_2 the quadrant charges, the relation

$$a_1-a_2=-b_1=b_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

may be taken as correct. It was then discovered that the constants in the two idiostatic cases (the needle being neither at earth nor at a high potential) do not always accurately correspond. The difference is, however, always less than $\frac{1}{1000}$th, as according to theory the idiostatic constants are proportional to a_1-a_2, and their differences can, therefore, be determined and equation (1) shown to be not accurately correct. But a simple alteration of the above connections may be used for testing the electrometer with alternating current to determine whether the difference between the idiostatic constants really exists or merely arises from observation errors. It appears that they may be present, for the differences obtained with alternating current and direct correspond with sufficient accuracy with those obtained by idiostatic measurements. The connections with alternating-current measurements are complicated, and care should be taken on this point when great accuracy is desired.

The different arrangements of connections which are used for alternating-current measurements in the Reichsanstalt for testing and other purposes have been published, special attention being paid to those methods which are employed in the testing of current and voltage transformers. The number of measuring transformers tested has steadily increased and is still rising. The transformers are tested at $\frac{1}{10}$, $\frac{1}{5}$ and $\frac{1}{2}$ of their primary current as well as at full load. A secondary load of 5, 15 and 25 volt-amperes is used and a power factor of 1 and either 0·8 or 0·5. The ratio of transformation is measured as well as the phase difference between the primary and secondary currents.

The measurement of the phase difference between primary and secondary current in the case of voltage transformers presented some difficulties at first. It appears that at high voltages the "tapped off" voltage is seldom in phase with the total voltage, though the division is effected by similarly built resistances. The differences are due to the capacity of the resistances from earth and from each other, and can be prevented by covering the resistances with conducting covers which must be charged to a certain known voltage.

The apparatus at present in the Reichsanstalt is sufficient for testing current transformers up to 1,000 amperes and voltage transformers up to 12,000 volts. It appears, however, that practice will require tests on apparatus carrying greater currents and voltages, but tests on them cannot unfortunately be made in the space available at present.

(To be continued.)

THE WOOD PULP AND PAPER MILLS OF THE ANGLO-NEWFOUNDLAND DEVELOPMENT CO.

A LARGE HYDRO-ELECTRIC SCHEME.

Introduction.—It was remarked, we believe by Carlyle, that his was an age of paper. And if this statement were true then how much the more true is it at the present time, when every profession and trade in the land has usually many organs devoted to its interests, while even an erotic amusement (such as roller-skating) cannot develop without its representative journal. It is, therefore, not surprising to find that the original sources of news paper are becoming somewhat exhausted, and that efforts are made to obtain the necessary raw materials from new sources. These attempts have been in the main successful, for wood-pulp treated with certain chemicals is now used in prodigious quantities as the basis of much of the paper used in modern newspaper production. This being the case, it is necessary for pulping mills to be erected near the wood supply, as the pulp is, of course, more easily transported than the wood. Turning to another side of the paper-making question, it is found to be an economical advantage for our great daily and weekly papers, with their huge circulations, to make their own paper, and this has recently resulted in the formation of the Anglo-Newfoundland Development Co., an offshoot of the Amalgamated Newspaper Co. of London, and whose object is to provide the various companies in that combine with its cheaper quality papers on reels.

An extensive site for the paper mills was chosen on the island of Newfoundland, near St. John's and Grand Falls, and here large wood-pulp and paper-making machines, driven by hydraulic turbines with an aggregate capacity of 23,500 H.P., have been erected. The conditions were specially favourable for the erection of such plant, first, because of the existence of adequate water-power with a sufficient fall (nearly 100 ft.), conveniently situated in respect to the mill buildings; and, secondly, from the existence of a vast area of timber-covered land, which could be transformed on the spot into wood-pulp, and subsequently fed to the paper-making machines for paper.

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General Arrangement of Hydraulic Works and Buildings.—The Exploits River is the source of power for the works. The river flows over a series of declivities which extend for nearly half a mile. At the top of these declivities the stream makes a bend, between the beginning and the end of which there is a fall of 112 ft. At the highest point a solid concrete dam 882 ft. long has been built, its width being 24 ft. at the bottom, and gradually diminishing to 6 ft. at the top, whilst the height varies from 20 ft. to 25 ft. Wing dams increase the length to 1,400 ft. A forebay is provided with eight gates each 12 ft. high × 8 ft. wide. The forebay in this case is a basin about 150 ft. square and 20 ft. deep, and the water flows from this basin to the power house through steel racks and then into two steel pipes, 15 ft. in dia. and 2,150 ft. in length. A general view of the exterior of the power house is shown in Fig. 2.

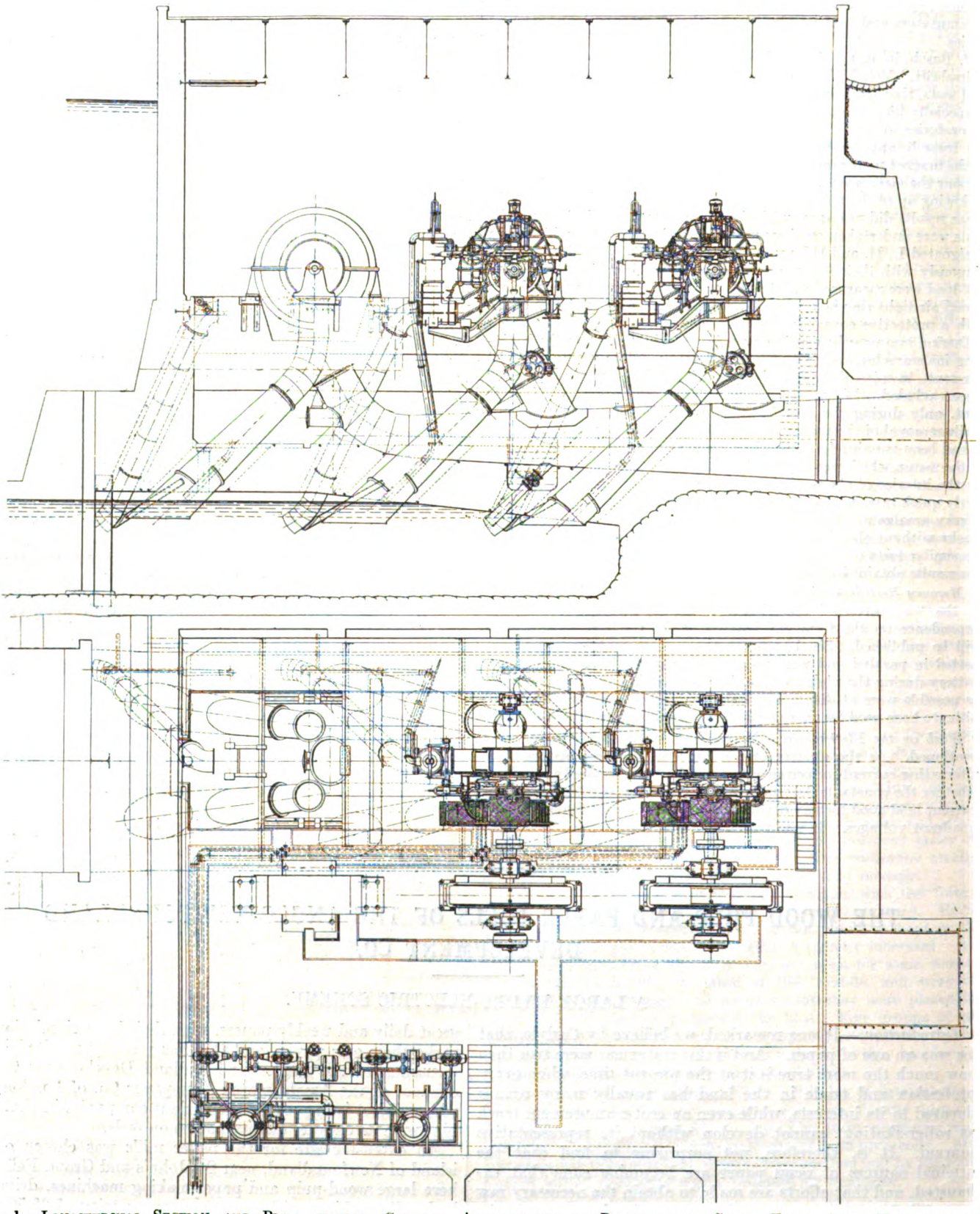

FIG. 1.—LONGITUDINAL SECTION AND PLAN SHOWING GENERAL ARRANGEMENT OF PLANT AT THE GRAND FALLS ANGLO-NEWFOUNDLAND DEVELOPMENT CO.'S POWER HOUSE.

Scale $\frac{1}{16}$" = 1 foot (approx.).

The power house and grinding room (Fig. 1) is a building

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270 ft. long × 60 ft. wide × 50 ft. high, being lighted from above by skylights. At the northern end are erected two 2,500 H.P. dynamos, which supply energy for light and power to the entire works, the remainder of the building being occupied by turbines operating the pulp grinders. There are three turbines in the generating room and four double pulp grinders turbines in the grinding room, each of these latter providing the power for six grinders. Each of the 24 grinders has an output of about 10 tons of dry pulp per 24 hours, or 240 tons of pulp per day. Ultimately the total output is expected to reach 2,500 tons per week of paper and pulp. Two systems of ventilation are provided, one natural, through a concrete shaft 16 ft. × 16 ft. at the end of the building, and extending to the roof, which in the autumn and winter is sufficient for the purposes. In the summer and spring a 90 in. blower is used as an addition. The pipe line from the water source is made up of two steel pipes, each 15 ft. in diameter and 2,150 ft. long, which connect with the turbine house by means of a cross tube 10 ft. in diameter. One of the principal pipes diminishes from 15 ft. to 10 ft. diameter, and supplies the generator turbines, while the other pipe forks into two branches of 10 ft. 9 in. diameter, and feeds the grinder turbines. The thickness of the 10 ft. tubes is ½ in., the rivetting being single for the circumferential seam and double for the longitudinal seam. Attention may be directed to the simple nature of the expansion joint, which is shown in detail in Fig. 3. It may be mentioned in this connection that with full load on the plant the water velocity in the principal pipes amounts to 8·25 ft. per sec.

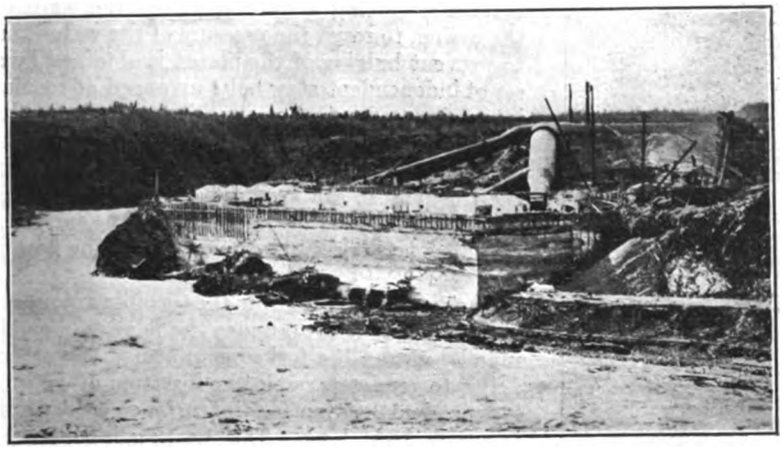

FIG. 2.—GENERAL VIEW OF THE EXTERIOR OF THE WORKS, SHOWING PIPE LINE.

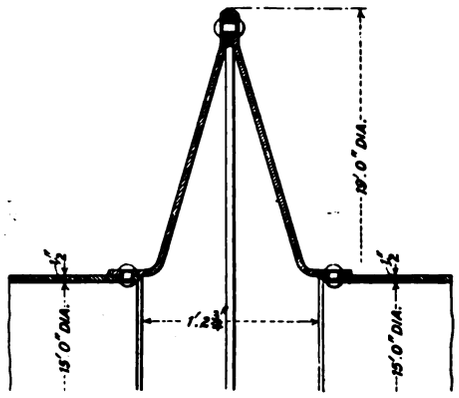

FIG. 3.—VIEW OF EXPANSION JOINT USED ON PIPE LINE.

Turbine Plant.—The turbine plant may be divided into three principal parts: (1) The sets driving the pulp grinders, (2) the sets driving the generators, and (3) the sets driving the oil pumps. Four turbines, each capable of developing 4,000 H.P. at 224 revs. per min. are used for the production of ground pulp wood. These operate under a head of 105 ft. with a discharge of 415 cubic ft. per sec. Each turbine is coupled on both sides to three large wood grinders, each requiring about 700 H.P. The raw material is brought into these grinders through a canal running through the centre of the turbine house. Into this course the round timber, cut into suitable lengths, is floated from outside. The output of pulp is led away through two channels which run round the walls of the turbine house and connect with the wood grinders by means of transverse channels.

The second turbine plant drives the special machines installed in the paper factory, which is situate some distance from the power station. It was therefore decided to use electric transmission, and for this purpose the power station is provided with three turbine generator units, each capable of developing 2,500 H.P. at their normal speed of 375 revs. per min. These sets operate under a head of 105 ft. and have a discharge capacity of 263 cubic ft. per sec.

The oil pumping plant installed, and for which the third set of turbines is employed, is for the supply of oil under pressure, which serves not only for the lubrication of the grinder turbines, but also for the generating turbines.

Pulp Grinding Plant.—The main inlet pipes which feed the 4,000 H.P. turbines are branched, each branch pipe connecting up two of the double 4,000 H.P. machines. Two main inlet pipes, therefore, suffice for the four turbines. The arrangement of the turbines as double units with double spiral inlets is that usually employed. Butterfly valves are used for shutting off the supply, each turbine being provided with two of these valves, which are so connected with each other that they can only be opened or closed simultaneously. The object of this arrangement is to eliminate axial shear stresses on the turbine shaft as far as possible. The outlet pipes from the turbines are of spiral arrangement, as the two concrete draft tubes attached to the two double quarter bends of the turbines diverge in opposite directions, due to the fact that two of the 4,000 H.P. turbines are behind each other in the direction of the outlet. The draft tubes have, therefore, a double curved centre line. The construction of the turbine is notable in many respects, and especially as to the distributing and regulating apparatus. The runner blades are of sheet steel, and surrounding the runner is the distributing apparatus,

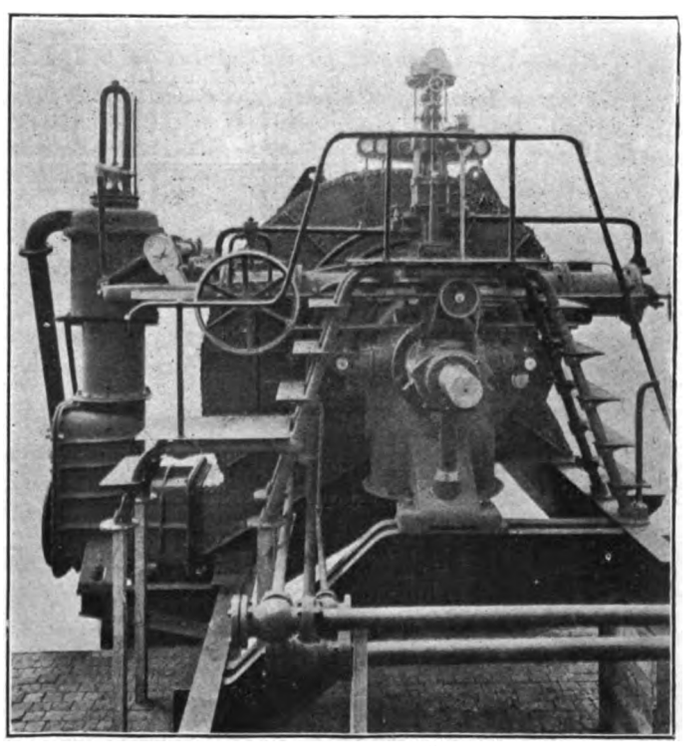

FIG. 4.—END VIEW OF A MAIN DOUBLE GRINDER TURBINE.

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which is arranged with 20 movable guide vanes. These, along with the crank pins which project through the guide wheel cover on both sides, are forged in one piece. The crank pins are set in the casing cover in removable bronze bushes, packing being effected by stuffing boxes fitted with screw caps At the

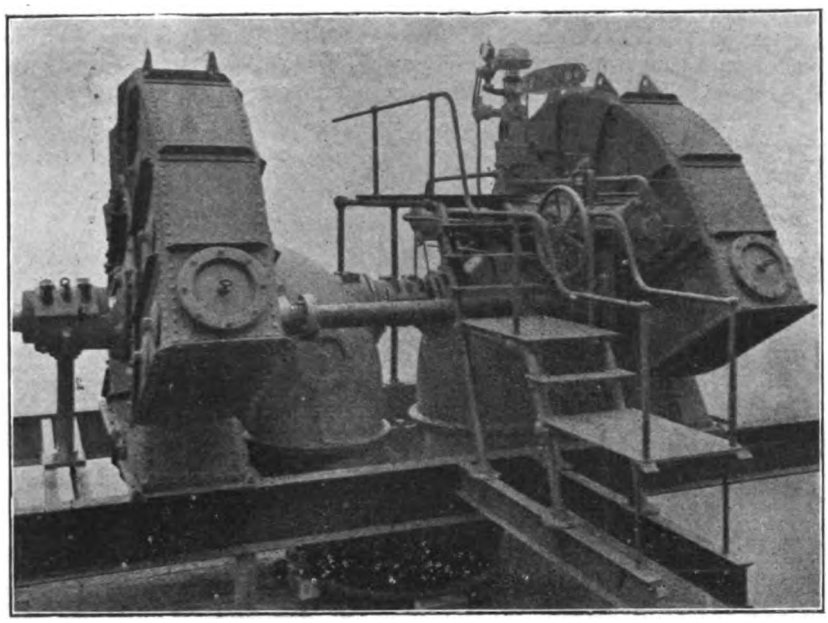

FIG. 5.—ONE OF THE MAIN DOUBLE GRINDER TURBINES.

place where connection is made with the regulating lever and the movable vanes a bushed outer bearing is provided, which is so constructed that it forms with the inner bearing a single connection between the casing covers, in order to take up their reaction pressure. This construction provides for easy dismounting and renewal of the bearings. Both inner and outer bearings are fitted with Stauffer lubricators. The connection of the regulating ring with the ends of the regulating lever is effected in the manner shown in Fig. 4.

The steel regulating ring is in one piece, and is movable in an axial direction over a drum seat by means of sliding blocks, which at the same time serve as stroke limits and secure the ring against axial displacement. The regulating movement of the governor pendulum and of the relay, or servo-motor, is communicated to the regulating ring by a pair of levers fixed on opposite sides of the turbine, as shown in Fig. 4. The inner surfaces of the guide wheel cover, which is the part most often in contact with the flowing water, are fitted with removable cast-steel piston or junk rings. The system of bracing adopted between the walls of the casing, to resist the pressure of the water and to prevent bulging of the plates, is obtained by a set of independent stay bolts arranged at regular intervals, and at the opposite end by bolts through the drum, which latter lies outside the guide blades. The bolts run through holes in the ribs, and so are kept out of contact with the water. Owing to their special shape the enclosing ribs offer no appreciable opposition to the flow of the water.

The discharge pipes from the turbines are simply curved and joined up under the floor to a single pipe by means of a forked connection, the object being to render possible the insertion of a third independent bearing for the turbine shaft, which is nearly 25 ft. long. This bearing is supported in the same manner on both the two quarter-bend discharge pipes, and can be readily moved out of its place. The two bearings fastened on the guide wheel cover are of the usual bracket type, though each has a special pedestal support. All three bearings are fitted with removable babbited bushes, and one of the bracket bearings is arranged as a collar thrust bearing. In order to allow the withdrawal of a single runner from the shaft without dismounting the grinders the grinder shaft is connected to the turbine shaft by means of a special coupling, and these when loose leave the necessary space free between the shaft ends to allow of the guide wheel cover and the runner being taken out. All the other parts of the turbine, including the

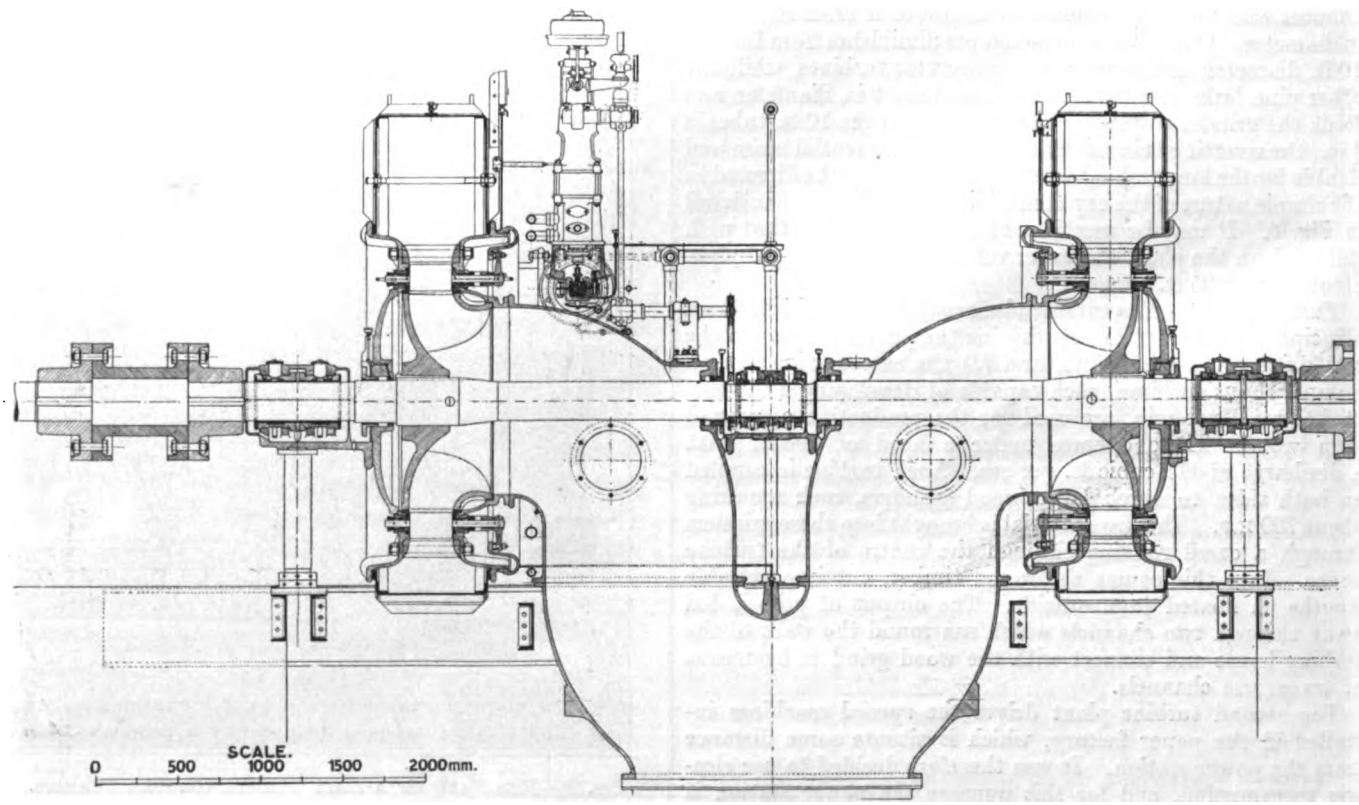

FIG. 6.—DETAILS OF DOUBLE GRINDER TURBINE.

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shaft, can be dismounted in this way without interfering with the three grinders coupled to each side of the double turbines.

Governing is effected by a pendulum governor and an assistant servo-motor. The latter sets in operation a principal servo-motor, the piston of which transmits motion direct to the regulating ring. The oil pressure supply is used in connection with this apparatus. The action of this is as follows: The rocking movement of the balance weight is changed into a motion in the direction of the pendulum axis. This operates the pendulum sleeve by means of the valve rod and front distributing rod. With this rod is connected a piston which serves at the same time as a distributing valve to the principal servo-motor, and opens the distributing ports below the cataract valve. Thus, by the upward movement of the piston, or sleeve, the delivery chamber is brought into communication with the discharge chamber.

The opening of the ports establishes connection with the principal servo-motor, and movement of the main piston is thus effected. This movement is in turn transmitted to the regulating ring by the pair of levers shown. To ensure that the regulating movement is completed at the proper time the valve passages must, of course, be closed again, and this is effected by a vertical motion which is imparted to the valves by a horizontal slanting surface formed on the piston rod of the principal servo-motor. The return or closing motion of the valves is effected by hand, or by an electric motor, while the machine is in motion. This method of governing gives a high degree of sensitiveness.

The principal servo-motor, consisting of two cylinders connected by a bayonet casting, is bolted to the turbine, and on the bayonet the assistant servo-motor and pendulum governor are fixed. The two pistons of the principal servo-motor are connected with each other by a common piston rod, to which are pinned the forked heads of the main regulating levers. The latter are in turn connected with the main regulating shafts, by which the motion of the pistons is transmitted to the cranks of the regulating ring. All drip oil is collected and brought back into the oil reservoir through a return pipe. The pendulum is driven through worm gearing in connection with a silent Morse chain. Besides the automatic regulation, hand gear can also be used. This arrangement, however, is only used when the oil pressure falls short.

The control apparatus, all of which is so situated as to be within easy reach of the operator, can be manipulated without leaving the machine platform, and the reading instruments are all mounted in one frame, enabling the number of revolutions, pressure in the turbine, pressure in the regulating cylinders to right and left, and the vacuum in the draught pipes to be readily observed. The two turbines possess one bridge in common, this serving the novel purpose of also spanning the canal running through the works down which the wood is floated to the grinders. A general view of one of the main turbines is given in Fig. 5, while Fig. 6 shows the various details of these machines.

(To be concluded.)

THE TESTING OF TRANSFORMER REGULATION.

BY C. V. DRYSDALE, D.SC.

Summary.—Where transformers are run in parallel it is important that all the transformers should have similar regulation curves. For inductive loads the curves are not similar, unless the ratio and phase displacement are the same for each transformer at the same fraction of full load. The usual short-circuit test is not very suitable for obtaining these data, as the instruments are generally working at the bottom of their range, and a small error in the indications makes a large error in the final result. The author therefore proposes a method in which the voltage of the transformer under test is compared with that of a second transformer of approximately the same ratio on open circuit. Results of tests by this method are given.

Whenever large transformers are banked together for power transmission it is of the greatest importance that their regulation curves should be similar, as otherwise some of them may be seriously overloaded while the others are running comparatively light. Two examples of this were given in the "Electric Club Journal" of June and July, 1905. In one of them a bank of transformers had been installed and were found so satisfactory that a repeat order was given. In the meantime, however, the constructors must have improved the regulation of their transformers, and when put in parallel with the old ones the new transformers burnt out after a few hours, owing to their taking nearly the whole of the load.

As is well known, the regulation of transformers cannot be satisfactorily determined directly by measurement of the voltages at various loads, owing to the smallness of the drop in comparison with the working voltage. Moreover, the effect of loading a transformer on a non-inductive load is not only to reduce the voltage from V_0 to V (Fig. 1), but to make it

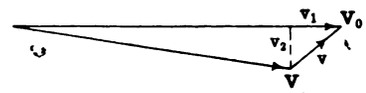

Fig. 1.—Transformer Voltage Non-Inductive Load.

lag; and the difference v_2 is as important as the drop v_1, since it represents the drop on fully inductive load, as in Fig. 2. In order that the transformers should share the load equally under all circumstances, the ratio and phase displacement must be the same in each at the same fraction of full load.

The direct test being unreliable, it has generally been sought to predict the regulation by measurement of the equivalent resistance and reactance of the transformer, derived from the short-circuit test. For this purpose one of the windings of the transformer is short-circuited, and alternating current passed through the other, the P.D. v, current C and power w being noted. Then the equivalent impedance is $I=\frac{v}{C}$, the equivalent resistance $r=\frac{w}{C^2}$, and the equivalent reactance $x=\sqrt{I^2-r^2}$.

This test, though simple in principle, is not always easy in practice. As in a good transformer the total full load drop is

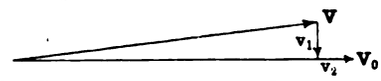

Fig. 2.—Transformer Voltage Inductive Load.

not more than 2 per cent., the voltmeter and wattmeter are generally working at the bottom of their range. Further, if as in many cases, the reactance is considerably smaller than the resistance, the resistance is nearly equal to the impedance, and a very small error in the measurements makes a considerable error in the reactance. It is easily proved that the percentage error in the reactance is $1+\frac{r^2}{x^2}$ times the percentage error in the P.D., current, or power, when the reactance is relatively small, and if $r=3x$ an error of 1 per cent. in the instruments causes an error of 10 per cent. in x, as is obvious from

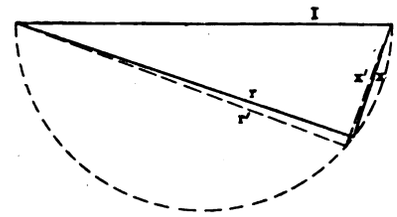

Fig. 3.—Error in Reactance produced by 1 per cent. Error in Resistance.

Fig. 3. When this is added to the unfavourable conditions under which the instruments are used, it will be seen that the test is not so reliable as might be thought. It must also be remembered that the resistance and reactance so determined are taken with the iron at a very low induction compared with the normal, and that the reactance may consequently be higher than when the iron is more saturated, as it is under working conditions.

When testing some even-ratio transformers for ratio and phase displacement as instrument transformers,* it was seen

* The Electrician, Vol. LVIII., p. 160. "Phil. Mag.," July, 1908.

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that a modification of the method would serve for testing the regulation of large transformers of any ratio under actual practical conditions with considerable accuracy. The basis of the method is to compare the voltage of the transformer under test with that of a second transformer of approximately the same ratio on open circuit. For the measurement of the difference of the voltages a wattmeter is employed, in which the moving coil circuit is connected to the constant voltage of the auxiliary transformer, while the main coils, in series with a non-inductive resistance, are used as a low resistance voltmeter. In order to measure the reactance or phase displacement with greater accuracy, a condenser can be inserted in the shunt circuit, as described in the previous communications.

The connections for the test are shown in Fig. 4, in which the transformer under test P_1, S_1 is shown connected to the supply mains and to a load exactly as in service, and in parallel with an auxiliary transformer, P_2, S_2, of approximately the same ratio. The size of the auxiliary transformer is quite immaterial, but if a bank of transformers is being made up any one of them will serve the purpose. If the secondary circuits of the transformers S_1 and S_2 are connected as shown, the P.D. between the two lower conductors will be the vector difference between the voltage of the auxiliary and test transformer. The main coil of the wattmeter W is connected between these two lower leads with a non-inductive resistance, R′, in series with it, and thus carries a current proportional to the vector P.D. v above referred to, while the moving-coil circuit is connected to the secondary of the auxiliary transformer, the voltage of which is conveniently kept constant by maintaining the supply voltage constant. The non-inductive resistance R in the wattmeter shunt circuit is, however, connected to a change-over switch which puts either this resistance in series with the moving coil or replaces it by a condenser, K. If a little care is taken in arranging the circuits beforehand the measurements can be made quite simple. The best way, as a rule, is first to select a suitable condenser for the moving coil circuit of, say, 1 mfd. or 0·5 mfd. capacity. The capacity reactance of this condenser is then $\frac{10^6}{Kp}$, where K is the capacity in microfarads and $p = 2\pi \times$ frequency. In the test described below, a 0·5 mfd. condenser was used with a frequency of 50 ∿, for which $p = 314{\cdot}2$. Hence the capacity reactance $= \frac{10^6}{0{\cdot}5 \times 314{\cdot}2} = 6{,}360$ ohms. The resistance of the moving coil of the wattmeter was 620 ohms, so that the impedance of the circuit with the condenser in series was $\sqrt{6{,}360^2 + 620^2} = 6{,}390$ ohms, or practically the same as the capacity reactance. If we deduct the moving coil resistance (=620 ohms) from the above we have 5,770 ohms, and if the non-inductive resistance R is adjusted to this value the current in the shunt circuit will be of the same amount whether the resistance or condenser is in circuit.* If we now have a small transformer which has a known ratio of, say, 10 to 1, and connect it to the secondary of the auxiliary transformer, then we know that if the P.D. of the auxiliary transformer is 100 that of the secondary of the small transformer is 10 volts and in phase with it. (The writer has shown that the P.D. ratio and phase of voltage transformers on open circuit is very closely correct.) We may now apply the main coils of the wattmeter in series with its non-inductive resistance to the terminals of the small transformer, and adjust this resistance until we get a convenient reading. In the experiment below a torsional wattmeter with 500 divisions on the torsion head was employed, and the resistance in series with the main coils was adjusted until with 100 volts on the shunt, and consequently 10 volts on the secondary of the small transformer, a deflection of 500 divisions was obtained, or of 50 divisions per volt. At the same time, the shunt circuit was changed over to the condenser, and a reading of 62·5 divisions was obtained. Had the change over to the condenser changed the wattmeter current into exact quadrature, there should have been no deflection in the second case, and the fraction $\frac{62{\cdot}5}{500} = 0{\cdot}125$ is the tangent of the angle by which the shunt current departs from quadrature, or tan θ in Fig. 5. This tan θ should have been equal to the resistance of the moving coil, divided by the capacity reactance $= \frac{620}{6{,}360} = 0{\cdot}0975$ if the condenser had no absorption, the difference $0{\cdot}125 - 0{\cdot}0975 = 0{\cdot}0275$ being approximately the power factor of the condenser. These preliminary calculations and adjustments seem complicated, but when once understood can be performed in a few minutes. When they have been done, and the voltage and frequency are kept approximately constant, the wattmeter becomes a direct-reading voltmeter, which, when the resistance R is in the shunt circuit, reads the component v_1 of any voltage v in phase with the "exciting voltage" on the shunt (in this case the voltage of the auxiliary transformer), while with the condenser in circuit it reads the component v'_2 in phase with the condenser current. As will be seen at once from Fig. 6, however, the quadrature component $v_2 = v'_2 - v_1 \tan\theta$ approximately, and, since tan θ is known, the two components are at once given.

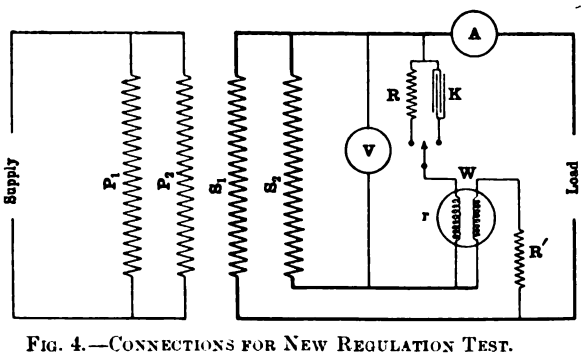

Fig. 4.—Connections for New Regulation Test.

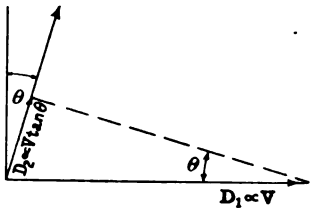

Fig. 5.

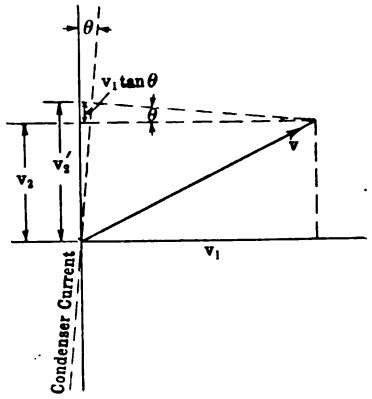

Fig. 6.

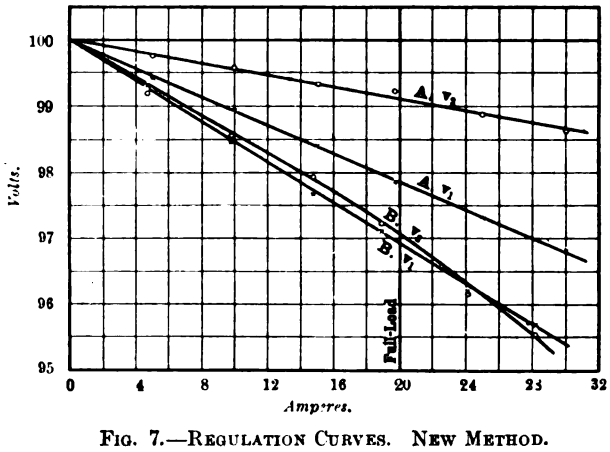

Fig. 7.—Regulation Curves. New Method.

* In some cases it might be more convenient to adjust the capacity to a given capacity reactance. Mr. Tinsley has made some adjustable condensers for phase splitting which are very suitable for this purpose.

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100 volts, 50 ∿.

Table I.—*Regulation Test. Transformer A.*

Amperes. c_1.	Wattmeter. Resistance. D_1.	Wattmeter. Capacity. D_2.	$v_1' = \frac{D_1}{50}$.	v_1.	$v_2 = \frac{D_1 - 0{\cdot}125D_1}{D_2\ \ 50}$	v.	Ratio per cent. of no load.	Displacement radians.	Equivalent resistance. r.	Equivalent reactance. x.
0	−37·5	−5·8	−0·75	0	0	0	100·0	0	...	...
5·0	−9·0	11·0	−0·18	0·57	0·246	0·62 ∠ 23·4°	99·43	0·00246	0·114	0·0492
10·0	15·3	21·2	+0·306	1·056	0·411	1·13 ∠ 21·3°	98·944	0·00411	0·1056	0·0411
15·0	41·5	37·1	0·830	1·58	0·667	1·72 ∠ 22·9°	98·42	0·00667	0·1053	0·0445
19·7	69·2	45·8	1·384	2·134	0·773	2·27 ∠ 20·0°	97·866	0·00773	0·1082	0·0392
25·0	96·5	67·1	1·93	2·68	1·133	2·91 ∠ 23·0°	97·32	0·01133	0·1072	0·0453
30·0	121·5	82·8	2·43	3·18	1·387	3·47 ∠ 23·6°	96·82	0·01387	0·106	0·0462
0	−37·0	−5·4	...	...	...	...	...	...	...	...

50 ∿.

Table II.—*No Load Test. Transformer A.*

Volts. V_1.	Amperes. C_1.	Apparent watts. W.	Wattmeter. Resistance. D_1.	Wattmeter. Capacity. D_1.	True watts. w_1.	$w_2 + 0{\cdot}125w_1$.	Magnetising current. $\frac{\sqrt{W^2 - w_1^2}}{V}$.	Magnetising current. $\frac{w_2 + 0{\cdot}125w_1}{V}$.	Core loss current. $\frac{w_1}{V}$.
15·06	0·300	4·52	−6·0	9·5	2·34	4·013	0·256	0·266	0·155
19·8	0·333	6·4	−8·8	12·8	3·44	5·43	0·273	0·274	0·1735
30·3	0·392	11·9	−18·5	21·5	7·22	9·22	0·313	0·310	0·238
40·6	0·451	18·3	−31·5	29·6	12·25	13·08	0·335	0·322	0·302
50·4	0·510	25·7	−43·9	39·2	17·15	17·45	0·379	0·346	0·340
59·0	0·549	32·4	−57·5	48·0	22·5	21·52	0·395	0·365	0·381
74·0	0·617	45·6	−85·5	67·7	33·4	30·58	0·419	0·413	0·452
80·8	0·676	54·6	−98·3	77·5	38·4	35·0	0·480	0·433	0·475
91·6	0·725	66·5	−122·7	97·0	48·0	43·8	0·502	0·478	0·524
101·0	0·794	80·2	−143·7	111·3	56·0	50·4	0·567	0·499	0·534
109·5	0·853	93·4	−163·7	135·0	63·8	60·7	0·623	0·554	0·583
119·0	0·911	108·5	−189·4	156·4	73·9	70·25	0·668	0·634	0·621

50 ∿.

Table III.—*Short-circuit Test. Transformer A.*

Volts. V_1.	Amperes. C_1.	Apparent watts. W.	Wattmeter. Resistance. D_1.	Wattmeter. Capacity. D_2.	True watts. w_1.	$w_2 + 0{\cdot}125w_1$.	Equivalent impedance. $I_1 = \frac{V_1}{C_1}$.	Equivalent resistance. $R_1 = \frac{w_1}{C_1^2}$.	Equivalent reactance. $\frac{\sqrt{W^2 - w_1^2}}{C_1^2}$.	Equivalent reactance. $\frac{w_2 + 0{\cdot}125w_1}{C_1^2}$.
0·295	2·5	0·737	−2·3	0·8	0·90	0·41	0·118	0·144	...	0·0657
0·612	5·6	3·43	−8·5	3·4	3·31	1·755	0·109	0·106	0·0285	0·0560
1·10	9·9	10·9	−27·0	10·6	10·52	5·44	0·111	0·107	0·0289	0·0555
1·61	14·5	24·35	−58·0	22·3	22·6	11·50	0·111	0·1075	0·0430	0·0548
2·14	18·7	41·9	−99·1	40·5	38·6	20·64	0·114	0·110	0·0469	0·0590
...	25·9	...	−183·3	78·2	71·5	38·44	...	0·1065	...	0·0573
...	29·5	...	−248·6	100·8	97·0	51·4	...	0·1113	...	0·0591

It goes without saying that the instrument so set up is suitable for all tests in which inductances or alternate-current vectors are required, and, as a matter of fact, it gets over the difficulty above mentioned of accurately measuring the reactance in the short-circuit test, as will be seen below.

The tests given below were made at the Northampton Institute on two 2 k.v.a. 2,000–100 volt transformers (A) by the Electric Construction Co. and (B) the Brush Co., loaded on a non-inductive resistance. The adjustments having been made as described above, the following tables for the first transformer are almost self-explanatory.

Table I. gives the results of the regulation test by the method above described. The two deflections D_1 and D_2 are those of the wattmeter with the resistance and condenser respectively in the shunt circuit. On dividing D by 50, the number of divisions per volt, we get the P.D. v_1', which is the component of the difference of the voltages of the two transformers in phase with the P.D. of the auxiliary transformer. In this case the first reading of $D_1 = 37{\cdot}5$ divisions shows that the P.D. of the auxiliary transformer was 0·75 volt lower than that of the test transformer on open circuit; and hence the real drop v_1 of the test transformer below its no-load voltage is obtained by adding 0·75 volt to each of the values of v_1' in the fourth column. The value of v_2 is given by $\frac{D_2 - 0{\cdot}125D_1}{50}$, while v is obtained in magnitude and phase from v_1 and v_2. By dividing the values of v_1 and v_2 respectively by the current C we get the equivalent resistance and inductance of the transformer which are shown in the last two columns, and are seen to be very fairly constant. The curves A, Fig. 7, show the regulation on non-inductive and inductive load of this transformer deduced from their results, while those marked B are similar curves for the other transformer, and clearly indicate the difference between the designs.

Table IV.—*Comparison of Results.*

	Transformer. A.	Transformer. B.
No load current, at 100 volts	0·785	1·25
Core loss current „ „	0·54	0·92
Magnetising current „ „ $\frac{\sqrt{W^2 - w_1^2}}{V}$	0·55	0·85
„ „ „ „ $\frac{w_2}{V}$	0·50	0·81
Equivalent resistance (short-circuit test)	0·109	0·144
„ „ (regulation test)	0·108	0·155
Equivalent reactance (short-circuit test) $\frac{\sqrt{W^2 - w_1^2}}{C^2}$	0·047	..
„ „ „ „ $\frac{w_2}{C^2}$	0·058	0·186
„ „ (regulation test)	0·040	0·15

In Table II. the results of a no-load test on the first transformer are given, while Fig. 8 shows curves for the two transformers. These tests call for no comment, except that as the condenser was available, the two components of the no-load

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current were measured in a similar manner to the components of the P.D. in the regulation test. In the case of transformer A the magnetising and core loss currents are so nearly equal that it should be almost equally accurate to determine the magnetising current by the formula $\sqrt{W^2-w^2}/V$, or by the condenser; and it will be seen that the two values so obtained are very fairly concordant, except at high voltages, where the greater saturation of the core probably considerably distorts

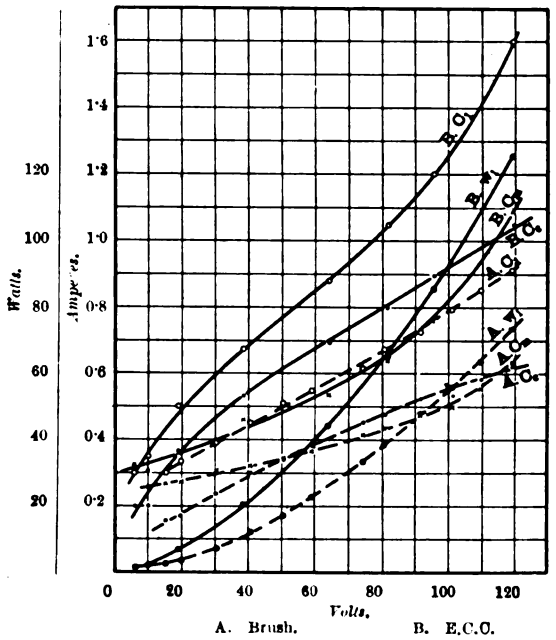

Fig. 8.—No-load Tests.

the magnetising current. The agreement is, however, sufficiently close to establish the reliability of the condenser method for the regulation and short-circuit tests.

Table III. and the accompanying curves, Fig. 9, apply to short-circuit tests on the transformers, the condenser being again employed. The equivalent resistance w/C^2 is obtained without any difficulty, but is so nearly equal to the impedance V_1/C_1 that the accuracy of measurement of the reactance $\sqrt{I^2-r^2}$ is very small. As will be seen, the average value of

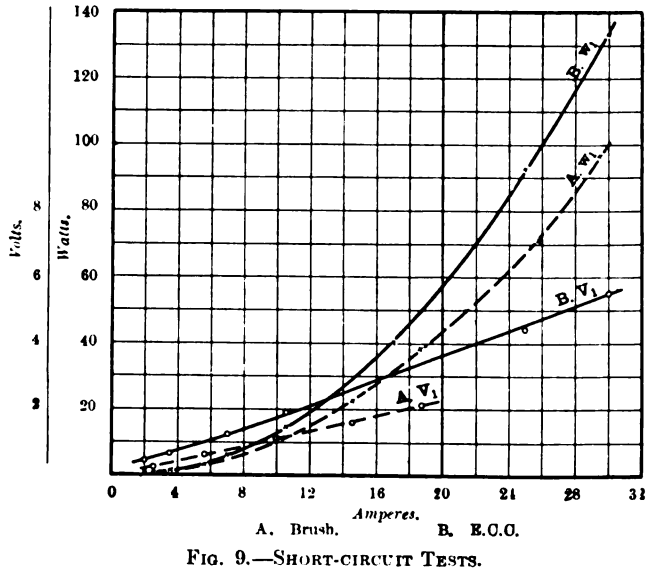

Fig. 9.—Short-circuit Tests.

the reactance comes out as about 0·038 ohm, while, according to the condenser test, it should have been about 0·057 ohm, or 50 per cent. greater.

Finally, Table IV. shows the comparison of the results obtained by the various tests. It will be seen that the values of the equivalent resistance obtained from the short-circuit test and the new regulation test are almost identical in the case of transformer A. In the case of transformer B the regulation test gives a higher value of the equivalent resistance. As to the reactance, in both transformers the value obtained from the regulation test is only 70 to 80 per cent. of that given by the short-circuit test, which must be attributed to greater core saturation, and shows that wherever close regulation tests are necessary some such method as that here described is required.

In conclusion, it should be stated that this test is obviously applicable in conjunction with loading-back devices; and that the whole of the tests could be very rapidly made by the alternate-current potentiometer described by the author,* in which the magnitude and phase of the P.D. and current vectors can be immediately read off.

The author's thanks are due to Messrs. A. C. Jolley and H. Gerrard for assistance in the tests, and to Mr. A. E. Burgess, B.Sc., for working out the results.

THE EXAMINATION OF WATER BY ELECTRICAL METHODS.†

BY W. POLLARD DIGBY.

Summary.—The author first describes a form of conductivity tube which he has devised for use, not only in the physical laboratory, but in everyday engineering work. It furnishes information as to whether condensers are leaking, the amount of the leakage, the amount of priming arising in boilers, and the control of oil eliminating and water softening plants. Details of tests carried out at various power stations are given.

That water in its varying degrees of impurity is anything but a medium of constant value comes within the experience of all engineers, and hence frequent resort is made by the engineer to the analytical chemist for advice and assistance. However, this is not always done as often as might be desired, and a variation in the nature of a supply may take place with no visible change in the appearance of the water, but yet with such changes in the constituents as would render the water quite unsuitable for boiler feed purposes. The author's object in the present Paper is to point out the value of simple tests made *in situ* as safeguarding the owners of boilers from such happenings, and as determining when the analytical chemist should be employed. These tests, however, are not intended in any degree to supersede the analyst, but may serve to determine when detailed analyses are necessary by indicating changes in the impurities in the water. The method resolves itself into a determination of the conductivity of the liquid at any predetermined temperature and a comparison of such determinations with the known values of analysed samples. Any marked variation from the normal should be followed by a further analytical examination.

Measurements of specific resistance of water have hitherto demanded careful laboratory determinations. The method most widely known, viz., that of Kohlrausch, depends upon the employment of the Wheatstone bridge, with an alternating current and a telephone receiver in place of the galvanometer used in ordinary resistance measurements. This method, while indubitably one of precision in the hands of those highly trained, permits of varied results from different experimenters. Another laboratory method provides for carrying the liquid to be measured in a glass tube forming a secondary short-circuited coil of a static transformer. While this device is visual rather than aural, the delicate instruments necessary, together with the calculations required, relegate this most ingenious apparatus to the physical laboratory. For determinations of the conductivity of liquids or electrolytes the apparatus to be employed should not necessarily involve the use of alternating currents, and a measuring apparatus fitted with a scale should indicate conductivity in reciprocal ohms or reciprocal megohms as a function of the current furnished by the generator. On the electrochemical side the effect of polarisation has to be limited. This can be effected by cir-

* "Phil. Mag.," March, 1909. The Electrician, April 16, 1909, p. 8.

† Abstract of an original communication accepted by the Council of the Institution of Electrical Engineers for publication in the Journal.

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culating the liquid under examination past the electrodes at such a rate as to wash away any adherent film of hydrogen bubbles.

An apparatus embodying these features has been devised by Mr. C. W. V. Biggs and the author, and has been used on all the experiments and tests described in this Paper. The original type consists of a straight glass tube so constructed as to hold the equivalent of a body of liquid 10 cm. in length and 1 sq. cm. in sectional area, the liquid being contained between platinum electrodes attached to plugs of ebonite fixed in cups which form enlargements of the ends of the tube. The electrodes are suitably connected to terminals in the ebonite ends, and are capable of being adjusted. The liquid to be tested is introduced into the main tube through a small tubulure, rising at an angle from the middle of the upper part; and when tested is run off through a small tube furnished with a tap attached to the middle of the lower part. At each end of the upper surface of the body tube a vent tube is attached, inclining to the middle

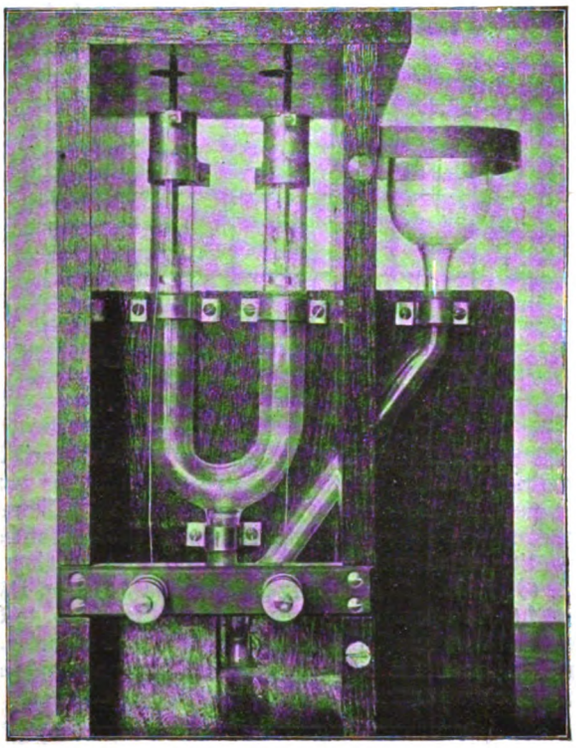

Fig. 1.

of the main tube, and the two unite at a height of about 2½ cm. above it, with a short vertical outlet. The arrangement is shown in Fig. 1.

Manifestly such a piece of apparatus is hardly suitable for use outside the laboratory. The form for practical work consists of a glass U tube, to which is attached at the lowest point of the bend the tube brought from the filling funnel, whilst the outlet, controlled by a glass tap, is joined to the inlet at its lowest point. Near the extremities of the limbs of the main tube overflow ways are sealed on, and terminate in indiarubber tubes grouped with the lower outlet. The form and arrangement of the electrodes are especially designed to minimise the disturbing effects of polarisation and other difficulties inseparable from the original type of tube. The electrodes are open cylinders of platinum, about 9 mm. in diameter and 3 mm. in height, connected by three equi-distant platinum wires to stout brass glass-covered rods passing through the brass covers which are connected to the terminals. The dimensions of tube and electrodes are such that the equivalent of a body of liquid having a length of 10 cm. and a sectional area of 1 sq. cm. is obtained. The apparatus is mounted on a strong wooden support carrying a thermometer, and the whole is contained in a lock-up portable case (Fig. 2).

The most convenient instrument for measuring the conductance is the "conductance meter" made for use with the tube by a well-known firm which the author has entrusted with the manufacture of the apparatus. It resembles the familiar "megger," but is furnished with a scale graduated in reciprocal megohms and ohms, and with a tube of sectional area one-tenth the length it gives readings of one-tenth of the specific conductivity—equivalent to the reciprocal of 10 times the specific resistance. Correction for variation of temperature for water containing less than 1 per cent. of dissolved salts may be made with sufficient accuracy by taking the coefficient as 2·19 per cent. per 1°C., as referred to 20°C.; but above 38°C. such correction is not reliable owing to complications arising from disengagement of small quantities of dissolved gases and also from physico-chemical action.

At the outset the author experienced considerable difficulty in determining standards for comparison. Distilled water, obtained either from the laboratory of the analytical chemist or from the shop of the pharmaceutical chemist, cannot be regarded as a standard product. Absolutely pure distilled water has probably never been obtained. The best that the author has heard of was a special sample prepared by Kohlrausch, which had a value of 0·043 reciprocal megohm at 18°C. This was prepared by distillation *in vacuo*, and collected in an especial glass cell which had been kept for 10 years full of distilled water. Of samples passing through the author's hands, good distilled water has varied in its specific conductivity from 4·0 to 1·362 reciprocal megohms for laboratory distilled water, and for distilled water from surface condensers the best has been 3·3 reciprocal megohms. As a general standard of comparison, good distilled water might possibly be defined as possessing a specific conductivity of 3·3 reciprocal megohms, or a specific

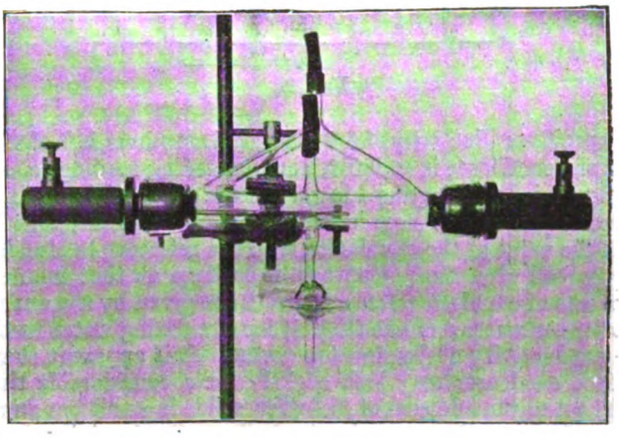

Fig. 2.

resistance of 300,000 ohms at about 20°C., this value representing an approximate average value of the output of the Liebig condensers in the laboratory of one of the author's friends, and also representing the best practice from central station surface condensers that has come under the author's notice.

All books on physics refer to the effect of minute traces of impurities as greatly increasing the conductivity of distilled water. The author has noticed that shaking 30 cc. of good distilled water in a *clean* 50 cc. stoppered flask for 30 seconds has resulted in doubling the conductivity, probably owing to the absorption of impurities from the imprisoned air. Some typical results of the author's investigations on the effect of minute traces of sodium chloride, sodium carbonate and calcium sulphate are given in the Paper. It must be remembered that the method of testing does not discriminate between different impurities.

Feed Water.—Fig. 3 shows the relation between degrees of hardness and conductivity of water when that hardness is due solely to calcium carbonate. It is apparent that conductivity tests also permit the checking of the operation of evaporators for make-up purposes at sea, or for the supply of distilled water for hydraulic gun mountings, and further provide a check on the operation of surface condensers in all places.

Condenser Tightness and Priming.—Given a boiler free from priming, a single conductivity measurement of the water pass-

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ing from the condenser to the hot well will indicate the tightness of the condenser tubes. It will be urged that any impurities indicated may after all be due to boiler priming. Any doubts upon this score can be readily settled. All that is necessary is to take, say, four or five samples (after running long enough to wash out possible impurities from the steam ways), one with the engine or engines turning round light, and other samples at stated points upon an increasing load. Then if the conductivity is high in the first reading, being anywhere well in excess

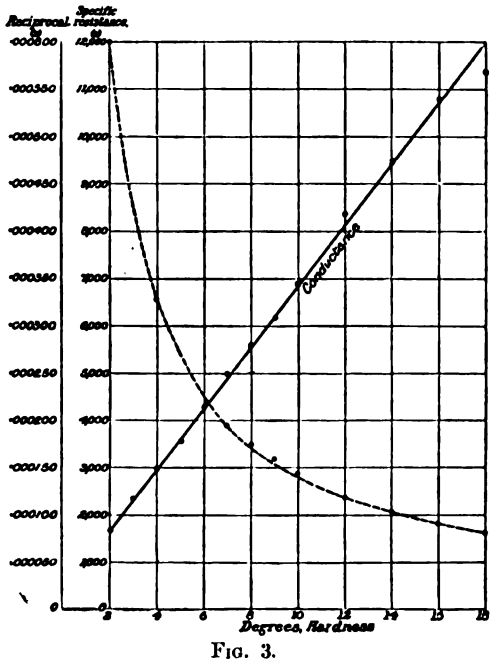

Fig. 3.

of a specific conductivity of 3·0 reciprocal megohms, it is obvious that the condenser is at fault, and succeeding readings should confirm this by indicating a lower specific conductivity. If the approximate rate of flow is known at any moment, together with the value of the circulating water, a reference to standard curves will give the percentage of leakage at that moment. Two sets of standard reference curves are given by the author, one for sea water and one (Fig. 4) for circulating water having the conductivity of London tap water. It is apparent that a surface condenser may leak slightly for a considerable time, and lead to the addition of dissolved solids in small but cumulative doses to the water in the boiler. Conductivity determinations, while indicating when overhauling is necessary,

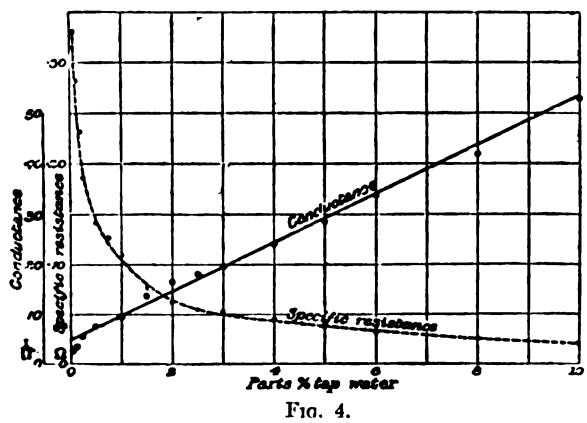

Fig. 4.

may save unnecessary examinations. If, on the other hand, the conductivity of the hot-well water, initially low, rises as the load on an engine increases, the only possible deduction is that the boiler is priming.

The grade of the water within boilers is subject to wide variation. The author has found the specific conductivity of water in boilers to vary from 11·1 reciprocal megohms to more than 90,000 reciprocal megohms. It therefore becomes necessary for each test for boiler priming to plot a special curve giving the conductivity of various portions of the water actually in the boiler mixed with standard distilled water. Fig. 4 is a special curve showing the conductivity of varying proportions of West London tap water and distilled water.

Tests have been carried out by the author and his staff on several typical installations of boilers. In each case, in addition to an initial checking of the tightness of the condenser, and the determining of the value of the water in the boiler, the following readings were obtained: (*a*) Height of water in gauge glass; (*b*) evaporation during period; (*c*) load on station in kilowatts; (*d*) conductivity of sample obtained; (*e*) percentage of priming deduced from (*d*). Inasmuch as this is the first occasion upon which a series of priming tests have been made upon such an exhaustive scale as was employed, and as the method involved permitted of an exactitude of measurement of priming not hitherto available, the author submits

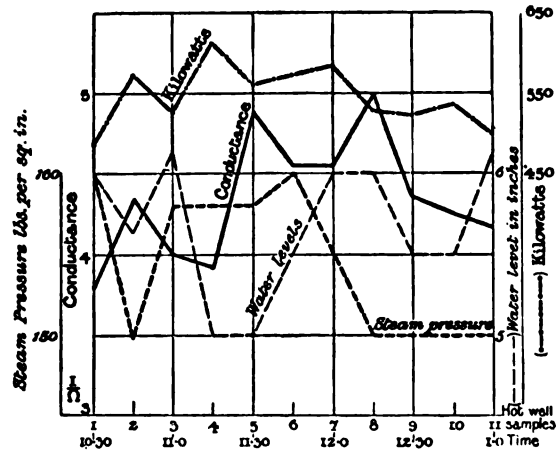

Fig. 5.

detailed results of certain of these tests. From April 25 to September 19, 1908, seven tests were taken under varying conditions. The first was on a Stirling boiler at the Shoreditch power station with a load of from 452 kw. to 616 kw., an hourly evaporation of about 15,000 lb., and pressure ranging from 150 lb. to 160 lb. The heating surface was 3,250 sq. ft., and the height of water in the gauge glass was from 5 in. to 6½ in. As was the case in all the other tests, hot-well samples were taken every quarter of an hour, whilst an average sample of the boiler water was secured by a slow uninterrupted trickle from

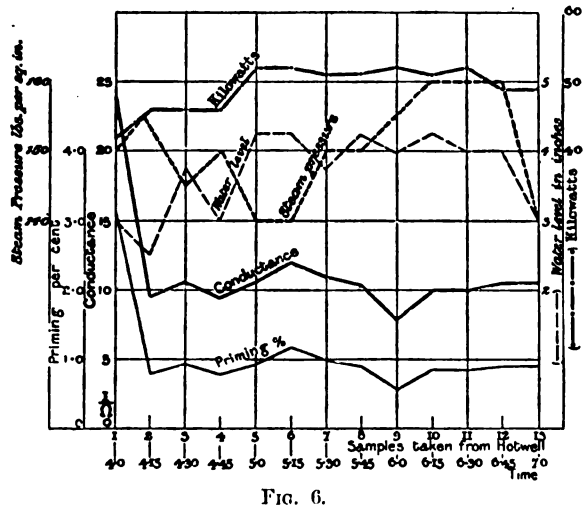

Fig. 6.

the gauge cock. The variation in specific conductance of the hot-well samples was very small, the minimum being 3·75 reciprocal megohms and the maximum 5·0 reciprocal megohms. The boiler water was unusually free from saline matter. Its specific conductance, which was 42·5 reciprocal megohms at 13°C., indicates that it contained only from 25 to 30 parts per million of dissolved solids. Fig. 5 shows the conditions and results of this test. A three hours' test taken on another Stirling boiler showed that the boiler water was of an exceptional

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degree of purity, and contained probably not more than 10 parts per million of saline matter. The author does not give curves for percentage of priming in these Shoreditch tests owing to the discovery of defects in the tubes, but it is manifest, from the very low conductance of the hot-well samples, that the priming must have been very slight—probably not greater than 0·1 per cent. in the first test, and not much above this figure in the second test.

The next test, at the Epsom power station, on July 15th, was on a dry-back boiler of the Davey-Paxman economic type, and extended over three hours with an hourly evaporation of from

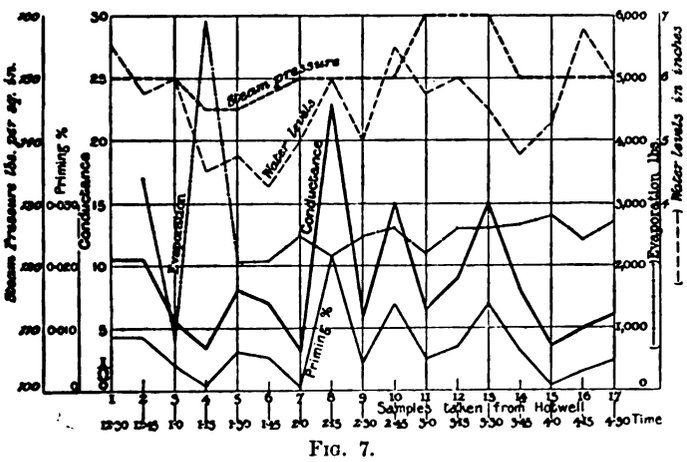

FIG. 7.

1,048 lb. to 1,185 lb. of water; a steam pressure of 140 lb. to 160 lb.; heating surface, 1,180 sq. ft.; height of water in gauge glass, 3 in. to 4¼ in., and a load of from 42 kw. to 52 kw. In this case the boiler water was of a totally different character from that at the Shoreditch station. Its specific conductance was 680 reciprocal megohms at 20°C., representing a proportion of dissolved solids amounting to several thousand parts per million. The hot-well samples varied in specific conductance from 8 to 24·5 reciprocal megohms; but the highest figure was not nearly approached in any other than the first sample taken, and may be ascribed to insufficient washing out of the interior of the pipes before beginning the collection of the samples. The corresponding amounts of priming vary from 0·6 to 3·0 per cent. The curves for this test are given in Fig. 6.

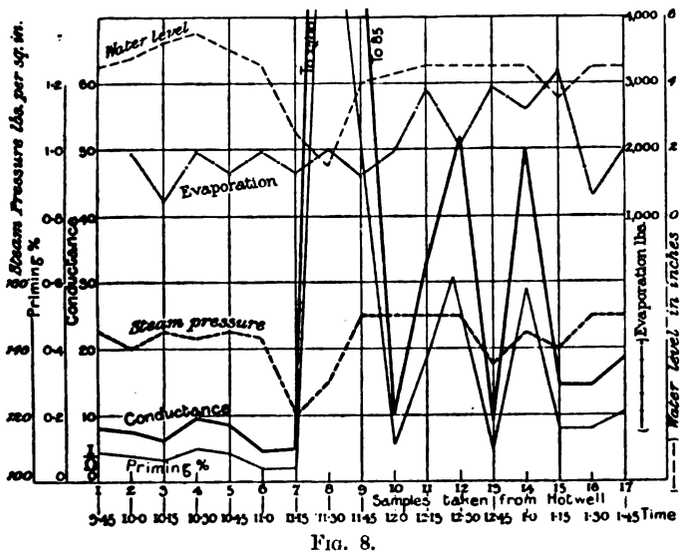

FIG. 8.

Particulars of a test taken at Kelham Island power station, Sheffield, on four Stirling boilers, are next given by the author. The first two of these boilers were of the marine type, the others were five-drum boilers. The boiler water from the former had a specific conductance of 66 reciprocal megohms, and that from the latter 870 reciprocal megohms at 26·5°C.; whilst the hot-well samples varied from 3·32 to 10·77 reciprocal megohms. The corresponding percentages of priming range from 0·06 to 1·24. As was the case at Epsom, the highest figure was obtained from the first sample only, and the same remarks apply.

Southend power station was selected for the next test, when the samples were collected during four hours. A Babcock & Wilcox boiler, with a heating surface of 2,900 sq. ft., and a water level of 4¼ in. to 6¾ in., was evaporating from 9,526 lb. to 10,940 lb. of water per hour at pressures of 140 lb. to 160 lb., with a load which varied considerably. The boiler water was strongly alkaline, and its specific conductance at 17°C. was approximately 91,240 reciprocal megohms. The hot-well samples had a specific conductance of from 3 to 23 reciprocal megohms at 16°C., indicating priming not exceeding 0·022 per cent. Fig. 7 gives details of this run.

At Southend power station a four hours' test was also begun on a Stirling boiler. After an hour and a half it was found necessary to join up a Babcock & Wilcox boiler, so that, although this run cannot be regarded as a comparative test, it shows very interesting results from the time of joining up the boilers until the end of the run (Fig. 8). The high conductance of the hot-well water when both boilers were joined up was probably due to the washing out of dirty steamways, for all the samples giving high readings were contaminated with more or less of earthy suspended matter.

The final test of this series was also taken at Southend power station on two Davey-Paxman Economic boilers, having a combined heating surface of 2,360 sq. ft., evaporating jointly from 8,736 lb. to 10,524 lb. of water per hour at a pressure of 145 lb. to 150 lb., with a very variable load. The water levels

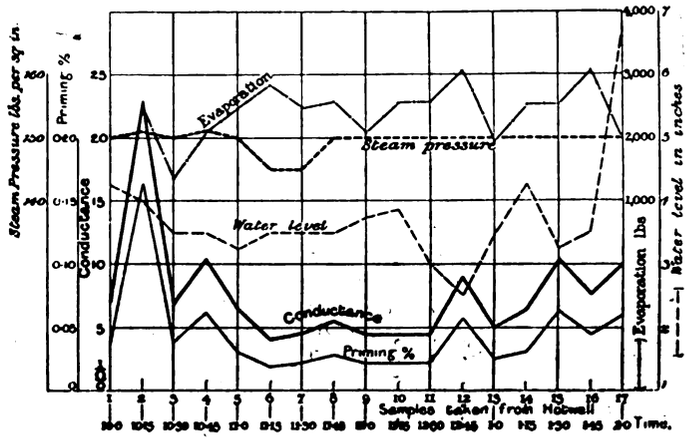

FIG. 9.

in the gauge glasses measured from 2½ in. to 7 in. The boiler water had a specific conductance of 14,910 reciprocal megohms at 18°C., whilst the hot-well samples ranged from 4·0 to 23 reciprocal megohms, and the extent of priming indicated varies from about 0·02 to 0·16 per cent. (Fig. 9).

So far as checking the operation of steam plants by conductivity methods is concerned, their application does not cease with checking the nature of the feed water or with ascertaining condenser tightness, or even with defining boiler priming. A film of oil is more to be dreaded than scale-forming impurities in the management of boilers. An oil eliminator in one form or another is a necessary adjunct in all electricity supply stations containing reciprocating sets, but their careless operation in a manner other than that designed by the makers may involve the substitution of a less evil for a greater one. The author has good reason to believe that in certain cases an excess of chemicals is added beyond that required for the elimination of the oil. This in cumulative small doses can only result in the increasing impurity of the boiler water through its enrichment with a substance which by common consent is regarded as a source of priming.

A last point may be mentioned. Where hard waters containing an excessive quantity of calcium and magnesium carbonates are softened by the Clark process, the conductivity tube and conductance meter can be used as a substitute for the standard soap test in defining how far the process of softening has been carried.

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Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON
(ONLY ADDRESS.)
Tel.: Holborn **6363** (Two Lines). *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

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With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fifty-first issue of the Supplement was published (Gratis) with the last number of "THE ELECTRICIAN."

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FEED WATER TESTS.

The testing of water is one of those operations which may require a good deal of expert knowledge, the extent of such knowledge depending upon the object in view. Thus, a complete analysis, including the determination of free and albuminoid ammonia, such as may be necessary for hygienic purposes, is elaborate, and cannot be attempted except by the trained chemist. On the other hand, the determination of temporary and permanent hardness is a much simpler matter, and fortunately, in the case of the boiler user, these are the points on which information is chiefly desired. Standard soap solution is easily obtained, and its use is one of the simplest operations in quantitative work. Even the determination of total hardness by evaporation presents no difficulties to anyone who is accustomed to the use of a balance. Moreover, determinations of this kind are not often required. Initially a fairly careful examination may be desirable, but the water of a locality does not as a rule change its quality to any great extent. The amount of temporary hardness is therefore the most important quantity in every-day running, and this may require checking from time to time, more particularly in connection with water-softening plant.

In a communication to the Institution of Electrical Engineers—of which an abstract will be found elsewhere in the present issue—Mr. W. POLLARD DIGBY points out that chemical tests are not the only tests that are available in the examination of water. Electrical methods may also be applied. Thus, his tests show that as the hardness increases, the conductivity also increases proportionally. This result was obtained with water in which the hardness was due solely to calcium carbonate. Doubtless such a result would apply more or less also to water containing other impurities, provided that a given quality of water

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was being considered. The difficulty, of course, is that an electrical test cannot distinguish between the different impurities. The effect on conductivity may be much the same whether the hardness is permanent or temporary, whereas it is important to be able to distinguish between the two. We think, therefore, that the electrical methods proposed by Mr. DIGBY will be more useful for the other objects that he mentions than for testing water for hardness alone.

The other uses to which we refer depend upon determining the amount of water finding its way into water of purer quality. Thus, in the case of condensed steam, the water will be of considerably lower conductivity than in the case of the circulating water. By measuring the conductivity of some condensed steam which is not passed through the condenser, and also the conductivity of the water passing from the condenser to the hot well, any alteration through the action of the condenser becomes evident. If these two figures are the same all is well, but if the conductivity of the water passing to the hot well is considerably higher than the figure obtained for condensed steam that has not passed through the condenser, it may be assumed that the effect is produced by leakage in the condenser tube. By referring to standard curves the extent of the leakage may be determined. Similarly, if the conductivity of the hot well water is low when the load on the engine is small, but increases as the load is increased, it may be inferred that the boiler is priming when giving more steam. By referring again to standard curves for the particular water in use, the percentage of priming can be found.

The apparatus used is simple, and consists of a conductivity tube with an electric generator and ohmmeter, on the lines of the familiar "Megger," but the pointer, instead of indicating megohms, indicates conductance or reciprocal ohms and megohms. In order to avoid trouble from polarisation the electrodes are tubes, and the water is made to flow through them so as to remove any polarising film.

It appears to us that such tests are distinctly useful, the more so as they afford means for determining effects, the results of which cannot be isolated easily by other methods. At the present time, when station engineers are striving to eliminate every possible inefficiency, it is well to have tests of this kind available, more particularly if, as in the present instance, they can be applied simply and without any great cost.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Theoretical Elements of Electrical Engineering. By CHARLES PROTEUS STEINMETZ. 3rd edition. (New York: The McGraw-Hill Book Co.) Pp. ix. + 437. $4 net.

It is somewhat amusing to imagine the feelings of those who might get hold of this work under the impression derived from its title that they were about to gain a general elementary knowledge of electrical engineering. Had the author entitled it "The Theory of Electric Generators and Motors" it would have saved some shocks. With this remark, however, criticism almost ends, as the presentation of this all-important subject is so unique and complete that there is no other work to compare with it. For those who have the time and ability to read it thoroughly it will prove most valuable and suggestive, but it must be regarded as essentially of an advanced character, as the bulk of the volume presupposes a knowledge of more than half of the author's "Alternate-current Phenomena."

The present volume commences with a short introductory section on "General Theory," which is perhaps intended to justify the title, but which is hardly happily conceived. The author teaches electromagnetism in his own way by speaking of magnetomotive force in ampere turns, and magnetising force as the number of ampere turns per centimetre. This required a little adjusting when permeability is brought in, and no indication is given to the unwary that there is anything unusual about this treatment. On p. 17 the form factor of an A.C. wave is given as the ratio of the ordinary form factor to its value for a sine curve, an innovation which is perhaps to be commended. On p. 26 the author defines the time constant of a circuit as the reciprocal of the ordinarily accepted term, and although he gives reasons for this in a footnote, it does not get over the fact that his quantity is not a time. The introduction of alternate-current vectors on p. 44 follows the same procedure as in the "Alternate-current Phenomena," deriving it from the polar diagram of the wave, but this method has had the objectionable feature of reversing the sense of rotation in vector diagrams, and the advantages claimed for it over the treatment of the rotating vector as a generating crank are not convincing. It need hardly be said, however, that none of these points in any way affect the results given us.

After some general applications of the theory to transformer and transmission lines which are more or less familiar, we are introduced to Part II., entitled "Special Apparatus." Dealing first with synchronous machines the calculation of E.M.F. leaves breadth coefficients out of account, although a somewhat vague hint is given as to the necessity for considering the phases of the E.M.F.s in the separate conductors. The elimination of harmonics by fractional pitch windings is, however, clearly pointed out.

Coming next to the important question of regulation, the author introduces the term "nominal generated E.M.F. for the fictitious E.M.F. generated on the synchronous impedance theory, which will probably find general favour. The effects and similarity of armature reaction and leakage inductance are pointed out, but the essential distinction between them that the former combines with the magnetising force of the field coils, and has its effect, therefore, affected by the saturation of the poles, while the latter is independent of it is not clearly indicated. True, we find later, when dealing with short-circuits, that the effect of armature reaction on the poles is considered as being annulled by secondary currents generated in the field coils, but the absence of this from the regulation section has brought about the omission of no-load and short-circuit characteristics, and the predetermination of load characteristics by the well-known methods. But against this we have to set some very interesting and original conclusions respecting sudden short circuits, effects of teeth, &c.

The remaining subjects dealt with are direct and alternating current commutating machines, synchronous converters and induction machines. As would be expected, the treatment of alternate-current commutator motors is of great interest, and we do not remember ever seeing anything like such a simple, clear and full description of the problems to be solved and the methods of solving them.

Space forbids dealing with the remainder of the book, but enough has been said to show that Prof. Steinmetz has given us a work of considerable originality, and which will be of great value to the designer and to advanced teachers.

C. V. DRYSDALE.

Technische Schwingungslehre. By Dr. WILHELM HORT. (Berlin: Julius Springer.) M.6·40.

The author of this little work, Dr. Hort, of the Siemens-Schuckert works, has set out to give in a fairly elementary form the theory of oscillation problems as found by engineers. As a number of these oscillations depend on the simple type of linear differential equations, the beginning of the book is devoted to the theory of such equations, with examples taken from undamped galvanometer swings and loaded beams. Following

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these come simple damped and forced oscillations, the practical applications being taken chiefly from electrical circuits, including a very interesting case in which the polarity of an exciter was reversed by the blowing of the fuses in the circuit of the dynamo excited by it; there are also descriptions of seismographs and vibration detectors.

The second section deals with more complex problems. After a brief exposition of Lagrange's equations and D'Alembert's principle, the author deals with the production of compound oscillations and their resolution by means of Fourier's theorem, an actual example of the latter being worked out for the crank effort diagram of a steam engine. Simple as the method is, it seems to be comparatively unknown to engineers, but with the aid of the convenient table of trigonometrical quantities given in the book, the harmonic analysis is rendered as simple as possible. The applications of these principles lead to the solutions of problems of great practical importance, although some of those considered are not strictly of an oscillatory type; for instance, the theory of the Yarrow-Schlick-Tweedy system of balancing is worked out, and it may perhaps be remarked that the whole system is ascribed to Schlick.

From an author whose work lies among electrical machinery it is natural to expect that the theory of engine governors would be fully treated, in view of the difficulties associated with parallel running of alternators, and this forms the most complete chapter in the book. The different types of governors are considered, including the "relay" type, together with the conditions under which oscillations may be set up when alternators are run in parallel. One can only regret that this chapter is not longer, as in the space devoted to it the theory is so condensed that such an important principle as that of the Hutin-Leblanc "amortisseur" is dismissed in four lines.

The remainder of the book deals with some very modern problems, such as the Schlick gyroscope apparatus for prevention of rolling in ships, and also the elementary theory of the mono-rail car as rendered stable by gyroscopes. The book is thus brought up to date, but unfortunately its completeness has to a certain extent spoilt it. Far too much has been attempted in the space available, so that in parts the matter is so condensed as to be almost obscure. But the author's idea is excellent, and an English translation considerably amplified should fill a distinct gap in text-books. At present there are too few books which illustrate the direct applications of the calculus to practical engineering problems.

F. J. DYKES.

ANALYSIS OF LEAKAGE REACTANCE.

BY J. REZELMAN.

(*Concluded from page 615.*)

Summary. The author continues his investigations into the leakage of the windings of alternating-current machines. The expression for the permeance λ_k is considerably simplified and made much more general; the expression for the slot permeance, too, is slightly modified. The leakages of many machines have been carefully analysed and the results are here given. Bar windings also are dealt with.

SEPARATION OF THE PERMEANCES.

1. *One Phase of the Three-phase Winding.*

$$\lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi \times 27{\cdot}7}{5}\right) + 1{\cdot}3 \times 3\left(0{\cdot}63 \times \log 1{\cdot}25\right)\right\} = 3{\cdot}89,$$

$p=4$; $q=3$.

whence

$$x_{s_k} = \frac{12{\cdot}5 \times 51{\cdot}5 \times 276^2}{4 \times 3 \times 10^8} \times 26 \times 3{\cdot}89 = 0{\cdot}0409 \times 26 \times 3{\cdot}89 = 4{\cdot}15\omega.$$

The table of experiments gives 41·2 volts for 10 amperes, which corresponds to a reactance $x_{s_k} = 4{\cdot}12\omega$.

$$\lambda_{s_a} = 0{\cdot}46 \times 3\left\{\log\left(\frac{2 \times 680}{210}\right) + \mathrm{A}\right\} = 1{\cdot}12 + 1{\cdot}38\mathrm{A}$$

$$\lambda_{s_c} = 0{\cdot}46 \times 3\left\{\log\left(\frac{2 \times 680}{250}\right) + \mathrm{A}\right\} = 1{\cdot}02 + 1{\cdot}38\mathrm{A}$$

whence

$$x_{s_a} = 0{\cdot}0409 \times 36\{1{\cdot}12 + 1{\cdot}38\mathrm{A}\} = 1{\cdot}65 + 2{\cdot}03\mathrm{A}$$

$$x_{s_c} = 0{\cdot}0409 \times 32\{1{\cdot}02 + 1{\cdot}38\mathrm{A}\} = 1{\cdot}33 + 1{\cdot}80\mathrm{A}$$

and $$x_{s_a} + x_{s_c} = 2{\cdot}98 + 3{\cdot}83\mathrm{A}.$$

The table of experiments gives $32{\cdot}1/10 = 3{\cdot}21\omega$, therefore $\mathrm{A} = +0{\cdot}06$. There remains

$$x_{s_n} = \frac{101{\cdot}3 - 41{\cdot}2 - 32{\cdot}1}{10} = 2{\cdot}8\omega \text{ and } \lambda_n = 2{\cdot}64.$$

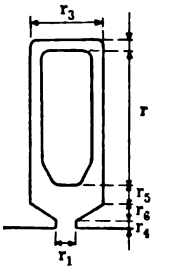

FIG. 5.

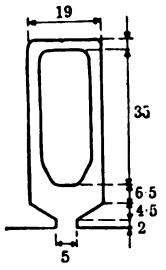

FIG. 6.

2. *Two Phases in Series.*

$$\lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi \times 27{\cdot}7}{5}\right) + 0{\cdot}8 \times 6\left(0{\cdot}68 + \log 1{\cdot}25\right)\right\} = 4{\cdot}57$$

$p=4$; $q=6$.

whence $$x_{s_k} = 0{\cdot}0818 \times 26 \times 4{\cdot}57 = 9{\cdot}72\omega.$$

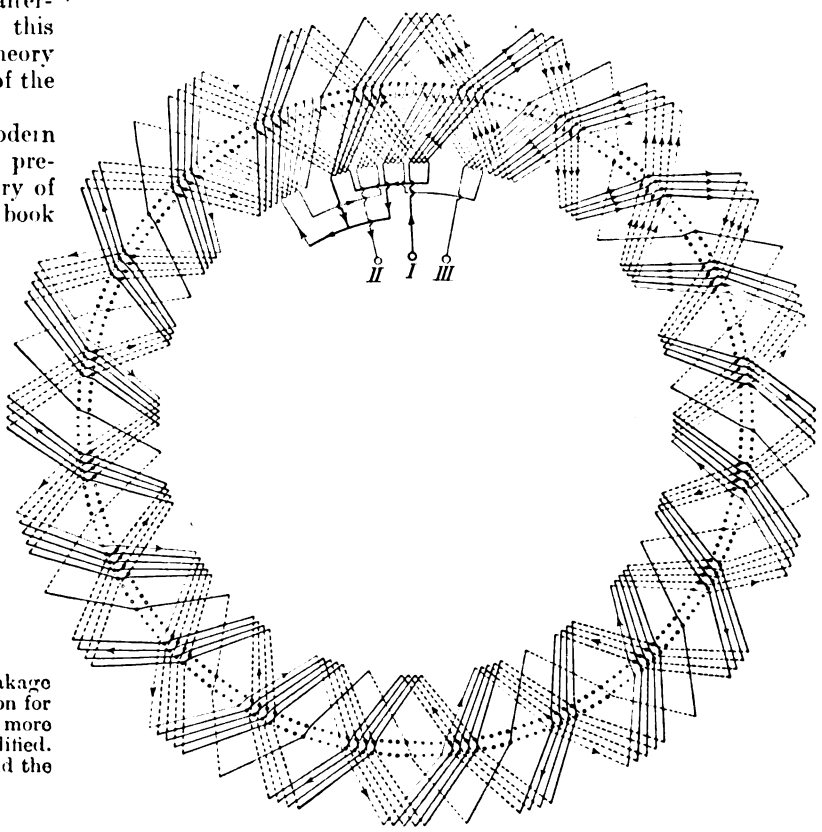

FIG. 7.—WINDING PER POLE. TWO BARS PER SLOT.
Phases I. and II. in series.

The table of experiments gives 96·8 volts for 10 amperes, whence $x_{s_k} = 9{\cdot}68\omega$.

The reactance of the coil ends is increased by

$$\frac{66{\cdot}2}{2 \times 31{\cdot}5} = 1{\cdot}05.$$

There remains

$$x_{s_n} = \frac{218 - 96{\cdot}7 - 66{\cdot}2}{10} = 5{\cdot}5\omega \quad et \quad \lambda_1 = 2{\cdot}59.$$

3. *Three-phase.*—The results are the same as in the preceding case; the mutual induction between the coil ends increases their reactance in the ratio $33{\cdot}5/31{\cdot}5 = 1{\cdot}06$.

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4. *One Phase of the Two-phase Winding.*

$$\lambda_k = 0{\cdot}92\left\{\log\left(\frac{\pi \times 27{\cdot}7}{5}\right) + 6\left(0.68 + \log 1{\cdot}333\right)\right\} = 5{\cdot}57$$

$p=3$, $q=6$.

Whence

$$x_{s_k} = \frac{12{\cdot}5 \times 51{\cdot}5 \times 414^2}{3 \times 6 \times 10^8} \times 26 \times 5{\cdot}57 = 0{\cdot}0614 \times 26 \times 5{\cdot}57 = 8{\cdot}90\omega.$$

The table of experiments gives $90/10 = 9\omega$.

$$\lambda_{s_a} = \lambda_{s_b} = 0{\cdot}46 \times 3\left\{\log\left(\frac{2 \times 680}{210}\right) + A\right\} = 1{\cdot}12 + 1{\cdot}38A$$

$$\lambda_{s_c} = 0{\cdot}46 \times 6\left\{\log\left(\frac{2 \times 680}{470}\right) + A\right\} = 1{\cdot}27 + 2{\cdot}76A.$$

Whence

$$x_{s_a} + x_{s_b} = 0{\cdot}0614 \times 36(1{\cdot}12 + 1{\cdot}38A) = 2{\cdot}47 + 3{\cdot}04A$$

$$x_{s_c} = 0{\cdot}0614 \times 32(1{\cdot}27 + 2{\cdot}76A) = 2{\cdot}49 + 5{\cdot}42A.$$

and $$x_{s_a} + x_{s_b} + x_{s_c} = 4{\cdot}96 + 8{\cdot}46A.$$

The table of experiments gives $\frac{72{\cdot}5}{10} = 7{\cdot}25\omega$.

Whence $A = +0{\cdot}271$.

The second phase with the same values l_s and U_s, although bent back and nearer to the iron, has practically the same reactance.

There remains $x_{s_a} = \frac{205{\cdot}5 - 90 - 72{\cdot}5}{10} = 4{\cdot}3\omega$

and $\lambda_a = 2{\cdot}71$.

5. *Two Phases in Series.*—The results are the same as for the preceding case; the experiment proves that the mutual induction between the phases is negligible.

6. *One Coil of three Slots, a, b and c.*—The reactance x_{s_k} of this coil separately excited is greater than when it forms part of one phase connected three-phase (case 1); there is an augmentation of $\frac{2{\cdot}63}{2{\cdot}24} = 1{\cdot}175$, again due to the disappearance

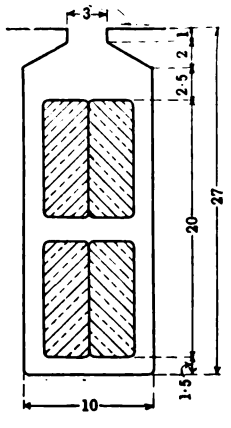

FIG. 8.

of the negative mutual induction between the coils. From the table of experiments the reactance of the end coils, calculated for four coils, is $4 \times \frac{9{\cdot}8}{10} = 3{\cdot}92\omega$, $x_{s_a} + x_{s_c} = 2{\cdot}98 + 3{\cdot}83A$, as in case 1, whence $A = +0{\cdot}245$.

For λ_a the value is still found to be 2·7.

7. *One Coil of two Slots, a and b.*

$l_s = 725$ mm.; $l_{s_a} = 375$ mm.; $U_{s_a} = 155$ mm.

$l_{s_c} = 350$ mm., $U_{s_c} = 175$ mm.

Calculated for four complete coils, we find

$$x_{s_a} + x_{s_c} = 3{\cdot}86 + 4{\cdot}08A = 5{\cdot}11\omega.$$

Whence $A = +0{\cdot}252$.

8. *One Coil of Two Slots, b and c.*

$l_s = 630$; $l_{s_a} = 350$; $U_{s_a} = 155$ mm.

$l_{s_c} = 280$; $U_{s_c} = 175$ mm.

In like manner we find

$$x_{s_a} + x_{s_c} = 3{\cdot}155 + 3{\cdot}55A = 4{\cdot}23\omega.$$

Whence $A = 0{\cdot}309$.

We see that for the coil excited separately (cases 6, 7 and 8), the value of A is about the same as for a winding per pole (cases 4 and 5), whilst it approaches zero for a winding per consequent poles (cases 1, 2 and 3).

This proves that it is, in reality, necessary to differentiate between the winding per pole and that per consequent poles.

By applying the above to several machines the following results have been obtained:—

Winding per pole.				Winding per consequent poles.			
H.P.	p	A	R = x_s measured / x_s calc. (A = 0)	H.P.	p	A	R = x^s measured / x_s calc. (A = 0)
48	1	+0·278	1·32	2,000	2	+0·065	1·08
220	1	+0·360	1·45	5,000	2	+0·05	1·05
220	1	+0·355	1·44	4,500	2	−0·05	0·94
350	7	+0·25	1·32	350	4	+0·065	1·09
175	3	+0·271	1·46	100	4	−0·03	0·96
175	3	+0·245	1·315	175	4	+0·06	1·08
175	3	+0·252	1·33				
175	3	+0·309	1·35				
175	4	+0·420	1·53				

1. *Winding per Pole.*
   A varies between +0·25 and +0·40, mean value: +0·30.
   R varies between +1·30 and +1·50, mean value: +1·4.

2. *Winding per Consequent poles.*
   A varies between −0·05 and +0·07, mean value: +0·03.
   R varies between −0·94 and +1·08, mean value: +1·03.

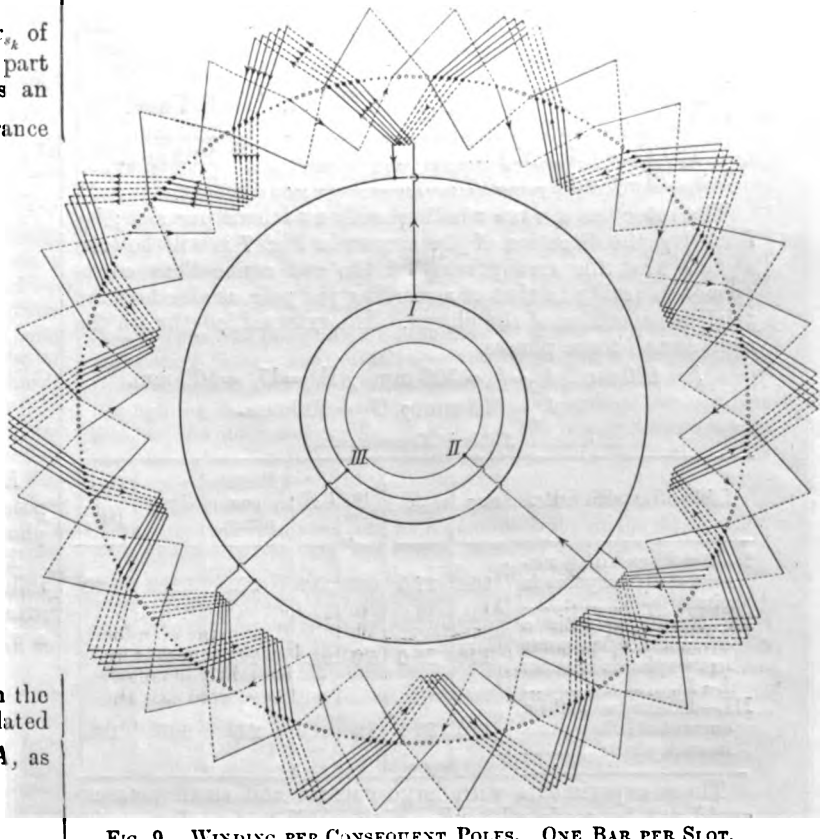

FIG. 9.—WINDING PER CONSEQUENT POLES. ONE BAR PER SLOT.
Phases I. and II. in series.

Eight machines with windings per pole, examined by the new formulæ, give an augmentation of the reactance of the coil ends, due to mutual induction, varying between 1·25 and 1·5, mean value 1·35.

For a winding per consequent poles this mutual induction is negligible.

3. *Permeance* λ_a.

It remains for us to analyse the permeance λ_a; we have written

$$\lambda_a = 1{\cdot}25\left(\frac{r}{3r_3} + \frac{r_5}{r_3} + \frac{2r_6}{r_1 + r_3} + \frac{r_4}{r_1}\right) \text{(Fig. 5)},$$

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but experience shows that the formula gives too small values. The error must be attributed to the two last terms, which must be rectified if we wish to take account of the exact importance of each part.

In tracing out the scheme of the lines of force, it is found that the permeance of the "slit" depends on $\frac{r_5}{r_1}$ and on $\frac{r_1}{r_4}$, so as to take the form $\frac{r_4}{r_1}\left\{1{\cdot}5+0{\cdot}015\left(\frac{r_1}{r_4}\right)^2\right\}=1{\cdot}5\frac{r_4}{r_1}+0\,015\frac{r_1}{r_4}$.

The third term can be made to agree more closely with the actual value by dividing the height r_6 into three equal parts; for simplicity we will divide it into two parts, $\frac{1}{3}$ from the bottom, near to the slit, and $\frac{2}{3}$ above. This term then becomes

$$\frac{2r_6}{5r_1+r_3}+\frac{2r_6}{r_1+2r_3}.$$

From the results of experiments, the curvature of the lines of force near to the slit is found to be so important for high voltage machines with large r_3 and r_6, that it is even necessary to take

$$\frac{3r_6}{5r_1+r_3}+\frac{2r_6}{r_1+r_3}.$$

The complete formula then becomes

$$\lambda_a=1\,25\left(\frac{r_2}{3r_3}+\frac{r_5}{r_3}+\frac{3r_6}{5r_1+r_3}+\frac{2r_6}{r_1+2r_3}+1{\cdot}5\frac{r_4}{r_1}+0\,015\frac{r_1}{r_4}\right).$$

Applied to the motor we have been considering we find (Fig. 6)

$$\lambda_a=1\,25\left(\frac{35}{37}+\frac{6{\cdot}5}{19}+\frac{3\times4{\cdot}5}{5\cdot5+19}+\frac{2\times4{\cdot}5}{5+2\times59}+1{\cdot}5\times\frac{2}{5}+0{\cdot}015\times\frac{5}{2}\right)$$
$$=2{\cdot}64.$$

Bar Windings.

Rotor of the three-phase 175 h.p. Asynchronous Motors, 4 poles, 50 periods, 750 revs. per min.

Dimensions.

$\phi_i=747$ mm.	$\tau=294$ mm.
$l=270-3\times7{\cdot}5$ mm.....	$l_i=260$ mm.
120 slots (10×27)	$t_1=19{\cdot}5$ mm.
S_a...$2-p=4$	$q=5$.

The rotor has a wave winding with two bars per slot; by following the direction of the arrows in Fig. 7 it will be seen at once that the arrangement of the end connections corresponds in reality to that of a winding per pole, as also does the relative deposition of the phases. The external lengths are the same for all three phases.

$l_a=420$ mm., $l_{a_a}=l_{a_b}=300$ mm.; $U_{a_a}=U_{a_b}=100$ mm.
$l_{a_c}=120$ mm.; $U_{a_c}=200$ mm.

Table of Experiments.

Table of experiments.	$e_{0-I.}$	$e_{I.-III.}$	e_k red.	c	Watts per phase.	Cos ϕ	$\frac{W}{I^2R_1}$
I.—Readings with a current of 100 amperes in phase 0—I.....	14·1	17·6	6·85	51·5	270	0·191	1·69
II.—Readings with a current of 100 amperes in two phases in series I.—II.....	17·6	35·0	8·5	51·5	245	0·139	1·57
III.—Readings with a current of 100 amperes in each phase	17·7	30·6	8·6	51·5	230	0·13	1·45

These experiments with large current and small pressure could not be made without an intermediate transformer for raising the voltage to a value suitable for the alternator; so the high harmonics falsify the results by giving too high voltages, especially for single phase.

Separation of the Voltages.

1. *Single Phase per Phase.*—The rotor slots are shown in Fig. 8.

$$\lambda_a=1{\cdot}25\left(\frac{20}{30}+\frac{2{\cdot}5}{10}+\frac{3\times2}{5\times3+10}+\frac{2\times2}{3+2\times10}+1{\cdot}5\times\frac{1}{3}+0{\cdot}015\times\frac{3}{1}\right)=2{\cdot}34.$$

Whence

$$\lambda_{a_a}=\frac{12{\cdot}5\times51{\cdot}5\times40^2}{4\times5\times10^5}\times26\times2{\cdot}34=0{\cdot}000515\times26\times2{\cdot}84$$
$$=0{\cdot}0314\omega.$$

The reactance $x_{a_k}=0\,0685\omega$ was determined by means of auxiliary coils, then $\lambda_k=5{\cdot}12$. Calculation gives

$$\lambda_k=0{\cdot}92\left\{\log\left(\frac{\pi\times16{\cdot}5}{3}\right)+1{\cdot}3\times5(0{\cdot}68+\log B)\right\}$$
$$=5{\cdot}2+5{\cdot}98\log B,$$

$p=4$, $q=5$.

whence B = 0.97.

From this experiment the permeance for a convex polar are seems to diminish less rapidly than the term $p/(p+1)$.

There remains for the end connections

$$\frac{13{\cdot}85-6{\cdot}85-3{\cdot}14}{100}=0{\cdot}0386\omega,$$

$$\lambda_{a_a}=\lambda_{a_b}=0{\cdot}46\times5\left(\log\frac{2\times420}{100}+A\right)=2{\cdot}12+2\,3A,$$

$$\lambda_{a_c}=0{\cdot}46\times5\left(\log\frac{2\times420}{200}+A\right)=1{\cdot}43+2{\cdot}3A,$$

$$x_{a_a}+x_{a_b}=0{\cdot}0002575\times30(2\,12+2{\cdot}3A)=0{\cdot}0164+0\,01775A,$$
$$x_{a_c}=0{\cdot}000515\times12(1{\cdot}43+2{\cdot}3A)=0{\cdot}0088+0{\cdot}0142A,$$
$$x_{a_a}+x_{a_b}+x_{a_c}=0\,0252+0{\cdot}03195A=0\,0386.$$

Whence $A=0{\cdot}42$ and $R=1{\cdot}53$.

2. *Single Phase, Two Phases in Series.*—The reactance x_{a_a} is still $0\,0314\omega$; the experiment gives $x_{a_k}=8{\cdot}5/100=0{\cdot}085\omega$. Whence $\lambda_k=6{\cdot}35$.

$$\lambda_k=0\,92\{1{\cdot}24+0{\cdot}8\times10(0{\cdot}68+\log B)\}=6{\cdot}15+7{\cdot}35\log B.$$

$p=4$, $q=10$.

We thus find for B a value even greater than unity.

There remains for the end connections $0{\cdot}175-0{\cdot}0314-0\,085=0{\cdot}0586\omega$; there is thus an augmentation of $0\,0586/0{\cdot}0386=1{\cdot}52$ by mutual induction.

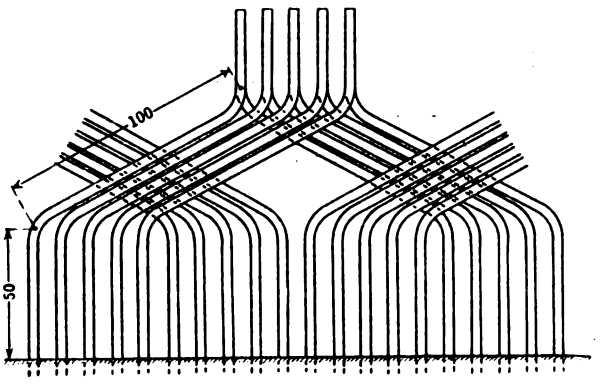

Fig. 10.—One Bar per Slot.

Rotor of a Three-phase Asynchronous 175 h.p. Motor, 20 poles, 50 periods, 800 revs. per min., 5 slots per pole and phase.

This rotor has a ware winding with one bar per slot; by following the arrows in Fig. 9 it can be seen at once that the arrangement of the end coils corresponds in reality to that of a winding per consequent poles, as also does the relative posi-

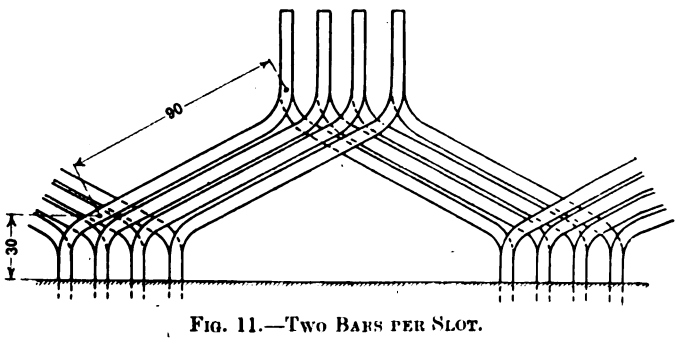

Fig. 11.—Two Bars per Slot.

tions of the phases. The sole difference is that the end connections on one side are not facing those on the other. Fig. 10 shows their arrangement exterior to the core.

Fig. 11 relates to the stator of this motor with four slots per pole and phase and two bars per slot, which therefore really forms a winding per pole.

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Resumé.—The reactance of the stator of an alternating current machine can be calculated by considering the three permeances, λ_a, λ_b and λ_c.

1. $\lambda_a = 1{\cdot}25\left(\frac{r}{3r_3}+\frac{r_3}{r_3}+\frac{3r_3}{5r_1+r_3}+\frac{2r_3}{r_1+2r_3}+1{\cdot}5\frac{r_1}{r_1}+0{\cdot}015\frac{r_1}{r_1}\right)$.

2. For a winding:

$q=\frac{1}{2}Q\ldots\lambda_c=0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right)+q\left(0{\cdot}68+\log\left(\frac{p+1}{p}\right)\right)\right\}$

$q=\ \ Q\ldots\lambda_c=0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right)+0{\cdot}5q\left(0{\cdot}68+\log\left(\frac{p+1}{p}\right)\right)\right\}$

$q=\frac{1}{3}Q\ldots\lambda_c=0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right)+1{\cdot}3q\left(0{\cdot}68+\log\left(\frac{p+1}{p}\right)\right)\right\}$

$q=\frac{2}{3}Q\ldots\lambda_c=0{\cdot}92\left\{\log\left(\frac{\pi z_1}{r_1}\right)+0{\cdot}8q\left(0{\cdot}68+\log\left(\frac{p+1}{p}\right)\right)\right\}$

3. For a winding per consequent poles, $\lambda_c=0{\cdot}46q_c\left(\log\frac{2l_c}{U_c}\right)$

in which λ_c must be divided into two parts a and c; the mutual induction between phases is negligible.

For a winding per pole $\lambda_c=0{\cdot}46q_c\left(\log\frac{2l_c}{U_c}+A\right)$ where l_c must be divided into three parts, a, b and c ($a=b$ for a winding in which q is an even number); A varies between 0·25, and 0·40; as an average value A = 0·3.

It may also be written $\lambda_c=0{\cdot}46q_c\times R\left(\log\frac{2l_c}{U_c}\right)$ where R varies between 1·3 and 1·5, in the mean R = 1·4.

For the winding per pole the mutual induction between phases augments the reactance of the coil ends by 1·25 to 1·5, an average of 1·35.

THE BEARING OF REFLECTION ON ILLUMINATION.*

BY A. S. MCALLISTER.

Summary.—The author describes a simple arithmetical method for taking into account the effect of reflections between surfaces and ascertaining the distribution of the light flux.

One of the problems connected with illumination which has usually been considered too complicated to admit of simple calculation is that dealing with the reflections and inter-reflections from and between the ceiling, floor and walls of a room. In practical illuminating engineering work the problem has been looked upon as being so complicated that use has been made of some approximate solution based largely upon the knowledge of results obtained previously under similar conditions.

The simple method here suggested has as its foundation on the absorption-of-light method of calculating illumination. According to this method, the lighting units in a room must produce the sum of the lumens absorbed by the various surfaces, the lumens absorbed by each surface being determined as the product of the area of the surface in square feet, the incident illumination density in candle-feet and the absorption coefficient. The method gives no clue as to the distribution of illumination over each surface, but takes fully into account all the inter-reflections between the various surfaces, and permits one to ascertain the total amount of light which the lamps must supply directly to each surface involved.

Thus, let us consider first the relations in an extremely narrow, long hall of great height, against one wall of which a total light of, say, 2,000 lumens (160 mean spherical candles) is sent directly from the lamps, the other wall being illuminated exclusively by the light reflected from the former wall; assume that the light-absorption coefficient for each wall is 0·20. The problem is to determine the total incident flux on each wall and the amount absorbed by each. Assign arbitrarily a value of 100 units to the total light incident upon the first wall. Eighty per cent., or 80 units, of this light are reflected to the other wall, where 20 per cent., or 16 units, are absorbed, 64 units being returned to the first wall. Thus, of the 100 units reaching the first wall 64 are reflected from the second wall and 36 come directly from the light sources. The 36 units of light are equal to 2,000 lumens, so that each unit has a value of 55·55 lumens. It is seen, therefore, that on the first wall the incident lumens have a value of 5,555, of which 2,000 come directly from the lamps and 3,555 are reflected from the second wall. The second wall receives $5{,}555\times0{\cdot}80=4{,}444$ lumens, and reflects $4{,}444\times0{\cdot}80=3{,}555$ lumens to the first wall. The former wall absorbs $5{,}555\times0{\cdot}20=1{,}111$ lumens, and the latter $4{,}444\times0{\cdot}20=888$ lumens, the total being the 2,000 lumens produced by the lamps. The calculations show that, quite independent of the wall upon which the light falls directly from the lamps, the illumination upon one wall cannot differ from that upon the other by more than 20 per cent. when the light-absorption coefficient has a value of 0·20.

Taking next the case where one wall has an absorption coefficient of 0·10 and the other a coefficient of 0·50, the author shows that, quite independent of the wall upon which the 2,000 lumens from the lamp fall directly, that wall receives an incident flux of 3,636 lumens, while the other wall receives a value less than this amount by the light absorbed by that wall upon which the rays from the lamp are directed. With the rays directed toward the wall having a low absorption coefficient the other wall received 3,272 lumens, while with the rays in the opposite direction the indirectly lighted wall received 1,818 lumens. It is evident from the above that reflection may play a highly important part in illumination, and that the direction of the light from lamps becomes of less and less importance as the coefficient of absorption decreases. The absorption-of-light method of calculation thus affords a valuable insight into the limitations upon the distribution of illumination between inter-reflecting surfaces, and represents a convenient simple method for solving certain of the problems in illumination usually considered complex.

It is interesting to apply this method to the determination of the exact amount of flux which the lighting units must direct toward each of two inter-reflecting surfaces illuminated to different light densities and having different absorption coefficients. Assume that in a room 10 ft. wide by 15 ft. long, having a ceiling absorption coefficient of 0·20 and a floor coefficient of 0·90, the incident ceiling illumination is to be 1 candle-ft. and the incident floor illumination 3 candle-ft. Neglect the reflection to and from the walls from and to the ceiling and floor, or rather assume that the light received by the walls from the ceiling and floor is equal to that reflected from the walls to the other surfaces. The total incident ceiling illumination will be $15\times10\times1=150$ lumens, of which $150\times0{\cdot}20=30$ are absorbed and 120 are reflected to the floor. The incident illumination on the floor will be $15\times10\times3=450$ lumens, of which 405 are absorbed and 45 are reflected to the ceiling. Of the flux of 150 lumens on the ceiling 45 come from the floor, so that the lamps must supply 105 lumens. Similarly, the lamps must supply $450-120=330$ to the floor. The ceiling receives directly from the lamps 105 lumens and absorbs only 30 lumens, while the floor receives 330 lumens from the lamps directly and absorbs 405. It will be seen that the total lumens absorbed are 435, and this total is equal to the sum of the fluxes sent to the surfaces from the lamps, but there is no immediate relation between the lumens directed toward each surface from the lamps and the lumens absorbed by that surface. Thus, the lamps send 330 lumens to the floor; which absorbs 405 lumens from a total of 450 received by it. It is noteworthy in this connection that the familiar point-by-point method applied to the lighting installation here assumed would indicate an incident flux on the floor and ceiling of 330 and 105 respectively, whereas the true values are 450 and 150, the increase being due solely to the inter-reflection between the two surfaces.

An objection which may be urged against the absorption-of-light method is that it ignores any lack of uniformity in the distribution of illumination over the individual surfaces considered. Such a criticism is fully justified by the facts, but it has no bearing on the value of the method both as a check on other methods which take into account the variation of light distribution and as a direct final method to be used in problems where the variation in light density is of no importance. For solving problems connected with the illuminating of reflecting surfaces, investigating quantitatively the effect of inter-reflection between surfaces and ascertaining the limits in the distribution of light flux between illuminated surfaces, the absorption-of-light method should prove of much value to the illuminating engineer.

* Abstract of an article in the "Electrical World."

TRACKLESS TROLLEY SYSTEMS ON THE CONTINENT.

In the autumn of last year the Bradford Corporation decided to appoint a committee to visit the various trackless trolley systems employed on the Continent, with a view to examining into their special features and to discovering whether any of them would be suitable for use in Bradford.

The committee left this country on November 27th last, and inspected a number of systems in use on the Continent, as well as a number of tramways worked in the ordinary way. They have now issued their report, which deals at considerable length with both these subjects.

After describing the Berlin and Vienna tramways, the report goes

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on to deal with the Mercedes-Stoll system used on the trackless trolley cars, on the outskirts of the latter city. In this system, it will be remembered, the overhead equipment is similar to that of an ordinary tramway, with the exception that the wires are supported in such a manner that the trolley bogie, which is simply a four-wheel trolley, runs along the wires similar to a bogie running on an ordinary railway track. This is electrically connected to the vehicle by means of an insulated cable terminating on a spring drum, which is so designed that the slack of the wire is automatically taken up, or additional cable paid out, according to the circumstances of the case. The driving arrangements on the platform are similar to those of an electric car. The motors on this particular system are gearless, and are contained in the hub of the rear wheels. The vehicle is rubber-tyred and has a seating capacity of from 12 to 15 persons, and runs along the road very smoothly and practically without noise. Due to the flexibility of the trolley arrangement, it is almost as free in its use of the road as a self-propelled type of vehicle.

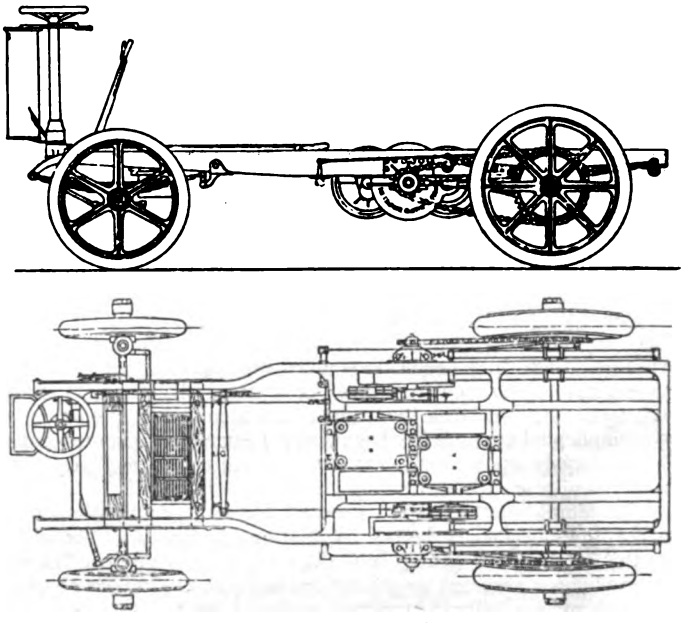
The steepest gradient on the route inspected by the deputation is 1 in 12, and the surface of the roadway being fairly good, the vehicles have no difficulty in negotiating it. The running speed of the vehicle is fairly high and comparable with that of an ordinary tramcar. The running cost of these vehicles in Vienna is very low, namely, 4·52d. per bus-mile. This is, however, with a driver only the entrance and exit to the vehicle being at the driver's end, thereby dispensing with the services of a conductor. The deputation were informed that the overhead equipment on this particular route cost from £700 to £800 per mile, but that was with the use of wooden poles, and the equipment generally was of a cheaper construction than what is usual in this country. The deputation estimate that in England the overhead equipment for railless electric traction would cost roughly from £1,200 to £1,500 per mile, thus showing a considerable saving on capital account, and hence in standing charges, over an ordinary tramway system costing, inclusive of permanent way, £13,000 to £15,000 per route-mile. This consequently renders the railless trolley system an almost ideal method for the testing of proposed routes for traffic purposes, and for the serving of districts where the population is so meagre that the laying of permanent way and the instituting of an ordinary tramway service is entirely out of the question. The roadway is of the ordinary macadamised type and similar to the high roads in this country. The deputation are of opinion that the wear and tear of the roadway, as a result of this traffic, is not in excess of that occasioned by ordinary road vehicles of similar size and weight; in fact, the use of rubber in place of iron tyres, which are mostly used by other vehicles of similar weight, should occasion less road wear. So far as the deputation can at present see, a vehicle suitable for English conditions, carrying about 20 passengers, with a driver and a conductor, could be operated on average roads in the Bradford district at about the same running cost per car-mile as an ordinary 60 passenger tramcar, viz., 7·25d. The Vienna Tramways Department have experimented largely with petrol-driven vehicles in competition with this system, but the high cost of maintenance of a petrol engine, coupled with the noise and smell, caused it to be very much out-distanced by the railless trolley vehicle.

A further system of railless trolley belonging to a company near the small village of Klostermenberg, about 20 miles from Vienna, was then inspected. This system differs from the one previously mentioned, in that only two trolley wires in place of four are used. The vehicles are similar to those in use in Vienna, but when two vehicles desire to pass it is necessary for drivers to bring their respective car platforms together and change trolleys from one car to the other.

At Milan the deputation inspected the "Filovia" system, which is in use in several parts of Italy. The route extends from Argegno to St. Fedele, which is on the summit of a range of mountains. The road is of the ordinary macadam type, but, due presumably to the steep gradient and curves, is not in a very good state of repair. It contains several very sharp "hairpin" turns, some of which are so stiff that notwithstanding the short wheel-base of the vehicle the driver found it necessary to proceed part way round the curve, reverse, and manœuvre in that way in many places where the gradient was in the neighbourhood of 1 in 8 or 1 in 9. The rise from Argegno, which is 656 ft. above sea level, is continuous up to St. Fedele, which is 2,582 ft. above sea level. The distance between the two places is a little under 5·5 miles, the average rise is therefore about 6 per cent. or 1 in 16·5, and reaches at places nearly 13 per cent. or 1 in 7·7.

The overhead line is composed of two trolley wires 9 mm. in diameter suspended in the usual way, and supported by wooden and steel poles. Unlike the Vienna system, only two wires are in use—a negative and a positive—these serving for the up and down cars. The line is fed with continuous current at a pressure of 600 volts by an overhead feeder carried by the same pole that supports the trolley wires. The car shed, which is situated at the summit of the line, is large enough to accommodate 12 cars, but at the present time the company has only four passenger cars and one goods wagon. The chassis, a diagram of one of which is shown herewith, are of the standard "Filovia" design, and are equipped with two 12 H.P. motors arranged for running in series or parallel.

The wheel-base on these cars has been kept shorter than usual (only 9 ft.) on account of the sharp curves, some of which have a radius of less than 20 ft. (The sharpest curve on the tramway system in Bradford is 40 ft.) The road wheels of the cars are fitted with single solid rubber tyres both front and back. The drive from the motor to the wheel is by means of sprocket wheel and chain, similar to the drive on a petrol motor omnibus without differential. Efficient brakes are fitted to the vehicle of both mechanical and electrical designs. The down trips on this route are always performed without utilising any electrical energy, with the exception of starting at the terminus. The cars are of the single-deck type, with seating capacity for 18 to 20 passengers, and accommodation for luggage on the roof. The weight of the cars when empty is 3½ tons. The deputation were informed that since the line was opened to the public there had been no serious interruptions, and if this is so it is a remarkable record, considering the very difficult character of the road. The railless system of traction which is being developed in Italy under the name of "Filovia" by the Società Trazione Elettrica of Milan has been found to be of considerable utility to the public. The first line of this system was laid from Pescara to Castellmare. This was constructed in 1904, and since that date a number of lines have been put in, totalling well over 50 miles in different parts of the



PLAN AND ELEVATION OF "FILOVIA" MOTOR CHASSIS.

country, all of which are in regular daily use. As a proof of the non-experimental character and stability of the railless trolley system in Italy it is interesting to know that the Italian Government have decided to grant a subsidy of £60 a year for each mile of line equipped on the railless system in districts not provided with railway or tramway service.

The trolley and current-collecting apparatus is different from that in use in the "Mercedes-Stoll" system. Instead of the four-wheel trolley bogie running on the upper-side of the wire these vehicles are equipped with an ordinary trolley pole with a specially designed head running on both wires, very similar in construction and operation to the trolley poles in use on the cars in Bradford. The mobility of the vehicle with the length of trolley-pole as in use on the Argegno line allows the car to travel on any portion of the 14 ft. of roadway, *i.e.*, 7 ft. on either side of the trolley wire. The vehicle may be stopped and turned completely round without any attention being paid to the trolley pole, the trolley taking its natural position according to the direction in which the car is travelling.

From figures supplied it appears that the energy consumed per ton-mile is about the same as that consumed on a tramcar. This is somewhat surprising, as one might expect the tractive effort of rubber tyres on an ordinary roadway to be much in excess of that of a tramway rail. The explanation, however, is probably to be found in the fact that more modern motors, of greater efficiency than the old type of tramway motor, are in use, and to the use of rubber

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tyres; in addition the freedom of each driven wheel to take its own course when rounding curves is a very excellent electrical differential. The steering and control of the car is quite as good, if not better, than the control of an ordinary petrol vehicle of similar dimensions.

The deputation are indebted to Herr Webber, the general manager of the Electric Tramways Company of Spezzia, who is working a railless trolley line on the "Filovia" system from Spezzia to Fezzana, for the following figures extracted from the tramway company's accounts :—

	Pence per car-mile.
Cost of energy	0·41
General expenses	0·59
Rubber tyres	2·16
Wages—Drivers and conductors	1·40
Renewals of vehicles and line (depreciation, &c.)	0·62
Repairs to vehicles	0·46
	5·64

The circumstances of the inauguration of the installation at Mülhausen are somewhat peculiar. The tramways of Mülhausen are company-owned and operated. Some years ago the municipality requested the company to run a line out to the Zoological Gardens—a pleasure resort about 1½ miles from the centre of the town. This, however, the company declined to do on the ground that the proposed route, in their opinion, would not pay. The Corporation, therefore, installed a system of railless traction municipally operated and managed. The vehicles are of somewhat peculiar design, being fitted with iron shod wheels, the motor being attached to the front wheels and forming part of the steering bogie. The trolley-pole is similar to the Italian system. The system seems to have proved itself of great utility to the Mülhausen Corporation, and residents are provided with a way out of what was, apparently, a deadlock, insomuch that an efficient means of transit was obtained to a point where possibly a tramway line would not have paid. The gradients on the road are very heavy, but the deputation were informed that no damage had been done to the roads, beyond what one would expect with an ordinary vehicle of similar weight and dimensions.

In conclusion, the deputation are of opinion that the railless trolley systems as seen in Vienna and in Italy are such that either system could be adapted to English conditions and prove of great value to tramway authorities and to the public, in providing a means of transit to districts where the heavy capital cost would prohibit the construction of an ordinary tramway.

CORRESPONDENCE.

THE CRADLE DYNAMOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the interesting article by Messrs. Davies and Shaw on the application of the cradle dynamometer, published in your issue of the 8th inst., and to the letter of Dr. C. V. Drysdale on the same subject, I beg to point out that since the year 1902 the Laboratorio di Elettrotecnica del R. Istituto Tecnico Superiore has possessed a cradle dynamometer with knife edge suspension, designed by myself, which gives very satisfactory results.

A brief illustrated description of the apparatus appeared, on May 1, 1903, in "Engineering," on the occasion of the visit to Italy of the Institution of Electrical Engineers. From it you may see that the suspension is a knife-edge articulated parallelogram, like the one which, with a different arrangement, has been used by Dr. Drysdale.

To confirm Dr. Drysdale's statements, I may mention that ball bearings were rejected by me *a priori* for lack of sensibility, while during the past eight years it has only once been necessary to overhaul the knives of the suspension. As to the position of the machine to be tested, I would point out that, in order not to overlook the windage losses, it is convenient to place the machine to be tested upon the swinging frame when the machine is a motor, and to place the machine to one side when it is a generator, in accordance with the disposition at the Northampton Institute. Doubtless, to centre the machine upon the swinging frame requires some care and takes some time; therefore, Dr. Drysdale's disposition is preferable for ordinary measurements.

I am sending you separately a Paper on my dynamometer, and I shall be glad if you will publish my letter in your much esteemed journal.—I am, &c.,

Milan, July 20. ING. ANGELO BARBAGELATA.

FISCAL POLICY AND THE ELECTRICAL INDUSTRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Hookham does not attempt to justify his "Imports pay for Exports" theory, but retires again behind his comprehensive challenge. To deal with this challenge adequately would require much more space than one could ask from a technical journal, while on the other hand (as one of your correspondents pointed out) "nut-shell arguments" are never complete. As I prefer to err on the side of brevity, I would submit the following lines of argument to Mr. Hookham as giving a first approximation to the truth.

(A) *Home Consumption* :—

1. Any rise in price due to Protection gives a bigger margin for the producer.
2. The consumer is in general also a producer, whether as capitalist, overseer or artisan.
3. While an individual loses as a consumer, he gains as a producer, and his purchasing power is not decreased, but probably slightly increased. (Example, wages and average prices in U.S.A.)
4. Home consumption will not go down.

(B) *Export* :—

1. Mr. Hookham says that under Protection the manufacturers will make a profit.
2. A paying industry can go in for development and can raise capital for subsidiary companies.
3. Foreign trade of recent years has depended more on enterprise and commercial development than on price. (Example, German trade with S. Africa, India and China.)
4. Even without Colonial preference our exports need not decrease, but rather the reverse.

(C) *Employment* :—

Assuming that the Home and Foreign demands remain the same, employment under Protection is obviously increased directly by the labour value of the "ready-made" goods excluded, and indirectly by the more rapid development of a dividend-paying industry.

If Mr. Hookham still objects that there must be imports to "pay" for exports, I would remind him that scientific Tariffs are not directed against foreign material, but foreign labour. Why should we be the only country that will take payment in any form the customer chooses?

One cannot help wondering where Mr. Anderson has been living for the last 10 years. Has he never seen goods "Made in Germany," or had to cut his prices in competition with a foreign firm? If he disregards the American competition of the recent past, and the German competition of the present, I suppose it is no use to suggest to him probable trouble from Japan in the near future.—I am, &c.,

Norwich, July 27. S. E. GLENDENNING.

THE DOLTER SURFACE CONTACT SYSTEM AT TORQUAY.

Our readers will remember that there has been a good deal of dissatisfaction in regard to the working of the Dolter surface contact system at Torquay, and that the Board of Trade recently decided not to renew the certificate under which the line was being worked. We have now received a copy of a report by Messrs. Mordey & Dawbarn to the Town Clerk of Torquay on the position of affairs, and in what follows we give an abstract of this report. The instructions received were to report (*a*) whether the present Dolter system could be improved and perfected so as to render it satisfactory, and (*b*) whether any other surface contact system could be substituted which would be satisfactory. The answer given to both of these questions is in the affirmative. Mr. Mordey visited the town in order to inform himself of the working of the system there, and also had an interview with Mr. T. B. Holliday, the engineer and manager of the Hastings Tramway Co., where the Dolter system is also being used. The report states that :—

The defects may be divided into those which cause dead studs, or studs which do not make connection between the cable and the car—or

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which are sluggish and do not make the connection quickly enough—and live studs, or those in which this connection is maintained more or less perfectly when no car is present. The principal external evidence of unsatisfactory working was the frequent flashing or arcing between the collector skate and the studs, and the flickering—or more often the complete extinction—of the lights in the cars at night, due to dead or sluggish studs. Some of these defects are caused by insufficient magnetisation of the collecting skates. When there are two or three dead studs together, the car can get no current. When a car by its momentum runs over such studs, or over two or three sluggish studs, the circuit is interrupted, the motors get no current, and at night, the lamps are momentarily extinguished. The number of these dead or sluggish studs may be illustrated by the fact, that on one journey of about a mile along the Torbay-road, there were no less than 63 total extinctions of the lamps. And on some other sections of the line, especially on down gradients, the extinctions were so frequent that it was not possible to count them. In spite of this condition, the cars were very seldom unable to start. Mr. Mordey saw only one such stoppage, the car having to be crow-barred a few feet to reach a working stud. This may be taken as evidence, that many of the studs which do not act when the cars are moving quickly, are merely slow in action. Many of them would probably respond sufficiently quickly to a more strongly magnetised skate.

After referring to the cause of arcing and of live studs generally, the report proceeds:

On two separate occasions when Mr. Mordey was present, a car was not stopped when the detector bell rang. This detector, consisting of a trailing wire brush which is carried by the car, indicates by means of an electric bell, the presence of live studs. This device appears to be quite effective, except in the case of some of the curves, where it was noticed the brush was not wide enough to reach the studs as the car passed round the curves. This could easily be remedied. The dead studs are much more numerous than the live ones. There have been a good many cases of horses receiving shock, and it was stated that two or three horses have been killed. It is known that horses are very susceptible to electric shock, and with the line in its present condition, it is not surprising that there have been complaints from this cause. We understand that there has only been one complaint of shock to a human being, and the effect in that case does not seem to have been at all serious.

Although these various faults are of very frequent occurrence, they do not seem to interfere with the traffic. The attention that is given to the studs is apparently just enough to prevent loss of revenue. We are of opinion that the number of the faults is largely increased by the fact that so many studs are allowed to remain in a known defective condition. For example, the presence of dead studs greatly increases the liability of the adjacent good studs to break down by throwing on them an unduly heavy load. The engineer stated that only three men were employed on the road on the upkeep of the studs.

Messrs. Mordey & Dawbarn understand that the company bases its claim to abandon the surface contact system and to install the overhead trolley system on the high cost of working the former. This is not borne out by a comparison with three other typical places having heavy gradients, viz., Bradford, Halifax and Huddersfield. Costs are also given for Wolverhampton and Lincoln, where surface contact systems are in use. Experience shows that the energy taken by the collectors is not large, and that surface contact systems do not take appreciably more energy than trolley systems. The engineer informed Mr. Mordey that leakage amounted to 0·7 to 1 ampere per mile of track. Traffic costs are also lower than the average of 19 tramways having car mileages comparable with that of Torquay. The management and general expenses at Torquay are rather high, but this is not due to the system. The cost of repairs is less than for the average three hilly towns mentioned. The cost of power is high, but this is not due to the system, and the price charged, namely, 1·57d. per unit is very reasonable. The report proceeds further:

The defects found at Torquay, which have led the Board of Trade to intimate its intention to withdraw its licence, must be regarded as matters of detail rather than of principle and are capable of being met by an improved working of the system without any necessity of changing the system. We believe that by greater care and attention, the present studs could, without prohibitive cost, be made to work satisfactorily and if there were no reasonable alternative to this course, we think it would enable the company to satisfy the Board of Trade. We find, however, that an offer has been made to replace the parts of the stud which have given trouble by a simplified and improved modification. This offer, of which you have been informed, has been made by Mr. E. A. Mitchell, who was the engineer to the company that put the system down. We have carefully studied this improvement and are of opinion that the studs, so modified, would give greatly improved results, and would be more easily maintained.

In conclusion Messrs. Mordey & Dawbarn state that Mr. Mitchell, the engineer of the company supplying the equipment, is willing to modify the studs at a cost of £590 per mile, or a total of £6,500, with a contract price for maintenance of the studs of 0·22d., or, including the maintenance of the collectors, 0·23d. per car mile, which is considerably less than the £10,000 which, it appears, the tramway company is prepared to spend in putting in a trolley system. They think that the company should be strongly urged to adopt Mr. Mitchell's proposal.

In regard to the second question, Messrs. Mordey & Dawbarn refer to the Lorain system at Wolverhampton and the "G.B." system at Lincoln, and state that if it were necessary to change the surface contact system at Torquay, which is not the case, there is no reason to doubt that either of these systems would give satisfactory results. Torquay presents special features, in that there are steep gradients, and that a short length of the line along the sea front is occasionally drenched with sea water. Messrs. Mordey & Dawbarn do not consider that these conditions would cause the Wolverhampton or Lincoln systems to be unsuccessful at Torquay, provided suitable precautions were taken.

In an appendix some particulars are given of the Dolter system at Hastings, where it is used on 4 miles of track along the promenade. Occasionally the sea washes over the road, in which case extra men have to be put on to keep the skate and collector equipment on the cars in order. The studs require a good deal of attention, and in the course of a year about half of them have to be taken out, repaired and put back. About 5 per cent. of the studs require replacing each year. Twenty cars are running, and a large part of the trouble with collectors and skates is probably due to the fact that the cars have to be adapted to the double service, skates having to be raised when they get on to the trolley part of the line. Mr. Holliday finds that the maintenance of the surface-contact part of the line is about double as much per mile as with the overhead, and there is also considerable expense in the upkeep of skates. Difficulties with live and dead studs are reduced to a minimum by careful attention. The studs that are reported as "alive" amount to about 7 per cent. of the total per annum. The detector works effectively. The causes of live studs, as at Torquay, are carbonised oil, water and contact levers sticking. In cold weather there are a greater number of live studs owing to increased viscosity of the oil. Hardly any explosions have been experienced. Dead studs are more common than live ones, about 43 per cent. of the former being reported in the course of a year.

PARLIAMENTARY INTELLIGENCE.

LONDON ELECTRIC SUPPLY BILL.

This bill, which constitutes the London County Council the purchasing authority in regard to the five remaining London electricity supply companies was read a third time in the House of Commons on Thursday last and a first time in the House of Lords on Monday.

LONDON UNITED TRAMWAYS BILL.

On Thursday last this bill came before the House of Commons Committee on Unopposed Bills (presided over by Mr. Emmott).

Mr. CRIPPS, for the company, explained that a number of rather onerous conditions for the protection of Richmond Corporation were imposed on the company by their 1902 Act authorising the construction of a tramway in Richmond, and the company had not thought it worth while to incur the expenditure involved. In 1909, however, the company were authorised to construct a tramway across Kew Bridge to link up with their system in Brentford. The Richmond tramway had, therefore, become desirable in order to avoid a hiatus in the system. Richmond Corporation had consented to the insertion of a clause in the bill enabling variations to be effected in the conditions imposed by the Act of 1902 as to the form of construction.

The Committee passed the bill, ordered it to be reported for third reading, and granted an extension of time for the Richmond tramway until Aug. 1, 1912.

LONDON COUNTY COUNCIL (TRAMWAYS & IMPROVEMENTS BILL).

The Select Committee of the House of Lords, presided over by Lord Clinton, concluded the consideration of this bill on Monday.

Amongst the proposals in the bill were tramways in south London along Effra-road and Dulwich-road to Norwood-road, and along the upper

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part of Tooley-street to a point near London Bridge. The House of Commons Committee which previously dealt with the bill passed the latter proposal as submitted and the former in an amended form.

The Committee decided to pass the clause relating to the line from Brixton-road to Norwood-road, that Dulwich-road should be widened, and that Lambeth Council should contribute £200 or (if a smaller sum) one-fifth of the cost of the widening.

The CHAIRMAN said the Committee were convinced that the extension of the line of tramway down Tooley-street would be an undue interference with the traffic and the legitimate business carried on there by wharfingers and others and they declined to sanction it.

Mr. ERSKINE POLLOCK, K.C., explained the proposal to erect and maintain shelters for passengers at Stamford-hill, New Cross and at the Blackfriars end of the Victoria Embankment. The two first would cost from £200 to £300 each, and the last mentioned (which would be 180 ft. long) £1,800.

It was agreed between counsel that the limit of time during which the Corporation could not demand the removal of the Embankment shelter should be 10 years.

The Committee decided that the shelters should be erected, subject to the 10 years proviso in respect to the Corporation.

SCIENTIFIC RESEARCH.

In the House of Commons on Thursday last Mr. LYNCH asked the Prime Minister whether, in view of the extension of higher education in neighbouring countries of recent years, and in view of the vastness of the industrial results which had had their origin in scientific research, he would consider what means could be taken to give a stimulus to such research in this country; and whether he would raise the office of the President of the Board of Education to the level of importance of that of any other great Department of State.

In reply, Mr. ASQUITH said the Government always had in view the objects advocated by the hon. member. He did not see how they would be promoted by the suggestion made in the second part of his question.

Scottish Electric Lighting Orders.—A Select Committee of the House of Lords, presided over by Lord Clinton, last week decided to allow the Electric Lighting Orders (No. 2) Bill to proceed. The bill relates to electricity supply undertakings in Ardrossan, Saltcoats and Cambuslang.

Bath Electric Lighting Extension Bill.—On Thursday last this bill, promoted by Bath Corporation, and which has already passed the House of Lords, was sent by the Examiner for second reading in the House of Commons.

Provisional Order [Confirmation Bills.—The unopposed bills to confirm the electric lighting orders granted to Clevedon District Council and the Gorseinon Electric Light Co. were passed by the Chairman of Committees of the House of Lords last week, and ordered for third reading.

Miscellaneous Bills.—On Monday in the House of Lords the Middlesbrough Corporation, Rhondda Urban District Council (Tramways Extensions, &c.) and Bradford Corporation Bills were read the third time and passed.

Royal Assent.—On Tuesday the Royal assent was given to the London Electric Railway Amalgamation, Metropolitan Railway, Wimbledon & Sutton Railway, Baker-street and Waterloo Railway and other bills.

LEGAL INTELLIGENCE.

Limited Liability Companies and Private Generating Plant.

In the Chancery Division on Tuesday, Mr. Justice Joyce heard a petition by the Hendon Paper Works Co. (Ltd.), of Sunderland, to sanction the extension of its objects in various ways, including the generation of electrical power for the purposes of lighting and heating their works.

The application was opposed by the Town Council of Sunderland on the ground that by their provisional order of 1891 they had the sole right to supply electricity within the borough, and that the extension of the applicants' powers as asked would enable them to finance or run an electric lighting company and so seriously depreciate the value of the Corporation's undertaking.

Having heard the arguments of counsel, his lordship made the order asked for by the company.

Unfenced Machinery.—At Birmingham Police Court on Friday, the Electric & Ordnance Accessories Co. were summoned for failing to have a machine fenced as required by the Factory Acts.

It was stated that a youth named Thorneywork was engaged at a milling machine cutting metal, and on reaching to adjust an arm, which had not been protected by a guard, his sleeve was caught by the circular saw and his hand and arm severely lacerated. Mr. Gibbs, for the defence, submitted that the guard was not on the machine owing to the negligence of a workman. The clerk pointed out that defendants were not exempt on this ground unless they had secured a conviction against the workman, and an adjournment was granted to enable proceedings to be taken against the workman.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The governing body of the Northampton Polytechnic Institute London, invite early applications for the appointments of senior assistant in the electrical engineering department, to take charge of new electric generating station (salary 45s. per week); junior assistant in electrical engineering department, chiefly to take charge of producer plant (28s. per week); second lecture assistant in electrical engineering department (£80 per annum); and assistant lecturer and demonstrator in the mechanical engineering department (£120 per annum). The appointments will take effect after the summer vacation. Particulars from the office of the Institute or from the principal, Dr. R. Mullineux Walmsley. See advertisement.

The Council of the University of Birmingham invite applications for the appointment of assistant lecturer and demonstrator in electrical engineering. Candidates must be graduates, and must have had experience in the test room of first-class electrical engineering firm. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by Sept. 17. See an advertisement.

Taunton Corporation require a borough electrical engineer. Commencing salary £200 and half pupils' premiums. Applications to the Town Clerk by 9 a.m., Aug. 4.

The Victoria Falls and Transvaal Power Co. require six shift engineers (£35 per month each), three boiler house superintendents (£35 per month), six senior switchboard attendants (£25 per month), and six junior switchboard attendants (£21 per month). Applications to the Secretary, 2, London Wall-buildings, London, E.C.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

A lecturer in mechanical engineering is required at Blackburn Municipal Technical School. Salary £120 to £140. Forms from the Director of Education. Applications by Aug. 13.

A teacher for evening classes in electrical engineering and magnetism and electricity is wanted for the Gt. Eastern Railway Institute, Stratford, London, E. Applications by Aug. 2 to Mr. T. O. Mein, Loco. Works, Stratford.

A second demonstrator in the department of chemistry is wanted at the City and Guilds of London Technical College, Finsbury, E.C. Salary £100, rising to £150. Applications by Sept. 1 to Prof. R. Meldola, F.R.S.

A lecturer in heat engines and in electricity applied to engineering is required for the Bedford Evening Institution. Salary (according to qualifications) up to £100 for the session (26 weeks). Applications to Mr. C. W. Kaye, Modern School, Bedford.

A sub-station attendant is required for Stepney electricity department. Commencing salary 30s. per week.

A Canadian publishing house advertise for an experienced editor for an electrical journal.

Alloa Council have appointed Mr. H. A. Tulloch as electrical engineer-in-charge of their electricity works, now in course of erection. Mr. Tulloch has been five years with Bruce Peebles & Co. and was for some years resident engineer of the Electric Supply Corpn.'s station at Dalkeith.

Mr. R. B. H. Craig, of Bermondsey, has been appointed assistant electrical engineer to Watford District Council, Mr. G. D. Vickers, who had been appointed, having withdrawn his application.

Mr. A. R. Sillar, formerly borough electrical engineer of Colchester, has been appointed by the Chinese Chartered Electrical Co. as chief electrical engineer of their electricity undertaking at Peking, China.

Mr. J. H. Havelock, A.M.I.E.E, Liverpool, has been recommended to the Kent Education committee for appointment as assistant master in the electrical department at the Gillingham Technical Institute at a commencing salary of £120.

The Engineering and Chemistry committee have unanimously agreed to recommend the governors of Robert Gordon's Technical College, Aberdeen, to appoint Mr. Alex. R. Horne, of Heriot Watt College, as head of the engineering department. The salary is £500.

Swansea Town Council on Wednesday appointed Dr. J. Mansergh Varley (principal of Devonport Technical School) as principal of Swansea Technical College, at a commencing salary of £500. Dr. Varley is 31 years of age. The final selection was made from the following six candidates:—A. B. Badger, M.A., B.Sc., J. H. Grindley, D.Sc., W. J. Lineham, B.Sc., W. L. Templeton, M.A., J. Mansergh Varley, D.Sc., and J. H. Vincent, D.Sc.

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On Tuesday Birmingham City Council approved the appointment of Mr. Howard Foulds as secretary of their electric supply department (referred to in our issue of July 15).

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

City and Guilds of London Institute.—At a meeting of the council on Wednesday the diploma of "Associate of the City and Guilds of London Institute" was awarded to 80 matriculated third year students of the Central Technical College who have completed a full course of instruction as prescribed by the Council, viz., 50 in civil and mechanical engineering, 25 in electrical engineering and 5 in chemistry. The following are the names of the students in electrical engineering:—

J. D. Peattie (awarded Siemens Memorial Medal and Premium), M. de Angelis, W. S. G. Baker, W. Barrs, P. R. Blamey, H. Clark, H. M. Dunkerley, D. H. Green, W. C. Griffith, G. E. W. Hitchcock, A. E. D. Kennard, G. Lambert, A. W. M. Mawby, P. A. McGee, D. J. McHatton, R. F. Niven, N. J. Perryman, L. C. Pocock, F. C. L. Racker, N. N. Roy, L. L. Ruderman, J. McL. Thornton, G. H. Tilly, F. J. Vinsen, and G. Watts.

In addition to the above, certificates have been awarded to 19 matriculated third year students who have completed a full course of instruction at the Central Technical College and to 56 students who have completed a full course of instruction at the Technical College, Finsbury.

University of London. University College.—The 1910-11 session begins on Monday, Oct. 3. Students desirous of entering the faculty of engineering with the view of taking a full degree or diploma course must have passed the matriculation examination or some other examination accepted in its stead. The fee for the full three-year diploma course in engineering, including the course for graduation (B.Sc.) in the faculty of engineering, is 120 guineas (payable in three instalments). Students who have already attained a sufficient standard may enter for a course occupying less than three years, and may obtain a general certificate of engineering after not less than two consecutive sessions. Graduates in science or engineering or students who have done the work equivalent to a degree may be admitted to special courses of study or to prosecute original research. Full particulars from the secretary, Mr. Walter W. Seton, M.A. Intending students should communicate with the Provost as soon as possible, and in any case not later than Sept. 20.

University of Birmingham.—The session 1910-11 commences on Monday, Oct. 3. The full courses in the engineering department extend over four years, and students who enter after matriculation and who pass successfully the examinations at the end of each year will be entitled to the degree of Bachelor of Science in the branch of engineering to which they devote themselves. The technical engineering classes include lectures on the strength of materials, theory of steam, gas and other heat engines, hydraulics, machine design, strength of structures and distribution of power, design of tools, prime motors, dynamos, &c. The courses in civil engineering cover a wide range. Lectures and demonstrations are given on all branches of electrical engineering and the electrical laboratory work comprises the testing of c.c. and a.c. machinery, instruments, meters, lamps and batteries and insulation and magnetic testing. The courses also include mathematics, physics, chemistry, geology and metallurgy. Syllabus, &c., from the Secretary.

University of Liverpool.—The session 1910-11 commences on Tuesday, Oct. 4. The courses of study in the faculty of engineering leading to the ordinary degree of Bachelor of Engineering extend over at least three years, and are so arranged as to afford a general scientific training for those who intend, with or without graduating, to become engineers, naval architects or architects and surveyors. Students who do not proceed to a University degree may take a course of not less than two years, leading to a certificate in engineering. The honours schools enable students to specialise in some branch of the profession, and opportunities are afforded for post graduate work and research. Prospectus of the faculty can be obtained from the Registrar, Mr. P. Hebblethwaite, M.A.

Wigan and District Mining and Technical College.—We have received a copy of the calendar of this college for the 54th (1910-11) session, which commences on Sept. 12. The book contains excellent interior and exterior views. The contents include lists of the members of the governing body, the teaching staff (of whom Mr. T. T. Rankin is the principal and Mr. H. G. Cotsworth the head of the electrical engineering department), the equipment of the laboratories and workshops, &c., and particulars of the courses. The sandwich system is adopted, a portion of each summer being spent in mines or mechanical or electrical engineering workshops. Details are given of the curriculum in the departments of practical mathematics, mechanical engineering, engineering and machine drawing, electrical physics, electrotechnics, chemistry of mining, metallurgy, assaying, coal and metalliferous mining, mine surveying, geology and mineralogy. There are also day apprentice classes, a pupil teacher department and special Saturday mining classes for colliery managers, firemen and shotlighters. The book is issued at 6d., post free.

Northampton Polytechnic Institute (London).—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Monday, Oct. 3.

The courses in mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include specialisation in radio-telegraphy. The entrance examination takes place on Sept. 28 and 29. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in engineering at the University of London. There are full and part time courses in all branches of technical optics. Particulars as to fees, &c., can be obtained at the Institute, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

University of Glasgow.—The next session will commence on Oct. 17 and end on March 23, 1911. In the departments of engineering, mining and naval architecture students usually spend the summer months in practical work, thus receiving their training on the Sandwich system. Prospectus of the course for the degrees of B.Sc. and D.Sc. in engineering and syllabus of classes may be obtained from the Assistant Clerk, Matriculation Office, The University, Glasgow

University of Manchester.—A prospectus giving particulars o the lecture and laboratory courses in physics, preparing for both the ordinary and honours degrees, will be forwarded on application to the Registrar.

BRITISH NOTES.

Amersham.—The Uxbridge & District Electric Supply Co. propose to transfer their undertaking to Callender's Co. and the latter are applying for a provsional order for Amersham Rural District.

Ashton-under-Lyne.—In a recent issue of a local journal there appeared an interesting letter advocating the use of water power, which appears to be available in the neighbourhood, for the generation of electric current.

The writer stated that there was sufficient water power running to waste within a mile of the Ashton tramway system, which, if efficiently harnessed and utilised, would save the burning of some 2,000 tons of coal yearly. That power could be had at a capital outlay not exceeding £5 per horse-power and working 8,000 hours in the year would yield about 1,500,000 units yearly, and could be obtained at ¼d. per unit (including working expenses, interest and depreciation). Within 8 miles of Ashton there is (continued the writer) a situation where some 500 H.P. was also running to waste. That was (according to the writer) an ideal power site provided by nature, for, in addition to the 500 H.P. there was abundance of virgin coal on the spot (one or two seams outcrop on the surface). Some time ago the site could be had for £50 per annum, which worked out at about 2s. per horse-power per year, and coal at 1s. per ton could not compete with that power, as the water would flow into and out of turbines by its own gravity. There being no coal to handle, fires to scale or cinders to clear away, consequently one man could with greater ease attend 2,000 H.P. (water) than a man could take

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care of 500 H.P. (coal). The writer suggested that the Ashton Council should acquire a site. There was a very suitable one where some 150 H.P. could be relied on 300 days in the year, the cost of developing and installing turbines would be from £600 to £700, the rent should not exceed £15. Power from that site would give 700,000 units yearly, and at a ¼d. per unit would save the corporation £972 (estimating cost of Ashton's current at 1d. the unit), and would save the burning of some 937 tons of coal yearly.

Aston.—Mr. H. Ross Hooper held an inquiry on Friday last into the application of the Corporation for permission to borrow £23,500 for the electricity department.

The difference between the tenders received and the estimates caused a reduction of the amount to £23,105. Of this amount £12,515 is for plant and machinery, and £10,590 for mains and services, and the Council asked that £6,000 of the last-named amount should be spread over their requirements for the next two years—viz., £4,500 for mains and £1,500 for services.

The INSPECTOR said the profits last year were eminently satisfactory, but asked if anyone could show him where the advantage came in of transferring to the reduction of the rates £1,500 with one hand and borrowing £1,500 with the other for an expenditure for like services, which was continually going on. It was no advantage to the ratepayers and no advantage to the undertaking. To borrow money with one hand at 3¼ per cent., and to pay it out as a bonus with the other, meant that the ratepayers had to pay the 3¼ per cent.

Mr. GODRICH (chairman of the Electricity committee) said they had acted in the interests of the ratepayers, the rates having been reduced in consequence of the contributions from the electricity undertaking.

Mr. HOOPER said it was only the well-to-do people who got the benefit of the reduction at a cost to the general undertaking. He asked them to withdraw that item, or put it down to mains, making the total for that purpose £6,000.

The latter suggestion was agreed to, and the inspector remarked that in future cost of services would be debited to revenue.

Ballyclare (Ireland).—The Council have decided to accept the offer of Messrs. Curran Bros. for supply of electric light in the town, subject to a satisfactory agreement.

Barnstaple.—The Council have adopted a minute of a special committee that "further expenditure on account of advertising or exhibitions on electricity account is undesirable until satisfactory arrangements have been made for the proper display and supply of fittings and further facilities afforded for wiring the premises of prospective consumers."

Coun. WHITE said he understood the committee had made various attempts to get someone in the town to take up the supply of electric fittings, and wiring of premises generally, on similar lines to those followed by the gas company. They had been unsuccessful. The committee was still on the look-out for an enterprising firm to undertake the work.

Bermondsey (London).—The Finance committee report that they have considered the accounts for the year ended March 31, together with the estimates for the current year, of the Electricity and Street Lighting committee.

The committee call the Council's attention to the fact that, on the year's working, with an outstanding loan indebtedness of £152,973 the surplus is only £43, against an estimate of £500. In their opinion the result is partly due to the very low price at which energy is being sold, and they think it behoves the Council to be careful as to how the undertaking is managed in the future, more especially with regard to the incurring of further capital liability. The current year's surplus is estimated at £600.

The Electricity committee report that with reference to the report presented by them to the Council at its last meeting, with respect to the quinquennial valuation of the electricity works at gross £3,399 and rateable £2,266 against the present figures of gross £2,693 and ratable £1,796, London County Council object to the proposed valuation of the electricity works and they claim a correction to gross value £8,000 and ratable value £3,000.

Birmingham.—The City Council on Tuesday authorised application by the Corporation for powers to construct and work a section of light railway in Beech-lane from the King's Head to the corner of Balden-road, and to complete it ready for inspection simultaneously with completion of the Hales Owen light railways, and to purchase the portion of the line between Balden-road and Quinton.

Bradford.—At the Valley-road electricity works on Wednesday the formal starting took place of two new 3,000 kw. Curtis turbines and alternators.

The turbines take steam at 180 lb. pressure per square inch and at 500°F., and utilise it until it is exhausted into the condenser at 13·5 lb. pressure. The a.c. current generated is 6,600 volts. All the work has been carried out to specifications and designs prepared by Mr. T. Roles, city electrical engineer. The principal contractors for the installation were the British Thomson-Houston Co., of Rugby, who made the turbines and alternators, and the sub-contractors for the condensing plant were the Worthington Pump Co., who manufactured the condensers and air and ventilating pumps; Thornton & Crebbin for the hydraulic accumulators and the main circulating pipes; Sheepbridge Coal & Iron Co. for pipes; Pearn & Co. for footstep pumps; Aiton & Co. for the piping in the engine room; Babcock & Wilcox for steel steam pipes and separators, and Messrs. Brook, Hirst & Co. for switch pillars. Other contractors, directly responsible to the Corporation, were Henry Barrett & Sons, engine-room floor; T. Obank & Sons, foundations and masonry work; S. Parsons & Co., steel towers carrying the circulating water pipes; Stewarts & Lloyds, steam pipes; E. & W. H. Haley, cast-iron connecting pipes, &c; and Sloan & Davidson, staircase connecting engine room and basement floor levels.

Brierfield.—The Council have decided to accept the offer of Nelson Corporation to supply electrical energy in Brierfield for lighting at 2½d. and for power at 1½d. per unit.

Camborne.—The Council have consented to an application by the Urban Electric Supply Co. for a provisional order for the Dolcoath Mine.

Cardiff.—The Tramway committee have decided to purchase 130 tramcar current meters at £3. 5s. each.

Chartered Institute of Patent Agents.—The qualifying examination of persons desirous of being registered as patent agents will be held in November next. A notice, giving particulars, appeared in the "Illustrated Official Journal (Patents)" of July 6, 1910, and a copy of the notice can be obtained from the Secretary of the Chartered Institute of Patent Agents, Staple Inn-buildings, London, W.C.

Church Lighting.—The electric light was used for the first time in Christ Church, Epsom, on Sunday, July 17. The cost of the wiring and fitting was £120.

Cirencester.—Mr. J. H. Edmonds is applying for a provisional electric lighting order.

Clutton (Bristol).—The Western Electric Distributing Corpn. have notified the Rural Council that they will apply for a provisional order.

Coventry.—The Education committee are having three schools lighted electrically, and if the experiment is satisfactory will also adopt electric lighting in other schools.

Fleetwood.—Permission is being sought to permit the Council to proceed at once with extensions of their electricity undertaking. Large demands for current are in hand and new machinery will be required during the ensuing winter.

Frodingham.—The Council have decided to go on with the electric lighting of the streets at Frodingham.

Fulham (London).—The assessment of the electricity works and appurtenances, at present assessed at £2,850 gross and £1,900 ratable value, has been inserted in the new valuation list at £10,500 gross and £4,500 ratable value.

Notice of objection will be given. London County Council have lodged notice of objection on the ground that the values should be £14,000 gross and £5,600 ratable.

The Electricity committee propose to supply current to lamps in the halls and staircases of maisonettes at a fixed rate. In such cases hour meters are to be provided instead of the usual recording meter, and, estimating that 1,640 hours per annum will cover the use of one lamp, the charge at 3½d. per unit, using an 8 c.p. carbon lamp, works out at 16s. 9d. per lamp per annum. For all current consumed in excess of 1,640 hours a further charge of 3½d. for every 30 hours, or portion of 30 hours, will be made.

Heston and Isleworth.—The Council have authorised the Electricity committee to make arrangements with approved electrical contractors for the engagement of canvassers, to be paid by contractors, and to take instructions from the Council's electrical engineer, the contractor to be paid a commission of 10s. per kilowatt for lighting and 5s. per kilowatt for power installations.

Hindley.—The question of the revocation of the Council's electric lighting order has been postponed for 12 months by the Board of Trade.

Gosport.—After July 31 the tramway routes are to be lighted by electricity instead of gas.

Hindley.—The Board of Trade have granted an extension of one year for carrying out the provisions of the 1901 electric lighting order.

Hospital Lighting.—Electric lighting is to supersede gas lighting at Hyde Corporation Hospital.

Ilkeston.—At a recent meeting of the Council Mr. Coun. Moss asked whether the Corporation were prepared to consider an offer for the purchase of the tramway system.

The MAYOR, in reply, said it was a matter that could best be considered by the whole Council in committee, and a special meeting was accordingly held, when it was unanimously decided not to entertain any offer for the disposal of the tramways.

Several members pointed out that although the cars were not actually showing a profit they were a great boon to the ratepayers, and if the control went out of the hands of the Corporation the convenience of the public would be a minor consideration. The Mayor stated that since

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the new manager, Mr. Stokes, had taken up his duties the service had been considerably improved and a great deal of reconstruction work carried out. There was every prospect of an improvement in the financial position of the concern. During the nine months Mr. Stokes had been in Ilkeston he has reconstructed two route miles of overhead work and one mile of track.

Inquest.—A verdict of accidentally electrocuted was returned at an inquest held at Blaydon last Saturday. A deputy overman named Barrett, aged 48, met his death at Blaydon Burn Colliery.

According to the evidence, Barrett was engaged leading water in a drift of the mine when the telephone bell rang. Barrett attending the call, received a shock on taking hold of the receiver. He was unable to leave hold of the instrument, and was afterwards found lying dead. The head electrician, Mr. Hall, explained that a steam pipe had recently been placed in the drift. Below this was an iron pipe, containing a cable for conducting a supply of electricity to the pick-sharpening shop. The steam pipe had evidently come in contact with the iron pipe, and the pressure had caused one of the joints to break, with the result that the insulation of the cable was damaged, and the current (250 volts) traversed the telephone wire. This was not sufficient to kill a man instantaneously and it was probably the continuousness of the current which had proved fatal to Barrett.

Launceston.—The Council have asked the Board of Trade not to revoke their 1903 electric lighting order, as they are considering an electric lighting scheme submitted by Mr. J. A. Purves.

London County Council.—At their meeting on Tuesday the Council adopted a report of the Finance committee in reference to loans to Islington Council for electricity mains.

The report states that Islington Council has in hand unexpended balances amounting to £35,765. 2s. 7d. in respect of loans for mains. The balances result from loans being obtained in advance of expenditure and the subsequent abandonment of some of the work, while other work for which the loans were granted has been carried out for less than the estimated cost, or has been deferred. The practice of the Borough Council in recent years has been to obtain sanction to loans in respect of current capital expenditure, but, instead of borrowing immediately under such sanctions, to utilise unspent balances of former loans. At the present time the borough Council has in hand unexercised sanctions to loans for electricity purposes amounting to £32,498. It appeared to us (continues the report) that this was far from satisfactory, and we communicated with the Borough Council; and the Borough Council suggest that the £35,765. 2s. 7d., should be repaid to the Council; and that the Borough Council should borrow from the Council, at a rate of interest equivalent, as nearly as might be, to the rates payable on the loans of which the unexpended balances form part, such an amount not exceeding the amount to be repaid as might be deemed necessary, and that for this purpose the sanctions in hand and those to be obtained for capital works executed in 1909-10 should be utilised. We suggest that the proposal of the Borough Council be agreed to. The rate of interest equivalent to the rates on the sum of £35,765. 2s. 7d., now to be paid off, is £3. 11s. 6d. per cent. The total of the outstanding sanctions for electricity purposes is £32,498, and the Borough Council desires that the advance of this sum should now be made on the terms agreed, repayment to be on the annuity system.

"The Borough Council also has in hand a sum of £5,042 unspent in respect of a loan of £7,468 (part of £45,206) for street lighting, advanced on Nov. 11, 1904, and it desires the Council to accept repayment of this sum in reduction of the loan. The total amount which the Borough Council wishes to repay is therefore £40,807. 2s. 7d."

The report goes on to recommend that an arrangement on the lines proposed should be carried out, and the loan of £32,498 granted, to be repayable as to £3,942 for purchase of freehold property within 60 years, as to £10,204 for mains within 30 years, as to £9,572 for machinery within 20 years, as to £3,685 for house services within 12 years, and as to £776 for mains, £3,200 for machinery, and £1,119 for meters within 10 years

L.C.C. Tramways.—London County Council has written Islington Council that, in view of the difficulties which have arisen between the Hackney and Islington Councils and the County Council in connection with the proposed Ball's Pond-rd tramways, the County Council has decided not to proceed with the proposals contained in the London County Council (Tramways and Improvements) Bill, 1910, with regard to the widening of that thoroughfare.

The new section of tramway between Woolwich and Eltham, which is worked on the overhead trolley system with an overhead return wire, was inspected by Major Pringle and Mr. A. P. Trotter on Thursday and opened for traffic on Saturday.

London Street Lighting.—Holborn Borough Council have referred back a report by the Works and General Purposes committee recommending the acceptance of an offer by the Gas Light & Coke Co. to light the borough throughout by inverted incandescent burner gas lamps. The Council requested the committee to obtain competitive prices.

Obituary.—The death is recorded on July 20 of Mr. Thomas Hurley (Messrs. Gent & Hurley). Mr. Hurley was in his 70th year.

Oldham.—The Corporation are prepared to give a supply of electricity to Alt in the Limehurst area, provided the Council of the latter district give their consent. The Lancashire Electric Power Co. also possess supply powers for the district.

Personal.—Mr. A. S. Esslemont, who has been for many years manager of the County of Durham Electric Power Supply Companies, will shortly resign this position in order to specially devote his time to the development of electro-metallurgical and other processes on Tyneside on behalf of the Newcastle-on-Tyne Electric Supply Co.

Mr. Arthur Greenwood (Messrs. Greenwood & Batley) has been appointed a director of the North Eastern Railway Co., to fill the vacancy caused by the death of Mr. Hy. Tennant.

Provisional Order Revocation.—The Board of Trade have revoked the Strood and Dartford (Rural Districts) Electric Lighting Order, 1903, as from July 18.

Sevenoaks.—On the recommendation of the Lighting committee (which has considered Messrs. Mordey & Dawbarn's report on the subject), the Council decided to apply for a provisional electric lighting order.

Southend.—A L.G. Board inquiry was held on Tuesday into the application of the Corporation for permission to borrow £20,467 for the electricity department. The purposes for which the money is required include the construction and equipment of two substations to serve the Chalkwell and Southchurch districts. There was no opposition.

Theft of Electricity.—At Manchester Police Court J. F. Churchard, of Second-avenue, Trafford Park, was fined 20s. and costs for fraudulently using electricity, the property of the Trafford Power & Light Supply (Ltd.), to the value of £1. 3s. It was stated that the prepayment meter was 73 tokens short (each token costing 3½d.). The meter was found to be in perfect order. Defendant admitted having inserted a wire, but said it was done in innocence. He had only done what others had done when they could not get any light.

Torquay.—Mr. H. Ross Hooper held an inquiry on Saturday into the application of the Corporation to borrow, amongst other sums, £3,500 for their electricity department.

The town clerk (Mr. F. S. Hex) explained that the money was required for the extension of the lighting mains to Chelston, to provide for further extensions and to cover excess expenditure of £525. It was decided to increase the amount applied for to £4,500, and the inquiry was closed.

Walsall.—The Council on Tuesday adopted a report of the Electricity committee recommending additions to the plant at the electricity works and extensions of mains to Birchills, Bescot and Bloxwich, at a cost of £23,225. The proposal to build a new generating station has been abandoned.

Walthamstow.—The Council are applying for sanction to a loan of £1,838 for mains extensions, house services, &c.

West Ham.—Mr. H. Ross Hooper held an inquiry on Wednesday into an application by the Corporation for permission to borrow £53,500 for the electricity undertaking.

It was stated that there were overdrafts on capital account of £71,730. The capital expenditure on the undertaking to March 31 last was £490,668, of which £15,553 had been contributed out of revenue. Mr. Elvey Robb representing the India Rubber, Gutta Percha & Telegraph Works Co., large ratepayers in the borough, said his clients had pending an action against the Corporation, who had given them no intimation that this inquiry was to be held. He questioned Mr. Couzens, the borough electrical engineer, as to the policy of supplying power consumers at 1·37d. per unit, and Mr. Couzens maintained that it was beneficial to the undertaking. The inspector eventually said he would report to the L.G. Board, and leave it to them to decide if a further inquiry should be held.

Wireless Telegraph Notes.—Whether or not it is found to be correct that the notorious Dr. Crippen and Miss Le Neve are on board the "Montrose" when she reaches Canada, or even if the arrest takes place in mid-ocean, it is to the credit of wireless telegraphy that it has been the means of placing the police on to a clue, which would have been impossible only a few years ago. The future has many added terrors for the criminal, for wireless telegraphy places a powerful weapon in the hands of the police authorities.

In another direction this week wireless telegraphy has served the highest purpose. 83 passengers and 125 members of the crew of the South Pacific Line steamer "Momus," bound for New Orleans from New York, were threatened with a terrible death at sea. The vessel caught fire, owing, it is said, to the carelessness of a passenger, and but for the wireless apparatus on board, all might have been lost. A sister ship, the "Comus," on the return journey, received the signal for help and was able to give ample assistance.

Workhouse Lighting.—The Canterbury Guardians are considering the question of lighting the workhouse electrically.

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"Electrical" Bowls.—The first annual bowling competition on a green constructed in a portion of the works yard of the St. Helens Cable Co., at Warrington, took place on Saturday. There were 84 entries, and the prizes were sets of bowls presented by Mr. T. O. Callender and Mr. James Taylor, directors. The green, which was laid out by the staff, accommodates six games simultaneously.

Football.—The Electrical Football League have a few vacancies for clubs connected with the electrical industries. Particulars from Mr. C. Phillips, 140, Minet-avenue, Harlesden, N.W. Referees with vacant dates please write to Mr. Fraser, 100, Bishop-road, Fulham, S.W.

COLONIAL AND FOREIGN NOTES.

Brazil.—The "Financial Times" contains particulars of a concession for electricity supply stated to have been granted to the Brazilian Electric Power Co.

The right to commence the supply of current generated by water power does not come into force until June 7, 1915 (the date upon which the concession held by the Rio de Janeiro Tramway, Light & Power Co. expires), unless the exclusive rights of the Rio de Janeiro company are previously extinguished. The latter, a Canadian company, is the only one at present in the field, and the concession to the Brazilian Company has been granted by the Prefecture of the Federal District of Rio de Janeiro, in accordance with the policy of free competition recently re-affirmed in a message delivered by the President of the Republic. The period of the new concession is 24 years.

Upon subsequent inquiry from the secretary of the Rio de Janeiro Tramway, Light & Power Co., the "Financial Times" learns that the Directors of that company have obtained an injunction in the High Court of the Brazilian Republic restraining any interference with their rights, and that the Prefect has, as a result of representations made by the Tramway Co. stated that he will protect their rights and restrain others from infringing their concession. The validity of the rights to which the parent company lays claim through its subsidiaries has been tested on various occasions in the Brazilian Courts, and in every case the verdict has been given in the company's favour.

Chili.—Consul E. F. Hudson, in his report on the trade of Iquique in 1909, intimates that the articles used in connection with the Chili nitrate industry include boilers, cooling tanks, electric light plants, light portable railways, &c.

Cuba.—The imports during 1907-8 included electric lamps, valued at $35,217 from the U.S.A. and from other countries $8,821.

Customs Duties.—A recent supplement to the Australian Customs Tariff Guide states that it has been decided that insulated bolts for fastening trolley wires to the wire supports, jars (other than glass) and zincs for electric cells, and vulcanite cells for galvanic cautery batteries are subject to an import duty of 17½ per cent. (British goods 10 per cent.); on paper discs for antiseptic attachments for telephone transmitters the duty is 30 per cent. (British 25 per cent.), while metal frames for the same attachments and electric valves for protection against resonance (British or other) are duty free. On tramcar platform gongs and sand boxes for tramcars the duty is 35 per cent. (British 30 per cent.)

A recent circular of the Servian Minister of Finance determines that No. 645 of the Servian Tariff of import duties (the duty being 75 dinars per 100 kilogs.) includes all electric light fittings not mentioned elsewhere (whether mounted or not), the only exception being porcelain insulators combined with iron and keys; and that the second paragraph of the same number (120 dinars per 100 kilogs.) includes Geissler and other similar tubes and lenses for Rontgen rays and other purposes.

India.—"Indian Engineering" says the construction of the Mussoorie electric tramways will be undertaken shortly.

A trial of electric light has been made in the Mall, Simla, with a view to ascertaining the cost of lighting the station electrically. The municipality have obtained a licence under the Indian Electricity Act.

The "Indian and Eastern Engineer" states that Lahore Municipal committee will shortly consider a scheme for lighting the city and the civil lines electrically.

The 1909 report of the Railway Board states that 480 railway carriages were fitted for electric lighting and 778 for gas during the year, making a total of 15,237 fitted for electricity or gas and leaving 5,071 not fitted.

Japan.—Acting Consul A. R. Firth says applications have been addressed to the Formosan Government by three rival groups for a concession for the construction of electric street railways in the city of Taihoku, which has a population of 84,000.

Mexico.—The report of Consul-General Stringer states that British capital has been invested on the Conchos River, near Santa Rosalia, for impounding the water of that river by a great dam, and it is intended to develop some 30,000 H.P. for the mining districts of Naica, Almolya, Parral, Santa Barbara and adjoining places, and to carry out irrigation work. The preliminary work is in hand.

Vice-Consul C. G. Scobell says that Chihuahua offers to capitalists who are interested in mining or industrial enterprises great opportunities for investment. It has waterfalls and great resources in minerals. The State Government is in communication with almost every part of the State through an efficient system of telegraphy.

Vice-Consul P. G. Holms (Guadalajara) says the introduction of electric power into the Hostotipaquillo district at £10 per horse-power per annum will enable immense reserves of low-grade ore to be utilised. Steam power formerly cost over £25 per horse-power. An amalgamation of power interests has resulted in the formation of the Chapala Electric & Irrigation Co., with a capital of $14,000,000 (Mexican currency). The Federal Government lends the company $3,000,000 (£300,000) for constructing a dyke across a portion of Lake Chapala, which will be the first step towards reclaiming about 123,500 acres, with a value of $12,500,000 (£1,250,000). The company has concessions which will enable it to generate over 100,000 H.P. from the Santiago River, an effluent from Lake Chapala. Power sells at from $100 (£10) to $125 (£12. 10s.) per horse-power per annum. Mining districts will absorb a fair amount of power in the Hostotipaquillo and other camps. The company will supply Guadalajara with power, and a contract has been signed to run transmission lines and power to the city of Aguascalientes, while it is possible that power may also be carried as far as Zacatecas.

Vice-Consul R. M. Cormack (Guanajuato) says a British subject owns a large electric light and power plant at Colaya, from which power and light is supplied to several neighbouring towns. The Guanajuato Power & Electric Co., who control the electrical situation in the States of Guanajuato, Michoacan and San Luis Potosi, have recently placed some $800,000 gold (£80,000) in bonds in the United Kingdom. This company (with its subsidiary companies) have recently purchased many of the principal lighting and power plants in the State, and are promoting agriculture by means of electrical pumping for irrigation.

South Africa.—The "South African Mining Journal" of June 25 states that Mr. Howard Pim has obtained, on behalf of the Transvaal Hydraulic Power Synd. a licence for the installation and working of an electric generating station, at Tweefontein, district of Middelburg.

The station is to use small and second class coal from the Tweefontein colliery, and is to obtain its water from storage reservoirs on the Olifants River and the Zaaiwater and Piet Spruits. It is proposed to form a company with a nominal capital of £926,000 to take over the undertaking. Power will be taken from the new station for electro-chemical works to be established at Tweefontein for the manufacture of nitric acid, cyanide, calcium carbide, fertilisers and other chemicals.

Klerksdorp Council have adopted a scheme for electricity supply, estimated to cost £9,500. Duplicate generating plant is to be installed.

Turkey.—The Belgian Vice-Consul at Tripoli (Syria) states that Tripoli municipality are considering the question of the erection of an electric generating station for lighting purposes and the construction of electric tramways and a telephone system.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Accrington.—The accounts of the electricity department for the year ended March show capital expenditure £74,989 (increase £3,345). The amount borrowed is £74,989, of which £54,888 is outstanding.

Income was £16,641, gross profit £7,416 (9·9 per cent. on the capital outlay). Interest and redemption required £5,469, leaving net profit £1,947, which (with a balance of £866 brought forward) has been appropriated as follows:—Depreciation and renewals £500, repayment of part of cost of 1890 Provisional Order £464, first instalment in repayment of deficiencies in previous years £140, cost of installations of wiring, meters, motors, economisers, pipework, paving and cost of Church Provisional Order, £1,709. The amount at credit of depreciation and renewals is £3,015. Units generated were 3,077,839. Private consumers took 1,779,795 (1,973,280), public lamps 37,574 (38,818) and tramways 1,063,299 (960,514). Working expenses were 0·768d. (0·673d.) per unit (including an increase of local rates of £599). The maximum supply demanded was 1,338 kw.

Bristol.—The accounts of the electricity department for the year to March 25 show capital expenditure £821,052 (increase £10,304), £798,108 has been borrowed, and the amount repaid and in redemption fund is £178,410.

Revenue was £79,572 (compared with £81,390), working and general expenses were £36,751 (£38,226), gross profit was £42,821 (£43,164), to which are added £2,346 refunded on adjustment of income tax and £97 transferred from redemption and sinking fund (No. 2) account. Dividends on stock, interest on loans, &c., required £22,082, repayment of capital £22,102, and £3,109 has been placed to reserve for renewals, the net result being a deficiency for the year of £2,030 (compared with £305). There is, however, a balance in hand from last account £6,230, so that £4,042 remains to carry forward. Units sold were 814,237 (increase 31,419). There are 3,388 consumers (increase 170), and the total connections are equivalent to 521,124 30 watt lamps (compared with 502,209). The total maximum demand was 5,729 kw. The metallic filament lamp has obviated the necessity of increased capital expenditure (except for connecting and supplying new consumers), but it has considerably reduced the revenue. Power connections increased by over 650 H.P. The load factor has fallen from 17·23 to 16·22. Costs have been slightly lowered, and it is believed the reduction in revenue due to the introduc-

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tion of the metallic filament lamp has now reached its limit, and that an increased consumption may be looked for each year.

The report and accounts were adopted by the Council on Tuesday when Ald. PEARSON said he had no doubt he would in 1911 submit a better report. The present position was an abnormal one, brought about by a change which must ultimately be for the good of the undertaking. He quoted instances in which there had been great reductions in the amounts of the accounts of individual consumers. They had in the sinking fund or in the shape of machinery paid for out of revenue £216,981, and he thought it would be difficult to find any company carrying on business on similar lines that could say that in 15 years 25 per cent. of the total capital was in its own works or in the sinking fund.

Carlisle.—The accounts of the electricity department for the year to March last show capital expenditure £70,360 (increase £6,164). The oustanding loans are £53,915, including £3,241, the amount of loans fund overdrawn. The total amount of loans raised is £75,084.

Income was £12,852 and expenditure (including £52 insurance and £44 allowance for bad debts) £4,933. Gross profit was £7,919. Net profit was £3,057 (an increase of over £800). Units generated were 1,557,487 (increase 170,234), public lamps took 72,720 (75,721), private consumers (including traction) 1,226,277, the increase in the power and private lighting demands being 154,455 and 8,459 respectively, and the decrease in the traction demand 4,428.

The report of Mr. S. T. Allen (borough electrical engineer) states that Carlisle takes fourth place amongst local authorities' undertakings in regard to the proportion of gross profit to capital expended (11·77 per cent.). There have been no engine failures during the year, and the general supply has been maintained without interruption. Motors aggregating about 90 H.P. were connected during the year, and applications were received for about 600 H.P. The motors connected total over 250, with a total power of over 600 H.P. Connections to the mains increased during the year by 4,254 (equivalent) 30-watt lamps. There were put in at the works during the year a coal bunker, with coal-handling gear, automatic stokers to each boiler (not quite completed at end of financial year), superheaters, two boiler feed ranges re-erected in sight above the boilers, and a new steam turbine set. The last mentioned showed an improvement on the maker's guarantee figures. Fuel cost 0·24d. (compared with 0·30d.) per unit sold, total works costs were 0·56d. (0·70d.) and total, including rates and taxes, management and insurance, 0·87d. (1·04d.)

Chesterfield.—The accounts of the Corporation tramways department for the year ended March last show capital expenditure £69,575 (no increase). £70,500 has been borrowed and £6,800 repaid, besides a contribution of £1,600 towards the cost of the Corporation Tramways Improvement Act, 1904.

Revenue was £11,859, working expenses £7,402, sinking fund contribution, interest, &c., amounted to £4,529, the net surplus being £26. Passengers carried were 2,430,326, car miles run 281,096, and units of current used 374,823, equal to 1·3 units per car mile. Total revenue was 10·12d. (compared with 9·51d. in previous year). Total costs (including power) were 6·317 (exclusive of capital charges). Reserve fund stands at £3,653, or 5·17 per cent. on the total capital expenditure.

Manchester.—The accounts of the electricity department show capital expenditure £2,678,630, an increase of £111,924 during the past year. The loan debt stands at £1,970,112, the amount of loans redeemed by sinking fund being £617,133.

The income during the year ended March last was £374,479 (compared with £367,240 in previous year), and expenditure was £181,398 (against £184,039). £23,822 (£21,495) was placed to renewals suspense account and £169,258 (£161,706) carried to net revenue account. Interest required £69,311 (£67,966), sinking fund £82,168 (£75,913), and instalment of loan repaid £6,198 (£6,031). £183 (£403) has been placed to reserve and the net profit is £12,000 (as in previous year). This has been devoted to relief of rates. Units generated were 95,542,254 (88,766,232), private consumers took 42,886,223 (37,150,022), public lamps 144,696 (99,593) and traction 28,526,468 (29,675,249). The total maximum demand for lighting and power was 24,193 kw. (20,956 kw.) and for traction 9,592 kw. (10,162 kw.).

The report of the Electricity committee states that the Tudor battery scheme at Dickinson-street and Bloom-street stations is in successful operation and the Contraflo condensing plants have also been satisfactorily installed. The large extensions of steam plant and accessories at Stuart-street station have been brought to a satisfactory conclusion, substantial improvements in the h.-t. switchboards having been effected and the works in connection with obtaining an independent water supply for the station are almost complete. The net addition to mains during the year is 16 miles 1,242 yds. The efficiency of the distributing system was 82·02 per cent.

Stafford.—The accounts of the electricity department for the year ended March last show capital expenditure £32,500 (no increase during the year) and the loans outstanding amount to £23,137.

Revenue was £4,344, working and general expenses £1,865, gross profit £2,479 (compared with £2,465), and after meeting capital charges the net profit was £374, of which £341 has been placed to depreciation fund. Units generated were 509,016 (compared with 505,139 in previous year), private consumers took 381,375 (371,688) and the public lamps 8,635 (8,665). The number of (equivalent) 8 c.p. lamps connected is 25,496 and motors connected 74 (=346 H.P.). The total maximum demand was 280 kw. (against 295 kw.)

Tunbridge Wells.—The accounts of the electricity department for the year ended March show capital expenditure £88,250 (increase £3,887).

Revenue was £13,728, working and general expenses £8,649 and gross profit £5,079. Contributions to loans fund required £4,375 and mortgage loan £989; total £5,364. Units generated were 1,078,018; public lamps consumed 253,111 (estimated) and private consumers 578,025. The number of lamps connected is 70,681 (increase 3,824). The total maximum demand was 569 kw. (648 kw.).

The resident engineer (Mr. J. W. Beauchamp) states that since June, 1909, the department has been under fresh management. The steam turbine, ordered by the consulting engineer, and the mechanical stoker (now being supplemented by a second one) were put into use. Extensive repairs to the whole of the plant were carried out. A reduction in coal and oil amounting to nearly £700 was effected, this figure being taken after correction for decrease in units generated. A considerable falling off in lighting revenue was experienced as a result of increased use of metal filament lamps. The use of these lamps with or without transformers is practically universal here on all new work, and the price of 4¾d. per unit under these conditions makes competition with gas (at 2s. 7d. per 1,000) comparatively easy. Some installations have been put in on the "Stannos" system, and changes in meter and service charges have been made in order to reduce the first cost of installation to consumers. Metal filament lamps are used for street lighting, and the older type of open arc lamps are being replaced by high candle power metal filament lamps. The electric lighting of the schools of the borough is now receiving consideration.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited up to Sept. 7 for supply of battery material and glassware to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Official Secretary in Great Britain of the Commonwealth of Australia, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to Aug. 30 for supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the office of the High Commissioner for the Commonwealth. See also an advertisement.

Tenders are invited for the supply of 3 tons 2 cwt. of bare h.d. copper cables to the Corporation of MELBOURNE (Australia). Specifications form of tender, &c., from the Agents of the City Council, Messrs. McIlwraith, McEacharn & Co., Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon, Aug. 16. See also an advertisement.

NEWPORT (Mon.) Electricity and Tramways committee invite tenders for supply of carbon filament electric lamps, radiator lamps (British made), flame arc lamp carbons for Excello and Oliver type lamps, and a.-c. and d.-c. two-rate and prepayment meters, during the ensuing 12 months. Specification and schedule from the borough electrical engineer and tramway manager, Mr. H. Collings Bishop, M.I.E.E. Tenders to the Town Clerk, Town Hall, Newport, Mon., by first post Aug. 15.

LONDON County Council invite tenders for the wiring and fitting for electric lighting of the second section of the central car repair depot, Woolwich-road. Specifications, &c., from the Clerk of the Council, County Hall, Spring-gardens, S.W. Tenders by 11 a.m. Tuesday, Aug. 30.

MANCHESTER Electricity committee want tenders by noon Aug. 2 for supply and erection of induced draught plant at Bloom-street generating station. Specifications, &c., from Mr. F. E. Hughes, Town Hall, Manchester.

CHELMSFORD Education committee want tenders by Aug. 31 for electric light wiring at Trinity-road school. Forms, &c., from Mr. W. H. Pertwee, London-road, Chelmsford.

Tenders are wanted by noon Aug. 2 for the electric lighting of the Royal Hospital for Incurables, DONNYBROOK, Dublin. Specification from Mr. T. Tomlinson, 15, Beresford-place, Dublin.

EDINBURGH School Board want tenders by Aug. 2 for the electric lighting of the Royal High School. Specifications from Mr. Geo. Thomson, 11, Randolph-place, Edinburgh.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON (N.Z.), until noon Dec. 15 for supply and erection of installations of wireless telegraphy at or near (1) Doubtless Bay, (2) Gisborne, (3) Cape Farewell, (4) Sumner, near Christchurch, and (5) Bluff. Specifications, &c., from 13, Victoria-street, London, S.W.

The Deputy Postmaster-General, BRISBANE, will receive tenders until noon Sept. 7 for supply of glass cells, corks and tubes and

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porous cups for batteries, battery material, chemicals, &c. Specifications, &c., from the High Commissioner for the Australian Commonwealth, London. Local representation is necessary.

The Deputy Postmaster-General, MELBOURNE (Victoria), will receive tenders until 3 p.m. Aug. 30 for supply of electrical sundries, insulators, wire and sulphate of magnesia. Local representation necessary. Further particulars from 72, Victoria-street, London, S.W.

The SECRETARY OF STATE FOR INDIA requires tenders by 2 p.m. Aug. 3 for supply of overhead floating staging and electrically-driven water supply pumps. Conditions, &c., from the Director-General of Stores, India Office.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

Tenders will be received at the French Government Telegraph Department, Rue de Grenelle, PARIS, on Aug. 6 for supply of 150 tons of 2 mm. and 100 tons of 3 mm. bi-metallic wire.

COPENHAGEN Lighting Department want tenders by noon Aug. 2 for the supply of electricity meters and by noon Aug. 4 for 11 months' supply of cables for their d.c. system. Specifications, &c. (in Danish), may be seen at 73, Basinghall-street, London, E.C.

The Italian State Railways Administration, 16, Via Ludovici, ROME, want tenders by Aug. 22 for supply of 584,000 common carbons for arc lamps. Only firms on list kept by administration are generally allowed to tender. Local representation is practically necessary.

Tenders will be received at Spezia and Venice until 11 a.m. Aug. 13 for supply of electric wires and cables to the ITALIAN STATE RAILWAYS Administration. Specification (in Italian) at 73, Basinghall-street, London, E.C. Only firms on Government list are usually allowed to tender.

TENDERS RECEIVED AND ACCEPTED.

London County Council have accepted the following tenders:—

Dick, Kerr & Co. (lowest tender), for platelaying of tramways from Battersea Park-road to Kings-road, Chelsea, £21,629. 12s. 2d. (Five tenders were received; highest £23,783. 10s. 4d. Chief engineer's estimate, £22,353. 11s.)

Ernest Scott & Mountain (lowest) for supply of electric winch for Forest Hill substation, £135. 1s. 6d. (Five tenders received; highest £202. Chief officer's estimate, £143.)

F. Mountford (Ltd.) (lowest) for 266 standard door locks for 133 sets of draught screens on electric cars, 7s. each, less 2½ per cent. Total £90. 15s. 6d. (Six tenders received; highest 10s. 6d., less 2½ per cent. Chief officer's estimate £95.)

For deal paving blocks at per 1,000: Burt, Boulton & Haywood (£6. 2s. 6d. to £6. 17s. 9d.), Improved Wood Pavement Co. £6. 2s. 6d. to £6. 18s.)

For Jarrah wood blocks at per 1,000: Millar's Karri & Jarrah Co. (£5. 10s. 6d. to £10. 18s. 3d.), and Wm. Griffiths & Co. (£5. 9s. to £10. 16s.)

Stepney (London) Council have accepted the tenders of the General Electric Co. for a power switchboard and of W. White & Co. for a lighting switchboard. The following were the tenderers and their amounts for the power and lighting boards respectively: Edison & Swan Co., £123. 9s. and £12; Kelvin & James White (informal), £130. 2s. and £21. 8s.; General Electric Co., £142 and £22; Elliott Bros., £144. 10s. and £22. 5s.; W. White & Co., £154 and £16. A. W. Penrose & Co. (both boards), £164; Crompton & Co. (both boards), £192.

Bermondsey (London) Council has accepted the following tenders:—

Loudon Bros., lathe, £45, and "champion" forge, £6. 7s. 6d.; Nelson Bros., pillar drilling machine, £29. 10s.; J. Howden & Co., spare piston block complete with rings, £21.

Leicester Corporation have accepted the tenders of Willans & Robinson for a steam turbine and Siemens generator, £7,353; Yates & Thom for steam-raising plant at £2,686; Bowles & Son for extension of power station, £3,118; and Cross & Cross for steel roof trusses, £150. 13s. 8d.

Fulham (London) Council have accepted the tender of the Electrical Co. for 150 electricity meters (3, 5 and 10 ampere at £1 each, 25 ampere £1. 3s., 50 ampere £1. 4s., 75 ampere £1. 9s., 100 ampere £1. 11s. 6d.); total £153. 10s.

Littleborough Council have accepted the tender of W. T. Henley's Co. for l.t. feeders and distributors and the erection of a transformer kiosk and supply of transformers and sub-station switchgear.

Hornsey Education committee have accepted the tender of F Bevan & Co. for the wiring, &c., for the electric light of Stroud Green school at £224. 17s. 2d.

Southend Corporation have accepted the tenders of the Jandus Arc Lamp Co. for 13 arc lamps at £104. 5s., and of Siemens Bros. Dynamo Works for an ampere-meter.

Hammersmith (London) Council have accepted the tender of the Standard Cable Co. for 2,500 yds. of 0·025 l.t. service cable at £181.

BUSINESS NOTICES.

John Allen Plumb and Fredk. Wm. Horsfield, electrical engineers, 64, Newman-street, W., and 62, Argyle-road, Tottenham, N., London, have dissolved partnership.

Dr. Alb. Lessing, of the Carbon Works, Nürnberg, announces that, in order to give the fullest technical attention to inquiries, he has withdrawn his London agency for the electrodes department, and invites those interested to communicate direct with the head office at Nürnberg.

We are informed that Mr. Henry W. Bowden and Mr. William Boby have entered into partnership as consulting engineers at Salisbury House, London, E.C. Mr. Bowden retains his offices at 30, Craven-street, Strand, W.C., for the present.

Messrs. Siemens Bros. Dynamo Works announce that their works at Tyssen-street, Dalston, London, N.E., will be closed during August Bank Holiday week, and that only urgent business can be attended to.

Messrs. Everett, Edgcumbe & Co. intimate that their works at Hendon will be closed during the whole of next week, and that urgent matters should be addressed to 117, Victoria-street, Westminster, S.W. Goods can only be received at the works.

The partnership between G. H. Bowden, F. C. Anderson and C. A. Atchlay, electrical engineers, London and Glasgow, has been dissolved.

Plant for Sale.—Two gas driven alternator sets of 250 kw. each are advertised for sale.

Dewsbury Corporation invite offers for one steam engine with two dynamos coupled to it, and also switchboard panel and resistances. The engine is of Willans & Robinson's make, two F compound 450 revs. per min. and built for 150 lb. pressure at stop valve. The dynamos are of Crompton's make, of 15 kw. each, and work at d.c. pressure of 220-250 volts. Can be seen running. Particulars from the borough electrical engineer, Mr. R. H. Campion. Offers to the Chairman, Electricity and Tramways committee, 93, Bradford-road, Dewsbury. See also an advertisement.

Patents Development.—The proprietors of patents No. 18,408/1906, for "Improvements in electric insulators for h.-t. conductors," and No. 23,878/1900 for "Improvements in process of and mechanism for separation of conductors from non-conductors," desire to enter into arrangements for exploiting same in this country. Communications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton buildings, London, W.C.

Old Type Arc Lamps.—Messrs. H. G. Mayer & Co., 67, Aldersgate-street, London, invite those who are thinking of scrapping their old open type arc lamps to apply for samples of their new Plania flame carbons suitable for these lamps.

Childs' Lifts.—Messrs. J. G. Childs & Co., of Willesden, have recently been making a large number of electrically worked lifts. Recent orders for this class of apparatus include 15 lifts for the Admiralty, of which nine are installed on H.M.S. "Lion" and six on H.M.S. "Orion." The lifts are controlled by push button apparatus, and are designed for both passenger and goods service. They work up and down the ventilating shafts. The same firm has also installed a 15 cwt. goods lift for the Lancashire & Yorkshire Railway at Waterloo Station, Liverpool, and two 1-ton goods lifts for the Great Western and Midland Railway Joint Committee at Worcester station. We understand that this firm are opening new works to cope with the increasing business of the lift and wind turbine departments.

Electrical Heating of Rooms.—Mr. S. L. R. Price forwards a pamphlet dealing with a system of electrical heating which is specially intended for use in warming glasshouses and other similar places. The method adopted is that of surrounding the area to be dealt with by a series of electrical tube heaters, or in drawing air over one or more heaters and circulating by a fan. In this way, it is claimed, an even heat is obtained, while the advantages of cheapness, security and speed are also secured. It is said to require ½ watt-hour to raise 1 cubic ft. of air 5° F.

Tuition by Correspondence.—From the Tutorial Press (Ltd.), Cambridge and London, we have received a copy of the Matriculation Directory (No. 55, June, 1910), of the University Correspondence College. On previous occasions we have referred to the good work done by this college and its staff of teachers. The Directory, which has been carefully prepared and edited, gives particulars of the various courses of instruction for the examinations of the University of London, and there are useful articles on text-books, courses of reading, &c. The questions set at the June matriculation examination of the University of

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London, together with model solutions, are given. Those who are desirous of graduating at the University of London should procure a copy. The published price is 1s. net.

Electricity Supply at Tunbridge Wells.—We have received from the Tunbridge Wells Electric Supply Department a well-illustrated pamphlet showing the uses to which electricity can be put. This is evidently intended for distribution amongst both actual and prospective consumers. It begins with an interesting historical description of the Tunbridge Wells works, and goes on to deal with the advantages of electric lighting by metal filament lamps, while details of new electric heating apparatus and the economies which may be effected by using this agent for both heating and cooking are also given. Modern shop-lighting by arc lamps and the uses of electricity in the garage are also dealt with.

Aberdeen and Industrial Development.—The Industrial Development committee of Aberdeen Corporation have issued an elegant pamphlet, containing effective views of the docks, Castlegate, King's College and the Market Cross, and a plan of the city and burgh of Aberdeen, and giving some information as to the history of the town, statistics relating to the municipal departments (electricity supply, tramway, gas, water, sewerage and cleansing), the facilities for transport to and from Aberdeen, the chief industries, wages of artisans, house rents, education, building sites, &c. Copies can be obtained from the Town Clerk.

CATALOGUES, &c.

Ball Bearings.—We have received from the Stefko Ball Bearing Co. a catalogue dealing with these bearings, the invention of a Swedish engineer, Mr. Sven, of Wingquist. These bearings have only lately been introduced into this country.

Electric Fittings.—Mr. G. Braulik has a new price list ready of c.i. and water-tight fittings for electrical work, &c.

Tantalum Lamps.—Messrs. Siemens Bros. Dynamo Works inform us that they are now placing on the market a tantalum lamp in a tubular bulb, suitable for single or series burning at 100 and 130 volts. The candle-power of this lamp is 25, and its price is 3s.

Wright & Wood Motors.—Messrs. Wright & Wood, Halifax, send us a copy of their list dealing with motor-generators, rotary-transformers and converters. These are made in a number of sizes and types, especial attention being paid to the use of these machines for biograph work, battery charging, X-ray work and boosting.

Electrical Accessories.—Among the firms who make it theirbusiness to supply electrical accessories of all kinds to the trade one of the most important is certainly the Sun Electrical Co. Their latest catalogue will, therefore, be of special interest to our readers, and we should recommend all those whose business it is to purchase electrical apparatus in large quantities to provide themselves with a copy. The first part deals especially with electric lighting accessories, including ceiling roses, wall plugs and small switches. Such apparatus as cutouts, ball and counter-weight fittings and accessories for wiring work are also described. The company expect to issue section 2 of this catalogue, which deals with distribution and switchboards, in due course.

Galvanic Batteries.—Messrs. Siemens Bros. & Co. send us a copy of a reprint dealing with the methods of manufacture employed at their Woolwich works in the making of dry cells. They will be pleased to send a copy of this fully illustrated description of a large variety of their batteries to anyone who cares to apply for it.

Silent Chains and Sprockets.—We have received from Messrs. Hans Renold (Ltd.) a new catalogue dealing with their new patent silent chains and sprockets. A new feature in this is a section dealing with the development of the Renold silent chain. Additions and alterations have been made, and the catalogue is now quite up-to-date.

Bolts and Nuts.—Messrs. T. W. Lench (Ltd.), of Fenchurch-street, have sent us a copy of a catalogue dealing with various bolts and nuts made by them. Black, bright and brass varieties are illustrated. We should recommend the study of this catalogue to anyone requiring bolts and nuts in large quantities.

Electrical Accessories.—The Victoria Electrical Works, od Upper Thames-street, have just issued a new illustrated price list, of which they have sent us a copy. In it are to be found illustrated details of all the various accessories which the wiring contractor has to use inthe course of his work.

Duddell Oscillographs.—In a note on this subject which appeared on p. 626 of last week's issue we mentioned that the Cambridge Scientific Instrument Co. were supplying one of these instruments to "a large firm of cable makers in Australia." This should have read "in Austria." In our opinion this makes the matter even more satisfactory.

BANKRUPTCIES, LIQUIDATIONS, &c.

Harold Bristow, electrician, &c., 368, Hessle-road, Hull, has been adjudicated bankrupt.

Walter Lee Grimsley, electrician, Eureka Motor Works, Shelley-road, Boscombe, Hants., has been adjudicated bankrupt. First meeting of creditors July 30 at Arcade-chambers, Bournemouth, and public examination Aug. 26 at the Town Hall, Poole.

A dividend is to be paid to creditors of Herbt. John Burdett, electrical engineer and contractor, 16, Regent-street, Rugby, and 32, Earl-street, Coventry. Claims to Mr. A. Cripwell, 12, Cherry-street, Birmingham, by Aug. 10.

Dividends are to be paid to creditors of Alfd. Ernest Felgate and Wm. Storey, electrical engineers, 10, Victoria-street, Reading, and also in respect of the separate estate of A. E. Felgate. Claims to Mr. B. P. Allnatt, 2, Forbury, Reading, by Aug. 5.

An application for the discharge of Hy. K. P. Barham (trading as the South of England Electrical Engineering Co.), 60, Fratton, Portsmouth, will be heard on Oct. 13 at the Court House, St. Thomas's-street, Portsmouth.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

*Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

April 22, 1910.

9,798 Wallace. Telephonic systems.
9,809 Lodge & Lodge. Electrical sparking plugs.
9,832 Wilson & Wilson. Electric condensers. (Date applied for, 9/6/09. Compri ed in application No 13,509, 9/6/09.)
9,883 Baker & Sanger-Shepherd. Measuring the photographic or other value of X-rays.
9,890 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Switches.*

April 23, 1910.

9,923 Hall. Electric ignition distributors.
9,924 Hall. Dynamo armatures.
9,925 Hall. Cut-outs for electric generators.
9,926 Hall. System of electric distribution.
9,964 Estelle. Manufacture of electrodes. (Date applied for, 13/5/09.)*†
9,966 Johnson & Marson. Handling and transporting cable drums and the like.
9,967 Gould. Electrical earthing switches.

April 25, 1910.

10,032 Raven. Connecting electric conductors.
10,036 Witzenmann. Method of and apparatus for armouring cables or the like with metal tubing. (Addition to No. 4,957/09.)*
10,037 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges., Germany.) Power operated and controlled railway signals.*
10,041 Malachowski. Electric glow lamps. (Date applied for, 3/9/09.)*†
10,048 Harris. Electric measuring apparatus and the like.
10,054 Ettlinger & Wormser. Protecting-devices for underground cables *
10,065 Regnart. Holders for electric incandescent lamps.
10,097 Löfquist. Electric heating apparatus.*

April 26, 1910.

10,162 Lee. Automatic telephones.*
10,164 Clare. Electrical terminals.
10,172 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H., Germany.) Polyphase electric series motors.*
10,175 Woltereck. Secondary batteries.
10,191 Adams Mfg. Co. (Cutler Hammer Mfg. Co., U.S.) Motor-starters.*
10,192 Saunders. Electric tramways worked on the conduit system.
10,208 Meynier. Dynamo-electric machines. (Date applied for, 26/4/09.)*†
10,222 Kellaway & Bowman. Electric ignition apparatus for internal-combustion motors.

April 27, 1910.

10,252 Hall. Multiple electric ignition apparatus.
10,312 Laurent. Indicating or alarm governors for motors. (Addition to No. 16,802/09. Date applied for, 11/2/10. Comprised in No. 16,802, dated 19/7/09.)*
10,315 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H., Germany.) Electric switches.*
10,334 Kretz. Coin operated mechanism for supplying electricity.
10,338 B.T.-H. Co. & Weidmore. Electric switches.
10,370 Marks. (Felten & Guilleaume Lahmeyerwerke Akt.-Ges., Germany.) Controlling electric motors by means of a Leonard connection.*
10,373 Haasted. Electric distance control of railway points and other movable parts. (Date applied for, 28/4/09.)*†

April 28, 1910.

10,423 Lundberg, Lundberg & Lundberg. Switches.*
10,454 Nicholls & Humphrey. Sparking plugs for igniting combustible mixtures.
10,474 Hirsch. Switches.*

April 29, 1910.

10,524 Bruce Peebles & Co. & Klapp. Electric-car ploughs for making electrical connection with conductors in conduits.
10,530 Hirst & Record. Apparatus for controlling electric circuits.
10,561 Weber & Schmidt. Zinc carbon-bag electric elements.
10,577 Graham. Telephone systems.*
10,595 Evershed & Vignoles, Schneider & Clark. Electrical heaters.*
10,606 B.T.-H. Co. & Clough. Alternating-current dynamo-electric machines.
10,607 Allgemeine Elektricitats Ges. Electric motors. (Date applied for, 30/4/09.)*†

April 30, 1910.

10,654 Hoadley & Tindall. Current limiter for use with fixed rate systems of charging for electrical energy.
10,692 Allgemeine Elektricitats Ges. Alternating-current dynamo-electric machines of the commutator type. (Date applied for, 1/5/09.)*†

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SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

5,062 SOMERS & CROWLEY. Electrical storage battery.
6,312 ALLGEMEINE ELEKTRICITATS GES. Dynamo-electric machines. (Date applied for, 17/3/08.)
7,754 KALLMANN. Testing electricity meters. (Date applied for, 18/7/08.)
7,791 GRAY. Electric conductors.
8,875 O'KILL. Electric accumulators or storage batteries.
9,055 SIEMENS BROS. & Co. (Siemens & Halske Akt.-Ges.) Semi-automatic telephone exchanges.
9,349 SILL. Electric controllers.
9,404 SIMPSON. Electrically-propelled vehicle brakes.
9,796 WILLIAMS, BRADLEY & BRADLEY. Electrolytic cells.
9,829 JACKSON & HURST. Electric controller contact fingers.
10,223 MULLIGAN. Telegraph transmitters or receivers.
10,345 GREENHILL & GODDARD. Electric locks.
10,409 BRUSH ELECTRICAL ENGINEERING CO. & BASTIAN. Vapour electric apparatus and methods of operating the same.
10,588 PARSONS, LAW & STOCKBRIDGE. Commutators of dynamo-electric machines.
10,655 COWPER-COLES. Electro-deposition of iron.
10,791 SCHAULI. Electrolyte for primary or secondary galvanic batteries.

COMPANIES' MEETINGS AND REPORTS.

Direct United States Cable Co. (Ltd.)

The sixty-sixth ordinary general meeting was held on Tuesday, under the presidency of Mr. E. M. UNDERDOWN, K.C.

The SECRETARY (Mr. William Miles) having read the notice calling the meeting and the auditors' report,

The CHAIRMAN said: The revenue for the six months to June 30 last, after deducting outpayments, amounted in round figures to £58,556, the working and other expenses, including income tax, but exclusive of the cost of maintenance of cables, absorbs £25,277, leaving a balance of £33,279 as net profit, which, with £6,859 brought forward from the previous half-year, gives a total of £40,138. This sum has been appropriated as follows: An interim dividend of 4s. per share to March 31 last required £12,142, and the proposed final dividend of 4s. per share, with a bonus of 2s. per share to June 30 will require £18,213; we have transferred £5,000 to the reserve fund, and we carry forward the balance of £4,783. Compared with the corresponding six months of 1909, the revenue shows an increase—not very large, but, at all events, very satisfactory—of £2,112. The working expenses are within £150 of the total of such expenses for the corresponding half-year of 1909. The reserve account has been credited with £9,772 from interest on investments, £137 profit on the sale of securities, and £5,000 transferred from revenue, as I have previously informed you. The amount debited for maintenance of cables during the six months was exceptionally small. We were fortunate in not having any serious interruptions to our cable at all, and the amount was only £3,584, as compared with £13,857 for the half-year to June, 1909. It is always gratifying not to have any interruption during a particular six months, but, of course, we cannot assume that we shall not have interruptions in our shorter cables from time to time. After charging the before-mentioned amount, the balance of the reserve fund account stands at £533,024, as compared with £510,267 this time last year, or an increase of £22,757 during the year. The investments representing this fund appear in the balance-sheet at £523,878, after allowing for the provision of £40,000 made three years ago on account of market depreciation, and it is satisfactory to be able to state that the market value of the securities on June 30 last amounted to £533,856, or £10,000 in excess of the balance-sheet figure, showing that we are recovering to a certain extent what we had to provide against. These accounts are for the second half of our financial year, so, summarising them, the revenue for the year amounted to £118,894, as compared with £112,780 in 1909, and the expenditure to £50,567, as compared with £50,400, leaving a balance of £68,327, which has been dealt with as follows: We have paid in dividends £54,639, as compared with £51,603 in the previous year, and have placed to reserve £12,500, as compared with £10,000. These two items amount to £67,139, and adding the increased balance in hand as compared with that at June, 1909, of £1,188, the above amount of £68,327 is arrived at. Now, the last time I had the pleasure of addressing you I informed you that we had in contemplation the shifting of the cable to a point in Newfoundland which you may, perhaps, recognise under the name of Harbour Grace. All the arrangements have been made for carrying out that work, and we trust that in the ensuing month the matter will be carried through. Naturally a good deal of negotiation was necessary in order to place us in a position to carry this through, and the *modus operandi* was that our manager, Mr. Fenn, went to Newfoundland, and on behalf of the company he has purchased land and buildings at Harbour Grace with a frontage to the sea suitable for the landing of the cable. These negotiations have been carried out on what we consider very advantageous terms. We have also acquired the landing rights for our cable, and various concessions from the Government and the Municipality, and a boat is now on its way to Newfoundland with the first consignment of cable and equipment for the new station. With regard to the position of the Direct Company generally, you have doubtless heard a great many statements with respect to alterations in rates and so on, but at present I need not trouble you with them, because no distinct arrangement has been carried out. Now, with respect to this satisfactory state of things, I said, in answer to a question on the last occasion, that as soon as our reserve fund had arrived or was maintained at a figure we considered necessary, we should give the shareholders the benefit of a certain portion of that amount. I must say that, in my opinion, for many reasons which it is not necessary for me to allude to, it is necessary that we should keep up this reserve fund, which so much strengthens our position. At the same time, we hope that inasmuch as the length of the main Atlantic cable will be somewhat shortened, the reserve may be regarded as favourable when compared with the expense of laying a new main Atlantic cable. The repairs have been paid for from time to time out of the reserve fund, and there is very little to remark with respect to them. I trust that we shall be able to continue to give you a satisfactory bonus. I referred at the last meeting to the sad death of our late secretary and manager, Mr. Finnis, and I also mentioned that we had ceased to keep up the combination in one officer of those two positions. We have now an experienced manager, who is thoroughly acquainted with the work on the other side as well as with the work on this side, and the late secretary has been succeeded by Mr. Miles, with whom we are entirely satisfied both in regard to the manner in which the business is now carried on, and the way in which the general staff arrangements are carried out. I should also speak favourably with regard to the staff in general. I now move the adoption of the report and accounts and the declaration of the dividends and bonus set out therein.

Sir JAMES PENDER, Bart., seconded the motion.

Answering Mr. C. R. Fry on the subject of the recent rumours reported in the financial journals,

The CHAIRMAN said: I did not allude to these so-called negotiations because I had nothing to tell you with respect to them. There have been very long reports in the financial papers of all sorts of things which are said to have taken place. Those things have not taken place; the statements made are not correct. Unofficial conversations have taken place with respect to the large company you spoke of, which, no doubt, is a very powerful organisation for the introduction and development of telephones in the United States. Our ally is the Western Union, which is a big telegraph company. It has also been said that the telephone company mentioned has control of our partner. Of that I know nothing. If control means a large majority, I do not think that is so; but you will, I am sure, appreciate what I say—that conversations of this kind published in the papers with more or less incorrectness are not things which I could profitably discuss with you. In fact, the position I take is that with this company no negotiations, properly so called, have taken place, and seeing the strong position we are in, with our good business and our satisfactory reserve fund, I think that propositions, if they were made, which would in any way affect our entity or position, would require to be examined with the utmost care. I do not think that anything is likely to be determined in a very short time, but naturally anything that is done must be done with the approval of this company, and what is done by this company must be done with the approval of its shareholders.

The motion was then carried unanimously. The retiring director, the Hon. T. H. A. E. Cochrane and Mr. John Varley, were re-elected, as were the retiring auditors, and a hearty vote of thanks to the chairman, directors and staff brought the meeting to a close.

City & South London Railway Co.

The fifty-second ordinary general meeting was held on Tuesday. The Right Hon. C. B. STUART-WORTLEY, K.C., M.P., presided.

The SECRETARY (Mr. W. F. Knight) read the notice convening the meeting, and also the auditors' report.

The CHAIRMAN said: Gentlemen, the main facts the half-year's accounts bring out are that our gross receipts are less by £731 and our expenses are more by £2,237, so we have a net revenue diminished by £2,968. Increased charges for interest on money borrowed, with other things, bring the diminished net revenue down to a total balance available for distribution less by £3,477. We, therefore, recommend a dividend at the rate of £1. 5s. per cent. instead of the £1. 15s. a year ago, but we carry forward £1,535 against £1,412. Various causes have contributed to our loss of traffic. We have carried close on 11½ millions of passengers in the half-year, a greater number than ever before in our history, and a greater number by close on 270,000 or 2·4 per cent. than a year ago, when the reduced fares had not come into operation. These reduced fares were, as regards through fares, forced upon us by the need of continuing to act in harmony with the policy of other tube railways with which we are in physical connection as well as organically allied by the common interest which arises from the fact that we and they are feeders each to the other. In face of the increased number of passengers carried it is impossible to say that our service is losing in popularity with the public. But we do not believe that at the old fares we should have got the new patronage, or even kept all our old customers. We have run 30,579 more train-miles than a year ago. Of these increased train-miles the new Sunday traffic accounts for 13,486 train-miles, or an increase of 44 per cent. The rest of the increase is due to our having continued in spring and summer the higher number of trains per day which ordinarily were regarded as necessary in winter alone. This we have done partly under the pressure of the Board of Trade in the matter of alleged overcrowding, and partly under the stress of competition to attract fresh traffic. This increased number of train-miles run has had the effect of reducing the receipts per train from a fraction over 18s. 3d. to a fraction over 17s. 4d., and the receipts per train-mile from 2s. 5·93d. to 2s. 4·37d. On the other hand, the total expenses per train-mile are up from 1s. 2·11d. to 1s. 2·25d. This increase is partly due to locomotive charges, which are up from 4·52d. per train-mile to 4·70d. It is, however, not due to traffic expenses, excluding lifts, for these are down from 4·37d. to 4·32d. Lift expenses per train-mile are up from 1·76d. to 1·84d. This is partly due to increased expenditure on wire ropes, which need not be expected to recur every half-year. Expenses generally have been added to by an

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increased weight of coal consumed of 544 tons, at an increased cost of £585, to which a rise in price has contributed at the average rate of 5½d. per ton.

On the subject of the increase of wages I may say a word. You doubtless have seen that, under what is known as the Conciliation Boards Agreement come to in 1907, most of the railway companies have, after discussion with their men at Conciliation Boards, and with or without recourse to arbitration afterwards, granted certain increases of pay to their men. This company and its employés are in one respect differently placed to others. With us the number of men and of classes of men are, comparatively speaking, so small, and the subordinate and intermediate functionaries so few, that the men have, and always have had, access to the supreme executive for the purpose of discussing grievances or anything else, with a freedom and readiness that is seldom found possible in the case of the much larger numbers employed by the great railways. And such has been the good sense and good feeling with which those discussions have been carried on, on the one hand by fully representative deputations of our men, and on the other hand by our excellent and popular general manager, that we are able to announce that an agreement has been arrived at, which gives certain of the men advantages, either in time or in money or in both. In return the men waive the institution of a conciliation board, and allow us to report to the Board of Trade that at present none has been found necessary. This agreement holds good till Dec. 31, 1914.

On the quinquennial re-valuation of ratable property in the metropolis we still have discussions pending with local authorities. These new valuations take effect from April, 1911. We believe we have greatly improved the condition of the atmosphere at our Clapham Common station by using an electrical apparatus which ozonises the air. Already our staff there tell us they have found great improvement in the atmosphere, and it is to be hoped that the public will notice and appreciate the like good effects. I now move the adoption of the report and accounts.

Mr. CHARLES SEYMOUR GRENFELL seconded the resolution.

Col. PERRY said he would like to suggest that the title or name of their railway be changed to "The North & South London Railway," instead of "The City & South London Railway." When the Manchester, Sheffield & Lincolnshire Railway came to London they did not retain their old designation, but called themselves the Great Central. Many people were still unaware that the City & South London Railway has any line to the north of the City. He therefore moved that this change of title be made

Mr. PORTER suggested the closing of two or three of the stations, thereby saving expense.

The CHAIRMAN said that the closing of three stations would be a serious matter. They had considered the question of closing City-road station, but there had since been some new places of business opened, and the traffic had a little improved.

A resolution approving the dividends was then carried.

Referring to the suggested change of name, the CHAIRMAN said: Our title, our statutory title, does not exactly describe what our railway is, but we have done all we can by circulating millions of maps and by illuminated electric signs and other forms of advertising, to inform the public that we run to Euston and that we give the public an excellent means of access to and from the City and King's Cross and Euston. The directors will take the matter into their consideration.

A hearty vote of thanks to the chairman, directors, officers and staff brought the proceedings to a close.

Crompton & Co. (Ltd.)

At the meeting yesterday (Thursday) the Chairman, Mr. JOHN TROTTER said that delay on the part of the building contractors had prolonged by a year the completion of an important contract in Madras, which had resulted in large additional and quite unexpected expenditure. However, the whole of the work had now been taken over and the contract might be said to be at an end. Loans from bankers had been considerably reduced, as had also the amount outstanding to sundry creditors. It was not satisfactory to go on trading with permanent loans from the bankers. Their liabilities had now been further reduced. The item to bankers was below £40,000, and the trade creditors item had been brought very much down. Their holding in the Electric Supply Corpn. had been reduced from £42,750 to £24,000 this year. These shares represented the price obtained by the Company for the Chelmsford electric lighting undertaking. Their holding in the Electric Supply Corpn. was higher than they considered the Company, as a manufacturing concern, was entitled to maintain. The profits of the Electric Supply Corpn. continued to increase, and the directors felt that in course of time there would be no difficulty in disposing of the remaining shares at satisfactory prices.

The £23,000 odd, which represented the loss carried forward, was a deplorable result, which, however, it would have been hard to avoid seeing that the gross profit was reduced from £60,500 to £31,826. The expenses at the works and head offices were £3,226 less than in the previous year, and in two years they had reduced expenses by £5,000. There seemed no apparent reason why prices should rise materially in the near future. Their only course was to increase sales and improve designs, and hope for some slight increase in market prices. There was every hope that some recent improvements in the designs of dynamos and motors would enable them to secure an increased amount of business, and as the designs admitted of economy in manufacture, they leave a better margin of profit. Their works were amongst the most modern of their kind, and he thought the cost of manufacture was as low at Chelmsford as anywhere in the country. He was glad to say that since Jan. 1 there was a distinct improvement in the value of colonial and foreign orders. Col. Crompton, although entitled to fees as consulting engineer, had asked him (the Chairman) to announce that in future he would forego these fees unless there was any special business to be entrusted in his hands.

Col. R. E. B. CROMPTON, C.B., said the person most hit by the adverse result they had sustained was himself. He brought a very large sum into the business, had added to his holding from time to time, and had never decreased it. The electric business in England was suffering along with the whole industrial world, and he did not think that their particular firm was suffering more or less than other well managed firms. They had had in a year when the output of the works was insufficient to cover expenses heavy and unforseen losses, for which no one in the Company could be blamed. Who could have forseen such a miscarriage of justice as took place in their lawsuit? The interpretation of a few words had cost the Company about £7,000. He agreed with the Chairman in not thinking that a substantial rise in prices was likely, but the works staff, in whose opinion he had the greatest faith, told him that if prices got no worse and the volume of orders got larger, they could again turn the corner and pay dividends. Nothing but prudence, patience, cutting down of expenses, and unremitting attention to everything that could secure increased sale of goods would avail them in returning to the dividend paying stage, and the board had appreciated this for a long time past.

Mr. G. BUTLER PAUL said he should like to offer their thanks and sympathy to the chairman and directors. The time must have been am exceedingly anxious and trying one, and it would be a satisfaction for tham to know that every shareholder present sympathised with them and thanked them for their attention to the business.

The CHAIRMAN said they much appreciated these remarks.

National Telephone Co. (Ltd.)

The forty-sixth ordinary general meeting of the shareholders of this Company was held yesterday at Hamilton House, Victoria Embankment, Mr. GEORGE FRANKLIN in the chair.

The SECRETARY (Mr. Albert Anns), having read the notice convening the meeting and the auditors' report,

The CHAIRMAN, in the course of his address, said: Ladies and gentlemen, I do not anticipate having to occupy very much time this afternoon, but there are a few points in regard to the report and accounts, as well as to the position of the Company generally, that I think the shareholders would like to have some information upon. First of all, with regard to the income accrued in respect of the business of the half-year, this year it has increased from £1,549,136 to £1,677,587, being an increase of £128,452 in the half-year—that is, this half-year as compared with the corresponding period of 1909. Then we come to the first deduction, the first tax, and that is the Postmaster-General's claim upon us, which is £161,529, as compared with £149,127, or an increase of £12,403, making the total sum which has been paid to the Postmaster-General for this tax upon this industry—for which he has rendered no service and done nothing at all—£3,295,434 of the shareholders' money. We next come to the net income, which amounts to £1,516,058, as compared with £1,408,008. That is an increase in the half-year of £116,049. The working expenses have increased from £890,798 last year to £974,757 this year, or an increase of £83,959. Then we come to the net result for the half-year, and we find that we have £541,300, as compared with £509,210, or an increase over the corresponding half-year of £32,090.

The administration and management expenses, office salaries and charges, operators' wages, &c., amount to £400,811, compared with £389,225, an increase of £11,586. This is more than accounted for by the increase in the operator's wages, which for several years have shown a tendency to rise, due first to the employment of more operators to cope with the increased business, and secondly to the fact that there has been a larger number of operators in the higher ranges or scale of pay. The maintenance and renewal of lines and instruments and depreciation allowances amounted during the half-year to £362,299, as compared with £316,049. That shows an increase of £46,250. Included in that expenditure is a sum which we show separately as an item for repairing damage caused by snowstorms, amounting to £20,331. That compares with about £7,000 in the corresponding half of last year, but apart from that increase in the snowstorm expenses, there is a large increase of between £30,000 and £40,000 in the maintenance and renewal of the Company's plant, and this large increase in maintenance may, I think, be accepted as an indication of the Company's determination, even at a present sacrifice, to maintain a high point of efficiency in the Company's plant and system. This policy has the advantage of enabling the Postmaster-General to acquire not merely our fine organisation and efficient staff, which he will get for nothing, but a plant and equipment fully maintained and in sound working condition, for which the Company will require payment. The sum of £125,970 which appears in the item Debtors for outstanding rentals, requires a word of explanation. We are dealing with five months of actual trade up to May 31, and one month of estimated trade, and that one month's figures are included in the debtor and credit balances in the June half-year in order that we might have our meeting before the holidays and distribute our dividend somewhat earlier.

The reserve fund will amount to no less a sum than £3,705,127. I have often explained at these meetings that that is the sum which is set aside as an insurance to provide for any possible diminution there might be in the Company's capital as a result of the valuation to be placed upon the Company's assets upon the sale to the Postmaster-General, and it must be satisfactory to the shareholders to be as far as possible

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secured against contingencies. Therefore I hope the shareholders will be satisfied with the view which the Directors take when they say they feel that it is essential, even at this late period of the business, to try and make the position of the Company in every way as strong as possible before it enters upon the arbitration or the dispute, if there be a dispute, or I will put it in another way—before it enters upon the Unknown. None of us can tell what will result from the steps which are being taken to have a value put upon our plant, and no one can tell what will be the price, or anything near the price, which the Postmaster-General may be expected to pay. Therefore the shareholders have got to look at it in this way. They have to have confidence in their board, which they have always shown in the past, and, secondly, they have to feel that the board and the company are in a stronger position by reason of having this large increase and addition to the reserve fund. I do not think I can leave the accounts without making a remark on the result of the adoption a few years ago by the company of the system of payment according to user, known as the measured rate. The adoption of this system caused quite a little excitement and opposition from chambers of commerce and other parties, on the ground that the company's scale of charges would prove a heavy burden on those using that system. How unfounded and groundless those fears were is proved by the fact that at the present time the company have in the provinces about 124,000 stations based on this measured rate system, producing to the company in annual subscriptions or revenues an average annual income of £5. 12s. 8d. for the use of a telephone station for a year, and that is the average income per station from this system. It must be a boon to have a telephone at that moderate figure, and this method of charge has become a boon to the small user, because no unlimited or other method could give to the user the use of the telephone at such a rate, and the small user is an advantage to the telephone system, because, obviously, the larger your telephone system is, the greater its use is to those who are already subscribing to it. This huge business, with 16 millions of capital, has been built up in spite of the most vigorous efforts which have been made from time to time to smother it, and in the face of the greatest possible difficulties, and it is satisfactory to know that here to-day, as compared with any other country in Europe, with the exception of Germany, we are at the head of affairs in regard to the number of instruments per population, and considering our difficulties, that is a fairly satisfactory position. (Cheers.) I mentioned at the last half-yearly meeting that in the absence of the agreement with the Postmaster-General as to the value of the company's assets such value will have to be determined by arbitration, and that the company's officers were engaged in the preparations necessary for the inventory upon which the company's claim might be founded. Since that time the work has still continued, and the preparations are still proceeding. I observe that the Postmaster-General, in speaking in the House of Commons the other evening on the Post Office estimates, stated that he had very small hope that the purchase of this company could be settled otherwise than by arbitration. If this be so, as it probably is, the board have confidence in the case which they will be able to put before the arbitrator, and whilst in the public interest they will always be ready to co-operate with the Postmaster-General as far as possible, the shareholders may rest assured that the board will strongly guard the interests committed to their care. I beg now to move that the report and accounts be received and adopted, and that the dividends as recommended in it be paid.

The VICE-PRESIDENT (Mr. Samuel Herrick Sands) seconded the motion, which was at once carried unanimously.

The retiring directors and auditors were re-elected, and the proceedings closed with a vote of thanks to the chairman.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The total receipts from Jan. 1 to June 30, including £1,894. 1s. 8d. brought forward, amounted to £208,949. 15s. 8d. Traffic receipts show an increase of £6,988 compared with the corresponding half-year of 1909. Working expenses amounted to £75,652. 10s. 10d., an increase of £3,307. 1s. 7d. The directors have, before declaring the net profits, set apart £10,000 to renewal fund, leaving £123,297. 4s. 10d. Quarterly interim dividends of 15s. per cent. on the ordinary stock, and £1. 10s. per cent. on the preferred stock were paid on April 30, absorbing £52,500, and second quarterly interim dividends of 15s. per cent. on the ordinary stock, £1. 10s. per cent. on the preferred stock, amounting to £52,500, will be paid on 30th inst. The balance of £18,297. 4s. 10d. will be carried forward.

BOMBAY ELECTRIC SUPPLY & TRAMWAYS CO. (LTD.)—At the ordinary general meeting on Thursday last Sir E. Sassoon, who presided, said the net receipts were £82,695. 13s. 8d., compared with £67,066. 16s. 3d. the previous year. Deducting debenture interest (£30,530. 5s. 9d.) there remained £52,165. 7s. 11d., making with £9,385. 9s. 1d., brought forward, an available £61,550. 17s. Preference dividend absorbed £35,983. 13s., whilst provision for sinking fund had required a further £6,000, leaving £19,567. 4s. The directors recommended that £15,000 be placed to depreciation account, and £4,567. 4s. carried forward. Of the sum for depreciation they proposed that £10,000 be invested outside the business. Revenue was £197,827. 19s. 3d., increase £19,972. 7s. 6d., and this increase was obtained by an increased expenditure of only £4,343. 10s. 1d. Revenue from the tramways accounted for £8,628 of the gross increase, and the receipts from electricity supply accounted for £9,837. It had been decided to construct 10 new single-truck cars, each seating 38 passengers, which would be attached to existing cars, and run as double-car trains. The balance carried to profit and loss account in the electricity supply section was £16,618. 1s. 4d., compared with £7,976. 19s. 1d. The directors had decided to substitute flat rates for the maximum demand system. This would apply specially to the domestic consumption—to the supply for lighting and electric fans, as distinct from contracts entered into with large consumers of electrical energy for power for industrial purposes. Experience had shown that while scientifically sound in principle, the maximum demand system of charging was not equally satisfactory in practice where the conditions to be dealt with were those of an Oriental city. The new tariff had not yet received the concurrence of the municipality, but the municipality and the large majority of consumers were strongly in favour of flat rates.

BRITISH ELECTROMOBILE CO. (LTD.)—The directors' report for the year ended June 30 states that the profits were £363 and that the adverse balance brought forward is reduced to £241.

CENTRAL LONDON RAILWAY CO.—The directors' report for the half-year to June 30 states the traffic receipts were £146,586 (increase £2,927) and total gross receipts £158,339 (increase £4,597). Working expenses were £87,628 (decrease £1,974), leaving balance to net revenue account £70,711 (increase £6,571). After providing for debenture interest, &c., there remains £85,078. 16s. The directors recommend dividends at the rate of 3 per cent. on the undivided ordinary and 4 per cent. per annum on the preferred ordinary stock, and the balance of £45,805. 4s. carried forward. Passengers carried were 20,664,896 during the half-year (compared with 18,989,109 for the corresponding half of 1909.) A contract has been entered into for the construction of the extension of the Central London line from the Bank station to the Liverpool-street station of the Great Eastern Co., with a connection to the Broad-street station of the London & North-Western and North London Cos., and work has practically commenced. A contract has also been let for the making of the public subway between the Bank station of the Central London Railway and the booking hall of the City & South London Railway in King William-street, the cost of which will be borne equally by the two companies.

EAST LONDON RAILWAY CO—At the meeting of this company on Tuesday Lord Claud Hamilton dealt with the question of electrification, and quoted statistics showing the excellent results obtained by the electrification of the Mersey railway. He said that in the case of the East London they would not have to go in for large capital expenditure to provide a power station. Like the shareholders, he was getting very tired of beating about the bush, and he proposed, and his colleagues had already given their approval, to approach one or two of the great electrical companies and see whether they could submit a scheme—probably on the principle of deferred payments extending over several years—under which they would undertake to carry out the entire work of electrification. If he succeeded in coming to terms, he would be in a position to go with something concrete to the six lessee companies, and, he trusted, with some prospect of success.

LANARKSHIRE TRAMWAYS CO.—For the half-year ended June 30 the revenue was £36,181. 13s. 3d., and the expenses were £20,599. 8s. 6d. Deducting the contributions payable to local authorities (£825. 10s. 9d.) and interest (£608), and adding amount brought forward the balance is £15,477. 7s. 3d. The directors recommend a dividend at the rate of 5½ per cent. (£9,432. 10s.), leaving £6,044. 17s. 3d. to be carried to revenue new account. The traffic receipts show an increase of £4,058 over the corresponding period of last year, due to improved trade conditions and to extensions opened for public traffic July, 1909. The expenses show an increase of £2,913.

LIVERPOOL OVERHEAD RAILWAY CO.—The accounts for the past half-year show an available balance of £9,592. 15s. 6d., and the directors recommend payment of the preference dividend, leaving £5,916. 18s. 6d. to carry forward.

LONDON, BRIGHTON & SOUTH COAST RAILWAY CO.—The directors' report for the half-year to June 30 states that the electrical trains on the South London railway continue to work very successfully, and the increase of traffic since the services were established is still maintained. The board have decided to extend the electrical system to other parts of the suburban area served by the railways of the company, and the work of equipping the line from Peckham Rye, where a junction is made with the South London Railway, through Tulse-hill to the Crystal Palace, has already been commenced. The capital expenditure during the half-year included £28,148 for the electrical equipment of the South London line.

METROPOLITAN DISTRICT RAILWAY CO.—The directors recommend a dividend for the past half-year at the rate of 3 per cent. on the 5 per cent. extension preference stock, placing £10,000 to renewals and carrying forward £8,527. A year ago a distribution at the rate of 3 per cent. per annum was made on the 4 per cent. guaranteed stock and £10,000 placed to renewals.

METROPOLITAN RAILWAY CO.—At the meeting on Wednesday the chairman (Sir Chas. McLaren) said it was proposed to place £10,000 to the electrical renewal and depreciation fund, against £5,000 in the corresponding half-year, but the extra £5,000 was the sum received from the Great Western Railway Co. under a recent settlement for work done during the past three years. The board had entered into a contract with the British Westinghouse Co. for a renewal of a large portion of the generating machinery at Neasden, which would not only largely increase the capacity of the power station, but it was expected would result in considerable economy in coal consumption. They might congratulate themselves upon the result of the half-year's working, and look forward confidently to increases in dividend in the future.

MEXICAN LIGHT & POWER CO. (LTD.)—The directors' report for 1909 states that the development of the business and the work of construction have made satisfactory progress. The demand for power in

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the City of Mexico and the Federal District increased so rapidly that it became necessary to press forward the completion of the entire hydro-electric works at Necaxa, and these are now rapidly approaching completion. By the construction of a series of tunnels and dams five large reservoirs have been formed, which will store a very large volume of water, thereby assuring a continuous supply of water during the entire year. On the completion of the work the hydro-electric power station at Necaxa will have a capacity of about 100,000 H.P., of which 50,000 H.P. is already used under peak loads. The carrying capacity of the high-voltage transmission lines also has been increased to 100,000 H.P. The accident in May, 1909, to one of the dams at Necaxa did not greatly add to the cost of construction and the completion of the dam was delayed only six months. The storage capacity of the five reservoirs is 129,500,000 cubic metres, but when the present works are completed it will be 173,000,000 cubic metres. It is anticipated that in future the company will not require to have recourse to steam power. The gross earnings for the year were $3,014,325, which, with $60,823 brought forward, made $3,075,149. From this has been deducted general operating expenses ($648,337), making the net revenue $2,426,811, out of which the management and fixed charges and the 7 per cent. preference dividend have been paid, leaving $1,186,528. From this surplus one-half of the extraordinary expenditure in connection with the operation of the steam plant has been deducted and a 4 per cent. dividend on the common stock has been paid, leaving $149,386 to be carried forward. Construction has been commenced on a branch transmission line from Necaxa to Pachuca and on a sub-station, and it is expected that power will be delivered from Necaxa by Sept. 1 next, when the Pachuca plant will be shut down, thereby reducing the operating cost.

MEXICO TRAMWAYS CO.—The net revenue (in gold for 1909, after paying expenses and fixed charges, amounted to $922,458, which, added to $371,350 brought forward, made $1,293,808. Four quarterly dividends at the rate of 6 per cent. per annum were paid, absorbing $577,464, leaving $716,344, out of which $300,000 has been carried to reserve as a special appropriation for depreciation, and $416,344 forward.

NEW GENERAL TRACTION CO. (LTD.)—The revenue for the year ended March 31 (received and accrued) amounted to £19,482. 1s. 10d., against £18,701. 8s. 9d. in the previous year. The general expenses were £1,792. 9s. 1d., against £1,990. 16s. 8d. The accounts show a profit of £500. 19s. 4d., after providing for the realised loss of £576. 11s. 11d. on the sale of $64,000 4½ per cent. first mortgage bonds of the Darby, Media & Chester Street Railway Co. and £1,500 towards depreciation of investments, thus reducing the balance of loss previously shown to £25,306.3s.9d. The dividend received from the Coventry Electric Tramways Co. for 1909 was the same as for the previous year (3½ per cent.); a dividend of 1¾ per cent. was received from the Norwich Co. (against 1¼ per cent.); the Douglas Southern Electric Tramways Co. paid 5 per cent. on its preference shares (compared with 5½ per cent.); and the income from the Philadelphia undertaking for the year was £10,324. 10s. 7d.

TRAFFORD POWER & LIGHT SUPPLY (LTD.)—The accounts for the year ended March 31 show a loss (after providing for interest) of £417 increasing the debit forward to £2,934.

VICTORIA FALLS & TRANSVAAL POWER CO.—At the recent meeting the Marquess of Winchester said they had few customers, but those customers had a large and increasing demand for power. Increased capital commitments had to be met by increasing the debenture issue To do that they must be able to prove that there was a substantial margin of revenue over and above that required to meet the debenture interest during the present year. They proposed to carry forward the balance profit on the past year's working. Not only had further contracts to take power been concluded, but certain of the contracting companies had also become financially interested as shareholders in the success of their undertaking. The Driehoek station, from the fact that the plant was not of an economical type, would have been closed down last year and merely retained as a stand-by until the installation of the more modern stations was completed, but owing to the increasing demands of the mining industry for power it was decided to keep the plant in commission. That, although not satisfactory from a revenue point of view, enabled them to give supplies to new consumers and to consolidate their position. Application had been made to the Transvaal Government to enable them to erect a new station on a suitable site selected.

NEW COMPANIES, &c.

NEW COMPANIES.

DAC ACCUMULATOR SYND. (LTD.)—(110,763).—Reg. July 13, capital £25,000 in £1 shares, to carry on the business of electrical engineers and contractors, manufacturers of and dealers in cells and batteries, suppliers of electricity, manufacturers of electrical and other apparatus, &c., and to adopt an agreement with G. Schauli, F. T. W. Price and H. E. Hughes for the acquisition of certain patents. First directors, F. T. W. Price and H. E. Hughes. Reg. office, 39, Red Cross-street, London, E.C.

DARTMOOR ELECTRIC SUPPLY CO. (LTD.) (110,871).—Reg. July 19, capital £4,000 in £1 shares, to carry on at Bovey Tracey and elsewhere the business of an electric light company and to adopt agreements with J. H. Lee and A. J. Wyatt. First directors, W. Aggett, H. A. Bentinck, J.P., D.L., H. Goodwyn, F.R.C.S., Lucy Hellier, W. G. Hole and P. W. Peters. Reg. office, 12, Market-street, Newton Abbott, Devon.

HOLOPHANE (LTD.) (110,941.)—Reg. July 22, capital £200,000 in £1 shares, to acquire from O. A. Mygatt, Paris, his interests in the Holophane system of illumination in all parts of the world, except France and the French Colonies, and including the business of O. A. Mygatt, 12, Carteret-street, S.W., and elsewhere as the Holophane Co., and all patents, secret processes, trade marks and designs relating to glassware for artificial lighting purposes belonging to the vendor. First directors, O. A. Mygatt, Lieut.-Col. F. J. P. Butler, G. C. Glynn, D.S.O., Lord E. W. Hamilton and R. Woodhouse, Jun. Reg. office, 12, Carteret-street, London, S.W.

METALITE (LTD. (110,919.)—Reg. July 21, capital £500,000 in £1 shares, to carry on the business of manufacturers of electric lamps, filaments, radiators, stoves, meters and fittings and apparatus and appliances of all kinds for use with electricity, and to acquire the businesses of the Bryant Trading Synd. (Ltd.) and International Filaments (Ltd.).

RECEIVERSHIPS.

BUCKHOLTZ REVERSIBLE TURBINE SYND. (LTD.)—Notice is made of the appointment of J. Ward, 4, Bennett-street, London, S.W., as receiver, on May 10, 1907, under powers contained in instrument dated Oct. 29, 1906. (Notified July 7.)

C. & A. MUSKER (1901) (LTD.)—Notice of the appointment of W. H. Walker, of 42, Castle-street, Liverpool, as receiver on June 29, under powers contained in trust deed dated July 8, 1901, has been filed.

NORFOLK ELECTRICAL CO. (LTD.)—Notice of the appointment of G. R. Ridsdale, of Winchester House, Birmingham, as receiver, on July 15, 1910, under powers contained in mortgage debentures dated July 22, 1908, has been filed.

WITNEY ELECTRIC SUPPLY CO. (LTD.)—Notice of the appointment of F. Habgood, of Witney, as receiver and manager, by order of Court dated July 15, 1910, has been filed.

CITY NOTES.

MEMORANDA (July 28).—**Bank rate 3 per cent. (since June 9, 1910). Price of silver,** 24⅛d. per oz. Consols 81⅞—81⅞ for money and for account. **Consols Pay Day, Aug. 4; Stock and Shares Continuation Days, Aug. 10 and 29; Ticket Days, Aug. 11 and 30; Pay Days,** Aug. 12 and 31; **Mining Shares Carry Over Day,** Aug. 9.

PRICES OF METALS (London).—*Copper*, cash, 54⅞; three months, 55¼. *Lead*, English, 12¾—13; foreign, 12⅝—12⅝. *Spelter*, 22¾—22¾. *Tin*, English, 148—149; foreign cash, 149½; three months, 150¼. *Iron*, Cleveland, cash, 48/8, three months, 49/5½.

BRISTOL TRAMWAYS & CARRIAGE CO. (LTD.)—The directors have declared an interim dividend at the rate of 4 per cent. for the half-year ended June 30.

BRITISH COLUMBIA ELECTRIC RAILWAY CO. (LTD.)—The directors have declared a dividend at the rate of 5 per cent. on the preferred ordinary stock for the half-year ended June 30, together with an additional dividend at the rate of 1 per cent. for the same period.

CHELSEA ELECTRICITY SUPPLY CO. (LTD.)—An interim dividend at the rate of 4 per cent. (2s. per share), less tax, has been declared on the ordinary shares for the past half-year.

CITY OF BUENOS AYRES TRAMWAYS CO. (1904) (LTD.)—The director have declared a dividend of 1s. 3d. per share (less tax) for the three months ended June 30.

DUBLIN & LUCAN ELECTRIC RAILWAY CO.—After payment of debenture interest the directors propose a dividend at the rate of 5 per cent. on the preference shares for the six months ended June and to carry forward £612.

ICELAND.—At the meeting of the Industrial & Engineering Trust on Friday the Chairman, Mr. F. L. Rawson, said the British North-Western Synd. (Ltd.) had an option to purchase for about £12,000 practically the whole interest in Dettifoss Falls which were capable of developing about 720,000 H.P.—nearly three times as much as the largest falls in Europe. He had had these falls valued by Mr. Hjorth (probably the leading authority in the world on water power), who had valued them at £900,000. There should be no difficulty in forming companies for the utilisation of the power, as it could be delivered on the quay side at a cost of about 11s. per H.P. per annum. This was the most economical power that he knew of anywhere in the world.

KENSINGTON & KNIGHTSBRIDGE ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares for the half-year ended June 30 at the rate of 8 per cent., payable 15th prox.

LISBON ELECTRIC TRAMWAYS CO. (LTD.)—An interim dividend of 3 per cent. (tax free) has been declared on account of the earnings for the current year.

METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)—The directors have declared an interim dividend at the rate of 4 per cent. for the half-year to June 30.

MONTREAL LIGHT, HEAT & POWER CO. (LTD.)—The directors have declared a dividend of 1¾ per cent. on the paid-up capital stock (at the rate of 7 per cent. per annum) for the quarter to 31st inst.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO. (LTD.)—The directors announce an interim dividend of 1½ per cent. on the ordinary shares, less tax.

REES ROTURBO MFG. CO. (LTD.)—An interim dividend at the rate of 5 per cent. has been declared for the half-year ended June 30.

WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)—An interim dividend at the rate of 10 per cent. per annum (less tax) is announced for the half-year to June 30.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Airdrie	July 15	249	+ 15	28	6,155	+ 118
Anglo-Argentine	„ 22	41,250	+ 2,953	29	1,280,878	+ 148,022
Ayr Corporation	„ 23	912	+ 37	10	4,015	+ 209
Baker St. & Waterloo Ry.	„ 23	3,200	+ 135	3	9,770	+ 235
Barnsley	„ 15	161	..	28	4,759	+ 140
Barrow	„ 15	350	+ 90	28	7,148	+ 1,013
Bath Electric Trams, Ltd.	„ 20	871	— 210	29	22,548	+ 1,274
Birmingham Corporation	„ 23	6,672	+ 417	16	109,799	— 383
Birmingham & Midland	„ 8	861	— 252	27	22,500	+ 186
Blackburn Corporation	„ 20	1,109	+ 70	‡17	18,328	— 841
Blackpool and Fleetwood	„ 23	1,173	+ 111	..	..	..
Bolton Corporation	„ 24	4,395	+ 154	17	39,231	— 546
Bombay	June 24	2,530	+ 114	25	68,220	+ 4,674
Bournemouth Corporation	July 20	3,243	+ 1,558	16	30,373	+ 3,801
Bradford Corporation	„ 23	5,484	+ 460	17	84,303	+ 2,569
Brighton Corporation	„ 24	1,039	+ 11	§16	15,494	— 415
Bristol Trams & Carriage	„ 22	5,977	+ 4	3	18,636	+ 893
Burnley Corporation	„ 23	1,259	+ 74	3	3,793	+ 93
Burton Corporation	„ 24	280	+ 2	16	4,375	— 41
Bury Corporation	„ 24	1,194	+ 78	§16	19,610	— 370
Calcutta Tramways Co.	„ 23	₹51,142	+ ₹2,002	3	₹157,236	+ ₹3,031
Camborne-Redruth	„ 23	121	— 1	29	3,523	— 122
Cardiff Corporation	„ 16	2,482	+ 225	16	34,612	+ 703
Cavehill	„ 15	249	+ 33	28	2,526	+ 221
Central London Railway	„ 23	5,642	+ 215	3	17,341	+ 1,012
Charing C., Euston & H'steac	„ 23	3,570	— 410	3	10,915	— 905
Chatham & Dist. Lt. Rys.	„ 21	827	— 185	29	23,551	+ 907
City & South London Rly.	„ 24	3,127	+ 138	3	9,254	— 14
City of Birmingham	„ 15	2,850	— 171	28	79,772	+ 1,656
Colchester Corporation	„ 20	215	..	..	..	..
Cork Electric Trams Co.	„ 21	553	— 28	29	13,914	+ 1,669
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	„ 15	421	+ 49	28	11,539	+ 1,432
Dover Corporation	„ 23	240	+ 7	16	3,429	+ 28
Dublin & Lucan Railway	„ 22	175	+ 16	3	523	+ 17
Dublin United	„ 22	5,888	— 49	3	18,793	+ 574
Dudley-Stourbridge	„ 15	872	— 38	28	21,079	— 697
Dundee Corporation	„ 23	1,210	— 29	§9	11,576	+ 263
East Ham Council	„ 23	1,027	— 141	¶16	17,010	+ 218
Exeter Corporation	„ 22	350	+ 1	16	5,237	— 634
Gateshead & Dist. Trams	„ 15	1,015	— 2	27	27,265	— 240
Glasgow Corporation	„ 23	13,537	+ 455	8	136,773	+ 8,509
Glossop Trams	„ 23	119	— 40	29	3,277	— 204
Gloucester Corpn.	„ 20	295	— 5	2	903	— 1
Gravesend-Northfleet	„ 15	225	— 6	28	5,591	+ 93
Great Northern & City Rly.	„ 23	1,302	+ 7	3	3,980	+ 51
Gt. Northern, Piccadilly, &c.	„ 23	5,430	+ 100	3	16,765	+ 330
Greenock & Port Glasgow	„ 15	674	+ 125	28	17,032	+ 2,550
Hartlepool Tramways	„ 15	285	+ 5	28	6,471	+ 303
Hastings Elec. Trams Co.	„ 21	1,118	— 16	3	3,468	— 117
Hong Kong	„ 23	$8,583	+ $551	3	$27,178	+ $3,299
Huddersfield Corpn.	„ 23	1,760	+ 162	16	28,754	+ 1,509
Hull Corporation	„ 23	2,726	+ 210	16	43,835	+ 2,837
Ilford District Council	..	..	..	..	..	..
Ilkeston District Council	..	..	..	..	..	..
Ipswich Corporation	„ 23	478	— 8	16	6,730	+ 182
Isle of Thanet Co.	..	..	..	..	..	..
Jarrow	„ 15	127	— 4	28	3,355	+ 186
Keighley Corporation	„ 21	181	+ 1	16	2,880	+ 90
Kidderminster & District	„ 15	148	+ 6	28	2,818	+ 76
Kilmarnock Corporation	„ 23	174	+ 9	10	1,534	+ 22
Lanarkshire Trams Co.	„ 21	1,558	— 141	29	40.138	+ 3,935
Lancashire United	„ 20	1,339	— 2	29	37,401	— 447
*Leamington	„ 15	204	+ 6	28	4,406	— 153
Leeds Corporation	„ 23	7,154	+ 170	16	115,553	+ 3,320
Leicester Corporation	„ 23	2,485	+ 162	..	..	..
Leith Corporation	„ 23	715	— 21	10	6,512	+ 179
Lincoln Corporation	„ 23	125	— 8	17	2,113	— 4
Liverpool Corporation	„ 16	4,846	+ 847	28	310.395	+ 11,926
Liverpool Overhead Rly.	„ 24	1,432	+ 2	4	5,750	— 76
Llandudno&ColwynBayRy.	..	..	..	..	..	..
*London County Council	„ 13	43,020	+ 7,315	¶15	628,286	+ 91,042
London United	„ 23	6,567	— 857	29	180,876	+ 9,370
Lowestoft	..	..	..	..	..	..
Maidstone Corporation	„ 23	229	+ 31	16	2,834	— 209
Manchester Corporation	„ 23	15,399	+ 567	16	253,629	+ 4,549
Mersey Railway	„ 23	1,984	+ 101	3	5,836	+ 20
Merthyr	„ 15	256	+ 24	28	5,684	— 198
Metropolitan Dist. Railway	„ 23	10,138	— 188	3	32.662	+ 1,311
Metropolitan Elec. Trams	„ 15	8,122	+ 1,684	28	204,006	+ 37,660
Middleton	„ 15	403	+ 48	28	8,668	— 550
Nelson Corporation	„ 23	163	+ 30	§16	2,370	+ 56
Newcastle-on-Tyne Corp.	„ 23	4,300	+ 495	¶16	65,429	+ 58
Newport (Mon.)	„ 23	690	+ 31	17	11,631	+ 429
Northampton Corporation	„ 22	497	— 18	§16	8,000	+ 1
Oldham, Ashton & Hyde	„ 15	611	+ 42	28	15.349	— 68
Oldham Corporation	„ 24	1,838	+ 4	17	32,318	— 941
Perth (N.B.) Corporation	„ 20	199	+ 13	§9	1,646	+ 124
Perth (W.A.) Elec. Trams	..	..	..	..	..	..
Peterborough	„ 15	124	+ 5	28	3,114	— 33
Portsmouth Corporation	„ 23	2,186	— 186	16	23,316	— 1,226
Potteries	„ 15	1,737	+ 23	28	48,750	— 497
Preston Corporation	..	..	..	..	..	..
Rotherham Corporation	„ 21	634	+ 77	16	9,892	+ 232
Rothesay	„ 15	570	+ 173	28	4,265	+ 173
Salford Corporation	„ 25	4,567	+ 179	†17	77,842	+ 435
Sheerness	„ 13	53	— 3	28	1,280	— 28
Sheffield Corporation	„ 24	5,910	+ 347	¶17	103,471	+ 5,830
Singapore Trams	„ 23	$9,523	+ $454	3	$29,922	+ $1,910
South Metropolitan	„ 15	933	+ 97	28	22,438	+ 1,279
South Staffs	„ 15	875	+ 42	28	23,035	— 3
Southend Corporation	„ 20	711	— 284	16	8,963	+ 673
Southport Tramways	„ 15	402	+ 71	28	7,854	+ 236
Stalyb'dge,Hyde,&c., Jt.Bd.	„ 23	787	— 34	¶16	11,789	— 1,133
Sunderland Corporation	„ 24	1,267	+ 11	17	18,895	— 435
Sunderland District	„ 20	462	— 53	38	15,839	— 1,201
Swansea Trams	„ 15	1,173	+ 167	28	29,205	+ 3,458
Swindon Corporation	„ 13	128	+ 1	..	..	..
Taunton	„ 15	43	— 11	28	1,142	+ 115
Tynemouth and District	„ 15	376	— 2	28	6,117	+ 523
Tyneside Trams Co.	„ 20	576	+ 61	3	1,411	— 9
Wallasey District Council	„ 23	1,076	+ 89	§16	15,454	— 272
Walsall Corporation	„ 23	539	+ 20	29	15,396	+ 727
Warrington Corporation	„ 21	442	+ 64	16	6,293	+ 103
West Ham Corporation	„ 15	2,591	+ 226	15	37,285	+ 1,437
Weston-super-Mare	„ 15	410	+ 122	28	2,878	+ 90
Wolverhampton Co.	„ 15	515	+ 22	28	11,725	+ 253
Wolverhampton Corpn.	„ 20	1,019	+ 152	16	15.195	+ 2,308
*Worcester	„ 15	334	+ 25	28	7,516	+ 179
Wrexham	„ 15	103	+ 7	28	2,672	+ 17
Yorkshire W.R. Trams	„ 24	1,093	— 2	30	36,479	..
Yorkshire Woollen District	„ 15	1,049	+ 149	28	27,073	+ 2,465

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Shrs	Last Dividend	NAME.	Price Wed., July 27	Rate per cent. Yielded.	Dividend Due.	Business Week to July 27 High-est.	Business Week to July 27 Low-est.
		Electricity Supply.		£ s. d.			
10	6/0	Boarnemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼—9½	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum, Second Pref.	10⅛—10⅜	5 13 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅛—7⅜	6 9 0	March	7⅜	7⅛
5	3/6	Do. 7 per Cent. Pref.	7 —7⅛	4 13 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3½—4	6 5 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4⅜	4 14 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	†Do. 4½ per Cent. Deb. Stock (red.)	99½—101½	4 8 6	..	101	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅜—4⅛	5 9 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.	3⅜—4⅛	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	9/0	City of London Electric Lighting Ord.	11½—12	6 15 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅜—12½	4 16 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	119 —123	4 1 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99½—102½	4 7 6	Jan, July	101½	..
5	..	County of Durham Elec. P. D. Ord.	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2½—3½	7 14 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.	7⅛—8	6 0 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞—11½	5 6 6	Mar, Sept	11⅛	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103½—103¾	4 4 6	Jan, July	105½	..
St.	4½%	Do. Second Deb. Stock	99 —102	4 9 0	May, Nov	101	100⅞
5	3/6	Folkestone Electricity Supply Co. Ord.	4½—4⅞	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7⅛	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	7 —7⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅞—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	94½—96½	4 3 6	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 —100	4 0 0	April, Oct	..	..
St.	4½%	†Kent Elec. Power Co. Irred Deb. Stk.	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	5 —5½	5 14 0	Mar, Sept	8⅛	8⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	90 —92	4 7 0	Jan, July	92	..
5	2/6	Metropolitan Electric Sup. Ord.	3 —3½	7 2 0	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4 —4⅛	5 0 0	Jan, July	4	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95⅝—97½	4 12 6	June, Dec	..	..
5	4/0	Newcastle Elec. Supply Ord.	3⅝—4⅜	4 11 6	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4⅝	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8⅜—8¾	5 9 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7⅛	4 15 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2¼—3½	6 11 0	April	..	..
St.	5%	Do 5 % 1st Mort. Stock (red.)	99 —102	4 18 0	..	100	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	¼—½	..	..	..	..
1	0/8⅓	Do. 7 per Cent. Cum. Pref.	1 —1¼	6 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	100	..
5	2/6	Urban Electric Supply Ord.	¼—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8⅜—8⅝	5 12 6	Mar, Sep:	..	..
5	2/3	†Do. 4½ per Cent. Cum. Pref.	4¼—5⅛	4 3 6	Jan, July	5¼	5
		Electric Railways and Tramways.					
St.	4%	†Baker St. & Waterloo 4% Perp. Deb. Stock	94 —96	4 3 6	Jan, July	95½	94½
1	..	Bath Elec. Trams Pref. Ord.	⅛—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅛	6 12 9	Jan, July	⅛	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	81½	..
10	6%	Bristol Tramways & Carriage Ord.	6¼—7	8 11 6	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7¼—7⅜	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	½—1	..	June, Dec	⅜	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅝—3½	..	Feb, Aug	2½	2⅜
St.	5%	Do. 5 per Cent. Perpetual Debs.	87 —91	5 10 0	April, Oct	89	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.	68 —73	6 3 0	May, Nov	70	..
St.	3%	Central London Ordinary Stock	66 —68	4 9 0	Feb, Aug	67½	66½
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	..	..
100	4%	†Do. 4 per Cent. Debs.	100 —102⅜	3 18 0	Jan, July	101⅜	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb. Stk.	93 —95	4 5 0	Jan, July	94	93½
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5¼	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	28 —29	3 17 6	Feb, Aug	29	28⅝
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	107 —109	4 11 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —106	4 14 3	Feb, Aug	..	..
St.	5%	Do. (1901)	101 —104	4 16 6	Feb, Aug	..	..
St.	5%	Do. (1903)	100 —103	4 17 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 —101	3 19 0	May, Nov	100¼	99½
10	6/0	Dublin United Trams, 6 per Cent. Pref.	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%).	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8 —8½	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	93 —95	4 5 0	Jan, July	93½	93½
5	..	Hastings & District Elec. Trams, 6% C. P.	⅝—1½	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅛—1⅜	4 4 0	Mar, Sept.	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	64 —69	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10¼	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 —71	5 12 6	Jan, July	70½	69½
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅝—¾	..	..	..	..
1	..	Do. Deferred	⅝—¾	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	5 0 0	Feb, Aug	⅝	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	96 —99	4 11 0	Jan, July	..	..
St.	..	Do. 5 per Cent. Db. Stk	94½—95½	..	..	96	..
St.	1%	Metropolitan Railway Consolidated	39 —39½	2 10 3	Feb, Aug	39½	38½
St.	2½%	Do. Surplus Lands Stocks	66 —68	4 1 0	Feb, Aug	66	..
St.	3½%	Do. 3½ per Cent. Preference	89 —91	3 17 0	Feb, Aug	90½	..
St.	3½%	Do. 3½ per Cent. "A" Preference	86 —88	3 19 6	Feb, Aug	87½	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	86 —88	3 19 6	Feb, Aug	..	..
St.	3½%	†Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	91⅞	91½

* In calculating the yield allowance has been made for accrued interest, but not for redemption.
†Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed. July 27	Rate per cent. Yielded.	Dividend Due.	Business Week to July 27 High-est.	Business Week to July 27 Low-est.
		Electric Railways and Tramways— *Continued.*		£ s. d.			
£t.	3½%	†Met. Rly. 3½ per Cent. "A" Deb. Stock..	90 —92	3 15 6	Jan, July	90½	
£t.	..	Metropolitan District Railway Ord.....	20¾—21¼	..	Feb, Aug	21¼	20½
£t.	..	Do. Extension Pref. (5 per Cent.).....	69 —71	..	Feb, Aug	70	..
£t.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	72 —7¼	4 14 6	Feb, Aug		
£t.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	75½	74½
£t.	4%	Do. 4 per Cent. Midland Rent-charge	99 —102	3 18 6	Jan, July	..	..
£t.	4%	Do. Guar. Stock 4 per Cent.....	102 —104	3 17 0	Mar, Sept	102½	102
£t.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	140 —142	4 4 6	Jan, July	..	..
£t.	4%	Do. 4 per Cent. Ditto.....	94 —96	4 3 6	Jan, July	..	..
1	4 d.	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	¼—½	6 14 0	Feb, Aug	..	..
£t.	4½%	Do. 4½ per Cent. Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—¼	..		..	..
£t.	4%	Do. 4 per Cent. Deb. Stock.....	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoup5	34 —36	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds.....	102 —103	4 17 0		102½	102
..	4½%	Do. 4½% Bonds with coup. 6	86 —88	5 2 0		87½	..
..	4%	Do. 4 per Cent. 1st Power Ho. Dbs. ..	98 —100	4 0 0		99½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	¼—½	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1¼—2½	..		..	..
£t.	4½	Do. 4½ per Cent. 1st Debs.....	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
£t.	4½%	‡Ancho Cable Co. 4½ % Deb. Stock	99½—101½	4 8 6		..	..
1	..	Aron Electricity Meter Ord.....	⅛—⅜	..		..	..
1	1/9	Do. 6% Cum. Pf.	⅜—½	6 16 3	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.....	5½—5¾	5 10 0	April, Oct	..	..
1	0/7½	Do Pref.....	1⅞—1⅞	3 16 3		..	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7	7 3 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.....	6 —6½	4 12 0	Jan, July	..	..
£t.	4½%	Do. 4 per Cent. 1st Mort. Deb. (red.)..	101 —104	4 6 6	Jan, July	..	..
£t.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	⅛—⅜	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	99 —101	5 19 0		100	..
£t.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	61 —63	3 3 6	Jan, July	62½	..
£t.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
£t.	4½%	Do. Perpetual 2nd Deb. Stock.....	23 —27	16 12 0	Jan, July	25	24½
5	10/0	Callender's Cable Con. Ord.....	9½—10½	6 8 0	Jan, July	9¾	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	4½—5¼	4 15 0	Jan, July	5¼	..
£t.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red)..	100½—102½	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.....	2⅜—2½	5 8 9	May, Nov	2⅜	2⅛
£t.	4½%	Do. 4 per Cent. 1st Mort. Deb. (red.)..	106 —109	4 3 6	Feb, Aug	..	..
1	1/0	†Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	5 19 0	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	⅝—¾	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	⅛—⅛	5 12 9	April, Oct	..	..
1	0/7½	Do 6 per cent. Cum. Pref.	⅛—⅛	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	¼—½	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	84 —87	5 15 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¾—1⅛	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	1⅛—1⅜	5 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	¾—1¼	5 6 6	Sept	..	..
£t.	4½%	Do. 4½ per Cent. Deb. Stock.....	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1¼	9 3 0	Feb, Aug	..	..
£t.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 15 0	June, Dec	..	..
£t	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅛—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1½	..	May, Nov	75	..
£t.	4½%	†Do 4½ per cent. 1st Mort. Deb. (red.)..	75 —76	5 18 0	Jan, July	75½	..
2	..	Electric Construction Co.....	¼—½	..	Jan, July	..	..
2	7%	Do. 7 per Cent. Cum. Pref.....	1⅛—1⅜	8 12 6	July	..	..
£t.	4%	†Do. 4 per Cent. Perp. 1st Mort. Debs ..	59 —64	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref..	7⅛—8	6 5 0	June, Dec	..	..
£t.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11½—12⅜	6 1 0	Feb, Aug	12½	11¾
5	2/3	Do. 4½ per Cent. Pref.	4¾—5¼	4 5 9	Feb, Aug	..	..
£t.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	103½—105½	4 5 6	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works....	14½—15½	6 10 6	Feb, Aug	..	..
10	5/0	Do 5 per Cent. Cum. Pref.	10½—10¾	4 12 0		..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April, Oct	..	..
1	..	National Elec. Construction Co.	⅛—⅜	..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—½	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅜—½	..	May, Nov	..	..
£t.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..		..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..		..	..
12	12/0	†Telegraph Construction & Maintenance..	33½—35½	5 19 0	Mar, July	34½	33½
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99 —101	3 19 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2 —2¼	4 9 3		2⅛	2
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1¼	4 0 0		1⅛	..
£t.	5%	Do. 5 per Cent. non-Cum. Preferred ..	109 —112	4 9 3		109	..
£t.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	103½	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	105	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	104 —106	4 14 3		..	..
10	10%	†J. G. White & Co. 6% Cum. Pref. xd & bonus	11½—12½	8 3 6		..	..
1	..	Willans & Robinson Ord.....	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1½—1¾	10 13 6	Apr, Oct	..	..
£t.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3¾	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan, July	..	..
£t.	15/0	Anglo-American	63½—65½	5 8 0	F,My,Ag,N	63½	63½
£t.	30/0	Do. Preferred	106 —108	5 12 0	F,My,Ag,N	107½	106
£t.	25/0	Do. Deferred	24½—25	5 0 0	F,My,Ag,N	25⅛	24⅛
£t.	4%	Commercial Cable 4 per Cent. Deb. Stk...	83½—85½	4 13 6	Jn,Ap,Jy,O	85½	85½
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 15 0	Feb, Aug	17	..
½	2/0	Direct Spanish Ord.	3½—3¾	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do 4½ per Cent. Deb.	99 —101	4 19 0	Jan, July	..	..
20	4/0	Direct United States Cable.....	14½—15	5 13 6	Ja,Ap,Jy,O	14⅛	..
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.).	98 —100	5 0 0	June, Dec	..	..
£t.	25/0	Eastern Ordinary	132 —135	5 4 0	Ja,My,Jy,O	134	132
£t.	17/6	†Do. 3½ per Cent. Pref. Stock.....	83½—85½	4 2 0	Ja,My,Jy,O	84½	..
£t.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	102 —104	3 16 0	May, Nov	..	..
£t.	2/6	†Eastern Extension	12½—12¾	5 15 0	Ja, Ap, Jy, O	12½	12⅜
100	4%	Do. 4 per Cent. Deb. Stock	101 —103	3 17 6	Feb, Aug	..	..
26	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	97½—101½	3 18 6	May, Nov	99½	..
10	5/0	G.N (of Copenhagen), with Coupon 80 ..	29½—30½	5 15 0	Jan, July	30	29½
2	52/6	Indo-European	53 —55	5 18 6	May, Nov	54½	54½
100	5%	Mackay Companies Common	85 —90	5 11 0	Ja,Ap,Jy,O	..	..
100	4%	Do Preference	75 —80	5 0 0	Ja,Ap,Jy,O	74½	..
1	..	Marconi's Wireless Teleg. Co.	⅛—⅜	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs.(red.)	96 —98	3 18 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	96 — 98	3 18 0	Jan, July	..	..
10	..	West India & Panama	⅛—¼	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9	6 12 6	May, Nov	8½	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	8½	..
100	5%	Do. 5 per Cent. Debs.	99 —101	4 19 0	Jan, July	..	..
10	3/0	Western Telegraph	13½—14½	4 18 0	Mr.Jn,O,D	13⅜	13⅛
£t.	4%	Do. 4 per Cent. Deb. Stock (red.).....	99 —101	4 19 0	June, Dec	100¼	..
—	4%	Western Union Telegraph, $1,000 4% Bds	103 —106	3 15 3		..	..
..	..	Do. $1,000 4½% Fdg. & Rl. Est. Gd. Bnds'	99 —102	..		..	..

Share	Last Dividend	Name	Price Wed., July 27	Rate per cent. Yielded.	Dividend Due.	Business Week to July 27 High-est.	Business Week to July 27 Low-est.
		Telephones.		£ s. d.			
100	2$	Amer. Telephn. & Telegh. Cap. St.	136 —138	5 16 6		..	..
£t.	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	91 —93	4 6 0	Jan, July	..	..
£t.	4%	Do. 4% Cons. Bonds 1936	103 —105	3 16 0		..	..
£t.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
5	3/0	Chili Telephone	9 —9¼	4 4 0	August ..	9⅛	..
1	0/7½	Monte Video Telephone Ord.....	⅜—⅝	7 10 0	Nov	½	..
1	0/6	Do. 5 per Cent. Pref.	⅜—⅝	5 13 9	May, Nov	..	..
£t.	6%	National Co. Pref. Stock.....	106½—108	5 11 0	Feb, Aug	107½	106½
£t.	6%	Do. Def. Stock	126½—128½	4 13 3	Feb, Aug	127½	126½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10½—10¾	5 10 0	Feb, Aug	10¾	10½
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10½—10¾	5 10 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.....	5⅛—5⅜	4 7 6	Feb, Aug	5⅛	5⅛
£t.	3½%	Do. Deb. Stock 3½ per Cent. (red.).....	96 —98	3 12 0	June, Dec	..	..
£t.	4%	Do. 4 per Cent. Deb. Stock (red.).....	98 —100	4 0 0	Jan, July	99⅜	..
	4½%	New York Telephone Co. 30 yr. Bnds.....	98 —99	4 11 0		99	98¾
1	1/0	Oriental	1⅛—1⅜	4 15 0	April, Oct	..	..
1	0/7½	Do 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 6	April, Oct	..	..
£t.	4%	Do. 4 per Cent. Red. Deb. Stock.....	86 —88	4 11 0	Jan, July	86	..
£t.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	98 —100	4 10 0	Jan, July	..	..
5	3/0	United River Plate Ord. ex rights	6½—7¼	5 12 6	July	7⅛	7⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 14 9	June, Dec	..	..
£t.	4½%	Do. 4½ Deb. St. Red.....	101 —103	4 12 6	Jan, July	102½	102¼
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2½—3½	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10¼—10½	5 8 3	Sp,DcMr Ju	10	10⅛
10	3/0	Do. 6 per Cent. Pref.	13 —13½	4 9 0	Sp,DcMr Ju	13⅜	13¼
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 10 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅜	5 10 0	April, Oct	4¼	4¼
5	2/6	Do. 5% Cum. 2nd Pref.....	4⅛—4⅜	5 9 9	Jan, July	4¼	4⅛
£t.	4%	Do 4% Deb. Stock	90 —91¼	4 7 6	June, Dec	95	90¼
£t.	4½%	Do. 4½% Deb. Stock	93½—96½	4 13 6		95¼	95
£t.	5%	Auckland Elec. Trams. 5% Deb. (red.).....	103 —105	4 15 3	Jan, July	..	..
5	4/6	Brisbane Electric Trams. Invest. Ord	6¼—6¾	4 11 3	May	6¾	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5¼	4 15 0	May, Nov	5¼	5⅛
£t.	4½%	Do. 4½ per Cent. Deb. Prov. Certs.....	99 —102	4 8 6	Jan, July	..	..
£t.	8%	British Columbia El. Rly. Df. Ord.	140 —145	5 10 0	Mar, Sept	141	..
£t.	6%	Do. Pref. Ord. Stock	124 —128	4 13 6	May, Nov	127½	127
£t.	5%	†Do. 5% Cum. Perp. Pref. Stock.....	108 —111	4 10 0	Jan, July	..	..
£t.	6%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
£t.	5%	†Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
£t.	4½%	Do. 4½% Perp. Con. Deb. St.	103½—105½	4 0 0		105	103½
£t.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99 —102	4 18 0	Mar, Sept	..	..
£t.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	97 —100	6 0 0	Feb, Aug	..	..
5	2/6	Calcutta Tramways (1 to 137,610).....	4 —4½	5 0 0	Mar, Sept	4½	4⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—4¾	5 2 6	Jan, July	4¾	..
5	2/6	Do. 4½% 1st Deb. Stock (red).....	96 —99	4 11 0	Jan, July	..	..
1	4½%	Cape Electric Tram Shares	⅛—¼	..		..	..
£t.	..	City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 9 6	F,My,A,N	5⅜	5⅛
£t.	4%	Do 4 per Cent. Deb. Stock.....	97 —100	4 0 0	June, Dec	..	..
£t.	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	95 —98	5 2 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
75	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	96 —99	5 1 0	Feb, Aug	95½	..
1	..	Kalgoorlie Elec. Trams Sh.	⅛—¼	..		..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock.....	92 —96	5 3 6	Jan, July	94	93½
5	6%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	73	..
5	0/7½	Lisbon Elec. Trams. Ord.	1⅛—1¼	4 8 0	July	1⅛	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1¼—1½	4 16 0	Jan, July	..	..
£t.	5%	Do. 5 per Cent. Reg. Mort. Debs.	97½—101½	4 18 6	Jan, July	..	..
£t.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	..	..
£t.	5%	Manaos Trams and Lt. Co. 5% Debs	86½—88	5 14 0		..	..
£t.	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	98 —100	5 2 0	Feb, Aug	..	..
100	$1½	†Mexico Trams Co. Com. St.	120 —122	5 6 6		123½	..
£t.	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	97½—98½	6 1 6		98¼	97½
£t.	6%	Do. 6% 50 yr. Mort. Bds.	97½—98½	6 1 6		98¼	97½
£t.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	102 —104	4 6 0	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0		..	..
1	0/6	†Perth Elec. Trams Ord.	⅛—⅜	5 15 5	May	¼	..
£t.	5%	Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 2 6		5⅜	..
£t.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0		..	..
100	$1½	†Rio Janeiro Tram, Lt. & P. Co.	87½—91½	4 12 0		93⅛	90¼
£t.	5%	Do. 30 yr. Gold Bnds.	97½—98½	4 1 6		98¼	97½
£t.	5%	Do. 50 yr. Mt. Bnds	87 —88	5 14 0		89⅛	87½
100	$2½	†São Paulo Tramway, Light & Power Co. $100 Stock	140 —142	7 1 0		145	142½
£t.	5%	Do. 5 per Cent. 1st Mt. $500 Db:	100 —102	4 18 6	June, Dec	101½	100½
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	101 —103	4 7 6	Feb, Aug	102¼	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5⅛—5⅜	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.....	10½—11	5 9 0		..	..
£t.	4½%	Do 4½ per Cent. Deb. Stk. (red).....	92½—94½	4 15 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock..	97 —99	5 1 0		..	..
		Calcutta Elec. Supply Ord.	6¼—6⅝	6 6 0	April, Oct	..	..
100	$3½	Canadian Gen. Elec. Co. Com. St.	103 —107	6 8 6		103½	..
£t.	5%	Do. 7% Cm. Pf. Stock	122 —125	5 12 0		124	123
100	$3½	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
100	5%	Elect. Development Co. of Ontario.....	85 —88	5 12 6		86½	..
£t.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
		Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..		..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	⅛—⅜	..		..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅜—½	8 0 0	April, Oct	100½	..
		Kaministiquia Power Co.5% Gold Bnds..	100 —102	4 18 0		2¼	..
		Madras E. S. Corp. Ord.	2¼—3	..		..	..
		Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..		..	..
£t.	5%	Do. 5% 1st Mortg. Deb. Stock.....	90 —92	5 7 6		..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	85 —86	5 16 0		85¾	85¼
1	0/7½	†Mexican Lt. & Power Co. Com. St.	77 —79	5 1 0		78½	77¼
£t.	$1	Do. 7% Cum. Pref. St.	101½—103½	6 15 3		102½	101½
£t.	5%	Do. 5% 1st Mort. Gold Bnds.	93¼—94¼	5 5 3		95	94¼
500	$1¼	Montreal Lt. Ht. & Power Co. Cap. St.	130 —134	5 7 3	F,My,A,N	133	..
£t.	£9	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	220	..
£t.	6%	Do. 6 per Cent. non-Cum. Pref. Stk....	105 —115	5 5 0	May	..	..
£t.	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	101¼	..
3/0		Rosario Ele. Co. Ord.	8½—9	..		..	..
3/0		Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
3/0		Do 2nd Pref.	8½—8¾	6 14 6		..	..
$1		†Shawinigan Water& Power Co.Ca	95½—97½	4 2 6		96¾	..
5%		Do. 5 per Cent. Bds.	105 —107	4 13 6	Jan, July	..	..
4½%		Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6		102½	101½
4%		Toronto Power Co. 4% Db. St.	99 —101	4 9 0		100¾	100½
6d.		Victoria Falls Power Co. Pref.(1 to 808,000)	⅛—¼	5 6 6	Jan, July	¼	..
		Do. (803,081 to 1,700,000)	⅛—⅜	..		..	..

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,681. [No. 17. Vol. LXV.] FRIDAY, AUGUST 5, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Street Lighting in the City of London.

THE report of Mr. F. SUMNER, engineer to the City of London, is always interesting, owing to the particulars given of the competitive forms of street lighting. Turning first to electric lighting, we notice that the companies are beginning to see that it is worth while to replace some of the old types of arc lamps, which still adorn the streets in certain quarters, by something more modern. Thus the City of London Co., on their own initiative, have substituted Oliver flame arc lamps for open type lamps in certain streets, the Corporation gaining by this move an advantage of a decreased cost of £8. 10s. per lamp per annum. We think that this policy is wholly desirable; in fact, it may be said to be imperative if street lighting with electric arc lamps is to obtain that popular support which is necessary at the present time. In regard to defective electric lamps, it is stated that 52 cases of this kind were reported during the year, the number of lamps in use being 447. Turning to that part of the report referring to gas lighting, the number of defects appears to be more serious. In ordinary incandescent gas lamps, there were 1,276 cases of feeble light and 20 cases of total failure. In addition there were 199 defects in lanterns, burners, &c., and the total number of defects was 1,841, viz., 1,495 in ordinary gas lamps and 346 in high-pressure lamps. As the total number of gas lamps is 2,720, it will be seen that the electric lamps show to considerable advantage. Another point to which attention is drawn is the synchronising of clocks. It will be remembered that in 1903 a by-law was passed by the City Corporation to the effect that any public clocks erected after that date were to be synchronised. This regulation, however, has not produced a very marked effect because most of the clocks were erected before the rule was made. It is really unfortunate that when the Corporation went so far as to make a regulation they did not make it retrospective and thus obtain a truly accurate time service throughout the City.

Metal Filament Economies.

THE position of the Leeds electricity undertaking during the last year or two has been so unusual that it is certainly worthy of mention. In spite of the fact that new consumers continue to be connected to the mains at a very satisfactory rate, the output of energy remains almost stationary, the total number of units sold during the past year being practically the same as two years ago. When it is seen that the sales of energy for power and heating have during this period increased by considerably over 1,000,000 units, it will be evident how great is the reduction that has taken place in the revenue obtained from lighting. As a matter of fact, the receipts from private lighting were for the past year only £64,518, as against £80,928 two years ago, notwithstanding a large influx of new consumers. This result is largely accounted for by the increasing use of metal filament lamps, with their resultant economy in current consumption. Moreover, the consumption per lamp installed is also decreasing. Thus, whereas in 1907-8 the number of units sold for private lighting per 35-watt lamp installed was 21¼, in the past year this figure fell to 17¾ units. This value appears to have been carefully obtained, and is not based merely on the hypothetical 8 c.p. lamp. As in practically all cases an increased amount of light is being obtained, electricity consumers in Leeds have evidently fully appreciated the great possibilities in the way of economy conferred by the new types of lamp. That electric lighting is also no longer a luxury can be gathered from the fact that the average price per unit sold for lighting was last year only 3·02d., the average figure for the whole supply of 12½ million units being 1·91d. The present position of course, will be quite altered when the change-over by consumers to metal lamps is completed; and as the supply of energy for power has shown considerable progress in spite of trade depression, we shall look at an early date

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for a rapid expansion of the undertaking. Even as it is, a sum of £8,930 has been handed over to the relief of the rates, but we regret that further provision is not being made for renewals.

WHEN it is remembered that the Leeds undertaking has not the benefit of a traction load, the excellence of the low figure at which the costs now stand is emphasised. Thus, with a load factor of only 15·9 per cent., the total costs per unit sold, excluding capital charges, are only 0·59d., fuel costing the remarkably low amount of 0·17d. per unit, a record figure, we believe, in the history of electricity supply, and one certainly reflecting great credit on Mr. H. DICKINSON, the city electrical engineer. The great reduction in the works' costs on the present occasion, compared with last year's and previous results, is probably largely accounted for by the turbo-generators which were recently installed, and which are apparently making considerable impression on the cost of generation. The striking economies introduced without any expansion of the output are certainly most instructive, as showing the difference between central station practice a few years ago and at the present time.

Competition by our Gas Friends.

So keen has the competition of our gas friends become that it is almost another term for "up-to-dateness" in that particular line. The following method, however, which is described in a letter we have received from a well-known London station engineer, is not merely up-to-date, but distinctly before its time:—

> Electrical engineers whose Councils are considering the lighting of their streets by metallic filament lamps, or who at present use this means of lighting, are warned that recently a gas company in London was found to remove temporarily the lamps from columns during lighting hours, their object in doing so being stated to be "for testing." Viewing the fragile character of the metallic filament lamp, it cannot be stated to be just competition to tamper with such apparatus; moreover, the fact that all tests as to efficiency of lighting can be carried out without interfering with the source of light, whether it is gas or electric, renders such an action unjustifiable. Although one cannot but admire the persistence with which the gas companies are waging a hopeless warfare in endeavouring to re-capture street lighting, I think they have overstepped the bounds of commercial morality, and have at the same time committed a breach of the law.

Such a proceeding appears to be most unjustifiable. Obviously a gas company has no right to tamper with electric lamps used in street lighting, though occasions may arise when some control is desired. Supposing, for example, that it was desired to extinguish some electric lamps for the purpose of making photometric tests of adjacent gas lamps, it would be merely common courtesy to request the electricity supply undertaking to switch off the lamps in question rather than to usurp any such authority. There is not likely to be any difficulty in following such a course. In the present instance there does not seem, so far as we can judge, to have been any photometric testing, but merely a wholly unnecessary examination of the lamps. From the point of view of the electricity undertaking such examination of lamps in competition is very undesirable, and unworthy motives suggest themselves. Considering the delicate position in which competitors find themselves under these conditions, we hope that the gas company concerned will see the obvious desirability of restraining the efforts of their staff.

Shop Window Fires.

THE accounts in the daily Press of the serious fire which occurred in a draper's shop at Accrington on Saturday last, involving the loss of five lives, have again drawn the attention of the public to the possible risks where electric lamps are employed in shop windows in close proximity to inflammable goods. Unfortunately, if the fire be held to have been of electrical origin—a fact not always easy to ascertain, with the result that electricity is frequently blamed in the absence of conclusive evidence as to the real cause of the outbreak—emphasis will be laid on the dangers of electric light generally, instead of on the indiscriminate use of flexible wires and lamps among the very inflammable goods, such as cotton wool, exhibited in shop windows. At the inquest on Wednesday we notice that Mr. H. GRAY, electrical engineer to the Accrington Corporation, commented on this dangerous practice, and mentioned that in some cases he believed goods were even pinned to the wires. In most cases the risks, although small, are not appreciated; but a periodical inspection of all installations by members of the staff of electricity supply authorities, when the attention of consumers could be called to the necessity of greater care in shop window illumination, would be of great service, since the number of fires during the past year must have caused shop owners serious anxiety. In the present instance the origin of the fire has not yet been definitely stated, but it is noticeable that the "bursting of an electric lamp" is becoming as stereotyped an expression of the non-technical reporter as the "fusing of an electric wire" has been in the past.

Personal.—Mr. A. C. Forshaw, the London superintendent of the Direct United States Cable Co., retired on pension at the end of July, after 36 years' service. The best wishes of all his old colleagues follow him in his retirement.

It is announced that Mr. George Westinghouse has been succeeded as president of the Westinghouse Electric & Mfg. Co. of America by Mr. Edward Atkins.

Automatic Telephony.—Consul E. Vicars, in his report on the Lyons district for 1909, states that the extensive trial of the Lorimer auto-commutator apparatus for automatic or exchangeless telephony was concluded in the autumn, after a year's duration, and may be pronounced a success; but it appears doubtful whether the Government will take up the invention, partly on account of its complicated, delicate and costly nature and partly by reason of the wholesale dismissal of women operators which its general adoption would entail.

Electric Traction in Copenhagen.—We understand that the Corporation of Copenhagen have decided to take over the working of the electric tramways in that city from August, 1911. According to the terms of the concession the tramways would revert to the city after 30 years from 1898, but could be taken over at a fixed price at the beginning of three-year periods, commencing with 1908. The decision of the Corporation to take over the tramways is against public opinion. The tramways in question include 25·5 miles of double track and 10 miles of single track, over which system operate 279 motor-cars and 191 trailers (five of which are single horse cars). Last year the tramways carried 70,949,345 passengers, and about 8,000,000 motor-car miles were run. It is feared that the result of the purchase will be an increase in the fares. At present a uniform fare of 1½d. is charged for all distances.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910
Bonny—Duala	Aug. 3, 1910

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The late Harry W. Cox.—Amongst other contributions received by Sir William Treloar to the fund on behalf of the widow of the late Mr. H. W. Cox, is a cheque of £150 from His Majesty's Royal Bounty, upon the recommendation of the Prime Minister.

Traction Problems in Pittsburg.—The question of how best to obtain really rapid transit between the centre of the town and the suburbs has long been exercising the minds of the municipal authorities of Pittsburg, with the result that they called on Mr. Bion J. Arnold to look into the matter. Mr. Arnold, whose report has just been issued, deals in detail with the solutions available, namely, an elevated railway, a subway, or the electrification of the existing steam suburban lines. The first of these is at once ruled out of court and the second accepted as being the best solution. It is estimated that a subway would cost between £200,000 and £400,000 per mile of single track, and that this expenditure should not be undertaken unless at least £6,000,000 is to be spent. The average annual earnings are estimated at 12 per cent. of the capital expenditure. These earnings will not increase appreciably with any increase in population, as extensions will then become necessary. The problems of routing and re-routing are gone into, but as these depend on the system of uniform fares, the conclusions arrived at are not applicable in this country.

Change of Resistance of Metals in a Magnetic Field at Different Temperatures.—In a recent issue of the "Philosophical Magazine," Mr. S. C. Laws describes a series of experiments carried out in the Physics Laboratory of the Blackburn Municipal Technical School on this subject. The results reached may be summarised as follows:—(1) In the case of the substances examined—cadmium, zinc and graphite—the change of resistance, $\delta r/r$, in a magnetic field H, is proportional to H^2 for the range of fields used. (2) This change of resistance in all cases increases at lower temperatures; for the metals cadmium and zinc $\frac{1}{H^2}\frac{\delta r}{r}$ at the temperature of liquid air is about 20 times as large as at atmospheric temperatures, while for graphite $\frac{1}{H^2}\frac{\delta r}{r}$ shows only a threefold change over this range of temperature. (3) The increase of resistance, $\delta r/r$, in the case of graphite is about 1 per cent. in a field of 11,000 C.G.S. units at atmospheric temperatures; this is about equal to the *decrease* of resistance of nickel in the same field, and is many times larger than the change of resistance occurring in any of the non-magnetic metals hitherto examined except bismuth.

Electrical Towing at Bremen.—According to "The Times Engineering Supplement," when the city of Bremen some time ago decided to resort to electrical towing for dealing with part of the navigation at the mouth of the Weser, ordinary towing locomotives were found inadmissible on account of the special local conditions. Two tracks of rails would have been required on the crest of the wall separating the two Weser sluices, which would have entailed the necessity of strengthening the wall at considerable outlay. Moreover, the top of the wall was occupied with the control apparatus of the sluice doors, and the traffic would have been impeded by the presence of so many rails. The following plan suggested by the Allgemeine Elektricitäts-Gesellschaft was therefore adopted:—A single line of rails was laid close to each of the outer edges of the wall where its strength was a maximum, thus leaving the remainder of the wall crest free. The usual form of locomotive was abandoned, and, instead, the engine was designed in the shape of a gantry of sufficient height to pass over the controlling devices, operators' cabins, conductor poles, &c. The necessity of passing under a passenger bridge, which is eventually to be erected, had also to be taken into account. The motor which is arranged on the top at the level of the cross-arm is of the three-phase type and drives the locomotive by means of intermediate gearing. The two wheels on each side of the engine are coupled together so as fully to utilise the adhesive force. The required pull of 1½ tons was readily obtained at the tests on delivery. The engine is manipulated by reversing controllers located on both sides immediately beside the controllers for the winches that operate the towing cable. These two winches which are placed in the upper cross-arm enable the towing cable to be let out to a length of upwards of 100 metres. In connection with this towing plant electric lighting plant for the sluice wall was installed. This comprises 18 poles, which are each provided with two 50 c.p. A.E.G. filament lamps, and at the same time carry the supports for the overhead wires feeding the locomotives. The 7,000 volt three-phase current derived from the municipal electricity works is reduced to 220 volts in a special transformer house before being supplied by water-tight cables through the sluice to the lamps and the overhead wires of the locomotive.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

We complete our description of the plant laid down by the Anglo-Newfoundland Development Co. for the manufacture of paper from wood pulp, the paper being used for the printing of the "Daily Mail" and other papers of the Amalgamated Newspaper Co.

We give an account of Dr. Schönherr's system of producing nitrates from the atmosphere.

Last week a joint meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers was held, and five Papers dealing with the electrification of railways were read. We give an abstract of three of these in the present issue, and an account of the discussion which followed.

The Annual Report of the Engineer of the City of London contains interesting details in regard to the public lighting.

The installation of wireless apparatus on board ships carrying 50 or more persons, and plying between ports over 200 miles apart, is compulsory according to a law recently passed in the U.S.A. The Act is fully set out elsewhere. A similar measure is before the British Parliament.

An effort is being made by the Postmaster-General to substitute the telephone for boy messengers in delivering telegrams.

It would appear from a report by Consul-General Smith that the disadvantages outweigh the advantages of exhibiting machinery at Russian exhibitions.

It is curious that the death of one railway servant has occurred in each of the years 1904-5-6-7-8-9 on the electric lines of railway in this country. As regards non-fatal accidents, the record of these lines is satisfactory.

Wireless telegraphy on railways is reported to have proved a success in Brazil.

A 12 months trial at Lyons (France) of the Lorimer "auto-commutator" apparatus for automatic or exchangeless telephony is said to have proved a success.

Tenders are invited by the Minister of Telegraphs for the supply and erection of five wireless telegraph installations in New Zealand.

Frome Urban Council have sealed the agreement with Edmundsons Electricity Corpn. for the transfer of their electricity undertaking to that company. The terms seem to be somewhat different from those usually arranged, and are interesting from that standpoint.

Legal.—An important judgment was delivered by Mr. Justice Neville on Friday last in the action brought by the Attorney General (ex rel. the India Rubber Gutta Percha & Telegraph Works Co.), against West Ham Corporation declaring that bankers' overdrafts for the electricity undertaking were ultra vires.

Companies' Meetings.—At the meeting of the South Eastern and Chatham Railway Companies there was an opinion expressed that the time was approaching when the joint companies would wisely take into urgent consideration the question of electrification.

At the meeting of the London, Brighton & South Coast Railway Co. on Wednesday the chairman referred to the continued success of the electrical train services on the South London Railway, and announced that the lines from Peckham Rye to the Crystal Palace and from Battersea Park to West Norwood were now in course of equipment for electrical working.

The meeting of the Anglo-American Telegraph Co. on Friday last week was made additionally interesting by the particulars given by the chairman concerning the negotiations which have been taking place between the Company and the American Telephone & Telegraph Co. in connection with the laying of another cable across the Atlantic, which, we understand, is to be the largest cored cable of any yet manufactured for this service.

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INSTITUTIONS AND SOCIETIES.

Institution of Mechanical Engineers.—It is a recognised axiom of British civilisation that the best way to entertain a fellow creature whom one particularly wishes to impress with one's own benevolence is to give him a good dinner. It was therefore only fitting that the joint Meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers, which was in progress last week, both in Birmingham and London, should be brought to a conclusion on Friday evening last by an entertainment of the prandial kind given by the British Institution to their American colleagues. The occasion was unique in another way; for it is our ungallant habit in this country to exclude ladies on these occasions, but at this particular dinner this rule was relaxed and invitations were extended to the fairer sex; and whether for this reason, or on account of the leaven provided by our American colleagues, it seemed to us that the proceedings went with much more go than is usual.

The dinner was held at the Connaught Rooms, Great Queen-street, under the chairmanship of Mr. J. A. F. Aspinall, President of the British Institution. The company was seated at 63 small tables, among those present being the United States Ambassador (Mr. Whitelaw Reid), Mrs. Aspinall, Dr. W. F. M. Goss (vice-president of the American Society of Mechanical Engineers), Mrs. Goss, Mr. James M. Dodge (past president A.S.M.E.), Mr. Oberlin Smith (past president) and Mrs. Oberlin Smith, Mr. A. H. D. R. Steel-Maitland, M.P., Sir W. and Lady White, Dr. Worcester, Mr. and Mrs. Hartley Wicksteed, Dr. and Mrs. F. W. Taylor, Dr. and Mrs. Wm. Maw, Mr. C. Hawksley, the Mayor and Mayoress of Windsor, Prof. and Mrs. Hutton, Dr. and Mrs. A. Swasey, Mr. E. P. Martin, Dr. W. C. and Miss Unwin, Mr. C. Kirchhoff, Mr. J. L. Griffiths (U.S. Vice Consul), Dr. and Mrs. J. Freeman, Sir Gerard Muntz (president, Institute of Metals), and Lady Muntz, Dr. and Mrs. R. T. Glazebrook, Mr. Henry Lea, Mr. C. F. Scott, Mr. and Mrs. J. Smith, Mr. and Mrs. J. Hartness, Mr. W. F. Marwood (Board of Trade), the Hon. William and Mrs. Wiley, Mr. Calvin Rice, Mr. and Mrs. Willis Hall, Mr. and Mrs. E. B. Ellington, Mr. and Mrs. Henry Gantt, Dr. and Mrs. Tudsbery, Mr. H. J. Grant, Mr. and Mrs. Mark Robinson, Mr. Frank Ree (L. & N.W.R.), and Mrs. Ree, Mr. and Mrs. A. Herbert, Mr. H. F. Donaldson, Mr. and Mrs. H. Heaton, Mr. F. M. Lea, Mrs. Angus Sinclair, and Dr. Hele Shaw.

The loyal toasts having been honoured with enthusiasm, Mr. ASPINALL, in the absence of the Lord Chief Justice, proposed "The Health of the President of the United States." He said that it sometimes occurred to him that the United States was like a great kaleidoscope, perfect in design and absolutely scientific in arrangement, but changing with the slightest movement, though always remaining uniformly symmetrical, each section pointing to a common centre towards which all the races forming the nation were tending—the Stars and Stripes.

The AMERICAN AMBASSADOR, on rising to reply, was received with prolonged cheers, not only from the American but from the British guests. He said that all Americans would appreciate the kindly terms in which the toast had been proposed, and he felt sure he was authorised to thank Mr. Aspinall and every Englishman present for the sentiments that had been expressed. He drew attention to the way in which the civilisation of the twentieth century had been influenced by the work of the mechanical engineer. Could the twentieth century be conceived, he asked, without the development made by the contributions of Watt and Fulton? Could the English speaking world of to-day be conceived without the lesser, but still gigantic, contributions of other mechanical engineers of the same common race—Stephenson, Fairbairn, Whitney Morse, McCormick, and at the present time Edison, Bell and Westinghouse? Those, like themselves, who had achieved such results and developed such a civilisation, were bound above others to seek constantly for its preservation. Influences were abroad tending to impair or destroy it, so that there was no safety for the work which they had built up and must preserve, save in obedience to law, in protection to life, and in those twin and vital safeguards, equal protection to individual liberty and to individual property, which was shadowed in that respect for authority that their toast enforced. In conclusion, he mentioned that it would, perhaps, be wise for the toast of the President of the United States to be honoured in the same way as that of the King—that is without reply. One thing was clear. The toast of these two great heads of States of the English speaking world were being more and more honoured in the same spirit on both sides of the Atlantic with the same loyal and patriotic hope for the continued sovereignty of law, and the preservation of ordered liberty, which was the real meaning of each of them.

Sir WILLIAM WHITE, in proposing the toast of "The American Society of Mechanical Engineers," mentioned the fact that it was founded only 30 years ago and now had a membership of about 4,000. Both societies had common objects and common ideals, and with a common desire to do their duty in the cause of humanity were being drawn closer and closer together. In the maintenance of law and order and the repression of rebellion and wrong the mechanical engineer bore an important part, and the cause of liberty and truth owed much to him.

This toast was replied to by Prof. HUTTON, Hon. Secretary of the American Society of Mechanical Engineers, in a thoroughly characteristic speech. After paying a tribute to the memory of King Edward, he went on to read into the joint meeting a broader significance than would be given by simply a gathering of friends. The American was so much at home in the United Kingdom because he and his host had a common ideal. As long as they had that common ideal, their civilisation rested on a bed-rock so massive that there was no force which could ever shake the nations apart. The reason why Englishmen had lost work which Americans had secured was that the latter had learned the trick of having the specifications written by the seller and his engineer, whereas the Englishman insisted upon having the specification written by the buyer or his engineer; but when the buyer purchased the standard product of the American engineer he bought what he wanted.

Other toasts were "Our Other Guests," given by Mr. E. B. Ellington, Vice-President of the Institution of Mechanical Engineers, and replied to by Dr. Glazebrook, while "Success to the Institution" was proposed by Dr. W. F. M. Goss and acknowledged by Mr. Aspinall.

Mr. J. A. F. Aspinall and the Council of the Institution of Mechanical Engineers gave a conversazione at the Institution, Storey's Gate, on Thursday last in connection with the joint Summer Meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. The proceedings were rendered more attractive by a number of short lectures, among them being one by Dr. Hele Shaw on "Streamline Experiments Illustrating Aeroplane Stability," while a musical programme was performed by a number of artistes and by the String Band of the Royal Artillery.

British Association.—A provisional programme of the sectional and other meetings of this Association at its annual meeting, which will take place at Sheffield from August 31 to September 6, has now been issued. The reception room will be at the Cutler's Hall and will include a large luncheon room. All the various meeting places are grouped within a radius of 400 yds. from this hall. The president's address and the popular lectures will be given in the Victoria Hall.

In Section A (Mathematical and Physical Sciences), the address of the president (Prof. E. W. Hobson, F.R.S.) will be delivered at 10 a.m. on Thursday, September 1. Two discussions are being arranged. On Monday, September 5, there will be a joint discussion with Section G on the Principles of Mechanical Flight, to be opened by Prof. G. H. Bryan, F.R.S.; and on Tuesday, September 6, Dr. C. Chree, F.R.S., will open one on Atmospheric Electricity. The section will meet with Sections G and B on Friday, September 2, to participate in the discussion on the report of the Gaseous Explosions Committee, and in the Papers which follow dealing with combustion. Several Papers have been promised to the Section, but the programme is still incomplete.

In Section B (Chemistry) the feature is the joint discussions with other sections. Among these may be mentioned "The Neglect of Science by Commerce," with Section L, and on "Combustion" with Sections A and G.

In Section G (Engineering) the presidential address will be delivered by Prof. W. E. Dalby, while Papers will be read on "The Testing of Lathe Tool Steels," and "A New Method of Testing the Cutting Quality of Files," by Prof Ripper; "Experiments on Aeroplanes," by Mr. W. A. Scoble; "Accelerometers," by Mr. H. S. Wimperis; "Optical Determination of Stress," by Prof. Coker; "Laws of Electro-Mechanics," by Prof. S. P. Thompson, F.R.S.; "The Electrification of the Brighton Railway," by Mr. P. Dawson; "Heat Insulation," by Mr. F. Bacon. The Gaseous Explosions Committee will make their report and there will be joint discussion on "Combustion" with Section B and on "Aerial Flight" with Section A.

Crystal Palace School of Engineering.—In the course of an address to the students of this school last Friday, Mr. J. C. Inglis, President of the Institution of Civil Engineers, remarked that it was not enough for students to confine themselves entirely to one branch of engineering; they should take a general view and try to master the principles in more than one direction. Transport would become an increasingly important subject, and there was sure to be an extended demand for the services of those who studied railway engineering.

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PROBLEMS OF RAILWAY ELECTRIFICATION.

On Friday last, July 29th, a joint meeting of the Institution of Mechanical Engineers and of the American Society of Mechanical Engineers was held at the Institution of Civil Engineers, Westminster, the subject under discussion being the electrification of railways. The Papers read were as follows: "The Electrification of Railways," by Mr. G. Westinghouse (President, American Society of Mechanical Engineers); "Economies of Railway Electrification," by Mr. W. B. Potter; "The Electrification of Trunk Lines," by Mr. L. R. Pomeroy; "Electrification of Suburban Railways," by Mr. F. W. Carter; and "The Cost of Electrically-propelled Suburban Trains," by Mr. H. M. Hobart.

Abstracts of the Papers by Mr. G. Westinghouse, Mr. W. B. Potter and Mr. H. M. Hobart are given below. The first of these Papers was read, in the absence of the author, by Mr. C. F. Scott, who, in conclusion, remarked that Mr. Westinghouse said he would like to have some one at the meeting who appreciated the author's purpose and motive in preparing this Paper. Mr. Westinghouse wished to remind them that several years ago when the question of the compulsory electrification of railways in tunnels and terminals was before the New York Legislature, and about the time of certain tunnel disasters, both in America and in Europe, he advocated the use of steel cars. He was severely criticised in some quarters, but he adhered to his suggestion, and now steel passenger cars were becoming the standard for that type of service in America. At the present time Mr. Westinghouse was endeavouring to give his best attention, from the railway standpoint, to the matter of electrification and thus to do a future service to railways.

An account of the joint discussion on these papers will be found on p. 701.

THE ELECTRIFICATION OF RAILWAYS.*

BY GEORGE WESTINGHOUSE.

Summary.—In this Paper the author calls attention to the need which exists at the present time for a system of electric traction that can be universally used. Besides uniformity in gauge, vehicles and brakes, agreement is also required in the system of electrical energy used and the way in which it is supplied. The requisites for a universal electric system are noted, and the future of electrification of railways is gone into. Appendixes deal with the design of the electric locomotives now in use in America and the different systems of electrification employed, while data of the lines operated by electricity are also given.

It is my intention in this paper to direct attention to the necessity for the very early selection of a comprehensive electrical system embracing fundamental standards of construction which must be accepted by all railway companies in order to ensure a continuance of that interchange of traffic which, through force of circumstances, has become practically universal, to the great advantage of transportation companies and of the public. The time is ripe for such a selection unless we are willing to regard with complacency the extension of the existing diversified systems and the creation of conditions which will prevent the general use of the most practical methods of operation. Indeed, the tendency seems to be toward diversity rather than unity, since different types of third-rail construction have been adopted, even for the several continuous-current systems in and about New York City, which renders interchange of cars or locomotives difficult or impossible.

Although the facts clearly show the contrary, there exists a popular impression that the electrification of railways is a simple matter, and that it requires only decisions by boards of directors to ensure the immediate substitution of the electric for the steam locomotive. The great difficulty in the electrification of standard railways is no longer the engineering problem of developing a locomotive and an electrical system which will operate trains, but it is a broad question of financial and general policy of far-reaching scope, considering the future electrification of railways in general as distinguished from isolated cases of limited extent, and requiring a combination of the highest engineering and commercial skill.

To ensure interchange of traffic, the fundamental requirements, so far as operation by steam is concerned, with full regard for safety, speed and comfort, are very few in number and are covered by the following: A standard gauge of track, a standard or interchangeable type of coupling for vehicles, a uniform interchangeable type of brake apparatus, interchangeable heating apparatus and a uniform system of train signals. The additional fundamental requirements for electrically-operated railways are: A supply of electricity of uniform quality as to voltage and frequency, conductors to convey this electricity so uniformly located with reference to the rails that, without change of any kind, an electrically-fitted locomotive or car of any company can collect its supply of current when upon the lines of other companies, and uniform apparatus for the control of electric supply whereby two or more electrically-fitted locomotives or cars from different lines can be operated together from one locomotive or car. Outside of economy in capital expenditure, and economy and convenience in operation by steam or electricity, it matters not whether each locomotive and car and the apparatus upon them differ from every other locomotive and car in size or details of construction so long as the constructions are operative and the materials employed are used within safe limits.

The development of alternating-current apparatus from the earliest time is then gone into by the author.

The various systems of electrical working on railways now employed are then described, and it is shown that they are all fundamentally alternating-current systems, while the essentials of a good railway motor, both of the continuous and alternating-current type are also considered. Locomotives equipped with each of the three types of motors have been in successful operation and have demonstrated their usefulness, capacity and reliability in practical railway service. The three-phase motor, having a definite constant-speed characteristic, is particularly adapted to certain conditions; but, on the other hand, it has a less general adaptability to the ordinary varying conditions of railway operation. The single-phase motor has a facility of voltage control which gives an efficient means of speed adjustment, and is in this particular superior to other systems. The relative weights and costs of the several types of motors, and of the locomotives designed to accommodate them, depend upon so many conditions that comparisons must necessarily be general. It will be found, however, that these differences in locomotive cost are in many cases more than offset by the cost of the other elements in the electrical system.

The controlling factor in the cost of electrification in nearly all cases is the system for transmitting power from the power house to the locomotive, and not the locomotive itself. The choice between the several systems must, therefore, be based upon a comparison of the complete systems. The differences between the methods of transmitting power are of far greater importance than the differences between power houses or between locomotives. The current for all systems is generated in usual practice as high-tension alternating current, for the reason that electric energy can be most economically transmitted by high-tension alternating current even though it is in some cases converted into direct current.

In selecting a proper electrical system for railway operation, it will probably be generally conceded that the following elements are of prime importance: The electric locomotives should be capable of performing the same kinds of service which the steam locomotives now perform. This will be most readily secured by electric locomotives which can practically duplicate the steam locomotives in speed and power characteristics. This includes a wide range of performance, embracing through passenger service at different schedule speeds; local passenger service; through freight service in heavy trains; the handling

* Abstract

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of local freight by short trains; and a variety of switching, terminal and transfer movements, and naturally calls for wide variation in tractive effort and in speed, both for the operation of different kinds of trains and also for the operation of the same train under the varying conditions usually incident to railway service. The electric locomotive should be capable of exceeding the steam locomotive in its power capacity. It should be able to handle heavier trains and loads, to operate at higher speeds, and in general to exceed the ordinary limits of the steam locomotive in these respects. The readiness with which several electric locomotives can be operated as a single unit enables any amount of power to be applied to a train. The electric system should adapt itself to requirements beyond the ordinary limitations of the steam locomotive in small as well as large things. It should be adapted for use on branch lines, and for light passenger and freight service similar to that so profitably conducted by interurban electric roads, which in many cases run parallel to steam roads, not only taking away the traffic of the steam roads, but building up a new and highly profitable traffic, both in passenger and in express service. A universal electrical system requires that power should be transmitted economically over long distances and supplied to the contact conductor. The system should utilise the most highly perfected apparatus for the electric transmission of energy and its transformation into suitable pressures for use. The contact conductor in an ideal system should be economical to construct, both for the heaviest locomotives where the traffic is dense, and for light service on branch lines. It should impose minimum inconvenience to track maintenance, should give minimum probability of disarrangement in case of derailment, or in case of snow and sleet, and should in general be so placed and constructed as to give a maximum assurance of continuity of service.

The use now made of electricity in steam railway service has been brought about, generally speaking, through compulsion. The steam locomotive has reached its limitations and has been found unsuitable and inadequate in tunnels or in terminal service. Even where other considerations may have been controlling, the problem has usually been a specific one of electrifying a relatively small area. The problem has been solved by considering those factors which were of immediate importance, without giving weight to uniformity with other systems or of extension.

Now the natural course of development will be the extension of these limited zones, until after a time they meet. Then there will arise great inconvenience and expense if the systems are unlike. For the present it may be a matter of little moment whether different systems have their contact conductors in the same position, or whether the character of the current used is the same or different. In the early days of railway work, it was of little consequence whether the tracks of the different systems in various parts of the country were alike or unlike, but later on it did make a vital difference, and the variation resulted in financial burdens which even yet lie heavily on some railways. It is this large view into the future of electrical service which should be taken by those responsible for electric railway development.

The complete electrification of a railway will necessitate a rearrangement of ideas and practices in regard to operations. Coaling and watering places will not be needed; passenger trains will be differently composed, some classes being of less weight, and they will operate more frequently, thus promoting travel; other trains will be heavier than at present, or will operate at higher speeds; and branch lines, by the use of electrically-fitted cars, can be given a through service not now enjoyed. The movement of freight will undergo great changes, due to the fact that electric locomotives can be constructed with great excess capacity, enabling them to move longer trains at schedule speed on rising gradients. The large percentage of shunting operations due entirely to the use of steam locomotives will no longer be required. The railway companies can combine upon some co-operative plan for the generation of electricity, thereby effecting large savings in capital expenditures, and can utilise their own rights of way for the transmission of the current, not only for the operation of trains but for many other useful purposes.

Notwithstanding the fact that great strides have already been made in cheapening the cost of generating electricity by steam engines, I foresee, from the progress made in the development of gas and oil engine power, a still further reduction in cost which will accelerate the work of electrifying existing railways.

One important aspect of this great question will engage the thoughtful consideration of every Government, namely, the military necessity for uniform railway equipment in time of war.

There will be serious difficulties to surmount in the selection of a general system. There naturally will be arguments in favour of one or another of the systems now in use and the inclination of those who have adopted a particular system to advocate its general use. There will be enthusiastic inventors, and there will be many advocates of the common view, namely, that there is room for several systems and that each system will best meet the requirements of a particular case. There will be those who give undue weight to some feature of minor importance, such as a particular type of motor or of locomotive, instead of giving a broad consideration to the whole system, and recognising that, in the general problem of railway electrification, facility and economy in transmitting power from the power house to the locomotive are of controlling importance.

Were there now only one system to be considered, there would be a concentration of the energy of thousands on the perfecting and simplifying of the apparatus for that system, to the advantage of railway companies and of manufacturers.

In conclusion, I can only repeat, and earnestly recommend to the serious consideration of railway engineers and those in authority, the pressing need of determining the system which admits of the largest extension of railway electrification and of a prompt selection of those standards of electrification which will render possible a complete interchange of traffic in order to save expense in the future and to avoid difficulties and delays certain to arise unless some common understanding is arrived at very shortly.

The Paper proper is followed by a number of appendixes, of which abstracts are given below.

APPENDIX I.

The first appendix deals with the single-phase system of the New York, New Haven & Hartford Railway, the various features of which have already been described and commented upon in THE ELECTRICIAN.*

During the past year, the electric service on this line has surpassed in efficiency all records previously obtained on this division with steam locomotives. The actual figures are given in Table I., which covers the movement of passenger trains over the 12 miles of third-rail operation and 21 miles of single-phase operation, for which 41

Table I.—*Record of Single-phase Service, New York, New Haven & Hartford Railroad for 12 months.*

——	Total miles run.	No. of loco-motive delays.	Miles run per loco-motive delay.	No. of power house delays.	No. of line delays.
1909.					
April	146,189	9	16,243	...	3
May	155,551	25	6,222	1	3
June	166,759	14	11,911	...	4
July	183,434	13	14,110	...	2
August	177,714	14	12,694	...	5
September	189,656	14	13,547	...	1
October	174,400	11	15,854	1	4
November	173,370	10	17,337	...	1
December	167,808	23	7,296	...	3
1910.					
January	163,274	28	5,831	...	2
February	138,929	12	11,577	...	1
March	156,901	12	13,075	...	1

* *See* Vol. LIX., pp. 299, 909, 1023; Vol. LX., p. 87; Vol. LXI., p. 203; Vol. LXII., pp. 290, 492, 748; Vol. LXIII., p. 286; Vol. LXIV., pp. 45, 974, 1045.

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locomotives, that have been used from 22 to 33 months, were available. The early fears as to difficulties in commutation have been dispelled by the records of performances, many of the motors have operated over 100,000 miles without turning or even sandpapering the commutators, and the brushes show an average life of from 40,000 to 45,000 miles. The average number of miles run per locomotive delay during the year exceeds 12,000, equivalent to a dozen trips between New York and Chicago, or 30 trips between London and Glasgow. The locomotive delays (many of which only slightly exceeded one minute duration) include not only those from electrical causes, but from mechanical defects as well, such as loose tyres, burst air hose, hot journal boxes, frozen steam hose, &c. A comparatively large number of delays in December and January were due to the very severe weather and the unusual amount of snow and ice. These locomotives have been making regularly an average of about 4½ trips of 33 miles per day, hauling trains 25 to 50 per cent. heavier, or even more in the case of express trains, than the locomotives were guaranteed to handle. Most of the locomotives have run about 100,000 miles, but there is seldom more than one (which is 2½ per cent. of the whole number) out of service for repairs, a record said by the officials of the company to be much better than for the steam locomotives which were replaced. These officials also say that the cost of maintenance per mile and the number of miles run per electric locomotive are far more favourable than with steam locomotives, even with the present very short run of 33 miles.

The cost of maintenance of the distribution system is relatively small compared with that of the low-voltage third-rail system. The delays due to the transmission lines and overhead construction, though few in number, include those brought about by extraordinary conditions, such as steam from switch engines and by wrong operation of switches. The heaviest traffic on the New York division of the New Haven road, and the occasion on which delays would be most deplored, is on the day of the annual intercollegiate football game at New Haven. The service on this day for 1908 and 1909 was as follows :—

	1908.	1909.
Regular trains	128	126
Special trains	30	29
Total trains	158	155
Number of train delays	2	0
Total duration of delays	17 min.	

In considering the capability of the single-phase system for continuous performance, the record of the six single-phase locomotives in service at the St. Clair tunnel of the Grand Trunk Railway* is worthy of mention. These locomotives have now been running two years and have made about 70,000 miles each, averaging about 100 miles per day, or 25 trips of four miles. It has not been necessary to use a steam locomotive since the regular electric service was started (May, 1908), and during the last 12 months the service has been responsible for but one train delay, of eight minutes.

APPENDIX II.

Data on Electric Locomotives of American Design.

The locomotives on which data are given were built for heavy railway service. They are for passenger service and for combined passenger and freight, and include locomotives for direct current, three-phase current and single-phase alternating current, and others adapted for operation on either single-phase alternating current or direct current. A brief description of these locomotives follows, including mention of some of their notable features.

Locomotives of the Westinghouse Electric & Mfg. Co.—Referring to Table II., the first column covers locomotives built for the New York, New Haven & Hartford Railroad, for operation on their electrified zone between New York and New Haven. The electrical system demanded that the locomotives be capable of operation both on single phase and direct current. There are 41 of these locomotives in operation. A gearless concentric motor for each driving axle is mounted on a quill flexibly connected to the driving wheels. The deadweight on the axles is thus reduced to a minimum. The second column deals with locomotives built for the Grand Trunk Railway for operation in the St. Clair tunnel under the St. Clair River. These locomotives are designed for operation with single-phase current only. They are handling the entire freight and passenger traffic through the tunnel. The third column deals with locomotives built for the Pennsylvania Railroad for operation in their New York tunnel. They are for passenger service only, and operate on direct current at 600 volts on the conductor. The first locomotive has been run 17,000 miles on test. The centre of gravity of these locomotives is high, as the motor is mounted well above the driving axles. The transmission from motor to wheels is by cranks and connecting rods. These parts are protected from possible damage due to short-circuit by interposing between the armature and its shaft a friction clutch which will slip before damaging stresses are imposed on the transmission. The motors are the largest railway motors ever built and are provided with commutating poles, making possible the use of a shunted field control which is applied to these locomotives. The fourth column deals with a locomotive built for the New York, New Haven & Hartford Railroad for use in high-speed freight and medium-speed passenger service. It also is fitted for operation both with single-phase and direct current. It has been run approximately 3,000 miles in test service, actually hauling regular freight trains, including the steam locomotives, over the electrified section of the railroad on the normal schedules for the movement of these trains. A pinion at each end of the motor meshes with a flexible gear whose centre is rigidly secured to the quill surrounding the axle, the flexible gear overcoming the difficulties in securing tooth alignment and division of load which are liable to occur when rigid twin gears are used. It is the only electric locomotive equipped with spur-geared motors which are bolted rigidly to the spring-supported parts of the locomotive. Each driving wheel is driven through helical springs, the arrangement being such that the driving wheel has practically free vertical play. The locomotive has two trucks, the draw-bar pull being transmitted through the truck frames. The body is spring-mounted on friction plates in place of being carried on truck centre pins in the usual manner. It is an exceptionally easy riding machine with very low rolling friction. The performance has been satisfactory, and a speed of 40 miles per hour was attained on level track with a 1,600-ton train. The fifth column deals with a locomotive for the same railroad and service as that just described. The comparison between geared and connecting-rod motors for identical service is a very interesting feature of this development. The weights given in both the fourth and fifth columns are those on which locomotives of these types would generally be built. The actual locomotives are somewhat heavier, due to particular features of design not inherent in the type. The effect on the connecting rods and pins of the pulsating torque of a single-phase current is avoided by the introduction of a flexible connection between the armature and its shaft. This locomotive has not been tested. The last two locomotives were ordered by the New Haven road to demonstrate the practicability of electric traction for freight service and to assist in determining the most suitable kind or type of locomotive.

The first column of Table III. deals with locomotives built for the New York Central & Hudson River Railroad for operation on the electrified zone of the New York City terminal. Forty-seven of these locomotives are in use, the first having been put in operation in July, 1906. They are used for passenger service only, and operate on direct current at 600 volts. The mechanical equipment of this locomotive consists of a main driving wheel base with four driving axles and a four-wheel guiding truck at either end. The motor is of the bi-polar gearless type, the armature being mounted directly on the driving axle, and the mechanical structure of the locomotive forming a portion of the magnetic circuit of the motors. The characteristic feature of the locomotive is the simplicity of its electrical and mechanical construction, which contributes to its high efficiency and low maintenance cost. The second column of Table III. deals with locomotives built for operation at the Detroit River tunnel. These are to be used for both freight and passenger service between Detroit, Mich., and Windsor, Ont., and will be operated at 600 volts direct current. The running gear consists of two trucks connected together with a massive hinge so as to form a single articulated wheel base, and buffers carried on the outer end frames of the trucks. The motor is of the direct-current geared type with commutating poles and is interesting as the first application of the commutating pole motor to this class of service. Twin gearing is used between the motor and driving axle, and consists of a pinion at each end of the armature shaft and a corresponding gear on the axle. The use of twin gearing relieves the armature shaft of torsional strains and maintains the parallelism of the shaft and axle. Five of these locomotives have been built and are awaiting completion of the tunnel. While they are not in actual operation, extensive tests made on a test track in hauling and accelerating freight trains up to 1,500 tons in weight have proved that this type is very satisfactory for the service. The third column deals with locomotives built for the Baltimore & Ohio Railroad for operation of both freight and pasenger service through the Baltimore Belt Line tunnel. Two of these locomotives are in use and operate on direct current at 600 volts. The general design is similar to the Detroit tunnel locomotive described above and the same type of motors are used, but the motors are geared for higher speed in order to meet the speeds required by passenger service on the relatively lighter grades of the Baltimore tunnel. The fourth column deals with locomotives built for the operation of freight and passenger trains through the Cascade tunnel of the Great Northern Railway. These locomotives are designed for three-phase operation at 25 cycle

* *See* The Electrician, Vol. LXV., p. 561.

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Table II.—*Data on Electric Locomotives of American Design. Built by the Westinghouse Electric and Manufacturing Co.*

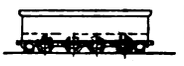
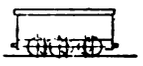
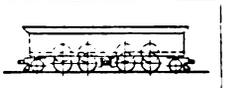
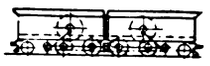
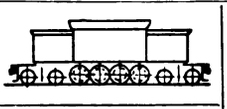
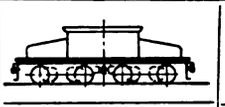
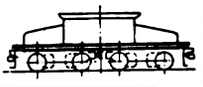
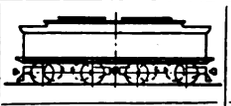
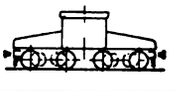
					
Built for	New Haven	Grand Trunk St. Clair Tunnel	Pennsylvania	New Haven	New Haven
Electric system	A.C., D.C.	A.C.	D.C.	A.C., D.C.	A.C., D.C.
Service	Passenger	Frt. & Pass.	Passenger	Frt. & Pass.	Frt. & Pass.
First placed in service	July 1907	February 1908	17,000-mile test	3000-mile test	building
No. in service or on order May 1910	41	6	24	1	1
No. motors per locomotive	4	3	2	4	2
Armature diameter, inches	39½	30	56	39½	76
Core length, including vent opening, inches	18	14¾	23	13	13
Weight one motor, pounds	16,420	15,660	45,000	19,770	41,600
Weight all motors on locomotive	65,680	46,980	90,000	79,080	83,200
Weight all electrical parts	110,400	58,400	127,200	130,000	135,000
Weight all mechanical parts	94,100	73,600	204,800	130,000	125,000
Weight complete locomotive	204,500	132,000	332,000	260,000	260,000
Weight on driving wheels	162,000	132,000	207,800	180,000	180,000
Weight complete locomotive for A.C. operation	196,000	132,000	D.C.	241,000	240,000
Max. guar't'd speed, miles per hr.	about 86	30	about 80	45	45
Feature limiting speed	track	armatures	connecting rod	armatures	armatures
Max. tractive effort	19,200	43,800	69,300	40,000	40,000
Loco. wt. in excess of 18% adhesion Max. T.E., A.C. operation	88,700	none	none	18,500	17,500
Designed for trailing load, tons	250	500	550	{1500 freight / 800 pass.}	{1500 freight / 800 pass.}
Balance speed on level with above load	about 75	about 25	60	{35 freight / 45 pass.}	{35 freight / 45 pass.}

Table III.—*Data on Electric Locomotives of American Design. Built by the General Electric Co.*

					
Built for	N. Y. C. & H. R. R.	Detroit River Tunnel	B. & O. R. R.	Great Northern	Paris-Orleans
Electric system	D.C.	D.C.	D.C.	3-phase	D.C.
Service	Passenger	Frt. & Pass.	Frt. & Pass.	Frt. & Pass.	Passenger
First placed in service	July 1906	tests completed	March 1910	July 1909	1899
No. in service or on order May 1910	47	6	2	4	11
No. motors per locomotive	4	4	4	4	4
Armature diameter, inches	29	25	25	35¾	23½
Core length, including vent opening, inches	19	11½	11½	16¼	12
Weight one motor, pounds	18,150	10,560	10,560	15,000	8,855
Weight all motors on locomotive	72,600	42,240	42,240	60,000	35,420
Weight all electrical parts	91,200	54,000	54,000	109,000	42,500
Weight all mechanical parts	138,800	146,000	130,000	121,000	67,500
Weight complete locomotive	230,000	200,000	184,000	230,000	110,000
Weight on driving wheels	141,000	200,000	184,000	230,000	110,000
Weight complete locomotive for A.C. operation	D.C.	D.C.	D.C.	230,000	D.C.
Max. guar't'd speed, miles per hr.	75	30	55	30	45
Feature limiting speed	track	armature	armature	armature	armature
Max. tractive effort	47,000	67,000	61,000	77,000	37,000
Loco. wt. in excess of 18% adhesion Max. T.E., A.C. operation	none	none	none	none	none
Designed for trailing load, tons					
Freight		900 on 600 2% grade	850 on 500 1½% grade	500 on 2.2% grade	
Passenger					
Balance speed on level with above load	{435 / 63}	{Freight 20.5 / Pass. 22}	{Freight 26 / Pass. 30}	15	{300 / 32}

and 6,600 volts on the trolley. The mechanical structure consists of an articulated wheel base similar to that of the Detroit River tunnel locomotive described above. The motor is a three-phase induction motor with external secondary resistance and fitted with a gear at each end of the armature shaft. The service for which they are ultimately designed is the operation of a division 57 miles long with ruling gradients of 2·2 per cent. and an average grade of 1·55 per cent. Four of these locomotives are in service, and it may be of interest to note that they were involved in the disastrous avalanche of March 1, 1910, which swept through the electrified yards at Wellington, Wash. The fifth column deals with locomotives built for the Paris-Orleans Railway for use in hauling passenger trains from the Austerlitz station to the Quai d'Orsay. They are designed for operating on 600 volts direct current. These locomotives are historically of interest, the first one of them having been delivered in 1899, and 12 being now in service. Each locomotive has two independent trucks, each truck equipped with two geared motors, and carrying weight of cab and platform on the centre pin with draft gear and buffer attached to this platform. This represents a type of locomotive of which a large number have been built, and which has proved highly satisfactory for light and medium classes of service.

APPENDIX III.

Comparison of Systems of Electrification.

The salient features of the three systems of railway electrification are presented in a number of diagrams so arranged as to permit of a ready comparison between their essential characteristics, particularly in the circuits and apparatus which transmit the power from the power station to the locomotive. In thickly populated districts congested with traffic, the generating stations, of which there should be not less than two in order to minimise interruptions to traffic, should probably be located at junction points or places demanding the greatest power and at distances not exceeding 30 or 40 miles. With such a disposition of power houses, the overhead trolley wires on a single-phase system will usually be sufficient for the supply of current. In like manner, where the traffic is not so heavy, the power houses can be placed at greater distances, bearing in mind, however, that the increase in traffic may subsequently demand intermediate power houses or sub-stations. In cases where power stations are long distances apart, the single trolley wire should probably be supplemented by an additional circuit in order to guard aginst interruptions due to defects in the trolley wire, and to give a sufficient supply of power for any contingency.

Fig. 1 shows the comparative losses between the generators and the locomotives for each of the three systems, based on a class of service where the input to the locomotives by the several systems is practically the same. As some kinds of service render one type of motor with its auxiliary apparatus and control more efficient, while under other conditions it may be less efficient, this variable element has been eliminated by assuming the same power delivered to each locomotive as a basis for a general comparison of the transmission losses. The total height of each column in the diagram indicates the

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total power delivered by the power house in the system designated. The height of the long portion at the lower part of each column indicates the amount of power which reaches the locomotive. The loss between power station and the locomotives is represented by the upper shaded areas. The respective losses in raising transformers, transmission line, lowering transformers, rotary converters and the contact line (comprising trolley or third-rail with track return) are segregated. It will be noted that the large losses in the rotary converters appear only in the direct-current system. The larger single-phase column shows the losses where the distances are such that it is necessary to use a transmission line and transformers. The smaller single-phase column represents the trolley wires connected to the

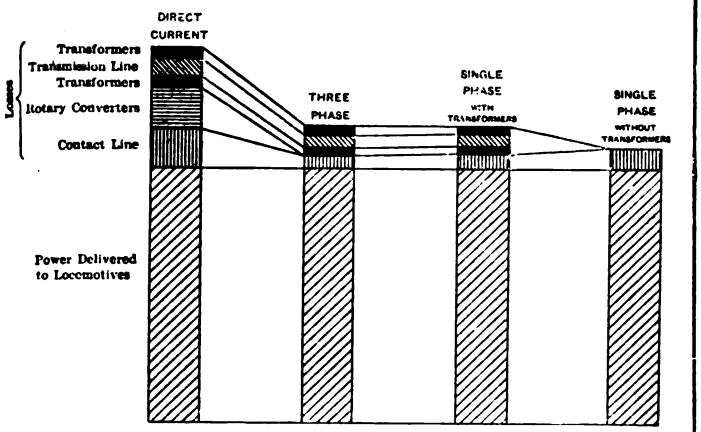

FIG. 1.—SHOWING COMPARATIVE LOSSES BETWEEN POWER HOUSE AND LOCOMOTIVES.

generators without any intervening transmission line or transformers. The loss of power between power house and locomotives is relatively small as compared with that in any of the other systems. This is the condition on the New York, New Haven & Hartford Railroad, where the power house is distant nearly 20 miles from one end of the line.

Fig. 2 shows the comparative estimates prepared a few months ago of first cost in a particular case for electrification by the direct-current system and by the single-phase system. In the preparation of these estimates the three-phase system was not called for and as no estimate covering it has been prepared, it is not included in the present

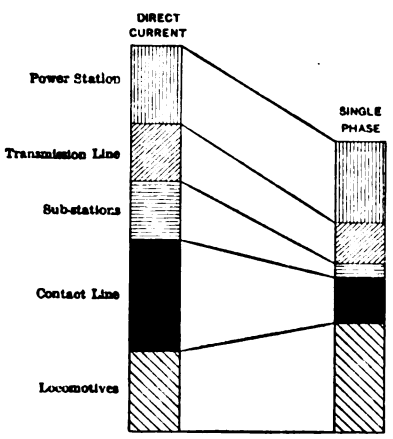

FIG. 2.—COMPARATIVE FIRST COSTS FOR DIRECT CURRENT AND SINGLE-PHASE SYSTEMS IN A PARTICULAR CASE OF A 100-MILE SERVICE.

comparison. The estimates cover a single track line 100 miles long involving both freight and passenger traffic in both through and local service and include 20 locomotives. The costs for power station include only the machinery and building and do not include cost of hydraulic development. It will be noted that the considerably less cost of the single-phase system in this case is due largely to the lower cost of contact line and sub-stations. Fig. 3 shows the comparative estimates of first cost for the three systems for a service on mountain gradients in a particular case involving the use of 12 locomotives. The total length of line is 32 miles, part of which is single track, part double track and part three tracks. In addition to the main line there is a large yard to be electrified, there being a total of 90 miles of single track. The location of the power station was fixed by non-electrical considerations. The distances were such that sub-stations were required when either direct current or three-phase current was assumed, but the entire system could be fed direct from the generators if single-phase current was used. It will be noted that in this case the omission of sub-stations and transmission effects a very considerable saving in favour of single phase as well as the usual large saving in cost of contact line effected by the use of this system. The cost of the part of the system between the power house and the locomotives in the direct-current system is nearly equal to the cost of both power house and locomotives. On the other hand, the cost of the single-phase contact line, the only intervening element between the power house and the locomotives, is less than one-half of the cost of the direct-current transmission and contact system.

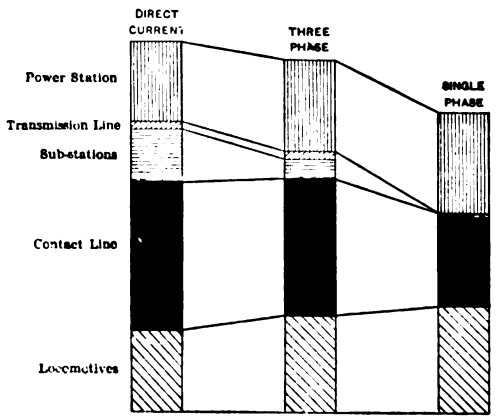

FIG. 3.—COMPARATIVE FIRST COSTS IN THE DIFFERENT SYSTEMS FOR A SPECIAL CASE OF PUSHER SERVICE.

Fig. 4 shows comparative operating costs for the three systems for the pusher service outlined in the preceding diagram of first costs. It should be noted that these costs do not include fixed charges. If fixed charges were included the difference in operating costs in favour of the single-phase system would be much more marked. In connection with this diagram it should be noted that sub-station attendance is required for the direct-current system only. The reason for the three-phase and single-phase systems being so nearly on a par is that this case is an ideal one for the application of the three-phase system since it involves constant-speed operation under constant-load conditions. It is notable, however, that even under these conditions the single-phase system shows somewhat lower operating costs than the three-phase system. The high operating cost with the direct-current system is seen to be due largely to the greater amount of power re-

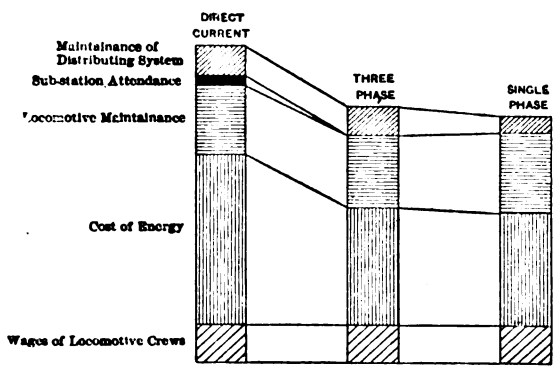

FIG. 4.—COMPARATIVE OPERATING COSTS IN THE DIFFERENT SYSTEMS IN A SPECIAL CASE OF PUSHER SERVICE.

quired for operation by this system on account of the large losses which occur between the power house and the locomotive in this system.

APPENDIX IV.

ELECTRIFIED STEAM ROADS AND ELECTRIC ROADS FOR TRUNK LINE SERVICE.

The accompanying tables give data upon many of the important railroads on which electricity is used in heavy railway service. Only such data are included as were conveniently available and such omissions or inaccuracies as may occur do not detract materially from the forceful presentation of the extent and character of the use which is now being made of electricity in railway service, The horse-power ratings of the various motor cars and locomotives are in general the nominal ratings for a short period, usually 1 hour, but as

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Table IV.—*Single-phase Electrification on Steam Railways and in Trunk Line Service.*

Road.	Miles of line.	Miles single track.	Line voltage.	Motor cars. No.	Motor cars. H.P.	Locomotives No.	Locomotives H.P.
N.Y., N.H. & H.R.R. Main line	21·0	100·0	11,000	4	600	41	1,400
						2	1,600
New Canaan Branch	8·0	8·0	11,000	2	500	...	...
Grand Trunk R.R.	3·5	12·0	3,300	...	...	6	900
Erie R.R.— Rochester Division	34·0	34·0	11,000	6	400	...	...
Colorado Southern Rly. Denver & Interurban	46·0	46·0	11,000	8	500	...	...
Baltimore & Annapolis short line	25·0	30·0	6,600	12	400	...	...
Swedish State Rly.	7·0	7·0	3,300	2	240	1	300
			20,000				
Midland Rly., England.	8·5	17·0	6,600	1	300	...	...
				2	360		
Prussian State Rlys.	16·5	31·0	6,600	20	250	1	1,500
				42	400		
				54	345		
London, Brighton & South Coast Rly.	8·6	17·2	6,000	16	460	...	...
Rotterdam-Haag-Scheveningen	20·5	46·5	10,000	19	360	...	...
Spokane & Inland	129·0	129·0	6,600	28	400	6	500
						5	720
Midi Rly. of France	75·0	...	12,000	30	550	2	1,600

Table V.—*Continuous-current Electrification on Steam Railways and in Trunk Line Service.*

Road.	Miles of line.	Miles single track.	Line voltage.	Motor cars No.	Motor cars H.P.	Locomotives No.	Locomotives H.P.
New York Central R.R.	33·0	132·0	650	137	400	47·0	2,200
Pennsylvania R.R.	20·0	75·0	650	180	400	24·0	4,000
West Shore R.R.	44·0	106·0	650	20	360	...	...
Long Island R.R.	42·0	125·0	650	137	400	2·0	1,200
West Jersey & Seashore R.R.	75·0	150·0	650	68	400	...	...
B. & O. R.R.	3·7	7·4	600	...	...	2·5	1,600
						5·0	1,100
North-Eastern Rly.	37·0	...	600	...	300	2·0	600
Mersey Tunnel	4·8	...	600	24	400	...	...
Lancashire & Yorkshire Rly.	18·0	60·0	600	...	600	...	...
Great Western Rly.	5·0	...	600	...	600	...	...
Metropolitan Rly.	...	67·0	600	56	600	10·0	800

Table VI.—*Car Equipment of Subway and Elevated Systems in American Cities. The Direct-current Third-Rail System at approximately 600 volts is used in all cases.*

Road.	Miles of single track.	Motor cars. No.	Motor cars. H.P.
Boston Elevated Railway	19·0	219	320
Brooklyn Rapid Transit	71·0	558	300
		101	400
Interborough Rapid Transit (New York)	190·0	969	250
		764	400
Hudson & Manhattan (New York)	12·0	140	320
Chicago & Oak Park	19·4	65	320
Metropolitan West Side (Chicago)	51·1	15	400
		210	320
North-Western Elevated (Chicago)	25·5	20	250
		128	320
Southside Elevated (Chicago)	36·5	150	180
		70	150
		150	110
Philadelphia Rapid Transit	11·0	100	250

Table VII.—*Three-phase Electrification on Steam Railways and in Trunk Line Service.*

Road	Miles of line.	Miles single track.	Line voltage.	Motor cars No.	Motor cars H.P.	Locomotives No.	Locomotives H.P.
Gt. Northern R.R. Cascade Tunnel	4·0	6·0	6,600	...	...	4	1,900
Italian State Railways. Valtellina Railway	66·0	...	3,000	10	400	2	800
						7	1,500
Giovi Railway	12·4	37·3	3,000	...	...	20	2,000
Mt. Cenis Tunnel	4·4	...	3,000	...	...	10	2,000
Savona Ceva	...	...	3,000	...	...	10	2,000
Swiss Federal Railways Simplon Tunnel	13·7	14·3	3,000	...	...	2	1,100
						2	1,300
Gergal Santa Fé (Spain)	13·1	14·4	5,500	...	...	5	320

these ratings have been adapted in some cases to the particular service in which the motors are to operate they cannot be taken as a basis for an accurate comparison between the capacities of different equipments.

ECONOMICS OF RAILWAY ELECTRIFICATION.*

BY WM. B. POTTER.

Summary.—The author, after a brief description of the different conditions met with in equipping a railway for continuous, single or three-phase current working, goes on to show how these conditions determine which should be employed and makes out a case for the 1,200 volt continuous-current system for interurban railways. Figures are given to show why this arrangement is the best, and why the single-phase system may come to be discarded in America for interurban work.

Much that has been written has treated the subject of electrification of steam railways from the general standpoint of averages, but, unfortunately, the economic application of electricity is not a subject for generalisation—unfortunately, because averages are convenient and usually available, but often lead to erroneous conclusions, either for or against electrification. It is a mistake to assume that the average of the expenses for the entire railroad represents the actual expense for the particular conditions usually existing on the division under consideration. Electrification, like any other engineering work, involves an investment against which there will be a fixed charge for interest and a liability of depreciation. The interest is a constant and permanent charge which must be met irrespective of any economy which may be secured by intelligent operation. The subject of depreciation is receiving more attention than formerly, the tendency having been to make the operating expenses cover this charge. However classified, the depreciation charge must be accounted for, and it is directly influenced by the character of the equipment with respect to reliability, durability and capacity to provide for future requirements.

The utilisation of higher trolley potentials, made possible with direct current by the development of the commutating-pole motor, and with alternating current by the development of the single-phase motor, the higher speeds of rotary apparatus in the sub-stations, and the development of the steam turbine, have effected a material reduction in the investment required and the cost of operation. The different methods of electrification applicable in any instance should be carefully analysed with regard to interest, depreciation and operating expense, and only the net result should be given consideration in determining the class of equipment. In this connection it is well to bear in mind that the expenditure is a lump sum which can be accurately determined, while depreciation and operating expense can only be approximated. Reference to the corresponding items of expense on railways operating under conditions comparable to those of the line to be electrified will supply the most reliable figures. Future traffic developments must not be overlooked, and the type of initial electrification should be selected with due regard to the ultimate requirements. There would, undoubtedly, be an advantage in having the character of the energy supplied to the contact conductor uniform, but this is out of the question on account of the great difference of specific conditions, such as congested urban or suburban service and comparatively infrequent trunk line train movements.

The development of apparatus for higher voltage direct current has so far increased its scope that direct current at either 600 volts or higher may be considered the most economical for city and interurban service, and for the electrification of steam railways where the density of traffic is sufficient to require a relatively large investment for rolling stock, as compared with that required for the secondary distribution system and the sub-station apparatus. Single-phase and three-phase rolling stock equipments are applicable only to exceptional conditions. The reason for this is the greater first cost of such equipments. This is especially true when comparing single-phase with direct current. The type of equipment used on the rolling stock may well be a more important factor in the economy of investment and operation than the scheme of power distribution.

In the selection of the electrical system best adapted to a particular set of conditions there are three items to be considered: (*a*) sub-stations, (*b*) contact conductors, (*c*) rolling stock. A comparison of these items determines the relative economic values of the systems. There are certain features under each of these items which may properly be examined. For trunk line service the values in Table I. will be found within reasonable limits for the usual requirements. From a level country to a limiting gradient of 1 or 1½ per cent. there will be little difference in the relative values of the systems. With steeper gradients the conditions will be more favourable for alter-

* Abstract.

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Table I.—*Reasonable Values for Trunk Line Service.*

SUB-STATIONS.

—	600 v. d.c.	1,200 v. d.c.	11,000 v 1 phase.	11,000 v. 3 phase.
First cost per kw., complete.....	£5. 4s	£5. 12s.	£2. 4s.	£2. 8s.
Comparison of installed kw., per cent.	200–250	100–125	100	100–125
Load factor, machines in service, per cent.	20–40	35–70	40–80	30–60
Average efficiency, —.....	78–88	87–92	97–98	97–98
Yearly operation and maintenance, each station	£1,000	£1,000	£500	£500

CONTACT CONDUCTORS.*

—	Third rail.		Overhead.	
First cost, per mile	£1,000 £1,400	£1,100 £1,500	£700 £1,400	£900 £1,600
Efficiency, per cent.....	88–92	90–96	93–97	93–97
Maintenance per mile per year ...	£15–£25	£20–£30	£20–£40	£25–£50

ROLLING STOCK.†

—	600 v. d.c.	1,200 v. d.c.	11,000 v. 1 phase.	11,000 v. 3 phase.
Locomotives—				
First cost, each.....	£8,800	£9,500	£12,800	£11,600
Weight, tons (2,000 lb.).....	125	125	160	160
Average efficiency, locomotive wheels to trolley, per cent....	85	85	79	81
Maintenance per locomotive per mile, pence.....	2	2	2·5	2·5
Motor Cars (complete)—				
First cost, each.....	£2,400	£2,700	£4,000	...
Weight, tons (2,000 lb.)	43	44	54	...
Average efficiency, wheels to trolley	82	81	73	...
Maintenance per car-mile, pence	1	1·1	1·75	...

nating current. Heavy individual train units favour the alternating-current system with the exception of the locomotives; light trains or multiple-unit operation favour the direct-current system. Infrequent service with a relatively small number of locomotives favour the alternating current, frequent service the direct current. With an increase in the number of trains, the direct-current systems gain relatively faster than the alternating current in economy of operation, due to the relatively decreased sub-station operation, the increased sub-station efficiency and the lower cost of equipment maintenance. It is, therefore, well to consider what the ultimate traffic density may be and select the system best suited to meet these requirements. Variations in the distance between stops and the schedule will not affect the relative value of systems unless extreme requirements, such as high schedule speed with short runs, make the use of direct current imperative. For a similar character of service throughout, the railroad may be of any length without affecting the relative desirability of the various systems. What is suitable for the first 50 miles will be equally suitable for any extension. An examination of these variables will show that a change in the conditions to be met with radically changes the relative economic value of the systems of electrification.

The single-phase system, by reason of the apparent simplicity of its elements and the utilisation of a higher potential for the contact conductor than is possible with direct current, is admittedly very attractive. There is the other side of the question: that it is impossible to build a single-phase commutating motor comparable in first cost and maintenance with a direct-current motor. Over this subject of alternating-current single-phase versus direct-current systems there has been a great deal of controversy. It is the author's opinion that comparative results obtained up to the present time are in favour of direct current. Desirable as would be a standard system for all classes of service, we cannot hope to establish such a standard should it impose an additional expense without adequate return. A summing up of all the elements of each electrical system will generally lead to a definite showing of which system is most desirable to meet specific conditions. For trunk line service a higher potential than 600 volts will unquestionably be used; 1,200 volts direct current will prove economical in some cases, but a still higher voltage is required to provide economically for the heavier intermittent service. Whether this potential will be 1,800 or 2,400 volts direct current or 11,000 volts alternating current cannot be settled arbitrarily.

The application of single-phase to new projects in the United States has been practically abandoned, there having been but one or two new installations in the last three years. This arrested development of a system which for a short time held forth considerable promise has been brought about by a general recognition of its limitations. Experience has shown these to be excessive weight and cost of the rolling stock, the high cost of equipment maintenance, the increased power consumption, the rapid depreciation of the motor, the rapid depreciation of the car bodies and trucks, and the increased cost of maintaining the track and roadway. Moreover, it is recognised that any interurban road in the United States must be capable of operating over existing city tracks on 600 volt direct-current system, a condition which hampers the single-phase system on account of increased complications in the control system. For interurban railways a potential of 1,200 volt direct current has been selected, because with the motors wound for 600 volts the car may be operated at the same speed from either 600 or 1,200 volt trolley by connecting the motors all in parallel for 600 volt operation, and two in series with groups in parallel on a 1,200 volt section. To show clearly the relative merits of the systems, the authorities made an analysis of an interurban railroad 100 miles long with cars in each direction every hour. This condition represents practically the minimum car requirements in the United States, and is, therefore, favourable to the single phase. It is obvious that any increase in traffic density will be relatively more favourable to the direct-current system on account of the lower first cost of cars, lower car maintenance and relatively lower cost of sub-station operation. A comparison of the general data required for the operation of a typical urban line on the three systems is given in Tables II. to VII.

There will be an additional cost of operation and maintenance with the single-phase system for the items of track and roadway, due to additional weight of cars, car shop expenses in providing greater facilities for shop inspection and repairs, and greater skill in superintendence of equipment. In a number of instances this

Table II.—*General Data for Cars.*

—	600 v. d.c.	1,200 v. d.c.	6,600 v. a.c.
Number of cars.....	15	15	18
Seating capacity, passengers	60	60	60
Distance between stops, miles.....	3	3	3
Schedule speed, miles per hour	33	33	33
Maximum speed, miles per hour.....	48	48	55
Weight each car, tons (2,000 lb.).....	35	36	43
Car-miles per day	3,000	3,000	3,000
Miles per car in service per day	300	300	300
Miles per car per day, average*	200	200	166
Estimated maintenance per car-mile, pence			
a Electrical	0·35	0·38	0·75
b Mechanical	0·5	0·5	0·62
Total car barn expense	0·85	0·88	1·37
Amperes starting car	520	280	75
Amperes running car	174	94	24
Kilowatt-hours per car-mile at car.....	2·8	2·88	3·78
Cost each car complete	£2,000	£2,300	£3,400

Table III.—*Sub-st...*

—	600 v. d.c.	1,200 v. d.c.	6,600 v. a.c.
Number of sub-stations	4	4	2
Estimated momentary demand—			
Cars starting	1	1	2
Cars running	1	1	0
Peak load, kilowatts.....	416	448	670
Average load, each sub-station, kilowatts...	52	120	275
Size each unit, kilowatts	300	300	300
Number of units	2	2	3
Load factor (machines in service)	0·17	0·40	0·46
Average efficiency	0·76	0·87	0·96
Cost each sub-station complete	£4,800	£5,280	£2,000

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* Variation in cost of third rail due to different weights of rail which may be required. Variation in cost of overhead due to variation in the class of construction, such as with wooden poles or with steel bridges.

† Other weights of locomotives will cost more or less about in proportion to their weights. With gearless direct-current locomotives, the average efficiency of locomotive wheels to trolley is approximately 88 per cent.

* On 12 American single-phase interurban roads the average miles per day called for on the published time tables, divided by the number of cars owned, is 138; on four 1,200 volt roads which have been operating over a year this number is 237, the larger number of alternating-current cars being required on account of the fact that a greater number are necessarily held in the barn for inspection and maintenance purposes. This explains why in the table above 18 alternating-current cars are assumed and 15 direct-current cars.

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Table IV.—*Feeder Copper Requirements.*

—	600 v. d.c.	1,200 v. d.c.	6,600 v. a.c.
Maximum momentary demand midway between sub-stations—			
Cars starting	1	1	2
Cars running	0	1	0
Amperes	520	374	150
Distance between sub-stations	11·8	28	66·6
Equivalent stub-end feed	2·9	7	16·6
Feeder required additional to 4/0 trolley	4/0	1/0	none
Cost overhead construction per mile, including both trolley and feeder	£460	£420	£380

Bonding taken as £80 per mile of track.

Transmission line taken in each case as £168 per mile of track and assumed to run entire length of right of way.

Power house: No power house is included, but it is assumed that power is purchased at the power station 'bus bars at 0·5d. per kilowatt-hour and fed at any convenient point into the transmission line.

Table V.—*Power Consumption.*

—	600 v. d.c.	1,200 v. d.c.	6,600 v. a.c.
Total kilowatt-hours per day at cars	8,400	8,650	11,400
Efficiency, secondary distribution	0·90	0·90	0·94
Sub-stations	0·76	0·87	0·96
Transmission line and power-house step-up transformers	0·94	0·94	0·94
Combined efficiency	0·64	0·74	0·85
Kilowatt-hours per day at power house	13,100	11,700	13,400

Table VI.—*Summary of Costs.*

First Costs.

—	600 v. d.c.	1,200 v. d.c.	6,600 v. a.c.
Transmission	£16,800	£16,800	£16,800
Sub-stations	43,200	21,200	4,000
Secondary distribution	46,000	42,000	38,000
Bonding	8,000	8,000	8,000
Cars	30,000	34,500	61,200
Total	£144,000	£122,500	£128,000

Annual Fixed Charges.—Depreciation.

—	Life years.	Annuity 5%.	600 v. d.c.	1,200 v. d.c.	6,600 a.c.
Transmission	20	30·34	£ 500	£ 500	£ 500
Sub-stations	20	30·34	1,300	640	120
Secondary distribution	15	46·34	2,120	1,940	1,740
Bonding	10	79·50	640	640	640
Cars (a.c.)	12	62·83	...	...	4,520
Cars (d.c.)	15	46·34	1,380	1,600	...
Total	...	...	£5,940	£5,320	£7,540
Interest 5 per cent., taxes 1·5 yer cent. of cost of electrical material			£9,200	£7,960	£9000,
Insurance 1·5 per cent. of sub-station and car costs			1,100	940	1,140
Total fixed charges			16,240	14,120	17,680

Annual Operation and Maintenance.

Transmission			£ 700	£ 700	£ 700
Sub-stations			3,400	1,520	100
Secondary distribution			1,800	1,800	2,000
Cars			3,700	3,900	6,020
Power at 0·5d. per kilowatt-hour			9,560	8,540	9,800
Additional cost: Maintenance of track of roadway, shops and supervision, due to heavier cars and more expert supervision required for single phase			...	...	2,180
Total			£19,160	£16,460	£20,800

Table VII.—*Comparison of Cost of Systems.*

—	600 v. d.c.	1,200 v. d.c.	6,600 v. a.c.
First cost	£144,000	£122,500	£128,000
Fixed charges	16,240	14,120	17,680
Operation and maintenance	19,160	16,460	20,800
Annual cost	£35,400	£30,580	£38,480
Based on 1,095,000 car-miles per year, additional annual charge per car-mile above the cost for 1,200 volts, pence	1·05	..	1·8

has been found to amount to several pence per car-mile. A conservative estimate would require at least 0·5d. per car-mile to be added for these items. The comparison in Table VII. brings out the fact that even for conditions selected as favourable to the single-phase system the 600 volt direct-current system is the more economical considering operation, maintenance and fixed charges. An examination of the elements which enter into the first cost and operation of a system will show at once that as the density of traffic increases there is a rapid gain in the relative advantage of the direct-current over the single-phase system.

The saving effected by the 1,200 volt direct-current system is so marked that a great increase in the adoption of this potential for this class of interurban railroading may be anticipated, and on the other hand it will not be surprising if the single-phase interurban system is entirely discarded in America, unless some marked improvement is made in the art and a more economical equipment made available. There is no question regarding the mere movement of trains by any particular system—this may be taken for granted. The study of electrification is really a problem in economic engineering, and not simply a technical problem.

Reliability of operation is of the greatest importance, not only to the public, but to the operating company, and in this respect the electric motor, with its simpler construction, even though the general service is supplied from a central power station, has proved its superiority over the steam locomotive. Except in the case of some extraordinary accident, the power station, sub-stations and transmission line, in their entirety, are rarely rendered inoperative. The liability to interruption is principally centred in the equipment of the rolling stock, and for this reason the mechanical and electrical design of the motors, control and equipment devices should receive careful consideration. The electrical equipment of motor cars and locomotive is exposed to a large extent to dirt, water and snow, and not being particularly convenient for inspection, it usually receives less attention than the apparatus in the power station and sub-stations. It is the custom on many roads to give the equipments a regular inspection once in 1,000 or 1,500 miles, depending on experience, and to dismantle them for a thorough overhauling once a year. The character of the rolling stock equipment is a factor of far more importance to the reliability of the service than is often appreciated.

The steam locomotive has been brought to its present state of development through many years of experience. It is an exponent of the highest type of mechanical design, and, notwithstanding its limitations, is remarkably efficient as a source of power. During the past 20 years the power of the steam locomotive has been practically doubled, but the demand to-day is for still greater power. The multiple-unit idea, to which electric service is so well adapted, was utilised in the design of the Mallet type of steam locomotive, where the driving engines of two practically separate locomotives are supplied with steam from a single boiler. Mallet locomotives have been built having a weight of 441,000 lb. on the drivers, the boiler having over 5,800 sq. ft. of heating surface and a grate area of 100 sq. ft. To fire properly a locomotive of this capacity is difficult, and, unlike the electric locomotive, its effectiveness depends on the steam from its own particular boiler. With existing road clearances, the steam locomotive unit, controlled by a single engineer, seems to have reached nearly the limit of power. The power of a steam locomotive being limited by the capacity of its boiler, an increase in speed can be secured only by a proportional reduction in tractive force. The electric locomotive, on the other hand, is supplied with practically unlimited power from an independent power station, and can maintain a speed and tractive force that would be impracticable with a steam locomotive. The application of electric locomotives to passenger and freight service will result in faster schedules with equal or even heavier trains than are at present handled by steam locomotives.

Since the electric locomotive is equipped with a number of independent motor units, controlled by one engineer from a single master controller, it makes no difference, considering the complete locomotive as a machine, whether it be built as a single unit or as two or three units having the same total weight on the drivers. For convenience in operation and repairs, it is probable that a single electric locomotive unit will be limited to a weight between 200,000 lb. and 300,000 lb. on the drivers, even when built for the heaviest service. There are electric locomotives now under consideration which as single units will exert a maximum tractive effort of 90,000 lb., and which will be capable of maintaining a tractive effort of 35,000 lb. at a speed of 30 miles per hour.

Many of the terminal and tunnel electrifications have been brought about from the desire to do away with the danger and nuisance caused by smoke and gas. The elimination of smoke has also an economic aspect in the electrification of terminal stations in per-

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mitting material improvement in the character and value of railway buildings. The Quai d'Orsay terminal of the Paris–Orleans Railway in Paris, which has been in operation since May, 1900, was the first instance where a steam railway profited by this feature of electrification.

The enhanced value of railway buildings is seen to a marked degree when terminals are electrified in large cities in which land values are high. The fact that electric operation will permit platforms on two or more levels adds greatly to the capacity of the station, or, conversely, decreases the land area required for given traffic facilities. In the case of the New York Central terminal in New York City there will be two levels of platforms, the entire suburban facilities being placed below those of the main line. The Pennsylvania terminal in New York is another instance of station design affording facilities for handling traffic that would be impossible under steam operation.

The electric locomotive is well adapted for the handling of trains where the character of the service will not permit the operation of individually equipped cars. Where the service is self-contained, individually equipped motor cars, operated in trains with multiple-unit control, are recognised as providing for the most efficient handling of traffic.

Economy in operation will be secured by proportioning the number of cars in a train to the traffic required during different hours of the day. The patronage on which the gross receipts depend will be much encouraged by providing a service with short intervals between trains. In the study of any scheme of transportation, due regard should be given, not only to economical operation, but also to the method of handling which will ensure the maximum gross receipts.

THE COST OF ELECTRICALLY-PROPELLED SUBURBAN TRAINS.*

BY H. M. HOBART.

Summary.—In comparing the cost of electrically-operated suburban trains the chief items which differ from those of steam locomotive methods are the cost of the energy, the annual charges for the rolling stock and the cost of the distributing system. For the sake of argument, the last of these is taken to be independent of the particular electrical system used, and calculations are made to determine the relative costs of the single-phase and continuous-current methods. Actual operating railways are taken, and it is shown that for suburban passenger traffic the continuous-current system has decided commercial advantages.

The commercial aspects of applying electricity to the propulsion of suburban trains involve many factors, and the thorough investigation of any one of these factors requires careful study. In the present paper the author's aim is to focus attention chiefly on the rolling stock, but it must not be inferred that he implies that the other factors affecting the total cost are of minor importance. It is absolutely insufficient to approach the subject of railway electrification from the standpoint that it resolves itself into a mere question of contrasting electric propulsion with steam locomotive propulsion. The reason for delay in replacing steam locomotive methods by electric propulsion is, so far as concerns the suburban passenger traffic, nearly always related to the large capital expenditure involved in effecting the change. For not applying electrical methods to other classes of railway traffic there is, so far as relates to Great Britain, the best of all reasons—namely, that steam is, at present, in almost all instances, more economical.†

In view of the circumstances, the question of the relative cost of various electrical systems of operating suburban lines becomes one of great importance. The two systems which are, at the present time, chiefly commanding attention are the systems employing on the trains continuous-current motors and single-phase motors respectively, and, with a view to concentration, only these two systems will be taken into account. For the particular investigation which constitutes the object of this paper, it will conduce to clearness to break away completely from these conventional methods of analysing costs.

In view of the circumstances that any single railway almost always traverses districts served by many different electricity supply companies, it is highly probable that for some long time to come, at any rate, a railway would, in many cases, be best serving its own interests by purchasing its electricity from electricity supply companies and municipal electricity supply undertakings. The author will, therefore, assume that the railway not only purchases its electricity from independent undertakings, but that it looks to these independent undertakings to provide all transmission lines from the points where the electricity is "generated," and also to provide all the sub-stations, thus delivering the electricity at the required points on the railway company's premises in the form in which it is collected by the trolley bows or rail shoes carried by the train. The sub-stations are thus the property of the electricity supply company. The railway is, however, the proprietor of all the cables and structures intermediary between the sub-stations and the trains. The price charged by the independent electricity supply undertakings will be for the electricity in the form in which it is delivered from the sub-stations, and owing to the greater cost and lower efficiency of the sub-stations when supplying continuous electricity, the railway will be obliged to pay a higher price for a given quantity of electricity when it is in the continuous form than when it is in the single-phase form. Prices arrived at by experience on a large scale are now quite well agreed upon for electricity in these two forms. While these prices vary greatly according to the price of fuel and various factors of like nature and while they also vary greatly with the nature of the load, they can nevertheless be estimated with certainty in any particular case.

Thus, so far as the outlay for electrical apparatus and equipment is concerned, this method of comparison leads us to the definite proposition of estimating the cost of the rolling stock and the cost of the structures along the line, intermediary between the sub-stations and the trains. While the cost of these structures has, up to the present, been higher with the single-phase than with the continuous system, the author does not propose in this Paper to discuss these differences, but he will, on the contrary, assume that the outlay for this portion of the work is the same for both systems. As to the cost of the trains estimates for each system will be made, since in this respect the two systems differ greatly from one another.

To fix ideas, the author will confine his comparisons chiefly to trains consisting of three double-bogie coaches. It is well known that, under reasonably favourable conditions, such trains usually yield gross receipts of some 40d. to 60d. per train-mile. The cost of the electricity required for the propulsion of the trains, together with reasonable estimates for the capital charges for the trains, including the outlay for their depreciation, repairs and renewals, make up an aggregate per train-mile which is usually of the order of from 35 to 40 per cent. of the amount of the gross receipts. Into the disposition of the remainder of the gross receipts it is not proposed to enter, since (taking the electrical structures along the line, that is, the equipment intermediary between the sub-stations and the trains, as representing the same outlay, irrespective of the particular system of electric traction adopted) the disposition of this remainder will be substantially the same, whichever system is employed, and hence does not materially affect the results in a comparison of systems. For high speeds with frequent stops, both the single-phase system and the continuous system have long been recognised to be adequate as regards their engineering features, but the former entails distinctly greater outlay and distinctly less net earnings. With decreasing speed for a given distance between stops, or with increasing distance between stops for a given speed, the disabilities of the single-phase system become less acute.

The severity of a train service is a function of the schedule speed and of the distance between stops. For a very severe service, many of the train axles are often driven by motors, while for more moderate services it suffices to concentrate the driving power upon but a few of the axles. In eliminating the locomotive and placing the motors under the passenger coaches, the space available for the motors is rather restricted, and the plan of distributing several relatively small motors on several axles is more often a consequence of this space limitation than of any regard for obtaining greater tractive effort by the greater total weight on the driven axles. Although this latter object is always kept in view, it may be said that even the high accelerations employed on electric railways rarely require so great a sub-division of the driving power as is, for severe services, usually resorted to, owing to the space limitations.

The author proposes first to analyse the design and performance of two 150 ft. trains designed for about the same "average output," and similar as regards the capacity and distribution of the electrical equipment. In the two 150 ft. trains which have been selected for this analysis, only two motors are employed, and these drive two of the four axles of a motor coach. Each of these 150 ft. trains comprises three 50 ft. coaches, of which one is a motor coach and the

* Abstract.

† This is usually the case. The presence of frequent tunnels may afford the chief reason for adopting electricity on a given section, owing to the elimination of smoke and steam. But if it is proposed to employ a bare 6,000-volt overhead conductor for supplying the trains, the presence of tunnels of small dimensions may afford the most cogent reason for adhering to the steam locomotive. Heavy grades are much more readily negotiated by electrically-propelled trains, and consequently, for mountain lines there is an additional incentive for substituting electrical propulsion for steam locomotive methods.

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other two are trailer coaches. Thus out of the 12 axles, only two are driven. The first of these two trains is a type designated A, which is employed on the Piccadilly Tube Railway in London and weighs 61 tons; the second is a type designated C, which is employed on the Heysham, Morecambe and Lancaster Branch of the Midland Railway and weighs 77 tons. The service for which the 61-ton Piccadilly Tube train is employed requires a schedule speed of 16·4 miles per hour, and the runs are of an average distance of 0·45 mile between stations. The 77-ton Heysham train has a schedule speed of some 31 miles per hour, and there is an average distance of 4 miles between stations. It might appear at first sight that these two services are not comparable, but brief calculations show that the average output to the axles is just about the same in the two cases. Furthermore, the average efficiencies of the two electrical equipments do not differ by more than 5 per cent. at the outside. This is also the case as regards the efficiencies in the two cases of 180 ft. trains, examined in a later section of this Paper, and with a view to avoiding a discussion of so unessential a matter as a few per cent. difference in efficiency, the author has throughout his comparisons employed the mean value of 70 per cent. His examinations indicate that in no one of the four cases (that is, the two 150 ft. trains and the two 180 ft. trains) is the average efficiency of the electrical equipment on the train for the services for which the trains are employed greater than 72 per cent. or less than 68 per cent.; consequently the employment throughout of the value of 70 per cent. is amply exact and is in the interests of simplicity. The two particular instances of two-motor 150 ft. trains have been taken because precise data of their design and performance are available, and because, while they are equipped for about the same average output, the one train carries continuous-electricity equipment and the other carries single-phase equipment. For the 61-ton Piccadilly train the output of the equipment averaged over the entire time, including stops, is 87 H.P.; for the 77-ton Heysham train the corresponding figure is 90 H.P. The total weight of the electrical equipment in the two cases is 8 tons* and 14·9 tons respectively. In each case the service is that for which the equipment was selected, and in each case the ultimate temperature rise in regular service is of moderate amount. The calculations for these two trains are set forth in parallel columns in Table I.

Table I.

—	Piccadilly train.	Heysham train.
Number of motor coaches	1	
Number of trailer coaches	2	
Total number of coaches in the train	3	
Number of motors	2	
Total number of axles in the train	12	
Number of axles driven by motors	2	
Length of train ... feet	150	
Weight of train ... tons	61	77
Schedule speed (a) ... miles per hour	16·4	31
Distance between stops ... miles	0·45	4
Energy consumption per ton-mile ... w.-hour	93	40
Energy per train-mile (b) ... kw.-hour	5·67	3·08
Average input per train ($a \times b$) ... kw.	93	95·6
Average output from motors to axles (taking average efficiency of electrical equipment as 70 per cent.) ... H.P	87	90
Weight of electrical equipment ... tons	8·0	14·9
Average output per ton of elec. equipment ... H.P.	10·9	6·04
Ratio of these two average outputs per ton of electrical equipment ...	$\frac{10·9}{6·04} = 1·8$	

Having now examined two 150 ft. trains composed of one motor coach and two trailers, let us turn our attention to two trains for more severe services. The two trains which the author has selected for his purpose are each 180 ft. in length and are each composed of two motor coaches and one trailer coach. Each coach is 60 ft. in length. Each motor coach is equipped with four motors, making up a total of eight motors per train. Thus eight of the 12 axles of the train are driven by motors, whereas in the two former trains only two out of the 12 axles were driven. The first of these two 180 ft. trains is of a type which may be designated as B, and which is employed on the Southport line, and the second, which may be designated as D, is one of the trains now operating on the South London Elevated Railway. The trains are thus somewhat longer and are much heavier than those which we have examined before. The weights of these two 180 ft. trains are respectively 118 tons and 138 tons. The Southport train runs at a schedule speed of 30 miles per hour, and the average distance between stations is 1·32 miles. The South London Elevated train, which will be designated the S.L.E. train, runs at a schedule speed of 22 miles per hour, and the average distance between stations is 0·88 mile. The striking similarity of these trains as regards their length (180 ft.), their seating capacity and the proportion of motor and trailer coaches, has led to the establishment of comparisons between them. But these comparisons have usually been of an utterly superficial nature. It has been said that since in the case of the Southport train the stops are less frequent and the speed is higher, the severity of the service is substantially the same as in the case of the S.L.E. train, and it has been assumed, though altogether incorrectly, that the more frequent stops in the case of the S.L.E. train offset the greater speed in the case of the Southport train. The author has, however, pointed out on various occasions that this is not the case. On the contrary, the power which is required at the axles in the case of the Southport 118-ton train is 42 per cent. greater than the power which is required at the axles for the S.L.E. 138-ton train, notwithstanding the 18 per cent. greater weight of the latter train, and the power required at the axles per ton of total train weight, is no less than 65 per cent. greater for the Southport service than for the S.L.E. service.

The service performed by the Southport 118-ton train requires of the electrical equipment an output to the axles, averaged over the entire run, of 319 H.P., whereas the relatively much less severe service of the S.L.E. 138-ton train requires an output to the axles of only 225 H.P. The weights of the electrical equipments in the two cases are, however, 30 and 44 tons respectively. The average horse-power output to the axles per ton of electrical equipment, works out respectively at 10·6 H.P. for the Southport train and 5·12 H.P. for the S.L.E. train. In Table II. these calculations are set forth in parallel columns.

Table II.

—	Southport train.	South London Elevated train.
Number of motor coaches	2	
Number of trailer coaches	1	
Total number of coaches in the train	3	
Number of motors	8	
Total number of axles in the train	12	
Number of axles driven by motors	8	
Length of train ... feet	180	
Weight of train ... tons	118	138
Schedule speed (a) ... miles per hour	30	22
Distance between stops ... miles	1·32	0·88
Energy consumption per ton-mile ... w.-hour	96	79
Energy per train-mile (b) ... kw.-hour	11·3	10·9
Average input per train ($a \times b$) ... kw.	340	240
Average output from motors to axles (taking average efficiency of electrical equipment at 70 per cent.) ... H.P.	319	225
Weight of electrical equipment ... tons	30	44
Average output per ton of elec. equipment ... H.P.	10·6	5·12
Ratio of these two average outputs per ton of electrical equipment ...	$\frac{10·6}{5·12} = 2·07$	

It will be observed that the average output per ton of electrical equipment varies greatly in the four cases which we have examined, and questions naturally arise as to the cause of these great variations. It might be suggested that the variations are attributable to diverging views as to correct methods of design. As it happens, however, the equipments were supplied by four different manufacturers who are amongst the half-dozen firms who probably have the greatest experience in the manufacture of electric railway equipments, and who are all on a substantially equal footing as regards ability to produce the best, lightest and cheapest apparatus for the purpose in view. Consequently, we must seek some other explanation for the striking difference in the results. The two first results are within 3 per cent. of each other and the two last results are within 18 per cent. of each other. The mean of the first two results is 10·8 H.P. per ton, and the mean of the last two results is 5·6 H.P. per ton. These two values have the ratio 1·93 : 1·00. The reason for this difference in weight of about 2 to 1 is that in the first two cases (that is, the Piccadilly Tube 61-ton train and the Southport 118-ton train) the equipments are designed for and operated with continuous electricity, whereas the last two cases (the Heysham 77-ton train and the S.L.E. 138-ton train) have equipments designed for and operated with single-phase electricity.

* This estimate of 8 tons is somewhat in excess of the weight usually assigned to the equipment of the Piccadilly Tube trains. The figure usually given is 7·3 tons, but the author prefers to take 8 tons since the weight of auxiliary equipment tends gradually to increase in successive installations. This is because with the development of electrical methods, refinements are introduced which were not deemed necessary in the earlier work. This estimate of 8 tons is ample to cover air-compressors and governor, all cables, slate switch-panels, collecting shoes, and shoe beams for both trucks of the motor coach, steel-tubing bolts, cleats, &c. The estimate of 14·9 tons is for the Siemens Co.'s equipment as installed on the Heysham train.

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As rough, but representative, values, we may take it that for a train equipped with continuous apparatus, the electrical equipment may, in actual service, and for approved overload and heating limits, be loaded up to an average output of 11 H.P. per ton weight of the equipment, whereas single-phase equipments can only be worked up to an average output of 6 H.P. per ton. It has been asserted that notwithstanding that the single-phase equipment for a train required to perform a given service weighs twice as much per horse-power as the corresponding continuous equipment, this does not seriously affect the total train weight, since the weight of the electrical equipment constitutes (it is alleged) only a small part of the total weight of the train. Let us investigate this assertion. In Table III. are given the total train weights, the weight of the electrical equipment, and the percentage which the weight of the electrical equipment constitutes of the total train weight.

Table III.

System.	Designation of train.	Railway.	Length of train.	Total train weight	Weight of electrical equipment.	Percentage which weight of electrical equipment constitutes of the total weight of the train.
			Feet.	Tons.	Tons.	Per cent.
Continuous.	A	Piccadilly	150	61	8·0	13·1
Continuous.	B	Southport	180	118	30·0	25·4
Single-phase	C	Heysham	150	77	14·9	19·3
Single-phase	D	S.L.E.	180	138	44·0	32·0

Comparing the 180 ft. trains, that is, trains B and D, we have seen that the Southport service is much the more severe, yet the electrical equipment of the Southport train only amounts to 25·4 per cent. of the total weight, as against 32 per cent. of the total weight for the much less severe S.L.E. service. It should be of interest to ascertain how a train of the "D" type would require to be modified in order to be suitable to perform the "B" service. This and subsequent calculations will be simplified by first working out, for all the trains, the average horse-power per ton weight of train required for the respective services. This is done in Table IV.

The values in the lowest horizontal line of Table IV. are the real criteria of the severity of the service, and we see that the Southport service requires 65 per cent. more average power per ton weight of train than is required for the S.L.E. service. The values in the lower line of Table IV. are (since the efficiency is the same) independent of whether single-phase or continuous apparatus is employed. For the Southport service there must be provided 2·7 H.P. per ton weight of train. Since we have seen that, with single-phase equipment, we obtain 6 H.P. per ton of equipment, we shall require 0·45 ton of electrical equipment for every ton of total weight of train. Thus 45 per cent. of the weight of the train will consist of electrical equipment.

Table IV.

System	Continuous.		Single-phase.	
Designation of train	A	B	C	D
Road	Piccadilly	Southport	Heysham	S.L.E.
Length of train.....feet	150	180	150	180
Weight of train .....tons	61	118	77	138
Av. output during service H.P	87	319	90	225
Do. per ton weight of train H.P	1·42	2·70	1·17	1·63

The motor coaches on the S.L.E. line weigh 54 tons each. Of this 54 tons weight of one of these motor coaches, only 22 tons, that is, only 41 per cent. of the total weight of the motor coach, is electrical equipment, and consequently the motor coach which is at present running the S.L.E. service, even with its motors re-wound for the required speed, would not have sufficient capacity (leaving the same margin as on the present S.L.E. service) to accomplish the Southport schedule with the same heating of the electrical equipment as in the S.L.E. service, much less could a train composed of two motor coaches and one trailer accomplish this schedule with normal heating and with appropriate overload capacity. In order to work the S.L.E. 180 ft. train to the Southport schedule, its electrical equipment must be considerably increased in weight. Let W equal the total weight of the S.L.E. 180 ft. train, in tons, when reinforced to render it adequate for the Southport service. Then the electrical equipment must weigh 0·45 W. The weight of the S.L.E. 180 ft. train, exclusive of the electrical equipment, is $138-44=94$ tons. Its revised weight, when provided with an equipment enabling it to conform to the Southport service, will consequently be

$$W=0{\cdot}45\times W+94.$$

Therefore we have $W=171$ tons.

The weight of the electrical equipment must thus be 77 tons, and the electrical equipment will be capable of delivering an average output of 462 H.P. Thus the equipment of the S.L.E. train must be increased, as regards its average output, from the 225 H.P. which sufficed for the S.L.E. service, up to the 462 H.P. necessary in order that it may accomplish the Southport service. This is an increase of 105 per cent. The revised S.L.E. train requires to have 462 H.P. average capacity as against the Southport train's 319 H.P. average capacity, an excess of 45 per cent. This further 45 per cent. serves no more useful purpose than to carry over the route the increased weight of expensive electrical equipment made necessary by the use of the single-phase system. The revised S.L.E. train weighs 171 tons, as against the Southport train's weight of only 118 tons. Thus the result is, that while both trains have the same length of 180 ft., the S.L.E. train, when altered to be adequate to perform the Southport service, weighs 45 per cent. more than the Southport train. Moreover, the revised three-coach single-phase train for the Southport service would have to consist of three motor coaches, in place of the two motor coaches and one trailer which sufficed to carry the necessary single-phase equipment to perform the S.L.E. service.

Let us next reverse the above process and adapt the Southport train to the S.L.E. service of 22 miles per hour and one stop every 0·88 mile. This service requires, as seen from Table IV., only 1·63 H.P. per ton of total weight of train. 1·63 H.P. of continuous equipment weighs only 0·148 ton. Consequently out of each ton of total train weight, only 14·8 per cent. will consist of electrical equipment as against the 32 per cent. seen from Table III. to be required when the S.L.E. service is provided by a train equipped with single-phase apparatus. Let us again represent by W the total train weight in tons. Then the weight of the electrical equipment in tons amounts to $0{\cdot}148\times W$. The weight of the Southport train, exclusive of the electrical equipment, is 88 tons. Consequently $W=0{\cdot}148\times W+88=103$ tons. The weight of the electrical equipment of the revised Southport train, that is, of the continuous train capable of working to the relatively moderate S.L.E. service, is only 15·3 tons, or only 51 per cent. of the 30 tons weight of the electrical equipment required for the Southport train performing the severe Southport service. Obviously then, were we to operate a 180 ft. train to the S.L.E. schedule, employing continuous equipment instead of single-phase equipment, we should not require two motor coaches, but we should make up our three-coach train of one motor coach and two trailers. The continuous equipment thus weighs only 15·3 tons, or only 34·8 per cent. of the 44 tons required for the single-phase train of equal length. It is interesting to note that this continuous-electricity train operating on the S.L.E. service is only required to give an average output of 168·5 H.P., which amounts to only 75 per cent. of the average output required of the motors on the single-phase 138-ton S.L.E. train.

Table V.

Electrical equipment of one train.	Weight.	Cost per ton.	Total cost.
	Tons.	£	£
Continuous train for Southport service.....	30·0	125	3,750
Continuous train for S.L.E. service	15·3		1,910
Single-phase train for Southport service....	77·0		9,630
Single-phase train for S.L.E. service.....	44·0		5,500

A rough but thoroughly representative figure for the cost of continuous equipment for railways is £125 per ton. Single-phase equipment at present costs decidedly more, but for the purposes of this investigation the author will take the cost of the electrical equipment, irrespective of whether it is continuous or single-phase, at £125 per ton. Thus for the four trains under consideration, the costs for the electrical equipment work out as shown in Table V.

The weight of each motor truck, including truck frames, wheels, axles, brake rigging, &c., will be taken at 6·5 tons, the weight of each trailing truck at 5·5 tons. In both cases, the cost of the complete trucks will be taken at £22 per ton.

The total costs of the four trains are made up as shown in Table VI.

Since these trains have a seating capacity of, roughly, one seat per foot, the two lower horizontal lines in Table VI. also give a fair representation of the relative costs and weights per seat. We see that for so severe a service as that at Southport, the cost of a single-phase train works out to be 65 per cent. greater per foot of length than is the cost of a continuous train. For the much more moderate service of the S.L.E. line, the excess cost of the single-phase train per foot of length is only 51 per cent., and the percentage continues to fall with every amelioration in the severity of the service.

It is usually preferable to reduce weights and costs to the basis of the weight and cost per foot length of train instead of per seat. Otherwise it is very difficult to effect comparisons, for not only have we to take into account the varying composition of trains as regards

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Table VI.

—	D.C. train.		Single-phase train.	
	For Southport service.	For S.L.E. service.	For Southport service.	For S.L.E. service.
	£	£	£	£
Trucks	815	770	860	815
Car bodies	4,320	4,320	4,320	4,320
Electrical equipment	3,750	1,910	9,630	5,500
Further costs	590	515	855	690
Total cost of train	9,475	7,515	15,665	11,325
Weight of train	118 tons	103 tons	171 tons	138 tons
Cost per ton	£80·3	£72·7	£91·6	£82·1
Length of train	180 ft.	180 ft.	180 ft.	180 ft.
Cost per foot	£52·6	£41·7	£87·0	£63·0
Weight per foot	0·655 ton	0·575 ton	0·95 ton	0·77 ton

Table VII.

Schedule speed in miles per hour.	Energy consumption in watt-hours per ton-mile for the various values of the distance in miles between stops set forth at the heads of the vertical columns, and for 20-second stops.							
	0·5	0·6	0·7	0·8	0·9	1·0	1·25	1·5
15	68	58	50	...	...	...	...	...
16	78	66	56	50	...	...	...	...
17	93	76	63	55	50	...	...	...
18	114	90	73	62	55	48	...	...
19	...	104	83	70	60	53	...	...
20	...	...	94	78	66	58	47	...
22	...	...	...	95	77	67	54	...
24	...	...	...	...	98	83	65	55
26	...	...	...	...	...	100	78	63
28	...	...	...	...	...	...	89	73
30	...	...	...	...	...	...	104	82

first and third-class carriages, but there is the further consideration that the policy of railways differs considerably as to the floor space and elbow room which are allotted to each passenger. Since, however, the average value of the seats per foot for representative passenger trains of mixed composition rarely varies much from unity, the values of the weight and cost per foot enable us readily to make mental calculations, as occasion requires, of the corresponding weights and costs per seat. It is preferable, in all cases, to take the weights of the trains themselves, and to leave out of consideration the weights of the passengers.

We have now deduced fairly definite values for the weights and costs of the rolling stock. The component of the total cost represented by the electricity consumed by the train is also fairly definite for a given service. The consumption at the train is for a given service about the same per ton-mile whether the electrical equipment be continuous or single phase. The values in Table VII. afford a reasonable basis for estimating the consumption at the train per ton-mile of actual performance, when the train is handled by a fairly experienced driver, and when it is running strictly to its time-table, and over a well-built, fairly straight and level permanent way. Although quite practicable variations in the acceleration and braking may easily occasion variations of 10 per cent. or more in the energy consumption at the train, nevertheless the values in Table VII. are representative of the customary results obtained under the conditions stated.

In the case of passenger trains it is preferable for uniformity's sake to estimate the ton-mileage on the basis of the weight of the empty train. The unrecorded ton-mileage corresponding to the weight of the passengers carried, together with that corresponding to shunting operations and other non-remunerative running, as well as the increased consumption on occasions when the time-table is disarranged, will usually bring up the total consumption at the train to a value some 30 per cent. greater than the values given in Table VII. This increase is only in small part due to the weight of the passengers, since with average loads the weight of the passengers rarely increases the weight of the train by more than some 5 to 6 per cent. In the following estimates the author will take the consumption of electricity at the train as 1·30 times the values in Table VII. To simplify the investigation he will not go into the question of whether the railway provides its own generating plant or purchases the electricity from a supply company; but he will merely assume that the electricity is obtained at a total cost of 0·65d. per kilowatt-hour as delivered to the sub-stations. Owing to the greater loss in transformation at the sub-stations and the greater cost of the sub-stations in the continuous, as contrasted with the single-phase system, he will take the cost of the electricity as delivered from the sub-stations at 0·70d. per kilowatt-hour for the single-phase system and at 0·87d. per kilowatt-hour for the continuous system. These amounts cover all outlays, both capital and operating, up to the outgoing cables from the sub-stations. The losses in the transmission system from the sub-stations to the trains are of but small amount in either system. To allow for them he will take the cost of the electricity delivered at the trains as 0·72d. per kilowatt-hour for the single-phase system, and 0·90d. per kilowatt-hour for the continuous system. These last increases in the cost simply allow for the electricity wasted in the process of being conveyed from the sub-stations to the trains, and do not allow for the capital and maintenance charges for the cables and the conductor rails or overhead structures by means of which the electricity is conveyed from the sub-stations to the trains. The two figures of 0·72d. and 0·90d. per kilowatt-hour respectively are thoroughly representative as regards their relative values though their actual values, while representative, will vary considerably according to many local circumstances.

Furthermore, these values are only applicable for the conditions of a suburban service of passenger trains where the trains in each direction run, as an average, at intervals of some 12 to 15 minutes during some 16 to 20 hours per day. For a less intense service, the price for continuous electricity will exceed that for single-phase electricity by a greater percentage, since the cost of the sub-stations will constitute a larger item, and the "all-day" efficiency of the sub-stations will be less. If, on the contrary, the trains run at intervals of only some three to six minutes, then also the relative figures of 0·72d. and 0·90d. at the trains are not applicable; 0·69d. for the single-phase system and 0·83d. for the continuous system would then be more appropriate, the latter in this case exceeding the former by only 20 per cent. as against 25 per cent. in the case of the 12 to 15 minutes' service. This is because, while the cost of the electricity, as delivered at the trains, in the case of both systems, decreases with the intensity of traffic, the decrease is a greater amount for the continuous system, owing to the better load factor at the sub-stations and the consequent considerable reduction in the capital charges and operating expenses of the sub-stations. For his further comparisons, however, the author will take the figures of 0·72d. for the single-phase system and 0·90d. for the continuous system for the cost of electricity per kilowatt-hour delivered at the trains.

With these data, we may now estimate the cost of the electricity consumed by 180 ft. trains operating in the Southport service (as an instance of a severe service) and in the S.L.E. service (as an instance of a much more moderate service). The price actually paid for the electricity for the S.L.E. trains is, at present, decidedly higher than the figures here taken, but the fairly high price in that instance is probably, to some extent, incidental to the experimental nature of the undertaking at this stage. It is well known that in most districts there would, under the conditions already indicated, be reasonable profit in supplying railways with electricity at the prices stated, and hence it is only on the basis of such prices that the comparisons will lead to useful results. To fix ideas, it can be taken that the author's figures relate to a hypothetical road so situated that his prices for electricity are applicable and have been quoted, and that the engineers of this road are engaged in determining whether to use the continuous or the single-phase system, and the schedule speed to be provided on various sections of line with various distances between stations.

Out of the 8,760 hours in the year, it is rarely practicable, on other than tube railways or railways providing the class of service associated with tube railways, to attain (for suburban passenger trains) to much more than 2,000 hours of actual service on the line. Usually the figure is decidedly less than 2,000 hours. For a schedule speed of 30 miles per hour, the profitable mileage per train per annum, on the basis of 2,000 hours, works out at 60,000 miles, and for a schedule speed of 22 miles per hour it works out at 44,000 miles. Under the conditions of actual service, there will not be so much difference as this between the annual average mileage per train for these two schedules. The more the service conforms to the conditions of a tramway service, the more uniform and continuous will be the sequence of trains; consequently, for the 22 miles per hour case the author will take the annual average mileage per train at 48,000 miles instead of the above 44,000 miles, and for the 30 miles per hour case he will take the annual average mileage at 54,000 miles instead of the above 60,000 miles. The total cost of electricity per annum per train is obtained as shown in Table VIII.

For comparative purposes the rough figure of 15 per cent. of the cost of the rolling stock is taken as the annual charges for interest, depreciation, repairs and renewals. He will term these the annual charges for capital, depreciation, repairs and renewals per train, and as a check to indicate their general reasonableness, he will in Table IX. show the corresponding values per train-mile.

Amongst the many and large remaining costs, there are none in which the adoption of the continuous system will entail greater costs per train than are incurred with the single-phase system.

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Table VIII.

Schedule speed, miles per hour	30		22	
Distance between stops, miles	1·32		0·88	
Designating number	I.	II.	III.	IV.
System	Continuous	Single-phase	Continuous	Single-phase
Weight of train (from Table VI.) ....tons	118	171	103	138
Net consumption of electricity at train in w.-hour per ton-mile (from Table VII.)	96	96	79	79
Do. in kw.-hour per train-mile	11·3	16·4	8.2	10·9
Miles per train per annum ...	54,000	54,000	48,000	48,000
Net consumption per train per annum (kw.-hour) ...	610,000	886,000	394,000	523,000
Gross consumption per train per annum (=1·30 × net consumption) kw.-hour...	793,000	1,150,000	512,000	680,000
Cost of electricity delivered at train, per kw.-hour...d.	0·90	0·72	0·90	0·72
Total annual cost per train for electricity .....£	2,970	3,450	1,920	2,040
Do. per train-mile.....d.	13·2	15·3	9·6	10·2

Table IX.

Schedule speed, miles per hour	30		22	
Average distance between stops .....miles	1·32		0·88	
Designating number	I.	II.	III.	IV.
System	Continuous	Single-phase	Continuous	Single-phase
Total annual cost per train for electricity .....£	2,970	3,450	1,920	2,040
Annual charges for capital, depreciation, repairs, and renewals, per train .....£	1,420	2,350	1,130	1,700
Sum of above two annual outlays, per train .....£	4,390	5,800	3,050	3,740
Cost per train-mile, for electricity .....d.	13·2	15·3	9·6	10·2
Annual charges for rolling-stock, per train-mile ...d.	6·31	10·43	5·65	8·55
Sum of above two outlays per train-mile.....d.	19·51	25·73	15·25	18·75
Amount by which the single-phase train costs more per train-mile than continuous-electricity train ...d.	6·22		3·5	

It is well known that the gross receipts for three-coach trains on services of this character are usually of the order of from 40d. to 60d. per train-mile. Let us fix our attention on a case where the gross receipts are 50d. per train-mile. It is evident from the results in the lowest horizontal line of Table IX. that in such a case, whatever be the net profits, they will be less if the single-phase system is used than if the continuous system is used. The percentage of the gross receipts which could be set aside as profits would, for the 30 miles per hour one-shop per 1·32 mile service, be 12·45 per cent. greater with the continuous than with the single-phase system. For the 22 miles per hour one stop per 0·88 mile service they would still be greater by 6·7 per cent. It is common knowledge that suburban traffic is at present very unremunerative, although this is not always obvious from balance-sheets where the profits shown are usually very largely from main-line and goods traffic. Confining our attention to the suburban traffic, it appears that while there may be a few services in which the margin in favour of electrification is great enough to stand the higher cost of the single-phase system, there are many in which the great difference which the author has shown as existing between the two systems would make all the difference between commercial success and commercial failure.

The subject is a large one with many important aspects. This investigation, however, clearly shows that the selection of the electrical system and also the determination of the service to be provided, as regards schedule speed, distance between stations and intensity of traffic, are all matters demanding the most careful attention and that they are interdependent. It is evident from the nature of the case, as illustrated by the problems the author has worked out, that the more severe the service and the more intense the traffic, the greater is the superiority of the continuous system. But it is also demonstrated that even for systems of such moderate severity as 22 miles per hour and one stop per 0·88 mile, and even when the intensity of traffic is only one train every 12 to 15 minutes in each direction, the superiority of the continuous system is still very substantial. It is, however, precisely for intense traffic, and for severe services—that is, for services exceeding the limits amenable to steam locomotive methods—that electricity is pre-eminently applicable.

A point of considerable interest, disclosed by a comparison of the values in the penultimate horizontal line in Table IX., is that, with the continuous system, the components of the total cost per train-mile which he has considered are 28 per cent. greater for the 30 miles per hour one stop per 1·32 mile service than for the 22 miles per hour one stop per 0·88 mile service, while with the single-phase system, the cost per train-mile is 37 per cent. greater for the former than for the latter service. This is another point of view from which the greater appropriateness of the continuous system for severe services is apparent.

With the object of basing his comparisons on thoroughly authenticated cases, the author has taken for the continuous-electricity services roads employing pressures of some 600 volts at the trains. There are, however, now a considerable number of roads employing a pressure of 1,200 volts with conspicuous success; indeed, in some of these instances, single-phase equipments have been replaced by 1,200-volt continuous-electricity equipments. As early as 1904 the author urged the advantages of doubling the customary pressure for continuous-electricity traction systems, and based his comparisons on the precise lines which are now being so successfully adopted. Upwards of a dozen roads have now adopted the 1,200-volt continuous-electricity system of traction. This system effects distinct economies over the 600-volt system, and very appreciably accentuates the contrast between the continuous-electricity system and the single-phase system.

THE WOOD PULP AND PAPER MILLS OF THE ANGLO-NEWFOUNDLAND DEVELOPMENT CO.

A LARGE HYDRO-ELECTRIC SCHEME.

(*Concluded from page 643.*)

Generator Turbines.—The turbines in the power house are also of the double type, but, unlike the grinder turbines, have only a single spiral inlet. They each have left and right discharge pipes. The junction inlet pipe rises from the main inlet pipe at an angle of 60 deg., and in this junction pipe is placed the butterfly valve, which is fitted with a hand-operated worm and quadrant for the purpose of shutting off the water. The two curved discharge tubes cross downwards into the draught tubes, which are cut obliquely with a view of securing a more convenient discharge of the tail water. The normal speed of operation of these sets is regulated to 375 revs. per min., which can, by means of the previously described apparatus, be altered as desired between 356 and 394 revs. per min. while the machine is working. It is further guaranteed that a speed variation of not exceeding 12 per cent. will result from a sudden throwing off of the load.

The electric generators, whose constant load capacity is 1,700 kw., supply a three-phase current of 1,800 amperes per phase at 600 volts and a frequency of 50 with a power factor of 0·8, and were built by Messrs. Brown, Boveri & Co., of Baden. Each set has an exciter attached which is constructed for a simultaneous excitation of two dynamos and for a load of 43 kw. at 115 volts. The variation of pressure from full load to no load varies from 8 to 20 per cent. The construction of the generator turbines, as well as the speed regulators, is very much the same as that of the 4,000 H.P. units. Mention may, however, be made of the pressure regulator attached to each generator turbine, the duty of which is to clear an opening for the outrush of water which occurs as a result of the turbine valve being quickly closed. This prevents an undesirable increase of pressure in the pipes. The fundamental idea of this apparatus has already been fully described

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by Prof. Prasil,* but is carried out in the present instance on a large scale in conjunction with the employment of a servo-motor. The discharge tubes of this pressure regulator empty themselves into the tail water, and are so bent off in their lower section that the violent outrush of escape water cannot attack the canal walls and bed.

The Oil-pump Installation.—Four three-cylinder piston pumps supply the necessary oil pressure for the plant, while for the equalisation of the pressure two air vessels of 2 ft. 4 in. diameter and 9 ft. 4 in. height are installed. The reservoir has an oil capacity of 1,760 gallons, and is installed in such a position that all the used oil from the regulators, including the drip, can flow back by gravity into the reservoir, being cleansed on the way by a filter.

The construction of the pumps exhibits some interesting features, due to their compact design and range of delivery. The pump is completely enclosed, rendering it possible for all

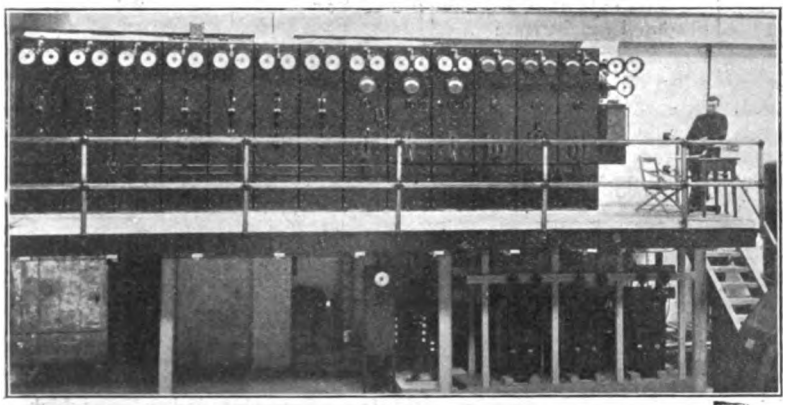

FIG. 7.—VIEW OF THE MAIN SWITCHBOARD WITH TRANSFORMER AND ARC LIGHTING APPARATUS UNDERNEATH.

the moving parts to circulate in an oil bath. The suction valve forms a part of the pump piston itself, whilst the delivery valve is arranged in the cover of the pump cylinder. Both valves work in conjunction with cataracts in such a manner that when a reversal of the stroke occurs the valve disc sinks softly into its seat, thus securing a noiseless working. In the case of the suction valve, which forms the movable cover of the pump piston, this cataract action is produced as follows: The hollow is rigidly enclosed by the pump piston. In the

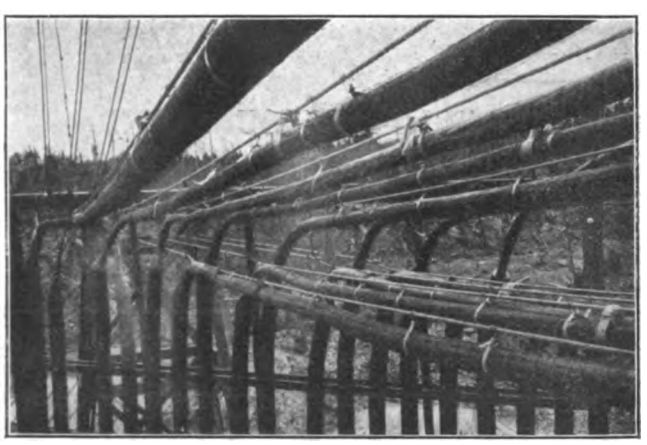

FIG. 9.—METHOD OF SUSPENSION AND ENTRANCE OF CABLES TO CONDUIT.

bore of the rod is a small piston, which can be moved outwards by means of a small hand wheel at the end of the rod, and is thus able to close the openings. A small cataract piston is rigidly connected with the hollow rod, and consequently also with the pump piston. The surrounding casing and the cover

* "Schweizerische Bauzeitung," 1896, "Die Turbinen und deren Regulatoren," Vol. XXVIII., Nos. 20-26.

of the cataract piston, which in its entirety forms the suction valve, is free to slide along the moving rod for a distance corresponding to the permissible valve stroke. Finally, under the pistons passages are arranged, which by means of the hollow rod can communicate with the openings, and in this way bring the chamber over the piston into communication with the chamber under the piston. If now the opening is partially

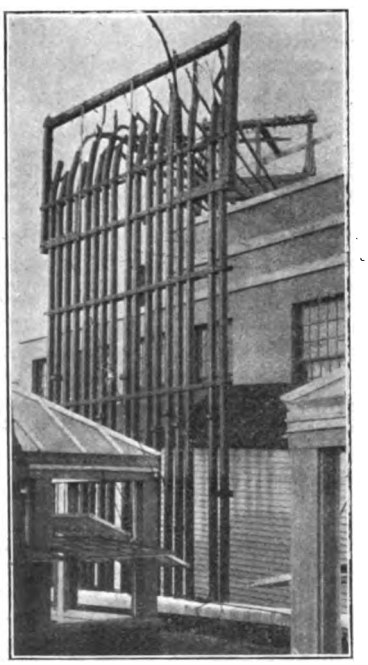

FIG. 8.—CABLES ENTERING POWER HOUSE. The pipes rise 50 ft. above the roof and 65 ft. above the switchboard.

closed through the small piston, the flow of the oil is checked, and on that account the casing can only move slowly relatively to the piston, and the pump piston becomes a rigid whole, and the suction valve, which is identical with the casing, can only, therefore, move slowly in its seat. This cataract action is attained in a somewhat simpler way through the pressure valve. The valve disc is here under the pressure of the helical spring, which can be regulated from the outside, and possesses in its hollow a piston, which extends a few millimetres into the casing

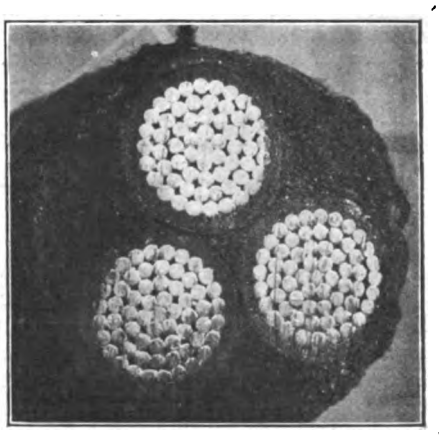

FIG. 10.—AERIAL POWER CABLE USED AT GRAND FALLS. Diameter 4½ in.

of the valve seat. In addition, there are openings in the valve seats, by which the speed of the oil compressed by the piston from the casing during the downward passage of the valve can be regulated, and thus procure the desired gentle movement of the valve disc into its seat.

The number of revolutions of the pump reaches 178 per minute, and the working pressure is 150 lb.; for this 80 gallons

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of oil per minute can be delivered by a three-cylinder pump. The speed, however, can conveniently reach 200 revs. per min., in which case the delivery increases to 92 gallons per minute.

Each group of pumps is driven by a motor, the speed of which is reduced from 710 to 180 revs. per min. by helical gearing running in oil. Each of the pumps is connected by means of a friction clutch to the shaft of its respective spur gearing, by which means each pump can be switched on and off as desired while working.

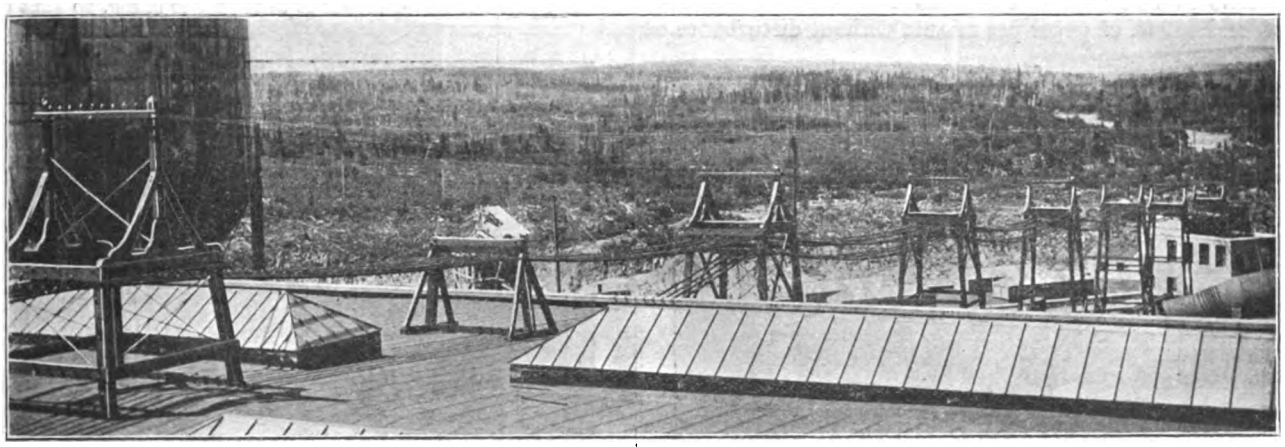

FIG. 11.—VIEW OF THE TRANSMISSION LINE FROM THE MILL ROOF.

Switchgear and Transmission Line.—The switchboard equipment of this plant was supplied by the Westinghouse Electric & Mfg. Co., and was planned and built throughout with an eye to ruggedness and hard service, unadorned with embellishments of any kind. There are (*see* Fig. 7) three exciter panels, three generator and seven feeder panels, each controlling two power circuits to the mill. Each feeder is fitted with a watt-meter on its own panel. All switches are of the positive break, laminated brush, oil type, and are capable of releasing their full rated load without injury. Voltage regulation is effected by means of a Tirrell five-voltage regulator, so that the switchgear is operated under very nearly automatic conditions.

There are 14 power circuits leaving the station, and the problem of getting these out of building and to the mill presented some difficulties. As stated above, the station is in a deep ravine 60 ft. below the yard level, and is surrounded by other buildings, conveyors, &c., thus making the entry of the cables a serious matter. The accompanying photographs (Figs. 8 and 9) give some idea of the solution adopted. During construction 18 6 in. wrought-iron conduits were placed in the concrete wall directly behind the switchboard, and these emerged at each power switch. These pipes rise to a height of 60 ft., at which point the cables are fixed to the messengers, and an overhead line is used. The power cables (Fig. 10) used here are probably the largest of the kind in the world employed for overhead work. Each circuit from the switchboard to the mill consists of three cables arranged in clover leaf form, having $\frac{1}{4}$ in. Para rubber between the conductors, which are taped double and backed up with jute for $\frac{3}{4}$ in. all round and between. Over all is a double heavy braid, which is weather-proofed. The smallest of these cables is 500,000 circular mils and the largest are 800,000 and 1,000,000 circular mils. The 1,000,000 circular mils conductors weigh nearly 20 lb. to the foot, so that special construction was necessary to provide adequate support. The cables are carried to the mill on Siemens-Martin double-galvanised $\frac{1}{2}$ in. seven-strand wire, and hung to it by Boston and Marlin cable clips, alternating each 4 ft. of conductor. The whole line is supported every 80 ft. on Georgia pine towers 40 ft. high and 8 ft. square at the top. The towers are also utilised for carrying watch clock, fire alarm, telephone and signal lines, as well as service and water supply pipes to the mill. The ruggedness of the transmission line is fairly shown in the photos (Figs. 11, 12 and 13).

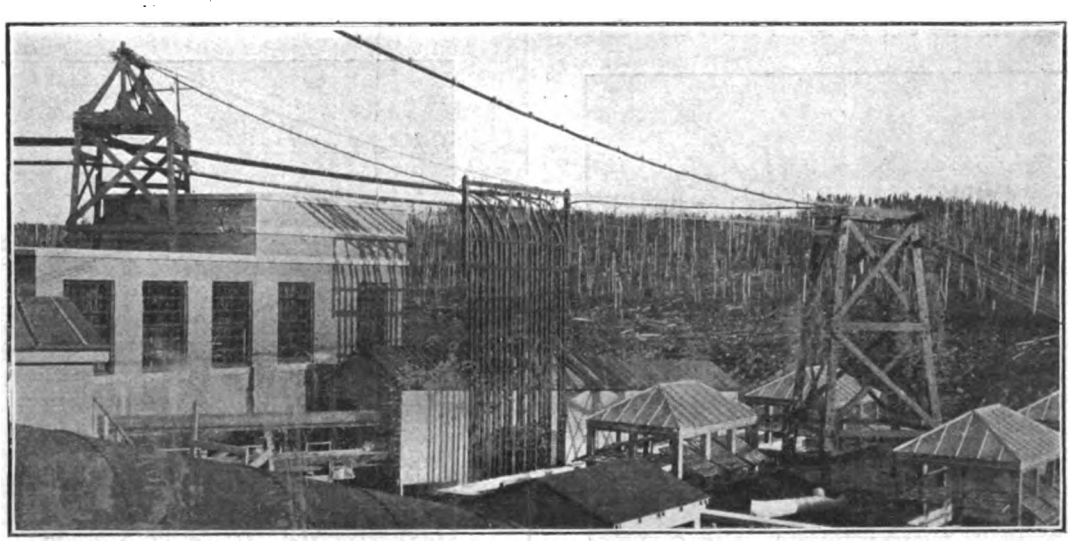

FIG. 12.—EXIT OF CABLES FROM POWER STATION.

All the machinery in the mill is driven electrically. There are at present a number of three-phase induction motors supplied by the Westinghouse Electric & Mfg. Co., with an aggregate output of 7,000 H.P., and varying from $2\frac{1}{2}$ H.P. to 300 H.P. in capacity. The motors have been placed in their positions with great care and attention to the nature of work to be done, with the result that in this mill, after nearly nine months of continuous 168 hours a week operation, with only a few minute occasional shutdowns, not a single fault has developed in any motor, a state of things which speaks very highly for

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the architect who decided on their positions and the manufacturers who supplied them. There are at present 130 motors in the mills. Two types of motors are used, squirrel cage and collector ring, employed according to adaptability and load, and the power factor of station under normal operation averages from 80 to 85 per cent.

The largest motors in the plant are of the 300 H.P. variable-speed type. They are used to drive the paper machines. With these motors a uniform change of speed in paper manufacture is possible in increments of 5 ft. to 6 ft. between limits of 325 ft. and 590 ft. of paper per minute without disturbance of

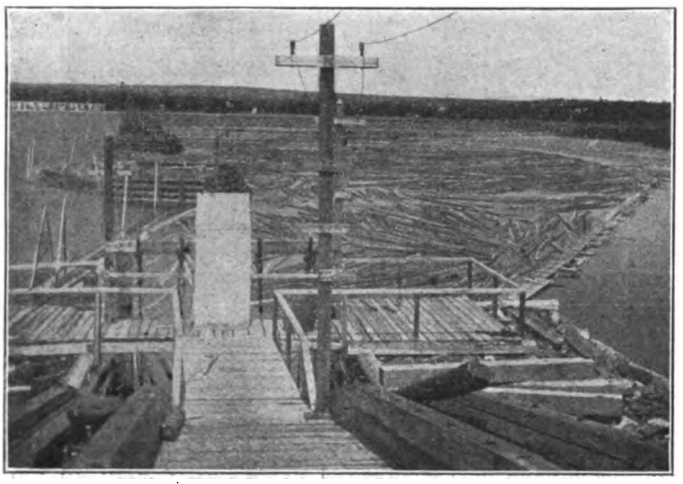

FIG. 13.—VIEW OF MAIN LOG POND.

any kind under continuous operation. There has been much discussion and study on this subject of paper machine drive and its merits and possibilities, but its flexibility and reliability alone are a clinching argument in its favour. The controller for these machines is placed close to the machine tender's hand for operation when necessary. There is no running up and down stairs looking for trouble; no attendance is necessary. There are no steam engine troubles, and no anxiety as to whether the speed is or is not changing, for with the system used the machine tenders can be at all times sure that the

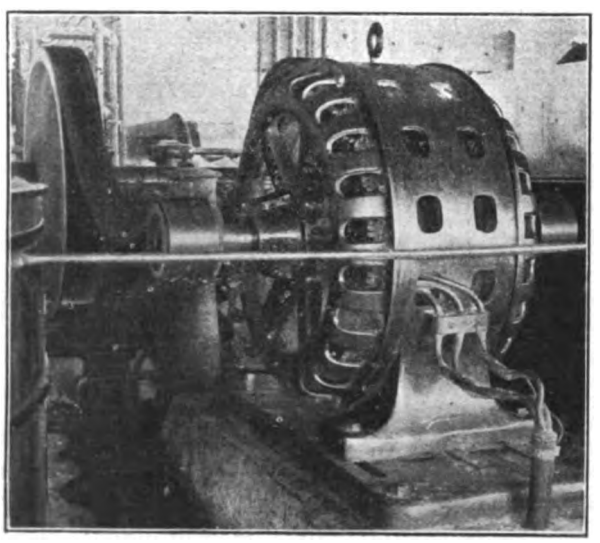

FIG. 14.—100 H.P. MOTOR DRIVING BEATING ENGINE.

driving engine is constant in speed. That machine which is auxiliary to the forming and drying of the paper, such as pumps, winders, &c., is driven by separate constant-speed motors. Figs. 14 to 16 show examples of the motors used.

Fig. 18 shows the wood conveyor working between the pond and wood-preparing room. This conveyor is 1,900 ft. long, and can be stopped or started by workmen at intervals of 40 ft. along its entire length by means of push buttons,

The mill lighting is done locally by incandescent lamps, while the general lighting is effected by Cooper-Hewitt vapour lamps of the alternating-current automatic type. The vapour lamps make an ideal lamp for paper mill-lighting, as their large volume, intense and steady glow provide just the qualities desired. All lamps are placed above the travelling crane, which traverses the entire length of the machine room. The question of colour effect has been of no importance thus far, for in the small amount of coloured paper made it is found that effect upon the same colour is always the same, so that opera-

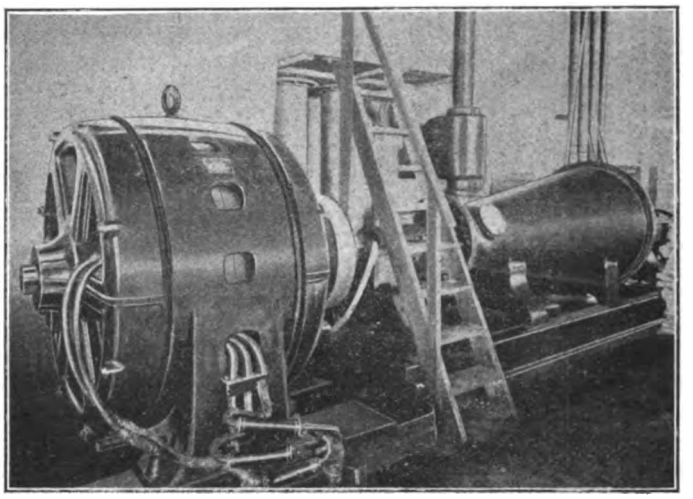

FIG. 15.—100 H.P. MOTOR DRIVING JORDAN ENGINE.

tors soon become entirely accustomed to it, and the materials effect the senses as in daylight.

Distribution is effected on the block system. Each room has a power and lighting centre from which all power cables are taken to the individual motors under the concrete floor; in this way all the walls and ceiling are kept clear of the electric wiring, except where absolutely necessary.

The lighting current is taken from the power 'bus bars in the station. It is transmitted on the three-phase system, and is

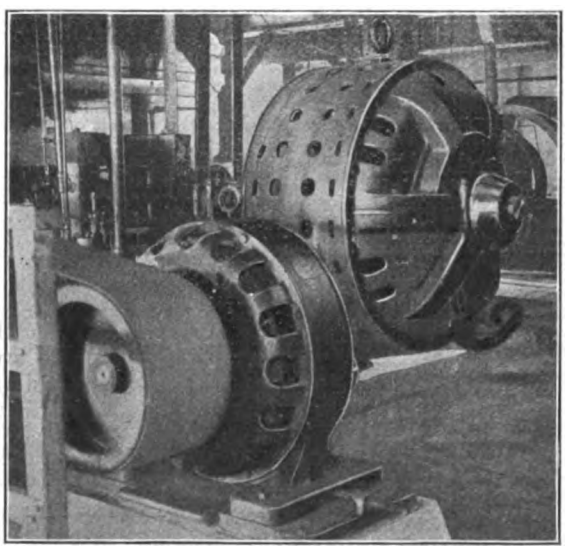

FIG. 16.—30 H.P. MOTOR DRIVING WINDER, AND 300 H.P. DIRECT-CONNECTED VARIABLE SPEED MOTOR DRIVING PAPER MACHINE.

distributed single phase to static transformers placed about the various apartments. A lighting centre is shown in Fig. 17. A lighting voltage of either 220 or 110, as desired, is used. A superstructure placed over the transmission line carries lighting wires to both mill and town. Electric heating is used to a large extent wherever the steam installation is distant or expensive to instal. Automatic signals are a feature in this mill, and play an important part in all departments of manufacture.

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The power and lighting system is an earthed conduit one throughout, while the town lighting and heating system is not an unimportant item in the electric installation at Grand Falls.

In the generating station under the switchboard are three Westinghouse 50 kw. lighting transformers, stepping up the current from 600 to 2,200 volts for the town houses and street lighting. Single-phase distribution is used entirely, and local transformers reduce the pressure to 440, 220 or 110 volts as desired for power or lighting.

There are at present over 300 buildings lighted, which number will soon be increased to 400. All these are lighted entirely by incandescent lamps. Outhouses, barns, &c., are also so lighted, so that there is absolutely no use or need for kerosene oil in any part of the town for lighting or heating. The streets are lighted by 25 series of enclosed arc lamps, with the usual regulator at the station, and were furnished by the Westinghouse Electric & Mfg. Co. Single-phase motors are used throughout the town for portable wood-sawing apparatus, wood-working shops, well pumping, the voltage being 220.

The citizens and workmen of Grand Falls have been wonderfully keen in appreciating the opportunities open to them by the cheap supply of electricity available, and irons, ovens, cookers and other heating apparatus are being ordered, for they are discovering that at the nominal rates charged for heating and cooking utensils, electricity is cheaper than wood

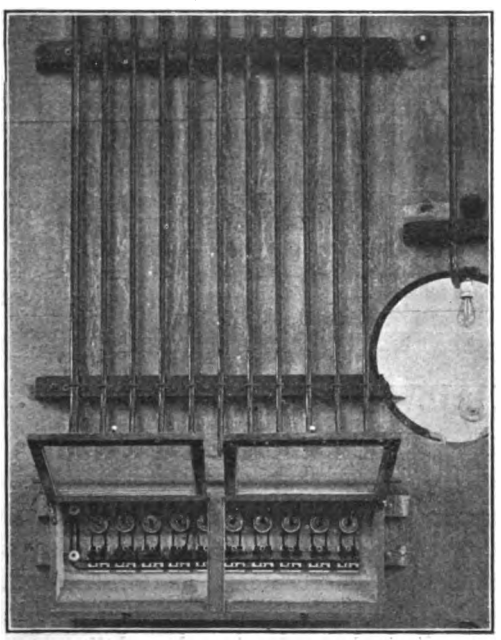

Fig. 17.—Typical Lighting Centre.

and coal during the warm months of the year. It is confidently expected that within two years 50 per cent. of the cooking in the town will be done by electricity.

A regularly appointed crew of firemen are assisted in their duties by an automatic electric fire alarm. At each street junction are placed fully equipped hose houses and hydrants, and at intervals half-way between street junctions are fire ladders, which are hung on racks well protected from the weather. Fire cards are posted in each house giving the position of the alarm stations and how to handle them. In this connection it may be mentioned that the alarm box is handled by the same type of switches as is installed for house lighting, so no possible confusion or mistake is possible in working it, even by the children.

The company have provided communication facilities among its officials, employés and departments by installing a central telephone station in the main office. This system comprises nearly 300 miles of telephone wire, including 12 local lines and three trunk lines. All the wood departments, some of them 150 miles away, are brought into direct communication at any minute, and the same is possible with the town of Botwood, on the sea shore, 25 miles distant. The whole system has been planned and carried out with the idea of permanency, flexibility, resistance to high winds and variable weather, economic upkeep within reasonable limits without stint, and ability to expand if future expansion of the general scheme requires it. Considering the size of the town, its age and population, there is hardly room for doubt that Grand Falls, Newfoundland, as regards the application of electricity to commercial and domestic requirements, holds a very high position among the cities of the world. The inhabitants have made it from choice one of the vital necessities, not only of their daily occupation, while in their own homes it has become essential to their mode of living.

The thoroughness with which the Anglo-Newfoundland Development Co. have dealt with their electrical equipment is only characteristic of its attitude in all other branches and departments of the gigantic enterprise which has transformed a wilderness into a live and a living industry and its attending city. That the end foreseen at its inception has been accomplished is amply shown by the grand success attained since the initial commencement of operations, and which has persisted during all the months that have followed, during which all previous records in starting up and in producing have been broken. Nor is this state of things confined to the mill, for it is significant of the satisfaction and contentment on the part of a people that they evince such a general desire of remaining to settle down in Grand Falls. In fact, the houses are snapped up and furnished as fast as 500 men can build and complete them.

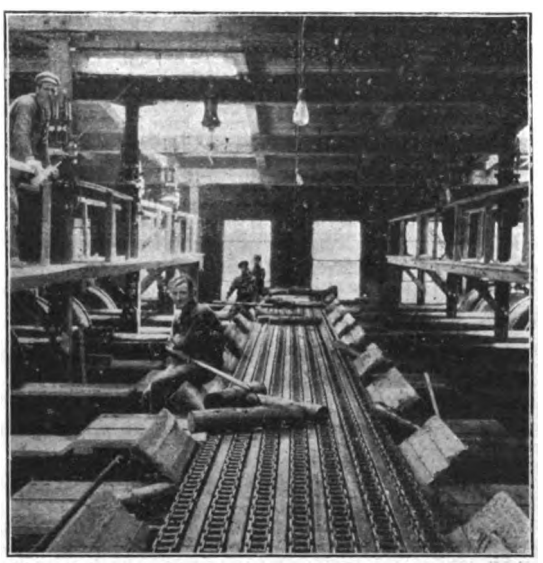

Fig. 18.—Motor-driven Log Conveyor entering Barking and Cleaning House.

The whole plant, consisting of complete turbines and regulators, was delivered in the spring of 1909, commenced working in the autumn of the same year, and has continued without interruption since. According to the results obtained, the guarantees of the wear of the turbines and speed variations under changing loads have been more than reached.

The contract for the turbine machinery was, after competition, awarded to the German firm of Amme, Giescke & Konegen Co., of Brunswick.

To the enterprise and farsightedness of Lord Northcliffe, whose place in the newspaper world of his time is unique, is due the inception and completion of an industrial departure of the first magnitude, and one which may have a great influence on the art and craft of paper making in the coming time.

In concluding this description of the new paper mill in Newfoundland we have to thank the proprietors of this interesting plant for providing us with the details and illustrations given above. It is manifest that great credit is due to Mr. Mayson M. Beeton and to Mr. G. F. Hardy, who prepared the plans and under whose direction the works were constructed and equipped. We are also indebted to Mr. T. F. Judge, who supplied us with details of the switchboard, transmission lines and power work generally.

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RAILWAY ELECTRIFICATION.

What is sometimes referred to as "the battle of the gauges" is well known to those who followed the development of the steam railway. At first each railway considered its own interest rather than the interests of railways as a whole; but as networks extended it became clear that interchange of traffic was desirable, and any serious differences in equipment became limited to the broad and narrow gauges, though later on brake equipment introduced difficulties once more. It was a long time, however, before the narrow standard gauge won the day, and it is not so very many years ago that the Great Western Railway presented the curious feature of a line with two gauges. Very possibly, with a desire for more powerful locomotives, some engineers may still wish that the broad gauge were available, though, on the whole, it is probably a good thing that the narrow gauge emerged victorious.

The same sort of difficulty is now becoming evident in the electrical equipment of railways. Electrical working is becoming more extended. Conversion to this form of locomotion is not taking place as quickly as one might desire, but, nevertheless, substantial progress is being made. So long as suburban traffic alone is in question, the point is not very urgent, but with the electrification of portions of main lines the interchange of traffic will become a more important matter. From this point of view a plea was put forward by Mr. GEORGE WESTINGHOUSE last week in a Paper read

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at the joint meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. Mr. WESTINGHOUSE urged that a choice should be made once for all between the continuous-current, single-phase and three-phase systems.

We quite admit that it would be an advantage to have one system, and one only, as Mr. WESTINGHOUSE points out. In that case the attention of engineers would be concentrated upon the perfection of a single system, doubtless with correspondingly satisfactory results. Also railway directors would feel that electrical engineers were working with a united front, and they would no longer be confused by a choice of systems. The fact that the benefits of electric traction can be obtained by at least three different systems, and that electrical engineers differ materially in the opinions they express, has, no doubt, had a retarding effect.

We fear, however, that the advice of Mr. WESTINGHOUSE is a counsel of perfection, and is almost impracticable. The choice is no simple one. It is not merely a question of deciding a single point of difference, such as the broad and narrow gauges, but a choice between systems whose respective virtues depend upon the conditions to be met. Moreover, would there not be some risk in making a final choice at this comparatively early period in the existence of railway electrification? Suppose, for example, that such a proposition had been made some years ago, the choice would then have been between continuous current and three-phase. Since that time, however, and it is less than 10 years ago—the position of affairs has quite altered. The single-phase system has sprung into existence, and has shown itself capable in a very short time of proving a serious rival to the older systems. It does not follow, of course, that within the next 10 years any similar advance will be made, but it appears to us that it would be extremely dangerous to exclude the possibility of advance along any direction at this early date.

Further, if the railways all belonged to the State it would be a simple matter to consider them as a whole, and possibly to choose that system which appeared best to meet the requirements of the railways generally. At present we are not in this position. Thus, as pointed out by Mr. J. G. WILSON in the discussion, we have the requirements of the Great Eastern Railway and of the Great Northern Railway, although near neighbours in London, very materially different. The Great Eastern Railway has a very heavy suburban traffic, whereas the Great Northern Railway is much more limited to main line working. It cannot be expected, therefore, that one railway would sacrifice economical working for the sake of another.

Apart from this large question, there was discussed at the meeting to which we have just referred the relative merits of continuous-current and single-phase systems for railway working. Such a programme is almost a *sine qui non* at the present time where electric railway problems are discussed broadly. As time goes on, however, it becomes increasingly evident that such discussions are futile. Generally, figures and hypotheses on which to base an argument for one system or another are of very little use, for, as pointed out very clearly by Mr. C. F. SCOTT, comparatively small differences in the assumptions made are liable to make considerable differences in the conclusions reached. As a matter of fact, all that we can say is that actual results of working are the only results that are of any value. We do not suggest that either system is capable of universal application to the exclusion of the other, but nevertheless, if it be found that the Midland Railway and the London, Brighton & South Coast Railway obtain satisfactory results from single-phase working, by which we mean satisfactory results commercially as well as electrically, then the single-phase system cannot be considered out of court, even for suburban traffic. In terms of the historic phrase, it is better to "wait and see," for the results of actual working are those on which the systems must finally rise or fall.

OBITUARY.

GEORGE FLETT.

As briefly recorded in our last week's issue, the death of Mr. George Flett took place on Wednesday, July 27th, at Birmingham, as the result of a motor car accident.

George Flett was born in January, 1855, at Wick, and had thus only reached the comparatively young age of 55 when he met with his untimely accident. He received his early education in Glasgow—a town which has played a great part in the supply of engineers—and as long as 28 years ago became associated with Messrs. Dick, Kerr & Co. As is of course well-known to our readers, there is perhaps no British firm which has played so large a part in electric tramway development in this country as have Messrs. Dick, Kerr; and with this pioneer work Mr. Flett was intimately connected. He saw the gradual extinction of the horse tramways, the partial adoption of cable traction, and the general use of electric traction. In our Editorial Notes a week or two ago we drew attention to the enterprise of the London County Council in spreading a network of electrically worked tramway routes over north and south London, but it must not be forgotten that the realisation of this excellent idea would not have been possible without the engineering and contracting experience of certain firms, of which Mr. Flett was not an unworthy representative.

While Mr. Flett's early experience was chiefly gained in contracting, for the last 12 or 13 years he had been closely associated with the manufacturing side of electrical engineering. In this work he had played a not unimportant part in some very notable developments. Among these may be mentioned the electrification of the Liverpool and Southport section of the Lancashire & Yorkshire Railway, while contracts for electric tramways at home and abroad were constantly engaging his attention. In connection with the Liverpool and Southport electrification it may be mentioned that this was again pioneer work, and that, as shown in the Papers read the other day before the Institution of Mechanical Engineers, the results there obtained have not been without their effect on the future development of electric traction.

Having made during his career prolonged journeys abroad, it was natural that he should have become associated with electrical schemes in other countries than his own. At different periods, in fact, he succeeded in carrying through important electrical contracts in Japan and the Far East. In addition to being managing director of Messrs. Dick, Kerr & Co., Mr. Flett was also a director of the Metropolitan Amalgamated Railway Carriage & Wagon Co., the Patent Shaft & Axletree Co., the Projectile Co., the British Aluminium Co., the Rio de Janeiro Tramway, Light & Power Co., the Mexican Light & Power Co., Monterey Railway, Light & Power Co., and the British Engineering Co. of Egypt.

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LEEDS CORPORATION ELECTRICITY SUPPLY ACCOUNTS.

Although the records of the Leeds Corporation electricity department for the past year show that electricity is being employed to an increasing extent both for lighting and power, the revenue obtained is much less than that recorded a year ago, notwithstanding that a greater number of units have been sold. This is accounted for by the reduction in consumers' accounts owing to the replacement of carbon lamps by metal filament lamps, and by the fact that a greater proportion of the units sold has been for power and heating.

The unusual conditions prevailing during the year may be gathered from the fact that, in spite of an increase of 394 in the number of lighting consumers, bringing the total number of such consumers to 6,026, the sales of energy for private lighting decreased from 5,241,523 units in the year ended March 31, 1909, to 4,575,975 for the 12 months terminated on March 31 last, *i.e.*, a decrease of no less than 12·7 per cent. The consumption of energy for public lighting has also been reduced owing to the adoption of more economical lamps, notwithstanding a slightly extended use of electric lighting.

On the other hand, it is very gratifying to record a substantial increase in the sales of energy for power and heating. This increase is not proportional to the growth in the aggregate horse-power of the motors connected to the mains, probably largely due to the continued depression in the trades in which electric power is most largely used. It is worth noting, however, that the total horse-power of motors connected during the 12 months is greater than in any previous year, so that under normal conditions a great expansion of supply will be expected. On March 31 last 2,088 motors were in use, of a total capacity of 12,836 H.P., an increase of 378 motors and 2,894 H.P. in the year. The number of consumers for power and heating was on the same date 1,127, so that, including the 6,026 lighting connections, there are 7,153 consumers connected to the supply mains.

In the following table, the consumption of energy is allocated to the different classes of supply.

—	No. of units, 1910.	No. of units, 1909.	Revenue, 1910.	Revenue, 1909.
Private lighting	4,575,957	5,241,523	£64,518	£73,087
Street lighting	937,193	988,785	4,881	5,150
Power and heating	6,908,014	6,164,810	29,669	25,911
Total	12,421,164	12,395,118	£99,081*	£104,148

A consideration of the revenue, &c., obtained per lamp and horse-power installed will prove instructive at this juncture. The figures for the last two years are as follows :—

—	Year ended March 31, 1910.	Year ended March 31, 1909.
Lighting.		
Units sold per 35 watt lamp installed	17·73	19·69
Average net price per unit	3·02d.	3·01d.
Revenue per lamp installed	4s. 5·58d.	4s. 11·34d.
Power and heating.		
Units sold per H.P. installed.....	595	686
Average net price per unit.....	1·03d.	1·01d.
Revenue per H.P. installed.....	£2. 11s. 1d.	£2. 17s. 8d.
Total sales.		
Units sold per 35 watt lamp (or equivalent) installed	20·66	22·91
Average net price per unit	1·91d.	2·02d.
Revenue per 35 watt lamp (or equivalent) installed	3s. 3·55d.	3s. 10·20d.

It will be noticed that there is a considerable reduction in the number of units used per horse-power of motors installed. This figure, of course, is to some extent an index of the state of the industries concerned during the periods in question, and there is little doubt that the revival of trade will result in the power supply side of the undertaking largely overshadowing the sales for lighting.

* Includes £13 for sundries.

The maximum load upon the plant during the past winter was 8,900 kw., compared with 8,220 kw. in the previous year, and the load factor works out at 15·9 per cent., the capacity of the generating plant remaining unchanged at 15,740 kw.

Turning now to the cost of generation, it is noteworthy that every group of items, with the exception of rates and taxes, shows a decrease compared with the previous year's figures, the aggregate reduction amounting to no less than £5,763, or more than sufficient to counteract the decrease in revenue.

The undertaking has benefited by a reduction in the price of coal, and in the amount used per unit. The cost of repairs and maintenance has been greatly diminished without any falling off in the attention devoted to the upkeep of the plant; whilst the necessity for extraordinary replacement of plant has for the present practically disappeared, in accordance with expectations previously held out. There has also been a saving in interest, due to the repayment by the Finance Committee of loans at a high rate.

The net result is an increase in the profit for the year, this being £8,930, compared with £8,248 for the year 1908-9. This surplus is the largest recorded in the history of the undertaking, and has been utilised in relief of the consolidated rate, bringing the total sum contributed for this purpose by the undertaking to £54,797.

We give below an analysis of the expenditure during the year ended March 31 last, together with the cost per unit sold, the latter figure being also tabulated for the previous year for the sake of comparison.

		Cost per unit sold. 1909-10.	1908-9.
Generating Costs.			
Fuel	£8,936	0·17d.	0·21d.
Oil, waste, stores, &c.	371	0·01d.	0·02d.
Salaries and wages at station ...	3,874	0·08d.	0·08d.
Repairs and maintenance	1,786	0·03d.	0·05d.
Total Generating Costs	£14,967	0·29d.	0·36d.
Distribution Costs.			
Wages	£2,189	0·04d	0·04d
Repairs and maintenance of mains, fuses, &c.	1,567	0·03d	0·05d.
Stores and miscellaneous.....	400	0·01d.	0·01d.
Total Distribution Costs	£4,156	0·08d.	0·10d.
Management Costs, &c.			
Salaries	£5,223	0·10d.	0·11d.
Printing, stationery, &c.	226	0·00d.	0·00d.
Insurance	369	0·01d.	0·02d.
Miscellaneous	1,156	0·02d.	
Extraordinary renewals	49	0·00d.	0·04d.
Total Management Costs, &c.	£7,023	0·13d.	0·17d.
Rates and taxes	£4,469	0·09d.	0·08d.
TOTAL COSTS (*ex.* capital charges)	**£30,615**	**0·59d.**	**0·71d.**
Capital Charges.			
Interest	£28,031	0·54d.	0·55d.
Sinking fund	31,206	0·60d.	0·59d.
Wages of permanent men not chargeable to loans	299	0·01d.	0·01d.
Total Capital Charges	£59,536	1·15d.	1·15d.
TOTAL COSTS (including capital charges)	**£90,151**	**1·74d.**	**1·86d.**
TOTAL RECEIPTS from all sources	**£99,081**	**1·91d.**	**2·02d.**
Surplus	£8,930	0·17d.	0·16d.

As mentioned above, the whole of this surplus has been handed over to the relief of the rates.

The total capital expenditure on March 31 last was £985,948, or £62. 12s. 10d. per kilowatt of plant installed, and this is apportioned between the various portions of the undertaking as follows :—

		Per cent. of total.
Generating station	£409,391	41·5
Mains, transformers, meters, &c.	526,939	53·5
Cost of provisional order, discount on issue of stock, &c.	49,618	5·0
	£985,948	100·0

The total amount set aside for repayment of debt is £231,707, whilst the reserve fund amounts to £3,150, and a sum of £1,826 has been contributed to capital account from revenue, so that the net amount of debt outstanding is £749,265.

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DR. SCHÖNHERR'S PROCESS FOR PRODUCING ATMOSPHERIC NITRATES.

Dr. Schönherr's method for forming nitrogenous products by the electric arc is to be used shortly on a large scale in Norway, and the furnaces which are being erected there will use part of the energy supplied by the large hydraulic plant of Rjukan. In view of the approaching industrial application of the process on a large scale, we give the following brief description of it, from data which have been furnished us by the Badische Anilin & Soda-Fabrik. This firm first operated the process in Germany, and will carry on the work in Norway.

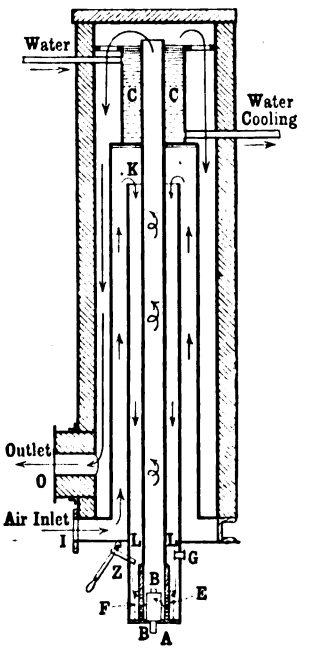
In the course of his researches on obtaining nitrates from the air, Dr. Schönherr found a simpler device than the electromagnetic arc with which we are familiar. It was thought that the arc should burn either intermittently or at least with very rapid vibrations in the air under treatment, such as is the case in the Birkeland-Eyde process. The inventor found that this is not essential, and he therefore uses a steady arc fed by a heavy current, burning very quietly. To carry out this method the arc is made to burn under special conditions. Dr. Schönherr finds that it is impossible to send large quantities of air through a voltaic arc, as is described in many patents, and only a small part of the air actually comes in contact with the arc, so that the resulting gas is very poor. Good results can be obtained by sending air along an arc, but even slow currents of air, and much more so the rapid rush of air which is needed, extinguish the arc, especially an alternating arc, which is the only one to be considered. The inventor succeeds, however, in overcoming all the difficulties inherent in the alternating arc. His principle is that when we send air along an arc not in a straight line, but in a helical or screw-thread path around the arc, the arc then burns steadily. We can thus place the arc inside a rather small metal tube, and it has no tendency to touch the sides. Using only an ordinary straight movement of the air along the arc, the latter would tend to touch the inside of the tube prematurely, so that a metal tube could hardly be used for enclosure purposes, while non-conducting tubes have certain disadvantages. For these reasons industrial practice shows that we must use exclusively arcs burning in the centre of a whirling current of air. The apparatus is simple. We place an electrode at the bottom of a tube from which it is insulated, and pass air with a whirling movement up through the tube, then causing the arc to strike in any convenient way between the electrode and the bottom of the tube. When an arc has been formed, the air current drives it up the tube, and it finally plays between the bottom electrode and the top of the tube, being thus a very long arc. It ends at a considerable distance from the insulated electrode, namely, at the spot where the gases become so highly heated by the arc that they have sufficient conductivity to allow the current to pass.

The construction of the furnace is shown in the diagram. At the bottom is the electrode A, which is insulated from the rest of the furnace. A heavy copper cylinder, water cooled, is employed, having an opening along the axis through which an iron rod, B, passes and projects. The rod forms the electrode proper, from which the arc springs, and it is the only part which is consumed, though the amount used up is small. The heat of the arc causes the end of the rod to become covered with a layer of melted magnetic oxide of iron, which is slowly volatilised. The rod at times is pushed up to allow for the wear, but it should be noted that the wear of the iron rods is too small to figure commercially in the process. The arc is started in the first place by an igniting rod, Z, a heavy iron rod leading from the mass of the tube, which serves temporarily as one electrode. Other methods, such as a fine wire, flame, &c., can also be used to start the arc.

The helical or whirling movement of the air is then produced in the inside of the apparatus, as will be further mentioned, and the arc is now formed throughout the whole length of the inner tube, having a length of 5 metres in the Kristianssand furnaces. The tube surrounding the arc is a simple iron tube, and the arc travels up to the top along this tube in the first place, but afterwards does not touch it, so that the tube is not eaten away.

At the top of the furnace is a special water cooling device, C, and by regulating the air supply we can make the arc rise up to this part. The helical movement of the air is given in a simple way by using a tangential inlet at the base. One such opening would give a screw-thread movement of the air around the arc from bottom to top, but using eight openings, E, greater steadiness is given to the current, and the arc is not deviated, but burns in a perfectly straight line. Over the air holes is placed a register ring, F, for regulating the air inlet. Two eye-holes, G, at the top of the furnace allow the upper part of the arc to be inspected. After having passed through the cooled upper end of the tube, the hot gases descend by the annular space between the metal part and the outer fire-brick portion of the furnace, and proceed thence through the outlet, O, to a common pipe, and thus reach the steam boiler, where their heat is utilised. While descending through the furnace the gases transmit a part of their heat to the inner tube, which they surround and through which the fresh air is brought in.

On the other hand, the air which enters the furnace at I goes first to the top, and takes up a part of the heat of the outgoing gases, as we have seen, then it changes its path under the



refrigerating part at K, and descends outside the tube containing the arc, thus continuing the heating. When it reaches the bottom, L, and is ready to enter the arc tube by the tangential openings, the air is now highly heated, as is required in this process.

After the first experiments at Ludwigshafen with a single 300 kw. furnace had been made, the next step was to build a larger plant at Kristianssand, Norway, so as to bring the process more nearly under commercial conditions. The plant worked very well from the start. It uses three-phase current coming over a 25,000 volt power line from a plant in the Saeters valley 18 miles distant. This is reduced to 7,200 volts for use in the furnaces. About 1,300 kw. is used for the purpose, employing three furnaces of 600 H.P. each. The company have also worked a 1,000 H.P. type of furnace with success, and expect to use it in future work. Even furnaces up to 2,000 H.P. can probably be built.

It is of interest to note that there is a consolidation of the various firms engaged in nitrogenous product manufacture. In fact, the Badische Anilin & Soda-Fabrik and several of its allied companies in Germany have made an association with the Norwegian Hydraulic & Nitrogenous Product Co., which owns the well-known Notodden works, as well as the Birkeland-Eyde patents. The united companies are to act in common for

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developing the industry in Norway, and will use various sources of hydraulic power. At the present time a large plant is being built at Notodden in order to test large Schönherr furnaces, such as it is proposed to use as soon as the new Rjukan plant is finished. Should the tests prove successful, this type will, no doubt, be adopted finally for Rjukan, and it is here that the Birkeland-Eyde and the Schönherr processes will be used for the first time in common.

Concerning the Rjukan plant, this great enterprise is to furnish no less than 250,000 H.P. The work is now being carried on very rapidly. The formerly desert region of the Maana river is to be transformed into an industrial valley of the first order, which will utilise the admirable cascade of the Rjukanfos. No less than 3000 workmen are engaged in the hydraulic construction. The head of water will be used in two stages of 280 metres each, and two turbine plants will be erected at Saaheim, the first of which is to begin operations about the middle of 1911. It will contain 10 turbine-alternator sets, each with an aggregate output of 17,000 H.P., which will be used in the large nitrogenous product works near by. A railroad line, 30 miles long, recently built, and also a barge service on lake Tyn, whose length is 24 miles, will bring the products to Notodden (nitrate of lime, nitric acid, &c.), and thence they will be conveyed to Skien by river. Large depôts will be erected at Skien, and from here the transport to the Continent is by sea. After 1911 the company expects to turn out more than 100,000 tons of nitrogenous products annually. The united production of Notodden and Saaheim will thus be 130,000 tons in 1911, comprising nitrates and nitric acid. Besides this, the Badische Anilin & Soda-Fabrik has secured the falls of Matre and Tyn in the western part of Norway, and these will also serve to supply electric furnace plants, so that when these various projects are put in execution there will be more than 400,000 H.P used in Norway for the manufacture of nitrogenous products.

SAFE METHODS OF WORKING ON HIGH-PRESSURE WIRES.

[COMMUNICATED.]

A comparison of the methods of installation, maintenance and working upon what the Yankees call "hot" circuits is very often an interesting and instructive process, when these methods are English and American.

English superintendents do not like, nor are they allowed in many instances, to trust their men to work on "live" circuits when these circuits carry currents of a dangerous pressure. But it must be admitted a company is frequently very much handicapped when it has to shut down a particularly heavy circuit, thereby depriving a great many customers of service, when some trivial repair or connection has to be made.

A great deal of criticism has been called forth on American methods on account of the great number of deaths and serious burning among linemen and central station men, due to the way in which work has been done on such circuits, and the insecure protection these men have against accidents, for it is a common thing in that country to work on almost any sort of circuit. The linemen, naturally a rugged, rough hardened set, accustomed to take life lightly, are mostly not of a very high grade of intelligence, and therefore do not fear to do their work, not perhaps because of ignorance, but because of their familiarity with danger. But there are times when even the best of them will be caught.

Beyond the regulation rubber gloves and shoes nothing was done until the introduction of the Linemen Protector Shield. This device is shown in the accompanying illustrations (Figs. 1, 2 and 3). As will be observed, the apparatus is simply an easily applied extra insulation in the form of a rubber trough, called by the manufacturers the "Shield," which covers not only the "live" wires, but also the "tie" wires, and taps, if there are any. In the use of the shield each wire which a man may touch must be covered with a shield, excepting only the wire on which he is working.

In placing the shield over an insulator the lineman grips it by rubber handles attached to the outside of each one for this purpose, so that the shield is between his hands and the wire. He then slips a hard rubber split ring (having an opening of one-half inch or so to admit the wire) over each end of the shield. These rings clamp the shield firmly to the wire and preclude any possibility of its becoming dislodged and falling, to the danger of passers by.

This device is recommended by the manufacturers for use on all "live" or "hot" circuits at pressures not exceeding 7,500 volts. It is in use, however, on circuits of as high as 10,000 volts pressure. Before leaving the factory each shield is tested in water up to 30,000 volts. With pressures above 7,500 volts the maker thinks there might be danger to the man—no danger perhaps on a dry day, but on a damp day the static charge might spread along the surface of the shield and give the lineman a sufficient shock to throw him off his balance and cause him to come into contact with a highly charged wire, or perhaps fall to the street. The shield is made of pure para rubber, such as is used in the best quality of insulated wires.

At the time each of the accompanying photographs were taken the full power at 4,600 volts three-phase was on three of the wires covered by shields. The current was not shut off during any part of the time that the work was being carried out.

This device has been adopted by more than 200 electric light and power companies throughout New York and some other States. One company which has used these shields for the past two years reports finding them a time saver as well as a great protection to the

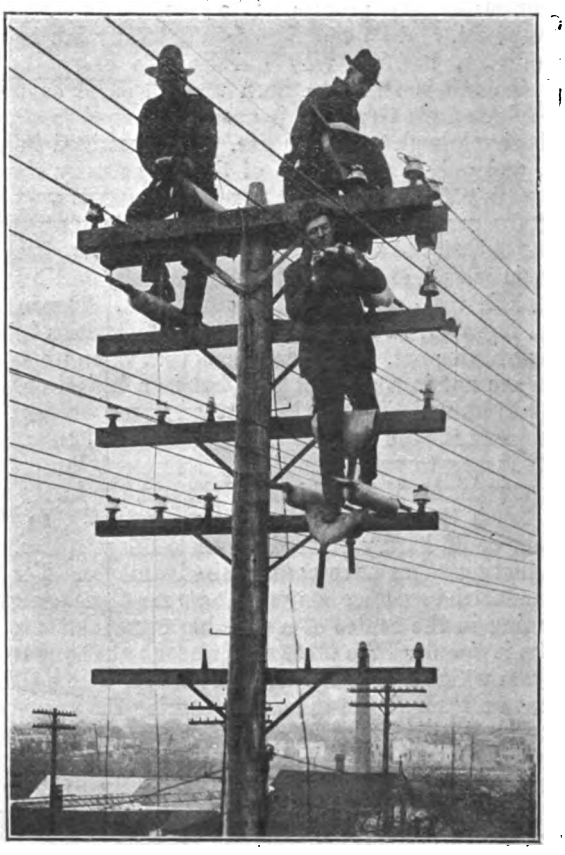

FIG. 1.—WORKING ON H.T. LINES, PROTECTORS IN USE.

men. Last April one of their foremen stated that they worked on 4,600 volt three-phase circuits under all weather conditions, and had not found it necessary to cut out any circuits in order to make taps, or do repairs to them, or shut down to move any transformers, during the 18 months which the shields had been in use. Prior to their use two men were killed within a year through short circuits while working on the high tension wires. Since adopting them they have not had an accident or a man burned while using them.

The device minimises the possibility of unintentional contact with other wires on the same pole, but, of course, does not do away with the risk entirely. The wire on which a man is working should still be handled with caution, and as an additional precaution it is wise to use rubber gloves in connection with the shield.

In the use of these safety devices there is the danger that the men will rely too much on them, and subject themselves to unnecessary exposure to "live" wires carrying an exceedingly heavy voltage. Having confidence in these devices, the linemen are tempted to do work on "live" wires which might, with a little planning, be performed when the wires are "dead"—in other words, the men may become over confident.

The manufacturers recommend three or four shields per wagon for use on single-phase circuits up to 2,300 volts, and six per wagon on all other circuits. It is a good plan to carry them in a

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box in the wagon when not in use, so as to afford protection from wet, grease, or mechanical injury as far as possible. The shields cost £5 apiece, and are made by the Lineman Protector Co., of Detroit, Michigan. The Fidelity and Casualty Co., of New York,

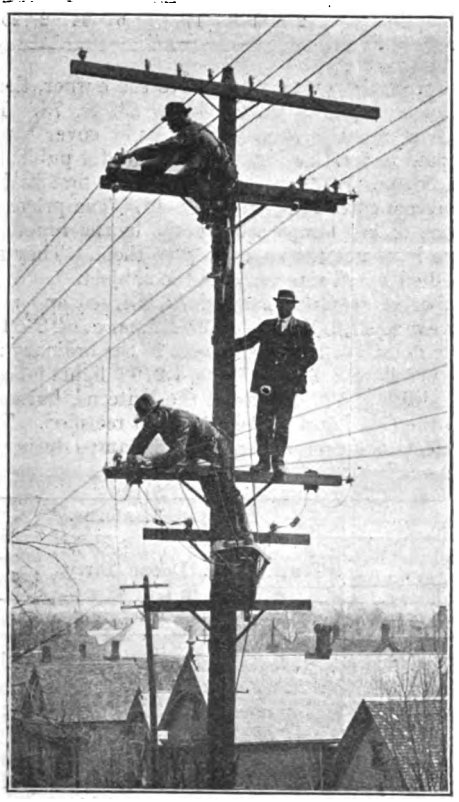

FIG. 2.—"SHIELDS" IN USE ON OVERHEAD LINES.

make it a rule to abstain from giving their endorsement to appliances of any kind. They depart from this rule in this case, because it is likely that the use of the given appliances would save lives. The greatest recommendation the American superintendents give it is

FIG. 3.—"SHIELDS" IN USE ON AN ARC LAMP CIRCUIT.

that it not only gives perfect safety to his men, but it enables them to perform their work better and faster, and at the same time effects important economies in time and money to the company.

We understand that the device will be placed on the English market shortly.

ANNUAL REPORT OF THE ENGINEER OF THE CITY OF LONDON.

In the annual report of Mr. Frank Sumner, engineer of the City of London, to the Improvements and Finance Committee of the Corporation, will be found many facts and figures relating to the "square mile" which should be of interest to our readers.

There is, first, the subject of public lighting, round which much controversy has raged, and a large amount of information is given about both the experimental and non-experimental types—both electric and gas. This part of the report reads:—

PUBLIC LIGHTING.

Electric Lighting.—The lighting of most of the main thoroughfares by arc lamps was continued throughout the year. The number of the original type "open" electric lamps in lighting at the end of the year, at a cost of £26 each, was 366, being a decrease of 32, accounted for by the substitution of the new and cheaper flame arcs in some of the thoroughfares. In addition to this number, there were 63 "Oliver" flame arcs (partly experimental), and 18 "Reason" enclosed arcs (experimental) in lighting during the year. These lamps were lighted on 18 days during the year when fog or unusual darkness occurred, at a total additional cost of £198. 0s. 5d. The number of defective electric lamps reported during the year was 52; deductions were made from the accounts of the City of London Electric Lighting Co. for such failures, which amounted during the year to £12. 9s. 2d.

New Flame Arcs.—A new rest being constructed in the carriageway of Gracechurch-street, opposite No. 40, the column lamp on the footpath at that spot was removed thereon, and an "Oliver" flame arc lamp, costing £17. 10s. per annum, was substituted for the "open" type of lamp, costing £26 per annum. The City of London Electric Lighting Co., on their own initiative, substituted an "Oliver" flame arc lamp for an "open" type of lantern on the rest at the southern end of New Bridge-street, by William-street, and 22 "Oliver" flame arc lamps were also substituted for open arc lamps in Old Bailey, Ludgate-circus, Ludgate-hill and St. Paul's Churchyard by the Company, at a decreased cost of £8. 10s. per lamp to the Corporation per annum.

The following table gives the number of arc lamps in lighting on December 31st, with the annual cost of the same:—

No. of lamps.	Description.	Price per annum per lamp.	Company.
366	Original type "open" lamps...	£26 0 0	City of London Electric Lighting Co.
53	"Oliver" flame arcs (partly experimental)	17 10 0	Ditto.
18	"Reason" enclosed arcs (experimental), Farringdon-st.	12 10 0	Ditto.
10	"Oliver" flame arcs (experimental), Cannon-street	17 10 0	Charing Cross Co.
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N.B.—The four "flame" arcs at Blackfriars Bridge Approach and the four at the Mansion House area put up by the City of London Company for their own experiment, and charged at £26 each per annum, were reduced in price during the year to £17. 10s. each per annum.

EXPERIMENTAL LIGHTING.

In accordance with the resolution of the Court of Common Council of July 25, 1907, whereby the two electric lighting companies having statutory powers in the City were permitted to experiment with the newest form of electric lamps for street lighting in the thoroughfares of Holborn, Holborn Viaduct, Old Bailey, Farringdon-street and Cannon-street (between St. Paul's Churchyard and Dowgate-hill), the Charing Cross & Strand Electricity Supply Co. have continued the lighting of their portion, viz., Cannon-street, with 11 magazine "flame" arcs, centrally hung, being suspended over the roadway by wires attached to the buildings on either side at a height of 28 ft. above the roadway. One lamp, at the corner of Dowgate-hill, was removed during the year owing to the re-building of the premises there. These lamps are charged at the rate of £17. 10s. per lamp per annum for the experimental period. The Charing Cross & Strand Company make this price conditional upon their having not less than 250 lamps to deal with.

The City of London Electric Lighting Co. have also continued their experiment with 21 "Oliver" flame arcs in substitution of a similar number of the original "open" arcs, adapting the existing columns in Holborn, Holborn Viaduct and part of Old Bailey, 20·5 ft. in height, whilst in Farringdon-street 18 enclosed arcs of the "Reason" type, fitted up on special short columns 14 ft. in height, in lieu of the

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Back Lamps.	Columns.	Brackets.	Lantern.		Ordinary Burners.									High Pressure.						Special.	Total, 1909.	Total, 1908.
			Sq.	Cir.	3	4·25	4·25$^{1/3}$	4·25^{20} (Cubic feet per hour.)	6$\frac{2}{3}$	8·50	12·75	16	21·25	10	20	30	100	25 Inverted. (Cubic feet per hour.)	60			
63	540	2,117	2,624	96	10	1,978	41	484	1	57	5	2	1	45	45	2	1	17	6	24	2,720	2,730

12 "open" arc lamps and columns in that thoroughfare, have been maintained during the year. The installation of these two areas was completed by November 20, 1907. The maintenance cost of the "Oliver" flame arcs in the Holborn area is £17. 10s. each per annum, being equivalent to the charge for similar lamps in Cannon-street, and the cost of the enclosed arcs in Farringdon-street is £12. 10s. each per annum.

Gas Lighting.

The number of gas lamps (including experimental lamps) paid for by the Corporation at the end of the year was 2,720, being a decrease of 10 during the year. The size and character of these lamps are set out in the above table.

High-pressure Inverted Gas Lighting.—On October 15, 1908, the Court of Common Council agreed to the proposal of the Gas Light & Coke Co. to re-light Fleet-street and Chancery-lane experimentally by means of 17 high-pressure inverted gas lamps of the "Keith" type, on brackets fixed to the house fronts, projecting over the footpaths, in lieu of the 36 double-burner (upright) incandescent lamps on the footways, and the two high-pressure lamps on rests at the eastern and western ends of the thoroughfare, and on the convenience opposite Fetter-lane. This change necessitated the laying down of a 6 in. high-pressure main in the centre of the roadway, with branch services to each lamp, the pressure being 54 in. (water gauge), or 4 in. of mercury, which is obtained from the company's "power house" in Essex-street, Strand, the gas consumption per lamp being at the rate of 25 cubic ft. per hour, with an illuminating power of 1,500 candles; the inclusive annual upkeep of the lamps, with gas at 2s. 5d. per 1,000 ft., was £16. 10s. each. This charge was reduced to £16. 0s. 10d. on the reduction in the price of gas in June, and further lowered at Michaelmas quarter to £15. 2s. 6d. per lamp per annum when the price of gas was lowered from 2s. 4d. to 2s. 2d. per 1,000 cubic ft., the gas company providing the necessary compressing plant, mains, services, brackets and lanterns. The lamps, which were put into lighting on December 24, 1908, have been maintained during the year.

Other High-pressure Incandescent Gas Lamps.—There are 102 other high-pressure "Keith" gas lamps in the City thoroughfares, 42 upright single-burner lamps being fixed in the neighbourhood of Billingsgate on brackets. These lamps consume 10 cubic ft. of gas per hour, and give an illuminating value of 300 candles each, at a cost of £6. 13s. 6d. per lamp per annum. They are erected from 60 ft. to 70 ft. apart on the diagonal, at a height of about 12 ft. from the pavement level, and are fixed upon the house fronts, the roadway being about 50 ft. to 60 ft. wide. The lamps burn at 10 in. pressure from a special water-compressing plant placed in the adjacent pipe subway. The Corporation provided the compressing plant, services, lamp brackets and lanterns.

Forty-five upright two-burner lamps are fixed in Queen Victoria-street, each consuming about 20 cubic ft. of gas per hour, and giving a light equal to 600 candles, the cost per lamp being about £12 per annum. The lamps are fixed upon columns on the footpaths, about 100 ft. apart on the diagonal. The burners are 13 ft. 6 in. above the pavement, the street being about 70 ft. wide. The lamps burn at 10 in. pressure from a high-pressure trunk main direct from the gas-works; the Corporation provided the standards and lamps. There are also several other "Keith" high-pressure lamps, fitted with upright two, three, four and six burners, on rests at the junctions of roadways, of 1,000, 1,300, 2,000 and 3,000 candles, making 119 in all.

Low-pressure Inverted Burner Lamps.—During the year a trial has been made of the "Carpenter" South Metropolitan inverted burner lamp in Cheapside and Paternoster-row. Two double-burner lamps were fixed on the rests at the east and western ends of Cheapside, and a single-burner lamp at the corner of Paternoster-row and Warwick-lane, with satisfactory results. The consumption of gas per burner is 4 cubic ft. per hour, and the duty claimed is 120 candles per burner, or an illuminating value of 30 candles per cubic foot of gas.

Low-pressure Gas Lamps.—The number of low-pressure gas lamps at the end of the year was 2,601, principally consuming 4½ cubic ft. of gas per hour each, the illuminating power being 60 to 70 candles. Owing to the narrowness of the streets the lamps are chiefly fixed on brackets about 60 ft. to 70 ft. apart on the diagonal, at a height of about 12 ft. from the pavement level to the burner, the annual cost of each lamp with gas at 2s. 2d. being £3. 5s. 7d. This includes maintenance of mantles, &c., but does not cover capital charges. The prices paid to the Gas Light & Coke Co. for public lighting with gas was 2s. 5d. per 1,000 cubic ft. during the first half of the year. This was subsequently reduced to 2s. 4d. The prices paid for the various types of gas lamps are set out in the report, but, unfortunately, we have not the space to give them. They should, however, be studied by all interested in the subject.

The number of defective gas lights observed and reported upon during the year was 1,841—viz., 1,495 ordinary and 346 high-pressure lamps. The details of lighting defects in the ordinary incandescent lamps were as follows: Feeble lights, 1,276; lights failed, 20; total, 1,296. In addition, 199 defects in the lanterns, burners, &c., were reported to the Gas Light & Coke Co. and rectified. The details of the total defects observed in the ordinary lamps during the year are as follows:—

Defective lights.			Defective Lanterns.						
Feeble lights.	Lights failed.	Bottoms.	Tents.	Sides.	Doors.	Dirty.	Protectors.	Burners	Total.
1,276	20	25	9	30	2	66	55	12	1,495

The public gas lamps were lighted, in accordance with the general instructions in force for many years past, whenever fog or unusual darkness occurred. This happened on 38 days during the year, and entailed an additional cost of £150. 14s. 4d.

This part of the report concludes with the conclusions of the deputation that visited the Continent in the spring of the year to inspect the various systems of lighting. This has already been given in The Electrician.

Clocks.—It appears that of the 96 private clocks fixed above the public ways of the City only 31 are synchronised from Greenwich, though all clocks erected or overhanging the public way since 1903 have been synchronised.

Overhead Wires.—Since 1899, when the Corporation took over the duty of supervision, a total of about 25 miles of derelict wire has been removed. All overhead wires must be identified by a zinc label. One of the results of roof inspection is that large numbers of wires are found to have been erected in the City without any notice at all having been given; and it is only due to very careful supervision that new lines are detected. This will readily be understood when regard is had to the enormous number of overhead wires now fixed in the City, which continue to increase, and during the year the number of private owners of lines was 141, and the number of companies increased to 26. Both have considerably added to their number of spans during the last 12 months, and these now total about 733,956 spans crossing public thoroughfares, as compared with 733,828 last year and 260,000 in 1899. There has been a decrease during the year of about 220 miles of National Telephone Co.'s wires, chiefly in cables which have been taken down from the London Wall exchange, whilst other companies and private owners have added about 16 miles to their lines.

Special attention has been given during the year to the question of lines that contravene bye-law 4, under the Overhead Wires Act, 1891—*e.g.*, where they cross the roof of a building at less than 6 ft. in height. As most of the roofs of the City buildings have a trap-door or fire exit, any wire or cable fixed at a less height than 6 ft. would not only impede the progress of persons endeavouring to escape during fire, but would cause them injury, apart from the liability in the darkness of night to stumble of fall over the low parapets into the street or yards below. Many contraventions of this character have been dealt with, and the lines raised upon notification. The tendency of the National Telephone Co. is to take down their "open wires" and small cables, and substitute for them heavy cables; the larger and more recent contain as many as 400 wires, the number of wires thus increasing in a greater ratio than the spans. In 1909 26 companies and 141 private owners possessed overhead wires.

Notifications were given to the principal owners by the Corporation in 5,765 cases of broken wires and other contraventions of the bye-laws during 1909, as compared with 5,602 the previous year.

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A matter of interest calling for notice is the use of aerial lines erected in the City for the purpose of intercepting wireless telegraphic and telephonic messages. During the month of September the British Radio-Telegraph & Telephone Co., of London Wall Buildings, Finsbury-circus, erected several such lines above the roofs of the before-mentioned building at a considerable height above the pavement. The lines have been put up by the Company for experimental purposes only. Two other companies came into existence during the year—*e.g.*, the Column Printing Co. (in connection with the "Central News" office), for the distribution of news to the Press, operating chiefly in the Fleet-street district among the newspaper offices. This company was formerly served by the National Telephone Co.'s lines; they have now their own plant and overhead system. Also the Intercommunicating Telephone Co., whose object is to connect up private firms by aerial lines.

DISCUSSION ON RAILWAY ELECTRIFICATION.

We give below an account of the discussion which took place on Friday last at the joint meeting of the Institution of Mechanical Engineers and of the American Society of Mechanical Engineers, when several Papers were read on the subject of railway electrification. Abstracts of the Papers read by Mr. G. Westinghouse, Mr. W. B. Potter and Mr. H. M. Hobart are given on pp. 677-689 of the present issue.

Mr. H. F. PARSHALL pointed out that both the New York Central and New Haven Railroads were handling a class of traffic that could not be handled by steam. He did not regard the New Haven Railroad as an electrical system, since the usual safeguards as to reliable operation had been most studiously eliminated and the system as it stood would not be operative in Great Britain. As regards Mr. Westinghouse's letter, the speaker considered it was erroneous to state that transmission was the principal element to be considered in respect to electric traction installations. Owing to the regulations of the Board of Trade in this country, the transmission system as a whole was a great deal more expensive than in the United States and the cost of the transmission system, including energy losses and capital charges, was about 15 per cent. of the total, as against 45 per cent. chargeable to the electromotive outfit, and 35 per cent. of the power station charge. The cost of the transmission system, even under the extravagant conditions obtaining in Great Britain (which did not obtain in America), was but one-third of the cost of the electromotive installation; and in applying the differences commonly recognised and proved, the difference between single-phase and continuous-current motors would more than wipe out the whole 15 per cent. in the transmission system. Further, if the energy were transmitted single phase, the cost of copper in the single-phase system, with the same power factor, would be one-third more for the alternating-current system than for the direct-current system. Allowing for 10 per cent. additional loss for the rotary converter of the direct-current system, for equal current density, the cost of copper with 0·75 power factor would exceed by 60 per cent. that of the direct-current system, and for equal energy loss would be double that of the direct-current system, always on a basis that the alternating-current train outfit was as efficient as the direct-current outfit. The characteristics of the collector system were only determinable from the nature of the service worked. Distance was only a factor in so far as the transmission system was concerned, and the transmission system in the case of a single-phase system was heavily handicapped. Further, owing to the compensating properties of the rotary converter, in a general system it would justify its existence, considering the material economy effected in having unity power factor in the transmission system. He did not attempt to analyse detailed figures, but pointed out that these naturally would be prepared with reference to conditions that could not be taken into consideration in a general discussion of the kind. In conclusion, he stated that the continuous-current system was the only one known in the present state of the art that could compete with steam in the classes of installation to which electricity was generally applicable, that is, to urban, suburban and dense interborough traffic.

Mr. J. DALZIEL (Midland Railway) said that both the English Papers before the meeting asserted that main line electrification was commercially impracticable, and that suburban working might therefore be dealt with quite aside from any main line considerations. While he did not agree with this view, he considered it more reasonable than that advocating separate consideration of every case. That course, to his mind, spelt chaos. He believed that main line electric working in this country was not only commercial but comparatively imminent, and if that was so, it was unquestionable that—other things being equal—to design to fit in with those future conditions was more important than anything else in scheming any electrification, and that therefore the finding of a generally applicable all-round system was the most important traction problem of the day. He took up that position in his joint Paper to the Institution of Civil Engineers last winter, and followed it out to show by the results of tests that the single-phase system was burdened with few if any of the disabilities attributed to it, more particularly in suburban work, and that—other things thus being equal—it emerged as the desired generally applicable system. According to the present Paper, that was also Mr. Westinghouse's opinion, and it also represented, apparently, that of Continental engineers, whose adoption of the single-phase system, particularly in Germany for heavy working, was almost universal. The tendency at the conference of the International Railway Congress within the last few weeks was towards a similar conclusion. Even granting that the single-phase system had disadvantages in suburban work, he did not see how electrification could be regarded as a narrow question of separate sections and districts. Leaving aside detail, into which he had entered elsewhere, the same policy necessarily evolved to meet the continuous growth of traffic that had led to doublings, widenings, and re-gradings pointed directly to electrification, and without information as to the existing railway conditions it was impossible for any correct judgment to be formed as to the actual demand for increased capacity. It was clear that with all the doublings and widenings that had taken place there must be lines which were approaching their maximum capacity; and where expensive methods, such as double heading, banking, and so on, were required, that the necessary increased capacity on those lines could be obtained far more cheaply by electrification than by doubling or re-grading. For example, though he made no allegation as to congestion on the lines in question, and spoke not at all for the Company with which he was connected, the disparity between the relative costs of electrification and of re-grading alone without doubling on the Derby-Manchester and Sheffield-Manchester sections of the Midland main line would clearly be overwhelmingly in favour of the electrical alternative. It was true there were no water powers in this country, but there was coal of cheaper quality than could be burned on a locomotive, and, in fact, electrification schemes on those very lines were in progress in Germany, while the heavy, continuous and mixed traffic, the large amount of shunting and terminal work, and the congestion and heavy grades of many sections and branches were factors favourable to electric methods here more than anywhere. To ignore main line work, then, would be to take a very serious risk of incurring future complications and retarding natural development, and that being so, single-phase in suburban work must have drawbacks very pronounced indeed to justify its being discarded. The English Papers before the meeting were adverse to single-phase, but the allegations made earlier in its history of inferior acceleration and higher power consumption for similar schedules had disappeared. There remained adverse weight and cost comparisons and unreliability. Mr. Potter's reports as to unreliability probably resulted to some extent from the double current working so largely used in America, which, by the complications it introduced, and which they hoped to avoid here, undoubtedly must reduce reliability as well as increase both cost and weight. Single-phase apparatus being new, progress in knowledge and design would assuredly reduce both weight and cost. In respect to reliability, and in particular to Mr. Carter's remarks as to the use of forced draught, he would like here to interject that the Midland's Westinghouse single-phase equipment at Heysham had had only four breakdowns in the 2½ years of its service; and these being caused by failures respectively of a lightning arrester, a badly made high-tension joint, a circuit-breaker trip coil and a motor armature, could hardly be attributed either particularly to the fact of the apparatus being single-phase or in any way to forced draught being used. With regard to efficiency, the lower single-phase efficiency was counterbalanced by the single-phase motor characteristic being better suited to heavy schedule suburban service because of its better sustained acceleration, a feature which might be accentuated by over-voltage tappings, and which increased coasting and decreased brake losses. In fact, cases in which the actual power station output or purchased energy for the railway were so appreciably greater with single-phase as to justify its being passed over if there was any possibility whatever of long distance extensions, were, notwithstanding the greater equipment and train weights, practically non-existent, and in most cases the single-phase should go in on its merits anyhow. Taking one example only, Mr. Aspinall's Liverpool-Southport trains had a consumption of 96 watt-hours per ton-mile. On a similar schedule the Midland Heysham train consumed on test 88 high-tension watt-hours per ton-mile with a very light train. With trains of similar accommodation, the respective power station outputs would be as 1·25 (direct current) to 1 (alternating current), the latter train being 3·8 per cent. the heavier, making no allowance for better working of the longer train. That schedule could be maintained by the alternating-current train continuously. He would like to say that Mr. Carter's direct-current efficiency in Fig. 5 was 93½ per cent. overall, so they must be specially good motors. He could not follow Mr. Carter's anti-forced draught remarks, as forced draught was being increasingly adopted and involved no difficulties not easily got over. Why not take single-phase motors, like other things, as they were? What he had to say on Mr. Hobart's Paper hinged largely on Table I. In the first place the Heysham trains were not primarily designed for the service analysed by Mr. Hobart. They took occasional loadings much in excess of those given, the Midland working time-table permissible loads being 400 tons between Heysham and Morecambe, and from Morecambe to Lancaster, and 185 tons Lancaster to Morecambe. On busy days in summer the cars took four coach trains for many hours together as rapidly as those trains could be got in and out of the stations, and that service was principally between Lancaster and Morecambe, which was a shorter distance and a higher speed schedule, being less restricted by curve restrictions than that in Table I. What those coaches were fully capable of doing might be typified by the 30 miles per hour 1·32 mile service with 88 watt-hours per ton-mile consumption already mentioned. Using with those the revised Siemens equipment weight he had made up another analysis of the Heysham train bringing out the correct horse-power per ton of electrical equipment at 8·83. Those figures were

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available to Mr. Hobart, and could have been used. A fair comparison on actual weight of the schedule he had used should have been based on the Westinghouse car, the equipment of which gave an output figure of 7·2 H.P. per ton. That, however, by no means ended his criticism. As Table I. was a comparison really of continuous output capacity and still remained one in which a forced draught motor made a worse showing than the naturally ventilated one, it was evident there was something still wrong. As a matter of fact, there must be a mistake in the ton-mile consumption given for the Piccadilly train. By a set of simple calculations which he, the speaker, had put in, and which were open to Mr. Hobart's criticism, it was easy to show that on that input the mean current input per motor was of the order of 95 amperes, so that the root-mean-square current per motor could not be less than 150 to 200 amperes, or the unheard of figure for a naturally ventilated motor of half to two-thirds of the one-hour rating. The Piccadilly consumption and that given for that schedule by Mr. Hobart in his Table VII. were entirely in disagreement with the consumption figures for that and like schedules in his own book, "Electric Railway Engineering." On pages 77 to 80, diagrams 90 and 94 to 96 of that book, practically that very schedule was given as requiring only a consumption of 56 watt-hours per ton-mile with 32 seconds coasting, up to 72·8 watt-hours with no coasting at all, that was the absolute maximum, the consumption being reduced on the track graded for acceleration and retardation to 30·7 watt-hours. The Piccadilly line was described in the tramway and railway world as graded, but the question of grading was extensive. He found by observation that coasting between the shorter distance stations averaged about 38 seconds, which would therefore make the working of the line correspond, even if level, to certainly no more than the above-mentioned 56 watt-hours per ton-mile. Giving Mr. Hobart for tunnel train resistance, which, according to his footnote on page 26 of his Paper, should not have much effect, an increased allowance up to 63 watt-hours per ton-mile, and revising his figures accordingly, his specified figure for output per ton of the Piccadilly equipment became 7·4 against the specific output of the Heysham train, already mentioned, of 8·8. Such a result was only to be expected in consideration of forced draught being in use on the latter. That corresponded to a root-mean-square current on the Piccadilly train of about 90 to 120 amperes, which was quite high enough.

Mr. SIDNEY STONE said that one very important thing in connection with electric traction had not received very much attention. He referred to the wear of the track, and he had rather hoped to have heard something from his American friends as to their experience of track wear. He believed it was a fact that the wear of the track on electric railways in this country was excessive, more particularly on those lines using the multiple unit system. On the City & South London Railway, where they had an electric locomotive, wear of track was not so marked, but on the other lines—more particularly on the District Railway, where they used long trains with probably three motor coaches, the wear was very marked. It had occurred to him that probably they had not looked quite at the right point to ascertain the cause of the wear. He had noticed when travelling on the District Railway how the rails were worn pretty regularly, the worn spots being about 40 ft. apart. Apparently the bogies were wearing and digging into one side of the rail until they met sufficient mechanical resistance to throw them over to the other side. He thought the cause of the wear, more particularly on the multiple-unit system, was due to the fact that the trains were running with a motor at either end, and when on a curve there was an increased mechanical resistance at the front coach causing frictional resistance on the rail. The motor at the rear of the train did not meet with the same resistance, with the result that it pushed the train up and out of line, particularly on curves or up gradients. With a locomotive which was always keeping tension on the draw-bar, the trains were pulled along the rail all the way through. If multiple-unit trains were to be used successfully then the power on the front motor would have to be increased, so that there was always tension and never compression on the draw-bar. He had some time since suggested a method by which the maximum propelling effort would always be obtained form the leading motor whichever way the train was running.

Mr. C. F. SCOTT (Past-President of the American Institute of Electrical Engineers) said that the range of the Papers had brought out one thing, viz., the breadth of the subject and the variety of conditions. He might almost add with regard to railway electrification that there were no general rules. In every case the various elements entering into the question, such as length of line, density of traffic, character of traffic, gradients and speeds, were all factors that had to be considered as a whole, not separately. Consequently, generalisations were very apt to lead to very peculiar results if applied to any specific case without modification. They were apt, also, in some of their engineering discussions on the other side of the water, to devote most of their energies to controversies as to the systems rather than to considerations as to the general features of railway application. Electricity had a way not only of doing the same things that had been done before and often doing them in a better way, but also of introducing new methods. Upon looking at the literature of 20 years ago regarding the electric motor one would find that it was largely a comparison of the relative power required, or the relative efficiency of transmission by shafting and motors. They all knew that the reason for using electric motors now was not that they might save power, but that they might be able to use more power efficiently and to secure the advantages of speed control, readiness of operation, reliability and convenience which the electric motor afforded. It had been brought out in the Papers that the increased capacity of a railway line at congested points by double tracking or other increase in track facilities might be secured by electric traction. New possibilities were also open to railway terminals. A railway terminus at the present time with many tracks utilised a great breadth of area in centres where ground was extremely expensive. Electrification, however, permitted double tracking, or even treble tracking of railways, so that the same number of tracks could be got one above the other into a very much less space than was now utilised. He mentioned that simply as an illustration of the kind of thing which electric traction might bring about. The construction described in Mr. Westinghouse's Paper in which the electric motor was shown placed well above the driving axles, the driving being by side rods, although used on the Continent, was quite new to America. The locomotives used on the Pennsylvania Railroad had very large motors in the cab, and he believed that those locomotives were the largest ever made. A new locomotive used on the New Haven Railroad was of interest, as each motor was mounted directly over the axle which it drove, the drive being by gearing at each end. The latest locomotives made for the New Haven line had been designed for both passenger and freight service. In regard to the comparisons that had been made between the direct-current and single-phase systems, he did not intend going into any detail, but merely wished to bring forward some general comparisons between the two systems. It had been quite properly brought out in the Papers that the real difference was that the single-phase equipment cost more and that the advantage of the single-phase system was in the lesser cost of the line. The need of careful observation of those considerations, and also of noting carefully the specific conditions in particular cases, was brought out by examining some of the figures which had been set out in the various Papers, and showing the different conclusions that might be drawn from a slight change in conditions or assumptions. In Mr. Hobart's Paper two elements were considered, the first of which was the equipment. That element had been taken up by previous speakers, and, moreover, he was not competent at the present moment to discuss it; but upon looking at the Paper generally he found that the other element was transmission, which was by some recognised as the large element to be considered, and was certainly a most important one. This had received almost no consideration. Mr. Hobart passed all that over by a statement giving the cost of electricity at the car as 0·9d. for direct current and 0·72d. for single phase, the former figure being 25 per cent. greater than the latter. That was the cost of power at the car, irrespective of the efficiency of the car itself. The losses in the direct-current system were greater than in the single-phase system between the power house and the car. The average all-year efficiency of a sub-station varied through a wide range, depending on the size of the sub-station and the load factor. For general average conditions he believed that an efficiency of about 80 per cent. for the sub-station would not be too high. In some cases it might be higher, and in some cases he knew it to be lower. One would not be very far wrong, therefore, for a general comparison if one said that the amount of power generated for the direct-current system was 25 per cent. greater than for the single-phase system for each kilowatt-hour delivered to the car. That was the ratio which Mr. Hobart had taken, allowing nothing for the greater first cost of the direct-current sub-station or for the operation of the sub-station. Those elements would evidently increase very considerably the cost of direct-current power. In Mr. Pomeroy's Paper some figures were given concerning the New York Central Railroad. He quoted Mr. W. J. Wilgus to the effect that the total cost of power was 2·60 cents (1·3d.) per kilowatt-hour. Of that amount only 40 per cent. was charged to the power station and 60 per cent. to the transmission and sub-stations. That showed that in a system where the transmission was within a radius of about 10 miles the cost of transmission and distribution was a very important item compared with the initial cost of power. Taking the cost of the sub-station part for alternating-current as about one-quarter of that for direct-current sub-stations, one obtained as a result a ratio which showed the cost of the direct-current power to be not 25 per cent. greater, but 50 or 60 per cent. greater than the cost of single-phase power. If those figures were applied to Mr. Hobart's Paper there would be quite a material change in the results. Hence, slight differences in assumptions might make very considerable differences in results. In regard to Mr. Carter's Paper, he noticed a statement to the effect that although both motors were dynamically capable of working the service, the direct-current motor alone had sufficient thermal capacity for the purpose, the other having to dissipate three times as much energy as it could get rid of by natural cooling. The speaker thought that that certainly could not be taken as a general statement applicable to all single-phase motors, for it would be impossible to work them if they were generating in themselves three times the heat that could be dissipated. Possibly, he thought, there might be some slip in the statement, but on the face of it the low efficiency attributed to single-phase motors was absurd, as was shown by the daily operation of these motors. Mr. Potter, in his Paper, gave some interesting figures for interurban electric service which the speaker would like to consider from two points of view: firstly, as to the figures given and assumptions made, and, secondly, as to the completed systems. He did not intend going into certain minor points about which he believed there would be some ground for discussion. For example, he noted that the maximum speed of the single-phase motors was given as 35 miles per hour, and that of the direct-current 48 miles per hour. He believed that requirement was excessive for the service, and would impose serious restrictions or extra cost on the alternating service. The speaker also noticed that the electrical maintenance for alternating current was given as 1½ cents (0·75d.) per car-mile. That, however, differed greatly on different roads, and in considering a system one ought to give due consideration to what could be done under good conditions as well as what could be done under all sorts of conditions. Taking the oldest single-phase

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line running, the electrical maintenance over a period of three years had averaged less than a cent (0·5d.) per car-mile as against 1½ cents (0·75d.), as given in the Paper. A correction had been made by a former speaker in the cost of the cars, reducing that item by something over $50,000 (£10,000), owing to a misprint, and he, the speaker, thought other reductions should also be made both in the cost per equipment and in the number of equipments. The road referred to was one which required six cars in service at one time. How many cars should be purchased in order to maintain six in service? That was a question of judgment and experience, but he thought they would all agree on one thing, viz., that the figure given in the Paper was excessive. Fifteen direct-current cars had been provided, meaning that nine cars were to remain idle, and for the single-phase cars the requirement was that for every car required in service two would be idle, making a total of 18. If the number of cars was reduced to, say, 10, each allowing two-thirds of the number of cars in service to lie idle, the car costs would be brought down very much, and by using the figure of $17,000 (£3,400) per car without question (he would reduce it somewhat) they would then have a very material reduction in the cost of cars, which was the largest item in the final summary. That would bring the total cost of the two systems very nearly equal. His point, therefore, was that slight differences in assumptions, and changed assumptions which were apparently not well founded, made very radical differences in the final results. The speaker then compared the capabilities of the two roads. The requirements for 1,200-volt direct current were that the line should be sufficient for starting one car and running one car at the momentary maximum demand between stations. As the stations were 28 miles apart, and as the conditions were substantially the same over a considerable distance there was therefore a distance of 10 to 14 miles for which the limit was the starting of one car and the running of another. Literally, therefore, two cars could not start without exceeding the maximum allowable momentary demand between the sub-stations. The alternating current was about on the same basis. Two cars might start between sub-stations, but the sub-stations were further apart. That meant that the cars must be kept one hour apart, and it seemed practically to bar all trailers, and any two car trains or extra cars. If three cars should get on one section at once that section would be overloaded, and the greater the overload the lower the voltage, and consequently the lower the speed of the cars. That could be remedied by increasing the line capacity. They could double the capacity of the line by doubling the number of sub-stations, but in one case the single-phase sub-stations cost only $20,000 (£4,000) while the direct-current stations cost over $100,000 (£20,000). The single-phase sub-stations had an annual maintenance of $600 (£120) and the other $3,200 (£640) as given in the Paper. In that typical interurban service, therefore, he would point out that the rolling stock had been put in to an excessive amount, whereas the line capacity had been put in at a minimum. They must, therefore, in comparing systems of that kind, give due consideration to those two elements, as it was not wise to provide three times as many cars as the line was able to supply current to, nor, on the other hand, was it wise to make the line capacity so small that it could not operate any cars in addition to the regular schedule when desired. In conclusion, the speaker referred to the fact that the earliest single-phase road, which was originally 40 miles in length, had been extended to over 100 miles, that its schedule speed was higher than any other interurban road, and that a recent official report showed the cost per car-mile to be less than that of any of the direct-current roads which traversed the same State (Indiana) and operated under substantially similar conditions. Moreover, the only distinctively heavy electric trunk line service in America, as distinguished from terminal and tunnel service, was on the New Haven road by the single-phase system; and, furthermore, this was the only road which was now actively proposing to extend its present electrical operation, and this extension would employ single-phase apparatus.

Mr. PHILIP DAWSON, in a telegram, which arrived at this juncture and which was read by the secretary, regretted his unavoidable absence, particularly as Mr. Hobart's fundamental data regarding the South London Elevated train were quite wrong. The weight of the equipment was 36 tons, not 44 tons; the energy consumption per ton-mile was 66, not 79 watt-hours; and six motors were quite satisfactory to run the service. Those errors alone vitiated all Mr. Hobart's conclusions.

Mr. H. M. HOBART made a few comparisons in connection with Mr. Potter's Paper which he thought might be of interest. Mr. Potter and himself seemed to be in good agreement on many points, but on the whole, in running through the various data, it was his (Mr. Hobart's) opinion that the cost of the continuous-current system, as given by Mr. Potter, was a little lower than his own data and that of the single-phase system a little higher. The result of running the figures so close was that it would take very little alteration in them to change the balance in favour of the single-phase system. His conviction was that in the case of the 100-mile line referred to, the single-phase system would be the cheaper and the more appropriate, though the difference would be very slight indeed. He had hastily compared the cost by taking the cost of the cars per ton weight. Thus $17,000 (£3,400) was high for the alternating current car, or, taking the relative figures, $10,000 (£2,000) would be low for the continuous-current car. The cost per ton for the continuous-current car worked out to £64 and the single-phase car to £89. Assigning to the single-phase car so much higher a first cost it was unreasonable to give it a life of only 12 years as against a 15-year life assigned to the car equipped with continuous apparatus. He thought that the balance would be in favour of the single-phase system for that line, but pointed out that such a line with only one train per hour was a case for steam, and could not be operated electrically at a profit unless the receipts per seat-mile were far greater than could be obtained in this country.

Mr. A. SINCLAIR referred to the question of extending electrical operations to freight service. Mr. Westinghouse thought that would gradually be done, but so far as the speaker's experience had gone with railway operating he did not think there was the least indication of such a thing. No such drastic change should be made without considering all possible difficulties. From what he had seen of railway operating in the United States the chances for electric traction for freight were very small indeed.

Mr. J. G. WILSON criticised what he took to be the keynote of Mr. Westinghouse's Paper. Mr. Westinghouse advocated the adoption of one system of electric traction to the exclusion of all other systems. From the point of view of those railway companies owning routes capable of profitable conversion to electric traction, three facts had so far been established from the actual results of electric traction. Firstly, on suburban routes with heavy and moderately heavy traffic, conversion to electric traction was capable of effecting a considerable reduction in working costs, even taking into consideration the capital that had to be spent. Secondly, the adoption of electric traction on suburban routes gave the only really effective and satisfactory means of competing with other systems of suburban traffic. Thirdly, there were inter-urban routes, and possibly, also—with all respect to Mr. Sinclair—there might be cases of exceptionally heavy freight movement where the adoption of electric traction might offer advantages and possibilities. Progress might have been more rapid but for the fact that there were at least two proven methods of making the conversion. The fact that there were two methods could not but perplex the railway man, and Mr. Westinghouse, in order to remove that bar to progress, advocated the adoption of one system of electric traction to the exclusion of the consideration of all others. The speaker was in entire agreement with Mr. Westinghouse so far, provided, of course, that such a thing were practicable. It would have many desirable results, but he (the speaker) could not escape from the conclusion that such a course was impracticable; moreover, it is not absolutely necessary, though desirable, and, further, it was not economically sound. As an example of the difficulties, he took an illustration of two railways entering London. One of them, the Great Eastern Railway, had what was certainly the heaviest and most important suburban traffic in the United Kingdom. The other, the Great Northern Railway, had a very small suburban traffic, but was an important mineral line on which the consideration of electric traction might crop up in the future. It could be shown that the cheapest method of dealing with the suburban problem on the Great Eastern Railway was by the adoption of the direct-current system; but for anyone considering the problem of the Great Northern Railway's mineral traffic it would be impossible not to take into consideration the claims of the single-phase system. If one of those railways, for the sake of interchange of traffic, was going to give way to the other, which was it to be and what inducement could be held out to the railway company which gave up any immediate advantage in the matter? He did not think it could be too emphatically insisted on, for the sake of the railway companies, that whereas the one system could not be adopted in all cases, yet in any individual case the cheapest and best system could be adopted with a great degree of certainty. Lastly, he did not think that to delay the conversion to electric traction for the sake of uniformity was commercially sound, because the advantages to be gained by uniformity were remote and problematical, whereas the advantages which in the meantime were being forgone were real and too large for a railway company to forego.

Dr. F. R. HUTTON thought there was no question that electrification was of great importance where there were a number of cities close together such as in this country, but the conditions in the United States were quite the reverse.

Mr. F. W. CARTER, in reply, said that Mr. Dalziel had referred to the question of efficiency. He (Mr. Dalziel) mentioned an efficiency of 93½ per cent., but the speaker did not quite know how he had obtained it. If he had referred to the efficiency of the motors, exclusive of the gear and friction losses, the figure he had mentioned was about correct for the continuous-current motor whose characteristics were given; in fact, the average value of this efficiency whilst running at full voltage was probably nearer 94 per cent. Mr. Dalziel had also suggested that he (the speaker) could have improved the showing of the single-phase motor if he had chosen different gear so as to get the same free running speed for the two motors. Mr. Carter did not think the free running speed was a matter of any particular importance, because that speed was never reached. The reason that particular gear was chosen was in order to obtain the same margin in the schedule and thus to give equal capacity for making up time with the two equipments. In connection with Mr. Scott's remarks, all he had wished to say in the Paper was that the single-phase motor whose characteristics were given was dynamically suitable for the service, but that it could not be used for the service unless forced draught were adopted to the extent necessary to carry off the extra heat. As a matter of fact, the continuous-current motor was run at about the limit of its thermal capacity with natural cooling.

Mr. H. H. BARNES, JR. (New York), in replying to the criticism on Mr. Potter's Paper, said that Mr. Scott had remarked that the number of cars shown for the three classes of equipment was excessive. As shown in the footnote the figures of the miles per car in service per day and the miles per day on the average were taken from present practice on the other side of the water. For the sake of argument, however, they might admit that the figures were low, and in order to illustrate where they would come out by a radical change, he had thoroughly checked the

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figures on the basis that instead of 15, 15 and 18 cars they only had half that number. Upon halving the number a condition was obtained under which the route could not be operated; but, nevertheless, on that basis he found approximately, that the difference in the annual cost of operation, consisting of fixed charges and the operation and maintenance charges, instead of being £6,400 in favour of the 1,500 volts, would drop to about £4,000. In other words, the cost would go down faster in the case of the alternating current, but it [still] left £4,000 in favour of the direct-current system. That represented about 14 per cent. on the actual total annual cost. Another point which had a bearing upon the total figures, and referred to by Mr. Hobart, was that of maintenance, the figures for which were considered rather high. The figures given, however, represented reasonable averages, and he thought that the brush maintenance (to take one feature of the maintenance only) in accordance with their experience between alternating current and direct current was about as 100 to 1 against the alternating current. As far as he was aware, also, the actual number of men employed for a given service on alternating-current lines, even though they had not any sub-stations, was as great; or greater, than on the corresponding direct-current lines with their sub-stations. The amount saved in the sub-stations was needed in the bonds. In conclusion, he again emphasised the fact that the table in the Paper was based upon conditions which were recognised as unfavourable to the direct current. That was done in order to give the alternating current as fair a showing as possible. Under more favourable conditions the improvement would be more marked.

Mr. J. A. F. Aspinall was very glad to see in Mr. Westinghouse's Paper the diagram illustrating the new electric locomotives that they were constructing for the hauling of their heavy electric trains. They very soon realised on the Liverpool and Southport line that if heavy electric trains were to be hauled and that if the cost of repairs to the motors and motor trucks was to be kept down they would have to revert to the large bearing surfaces used in locomotive practice, which experience had shown them to be necessary in any hauling machine. The practice which they were now establishing in the United States got over the difficulty of low centre of gravity of the motor trucks in the multiple unit trains and of the weight not being spring-borne, this being the cause of excessive wear and tear of the rails. The experience of four or five years' running on the Liverpool and Southport line had shown that the electrical system, such as they had, was perfectly satisfactory. One speaker had touched upon the great diversity of opinion between electrical engineers. As a general manager of one of the English railways, he thought that no general manager could afford for one moment to close his eyes to the possible utilisation of either one or the other system, whichever might prove to be commercially right, and the utilisation of the rolling stock to its greatest possible capacity was one of those items to which much greater attention must be paid than to almost anything else. He was, therefore, pleased to see in Mr. Pomeroy's Paper a diagram illustrating in a very clear manner what a very small proportion of the time of a locomotive, whether steam or electric, was occupied in doing useful commercial work, that 22 per cent. of the time was spent in the shops in repairs and maintenance, that only 28 per cent. of the time was commercially used, and that 50 per cent. was wasted in waiting at terminal yards, side tracks, &c. There was more money to be made out of that little diagram than in all the variations of system.

THE LATEST G.E.C. "WITTON" SWITCHES.

The General Electric Co. have recently placed upon the market a complete line of chopper type switches—to be known as the "Witton" type—which are manufactured throughout at Witton

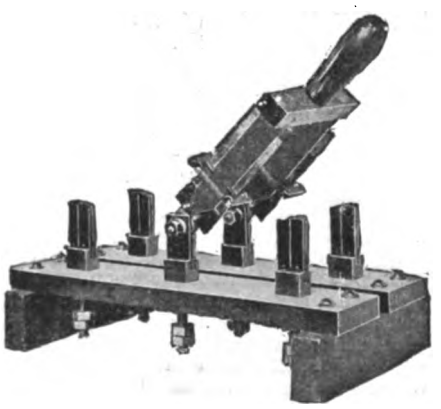

Fig. 1.—Double Pole Change-over "Witton" Switch.

Works. The switches are made and stocked for maximum currents of 30, 60, 100, 200, 300, 400, 600, 800 and 1,000 amperes, while any larger capacities up to a maximum of 10,000 amperes capacity can be made up at short notice. The advantage of the many sizes is evident, if one considers that it does away with the necessity of paying for, say, a 600 ampere switch when the maximum current is only 350 amperes, because the 600 ampere switch happens to be the nearest larger size.

The same general design has been carried through the whole range, and the appearance of the switches of different capacities is therefore similar, an obvious advantage which will be readily appreciated by switchboard makers, as it certainly improves the appearance of a switchboard if the apparatus mounted thereon is of uniform type.

The switches are amply dimensioned, the current density nowhere exceeding 1,000 amperes per square inch sectional area, and 60 amperes per square inch surface area in the contact clips. With regard to surface density, it is claimed that these switches are the most amply rated of any obtainable; this is a decided advantage as most losses in switches are due to insufficient contact surface in the clips. Moreover it allows of the switches being overrated as much as 50 per cent. permanently without dangerous heating, and much higher for short periods. This may be very desirable in an emergency.

The accompanying illustrations show sufficiently the general design, and it is only necessary to point out a few details. For instance, the flipper blades, which give the quick break, are fitted with a steel stamping where they are hinged, and the main blade is bushed with a steel bush for the hinge pin, which makes the actual wearing parts very strong. At the handle end, the main blades, up to and including those on the 200 ampere size, are provided with pressed steel clips to which the handle or, in multipole switches the bridge is attached. Over this size solid square steel ends are used. To hold the blade in the "off" position in change-over switches, or where there is no room to swing the switch right over, shaped steel springs are provided, which are fixed to the side of the hinge contact, and

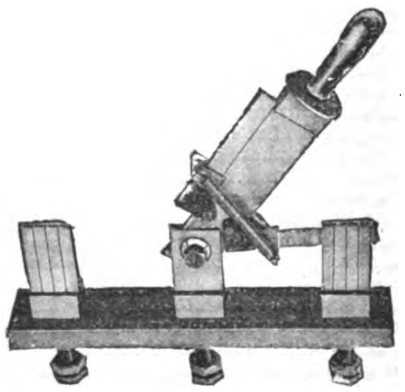

Fig. 2.—Single Pole Change-over "Witton" Switch, Showing Flipper Blade.

act on the rounded end of the flipper blade pivot pin. The switches are stocked in the "single," "double" and "triple" poles type, and for either front or back connections. A larger number of poles can be made up on short notice. The switches are jig made and all parts are interchangeable. The finish is copper and black.

LEGAL INTELLIGENCE.

Attorney General (ex. rel. India Rubber, Gutta Percha and Telegraph Works Co.) v. West Ham Corporation.

Mr. Justice Neville, in delivering judgment in this case on Friday last, said the statutory powers of the defendant Corporation included the supply of electricity and electrical fittings, and they had been entrusted with extensive powers of borrowing, to be exercised with the sanction of the Local Government Board. They had 10 different accounts at their bankers, into one of which, the general account, they paid all receipts on account of the borough fund and the general district rate, and upon which they drew in respect, amongst other things, of their expenditure upon their electrical undertakings. The Corporation kept in their books two electricity accounts, one called the capital account, dealing with expenditure on fixed capital, and the other the revenue account, which, besides showing the surplus or deficiency on the year's working, included their expenditure on electrical fittings and stores. For the latter they had borrowing powers, to be exercised with the sanction of the Local Government Board, but they had not, on March 31, 1908, obtained any such sanction. Any deficiency upon the year's working was estimated for in the rate for the following six months and levied; but no estimate was made in respect of the capital expenditure upon the electrical undertaking, whether fixed or floating; this was found either from other funds of the Corporation not properly applicable for that purpose, or by overdraft from the bank. On March 31, 1908, the overdraft on the electricity revenue account was over £44,000 and on the capital account over

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£92,000. In my opinion these overdrafts were illegal. On April 15 sanction was obtained from the Local Government Board for a loan on electricity capital account of some £64,000. Towards the end of 1905, by this and other expenditure made for legitimate purposes, but which was intended to be met out of funds to be produced by the exercise of their borrowing powers, and for which, consequently, no estimate was made or rate levied, the Corporation had got themselves into considerable financial difficulties, and were unable without financial assistance to provide for their current expenditure. They had at this time unexhausted borrowing powers which (upon the sanction of the Local Government Board being obtained) would, if exercised, have to some extent enabled them to recoup their expenditure upon capital account, and in December, 1905, they applied for sanction to borrow moneys in respect of certain works. It is only fair to the Corporation to say that the sanction which was ultimately given in respect of the greater part of their application was not so given until April 1, 1908, and this delay undoubtedly added to their embarrassment, and tended to prolong the period during which they sought assistance. In November, 1905, the Corporation applied for an overdraft to the London & County Bank, and after some negotiations an overdraft was granted to them to the extent of £120,000, subsequently increased to £200,000. From the time when the overdraft was granted until shortly before the commencement of the action the accounts were almost continuously overdrawn. At the time the Corporation obtained the overdraft they had unexhausted borrowing powers, and he would assume that these were in excess of the overdraft, though the evidence was somewhat meagre on the point. The Corporation appear to have considered, and they certainly acted as though they were entitled to use, moneys borrowed under specific powers, not merely for the specific purposes for which the powers were bestowed, but for any purpose to which any funds of the Corporation could lawfully be applied, so long as they kept proper accounts of the expenditure. He thought the correspondence and applications to the bank showed that the Corporation intended so to apply the bank's advances from the first; and, in fact, the overdraft was allowed on all the accounts and a general balance struck daily. In his opinion this view of the position of the Corporation was erroneous. If they raised moneys under a borrowing power they were bound to apply the moneys so raised for the specific objects indicated by the statute. He thought that upon this ground the obtaining of the overdraft was ultra vires. Whether an overdraft extended over several years for substantially the whole amount of the authorised loan could be justified as a temporary loan within the meaning of the decisions he need not decide; but in his opinion the question was at least doubtful. Upon the point whether they were entitled to borrow money by way of overdraft for general expenditure, at all events, except under special circumstances, he also reserved his decision. The impropriety of municipal corporations incurring large expenditure on capital account in anticipation of sanction for loans not yet obtained was well illustrated in the present case, where the Corporation failed to obtain sanction for a loan in respect of an expenditure of over £10,000 on electricity account, with the result that they were driven to make a levy for the amount—in his opinion an illegal levy, inasmuch as the proceeds were applied in payment of liabilities incurred more than six months before the levy of the rate. The bank having agreed terms, he refrained from discussing what, upon the evidence, their position would have been in respect of their advances. On March 31, 1908, the general account of the Corporation with the bank was overdrawn to the extent of some £38,000, after deducting the amount due to the consolidated loans fund, but which had from time to time been paid into the account in reduction of the overdraft, in accordance with an arrangement with the bank. In his opinion the application of the amounts due to the consolidated loan fund in reduction of the overdraft was illegal.

At the trial application was made for leave to plead the Public Authorities Protection Act, 1893, and the Trustee Relief Act, 1888. In the course of the trial he gave such leave, and the matter proceeded upon that footing. Counsel for the Attorney-General having refrained from asking for relief against the defendant Patterson personally, the Trustee Relief Act could have no application. The question of the applicability of the Public Authorities Protection Act, 1893, was not fully argued. In his opinion it would apply in favour of the Corporation and the borough treasurer in respect of acts completed more than six months before the action. The overdraft, however, from the bank and repayment out of moneys due to the consolidated loans fund continued up to a period within six months before the commencement of the action, and he thought the plaintiff was entitled to declarations in respect of such continuing illegality, although the plaintiff was not entitled to all the relief claimed. Having regard to the time at which the application to amend was made, he thought this should make no difference as to the incidence of the costs of the action. He proposed to declare (1) that the overdraft obtained from the bank for general purposes in respect of borrowing powers granted for specific purposes was ultra vires and illegal; (2) that the application of money due to the consolidated loan fund in repayment of such overdraft was altra vires and illegal; (3) that the borrowing of money from the bank for the purpose of the electricity accounts, otherwise than in the exercise of borrowing powers with the sanction of the Local Government Board, was ultra vires and illegal. The defendant Corporation and the defendant Patterson must pay the costs of the action.

Mr. DANCKWERTS (for the Corporation): Your lordship promised to say something about the sanction of the Local Government Board being held back. If we get the sanction it will put us straight and we shall be able to proceed.

His LORDSHIP said he could not make any statement as to that.

Mr. DANCKWERTS asked his lordship for time, so that the Corporation could put themselves straight. He suggested until March 31, so that they should not be presumed to intentionally break the declaration that your lordship has made.

His LORDSHIP said he did not think there were any means by which the declarations he had made could be enforced. He had not granted an injunction. He thought his judgment had no further operation than that it made it res judicata between the Attorney-General and the Corporation.

J. & H. Gravener v. J. M. Smith.

In the Shoreditch (London) County Court on Tuesday, before his Honour Judge Smyly, K.C., plaintiffs sued defendant to recover £14. 0s. 3d. for arc lamps and carbons supplied.

Evidence for plaintiffs was to the effect that in September, 1909, they negotiated at their Manchester branch with defendant to supply arc lamps to the value of £10 and carbons to the balance of the debt. It was agreed they were on sale or return for 14 days. From that time they heard nothing until payment was pressed for, when there was a query as to the current taken by the lamps, and that was put right.

Defendant said the lamps were sent on approval to be tried. He found they burned far too much electric current and decided to reject them, but offered to pay for the carbons as they were all right. Plaintiffs agreed to pay the carriage both ways if he did not like the lamps.

Judge SMYLY: How long were the lamps used?—Defendant: About three months.

Judge SMYLY: But surely you are not entitled to use electric fittings for three months and then reject them?—Defendant: My agreement was that I should have them a reasonable time for testing, but no definite period was fixed.

Judge SMYLY: But can you call three months a reasonable time? it seems very unreasonable to me. Defendant: They had to be tested, and I had to use different carbons to do that, which could not be done in a few days. My refusal of them was because I found out afterwards why there was so much current used and that there had been misrepresentation. Then again, I object to being brought to London from Bolton when the affair was arranged in Manchester.

Judge SMYLY: Payment would be in Manchester, so I have no jurisdiction.

Mr. WHITE (for plaintiffs): Defendant knew he was dealing with a London firm.

Defendant: No, I did not; I had no knowledge of a London office.

Judge SMYLY: The contract was made in Manchester, and it is a great hardship bringing a man up all this way.

Mr. WHITE: Anyway he admits his liability for the carbons.

Judge SMYLY: But that is not the point. It is a great shame to launch such actions in London, as it often happens that a person who has got a thoroughly good defence has no money to fight the action by way of coming to town, and judgment is obtained against him illegitimately. I decide the Court has no jurisdiction, and the action is dismissed.

Defendant: Can I have my costs of coming to London?

Judge SMYLY: Yes, most certainly.

Overhead Telephone Wires.

Last week the Railway and Canal Commission heard the appeal of Croydon Corporation against the decision of Judge Harington, allowing the Postmaster-General to erect telephone poles for overhead wires in roads in Croydon, Norbury, &c. The facts were reported in THE ELECTRICIAN for June 24 (p. 447), but additional witnesses were called for the Postmaster-General, and, in the result, the chairman of the Commissioners (Mr. Justice A. L. Lawrence) delivered judgment upholding Judge Harington's award.

PARLIAMENTARY INTELLIGENCE.

Royal Assent.—On July 26 Royal Assent was read to the following new Acts of Parliament, in addition to those mentioned in our last issue: Dunfermline and District Tramways (Extensions) Order Confirmation, Wemyss Tramways (Extensions) Order Confirmation, Electric Lighting Orders Confirmation (No. 3) Bishop's Stortford, Harlow and Epping Gas and Electricity, Yorkshire Electric Power, Reading and District Electric Supply and Belfast Corporation (Tramways). The London County Council (Tramways and Improvements) Act received the Royal Assent on Wednesday last.

Birmingham Extension Bill.—The Select Committee of the House of Commons, presided over by Mr. D. A. Thomas, which has been considering the bill to confirm a provisional order made by the L.G. Board for extending the boundaries of the City of Birmingham, decided on Wednesday to confirm the order, except so far as it relates to the separation of Handsworth from the West Bromwich Union. The added area includes Aston, Erdington, Yardley, &c.

Customs Duties.—A recently issued supplement to the Australian Customs Tariff Guide states that it has been decided that automatic arc lamp couplings (not integral parts of the lamps) are subject to import duty of 17½ per cent. (British goods 10 per cent.), and switch cases, consisting of c.i. case enclosing switches and fuses with or without ammeters, voltmeters, &c., 20 per cent. (British or otherwise), bronze statuettes with conduit passing through for electric wires or gas 25 per cent. (British 20 per cent.). Magneto parts (imported in sets) are duty free.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Council of the University of Birmingham invite applications for the appointment of assistant lecturer and demonstrator in electrical engineering. Candidates must be graduates, and must have had experience in the test room of first-class electrical engineering firm. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by Sept. 17. See an advertisement.

The governing body of the Northampton Polytechnic Institute London, invite early applications for the appointments of senior assistant in the electrical engineering department, to take charge of new electric generating station (salary 45s. per week); junior assistant in electrical engineering department, chiefly to take charge of producer plant (28s. per week); second lecture assistant in electrical engineering department (£80 per annum); and assistant lecturer and demonstrator in the mechanical engineering department (£120 per annum).

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

A lecturer in mechanical engineering is required at Blackburn Municipal Technical School. Salary £120 to £140. Forms from the Director of Education. Applications by Aug. 13.

A Canadian publishing house advertise for an experienced editor for an electrical journal.

An instructor for engineering workshop classes is required at Guildford Technical Institute. Applications by Aug. 10.

Assistant Examinerships in the Patent Office.—Applications to enter for the forthcoming examination to qualify for appointments as assistant examiners (20-25) must be sent in by Sept. 1. Forms and particulars from the Secretary, Civil Service Commission, Burlington-gardens, London, W

EDUCATIONAL NOTICES.

University of London, University College.—The 1910-11 session begins on Monday, Oct. 3. Full particulars from the secretary, Mr. Walter W. Seton, M.A. Intending students should communicate with the Provost not later than Sept. 20.

University of Liverpool.—The session 1910-11 commences on Tuesday, Oct. 4. The courses of study in the faculty of engineering leading to the ordinary degree of Bachelor of Engineering extend over at least three years, and are so arranged as to afford a general scientific training for those who intend, with or without graduating, to become engineers, naval architects or architects and surveyors. Students who do not proceed to a University degree may take a course of not less than two years, leading to a certificate in engineering. The honours schools enable students to specialise in some branch of the profession, and opportunities are afforded for post graduate work and research. Prospectus of the faculty can be obtained from the Registrar, Mr. P. Hebblethwaite, M.A.

University of Glasgow.—The next session will commence on Oct. 17. Prospectus of course in engineering and syllabus may be obtained from the Assistant Clerk, Matriculation Office, The University, Glasgow.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

East London College (University of London).—The new session commences Sept. 26. There are courses in civil, mechanical and electrical engineering. Fees, 10 guineas per session. Courses in the evening are also held at moderate fees. Calendar may be obtained free from the Registrar or of the Principal (Mr. J. L. S. Hatton, M.A.). The college is situated in the Mile End-road, near G.E. and L.T. & S. stations.

BRITISH NOTES.

Accrington.—The Electricity committee have drawn up terms for the supply of current to Haslingden Corpn., and it is proposed to apply to the Board of Trade for an order permitting the Accrington Corpn. to supply current in bulk to Haslingden.

The committee have decided to instal a storage battery, the cost to be defrayed out of revenue.

A permanent showroom is to be opened for exhibiting electric motors, fittings, &c.

Bath.—The City Council has decided to invite tenders for the lighting of the Long Acre Technical Institute. The electrical engineer (Mr. F. Teague) is to prepare specifications.

Brighouse.—At a meeting of the Council last week a report was presented in reference to an interview between representatives of the Corporation and the officials of the Yorkshire Electric Power Co.

Negotiations had been in progress for the supply of electric energy for power at a cheaper rate than hitherto. Under an agreement the Corporation now takes electricity in bulk from the power company at a maximum charge of 1½d. per unit. The company made the following offer: "For supply to power users connected to the Corporation's existing d.c. system (the amount to be deemed at 67 H.P.), a flat rate of ¾d. per unit; for units used for balancing, ¾d. per unit; for all other current, 1½d. per unit. If the total charge ascertained as above exceeds the charge of the sliding scale in the existing agreement, the account will be rendered on the lower basis." These terms were accepted, provided they apply to all energy taken by the Corporation from the company on the d.c. system up to a maximum of 250 kw. It has also been decided to supply current for power at 1d. per unit to any consumer in the town with a minimum consumption of 5,000 units per quarter. The Power Co. are to be allowed to lay mains through Brighouse, partly underground and partly overhead, for supplying in Sowerby Bridge.

Chelmsford.—Tenders for lighting the public lamps for three or five years from April 1 next have been received from the Electric Supply Corpn. (who carry out the public lighting at present), and the Chelmsford Gas, Light & Coke Co.

The former company state that they have decided to substitute metal filament lamps for Nernst lamps. They offered to light the north and south wards with 21 flame arc lamps at £25. 5s. per lamp per annum with 23 incandescents at street corners of 200 c.p. and with 280 of 100 c.p. at 3 guineas per lamp per annum, and also to provide the Springfield ward (now lighted by gas) with 33 100 c.p. incandescents at 3 guineas per lamp per annum. The gas company have submitted three tenders, the last one stating they are prepared to supply all the necessary lamp columns, lanterns and other apparatus for lighting the whole of the borough for £3. 4s. 6d. per lamp per annum; the lighting power of the single-burner lamps to be of 125 c.p., and of the double-burner lamps at street corners 160 c.p. In place of the flame arc lamps they would agree to erect, light, and maintain 21 incandescentgas "arc" lamps of 1,200 c.p. for £18 per lamp per annum.

The tenders have been referred to a sub-committee.

Croydon.—The borough electrical engineer (Mr. A. C. Cramb) reports that the regulations of the Home Office as to factories will necessitate an estimated expenditure at the electricity station of £1,176.

Delivery of Telegrams by Telephone.—The Secretary of the General Post Office has issued the following letter (dated July 26) to subscribers to the Post Office telephone system:—

The Postmaster-General is desirous of substituting delivery of telegrams by telephone for delivery by boy messenger, and this method is now being adopted experimentally in the case of telephone subscribers whose telegrams are ordinarily sent to them from the ——— Post Office. Delivery is quicker by telephone than by messenger and, where attention cannot be obtained at once by telephone, the message is sent out in the usual way by hand. In every case of telephone delivery the written telegram is forwarded by post. Unless you notify to the contrary, the Postmaster-General will assume that he will receive your co-operation in the experiment.

Any communication with regard to this matter should be addressed to the General Manager, Post Office London Telephone Service, General Post Office (South), E.C.

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Eccles.—Sanction has been received by the Council to a loan of £3,234 for generating plant and mains extensions.

Exhibition.—An international exhibition of iron and metal wares and machinery will be held at Budapest (Hungary) in May next.

Fleetwood.—An inquiry was held here on Thursday into the application of the Council to borrow £4,100 for extensions of the electricity undertaking.

Frome.—The Council last week sealed the agreement to transfer their electricity undertaking to Edmundson's Electricity Corpn. The Council agree to pay the company £8,278, balance of the capital amount due to the company, and to take a supply of electricity for lighting the streets until April 6, 1928, the prices to be revised next year, and every subsequent five years. The company agree to repay in half-yearly instalments the interest and sinking fund or instalments on loans (amounting to £43,278) which the Council have incurred. The company may be required by arbitration to sell the undertaking to the Council, the valuation of lands, buildings, and works not to exceed £70,000.

Glasgow.—On Friday the Electricity committee approved the accounts for the year ended May 31. No change is to be made in the charges for electric current during the present year.

The Electricity committee recommend the following rates of depreciation on the various items in the capital account for 1909-10: Land and buildings, 1 per cent.; machinery, plant, instruments, transformers, &c., 3½; accumulators, 5; mains and cables, 2; and meters and indicators, 4. On the basis of the rates for 1908-09 the depreciation for the year 1909-10 would be £57,930. 18s. 4d., and on the basis proposed the amount will be £43,474. 18s. 1d.

Hammersmith.—The New Olympia Co. have decided to generate their own current for the purpose of demonstrations of country house lighting at the electrical exhibition to be held at Olympia in September, 1911, and will pay Hammersmith Council a royalty of ¾d. per unit, as the company are under an agreement to take all current required from the Council's works at a low price.

Holborn (London).—The Council have rejected by 15 votes to 6 a recommendation of the Works and General Purposes committee to enter into a 10 years' contract with the Gas Light & Coke Co. for street lighting with inverted burners.

The matter is to be brought up again in October, and in the meantime a tender for electric lighting will be obtained. Councillor H. Foulds was the leading opponent of the committee's recommendation.

The Borough Surveyor reported having prepared an estimate of the cost of alternative systems of electric lighting applied to High Holborn and New Oxford-street only as follows: By existing lanterns adapted, 18,000 c.p., first cost £75, annual cost £483; by new standards for arc lighting, 40,000 c.p., first cost £800, annual cost £680; by new suspended lamps for ditto, across street, 40,000 c.p., first cost £290, annual cost £680; by flame arc lighting, 120,000 c.p., first cost £1,000, annual cost, £680. The committee considered that the adoption of either electric light or high-pressure gas would involve considerable expense and the disturbance of the pavements, and, therefore, they did not recommend either.

Institute of Chemistry.—The pass list of the July examinations has been issued and shows that:—

59 candidates presented themselves. 17 passed the intermediate examination: D. L. Allan, S. W. Bridge, G. M. Carruthers, D. S. Dawson, B.Sc., F. E. Day, B.Sc., G. J. Eastburn, W. J. S. Eastburn, H. D. Elkington, Maud Gazdar, B.Sc., D. Hamilton, G. Hamilton, W. P. Harmsworth, W. Jewell, R. W. Pope, S. P. Schotz, J. Sorley, J. C. White. In the final examination 1 candidate passed in mineral chemistry: C. S. Grace, B.Sc.,; 1 in metallurgical chemistry: W. A. Riley; 10 in organic chemistry: F. L. Bassett, B.Sc., F. Challenger, B.Sc., F. A. F. Crawford, B.A., E. G. Davis, W. Dickson, J. R. Nicholls, G. C. Petrie, E. F. Pollock, T. Schwarz, T. A. Simmons, B.Sc.; and 8 in the chemistry of food and drugs, &c.: H. M. Harvey, D. Henville, F. E. Laughton, H. R. Lyell, W. M. Paulley, B.A., P. L. J. Smith, M.A., R. W. Warrick. 1 passed a final (A.I.C.) examination in general chemistry: J. B. Solomon, A. R.S.M., A.R.C.S.; 1 passed a special examination for the fellowship: Colin C. Frye; and 1 passed in the chemistry of food and drugs, &c.: G. W. Monier-Williams, B.A., Ph.D., F.I.C.

Leicester.—An inquiry was held on Friday last into the Council's application for sanction to borrow £19,190 for extensions of the generating plant at the tramway power station.

It was stated that the loan was required to meet the increasing demand for power. From September, 1908, to the end of the year, 63,192 units were supplied for power from the station; in 1909, 434,262 units; in the half-year ended June last, 609,285 units; and the engineer's estimate for the whole of the present year is 1,250,000 units. In view of the constantly increasing demand the proposed extension was considered to be the minimum the Corporation could safely ask for.

The electrical engineer (Mr. T. R. Smith), who gave evidence in support of the application, was of opinion that the extension would meet demands for the ensuing 18 months or two years.

Listowel (Ireland).—Messrs. Wilkins & Burden, of Dublin, are asking the Council's consent to their electricity supply scheme for the district. It was decided to take no action.

Marylebone (London).—An agreement has been entered into for the supply of electricity to the London Polytechnic's new premises in Regent-street under a restricted hour basis. The electricity department has arranged with the Metropolitan Railway Co. for lighting with electricity the gas lamps belonging to the company over the "blow-holes" of the railway in the Marylebone-road.

New Atlantic Cable.—Reuter's Agency announced that the Telegraph Construction & Maintenance Co.'s s.s. "Telconia" arrived at St. Johns, Newfoundland, on July 31, to lay the shore end of the Western Union Telegraph Co.'s new cable at Bay Roberts. Another cable ship (belonging to the T. C. & M. Co.) is to follow shortly with the deep sea section.

Personal.—We are informed that Mr. George G. L. Preece, A.M.I.E.E., M.Inst.M.E., for 15 years with W. T. Glover & Co., and for the last few years acting as their technical and special outside cable expert, has joined the firm of Bruce Peebles & Co.

Mr. Jas. R. Wilkinson, son of Mr. Geo. Wilkinson, borough electrical engineer, Harrogate, has finished his course at University College, London, by obtaining the College diploma in engineering, "with distinction," and winning three prizes. He has also obtained the London degree of B.Sc. in the second class honours division. During the college course Mr. Wilkinson has been a member of the Officers' Training Corps and has passed the examinations qualifying for a commission in the special Army Reserve of Officers. He is to be gazetted, and afterwards joins his regiment for four months' military training. At the expiration of this period he has been appointed to take a three years' course of practical engineering in the Royal Arsenal at Woolwich.

Presentation.—On the occasion of his marriage, Mr. W. A. Walker, electrical engineer at Kettering, has been presented by the chief officers of the Council with a Sheraton timepiece.

Preston.—In connection with the express parcel delivery system on the tramways, which was introduced at the beginning of the year, between 3,000 and 4,000 parcels have been carried at a minimum charge of 2d. per 14 lb. It is now proposed to reduce the minimum charge to 1d. for 7 lb.

Provisional Order Revocation.—The Board of Trade have revoked the Market Harborough Electric Lighting Order, 1906, as from July 20.

Railway Accidents.—The report to the Board of Trade by Mr. W. F Marwood, Assistant Secretary (Railway Department) on the accidents on the railways of the United Kingdom in 1909 states that the total route length of the railways was 23,264 miles.

In Class I. (train accidents) two occurred on electrically-worked lines, one being the collision at Marsh-lane Junction on the Lancashire & Yorkshire Railway on Jan. 21, and the other the collision of an empty train with the buffer stops at Ealing Broadway station on Nov. 18. In the latter the motorman and one of the conductors were killed.

In Class II. none of the accidents are specially described as electrical.

In Class III. it is mentioned that, although these accidents are not as a rule attributable to railway working, an exception must be made in the case of accidents caused by contact with the live rails and wires of electrified railways, which are distinctly railway accidents, though not caused by the movement of vehicles. To this cause must be set down the death of 1 servant and injury to 9 others in 1909. In 1908 1 servant was killed and 14 were injured in this way, in 1907 1 killed and 13 injured, in 1906 1 killed and 10 injured, in 1905 1 killed and 13 injured, and in 1904 1 killed and 9 injured. Precautions against the recurrence of such accidents have been taken by covering the live rail at exposed places, improving fencing and posting warnings. Accidents of this class have become less frequent than they were when electrical working was introduced.

St. Paul's Bridge.—At their meeting on Thursday last, the City of London Court of Common Council discussed a communication from London County Council in reference to the proposed additional bridge over the Thames between Southwark and the City.

The letter stated that the Improvements committee of the County Council were prepared to recommend the Council to make a contribution limited to one-half of the net cost of the proposed widening of St. Paul's Churchyard, this contribution being limited to £300,000, and subject to the condition that the Council shall be satisfied as to the details of the scheme in all respects, and in particular as to the adequacy of the southern approach to the bridge, the whole arrangement to be further subject to the Council being afforded such facilities as it may desire for constructing tramways on the new bridge and approaches, it being understood that the Council shall be under no obligation to construct such tramways, or, if constructed, to extend them to the north of Cheapside, so as to link up with the existing tramways in Aldersgate-street.

Mr. THOMAS said the Bridge House Estates committee would report after the vacation, and the court might then decide to proceed with the applications to Parliament without the concurrence of London County Council.

Sewage Pumping by Electricity.—An automatic electric pumping station owned by Norwich Corporation was opened at Eaton Village last week. The installation comprises Rees Roturbo centrifugal

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pumps and electrical plant supplied by Messrs. Laurence, Scott & Co. A float in the sewage chamber automatically turns the switch to start or stop the pumping plant. The plant was erected under the supervision of the city engineer (Mr. A. E. Collins) and his deputy.

School Ventilation.—A "Daily Express" correspondent states that electric pumps for supplying filtered air are being installed in new elementary and grammar schools in Vienna, as the dust in the air has been found to be the chief cause of consumption.

Southgate.—The agreement with the North Metropolitan Electric Power Supply Co. for the supply of electricity has been sealed. The company must lay the mains within 18 months in a number of the leading thoroughfares, but it is anticipated that supply will be available January next.

Stoke-on-Trent.—The Council on Thursday last decided, on the recommendation of the Electricity committee, to give three months' notice to terminate the engagements of the present electrical engineers of the electricity works at Burslem, Longton and Stoke (which towns, with Hanley, are now included in the new federated borough of Stoke), an amendment, moved by Ald. Malkin, that their services be retained until the chief engineer (Mr. C. H. Yeaman, hitherto of Hanley) had obtained a thorough knowledge of all the undertakings having been defeated.

West Bromwich.—The Electricity committee have declined an offer of the Shropshire, Worcestershire and Staffordshire Electric Power Co. to supply electricity in bulk to the Corporation electricity department, charges being considered too high.

West Ham.—Application is to be made to the L.G. Board for sanction to a loan of £1,500 for water-cooling plant. This loan is to be added to an application for £52,000 already before the Board.

The Borough Treasurer reported at the last meeting of the Council having received a letter from the borough electrical engineer (Mr. H. H. Couzens) as to proceeding with certain works included in the application for loan sanction, and stating that the most important matters appeared to be the Silvertown and Stratford extensions. The Borough Treasurer asked for instructions, and it was decided that a deputation from the Council, headed by the Mayor, should interview the President of the L.G. Board with a view to obtaining the necessary sanction.

Mr. Couzens has reported on the question of purchasing meters out of revenue, and has given a comparison between the cost to be defrayed each year if purchase is made direct from revenue, or on the basis of five years' loan. The figures show that while the average increase over the five years' period by paying direct to revenue on this basis is 30 per cent., the increase for the earlier years is much more, amounting in the first year to 300 per cent.

It was decided that in future the cost of meters be charged direct to revenue.

The chairman of the Electricity committee and Mr. Couzens were empowered to accept the most favourable tender for ash conveyers at the generating station. The estimated cost is £500.

In regard to a bulk supply to the Port of London Authority heads of agreement have been arranged.

It has been decided to support the Municipal Electrical Association in their efforts to promote a bill to amend the Electric Lighting (Amendment) Act, 1909, so as to secure powers to local authorities to supply and fix fittings and wires on consumers' premises, and the inclusion of the stand-by clause and the clause dealing with "supply by unauthorised undertakers," which were struck out of the act.

The borough surveyor has been instructed to obtain prices for 15 fire alarms.

Weymouth.—The L.G. Board have sanctioned a loan of £150 for tools, &c., at the electricity works.

Will.—The will of the late Major Philip Cardew, of Messrs. Preece & Cardew, and a director of the L.B. & S.C. Railway, who died on May 17 last, has been proved of the gross value of £30,332; net personalty £10,925.

Wireless Telegraph Notes.—It is announced that the traffic over the Marconi Wireless service in connection with the Crippen affair has reached nearly 100,000 words.

The interchange of duties between the signal and the wireless telegraph branches of the British nautical service has, owing to the fact that the telegraph branch cannot reach its full strength for some time, occupied the attention of the Admiralty authorities, who have directed the following steps to be taken to expedite the wireless organisation on board ship to the full extent possible with the number and grades of ratings available:—

1. Every effort is to be made to train young signalmen to take a share of the work in the wireless room in conformity with the intention of the Admiralty letter issued July, 1908, and, so far as is practicable, ordinary deck hands are to be utilised in subsidiary wireless telegraphy duties. With daily practice and careful training it should be possible to make in any case a proportion of the signal staff competent to take their turn in the wireless cabinet.

2. Commanding officers are also to take steps to secure, if possible, further interchange of duties between the wireless and signal staffs by employing wireless ratings off watch for two or three hours a day on the bridge. It is considered that the ordinary day's work of wireless ratings need not necessarily be limited to a maximum of six hours in the wireless room, and that a turn of employment on deck would be of advantage.

3. In order to afford further relief to the signal and wireless staff, all signalling is to be reduced to a minimum, compatible with actual service requirements.

In another column of this issue, an Act is set out which recently came into effect in America, providing for the compulsory equipment of wireless telegraph apparatus on board certain vessels entering or leaving United States ports. A similar measure is before the British Parliament, and is being discussed in shipping circles. At a recent meeting of the North of England steamship owners a special committee was appointed to draft objections to this measure.

The success which has attended trials of wireless telegraphy on one of the Brazilian railways (the Madeira-Mamoré Railway) has led to the Minister of Public Works being authorised to receive proposals for the installation of three radio telegraphic stations (Marconi system) in the Province of Acre, for which there may be a public call for tenders.

We recently reported that the use of wireless telegraphy by the fishing fleet which centres at Grimsby had not proved of the service which was anticipated. The owners of a German fleet of fishing boats appear to have been more successful, and have employed wireless communications as a means of consolidating their fleet and systematising the catch, at the same time regulating their supplies to the markets in such manner as to make them more regular and by avoiding gluts of greater value.

It was to be expected that the most would be made of the opportunities afforded by wireless telegraphy on board the ocean liners by those who are blessed with a large share of this world's wealth. It is reported that a number of ladies travelling on the liners have utilised these facilities for "shopping by wireless." While the money lasts there are potentialities here.

Workhouse Lighting.—At the meeting of Tipperary Guardians last week the chairman referred to a motion standing in his name in reference to the borrowing of £2,280 for lighting and heating the workhouse, which motion, he said, fell through on account of his unavoidable absence.

He saw by the press reports that he was supposed to be under censure for handing in such a motion, but a majority of the board had signed a form in favour of borrowing the amount. Mr. Lawless (electrical engineer) had estimated that the total yearly cost of repaying the principal and interest on the loan, depreciation and cost of fuel and wages would be £405. 10s., whereas the lowest figure to which fuel and gas could be brought was £682, so that there was a balance of £277 odd in favour of electricity.

The chairman subsequently gave fresh notice of the motion.

Wrexham.—The Council have applied for sanction to a loan of £3,345 for extensions of the electricity works.

COLONIAL AND FOREIGN NOTES.

Australasia.—The "Age" (Melbourne) states that Melbourne Corporation intend to raise a loan of £300,000 for public works, including £86,000 for extensions of the electricity supply undertaking.

For the supply of water from the Hawkesbury river to Hawkesbury Agricultural College electric pumping plant has recently been installed for the N.S.W. Public Works Department. The plant includes a Sentinel engine coupled to a British Westinghouse dynamo, which supplies current for operating "Bon Accord" centrifugal pumps. The water is pumped nearly 4 miles, and the current is transmitted that distance from the generator at the college to the motors for operating the pumps at the river side. The supply of water thus delivered averages 9,700 gallons per hour.

The "Australian Mining and Engineering Review" says Mr. G. H. Lofts has prepared plans in connection with the projected electric lighting and power supply in Ulverstone (Tasmania), and tenders will shortly be invited for supply of plant, including two Babcock & Wilcox boilers with superheaters, 80 B.H.P. non-condensing engine direct-coupled to a 50 kw. 440-500 volt dynamo, two balancers and boosters, &c. A 250 cell storage battery is also to be installed, and about 36,500 yds. of mains and cables will be required.

Chillagoe (Queensland) Council have been approached on the subject of lighting the streets electrically.

Euroa (V.) Shire Council have appointed a sub-committee to report on the practicability of establishing municipal electricity works.

Austria-Hungary.—It is stated that Budapest Municipality have not been able to come to an agreement for taking over the remainder of the concession of the two great electric supply companies of that city, and are consequently considering a project for the erection of a third electric power station to be carried on under their own control.

France.—Consul C. A. Payton (Calais) writes that the harbour authorities are arranging a submarine bell at the extremity of the east pier at Calais, so that the mail boats, being fitted with telephonic

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receivers, will be able to direct their course to the entrance of the harbour.

From Boulogne Vice-Consul Farmer reports that there is a "Renard" road service between Wimereux and Audresselles.

Vice Consul Walker (Lille) states that his attention has been drawn to the difficulties experienced at the customs since April 1 by importers of British machinery, when the new tariff came into force. To avoid trouble and possible fines it should be observed that on declaration at customs a plan or drawing of the machine must be produced. The weight of the machine must be given very exactly, and extra change pieces should be packed apart from the machine, and declared separately.

Holland.—The communal authorities of Groenlo have granted a concession for the construction of a tramway from Boreulo to Winterswijk, thence to the German frontier.

Nymegen communal authorities have decided to take over the working of the steam tramways and to convert them to electric traction at a cost of about £80,000.

Amsterdam Municipality are purchasing some new machinery for their electric power works and are about to enlarge the electric tramcar depots.

A project for the establishment of an electric power station for the towns of Deventer and Zwolle has been adopted by Deventer Municipal Council.

Italy.—The Italian State Railways Department, have prepared a project for the electrification of about 553 miles of the State Railways, and the erection and equipment of hydro-electric works near the river Wuocken.

Japanese Customs Duties.—A publication is issued by the Tariff Commission on the effect which the proposed Japanese Tariff (which comes into force July 1, 1911) will have upon British Trade.

It is stated that taking the 16 leading groups of commodities exported to Japan (which accounts for 90 per cent. of the trade) the increases since 1895 have been: United Kingdom £4,750,000, or 116 per cent.; Germany £3,000,000, or 300 per cent.; United States £3,000,000, or 1,400 per cent. German progress in Japan is especially marked in iron and steel and chemicals, and the United States has advanced mainly in iron and steel and machinery. The United States has the predominant share of Japanese import trade in electrical machinery; Germany predominates in locomotives and iron bars; and Gt. Britain in ships and in textile machinery.

According to Japanese trade returns the average duty collected on dutiable goods from all countries in 1909 was 16 per cent. An examination of items representing over 85 per cent. of these imports shows that if the new tariff comes into force without amendment the average rate of duty on dutiable goods from all countries will be increased to 23 per cent., or nearly one-half. On United Kingdom imports alone the average rate will be increased from 10½ to 17½ per cent., or two-thirds. The dutiable imports from the United Kingdom are about one-third of the total from all countries. The United Kingdom, however, sends about one-half of the articles which have to bear the principal increases of duty. Thus the amount of imports from the United Kingdom likely to be excluded under the new tariff is estimated at between one-third and one-half of the total of 20 million yen.

Amongst the proposed new duties are the following (present duties shown in parentheses):—Incandescent lamp filaments, 20 per cent. (30 per cent.); electric batteries (other than accumulators and dry batteries), 25 per cent. (20 per cent.); steam turbines, 20 per cent. (15 per cent.); dynamos combined with steam turbines, 20 per cent. (15 per cent.); motive machinery (n.o.p.), 20 per cent. (15 per cent.); gas engines 26·4 per cent. (15 per cent.); motors 28·4 per cent. (15 per cent.).

Statistics appended to the publication show that amongst the imports to Japan in 1909 from the U.K. and from all other countries were the following:—Submarine and underground cables, British, £20,000, other countries, £37,000; insulated wire £109,000 and £155,000; parts of electric cars, £36,000 and £115,000; steam engines £59,000 and £72,000; gas, oil and hot air engines £30,000 and £39,000; steam turbines £4,000 and £24,000; electric machinery £84,000 and £306,000; steam boilers £86,000 and £93,000.

Russia.—Mr. C. S. Smith, British Consul-General at Odessa, has written an interesting note on the subject of the advantages and disadvantages of exhibiting machinery at Russian exhibitions. The general trend of Mr. Smith's remarks go to show that the game is not worth the candle. The expenses of exhibiting in Russia appear to be very heavy without showing any adequate return.

U.S. Compulsory Wireless Act.—Following is a copy of the Compulsory Wireless Act recently passed by Congress (and formally approved June 24, 1910), and which has now become law in the United States:—

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after July 1, 1911, it shall be unlawful for any ocean-going steamer of the United States, or of any foreign country, carrying passengers and carrying 50 or more persons, including passengers and crew, to leave or attempt to leave any port of the United States unless such steamer shall be equipped with an efficient apparatus for radio communication, in good working order, in charge of a person skilled in the use of such apparatus, which apparatus shall be capable of transmitting and receiving messages over a distance of at least 100 miles, night or day: Provided, that provisions of this Act shall not apply to steamers plying only between ports less than 200 miles apart.

(2). That for the purpose of this Act apparatus for radio-communication shall not be deemed to be efficient unless the company installing it shall contract in writing to exchange, and shall, in fact, exchange, as far as may be physically practicable, to be determined by the master of the vessel, messages with shore or ship stations using other systems of radio-communication.

(3). That the master or other person being in charge of any such vessel which leaves or attempts to leave any port of the United States in violation of any of the provisions of this Act shall, upon conviction, be fined in a sum not more than $5,000, and any such fine shall be a lien upon such vessel, and such vessel may be libeled thereafter in any district of the United States within the jurisdiction of which such vessel shall arrive or depart, and the leaving or attempting to leave each and every port of the United States shall constitute a separate offence.

(4). That the Secretary of Commerce and Labour shall make such regulations as may be necessary to secure the proper execution of this Act by collectors of Customs and other officers of the Government.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Aberdeen.—The accounts of the tramways department for the year ended May 31 last show capital expenditure £353,078, against which £37,250 has been appropriated for depreciation, £28,399 contributed to sinking fund, £103,601 placed to renewal account, while the amount paid out of revenue for preliminary and Parliamentary expenses and written off property is £7,658.

Revenue was £71,121 (decrease £559), including traffic receipts £70,078, of which £64,688 was received on Corporation cars and £5,390 on the Suburban Co.'s cars. Working expenses were £40,452 (increase £257), gross profit was £30,670. Interest, commissions and stamp duty required £8,574 and sinking fund £3,858. The amount provided for depreciation was £3,370, while £214 was written off property and £14,654 placed to renewal account. 17,156,050 passengers were carried and 1,585,137 car-miles run. Total income was 10·77d. per car-mile, working costs 6·13d., gross profit 4·64d., and the net balance of £14,654 (after payment of interest, sinking fund, &c.) was equal to 2·22d. Current consumed was 1·18 units per car-mile, the cost per unit was 1·08d. and the cost of current per car-mile 1·27d.

The report of the general manager, Mr. R. S. Pilcher, states that the Highland and Agricultural Show last year accounts for £500 of the difference in revenue. At the beginning of the year all the cars were equipped with meters, and £571 was saved by this means. Corrugations are beginning to appear on all the rails, and it is noticeable that where the speed of cars is increased the corrugations get gradually worse. Carborundum blocks have been fitted to a car, and it is found that corrugations are easily ground out by running this car backwards and forwards.

Bath.—The accounts of the electricity department for the year ended March last show capital expenditure £164,945 (increase £951). The total amount borrowed is £162,698 and £47,710 has been repaid or set aside for repayment.

Revenue was £19,651 and working and general expenses £10,460, leaving gross profit £9,187. After writing off £4. 13s. 7d. for bad debts, £1,661 was brought from suspense fund to meet the balance brought forward from last account, and £882 has been taken from reserve to meet interest, sinking fund contribution and £128 charged for depreciation, a debit balance of £580 being carried forward. 1,752,420 units were generated, 409,392 supplied to public lamps, 9,120 by contract and 965,177 to private consumers by meter. The total maximum demand was 1,101·6 kw. There are 187 arc and 62 incandescent lamps for public lighting.

Bradford.—The profit on the electricity undertaking during the past year was £7,399 (compared with £2,146 the previous year). Income was £3,740 more, and working and administrative expenses £1,284 less than in the previous year. Interest and sinking fund charges were £55,736 (decrease £230).

The city electrical engineer (Mr. T. Roles) states that the increase in income was almost entirely due to current supplied for power and to bulk supply consumers, and it is hoped that the further reduction in charge recently made to this class of consumers will increase the connections and thus further increase the revenue.

Epsom.—The accounts of the electricity undertaking for the year to March last show capital expenditure £39,507 (increase £2). £10,166 has been repaid out of £39,242 borrowed.

Revenue was £5,358 and expenditure £2,427, and after allowing £27 for bad debts and allowances the gross profit was £2,903 (compared with £2,064 on previous year). Loan charges were £2,718 (against £2,744) and there was a net profit of £185, compared with a deficit of £680 on previous year's working. Units generated were £299,283 (compared with 276,395), public lamps took 109,948 (106,588) and private consumers 140,932 (115,535). The total maximum demand was 198 kw. (196 kw.). The number of (equivalent) 8 c.p. lamps connected for private consumers is 18,111.

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Hove.—The accounts of the Corporation's Aldrington electricity supply undertaking for the year ended March show capital expenditure £9,314 (increase £294), loan outstanding £7,905.

Revenue was £746, working and general expenses were £590, balance carried to net revenue account £156. Capital charges were £561, so that the net deficit is £404. The units purchased from Brighton Corporation were 41,407; public lamps used 7,525 and private consumers 30,914. The total maximum supply demanded was equal to 35·5 kw.

Tonbridge.—The accounts of the electricity department for the year ended March show total capital expended of £25,887, an increase of £1,007 on the year.

Income from the sale of current by meter was £2,656 and from public lighting £622, the total receipts being £3,444. Working expenses were £1,742, leaving a gross profit of £1,701 to meet interest £(789) and sinking fund instalments (£928). The net deficit was £16, against £199 243,302 units were generated; 193,493 units were sold (145,810 to private consumers and 47,683 supplied to public lamps). The total maximum supply demanded is 157 kw. (against 133 kw.).

Tunbridge Wells.—*Correction.*—In the note on page 664 of our last issue the price of current for lighting was stated to be 4¼d. This should be 4½d.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W., and also from Messrs. R. W. Cameron & Co., 23, South William-street, New York, and Mr. H. Stephenson Smith, 244, California-street, San Francisco, Cal. Tenders must state the name of the country in which the apparatus, &c., will be manufactured. Further particulars are given in an advertisement.

LONDON County Council invite tenders for the covering with asbestos tape of certain electric cables in manholes in the south of London. Specification, drawing, form of tender, &c., from the Clerk of the Council, Spring Gardens, S.W. Tenders must be in by 11 a.m. Aug. 30. See also an advertisement.

LONDON County Council also invite tenders for wiring and fitting for electric lighting of the second section of the central car repair depot, Woolwich-road. Specifications, &c., from the Clerk of the Council, County Hall, Spring-gardens, S.W. Tenders by 11 a.m. Tuesday, Aug. 30.

Tenders are invited for supply to the Corporation of the City of MELBOURNE of 4,840 yds. single conductor lead-covered cable, suitable for use on a circuit having a working pressure of 460 volts, and 880 yds. concentric lead-covered cable for use on a circuit having a working pressure of 2,000 volts. Specifications, forms and conditions from Messrs. Mellwraith, McEacharn & Co. Proprietary (Ltd.), Billiter Square-buildings, London, E.C., to whom tenders by noon Tuesday, Aug. 23. See also an advertisement.

Tenders are invited up to Sept. 7 for supply of battery material and glassware to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Official Secretary in Great Britain of the Commonwealth of Australia, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to Sept. 20 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA (Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

The Burgemeester en Wethouders van AMSTERDAM announce that on Aug. 22, 1910, the Corporation will receive tenders for delivery and erection of a 6,000 kw. steam turbo-generator unit for the Corporation electricity works. Specification (in German), price Fl.2.50) and further particulars from the Gemeente-Electriciteitswerken, Hoogte Kadyk 200, Amsterdam, Holland. See also an advertisement.

NEWPORT (Mon.) Electricity and Tramways committee invite tenders for supply of carbon filament electric lamps, radiator lamps (British made), flame arc lamp carbons for Excello and Oliver type lamps, and a.-c. and d.-c. two-rate and prepayment meters, during the ensuing 12 months. Specification and schedule from the borough electrical engineer and tramway manager, Mr. H. Collings Bishop, M.I.E.E. **Tenders to the Town Clerk, Town Hall, Newport, Mon., by first post Aug. 15.**

OLDHAM Surveyor's and Tramways committee require tenders by Aug. 17 for materials and labour (except electrical equipment) required in construction of a tramway. Forms, &c., from the Borough Surveyor.

CHELMSFORD Education committee want tenders by Aug. 31 for electric light wiring at Trinity-road school. Forms, &c., from Mr. W. H. Pertwee, London-road, Chelmsford.

SALFORD Tramways Committee want tenders by 10 a.m. Aug. 15 for supply of 500 tons of steel tramway rails. Specification, &c., from general manager.

DUNDEE Corporation want tenders by 10 a.m. Aug. 8 for supply of 45 tons of steel tramway rails. Specifications, &c., from City Engineer.

SOUTH SHIELDS Corporation require tenders by Aug. 8 for the supply of a travelling crane for the tramcar depot. Particulars from the Manager and Engineer.

Tenders are required by 11 a.m. Aug. 9 for erection of CHISWICK telephone exchange. Specification, &c., from Mr. J. Rutherford, H.M. Office of Works, London, S.W.

BELFAST Harbour Commissioners want tenders by Aug. 10 for the supply of 22 electric flame arc lamps. Specification, &c., from the harbour engineer, Mr. W. Redfern Kelly.

Tenders are invited for the supply of 3 tons 2 cwt. of bare h.d. copper cables to the Corporation of MELBOURNE (Australia). Specifications form of tender, &c., from the Agents of the City Council, Messrs. Mellwraith, McEacharn & Co., Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon, Aug. 16.

The Deputy Postmaster-General, BRISBANE, will receive tenders until noon Sept. 7 for supply of glass cells, corks and tubes and porous cups for batteries, battery material, chemicals, &c. Specifications, &c., from the High Commissioner for the Australian Commonwealth, London. Local representation is necessary.

The Deputy Postmaster-General, MELBOURNE (Victoria), will receive tenders until 3 p.m. Aug. 30 for supply of electrical sundries, insulators, wire and sulphate of magnesia. Local representation necessary. Further particulars from 72, Victoria-street, London, S.W.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The Italian State Railways Administration, 16, Via Ludovici, ROME, want tenders by Aug. 22 for supply of 584,000 common carbons for arc lamps. Only firms on list kept by administration are generally allowed to tender. Local representation is practically necessary.

Tenders will be received at Spezia and Venice until 11 a.m. Aug. 13 for supply of electric wires and cables to the ITALIAN STATE RAILWAYS Administration. Specification (in Italian) at 73, Basinghall-street, London, E.C. Only firms on Government list are usually allowed to tender.

The Direction Générale des Ponts et Chaussées, 38, rue de Louvain, Brussels, want tenders by Sept. 11 for supply and erection of four electric travelling cranes on the tidal quay at OSTEND. The conditions are set out in "Cahier des Charges," No. 54 of 1910, which may be obtained (price 4d.) from the Bureau Central des Renseignements, 15, rue des Augustins, Brussels.

The directorate of the Austrian State Railways, Vienna, will open tenders on Aug. 7 for the erection and equipment of electricity supply works at PARDUBITZ (Austria).

LOURENÇO MARQUES Harbour & Railway Board want tenders by 2:30 p.m. Sept. 5 for supply of seven electric 5-ton quay cranes and one electric 10-ton quay crane. Conditions, specifications, &c. (on deposit of 40/6) and English translation of conditions (20/3) from the Direcção dos Caminhos de Ferro Ultramarinos, Lisbon, from the Railway & Harbour Board, Lourenço Marques, or from their agent at Johannesburg.

TENDERS RECEIVED AND ACCEPTED.

St. Pancras (London) Council received the following tenders for 21 flame arc lamps:—

Union Electric Co. (Excello), (*accepted*) **£216. 11s.**; Electrical Co. (tender incomplete, carriers not included), £86. 13s. 6d.; Foster Arc Lamp & Eng. Co. (did not supply sample lamp), £116. 7s. 6d.; Abbey Electric Co. (no carriers included, tender incomplete), £165; Arc Lamps (Ltd.) (more substantial carrier £60 extra), £183. 8s.; Gilbert Arc Lamp Co., £184; Beck Flame Lamp Co. (the tenderers suggested that present carriers will be suitable, but this was not found to be so), £189; Maxim Lamp Works, £210; Johnson & Phillips, £213; Crompton & Co. (arbitration clause and penalty objected to), £222; Oliver & Co. (includes London Electric

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Firm's lowering gear; if no gear then £220), £250; General Electric Co., £300; British Westinghouse Co., £308; Jandus Arc Lamp & Electric Co., £315. 9s. 6d.

The engineer-in-chief (Mr. S. W. Baynes) reported that he had kept the lamps in the seven lowest tenders which complied with the specification under observation for some weeks—the Davy, Gilbert, Beck, Maxim, Johnson & Phillips, "Excello" and Crompton. He found the "Excello," Crompton and Johnson & Phillips lamps the most suitable for the Council's purposes, and of these three he recommended the "Excello" as the one which should be accepted, especially as this lamp had been in use outside the Council's showrooms for nearly four years with marked success.

The following tenders were received by St. Pancras (London) Council for an additional boiler at King's-road generating station :—

Edwin Danks & Co. (*accepted*), **£2,600** (cost of re-erecting if required, £200), alternative, £2,400 (£49); Hawksley, Wild & Co., £3,081 (£70); Babcock & Wilcox, £3,200 (£70); Clarke, Chapman & Co., £3,260 (£100).

Mr. Baynes' report on the tenders gave the relative grating and superheating areas of the boilers quoted for, and advised that the lowest offer be accepted. A communication had been received from Babcock & Wilcox stating that, for the efficiency guaranteed by Messrs. Danks it was essential to adopt the system of baffling, which is a subject matter of a patent of theirs for the type of boiler offered, and the firm considered it advisable to inform the Council that Messrs. Danks & Co. had recently issued a publication copying their marine type boiler and embodying a patent of theirs, and they had accordingly entered an action for infringment against E. Danks & Co., who, however, had given a satisfactory indemnity, and have agreed that 45 per cent. of the contract money should be retained by the Council until all patent rights were legally decided.

Ealing Council have received the following tenders for supply and erection of surface condensing plant.

Willans & Robinson (*accepted*)	**£2,095**
Browett, Lindley & Co.	2,700
Cole, Marchent & Morley	2,605
Davenport Engineering Co.	£2,410 and £1,984 10s.
J. P. Hall & Sons	2,385
Mirrlees-Watson Co.	3,050
L. Schwarz & Co.	£3,308 and £2,529
I. Storey & Sons	3,141
G. & J. Weir	3,670
West London Engineering Co.	1,965
Worthington Pump Co.	£2,730 and £2,160
Ledward & Beckett (evaporative condenser)	7,100

Grimsby Council have accepted the tender of Accumulator Industries (Ltd.) for supply of metallic filament lamps for street lighting, and that of E. A. Hall for fixing two 18 in. fans in the Council chamber at £20. 2s. 6d.

Leyton Council have accepted the tender of Headland & Headland (at £9. 10s.) for supplying tantalum lamps of 32 c.p., each, and an order has been placed with the Electrical Joint Box Co. for 25 additional public lighting lanterns.

Littleborough Council have accepted the tender of W. T. Henley's Telegraph Works Co. for h.t. feeder cables, l.t. distributors, road work, &c., and for transformer kiosk with transformers and equipment and switchgear in sub-station.

Stoke-on-Trent Council have accepted the tender of the Sloan Electrical Co. for 1,000 pairs of Excello flame arc lamp carbons at £20. 4s. 2d.

The North Riding of Yorks Council have accepted the tender of Cox-Walkers (Ltd.) for telephones at Northallerton County Hall and police buildings.

West Ham Council have placed an order with the British Thomson-Houston Co. for a Tirrill regulator at £83, and with the British Westinghouse Co. for switchgear at £573.

Beckenham Council have accepted the tender of O. Jones & Co., for wiring Alexandra Schools at £202.

Luton Council have accepted the tender of Clarke, Chapman & Co., for a watertube boiler and superheater, with stoker, at £1,617.

Hendon Council have accepted the tender of Waring & Gillow for wiring the Council's offices.

Rotherham Education committee have accepted the tender of Hall & Matthews for wiring the South Grove schools at £117.

Rugby Council have accepted the tender of W. T. Henley's Telegraph Works Co. for cables.

Bridlington Council have accepted the tender of the British Westinghouse Co. for 12 months' supply of metal filament lamps.

The Chloride Electrical Storage Co. are supplying a battery and Entz booster equipment for Delagoa Bay.

BUSINESS NOTICES.

Wm. J. R. Fox the younger and Arthur Brooke (trading as Fox & Co.), electrical engineers, Victoria Garage, Bradford-road, Batley, have dissolved partnership. Debts by Mr. Brooke

The telegraphic address of Mr. D. Jaroslaw, of 5, George-street, Tower-hill, London, E.C., is now "Splittings London."

The Dowson & Mason Gas Plant Co. (Ltd.) has been formed to combine the business of the Dowson Co. with that of the Mason Co., of Manchester. The Dowson gas plants will still be used for engine work, and the Mason furnaces and producers will be used for furnace work. The works of the combined company will be at Levenshulme, Manchester, and the London office will be continued at 39, Victoria-street, Westminster. Mr. Dowson will act as engineer and managing director of the combined business.

We are asked to state that Mr. E. P. Allam has disposed of his entire interests in the Premier Electric Control (Ltd.), and has now no connection with the company.

The London offices and showrooms of the British Home & Office Telephone Co. have been removed from 6, Holborn-viaduct to 15, and 17, City-road, E.C.

Plant for Sale.—Two gas driven alternator sets of 250 kw. each are advertised for sale.

Patents Development.—The proprietors of patents No. 23,878/1900 for "Improvements in process of and mechanism for separation of conductors from non-conductors," and No. 29,363/1904, for "Improvements in and relating to electrical measuring instruments," desire to enter into arrangements for exploiting same in this country. Communications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton buildings, London, W.C.

The proprietor of patent No. 21,299/1907, for a "System of directed wireless telegraphy," desires to arrange by licence or otherwise for the manufacture and commercial development of the invention in this country. Address Messrs. Herbt. Haddan & Co., 31 and 32, Bedford-street, London, W.C.

The proprietor of patent No. 18,565/1906, relating to "Electrodes for secondary batteries," desires to license British manufacturers to work the patent in Great Britain, and he is also willing to consider propositions for the sale of the patent. Address Messrs. Boult, Wade & Tennant, 111 & 112, Hatton-garden, London, E.C.

The proprietor of Patent No. 27,006/1906, relating to "Apparatus for producing oxides of nitrogen by electric process," desires to enter into arrangements for exploiting same in this country. Particulars from Messrs. Wheatley & Mackenzie, 40, Chancery-lane, London, W.C.

Science at the Japan-British Exhibition.—In connection with our note on this subject last week Messrs. H. Tinsley & Co. point out that the double wattmeter, phase shifting transformer and alternate-current potentiometer there shown were made by them and were largely designed and developed in their shops. The same firm is responsible for the manufacture of Dr. Drysdale's current potentiometer.

CATALOGUES, &c.

Siemens' Electro-medical Apparatus.—A recent catalogue of Messrs. Siemens Bros. & Co. deals with "The Skiafax." The apparatus described therein is a simple and inexpensive fixing and holding device for securing the head and all the parts of the body in any desired position during X-ray treatment. It should meet a long-felt want, in that in the majority of cases it entirely supersedes sand bags, pillows, straps and other inefficient methods of holding, involving considerable trouble and time in their preparation for use. A supplement (No. 4) deals with "X-ray Outfits with Rotating High-tension Rectifiers." This supersedes one of similar title dated April, 1909, and describes and illustrates new and improved patterns of these modern X-ray outfits, which are claimed to be superior to any other similar form of outfit now on the market. Another supplement (No. 10) is entitled "Universal Electro-medical Apparatus," and describes apparatus which has been designed as a result of long experience in connection with medical applications of electricity for cautery, faradisation, galvanisation, galvano-faradisation, light, &c. It combines all these applications in a handy and portable form, its chief qualification being that it is entirely "earth free." "Tantalum Dental Instruments" are dealt with in the last of a series of pamphlets. These instruments are made of pure tantalum metal with the usual steel handles. They are particularly suited for certain specific dental purposes on account of the fact that they are not affected by any re-agent met with in dental practice, being attacked by only one acid—hydrofluoric acid. In consequence, they may be used with all silicate cements without being affected by the cements or staining them, as is the case with steel instruments. In addition, they are very hard, and sufficiently elastic to enable them to be made fine enough to penetrate into difficult positions, which is not the case with agate and ivory, as frequently used with silicate cements.

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BITUMEN CABLES AND MINING ACCESSORIES.—The British Insulated & Helsby Cables have issued a catalogue dealing with this subject, wherein is to be found just the required information on cables, both for power and telegraph and telephone work; on cable accessories, such as drum stands, shaft cleats, cable suspenders and joint boxes; and on switches, switch fuses and watertight fittings. Details are given of electric haulage locomotives, tramway fittings and accessories for overhead electric power work generally. Exploders, mining bell apparatus and telephone instruments are also dealt with. The catalogue should be in the hands of all mining engineers, representing as it does the methods by which this class of work should be carried out.

MOTOR COACHES AND LOCOMOTIVES FOR SINGLE-PHASE RAILWAYS.—An interesting brochure is to hand from the Allgemeine Elektrizitäts Gesellschaft of Berlin containing what is practically an historical account of the single-phase motor in its application to railway working. The booklet should be especially interesting when studied in connection with the Papers which have been read during the past week before the Institution of Mechanical Engineers. Excellent illustrations are given of various types of single-phase motor cars and locomotives made by the company.

BANKRUPTCIES, LIQUIDATIONS, &c.

A first and final dividend of 7s. 3d. will be payable on Aug. 11 at 10, Acresfield, Bolton, to creditors of Joseph Platt and Richd. Bleasdale, electrical engineers, Victoria-square, Bolton.

The first meeting of creditors of Harold Bristow, electrician, &c., 368, Hessle-road, Hull, will take place on Aug. 4 at York City Bank-chambers, Lowgate, and the public examination on Aug. 15 at the Town Hall, Hull.

The discharge of A. J. Hollington, electrical engineer, of 37, Walbrook, E.C., has been granted, subject to a judgment for £25 to be satisfied within a month.

The Newarc Lamp Synd. (Ltd.) is being wound up voluntarily. Mr. J. C. Young, 9, King William-street, London, E.C., is liquidator.

The Crystalate Mfg. Co. (Ltd.) is being wound up voluntarily for reconstruction. Mr. P. Warnford-Davis and Mr. J. P. Bell, both of 61½, Fore-street, London, E.C., are liquidators.

Deed of Assignment.—A dividend is to be declared under a deed of assignment executed on August 17, 1909, by Wm. G. Stillman and Hy. A. Stonham, electricians, Mount Ephraim, Tunbridge Wells. Claims to Mr. W. D. Goatly, 11, Old Jewry-chambers, London, E.C., by August 22.

COMPANIES' MEETINGS AND REPORTS.

Anglo-American Telegraph Co. (Ltd.)

The half-yearly meeting was held on Friday last, Mr. R. H. BENSON presiding.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting and the auditors' report.

Mr. R. H. BENSON said the shareholders would be sorry to hear that the chairman of the company, Mr. Bevan, was too unwell to be present. The traffic receipts, as compared with those of last year, showed an increase of £7,000, but the amount earned by the ss. "Minia" being £10,300 less than in the corresponding period, there was, including other items, a net decrease of receipts of £2,810. The figures, after all, were for the half year only. The more important accounts were those which would be presented next January for the half-year which ended on Dec. 31. He had to touch upon a matter of general policy, and in order to make it intelligible it was necessary to shortly recapitulate the strategic position of Atlantic cables. There were to-day 16 cables laid between Europe and America controlled by four different competing parties. Seven out of 16 cables, including the four which the company owned, were in partnership for the purpose of mutual assistance and better service to the public. One of their partners was the Direct Company owning one cable; the other was the Western Union Telegraph Co., which, besides two cables, owned some 1,400,000 miles of land lines in North America. Similarly the Commercial Cable Co., with five cables, owned the Postal Telegraph Co., with 330,000 miles of land lines reaching the most important cities. In addition to the Western Union and Postal Companies, which were telegraph companies only, there had grown up a still more powerful company, the American Telephone & Telegraph Co., with over £100,000,000 sterling of capital and surplus, and which pays 8 per cent. dividend on £50,000,000 to £60,000,000 capital stock. Last winter that great company became interested financially in their partner, the Western Union Telegraph Co. There were businesses in which competition, so dear to the Anglo-Saxon heart, failed to produce the most economical results. The telephone, telegraph and cable business was an instance. It happened that the chairman of the American Telephone & Telegraph Co. was in England during the month of May on a holiday, and while he was here he gave the order to lay another cable in the Atlantic. The board viewed with great interest this order for a new Atlantic cable given by the chairman of a powerful and independent company which owned over 10,000,000 miles of land wires, of which 1,800,000 miles were trunk lines available for telegraphs as well as telephones. They were glad to find that there was no question of introducing more competition into the ocean business, and in fact the order for the new cable, although given by the chairman of the Telephone Company, was given with the intention of using it on behalf of their friends and partners the Western Union Telegraph Co., and in anticipation of their coming to terms. The prime object of this move was greater efficiency and a better service to the public to be followed by a larger business, less friction, and finally greater economy of operation. Whereas in 1896 (a year of extreme depression) the total revenue was £324,899 gross and £185,500 net, last year it was £426,753 gross and £255,644 net. Though the increase was encouraging, during those 14 years the general business of America had increased in greater ratio still, and, although our staff transmitted more than 24 per cent. more traffic than in 1908, and during the six months under review 40 per cent. more than in the corresponding period last year, they had not, nor had their partners, the Direct and the Western Union, under existing conditions and arrangements, profited as much as they were entitled to expect in the total increase of cable traffic. It was possible that if they succeeded in identifying their interest with that of the American Telephone & Telegraph Co. they might participate more largely henceforward in the growth of the business. The board were unanimous in desiring an agreement on the basis of not jeopardising present dividends and of securing besides a fair percentage of whatever increase of cable business the future might bring forth. They also wanted more unity of management, and complete harmony of the component parts in the organic whole. If this could be accomplished, and a better service offered, the board had no doubt that the public would respond by giving the company more messages. Their company, the Anglo, was agreed on principles with the American Telephone & Telegraph Co., but not yet on details. There was still much to be done. They were partners with the Direct Company and the Western Union, under an agreement which lasted for 10 more years, and no modification of it could be made without everybody's consent. If they succeeded in defining the community of interest between the four parties concerned and reached an agreement, it would be put into print and submitted to the shareholders, who would then be able to discuss it, and accept or reject it. Until then he suggested that they should refrain from putting questions which he could not answer, especially in the chairman's absence, for it was to Mr. Bevan that they owed the conduct of these negotiations. He hoped that, if they resulted in agreement, Mr. Bevan would himself be there in the best of health to submit them to the shareholders.

Mr. H. S. LEON seconded the motion for the adoption of the director's report, and

Mr. J. D. SANTILHANO having assured the chairman of the support of the Dutch shareholders in regard to the proposed agreement, a short discussion followed and the report was adopted.

London, Brighton & South Coast Railway Co.

At the shareholders' meeting on Wednesday the chairman (the Earl of Bessborough, C.V.O., C.B.) referred in terms of regret to the death of Major P. Cardew, who was a member of the board. There had been an increase of over 2,000,000 passengers and a net increase of £50,282 in gross revenue. The total increase in expenditure was £35,038, and the balance to net revenue was increased £15,244. Locomotive power expenses showed an increase of £9,092, but the item comprised both steam and electric working, and the increase might be attributed to the cost of electric current. The institution of electrical working, particularly on the system they had adopted, was admittedly a big experiment. It was not thought advisable to embark any of their own capital in erecting a generating station, and, therefore, they made arrangements with the London Electric Supply Corpn. for the supply of energy. At first only a small quantity was required, and without experience on either side it was difficult to arrange a very close contract, but now it had been decided to extend the system, and they had been able to revise the arrangement upon a very favourable basis, the working of which would produce a substantial decrease in the cost of current. The directors' report referred to the continued success of the electrical train services on the South London Railway, and the chairman said that a further portion of the suburban railways was now in course of equipment for electrical working. He told them in February of the large increase in the number of passengers which had taken place even at that early stage of the South London services, and he was glad to state that that progress had been uninterrupted, whilst there was still nothing but praise for the system from the mechanical point of view. It was too early to say much about the comparative cost of electrical and steam working, but, so far as could be foreseen, there was nothing else likely to throw any extraordinary expense upon them. In those circumstances the board felt sure the proprietors would endorse its decision to extend the system.

The present extension scheme consisted of the equipment of the railway from Peckham Rye, where a junction was made with the South London Railway, through Tulse Hill to the Crystal Palace, and from Battersea Park, where the South London Railway was joined again, through Clapham Junction, Balham and Streatham Hill to West Norwood, where the first-mentioned line was met. These lines formed a very important part of the company's suburban system, and served some of its most populous districts, most of which were intersected by the London County Council tramways. The improved services which electrification would make possible could not fail not only to bring back to the railway some of the traffic which had gone to the trams, but would also be of general benefit to the districts and in all probability produce entirely new business. Moreover,

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the scheme would be of considerable advantage to the Crystal Palace, and the board had special regard to it at this moment because of urgent representations for improved services which had been made by the promotors of the Imperial Pageant, which it was proposed to produce at the Palace in the spring of next year, and the contracts for the railway works were fixed to be completed by that time. Whilst giving full credit to the elevated electric for its part in increasing the number of passengers, of which it accounted for nearly 1,750,000, he might point out that there had been a substantial gain also in the number conveyed on their main line.

Mr. DINGWALL (shareholder) congratulated the board upon the success of the electric working and upon the generally satisfactory character of the report and accounts, which were then adopted.

BAKER STREET & WATERLOO RAILWAY CO.—The gross receipts for the half-year ended June 30 amounted to £93,891. 3s. 10d., an increase of £2,380. 18s. 2d. on the receipts for the corresponding half of last year. The working expenses were £42,078. 15s. 1d., a decrease of £145. 14s. 5d. After providing for interest, rents and preference dividend, and reserving £4,000 for contingencies and renewals, £21,973. 14s. 9d. is available for dividend, and the directors have decided to pay a dividend at the rate of 3 per cent. per annum on the "A" ordinary shares and a dividend at the rate of 2 per cent. per annum on the "B" ordinary shares, leaving £2,869. 1s. 9d. to be carried forward. The number of passengers (including workmen and season ticket holders) was 14,807,736, against 14,325,065; the average receipt per passenger was 1·43d., against 1·46d.; the train mileage was 613,316, against 637,202; and the car-mileage 1,849,918, against 1,918,562.

BLACKPOOL & FLEETWOOD TRAMROAD CO.—The directors' report for the half-year ended June 30 states that the balance of profit (including sum brought forward from previous half-year and after providing for debenture interest) is £5,277. 16s. 4d. A dividend at the rate of 4 per cent. is proposed. Passengers carried were 997,574, total receipts £11,997. 0s. 1d., and car-miles run 221,356½, compared with 232,407 in the corresponding half of 1909.

CHARING CROSS, EUSTON & HAMPSTEAD RAILWAYS CO.—The directors' report states that the London Electric Railway Amalgamation Act, 1910, received the Royal Assent on July 26, and under the provisions of that act, the undertakings of this company and the Baker Street & Waterloo Railway Co. have been amalgamated with the undertaking of the Great Northern, Piccadilly & Brompton Railway Co., as on and from July 1, 1910, and that the name of the company has been changed to the London Electric Railway Co. Arrangements will be made as soon as practicable for exchanging stock and share certificates existing prior to the date of amalgamation into stock and share certificates of the new company. The gross receipts amounted to £105,626. 12s. 5d., an increase of £444. 2s. 1d. on the receipts for the corresponding half of last year. The working expenses amounted to £55,538. 19s., a decrease of £2,256. 7s. 2d. After providing for interest and rents, and reserving £3,000 for contingencies and renewals, £16,782. 19s. 7d. is available for dividend, and the directors have determined that a dividend at the rate of ¾ per cent. per annum be paid on the ordinary shares, leaving £560. 9s. 7d. to be carried forward. During the half-year 15,264,355 passengers (including workmen and season ticket holders) were carried, against 14,862,882 in the June half of 1909. The average receipt per passenger was 1·56d., against 1·63d.; the train mileage was 1,007,534, against 991,747, and the car-mileage 2,776,545, against 3,037,858.

DEUTSCH-UEBERSEEISCHE ELEKTRICITATS GESELLSCHAFT.—The report for 1909 shows gross profit M.17,631,155 (£881,558), against M.15,077,892 (£753,895) in 1908. Net profit was M.8,346,094 (£417,305), against M.7,811,581 (£390,579). A dividend of 10 per cent. is declared, against 9½ per cent. The report contains particulars of the progress made by the Buenos Ayres electricity works and the Chili hydro-electric station, the first portion of which is practically complete.

DUBLIN UNITED TRAMWAYS CO. (1896) (LTD.).—The accounts for the half-year ended June 30 show that the amount available for division is £45,191. 4s. 8d. Besides the preference dividend, it is proposed that 6 per cent. be declared on the ordinary shares, that £4,000 be reserved for renewal of cars and the balance (£7,291. 4s. 8d.) be carried forward. Passengers carried during the half-year were 26,314,318 (compared with 25,420,241 in the corresponding half of 1909) and the car-mileage was 3,811,150 (against 3,805,979). The current consumed for operating cars, lighting, &c., being 5,779,786 units (against 5,666,876).

At the meeting on Tuesday the chairman, Mr. W. M. Murphy, said a satisfactory feature of the working of the past half-year was the increase in receipts of £5,291. The gross receipts (£144,916) exceeded even the corresponding half of the exhibition year by £2,555, and the board believed the traffics would continue to grow for years to come. In addition to the ordinary expenditure they had charged against revenue the cost of lining with ferro-concrete the steel chimneys at Ringsend (£1,161. 19s.) and the cost of an underfeed automatic stoker (£309). It had been found that the underground feeder cable on a section of the Howth line where the tide flowed was subject to frequent interruptions owing to the corroding effect of the sea water on the covering of the cable, and an overhead feeder cable (costing £653) had been fixed along that section, and the cost of that had also been charged to revenue. From a promised refund of overpaid income tax, and by the aid of part of the profits of the half-year ended Dec. 31 last, £15,000 was appropriated in advance towards relaying the tram rails. The income tax authorities ultimately refunded £6,202, reducing the appropriation for relaying rails from £15,000 to £13,051. A provision of £4,000 had been made for six new double-truck top-covered cars for the Dalkey line. The board were offering to the shareholders (at £11. 10s. per share) the additional capital which they propose to raise. They had been engaged for the past three or four years in renewing the track, and they had had proof that the increasing traffic and increasing gross profits were able to meet all demands without affecting the dividends, which they had been regularly paying for the past seven years.

EDMUNDSON'S ELECTRICITY CORPN. (LTD.)—The chairman (Mr. P. Debell Tuckett) stated at the recent meeting that all-round progress had distinguished the operations last year. The expenses were reduced by over £1,000, while the loss on working the local authorities' undertakings had been reduced by £722. 13s. 10d. and the Urban Company guarantee was less by £2,505. After paying debenture interest (£10,768) and adding £14,809 brought forward, there remained £25,577, which the directors recommended should be carried forward.

GREAT CENTRAL RAILWAY CO.—The report of the directors states that good progress has been made with the electric railway between the Alexandra Dock, Grimsby and Immingham, which will shortly be ready for opening.

GREAT NORTHERN & CITY RAILWAY CO.—The report of the directors for the half-year ended June 30 states that the total revenue for the six months amounted to £39,662. 16s. 3d., and the cost of working to £19,878. 19s. 5d., equal to 50·12 per cent. of the receipts. Net revenue amounts to £19,783. 16s. 10d., which is insufficient to meet the fixed charges for the half-year, and £3,162. 16s. 8d. has been provided from outside sources. The number of passengers for the six months (including season ticket holders) was 5,966,114, against 6,041,755 for the corresponding period last year. The number of local season tickets issued during the half-year was 2,539, against 3,345. The number of three-route season ticket holders was 2,728, against 2,725.

At the general meeting on Wednesday the chairman of the company (the Earl of Lauderdale) said that the traffic showed a decrease of 75,641 passengers and of £525 in revenue, compared with the same period of last year. Of the net decrease, more than half, or £288, was attributable to local bookings, where tram competition was severely felt. Added to the deficiency in traffic revenue they had also suffered a decrease of £614 in miscellaneous receipts. On the other hand, they had reduced the working expenses by £1,161, leaving a small balance in favour of the past half year, and reducing also the percentage of working expenses from 51·56 to 50·12 per cent. As to the final result, they were short by £3,163, against £3,029 last year, and that deficiency had been balanced, as before, by a gift from those of their friends who were interested in the welfare of and had confidence in the undertaking. The bill for subway communication between their station at Moorgate, the City & South London Railway and the Metropolitan Railway had passed through Parliament, and the work would be undertaken as soon as practicable. The whole of North London had been extraordinarily affected in the last few years by the opening of the electric trams and of the Great Northern, Piccadilly & Brompton Tube. The midday traffic of ladies shopping, which used to form a regular feature of their own railway, had greatly diminished, and, for the time, at any rate, shoppers appeared to be going further afield. The convenience of the electric trams had been dearly bought at the expense of the people, but fortunately it was impossible to place any limit on the growth of London traffic, and they could only hope that their railway would ere long once more begin to attract that traffic which its convenience, speed and cheapness merited.

GREAT NORTHERN, PICCADILLY & BROMPTON RAILWAY CO.—The London Electric Railway Amalgamation Act, 1910, which has received the Royal Assent, provides for the amalgamation of the undertakings of the Baker Street & Waterloo and the Charing Cross, Euston & Hampstead Railway Cos. with the undertaking of this company from the July 1, and the name of the company has been changed to The London Electric Railway Co. Arrangements will be made as soon as practicable for exchanging stock and share certificates existing prior to the date of amalgamation into stock and share certificates of the new company. The gross receipts for the half-year ended June 30 amounted to £166,106.10s.3d, an increase of £8,113. 6s. 2d.; the working expenses were £69,602.12s.10d., a decrease of £3,802. 0s. 3d. After providing for interest, rents and guaranteed preference dividend, and reserving 6,000 for contingencies and renewals, £46,832. 0s. 3d. is available for ordinary dividend, and the directors have decided to pay a dividend at the rate of 1½ per cent. per annum on these shares, leaving £8,972. 6s. 3d. to be carried forward. The number of passengers carried, including workmen and season-ticket holders, was 19,973,049, against 19,155,883; the average receipt per passenger was 1·87d., against 1·89d.; the train mileage was 1,267,581, against 1,236,320; and the car-mileage 3,880,893, against 3,671,512. The directors express their warm appreciation of the services rendered to the company by Sir George S. Gibb, who is retiring from the board in consequence of his having accepted the chairmanship of the Road Board. Lord George Hamilton has consented to act as chairman of the company, and to fill the vacancy caused by Sir George S. Gibb's retirement, Mr. Albert H. Stanley will be appointed managing director.

HARPER ELECTRIC PIANO CO. (LTD.)—The report of the directors for the year ended June 1 last was submitted to a meeting of shareholders yesterday, and states that the business has again progressed, and that the turnover was the largest since the formation of the company. To bring about a development of the business, and to provide extra working capital, the assets were sold to the Harper Electric Piano (1910) Co. (Ltd.), the purchase taking effect from June 1 last. The directors recommended a dividend on the deferred shares at the rate of 15 per cent. (making 10 per cent. for the year) and £1,888 was carried forward.

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LANCASHIRE ELECTRIC POWER CO.—At the meeting on Friday the chairman (Mr. H. F. Parshall) said the business had progressed so that it was estimated that the trading profit was now £5,000 per annum. During the past year the connected load had increased by 1,750 H.P. The average customer was about 200 H.P., and the bulk of the business was done with the cotton trade. There was something like 1,800 H.P. contracted for but not connected. The new load was largely in connection with the coal-mining industry. The price per unit had increased. £13,115 had been invested in the Power Co., and of this £9,315 had been spent on distribution, and £3,000 on the new power house. £800 had been spent on Parliamentary proceedings which prevented local authorities from operating within the company's area of supply without their sanction.

LIVERPOOL OVERHEAD RAILWAY CO.—The report of the directors for the half-year ended June 30 states that gross revenue receipts were £36,156. 16s. and working expenses £26,848. 8s. 8d. Passengers carried during the half-year were 5,090,080, compared with 4,900,216 in June half of 1909. Revenue has increased during the half-year by £824. The saving during the half-year in working charges amounts to £524, the mileage run being practically the same. After providing for working expenses and amount transferred to renewal fund (£26,848. 8s. 8d.) there was a balance of £9,308. 7s. 4d. Mortgage debentures, and calls paid in advance absorbed £4,329. 8s. 2d., leaving £4,978. 19s. 2d., and with balance forward from Dec. 31 (£4,613. 16s. 4d.) there is available for dividend £9,592. 15s. 6d. The directors recommend payment of the preference dividend, leaving £5,916. 18s. 6d. to carry forward.

METROPOLITAN DISTRICT RAILWAY CO.—For the half-year ended June 30 the capital expenditure was £51,672. The expansion of the company's traffic has been satisfactory. Gross receipts were £300,046, increase £26,727, and working expenses £143,331, decrease £4,765. On March 1 the company inaugurated a through service of trains to Uxbridge. Net revenue account shows a credit balance of £62,277, and the directors recommend dividends at the rate of 4 per cent. per annum on the 4 per cent. guaranteed stock, and at the rate of 3 per cent. per annum on the 4½ per cent. first preference stock.

SOUTH-EASTERN & CHATHAM RAILWAYS.—At the meeting on Thursday last the chairman, Mr. H. Cosmo Bonsor, said there was hardly a station on the two systems that did not show a progressive rate of business, with the exception of the lines between Victoria and Snow-hill and Nunhead. There they showed a decrease, accounted for partly by the competition of their Brighton neighbours with their electrified line. They had lost a considerable number of passengers, but not a considerable amount of money. The electrification of the Brighton line had, he was glad to say, filled that company's trains, and he could only say that the board would watch that experiment with very great interest.

At the meeting of the London, Chatham & Dover Railway Co. on the same day Mr. Robranachi said he was an advocate of the electrification by the Brighton Co. of their lines in the suburban district, and he thought the company might follow that company's example.

The chairman said they would wait to see the results on the Brighton Railway before considering anything of the kind in connection with the Chatham line.

NEW COMPANIES, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

BRACUHY FALLS AND METALLURGICAL SYND. (LTD.) (110,780)—Reg. July 14, capital £48,000 in £1 shares, to carry on the business of concessionaires, promoters, constructors and workers of tramways, railways, telegraph and telephone lines and electrical works, electricians, mechanical engineers, suppliers of electricity, &c. Private company.

CHAPMAN MOTOR STARTER SYND. (LTD.) (110,934.)—Reg. July 22, capital £5,000 in £1 shares, to adopt agreement with A. S. J. Chapman for acquisition of the invention for an improved arrangement of a combined collector ring commutator and switches for use with a small battery to start petroleum engines fitted with magnetic-igniting apparatus. First directors, T. Wilkins (manager), J. Metcalf and P. W. Chapman. Reg. office, 21, Great St. Helens, London, E.C.

GREENHILL & CRAIG (LTD.) (3,591.)—Reg. in Dublin July 25, capital £6,000 in £1 shares, to acquire the business of machinists and electrical and general engineers carried on at Belfast by E. E. Craig, as Greenhill and Craig. Private company. Reg. office, 29-37, King-street, Belfast.

HORSE POWER & SMELTING SYND. (LTD.) (111,094.)—Reg. July 29, capital £12,000 in £1 shares, to carry on the business of manufacturers of and dealers in machinery for the treatment of ores and the generation of electricity. Private company.

JOHNSON BILLINGTON ELECTRICITY METERS (LTD.) (111,063.)—Reg. July 28, capital £8,000 in £1 shares, to carry on the business of manufacturers of and contractors for the manufacture and supply of meters of all kinds, &c., and to adopt an agreement with A. M. Billington and H. S. Johnson. Private company. First directors, A. M. Billington and H. B. Spiller.

LOCH LEVEN ELECTRICITY SUPPLY CO. (LTD.) (110,980.)—Reg July 25, capital £10,000 in £10 shares, to take over so much of the undertaking of the Loch Leven Water & Electric Power Co. as relates to the supply and distribution of electrical energy (other than the supply to the factories and works of the British Aluminium Co.), to acquire supplies of electrical energy in bulk from the Loch Leven Water & Electric Power Co. or the British Aluminium Co. (Ltd.) for the purpose of distributing the same, and to carry on at Kinlochleven and elsewhere in the counties of Inverness and Argyll the business of an electric light and power company Private company.

MORTGAGES AND CHARGES.

EVERETT, EDGCUMBE & CO. (LTD.)—A memorandum of satisfaction in full of debentures dated June 9, 1905, securing £700, has been filed.

INSTITUTION OF ELECTRICAL ENGINEERS.—Mortgage and instrument of charge, both dated July 15, to secure £11,500. Property charged, 15-18, Tothill street, Westminster, and land in rear thereof. Holders, Economic Life Assurance Society.

JOHNSON-LUNDELL ELECTRIC TRACTION CO. (LTD.)—A memorandum of satisfaction in full of mortgage dated April 5, 1906, in respect of which £4,070. 14s. 6d. was outstanding on July 1, 1908, has been filed.

MUNSTER ELECTRIC LIGHTING CO. (LTD.)—Second and third debentures dated July 7, 1910, to secure £500 and £330 respectively, charged on company's undertaking and property, present and future, at Fethard, Tipperary. Holders, R. H. Bindloss and Dargue, Griffiths & Co.

NORTHAMPTON ELECTRIC LIGHT & POWER CO. (LTD.)—Particulars of £50,000 debentures, created June 23 and secured by trust deed dated July 8, 1910, have been filed. Property charged: Company's undertaking and property, present and future, including uncalled capital. Trustees, T. W. Thornton, J.P., C. A. Markham and T. E. Manning.

THOMAS BRITTAN (LTD.)—Particulars of £300 debentures, created July 5, 1910, have been filed, the whole amount being now issued. Property charged: company's property, present and future, including uncalled capital. No trustees.

RECEIVERSHIP.

MAGNETO CO. (LTD.)—Notice of the appointment of C. H. McPhers on 35, Newhall street, Birmingham, as receiver or manager, on July 18, has been filed.

CITY NOTES.

MEMORANDA (Aug. 4).—**Bank rate 3 per cent. (since June 9, 1910). Price of silver,** 24½d. per oz. Consols 81⅞—81⅞ for money; 81½—81⅝ for account. **Consols Pay Day, Sept. 1; Stock and Shares Continuation Days,** Aug. 10 and 29; **Ticket Days,** Aug. 11 and 30; **Pay Days,** Aug. 12 and 31; **Mining Shares Carry Over Day,** Aug. 9.

PRICES OF METALS (London).—*Copper*, cash, 55½; three months, 56¼. *Lead*, English, 12¾—13; foreign, 12½—12⅝. *Spelter*, 22⅝—22¾. *Tin*, English, 149—151; foreign cash, 151; three months, 151⅛. *Iron*, Cleveland, cash, 49/4, three months, 50/1.

BROMPTON & KENSINGTON ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend at the rate of 9 per cent. per annum (4s. 6d. per share) on the ordinary shares for the half-year to June 30.

CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend at the rate of 5 per cent. on the ordinary shares of the West End undertaking.

CONSOLIDATED ELECTRICAL CO. (LTD.)—It is stated that the directors have declared a dividend of 3½ per cent. (less tax) on the ordinary shares for the year ended March 31.

ELMORE'S GERMAN & AUSTRO-HUNGARIAN METAL CO. (LTD.)—Shareholders have received the following notice, dated July 28:—

During the six months ending June 30 last, the sale of tubes, &c., produced at Schladern shows an increase of 5·15 per cent. in tonnage over the amount sold during the six months ending June 30, 1909. Unfortunately, the selling price has not shown the desired improvement, but in view of the increase in the demand in Germany for the class of goods produced by the Metall Co., it is reasonable to assume that the margin between the price of the raw material and the selling price of the finished article will increase rather than decrease during the latter half of the year. The weight of orders and contracts in hand amounts to 500 tons. The Metall Co. has entered into a contract for the supply of copper rollers necessary for the satisfactory and economical working of an invention which it is believed will ultimately prove of great value to the printing and allied trades. Our works manager, Mr. Ernst Preschlin, has been able to afford considerable assistance to the inventor in perfecting the process, and placing it on a commercial basis, and it is believed from the information we have at our disposal that the result will in time be satisfactory from a financial point of view.

The scheme for the re-arrangement of capital, to which the chairman referred in his speech on May 11 last, has not been proceeded with, owing to opposition by the holders of a considerable amount of debenture stock, but with an improvement in the selling price of copper tubes, coupled with a satisfactory return from the above-mentioned contract, it may not be necessary to proceed further with such scheme, and the directors have decided to allow the matter to remain in abeyance until the end of the year.

HADFIELD'S STEEL FOUNDRY CO. (LTD.)—An interim dividend of 1s per share has ben declared on the ordinary shares.

HOVE ELECTRIC LIGHTING CO. (LTD.)—For the period to June 30 the directors have declared an interim dividend on the ordinary share-at the rate of 8 per cent.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Aug. 24 a special settling day in a further issue of 100,000 £3 fully-paid 10 per cent. preference shares and £225,000 4 per cent. mortgage debenture stock of the *British Westinghouse Electric & Mfg. Co. (Ltd.)*, and have granted a quotation to £300,000 5 per cent. debentures (in lieu of scrip now quoted) of the *Amazon Telegraph Co. (Ltd.)*.

VICKERS, SONS & MAXIM (LTD.)—The directors annnouce interim dividends for the half-year ended June 30 at the rate of 2½ per cent. (less tax) on the preferred 5 per cent. stock and 5 per cent. preference shares, and 1s. per share (tax free) on the ordinary shares.

WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)—The directors have declared an interim dividend at the rate of 10 per cent. (5s. per share), less tax, on the ordinary shares for the half-year ended June 30.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.		Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
			£	£		£	£
Aberdeen Corporation	July	27	1,462	— 66	8	12,209	— 154
Airdrie	,,	22	183	— 27	29	6,339	+ 91
Anglo-Argentine	,,	29	42,877	+ 7,443	30	1,323,755	+ 155,465
Ayr Corporation	,,	30	505	+ 21	11	4,520	+ 231
Barnsley	,,	22	166	..	29	4,925	+ 140
Barrow	,,	22	333	+ 61	29	7,479	+ 1,074
Bath Electric Trams, Ltd...	,,	27	889	— 111	30	23,438	+ 1,163
Birmingham Corporation ..	,,	30	6,662	+ 216	17	116,461	— 167
Birmingham & Midland	,,	15	940	+ 55	28	23,440	+ 241
Blackburn Corporation	,,	27	1,076	+ 37	‡18	19,404	— 783
Blackpool and Fleetwood ..	,,	30	1,292	+ 91	..	..	..
Bolton Corporation	,,	31	2,526	+ 316	18	41,758	— 230
Bombay	,,	1	2,411	+ 150	26	70,631	+ 4,824
Bournemouth Corporation..	,,	24	1,875	+ 164	17	32,248	+ 3,966
Bradford Corporation.....	..		..	..	..	..	..
Brighton Corporation.....	,,	31	1,391	+ 173	§17	16,885	— 241
Bristol Trams & Carriage ..	,,	29	6,209	+ 408	4	24,845	+ 1,301
Burnley Corporation	,,	30	1,287	+ 11	4	5,080	+ 104
Burton Corporation	,,	31	300	+ 9	17	4,676	— 32
Bury Corporation	,,	31	1,234	+ 142	§16	20,844	— 229
Calcutta Tramways Co.....	,,	30	₹50,768	+ ₹3,318	4	₹208,004	+ ₹6,349
Camborne-Redruth	,,	30	12	+ 1	30	3,644	— 121
Cardiff Corporation.....	,,	23	2,325	— 104	17	36,737	+ 599
Cavehill.....	,,	22	120	— 2	29	2,646	+ 219
Central London Railway ..	,,	30	5,293	+ 77	4	22,634	+ 1,089
Chatham & Dist. Lt. Rys. ..	,,	28	897	+ 42	30	24,448	+ 949
City & South London Rly...	,,	31	3,128	— 51	4	12,382	— 65
City of Birmingham	,,	22	2,835	+ 23	29	82,705	+ 1,777
Colchester Corporation	,,	27	221	+ 2	..	..	..
Cork Electric Trams Co....	,,	28	533	+ 31	40	14,447	+ 1,670
Croydon Corporation	..		..	..	..	..	..
Devonport & Dist. Trams ..	,,	22	400	+ 17	29	11,939	+ 1,449
Dover Corporation	..		..	..	..	..	..
Dublin & Lucan Railway ..	,,	29	156	+ 10	4	679	+ 27
Dublin United	,,	29	5,640	+ 154	4	24,433	+ 828
Dudley-Stourbridge	,,	22	827	— 35	29	21,906	— 732
Dundee Corporation	,,	27	1,308	+ 31	§10	12,895	+ 294
East Ham Council	,,	30	1,036	+ 71	¶17	18,045	+ 282
Exeter Corporation.....	,,	29	345	+ 5	17	5,583	— 629
Gateshead & Dist. Trams ..	,,	22	1,054	+ 11	29	28,319	— 229
Glasgow Corporation	,,	30	14,708	+ 13	9	151,481	+ 9,565
Glossop Trams.....	,,	30	122	+ 3	30	3,499	— 201
Gloucester Corpn.....	,,	27	292	+ 11	3	1,195	+ 10
Gravesend-Northfleet.....	,,	22	224	— 91	29	5,815	+ 2
Great Northern & City Rly..	,,	30	1,279	+ 33	4	5,259	+ 84
Greenock & Port Glasgow ..	,,	22	718	+ 5	29	17,750	+ 2,556
Hartlepool Tramways	,,	22	310	+ 19	29	6,780	+ 321
Hastings Elec. Trams Co. ..	,,	28	1,210	+ 50	4	4,678	— 67
Hong Kong	,,	30	$8,916	+ $105	4	$36,094	+ $3,404
Huddersfield Corpn.	,,	30	1,782	+ 197	17	30,536	+ 1,706
Hull Corporation.....	,,	31	2,746	+ 94	17	46,582	+ 2,931
Ilford District Council.....	,,	30	518	+ 31	17	9,290	+ 4 24
Ilkeston District Council ..	,,	27	127	— 8	17	2,171	— 114
Ipswich Corporation	,,	30	589	— 117	17	7,320	+ 313
Isle of Thanet Co.	,,	30	1 433	+ 184	¶42	20,121	+ 1,063
Jarrow	,,	22	144	+ 12	29	3,499	+ 190
Keighley Corporation.....	,,	28	188	+ 9	17	3,068	+ 99
Kidderminster & District ..	,,	22	132	— 10	29	2,950	+ 66
Kilmarnock Corporation ..	,,	30	244	+ 7	11	1,777	+ 29
Lanarkshire Trams Co.	,,	28	1,131	— 70	30	41,269	+ 3,865
Lancashire United	,,	27	1,314	+ 45	30	38,732	— 379
*Leamington	,,	22	190	— 29	29	4,596	— 181
Leeds Corporation	,,	30	8,328	+ 1,673	17	123,882	+ 4,980
Leicester Corporation.....	..		..	..	..	..	..
Leith Corporation	,,	30	633	— 23	11	7,146	+ 156
Lincoln Corporation	,,	30	121	— 2	18	2,234	— 6
Liverpool Corporation	,,	23	11,627	+ 539	29	322,023	+ 12,465
Liverpool Overhead Rly. ..	,,	31	1,517	+ 65	5	7,267	— 11
Llandudno&ColwynBayRy.	,,	29	573	+ 39	§34	7,530	— 14
*London County Council	,,	20	41,776	+ 2,010	¶16	670,063	+ 93 053
London United	,,	30	6,451	+ 58	30	187,327	+ 9,429
Lowestoft	,,	31	313	+ 15	44	7,175	+ 324
Maidstone Corporation	..		..	..	..	..	..
Manchester Corporation....	,,	30	15,051	+ 160	17	268,690	+ 4,758
London Elec. Ry. Co.....	,,	30	12,020	+ 45	4	49,470	— 295
Mersey Railway	,,	30	2,082	+ 92	4	7,918	+ 112
Merthyr	,,	22	212	— 5	29	5,895	— 203
Metropolitan Dist. Railway..	,,	30	10,752	+ 1,011	4	43.414	+ 2,322
Metropolitan Elec. Trams ..	,,	22	7,677	+ 445	29	211,683	+ 38,105
Middleton	,,	22	369	— 17	29	9,036	— 567
Nelson Corporation.....	,,	30	157	+ 15	§17	2,527	+ 72
Newcastle-on-Tyne Corp. ..	,,	30	4,017	+ 156	¶17	69,445	+ 214
Newport (Mon.)	,,	30	696	+ 24	18	12,328	+ 454
Northampton Corporation..	,,	29	497	..	§17	8,496	— 1
Oldham, Ashton & Hyde ..	,,	22	594	— 12	29	15.944	— 79
Oldham Corporation	,,	31	1,864	+ 124	18	34,182	— 817
Perth (N.B.) Corporation ..	,,	27	211	+ 15	§10	1 858	+ 140
Perth (W.A.) Elec. Trams ..	..		..	..	..	..	..
Peterborough	,,	22	119	— 15	29	3,233	— 48
Portsmouth Corporation ..	,,	30	2.274	— 168	17	35,590	— 1,394
Potteries	,,	22	1,736	— 7	29	50,486	— 504
Preston Corporation	,,	27	735	+ 21	17	12,483	— 265
Rotherham Corporation....	,,	28	619	+ 73	17	10,511	+ 305
Rothesay	,,	22	933	+ 71	29	5,199	+ 244
Salford Corporation	Aug.	1	5,030	+ 476	†18	82,872	+ 1,188
Sheerness	July	22	55	— 24	29	1,335	— 53
Sheffield Corporation	,,	31	5,895	+ 443	¶18	109,366	+ 6,272
Singapore Trams.....	,,	30	$9,748	+ $898	4	$39,670	+ $2,808
South Metropolitan.....	,,	22	834	— 74	29	23,272	+ 1,205
South Staffs.....	,,	22	844	+ 18	29	23,879	+ 15
Southend Corporation	,,	27	756	— 71	17	9,719	+ 601
Southport Tramways	,,	22	351	— 4	29	8,205	+ 233
Stalyb'dge,Hyde,&c.,Jt.Bd.	,,	30	780	+ 77	¶17	12,569	— 1,056
Sunderland Corporation....	,,	31	1,298	+ 64	18	20,193	— 371
Sunderland District	,,	27	504	— 2	39	16,343	— 1,204
Swansea Trams	,,	22	1,146	+ 130	29	30,351	+ 3,588
Swindon Corporation	,,	27	136	+ 8	..	..	..
Taunton	,,	22	48	— 7	29	1,190	+ 122
Tynemouth and District....	,,	22	484	— 47	29	6,601	+ 476
Tyneside Trams Co.	,,	27	528	+ 107	4	1,939	— 98
§Wallasey District Council ..	,,	30	1,079	+ 80	§17	16,533	— 192
Walsall Corporation	..		..	..	..	..	..
Warrington Corporation....	,,	28	392	+ 14	17	6,682	+ 117
West Ham Corporation	,,	21	2,503	+ 28	16	34,789	+ 1,460
Weston-super-Mare	,,	22	306	+ 13	29	3,184	+ 104
Wolverhampton Co.	,,	22	416	+ 7	29	12,141	+ 260
Wolverhampton Corpn.	,,	27	908	+ 120	17	16,103	+ 2,428
*Worcester	,,	22	323	+ 1	29	7.840	+ 180
Wrexham	,,	22	96	— 4	29	2.769	+ 13
Yorkshire W.R. Trams	,,	31	1,282	+ 151	31	37,761	..
Yorkshire Woollen District.	,,	22	1,029	+ 61	29	28,102	+ 2,527

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Stock	Last Dividend	NAME.	Price Wed., Aug. 3	Rate per cent. Yielded.	Dividend Due.	Business Week to Aug. 3. High-est.	Low-est.
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9⅛	5 15 6	Mar, Sep	9⅛	..
10	4/6	Do. 4½ per Cent. Cum. Pref.....	9¼—9½	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼—10½	5 11 6	Feb, Aug	10⅝	10⅜
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	102½	..
5	5/6	Brompton & Kensington Elec. Sup. Ord. ..	7⅛—7⅜	6 9 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.....	7 —7⅛	4 13 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¼—4	6 5 0	Feb, Aug	3⅜	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 14 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99½—101¼	4 8 6	..	..	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¼—4½	5 9 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.....	3¾—4½	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	†City of London Electric Lighting Ord.	11¼—11⅞	6 8 6	Feb, Aug	11⅞	..
10	6/0	† Do. 6 per Cent. Cum. Pref.	11¼—12¼	4 18 0	Jan, July	11⅜	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	119 —123	4 1 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99½—102½	4 7 6	Jan, July	..	..
5	5%	County of Durham Elec. P. D. Ord.....	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾—3½	7 14 0	April, Oct	..	..
10	4/0	†County of London Elec. Supply Ord.	7¾—7⅞	6 7 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½—11	5 9 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	103½—105¼	4 4 6	Jan, July	105⅛	105¼
St.	4½%	Do. Second Deb. Stock	99 —102	4 9 0	May, Nov	101¼	101
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4½	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Co.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.....	7 —7⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	5¾—6¼	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	84 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅝—2	4 10 0	Mar, Sept	1⅝	..
5	3/0	Do. 6 per Cent. Pref.....	5 —5¼	5 14 0	Mar, Sept	5⅜	5⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/6	Metropolitan Electric Sup. Ord.	3 —3¼	7 3 0	April, Oct	3⅛	3¼
5	2/3	Do. 4½ per Cent. Cum. Pref.....	4 —4½	5 0 0	Jan, July	4¼	4
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	..	—
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95¼—97½	4 12 6	June, Dec	..	..
5	1/6	†Newcastle Elec. Supply Ord.....	3¼—4½	4 14 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¼—4½	5 5 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	12½	12⅜
10	4/6	Oxford Electric Ord.	6½—7	5 0 0	March	..	..
5	5/0	†St. James' & Pall Mall Elec. Ord.....	7¼—8¼	5 14 0	Feb, Aug	8⅛	8
5	3/6	†Do. 7 per Cent. Pref.....	6¾—7¼	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2¼—3½	6 11 0	April	2⅜	..
St.	5%	Do 5 % 1st Mort. Stock (red.).....	99 —102	4 19 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅜—½	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	¼—1 1/16	6 12 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.).....	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	¼—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	†Westminster Elec. Sup. Ord.....	¼—8½	5 16 0	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5¼	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	94 —96	4 3 6	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.....	⅜—½	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅜	6 12 9	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.).....	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	80½	..
10	6/0	†Bristol Tramways & Carriage Ord.	6¼—6½	5 18 0	Feb, Aug	..	..
10	4/0	Do Cum. Pref. (fully paid)	7¼—7½	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¼—1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2¼—3½	..	Feb, Aug	..	..
St.	5%	Do. 5 per Cent. Perpetual Debs	87 —91	5 10 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	68 —73	6 3 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	66 —68	4 9 0	Feb, Aug	66½	66
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	101½	100⅝
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	93 —95	4 5 0	Jan, July	94½	94
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5¼	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord. ..	27½—28	3 18 0	Feb, Aug	29⅛	28⅛
St.	5%	†Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	†Do. (1896)	102 —104	4 16 0	Feb, Aug	..	..
St.	5%	†Do. (1901)	99 —102	4 18 0	Feb, Aug	..	..
St.	5%	†Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.....	99 —101	3 19 0	May, Nov	100	..
10	6/0	Dublin United Trams, 6 per Cent. Pref....	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8½—9	..	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	93 —95	4 5 0	Jan, July	94½	93½
5	..	Hastings & District Elec. Trams, 6% C. P.	¾—1½	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	75	73½
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1 1/16—1 3/16	4 4 0	Mar, Sept.	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock	64 —69	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10 1/16	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	2	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	67 —71	5 12 6	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.....	1/16—⅛	..	..	..	..
1	..	Do. Deferred	1/16—⅛	..	April	..	..
1	0/6	Do. 5 per Cent. Pref.	1/16—⅛	5 0 0	Feb, Aug	1/16	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	96 —99	4 11 0	Jan, July	..	..
St.	..	Do. 5 per Cent. Db. Stk	94½—96½	..	..	..	..
St.	1½%	†Metropolitan Railway Consolidated.....	38½—38⅞	2 10 0	Feb, Aug	38⅞	38½
St.	2½%	†Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	65	..
St.	3½%	†Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	88½	..
St.	3½%	†Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	84½	..
St.	3½%	†Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	86	84
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	92½	92½

* In calculating the yield allowance has been made for accrued interest, but not for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shre	Last Dividend	NAME.	Price Wed. Aug. 3	Rate per cent. Yielded.	Dividend Due.	Business Week to Aug. 3. High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	90 —92	3 15 6	Jan, July	90⅛	89⅞
St.	..	Metropolitan District Railway Ord.....	20½—20⅝	..	Feb, Aug	21⅛	20½
St.	..	Do. Extension Pref. (5 per Cent.).....	69 —71	..	Feb, Aug	72	70⅛
St.	3½%	†Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	70 —72	4 17 0	Feb, Aug	72	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	99 —102	3 18 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	103½	102½
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	140 —142	4 4 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto.....	94 —96	4 3 6	Jan, July	..	..
1	4 d.	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅛—¼	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	7 d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—¼	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoup5	36 —38	..	June, Dec	36	..
..	5%	Do. 5% Prior Lien Bonds.....	102½—103½	4 16 6	..	103	102¼
..	4½%	Do. 4½ Bonds with coup. 6	86 —88	5 2 0	..	..	..
..	4%	Do. 4 per Cent. 1st Power Ho. Dbs. ..	98 —100	4 0 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	⅛—¼	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1¼—2¼	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	99½ —101½	4 8 6	..	..	..
1	..	Aron Electricity Meter Ord.....	⅛—⅜	..	..	..	..
1	1/9½	Do. 6% Cum. Pf.	⅛—⅜	6 16 3	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.....	5⅜—5⅝	5 7 6	April, Oct	..	..
1	0/7½	Do Pref.....	1⅞—1⅝	3 16 3	..	6⅜	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7¼	6 18 0	July, Feb	..	..
5	3/0	†Do. 6 per Cent. Pref.....	5¼—6¼	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	101 —104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	⅞—⅞	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	99 —101	5 19 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	61 —63	3 3 6	Jan, July	..	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	23 —27	16 12 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9½—10½	6 8 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	4⅛—5⅛	4 15 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	100⅛—102½	4 7 6	Nov, May	2⅛	..
1	1/3	Castner-Kellner Alkali Co.....	2¼—2⅜	5 8 9	May, Nov	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.)..	105 —107	4 4 0	Feb, Aug	..	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	5 19 0	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	⅛—¼	7 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	⅛—⅛	5 12 9	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	⅛—⅛	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	¼—⅜	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red)..	84 —87	5 15 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¾—1⅛	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	1⅛—1⅜	5 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	1 —1⅛	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United (" A " Sh.) (£3 pd.)	⅞—⅞	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 15 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅛—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1⅝	..	May, Nov	7⅛	7⅝
St.	4½%	Do 4½ per cent. 1st Mort. Deb. (red.)..	75 —76	5 18 0	Jan, July	..	..
2	..	Electric Construction Co.....	⅛—¼	..	Jan, July	8⅜	..
2	2/9½	†Do. 7 per Cent. Cum. Pref.....	1¼—1½	4 13 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	59 —64	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref..	7⅛—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	12 —12⅛	5 17 6	Feb, Aug	12⅛	12⅛
5	2/3	Do. 4½ per Cent. Pref.	4⅜—5⅛	4 8 9	Feb, Aug	4⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	104 —106⅝	4 5 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works....	14½—15½	6 10 6	Feb, Aug	..	..
10	5/0	Do 5 per Cent. Cum. Pref.	10½—10¾	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	..	..
1	..	National Elec. Construction Co.	⅛—¼	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅛	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—⅛	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½ ..	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5⅛	..	..	3⅝	3⅝
12	12/0	Telegraph Construction & Maintenance..	33½—35½	3 19 6	Mar, July	..	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99½—101⅛	3 18 6	Jan, July	1⅛	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2 —2⅛	4 9 3	..	1⅛	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1¼	4 0 0	..	111½	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	109 —112	4 9 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 6 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	104 —106⅛	4 14 3	..	104½	..
10	10%	J. G. White & Co. 6% Cum. Pref.	13 —14	8 11 6	..	..	..
1	..	Willans & Robinson Ord.....	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1¼—1½	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3½	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan, July	..	..
St.	15/0	†Anglo-American	64½—66½	5 9 0	F,My,Ag,N	..	..
St.	30/0	†Do. Preferred	107 —109	5 10 0	F,My,Ag,N	108½	107
St.	25/0	Do. Deferred	25½—26	4 15 6	F,My,Ag,N	26⅛	24⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	83½—85½	4 13 6	Jn,Ap,Jy,O	85⅜	..
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16⅜—17½	5 15 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3½—3⅝	5 15 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	99 —101	4 19 0	Jan, July	..	..
20	6/0	†Direct United States Cable 3rd & bonus ..	14½—15½	5 18 0	Ja,Ap,Jy,O	14⅛	..
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.).	98 —100	5 0 0	June, Dec	98	..
St.	25/0	Eastern Ordinary	132 —135	5 4 0	Ja,My,Jy,O	133½	..
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	84 —86	4 1 6	Ja,My,Jy,O	85½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	102 —104	3 16 0	May, Nov	103⅛	102½
St.	2/6	Eastern Extension	12½—12⅝	5 15 0	Ja, Ap, Jy,O	12⅝	12⅜
100	4%	†Do. 4 per Cent. Deb. Stock	99 —102	3 18 0	Feb, Aug	99⅛	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	99½—101⅛	3 18 6	May, Nov	..	..
10	5/0	G.N (of Copenhagen), with Coupon 80 ..	29½—30½	5 15 0	Jan, July	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	54⅛	53⅛
100	5%	Mackay Companies Common	84 —88	5 14 0	Ja,Ap,Jy,O	..	..
100	4%	Do. Preference	76 —80	5 0 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛—⅛	..	April	⅛	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	96 —98	3 18 0	June, Dec	96	..
2½	1/3	West Coast of America	1¼—1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	96 — 98	3 18 0	Jan, July	..	..
10	..	West India & Panama	⅛—¼	..	May, Nov	⅛	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9	6 12 6	May, Nov	8½	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	99 —101	4 19 0	Jan, July	..	..
10	3/0	Western Telegraph	13⅜—14⅜	4 18 0	Mr,Jn,O,D	14⅛	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	99 —101	4 19 0	June, Dec	..	..
..	4%	Western Union Telegraph, $1,000 4% Bds.	103 —106	3 15 3	..	..	..
..	4½%	Do. $1,000 4½% Fdg. & Rl. Est. Gd. Bnds.	99 —102	..	..	..	..

Shre	Last Dividend	NAME.	Price We d., Aug. 3	Rate per cent. Yielded.	Dividend Due.	Business Week to Aug. 3. High-est.	Low-est.
		Telephones.		£ s. d.			
100	2$	Amer. Telephn. & Telegh. Cap. St.	135 —138	5 16 6	..	135	..
	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	91 —93	4 6 0	Jan, July	..	..
	4%	Do. 4% Cons. Bonds 1936	103 —105	3 16 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
5	5/0	†Chili Telephone	9 —9½	4 4 0	August ..	9½	..
1	0/7½	Monte Video Telephone Ord.....	⅛—⅜	5 9 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅜—⅝	5 13 9	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	106½—108	5 11 0	Feb, Aug	107½	106½
St.	6%	Do. Def. Stock	126½—128½	4 13 3	Feb, Aug	128	127
St.	6%	Do. 6 per Cent. Cum. 1st Pref.....	10⅛—10⅝	5 10 0	Feb, Aug	10⅛	..
	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10⅛—10⅝	5 10 0	Feb, Aug	..	..
10	6/0	Do. 5 per Cent. non-Cum. 3rd Pref.....	5⅛—5⅜	4 7 6	Feb, Aug	..	..
5	2/6	Do. Deb. Stock 3½ per Cent. (red.)....	97 —99	3 11 0	June, Dec	..	..
St.	3½%	Do. 4 per Cent. Deb. Stock (red.).....	98½—100½	3 19 6	Jan, July	..	..
St.	4%	New York Telephone Co. 30 yr. Bnds.....	98 —99	4 11 0	..	99½	98⅜
	4½%	Oriental	1 7/16—1 9/16	4 15 0	April, Oct	..	..
1	1/0	Do 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 6	April, Oct	..	..
1	0/7½	Do. 4 per Cent. Red. Deb. Stock.....	86 —88	4 11 0	Jan, July	..	..
St.	4%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	98 —100	4 10 0	Jan, July	98⅛	..
St.	4½%	†United River Plate Ord. ex rights	6½—7	5 14 0	July	7	6⅛
5	8/0	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 14 9	June, Dec	..	..
5	2/6	Do. 4½ Deb. St. Red.....	101 —103	4 12 6	Jan, July	101	..
St.	4½%						
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2½—3½	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10¼—10½	5 8 3	Sp,DcMr Ju	10⅜	10⅛
10	3/0	Do. 6 per Cent. Pref.	13 —13½	4 9 0	Sp,DcMr Ju	13⅜	13⅛
10	6%	Submarine Cables Trust (Cert.)	128 —131	4 10 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4 15/16—5 1/16	5 10 0	April, Oct	4⅛	4⅛
5	2/6	Do. 5% Cum. 2nd Pref.....	4⅛—4⅜	5 14 0	Jan, July	..	..
St.	4%	Do 4% Deb. Stock	90 —91⅛	4 7 6	June, Dec	91⅞	90⅜
St.	4½%	Do. 4½% Deb. Stock	93⅛—96⅛	4 13 6	..	95	94
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)....	103 —105	4 15 3	Jan, July	..	..
		Brisbane Electric Trams. Invest. Ord	6½—6⅞	4 11 3	May	..	..
5	4/6	Do. 5 per Cent. Cum. Pref.	4⅛—5⅛	4 15 0	May, Nov	..	..
5	2/6	Do. 4½ per Cent. Db. Prov. Certs.....	99 —102	4 8 6	Jan, July	143	..
St.	4½%	British Columbia El.. Rly. Df. Ord.	140 —145	5 10 0	Mar, Sept	..	142½
St.	£3	†Do. Pref. Ord. Stock and bonus	122 —126	4 15 0	May, Nov	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock.....	108 —111	4 10 0	Jan, July	..	..
St.	5%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
40	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
100	4½%	Do. 4½% Perp. Con. Deb. St.	103½—105½	4 0 0	..	104⅞	104½
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99 —102	4 18 0	Mar, Sept	100	99
St.	6%	†Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	..	..
		Calcutta Tramways (1 to 137,610).....	4 —4½	5 0 0	Mar, Sept	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅛—4⅜	5 2 6	Jan, July	..	..
100	2/6	Do. 4½% 1st Deb. Stock (red).....	96 —99	4 11 0	Jan, July	..	..
100	4½%	Cape Electric Tram Shares	⅛—¼	..	..	..	..
		City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 9 6	F,My,A,N	..	..
1	1/3	Do 4 per Cent. Deb. Stock.....	97 —100	4 0 0	June, Dec	..	..
5	4%	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	95 —98	5 2 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	96 —99	5 1 0	Feb, Aug	97½	..
100	5%	Kalgoorlie Elec. Trams Sh.	⅛—¼	..	..	94½	..
100	5%	Do. 5 per Cent. " A " Deb. Stock.....	92 —96	5 3 6	Jan, July	..	..
5	6%	Do. 6 per Cent. " B " Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	Lisbon Elec. Trams. Ord.	1⅛—1¼	4 8 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 16 0	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	97½—101½	4 18 6	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	87⅛	..
St.	5%	Manaos Trams and Lt. Co. 5% Debs	86½—88	5 14 0	..	..	..
100	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	98 —100	5 2 0	Feb, Aug	121	..
100	$1⅛	Mexico Trams Co. Com. St.	119 —121	5 19 0	..	99	120
100	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	98 —99	6 1 0	..	98⅛	97⅛
St.	4½%	Do. 6% 50 yr. Mort. Bds.	97 —98	6 2 0	..	..	..
		†Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	100 —102	4 8 0	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	..	..
1	0/7½	Perth Elec. Trams Ord.	1/16—⅛	5 15 5	May	..	..
100	0/6	Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	..	..
St.	5%	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅜—5⅞	5 2 6	..	..	..
5	3/0	Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	91⅛	91
34⅛		Rio Janeiro Tram, Lt. & P. Co.....	90 —92	4 12 3	..	95⅛	97⅜
St.	4½%	Do. 30 yr. Gold Bnds.	97½—98⅛	4 1 6	..	89⅛	87⅜
100	$1⅛	Do. 50 yr. Mt. Bnds	87⅜—88⅛	5 13 6	..	..	..
100	5%	Sao Paulo Tramway, Light & Power Co. $100 Stock	142 —144	7 2 6	..	143	140
100	$2½	Do. 5 per Cent. 1st Mt. $500 Db.	100⅛—102½	4 17 6	June, Dec	102	101
	5%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	101 —103	4 7 6	Feb, Aug	101¼	..
100	4½%						
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5⅛—5½	5 2 0	Mar, Sept	..	..
10	6/0	†Bombay E.S. & T. 6% Cm. Pf.....	10¼—10½	5 12 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red).....	92½—94½	4 15 0	Jan, July	..	..
5	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock..	97 —99	5 1 0	..	..	..
		Calcutta Elec. Supply Ord.	6⅛—6⅜	6 6 0	April, Oct	6½	6⅜
		Canadian Gen. Elec. Co. Com. St.....	103 —107	6 8 6	..	..	..
100	5%	Do. 7% Cm. Pf. Stock	122 —125	5 12 0	..	124	..
		Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co. of Ontario.....	85 —88	5 12 6	..	86⅛	..
500	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—¼	8 0 0	April, Oct	..	..
	5%	Kaministiquia Power Co. 5% Gold Bnds..	100 —102	4 18 0	..	..	..
84½	..	Madras E. S. Corp. Ord.	2⅛—3	..	..	2⅜	..
102½	St.	Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
124	St.	Do. 5% 1st Mortg. Deb. Stock.....	90 —92	5 7 6	..	..	..
99⅛	..	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	85 —86	5 16 0	..	85⅛	..
	St.	Mexican Lt. & Power Co. Com. St.	77 —79	5 1 0	..	78	77½
53⅛	St.	Do. 7% Cum. Pref. St.	101 —103	6 16 0	..	102⅜	101¼
	5%	†Do. 5% 1st Mort. Gold Bnds.	91½—93½	5 7 0	..	94⅛	92
	5%	†Montreal Lt. Ht. & Power Co. Cap. St.	128 —132	5 6 0	F,My,A,N	..	..
		River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	..	..
		Do. 6 per Cent. non-Cum. Pref. Stk. ..	105 —115	5 5 0	May	..	..
		Do. 5 per Cent. Deb. Stock	100½—102⅛	4 17 6	Jan, July	..	..
		Rosario Ele. Co. Ord.	8½—9	..	..	..	..
		Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
		Do. 2nd Pref.	8½—8⅝	6 14 6	..	..	..
		†Shawinigan Water& Power Co.Ca.	95½—97½	4 2 6	..	97⅛	..
		Do. 5 per Cent. Bds.	106 —108	4 12 6	Jan, July	107⅛	..
		Do. 4½ Per Cen. Mt. Db. St.	101 —103	4 7 6	..	103⅛	102½
		Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	100⅛	100⅛
		Victoria Falls Power Co. Pref. (1 to 808,000)	⅛—¼	5 6 6	Jan, July	..	..
		Do. (803,081 to 1,700,000)	⅛—¼	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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UNIVERSITY OF CALIFORNIA

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,682. [No. 18. Vol. LXV.] FRIDAY, AUGUST 12, 1910. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Railway Electrification.

WHILST many engineers consider the question of railway electrification in this country to be confined to suburban lines, others, among them Mr. J. DALZIEL, of the Midland Railway Co., believe that electric traction will be adopted for main line working in the near future. Whatever opinion is held, there can be no doubt that the recent joint discussion of this subject by American and English engineers has proved most instructive. Mr. PHILIP DAWSON, although unable to be present at the meeting, has contributed some interesting remarks to the discussion. It will be seen from his communication, which we reproduce elsewhere in this issue, that the comparisons made by Mr. H. M. HOBART in his paper are apparently based on inaccurate figures for the South London line. Thus, Mr. HOBART takes the weight of the electrical equipment as 44 tons instead of 36 tons, and calculates that the cost of electrical energy is from 10d. to 15d. per train-mile, whereas Mr. DAWSON states that the actual cost is 4·83d. per train-mile if the cost of current is taken as ½d. per unit—a figure likely to be reached at an early date. In view of the importance of reliable data, it is to be hoped that details as to the cost of operation over an extended period will soon be available for the single-phase system. At the meeting of the London, Brighton & South Coast Railway Co. last week the Chairman mentioned that it was still a little early to say much about the comparative cost of electrical and steam working, but it is interesting to notice that he had nothing but praise for the new system from the engineering point of view.

THERE is, of course, little doubt that the greatest benefits of electrification are usually experienced on suburban lines. Tramway competition in the neighbourhood of large towns has become so severe that the railway companies are faced with the loss of a considerable portion of their traffic under present conditions of working. As will be seen from a note in another column of this issue, a scheme of electrification is being considered for the Manchester district by the Great Central and London and North-Western Railway Companies. The extensive tramway system of the Manchester Corporation must have had considerable effect on the above railway companies, and if the latter electrify their lines keen competition is likely to result. In fact, it is probable that in future the tramways in many large centres of population will find the electric railway no mean competitor.

The Quadrant Electrometer.

IN his article on "The Elementary Theory of the Quadrant Electrometer," Dr. BEATTIE calls attention to certain points which are not so familiar as they might be to those persons whose duty it is to make a study, careful or otherwise, of this historic instrument. His remarks are eminently worthy of the consideration of the practical man who has to use the quadrant electrometer, and they are of no less importance to the student. Unfortunately it has become the practice among certain writers of text-books to endeavour to treat a somewhat difficult subject in an elementary and more or less popular manner; and, moreover, the practice is not confined entirely to authors, but even extends to teachers. The excuse offered is either lack of space or time; while in some cases the work is left undone out of mistaken kindness for the reader or student. Of course, what is written or said is good enough to satisfy

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an examiner, and so the mischief is done. Dr. BEATTIE'S article is devoted to correcting an error which has been a feature of text-books for many years, and he does it with the greatest simplicity. He shows clearly that the controlling couple acting on an electrometer needle is not due to the suspension alone, and then proceeds to draw an interesting comparison between the electrometer and the moving-coil alternating-current galvanometer.

Central London Railway.

IT is probable that penny fares will become a permanent feature of the Central London Railway, which in its early years was almost universally known as the "Twopenny Tube." For some time the uniform fare of 2d. proved satisfactory on this railway, but diminishing traffic—due largely to the keen competition of motor omnibuses—led the directors to seek means of checking the marked decline in revenue. After due consideration, it was decided to increase the fare for long distances to 3d., while short-distance passengers were catered for by the introduction of 1d. fares. These latter naturally require to be in operation for some little time before their full effect can become apparent, but they seem already to be exceedingly popular, as may be gathered from the statement of the Chairman, Sir HENRY OAKLEY, at the meeting last week. It appears that the number of 1d. fare passengers increased in the half-year ended June 30th by 2,290,390, while the total number of passengers carried during the same period also showed an increase of 9 per cent., compared with the traffic for the corresponding six months of last year, the gain in revenue being 2 per cent. Although small, this is a move in the right direction, and it is gratifying to notice that the working expenses have not increased with the growth of traffic. One of the most interesting points to which attention was drawn last week by the Chairman was the considerable increase in "through-bookings." The co-operation between the various underground railways stands out as one of the most pleasing features of the London traffic problem, and it has certainly done much to bring the "Tubes" into public favour. Further benefit should undoubtedly result to the Central London Railway from the interchange of traffic when the extension of the railway to Liverpool-street is completed.

Electricity in Peru.—At the meeting of Ferrobamba (Ltd.) last week Mr. M. F. Kindersley said the Company had the right to utilise the water-power of the river Chalhuahuacho (Peru) and its affluents, and application had been made for similar rights on the river Apurimac. They would, therefore, have sufficient power to work the smelter, for operating a local railway system and for all other possible requirements. Electrical energy would be used for all power purposes, including the railway for joining up the Company's several properties, and perhaps a considerable mileage of the future railway system that would connect their properties with the coast would be similarly operated.

Cable Interruptions.

	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910
Bonny—Duala	Aug. 3, 1910

Manchester Suburban Railway Electrification.—At the recent meeting of the Great Central Railway Co., the chairman (Sir Alex. Henderson) referred to the fact that the directors of the Company, in conjunction with the L. & N.W. Rly. Co., had been considering the advisability of electrifying the South Junction and Altrincham line. It is stated that the proposal is only part of a large scheme in which the whole of the railway companies serving Manchester are concerned. The L. & N.W. Co. have already decided to give a trial to motor trains on the line between Manchester and Wilmslow, and if these are found to be a success it is anticipated that the whole of their branch lines will be electrified. The other companies are making investigations both at the local stations and at the tram termini, with a view to determining the amount of local passenger traffic at various times of the day, and the delays and inconveniences caused by the present arrangements. It is regarded as practically certain that this movement on the part of the railway companies is a general one, which will affect not only Manchester but other large centres of population.

200,000 Volt Testing Transformer. — The "Electrical World" gives an account of a 20 kw. 200,000 volt testing transformer which students in the electrical engineering school of Purdue University have recently completed, under the direction of Profs. C. F. Harding and J. W. Esterline. The material used in building this apparatus was part of that employed in the famous "million volt" transformer exhibited at the Louisiana Purchase Exposition at St. Louis in 1904, and afterwards acquired by Purdue University. The reconstructed transformer is air-insulated, and measures over-all 76 in. by 55 in. The rectangular core is 10 in. by 5¼ in. in section, and the magnetic circuit has a mean length of 222 in. The 100 volt primary winding comprises 38 turns of No. 4-0 stranded copper cable. The secondary winding is made up of 76,000 turns of No. 30 silk-covered wire, having a total resistance of 68,000 ohms. The magnetising current is 22·6 amperes, having a power component of 16·1 amperes. The transformer is to be used for research study in high-tension phenomena.

Sleeping Cars on Electric Railways.—It will be remembered that some years ago sleeping cars were introduced on the Illinois Traction System between Springfield and St. Louis, the line being electrically worked. Now, according to "The Engineer," additional cars have recently been built for a service between Peoria and St. Louis, and these embody several new features. The former cars were of the Holland type. The new cars resemble the Pullman type, but have the sections separated by permanent transverse partitions. An important feature is that the passenger, arising in the morning, can fold the berth against the side of the car, and a folding chair in the open space then facilitates his toilet. The upper berths have large windows, extending up to the eaves of the roof. Each berth has electric lights (current being supplied by storage batteries), and a small locker for watches, jewellery, &c. Permanent partitions separate the sections, and at night the sections are shut off from the centre aisle by curtains. The cars are not equipped with motors, but will be hauled as trailers, thus minimising the noise and vibration.

Terminology.—At the recent congress of the National Electric Light Association, the Committee on Terminology submitted a list of definitions for immediate publication and distribution in order to invite criticism. Among those which appear to be novel are the following: *Block rate.*—A method of charging for electric service at different successive rates per kilowatt-hour consumed, each successive rate applying only to a corresponding successive block or quantity of the total current purchased during the period covered. *Corrective motor.*—A synchronous motor running either idle or under load, whose field may be varied so as to modify the power of the circuit to which it is connected, or through such modification also influence the voltage of the circuit. *Dispersion factor.*—The factor applied to light intensity after dispersion, which gives the intensity if the dispersion agent were removed. *High frequency.*—A frequency so high that Ohm's law does not apply even approximately. *Intensified arc lamp.*—An arc lamp

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with one of the carbons of small diameter to give a large current density per unit of arc, on which the arc plays thereby to intensify the light. *Operating time factor.*—The ratio of the number of hours of operation to the number of hours in the interval considered. *Operating time load factor.*—The load factor considered only during the time of operation. *Step rate.*—A method of charging for electric service at definite specified rates per kilowatt-hour consumed. A number of "factors" are also defined as follows: *Capacity factor.*—The ratio of the average station output to the maximum capacity of the station in kilowatts. *Demand factor.*—The maximum connected kilowatts of capacity divided by the actual kilowatts of demand. *Effective load factor.*—The main load of a part of the system determined by the load at the time of the system's maximum. *Load factor.*—The average load over any given period divided by the highest average load for any one minute during the same period. *Simultaneous demand factor.*—The ratio of the simultaneous demand and the connected load.

Electricity in Mines.—It is stated that the Departmental Committee of the Home Office on the use of Electricity in Mines, which has for some time past been taking evidence as to the working of the existing Home Office rules, will not take any further evidence. When the Committee resumes its sittings in the autumn, under the chairmanship of Mr. R. A. S. Redmayne, H.M. Chief Inspector of Mines, the draft report of the Chairman will at once be considered by the Committee, and it is expected that the report will be presented to the Home Secretary before the close of the present year. It will be remembered that the Committee is composed of Mr. Redmayne, Mr. Charles H. Merz and Mr. Robert Nelson, H.M. Electrical Inspector of Mines.

Obituary.—We regret to record the death on July 31st, after an operation, of Mr. W. B. Sisling, electrical engineer and one of the managing directors of Messrs. Laurence, Scott & Co., of Norwich. Mr. Sisling, who was 50 years of age, had been connected with the firm from its inception in the early eighties and was for some time the secretary of the Company, being appointed a director in 1898. He has left a large number of friends, all of whom held a high opinion not only of his business capability and integrity, but also of his technical knowledge in electrical matters.

Nickel for Resistance Thermometers.—In an article in a recent issue of the "Physical Review" Mr. C. E. Marvin remarks that whilst probably no other metal can compete with platinum for use at high temperatures, the striking advantages of nickel wire for the construction of resistance thermometers over a considerable range of moderate temperatures is not generally recognised. Nickel exhibits an inversion point between 350°C. and 400°C., and sufficient data to determine its suitability for resistance thermometers at very low temperatures are not at present available. Its greater resistance, greater change of resistance with temperature, and its small cost as compared with platinum, all render nickel better than platinum for thermometric purposes over a considerable range of temperature. While it may possibly be difficult to procure nickel wires of a uniformly high purity, yet the maximum purity seems unessential, since what passes as commercially pure nickel seems to posses the advantages required. Callendar has already shown that the temperature resistance curve of platinum is a parabola. At least three points must be located to define the parabolic curve. The nickel resistance curve seems to be very accurately represented by a logarithmic curve of the form $\log R = a + mT$, and only two points are required to locate such a curve. The coefficient m depends upon the quality, that is, the purity, and possibly some other of the physical properties and conditions of the metal. The data at present available to the author in support of the logarithmic curve are conceded to be too scanty and inadequate to demonstrate anything like a general law, but the conformity is sufficient for a great many purposes, and is shown by a table in the article. The data from the Bureau of Standards, however, are not so well fitted by a logarithmic curve. The point at 0°C., especially, is discordant; but from 100 deg. to 375 deg. the conformity is much closer. Admitting that the nickel wire temperature-resistance curve is approximately logarithmic, the author points out that resistance readings of a nickel thermometer on the usual form of slide-wire bridge, or equivalent, having a scale of equal parts, may also be made to give gas scale temperatures with very considerable accuracy.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. R. Beattie, D.Sc., contributes an article on "The Elementary Theory of the Quadrant Electrometer."

We give abstracts of the Papers read by Mr. F. W. Carter and Mr. L. R. Pomeroy at the recent joint meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. Mr. Philip Dawson sent in a written communication in connection with the discussion on railway electrification at the same meeting.

We continue our account of the work carried out at the Reichsanstalt during the past year.

A memorandum has been prepared setting forth the objects of the Association of Consulting Engineers.

We analyse the accounts of the Manchester Corporation Tramways Department for the year ended March 31st last.

Wimbledon Corporation have received sanction for borrowing £6,600 for mains, house services and meters.

"Telephonist" contributes a communication on the subject of the National Telephone Co.'s position. His communication is open to much destructive criticism, and the writer is wise to prefer anonymity.

Hereford Corporation have received sanction to a loan of £3,500 for mains and services.

Companies' Meetings and Reports.—At the Central London Railway Co.'s meeting last week resolutions authorising the raising of £480,000 share capital for constructing the Bank-Liverpool Street extension line were approved.

At the meeting of the Great Central Railway Co. last Friday Sir Alex. Henderson said he had reason to believe that the improved telephone service which was now available all over the country had affected railways by enabling business to be carried on with a fewer number of journeys between place and place. Sir Alex. Henderson also referred to the probability of electrifying the Altrincham line, which was jointly owned by the L. & N.W. and G.C. companies. A final decision has not yet been arrived at. (It is stated that the railway companies serving Manchester are considering a scheme for the electrification of all the Manchester suburban lines.)

The Liverpool Overhead Railway Co. are able to pay the 5 per cent. dividends on both classes of preference shares for the first time since 1907.

The directors of Brown, Boveri & Co. report a somewhat unsatisfactory year's work owing to the steady fall in prices, and they deplore the continued difficulty of obtaining contracts which leave a margin of profit to the manufacturers.

At the meeting of the Metropolitan District Railway Co. on Wednesday the chairman (Sir Geo. S. Gibb) was able to present a very satisfactory report of the progress of the Company. There was a large increase in the number of passengers, and expenses had decreased. He stated that the financial position had been improved and that the outlook was very encouraging.

INSTITUTIONS AND SOCIETIES.

THE TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.—The Official Circular of this Association for July contains Mr. J. A. Panton's reply to the discussion on his Paper, "Brake Shoe Standardisation," read at the Dublin Congress; a report of the valuation appeal by the Glasgow Corporation, with opinions of Lord Dundas (April, 1910) and Lord Shand (March, 1873); a full report of a case in regard to Parliamentary deposits, which was recently decided, with judgment by the Master of the Rolls in Court of Appeal, April, 1910.

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MANCHESTER CORPORATION TRAMWAYS.

The tramways undertaking of the Manchester Corporation has certainly proved a very profitable investment for the ratepayers, as may be gathered from the fact that during the last nine years a total sum of £452,000 has been handed over by the Tramways Committee in relief of the rates. The contribution for the year ended March 31, 1910, is the largest so far recorded, namely £75,000, compared with £70,000 in 1908-9. As the renewals and depreciation fund stands at £422,210, with a total capital expenditure of under £2,000,000, and £284,812 has been applied in the reduction of debt, the City Council may well regard the future of the undertaking with equanimity.

In their report for the past year the Tramways Committee state that the aggregate length of single track open for traffic is now 181 miles 1,351 yds., including the lines over which the Corporation are exercising running powers.

The total number of passengers carried during the 12 months was 159,049,096, an increase of 4,037,212 compared with the previous year's figure, and the largest number of passengers recorded. As the number of car-miles run decreased from 17,316,753 to 17,161,774, it is not surprising that the average traffic revenue has grown from 10·728d. to 10·869d. per car-mile during the year, and the average number of passengers from 8·95 to 9·26. The population served by the tramways is estimated at 850,000, so that the average number of journeys per head of population per annum is now no less than 187, as against 182 a year ago. This steady increase in the habit of "tramming" must be regarded by the Committee with favour.

It is interesting to notice the proportion of passengers carried at the various fares. This is given below, and seems to show that the increase in traffic is mainly at the lower fares.

	1909-10. Per cent.	1908-9. Per cent.	1907-8. Per cent.
½d.*	8·40	7·35	6·92
1d.	67·10	67·04	67·82
1½d.	13·36	13·14	12·80
2d.	6·65	7·28	7·24
2½d.	2·09	2·05	2·10
3d.	1·62	2·05	1·80
Fares above 3d.	0·78	1·09	1·32

The total number of units used by the cars was 29,335,144, or 1·709 units per car-mile, compared with 1·748 units in the previous year and 1·76 units in 1907-8. This steady decrease in the consumption of energy, in spite of an increase in the number of passengers per car-mile, is worthy of note. The current, as will be seen from our analysis of the accounts, is purchased from the Electricity Committee at the average price of 1·01d. per unit.

The total number of cars in stock at March 31, 1910, was 582. Of these cars 321 were of the single-truck type, 216 had double trucks and 45 were combination cars. It may also be mentioned that 310 cars have covered tops. During the year 15 new cars (the bodies for which were manufactured in the tramway department's workshops) were put in service, whilst a further 35 cars were nearing completion.

The system of parcel carrying commenced in October, 1906, on these tramways, and has developed considerably since its inauguration. This is indicated by the fact that, on an average, 16,072 parcels are now dealt with every week, compared with 12,942 last year and 9,101 in 1908. The total receipts for the year under this heading are £8,678 and the total profit £2,264.

From the analysis which we give below of the tramway accounts it will be noticed that the working expenses have increased by 0·10d. per car-mile, and are now 7·15d. per car-mile. This result is mainly due to the increased payment for local rates, no less than £38,498 being paid under this head, an increase of £6,148 or 0·09d. per car-mile, compared with last year's figure. In the analysis of the accounts below, the cost per car-mile for the previous year is also given to facilitate comparison.

* ½d. fares are adopted on the circular and cross routes only, not on the main routes.

		Cost per car-mile. 1909-10.	1908-9.
Traffic Expenses.			
Superintendence	£2,154	0·03d.	0·03d.
Wages of drivers and conductors	142,113	1·99d.	1·97d.
Wages of other traffic employés	23,248	0·32d.	0·32d.
Cleaning and oiling cars	24,073	0·34d.	0·33d.
Cleaning track	2,848	0·04d.	0·03d.
Depot expenses	11,886	0·16d.	0·13d.
Ticket check	11,345	0·16d.	0 16d.
Uniforms	6,309	0·09d.	0·08d.
Miscellaneous	1,956	0·03d.	0·03d.
Total Traffic Expenses	£225,932	3·16d.	3·08d.
General Expenses.			
Salaries and wages	£12,677	0·18d.	0·17d.
Store expenses	1,299	0·02d.	0·02d.
Rents	4,092	0·06d.	0·06d.
Rates	38,498	0·54d.	0·45d.
Printing and stationery	1,285	0·02d.	0·02d.
Fuel, light and water for offices	1,178	0·02d.	0·02d.
Law charges	381	0·00d.	0·00d.
Compensation	10,278	0·14d.	0·16d.
Insurance	665	0·01d.	0·01d.
Miscellaneous	3,748	0·05d.	0·05d.
Total General Expenses	£74,101	1·04d.	0·96d.
Repairs and Maintenance.			
Permanent way	£16,371	0·23d.	0·21d
Electrical equipment of line	9,630	0·13d.	0·12d.
Buildings and fixtures	3,767	0·05d.	0·05d.
Machinery and plant	477	0·01d.	0·01d.
Cars	56,110	0·78d.	0·77d.
Other rolling stock	1,111	0·12d.	0·02d.
Total Repairs and Maintenance	£87,466	1·22d.	1·18d.
Power Expenses			
Current purchased at average price of 1·01d. per unit	£123,571	1·73d.	1·83d.
TOTAL WORKING EXPENSES (*ex.* capital charges)	£511,070	7·15d.	7·05d.
Capital Charges, &c.			
Interest	£53,500	0·75d.	0·69d.
Sinking fund	47,215	0·66d.	0·60d.
Income tax	5,661	0·08d.	0·10d.
Rent of leased lines, &c.	25,753	0·36d.	0·37d.
Miscellaneous	1,192	0·02d.	0·02d.
Total Capital Charges, &c	£133,321	1·87d.	1·78d.
TOTAL EXPENSES (*inc.* capital charges)	£644,391	9·02d.	8·83d.
Revenue.			
Traffic revenue	£777,219	10·87d.	10·73d.
Rents, sundries, &c.	8,546	0·12d.	0·12d.
Parcels department	2,264	0·03d.	0·02d.
Bank and other interest	5,431	0·08d.	0·04d.
TOTAL REVENUE	£793,460	11·10d.	10·91d.
Balance	£149,069	2·08d.	2·08d.

This balance is allocated as follows :—

Reserve, renewals and depreciation fund	£70,021	0·98d.	1·06d.
Street improvements, &c.	4,048	0·05d.	0·05d.
Contribution in aid of rates	75,000	1·05d.	0·97d.

As mentioned above, the reserve, renewals and depreciation fund now stands at £422,210. During the past year sums of £41,547 for renewal of permanent way and overhead equipment, and of £7,088 for renewal of cars and car equipments, were taken from the fund.

The capital expenditure during the past year amounted to £120,504, £43,036 of this being on account of the Princess-road car-shed buildings, £22,621 for new cars and £33,779 for permanent way. The total expenditure on the electric tramways to March 31, 1910, was £1,957,594. The various items comprised in this total are as follows, the percentage each bears to the total outlay being also given :—

		Per cent.
Permanent way	£645,495	33·0
Overhead equipment	181,306	9·3
Depots and car sheds	381,869	19·5
Cash offices	3,940	0·2
Rolling stock	388,414	19·8
Machinery and plant	13,039	0·7
Office furniture	6,472	0·3
Cost of Carriage Co.'s undertaking	291,553	14·9
Preliminary expenses	25,751	1·3
Promotion expenses	19,755	1·0
	£1,957,594	100·0

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ELECTRIFICATION OF SUBURBAN RAILWAYS.*

BY F. W. CARTER.

Summary.—The author considers there is little prospect of the general electrification of the railways of this country, but believes that an investigation of the cost of electrification and the economic results of providing improved facilities would in many cases justify the conversion of suburban railways to electrical working. Interesting particulars are given of the cost of conversion, the maintenance of electrical trains and of train delays, together with brief descriptions of the electric lines in this country.

Many of the railways of this country have, so far as their suburban passenger traffic is concerned, been affected very adversely in recent years by the great and increasing competition of tramcars and motor omnibuses. The companies concerned appear undecided at the present between giving up a great portion of this class of traffic permanently and endeavouring to regain it by electrification of their suburban lines. The latter expedient, although an expensive one, has hitherto invariably been found successful in regaining much of the lost traffic, and the problem confronting a company in regard to any section of its suburban lines is that of determining whether the expected gain from electrification will justify the expense to be incurred.

Modern electric railway apparatus leaves little to be desired in the matter of freedom from breakdown, the delays from all causes, electrical and mechanical, for the month of December, 1909, averaging about 33 seconds per day per train on the District Railway and only 2½ seconds per day on the Underground Electric Railways' tubes. The total cost for maintenance and repairs of rolling stock on these lines does not exceed 0·6d. per car-mile.

In typical suburban service the greater part of the energy input is used in accelerating the train, and the energy consumption per ton-mile depends principally on the nature of the schedule. A high initial rate of acceleration involves great mechanical strains on the bogies, and should not be employed unless the difficulty of the schedule renders it necessary. The equipment losses during acceleration are of the same order of magnitude in the continuous current and the single-phase systems, in spite of the rheostat losses in the former system. The performance of a given electric train under given conditions of suburban service can be very closely predetermined, for the factors liable to uncertainty have but small effect on the result. Schedule calculations, however, are inadequate by themselves to determine the question of the suitability of an equipment, as the limiting features are usually connected with the heating of the motors, which again depends on the energy loss in the motors. This loss is much greater in the single-phase system than in the continuous-current system.

There appears little prospect of general electrification of the railways of this country, as no advantage is apparent which would in any way justify the expense. It is only in the case of heavy suburban service that there is prospect of commercial advantage accruing from electrification, and whilst there may be other local opportunities for electrical working, there is at present no indication that the steam locomotive can be superseded with advantage for ordinary main line work.

The extensive tramway systems that radiate from most of our large cities and motor-omnibuses have resulted in a great shrinkage of suburban railway traffic. The railway companies affected appear for the most part undecided between allowing their short-distance traffic to go, employing their energies in fostering the longer-distance traffic, and endeavouring to reduce the effective range of tramway competition by electrification of their suburban lines. The latter alternative, wherever it has been tried, has invariably succeeded in recovering a portion of the lost traffic, besides creating a more desirable traffic for longer distances by the improvement of facilities. Whilst it is by no means certain that local electrification would prove the best commercial policy in the case of all railways handling suburban traffic, it is the author's opinion that there is considerable scope for well-considered electrification schemes in this country. Where a suburban railway is regularly used to near the limit of its capacity and there is still possibility of increased traffic, there is every reason to expect a commercial advantage from electrification. The capital cost is further justified by the greater use that can be made of existing lines and terminals under electrical operation. The cost of electrification should in fact be set against the cost of widening and improving the railway to accommodate the traffic in view.

In the more usual case, however, the management of a railway are compelled to estimate the chances of success from far less certain data, the difficulty confronting the management being to estimate the increase in receipts which would accrue from the improved facilities. The capital outlay and operating expenses can be closely approximated in any particular case, and the amount will depend largely on the difficulty of the proposed schedule. It is in the power of electricity to improve very greatly on the performance of steam trains; but the greater the improvement the higher the capital and operating costs and the greater the attractiveness of the line. It is a matter of nice estimation and computation to determine what improvement of service will result in the greatest commercial advantage to the railway. The Tynemouth lines and the Liverpool–Southport line do not differ greatly in the distance between stops. The schedule speed, however, is considerably higher on the Liverpool–Southport line, and the effect of this on operating expenses partly accounts for the experience of the Lancashire & Yorkshire Railway that the cost of electric working, as they had expected, was, when proper allowances were made for the depreciation of the more costly plant, slightly higher per train-mile run than that of steam working.

The electrification of a steam railway can of course be considered commercially expedient only when the estimated net profit under electrical operation exceeds that under steam operation by more than the interest on the extra capital involved. It is chiefly the burden of capitalisation which limits electrification to lines of heavy traffic. The extent of the burden is in practice very variable. The total capital involved in the Tynemouth electrification to date is approximately £244,000, and the annual electrical train-mileage, 1,215,000; taking the interest at 4 per cent. the capital burden is seen to be about 1·93d. per train-mile. Again, the capital involved in the electrification of the South London elevated line has been given as approximately a quarter of a million sterling, and the yearly train-mileage is at the present time some 375,000, to be eventually increased to approximately 585,000 miles. The burden of the capital is therefore about 6·4d. per train-mile at present, decreasing to 4·1d. if the improved service can be realised without adding to the capital expense. The capital burden in the case of the Mersey Railway has been given as 4·3d. per train-mile, and in the case of the Lancashire & Yorkshire electrified lines as about 2d. per train-mile. These two cases of course include generating station, which is absent in the first two.

An indispensable requirement to the success of any system for working suburban traffic is immunity from all forms of breakdown competent to delay the service. In this respect modern electric railway apparatus, if chosen with reference to the nature of the service and maintained with care, leaves little to be desired. Even when first installed the troubles are usually of a minor character, and the consequent delays unimportant, whilst ordinary operation is exceedingly reliable so far as the electrical plant is concerned. Table I. gives particulars of all delays on all lines of the Underground Electric Railways Co. of London for the month of December, 1909. The much greater loss of time on the Metropolitan District Railway, as compared with the tube lines, is almost entirely due to the fact that District trains operate to a considerable extent over foreign lines, worked for the most part in the interests of steam trains. The comparative immunity from breakdown is duly reflected in the low maintenance cost of the train equipments. Mr. Chapman dealt with this subject at a valedictory dinner given in his honour on February 7, 1910, on the occasion of his retirement from the position of chief engineer to the Underground Company. He said that they (the Underground Railways Company) "owned over 800 motors, and that every one was the same throughout, no matter whether it was working on the District or a Tube, under a car or on a locomotive, all were interchangeable; and to-day, several years after the original purchase, they were negotiating for some more of the same motors to meet the increased traffic requirements of the District Railway. On no one of their properties did the cost of rolling-stock maintenance and repairs exceed 0·6d. per car-mile. The 10 District Railway electric locomotives, now five years old, made 1,300 miles per day at a cost of ½d. per mile for all maintaence and repairs. Two of them coupled handled a London & North Western Railway nine-coach train to Mansion House far better than a steam locomotive had ever done. The maintenance cost was 1d. per train-mile. The North Western costs for maintaining a steam locomotive were 4d. per mile; the average cost for all English railways was 3½d. per mile."

The railways in this country operated wholly or in part electrically are 18 in number, working over a total of approximately 200 miles of route and 410 miles of track. The trains are worked by 87 locomotives and 821 motor-coaches. The aggregate nominal power of the driving motors is approximately 360,000 H.P., of which 184,000 H.P. is provided by one type of motor alone, namely, that used exclusively by the railways operated by or in conjunction with the Underground Electric Railways Co., London, and partly by the Metropolitan Railway.

* Abstract of a Paper read on July 29th at the joint meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. An account of the joint discussion on this and other Papers appeared in our last issue.

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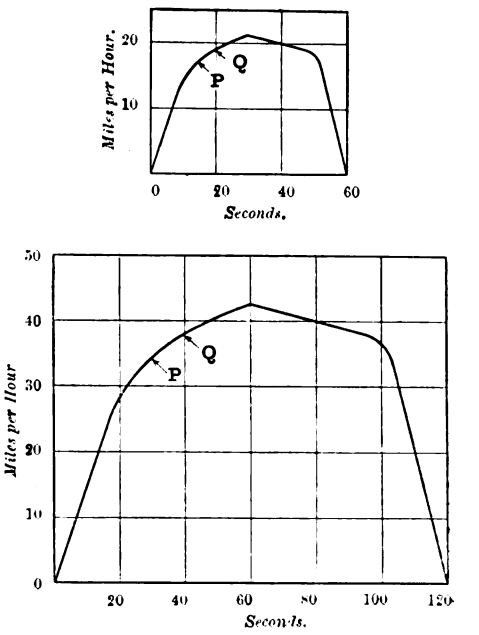
Table I.

—	District.	"Tubes." *
Total number of train-miles	401,295	499,908
Total number of delays (all causes)	303	44
Total time lost by delays....mins.	1,186	107
Train-miles per delay	1,324·4	11,361
Train-miles per minute lost	338	4,672
Total number of delays due to electrical troubles on the trains	54	21
Time lost due to electrical troubles on the trains, min.	135½	75
Train-miles per electrical delay	7,431	23,805
Train-miles per min. delay on account of electrical troubles	2,961	6,665
Average mileage per train per day	185	194·85
Average delay per train per day due to electrical troubles on the trains....mins.	0·062	0·029
Average delay per train per day due to all causes mins.	0·548	0·042

The author proceeds to give a brief comparative summary of the electric lines in this country. By far the greater portion of the electrically operated traffic is worked by motor-coaches rather than separate locomotives. This method of operation is peculiarly adapted for working suburban railways and will no doubt remain the standard. The chief advantage of locomotive operation is that the greater portion of the electrical apparatus is immediately under the eye of the driver. If the apparatus was less immune from breakdown this would be worth making considerable sacrifice to attain, but practically the advantage is small, as balanced against the advantages of motor-coach operation. The multiple-unit system of control in which the motors on any bogie and the corresponding motor controllers form a unit—all such units on a train being operated from the driver's cab—is practically universal in the latest equipments, as well for locomotives as for motor-coaches. Most of the multiple-unit trains used on surface lines carry the motor-controlling apparatus suspended on the underframe of the motor-coach. In the case of the tube lines, however, it is invariably located inside the motor-coach, in order to be accessible in case of emergency. In the smaller tubes the control compartment is placed over the motor-bogie on a raised platform.

Most of the passenger coaches are of the saloon type; there is, of course, nothing in the nature of electrical working to render this type of coach indispensable, although the shortness of the station stops and the high rate of acceleration usual in electrical service render it preferable from the operating point of view. Some of the most popular of the Metropolitan Railway trains, however, are of the compartment type, being bogie trains, dating from the time of steam operation, converted for electrical working. The London, Brighton & South Coast Railway have sought to combine some of the advantages of both types of coach in the new rolling-stock for their South London Elevated Electric line. The coaches are of the corridor type, being divided into compartments, and having side doors, but having a corridor running the length of the coach for distributing the passengers. Although most of the railways in this country employ the vacuum brake, the electric railways, with the exception of the Lancashire & Yorkshire and the Midland, have adopted the Westinghouse type of brake. The chief reason for this is that compressed air can be stored to take off the brakes at a moment's notice.

In suburban service the greater part of the energy expended is used in giving speed to the train and is ultimately dissipated in the brakes. Other things being equal, therefore, the more frequent the stops the greater is the energy required per mile, and the more difficult the service. The energy-consumption per ton-mile, unless abnormal, is, in fact, a very good measure of the difficulty of a service. If this were more generally realised the world might be spared some of the absurd comparisons of energy-consumption between different systems, in which credit is claimed for obtaining a low energy-consumption, which is really due to comparatively easy service. If it be granted that the natural and normal energy-consumption per ton-mile is a reasonable measure of the difficulty of a schedule, an even more reasonable measure is to be found in a certain acceleration immediately expressible in terms of the particulars of the service, namely, the acceleration that would cause the train to reach a speed equal to the mean running speed in a distance equal to that between stops. This is merely a dynamical result, and in order to show it let Figs. 1 and 2 represent speed-time curves corresponding to two schedules, the curves being such that that of Fig. 2 is simply that of Fig. 1 magnified twice in every direction. The distance represented in Fig. 2 is then four times that in Fig. 1. At corresponding points P on the two curves, the acceleration, and therefore the tractive effort per ton necessary to produce it, will be the same. The power per ton required at P to produce the acceleration, being proportional to the tractive effort and speed, is twice as great in Fig. 2 as in Fig. 1. The energy per ton required to accelerate between corresponding points P and Q, being proportional to the power and to the interval of time will be four times as great in Fig. 2 as in Fig. 1. But the distance is also four times as great, and thus the energy per ton-mile used in accelerating—probably some two-thirds of the whole—is the same for the two services. If the mean train-resistance per ton were the same for the two curves, the energy per ton-mile required to overcome the resistance would also be the same, and we might then assert that the total energy-output per ton-mile would be the same in the two cases. As it is, there is a small error affecting a comparatively small portion of the energy, which will have to be neglected. This is in general of little consequence in cases in which it would be expedient to employ the result, that is, in suburban service, where a ratio of four to one in distance with simliar speed curves, is, of course, a very exaggerated case. It will be seen that the acceleration referred to above, which will be called the specific acceleration of the schedule, is the same for the two curves, being the square of the mean running speed divided by twice the distance. It will also be seen that the method is perfectly general; so long as the speed-time curves for two services are similar the specific acceleration will be the same, and the energy output of the equipments practically the same. It follows that of two services, that having the higher specific acceleration may be expected to show the higher energy consumption per ton-mile. Also that if two services have the same specific acceleration but differ in energy consumption the higher can be reduced, in so far as it is not due to lower equipment efficiency, by running so as to assimilate its speed-time curve to that of the lower. The specific acceleration of a schedule is a better index of the difficulty of the schedule than the energy-consumption, inasmuch as it is independent of the equipment efficiency and of the particular manner of running the schedule, in effect reducing equivalent services to the same mode of operation. This, of course, presupposes that the line is not specially graded to reduce the difficulty of operation.



FIGS. 1 and 2.—SPEED-TIME CURVES CORRESPONDING TO TWO SCHEDULES.

The above is an application of a method which the author has more fully elaborated elsewhere.* Table II. gives some characteristic schedules arranged in order of difficulty as indicated by the specific acceleration.

A difficult service—in the sense of a service in which the specific acceleration is high—is one in which it is advisable, in the interests of low energy-consumption, to employ high rates of acceleration and retardation; in an easy service this is of smaller consequence and hardly worth securing at the cost of heavy mechanical strains on the bogies, &c., with the great draught of power incident to the use of a high rate of acceleration. The account of the tests on the Liverpool overhead trains indicated a maximum rate of acceleration of 4·2 ft.

* i.e., Baker Street & Waterloo Railway; Great Northern, Piccadilly & Brompton Railway; Charing Cross, Euston & Hampstead Railway.

* "Journal," Inst. of Electrical Engineers, Vol. XXXVI., p. 240.

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Table II.

Line.	Average distance between stops.	Schedule speed.	Time of stop.	Av. speed excluding stops.	Specific acceleration.
	feet.	m.p.h.	secs.	m.p.h.	m.p.h. per sec.
Liverpool Overhead.....	2,145	19·5	11	22·9	0·179
Liverpool–Southport	6,535	30	15	33·4	0·125
Underground, Inner Circle	2,555	15·7	20	19·2	0·106
Baker Street and Harrow	5,000	23	20	26·6	0·104
South London Elevated.	4,540	21·5	20	25	0·101
Hammersmith and City.	2,830	16	20	19·2	0·096
Central London.....	2,540	14·7	20	17·7	0·090
North-Eastern, Tynem'th	6,000	20·5	30	24·1	0·071
Mid. Heyshm-Morecambe	23,500	26·7	120*	33·4	0·035

per second per second (2·9 miles per hour per second), and this is perhaps as high as it is advisable to employ in service.

During the period of acceleration by controller notching, considerable energy loss is inevitable in the equipment. In the continuous-current system the average equipment efficiency during notching is usually only about 57 per cent., the remaining 43 per cent. being lost in the motors, rheostats, &c. It has been hastily assumed by some that the avoidance of rheostat losses in the single-phase system would result in much lower losses and higher mean efficiency during notching. That this is an unwarranted conclusion is shown by the authors of a recent Paper on the Heysham electrification,† who, although by no means blind to the merits of the single-phase system, found as the result both of test and calculation, that the mean efficiency of the equipment during notching was only 56 per cent. in the cases considered. The efficiency after notching is, of course, considerably higher for continuous current than for single-phase equipments.

The claim that the performance of a suburban electric train can be very closely predetermined may seem an extravagant one, until it is considered how very few are the conditions on which it depends. The quantities most likely to be subject to some uncertainty beforehand are the voltage at the train and the train-resistance. In suburban work, however, a small error in these has but little effect either on the schedule speed or energy-consumption. Perhaps an idea of the accuracy with which the running can be predetermined will be best conveyed by disclosing that the author's practice, in making a guarantee of energy-consumption, is to compute it as closely as possible under the expected conditions of test and add 5 per cent. to cover bad driving and other unforeseen contingencies. Such a guarantee would, of course, be of little use unless accurate instruments were available for making tests. Train-testing instruments should be specially designed for the work, so as to secure exceptionally large torque and heavy damping. The delicacy of ordinary stationary instruments renders them useless for train-testing where they are subject to great vibration in all directions.

These schedule calculations are easy and commonplace but quite inadequate by themselves to determine whether an equipment is suitable for a given service. More important in this connection are the calculations involving the magnitude and distribution of the losses in the motors, with the facilities for transferring and dissipating the heat generated. Such calculations, however, are almost necessarily confined to the designers of equipments, as the data on which they are based are not generally available. In order to give a rough idea of the quantities involved, it may be stated that the ultimate temperature rise of the hottest accessible part of an ordinary railway motor, totally enclosed and without forced ventilation, as measured by Centigrade thermometer after continuous service, is given approximately by $T=7Ww^{-\frac{1}{3}}$, where W is the mean motor loss in service (not including gear loss) in watts, and w is the weight of the motor in pounds, excluding gear and gear case. The motor losses in suburban service usually take from 6¾ per cent. to 7 per cent. of the input to the driving equipment‡ in the continuous-current system, and from 15 per cent. to 18 per cent. of this input in the single-phase system. The great motor losses incident to the single-phase system form the foundation of all the objections raised to the use of this system for suburban service.

The heating of the motors has always been a limiting feature in the design of equipments for this class of service, and the practicable and desirable means of dealing with it are well understood. The use of forced draught for cooling the motors, whilst practicable for locomotives and single cars, is quite out of place on multiple-unit trains intended for suburban service, where, since the equipment may not be inspected for hours together, it cannot fail to lead to breakdown, increasing maintenance charges and causing delays to traffic.*

Fig. 3 gives speed, power and motor-loss curves corresponding to typical suburban schedule runs with continuous current and with single-phase equipments, the former of which carries 20 tons per motor and the latter 23 tons. It will be seen that the great difference between the systems is in the motor loss, which amounts to 6·75 per cent. of the input in the continuous-current case and to 17·8 per cent. in the single-phase case. Although both motors are dynamically capable of working the service, the former alone has sufficient thermal capacity for the purpose, the other having to dissipate three times as much energy as it can get rid of by natural cooling.

The author has confined his remarks to the subject of "Suburban Electrification," inasmuch as there appears little prospect at present of general electrification of railways in this country. The properties which give to electrical working its predominant advantages in the case of heavy suburban service become of minor importance when the distance between stops is considerable and the service infrequent. Even in the case of heavy suburban service, moreover, the margin in favour of electrification is by no means overwhelming. This much can be affirmed, however, that where there is any considerable suburban traffic, an investigation of the cost of electrification and the economic results of providing improved facilities will repay the trouble and expense, and in many cases justify proceeding with the conversion.

The above remarks are intended to apply to the electrification of existing steam-operated lines. The case of entirely new railways is different and much more favourable to electrical operation. In laying out a new branch to an existing railway, again, it may be well

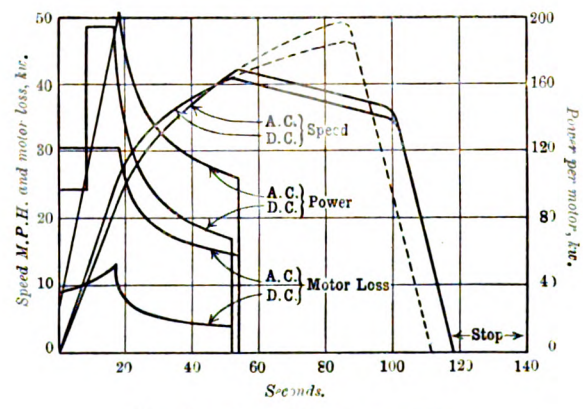

Fig. 3.—Train Characteristics.

worth while to consider electrical operation, the capital cost of which might be more than saved in the cheaper roadbed, since steep grades are much less objectionable on an electrical than on a steam road. There are also likely openings for local electrification on existing railways even apart from suburban systems; and again, where electric power is already available at goods yards and docks, the shunting might be more efficiently carried out by specially designed electric locomotives, fed perhaps by a suitable surface-contact system, than be steam locomotives. For ordinary main-line work, however, there is at present no indication that the steam locomotive can be superseded with advantage in this country.

The Braking of Alternating-Current Motors.—In a recent number of "L'Industrie Electrique," Mr. A. Héreny suggests a method for quickly braking induction motors by providing a suitable excitation for the stator during the act of stopping, thus enabling the rotor to generate alternating currents and to absorb energy. This may be attained by coupling a small series direct-current machine to the motor, connected so that when the main circuit is opened, the direct-current machine is coupled to one of the stator phases and excites the field, while the rotor is either short-circuited or connected to a resistance. Alternatively a rectified current derived from one of the rotor phases—in the case of a wound rotor with slip rings—may be used to excite the stator field, the current being rectified either by an electrolytic valve, a commutator, or other means.

* Assumed.
† "Proc." Inst.C.E., Vol. CLXXIX., pp. 188 and 189.
‡ That is, motors and rheostats.

* In this connection, *see* "Electric Traction on Railways," by Philip Dawson, p. 165.

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COHERERS.*

BY W. H. ECCLES, D.SC., A.R.C.S.

Summary.—A method of investigating detectors is developed with special reference to the relations between the energy given to the detector in the form of electrical vibrations and the energy delivered by the detector, as direct current, to the circuit of the indicating instrument. The response of the detector was measured by comparing the sound in its telephone with the sound produced in the same telephone by interrupting a measurable direct current. The results of experiments on coherers made of oxidised iron wire dipping into mercury, and on coherers made of a clean iron point touching an oxidised iron plate, are recorded. The author puts forward the hypothesis that the properties of an oxide coherer may arise solely from the temperature variations caused in the minute mass of oxide at the contact by the electrical oscillations and by the applied E.M.F. He examines the hypothesis mathematically and shows that most of the phenomena recorded can in this way be accounted for as perfectly as the present state of the measurements permits.

It is well known that an imperfect contact between almost any pair of good electrical conductors suffers a change of resistance when electrical oscillations of sufficient intensity occur in the circuit containing the contact. Prof. Branly, in 1896, concluded after much investigation that the effects observed were due to a modification of the electrical conductivity of the film of dielectric that happened to separate the conductors. For example, a mass of metal filings melted down in resin showed appreciable alteration of resistance when a spark or discharge occurred near it; and a pair of pieces of metal in very light contact, yet separated by their surface films of condensed gas, showed the phenomenon excellently. Sir Oliver Lodge at that date held the view that the alteration of resistance, usually a diminution, was due to the piercing of the dielectric and a consequent cohesion of the metals. He gave the name "coherer" to instruments exhibiting or utilising the phenomenon, and this name has been universally adopted and the suggested explanation widely accepted. It has often been pointed out that Lodge's explanation is inapplicable to known cases where the resistance of the coherer is increased by the passage of electrical oscillations. In the present Paper it will be shown that there is no need to adopt the "cohesion" hypothesis, even in the case of typical coherers where the resistance is lowered by the action of electrical oscillations.

Ten years ago the known ways of investigating a coherer required the device to submit itself to powerful electric discharges. We find investigators of filings coherers watching the sparks between the filings and boasting of fusing the filings into chains of quite considerable tenacity. But the engineers who were at that date nursing the infant wireless telegraphy were, on the whole, more gentle with the coherer than were the men of science. At most, the engineers required that the current through the coherer when it "cohered" should work a delicate relay. A few years later they merely asked that the coherence current should move the diaphragm of a telephone receiver. The oscillatory voltages that need be applied to a coherer in order to produce a resistance change perceptible by an ear at the telephone are very small indeed; and in these cases a good coherer spontaneously and very perfectly recovers its original resistance when the oscillations cease. The "cohesion" explanation appears improbable here, though in the cases familiar 10 years ago, where the alteration of resistance is permanent, that explanation seemed plausible.

Within the past six years the problem of the coherer has often been attacked, and each observer has in turn found all the theories of the action of coherers insufficient to explain his experiments, and has added some suggestion of his own. For example, A. Blanc,† in 1904, concluded that neither oxide nor condensed gases played a part in certain coherers, and believed that particles of the two surfaces diffuse at a rate depending on the current, temperature and pressure. On the other hand, Robinson‡ decided that in single point coherers the resistance is that of an elastic film of oxide, and that permanent coherence implied injury or thickening of the oxide: while Huth§ attributes coherence to the ionisation of the film rather than to the thickening of the oxide. From the point of view of the results of some of the experiments to be described in this Paper, the observations of A. H. Taylor are of special interest. He found that the current through a single point steel coherer shows three stages as the gap is diminished. In the first stage there is a feeble leakage current due, he thinks, to vapour conductivity; in the second, conduction due to metallic ions (in this stage a small rise of E.M.F. produces a great increase of current); in the third stage ordinary conduction occurs. In a Paper entitled "Recherces sur les Contacts Imparfaits" ("Journ. de Physique," ser. 4, III., 1904, p. 350), A. Fisch describes his experiments on the voltage-current curves for a coherer consisting of two spherical surfaces of steel whose separation was capable of fine adjustment. He found, from a study of numerous curves, that the average curve exhibits three stages: (1) As the current is raised the P.D. across the contact increases more and more slowly to a critical value constituting stage (2), where, though the current increases, the P.D. remains constant. Then (3) increasing current is accompanied by continually rising P.D. This curve of Fisch's is precisely the curve II. of Fig. 8 below. Besides these investigators there are others who have advocated that the electrostatic attraction between the conducting surfaces may account for the phenomena.

Very few, if any, experiments with electrical oscillations of very minute measured voltages have so far been published, yet only minute voltages nowadays arise in practice. The purpose of the present investigation is to examine the action of a certain kind of coherer under "weak signals," especially in respect of their energy relations.

Method of Experiment.—The self-restoring coherer to be examined was placed in a circuit comprising the necessary source of steady E.M.F. and a telephone receiver. At the same time it was also connected in series with a condenser, to form, as in practical wireless telegraphy, a shunt across the condenser of an oscillatory circuit (Fig. 1). This oscillatory circuit was made a secondary circuit in relation to a tuned primary oscillatory circuit. The coupling was always extremely loose. Trains of damped oscillations, of maximum

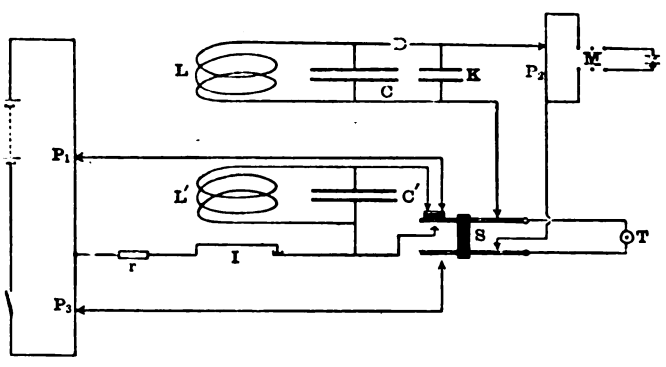

Fig. 1.

amplitude of the order of a few hundredths of an ampere could be excited in this primary; and hence feeble electrical oscillations of calculable magnitude could be excited in the secondary. The amplitude of the oscillatory E.M.F. at the coherer contact, and the energy delivered to the coherer, can be computed from the amplitude of the primary oscillations; but, besides other considerations, the lack of facilities for measuring the small mutual inductance between primary and secondary made another method (described below) of determining the energy seem preferable.

The trains of damped oscillations in the primary were produced by making and breaking a small current running through the primary inductance. In consequence, the coherer yielded a sound in the telephone connected in series. As a general rule, the telephone sound is greater the greater the amplitude of the oscillations in the primary, because the response of the coherer is greater. To measure the response of the coherer, the intensity of the sound was balanced against another sound which was produced in the same telephone by the interruption of an independent source of direct current, which could be switched into the circuit of telephone and interrupter in the place of the coherer. In this way the behaviour of the detector could be quantitatively recorded when the steady current through it, or the oscillatory energy delivered to it, underwent desired variations. The method has enabled me to attain some degree of consistency in measuring the effects of oscillatory voltages as low as $\frac{1}{10}$ volt, and energy transformations of the order of a few thousandths of an erg.

Only one type of coherer has been examined closely. This is a mercury and oxidised iron coherer—a kind I have used for many years, and chosen for these experiments after careful comparison with a number of similar coherers of more modern vogue. As is well known, almost any conductor that can be coated with a closely

* Paper read before the Physical Society. A short account of the discussion following the reading of this Paper appeared in THE ELECTRICIAN, April 1, 1910, p. 1021.

† "Science Abstracts," Vol. VIII., 1,923, 2,248.

‡ *Ibid.*, Vol. VII., No. 1,135; "Ann. der Phys." XI., 4, p. 754 (1903).

§ *Ibid.*, Vol. VII., No. 1,136; "Phys. Zeit.," IV., p. 594 (1903).

‖ *Ibid.*, Vol. VII., No 157; "Phys. Review." XVI., p. 199 (1903).

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adherent, tenacious and very thin film of solid or liquid of not too high resistivity makes a good coherer: for example, oxidised or sulphided copper against any solid conductor; oxidised iron, steel, nickel, tantalum, or any similar metal, against mercury or other conductor are all good.* I have tried also iron-mercury coherers made by the action of organic acids and other reagents on iron. For example, even the graphite (?) films left on a steel knife that has been unwisely used as a fruit-knife make coherers. Amongst all these and others I have found that the best for my present purposes is the coherer made by dipping the end of a carefully oxidised fine iron wire or steel needle into a pool of clean mercury. It is important that the layer of oxide on the wire should be of uniform very small thickness. Seven or eight years ago I found that this can be accomplished very well by heating the wire in a glass tube carrying steam from a boiling flask. The wire should be watched till the film of oxide yields one of those interference colours familiar in the tempering of steel. For instance, a blue film makes a splendid coherer, which works well for a month or two in the open air. Most of the experiments discussed below were carried out on coherers made in this way.

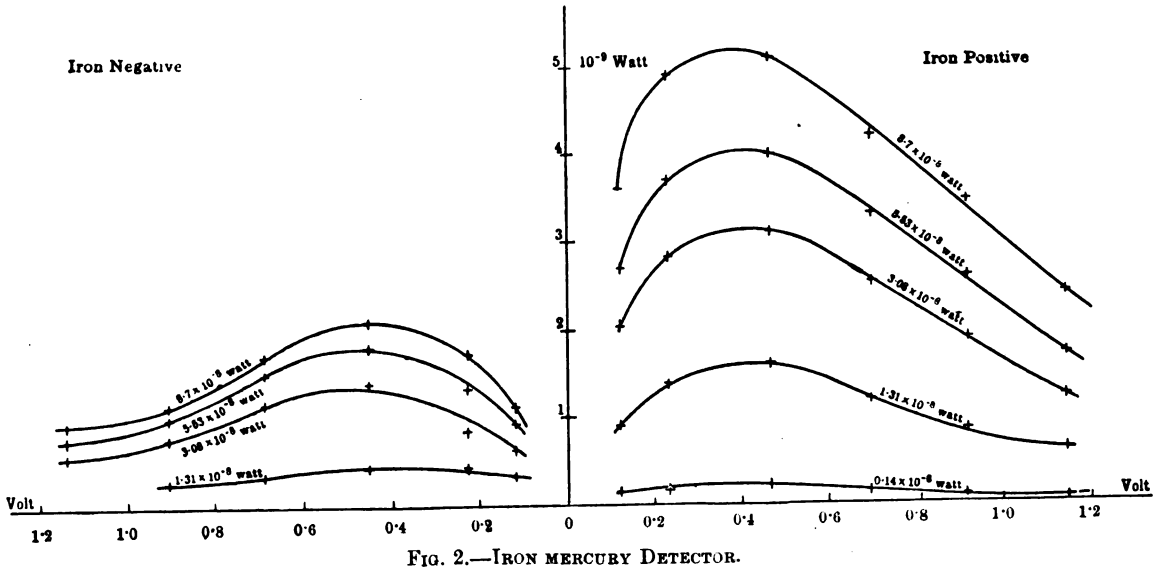
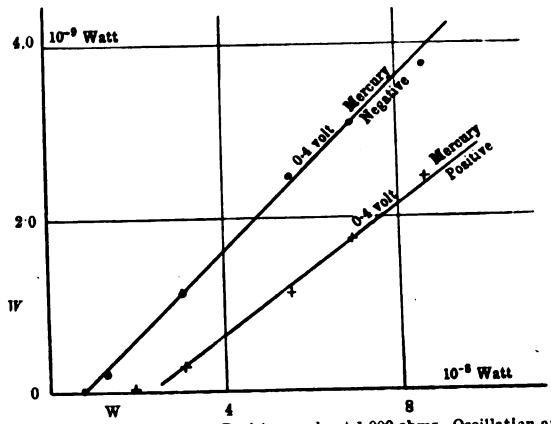


FIG. 2.—IRON MERCURY DETECTOR.

Apparatus.—Fig. 1 is a diagrammatic plan of the apparatus. The primary circuit consists of the coil L′ and condenser C′; the secondary of L and C. The detector D and condenser K are arranged shuntwise to the condenser C. C and C′ are variable condensers of the Marconi pattern. K is an air condenser. L and L′ are coils wound on waxed cardboard tubes. The six-contact key S is designed to throw the telephone T quickly from the detector circuit to the direct-current circuit. In the position of S shown in the diagram the telephone is in series with the detector and part of the potential divider P_2, and at the same time the primary inductance L′ is connected through portion of the potential divider P_1 and the interrupter I. When the key S is depressed the telephone is connected directly through the interrupter I and the potential divider P_3, and the secondary circuits are disconnected. The mutual inductance between primary and secondary can be varied by running L′ along a straight slipway to or from the coil L; but usually the coils were held so that their mutual inductance was a few hundreds of centimetres. The resistance r is an important detail. Its purpose is to prevent the formation of oscillations in L′ at the make of the primary current; calculation (as well as experiment) shows that if r lies within certain limits oscillations occur in L′ at the break only. The amplitude of the oscillations is governed by aid of the potential divider P_1. The frequency of the interrupter I was chosen of the low value 22 per second; thus resonance with the telephone diaphragm was avoided, and the balancing of the sound produced by the detector with that produced by P_3 facilitated. The electrical dimensions of the apparatus were as follows: L′ = 33,700 cm., C′ = 5,020 cm., L = 42,700 cm. C = 3,940 cm., K = 1,210 cm., r = 20 ohms, T = 311 ohms. The mutual inductance between L and L′ ranged from 200 cm. to 2,500 cm. in obtaining the results described below. These sizes were settled upon after many changes, partly because they were practical sizes (wave-length about 820 metres), but chiefly because certain later calculations were made easier.



W = power supplied as oscillations. Resistance about 1,000 ohms. Oscillation amplitude at coherer = 442 × √W volt.

FIG. 3.—IRON-MERCURY DETECTOR.

Details of Method.—In the experiments the primary and secondary were used slightly out of tune. This is very necessary when detectors whose resistance varies are under study; for the variations of a coherer's resistance are quite wide enough to carry the secondary circuit erratically from one side to the other of perfect resonance if the circuits are initially very near that condition, with the result that inconsistent measurements would be inevitable. It is, of course, as easy to deduce formulæ for the mistuned as for the tuned circuits. The expression for x, the current through the detector at break of primary current, is of the form

$$x = le^{-at} + ke^{-mt}\cos(pt+q) + ke^{-bt}\cos(ct+d),$$

where m and p belong to the primary circuit and b and c to the secondary circuit, the coupling being very feeble. The coefficients l, h, k are complicated functions of the electrical dimensions of the circuits. Hence the energy delivered to the detector at a break appears as six terms, of which, with the dimensions adopted, only two are of

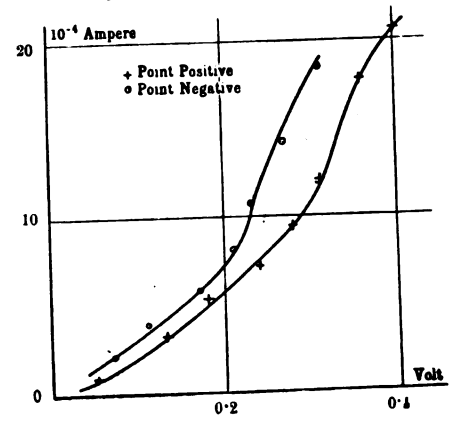


FIG. 4.—IRON-MERCURY DETECTOR, STEADY CURRENT CURVES.

* *See* Branly, "Comptes Rendus," CXXXIV., pp. 347, 1197 (1902).

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numerical importance—namely, $h^2/4m$ and $2lh/m$. The other terms are less than 1 per cent. of the larger of these. Both h and l involve m, the damping factor of the primary, but not prominently. This fact enabled m to be determined easily and with sufficient accuracy. A calibrated thermo-galvanometer with a heater and series resistance totalling 1,000 ohms was put in the usual place of the detector; the mutual inductance between the circuits was increased (but the coupling was still very small), the speed of the interrupter was raised, and heavier primary currents were used than was customary when a detector was in position. Thus a considerable deflection of the thermo-galvanometer was obtained and recorded. Then a short loop of very thin copper wire of known high-frequency resistance was put in series with L″, and the observation repeated. Since the energy received by the thermo-galvanometer is proportional inversely to the resistance of the primary on each occasion, the high-frequency resistance of the coil L′ can be calculated from the observations. The mean of several determinations gave 0·78 ohm. The steady-current resistance was 0·22 ohm.

The power delivered to the detector in the standard conditions of the circuits and primary currents can be computed as just indicated. For accurate results it is necessary to know M, the mutual inductance between primary and secondary, and m, the primary damping factor, very accurately. As neither of these could be determined with the precision desirable, the thermo-galvanometer was invoked to determine the power passing from primary to secondary. In fact, the experiment to determine m, just described, may be taken as determining the factor of transference of power. Similar observations to the above were therefore made with primary currents of different values and with rather high speeds of interruption

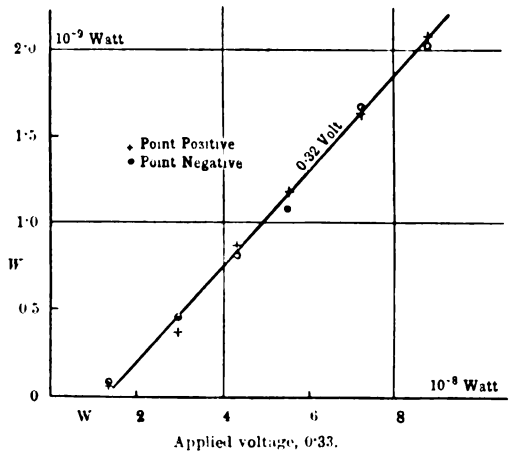

Fig. 5.—Iron Point on Oxidised Iron Plate (light blue film).

(nearly 200 per second), and the fact was established, obvious theoretically, that the power passed to the thermo-galvanometer was proportional to the square of the primary current and to the frequency of interruption. Finally, by observation of the thermo-galvanometer deflection, when a primary current of $\frac{1}{10}$ ampere was interrupted 168 times a second, the result was established that with the primary and secondary in their standard relation a quantity of energy amounting to very approximately $4{\cdot}82 \times 10^{-11}$ joule, or about 0·0005 erg, is passed to a detector of 1,000 ohms resistance at each break of a primary current of 0·01 ampere. This corresponds to a power delivery of 0·01 erg per second when the interrupter is running at the standard frequency. Corresponding figures were obtained for the cases where the detector has different resistances between 100 ohms and 2,000 ohms.

In the actual experiments on detectors two things were chosen for variation, namely, the E.M.F. applied to the detector and the oscillatory energy passed from the primary to the detector. The effect observed was the loudness of the sound in the telephone. The curves of Fig. 2 have as abscissæ the varying external E.M.F. applied to the coherer, and as ordinates the consequent effect in the telephone. Each curve in the diagram is obtained by supplying to the coherer the constant power marked on the curve. The curves in Fig. 3 have as abscissæ the power supplied to the coherer when its applied E.M.F. is unvarying; the ordinates are the effect in the telephone. The telephone effect is plotted as estimated power given by the coherer to the telephone circuit. The numerical connection between the power passed into the telephone circuit and the measured intensity of the sound in the telephone was determined as follows: The thermo-galvanometer was put in the telephone circuit in series with the telephone, and a large primary current was interrupted at the normal rate. The intensity of the loud sound in the telephone was measured by the potential divider, and at the same time a reading of the galvanometer deflection was taken. A resistance was then put in series with the telephone and the galvanometer, and the measurements repeated. These readings give sufficient data to determine the amount of energy being dissipated in the telephone when the intensity of a sound is equal to that due to any assigned length of the potential divider P_3. The measurements thus made show, both sides, that the power delivered by the detector to the thermo-galvanometer and telephone was practically proportional to the square of the length of P_3 required to produce equal sounds in the telephone. It is rather a big extrapolation to extend these results obtained with currents large enough to affect the thermo-galvanometer to currents that give only faint sounds in the telephone; but if we do this, we find that when the intensity of sound produced by a detector is equal to that obtained by interrupting a telephone current of 1 microampere 22 times per second, then the power passed from the detector into the telephone circuit is $4{\cdot}38 \times 10^{-12}$ watt, *i.e.*, $4{\cdot}38 \times 10^{-5}$ erg per second. By the aid of this factor the curves of Fig. 2 and 3 were drawn.

Results.—The most striking outcome of the measurements is embodied in Fig. 3. The curve connecting the power delivered to a coherer as electrical oscillations and the power passed by the coherer to the telephone turns out to be a straight line passing nearly through the origin. The line is different for different values of the steady E.M.F. applied to the detector. The upper curve of Fig. 3 was obtained from a rather insensitive coherer, which happened to have a resistance of about 1,000 ohms at its most sensitive voltage, the iron being positive. The lower curve is one selected under similar considerations with the iron negative. The approximate equation of the former curve is $w = 0{\cdot}024(W - 0{\cdot}9 \times 10^{-8})$, and the latter $w = 0{\cdot}019(W - 2{\cdot}2 \times 10^{-8})$, the unit being a watt. All the other curves that have been obtained with coherers of various construction, resistance, applied E.M.F., are very like these. The more sensitive the coherer the steeper the line, is the only rule that has yet come to light (and in some

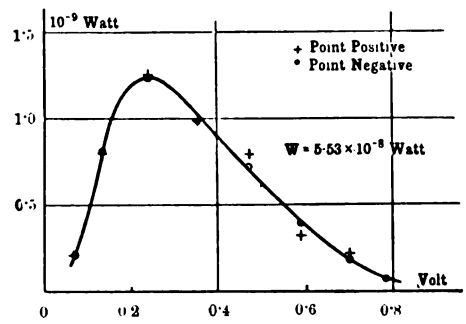

Fig. 6.—Iron Point on Oxidised Iron Plate.

iron-mercury coherers the gradient of the line is 0·06); there is no rule yet proved for the constant term subtracted from W. It may be mentioned again that the absolute value of the multiplier of W in the above equations is rather doubtful, because of the big extrapolation necessary in calibrating the telephone. But doubt on this point does not affect the character of the curves; it affects only their gradient. As written above, the approximate equations for the curves suggest that for a particular detector under invariable conditions there is a fixed wastage of oscillation energy amounting constantly to about one-tenth of an erg per second, however large or small the oscillation energy given to the detector may be. If, however, the equations be written $w + 0{\cdot}022 \times 10^{-8} = 0{\cdot}024W$ and $w + 0{\cdot}042 \times 10^{-8} = 0{\cdot}019W$, the inference is that a small quantity of energy, which is invariable while the detector is undisturbed, is delivered by the detector to the telephone circuit in a form that never makes any proportion of itself manifest as sound. Whatever the cause of this small energy wastage may be, the curves of Fig. 3 show that the coherer must be put amongst those detectors that have been called "integrating" detectors. Thus the coherer is not, as has usually been supposed, a "voltage-operated" detector. As detectors go, it has a very good efficiency (*i.e.*, ratio of energy conversion), but evidently its efficiency falls rapidly as signals get weak.

The curves of Fig. 2 show how the sound heard in the telephone varies with alteration of the P.D. applied to the coherer and telephone in series. Each curve is obtained by submitting the coherer to the fixed excitation whose value in watts is marked on that curve. As the excitation diminishes the maxima accompanying variation of applied voltage becomes less marked. The resistance of the coherer was kept as constant as might be during these experiments, but wide variations of resistance are inevitable. The asymmetry of the coherer under positive and negative voltages shown in these curves obtained by the action of electrical oscillations on the instru-

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ment is no doubt connected with the similar phenomenon mapped in Fig. 4, where typical steady current curves, plus and minus, are drawn. In these curves the abscissæ are the P.D.s applied at the terminals of the coherer. In both cases the lack of symmetry is due to the use in the coherer of two metals so different as iron and mercury. In order to examine whether this asymmetry was responsible for the failure of the curves of Fig. 3 to pass through the origin, a new series of experiments on a different form of iron-oxide coherer was undertaken.

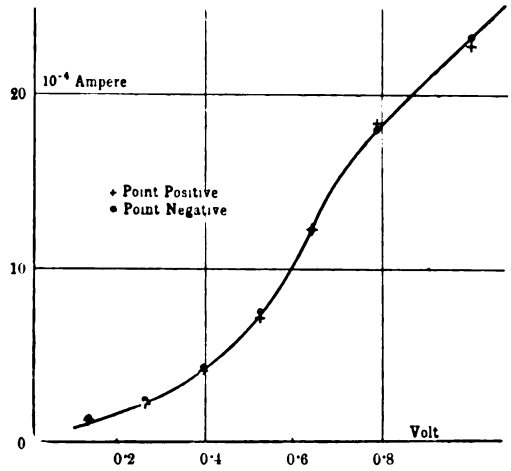

FIG. 7.—IRON POINT ON OXIDISED IRON PLATE, STEADY CURRENT CURVES.

Additional Experiments.—A coherer was made by heating a polished iron plate in air till rings of colour round the small heated area indicated that the plate was covered with a thin film of oxide. The end of a clean piece of iron wire was so held as to press on the plate at any desired place with a constant force. The plate was made one terminal of the coherer and the wire the other terminal, and this coherer was examined in precisely the same way as the others. A typical series of measurements is set forth in Figs. 5 and 6. The curve connecting the energy given to the coherer and the energy passed to the telephone is again a straight line passing

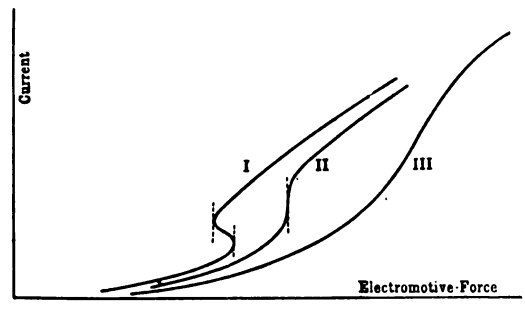

FIG. 8.—IDEAL CURVES SUGGESTED BY THEORY.

some distance from the origin. The equation of the curve is $w=0{\cdot}028(W-1{\cdot}4\times10^{-8})$. The curve is the same whether current passes from point to plate or in the opposite direction, which clearly indicates that the asymmetry of the other curves was due solely to the use of two metals. The curves connecting applied voltage and steady current for these iron-point iron-plate coherers are also the same whatever the direction of the current. Fig. 7 shows such a curve, which has been selected from a large number as typical.

(To be concluded.)

Telephone Improvements at Panama.—According to the "Electrical World," the telephone exchanges at Culebra and Paraiso, in the Canal Zone, are to be consolidated with the Empire exchange as soon as the work of installing new equipment at Empire is completed. The "central" at Paraiso has been abolished, and the stations served by it were temporarily connected with the Culebra exchange. The consolidation is designed to increase the efficiency of the service by centring the operations at a point where they can be given closer supervision. A saving in operating expenses will also be effected. The new equipment at Empire will include a modern common-battery two-section switchboard to serve 400 stations.

GAS ENGINES IN CITY RAILWAY AND LIGHTING SERVICE.*

BY E. D. LATTA, JUN.

Summary.—The author first describes the plant in the small, but thoroughly equipped, central station of the Charlotte Electric Railway Co., in which gas engines are used for prime movers, and current is supplied for street railway purposes, electric lighting and motors in small units. He also gives from the daily operating reports some figures from which can be formed an idea of the reliability, efficiency and adaptability of the plant. He sets forth data on the subject of producer gas manufacture, finally offering a few remarks on the adaptability and advisability of gas engines for certain kinds of work.

The period covered by this Paper, viz., 12 months, dates from January 1, 1909, when the plant had been in operation for about six months, and could be considered as being fairly well under way.

The engine room equipment consists of two 810 B.H.P. horizontal twin-tandem double-acting four-stroke cycle gas engines and one 60 H.P. single tandem exciter engine. The 540 kw. three-phase 60-cycle 2,300-volt alternators are direct and rigidly coupled to the crank shafts of the main engines, and a 40 kw. direct-current generator is direct-connected to the exciter engine. In addition to this apparatus there is an induction motor-driven exciter set of the same capacity as the engine exciter, a 300 kw. and a 500 kw. rotary converter, and the usual switchboard equipment.

The producer apparatus is contained in a building about 100 ft. from the power house, and consists of two 1,000 H.P. units of twin generator down-draught producers, having a continuous overload capacity of 50 per cent. Each unit consists of two 9 ft. generators, 16 ft. high, having a fuel space 7 ft. in diameter by 8 ft. high above the grate bars, which are of arched fire-clay tile. The generators are connected at the bottom by openings, lined with firebrick, containing water-cooled gate valves, to an economiser or vertical boiler of 100 H.P. rating. From the top of the boilers a 16 in. pipe leads to the bottom of the wet scrubber and from the top of the wet scrubber to the exhauster, or through a by-pass around the exhauster to the dry scrubber. A 60,000 cubic ft. holder receives the gas from the producers and delivers it to the engines. The flywheels of the engines are 16 ft. in diameter and weigh 34,000 lb. Each engine occupies a floor space of 18 ft. by 44 ft. All parts of the engine that come in contact with the hot gases are water-jacketed, including cylinders, pistons, piston rods, mixing chamber, valves and valve seats, and the exhaust pipe down to the floor level. The jacket water from the various parts of the engine empties from separate pipes into open funnels, which enables the operator to determine at all times the temperature of the different parts of the engine. The ignition is low tension make-and-break, with two igniters to each end of cylinder. The ignition current is supplied by one of three batteries of five cells each, and requires about 10 volts. The governors are of the Jahns type, in which the centrifugal force of the weights revolving in a horizontal plane is resisted by the direct pressure of coiled springs, the weights turning on rollers in a constant oil bath which practically eliminates friction. The governor is driven by a belt from the camshaft, and governing is done with a uniform mixture. A plunger in the face of the flywheel works in and out radially against a coiled spring. In case of excessive speed of the flywheel, centrifugal force drives the plunger out beyond its normal position and opens a switch in the igniter circuit, thus shutting down the engine and preventing racing in case of the governor belt breaking or the governor otherwise losing control of the engine. This device is tested at regular intervals by depressing the governor, and is found invariably to operate within five or six revolutions above normal speed.

The problem of piston packing, which for many years was one of the greatest difficulties in the way of building double-acting engines, has been solved in a fairly satisfactory manner by the use of metallic packing contained in packing cases. The packing cases each contain five rings of special cast-iron made in segments, with overlapping joints, the segments being held in place against the piston rod by a $\frac{3}{16}$ in. garter spring drawn around the circumference. The packing case is bolted to the cylinder head by means of a flange, between which and the cylinder head is a ground joint. About once a month each packing case is removed and supplied with clean packing. The packing removed is then thoroughly cleaned when convenient and put aside for use at another time. If a high grade cylinder oil is used and the packing is regularly cleaned, the troubles from this source are practically eliminated.

During the summer months about 15 gallons of water, at an initial

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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temperature of 80°F., are required per horse-power-hour for cooling, the temperature of discharge being about 120 deg. During the winter months 10 gallons of water per horse-power-hour at 60 deg. are sufficient, and are discharged at about 100 deg. The difference in the amount of water required in summer and winter is apparently due to the fact that the heat lost by radiation is much greater in winter. The jacket water after being discharged from the engine flows by gravity to a hot well of the cooling system, from which it is drawn by an electrically-driven centrifugal pump of 50,000 gallons per hour capacity, against 15 lb. pressure, and forced through sprays into a basin in the middle of which is a cold well. From the cold well it is taken by a two-stage turbine pump of 15,000 gallons per hour capacity against 30 lb. pressure, and returned to the engine. These pumps are driven by the same motor. As the capacity of the single-stage or hot-well pump is three times as great as that of the cold-well pump it follows that an excess of water is sprayed into the basin over that taken out of the cold well; this excess water overflows and returns to the hot well where it is again pumped through the sprays. In this way all the water passes through the sprays three times to each time it is used in the engine and ample cooling is obtained, the water in the cold well being reduced to a temperature slightly below that of the atmosphere. The loss in water by evaporation to attain this degree of cooling is about 10 per cent.

There are three classes of disturbances that take place infrequently in these engines, as is the case with all gas engines, viz., pre-ignition, back-fires and muffler explosions. The first of these is caused by the use of gas over-rich in hydrogen, which ignites very readily under high compression without other application of heat; also by particles of carbon or other solid matter which become lodged in the cylinder and become incandescent under the temperature of compression, or when any of the water-cooled parts of the engine are insufficiently cooled by using too little water, or water at too high temperature. A back-fire occurs when the gas admitted to the cylinder is ignited on the suction stroke, but can also be caused by a leaky inlet valve, in which case the gas in the inlet pipe is ignited during the explosion stroke. Ordinarily a back-fire is caused when gas of a too lean nature is used, so that the gas burns very slowly and continues to burn in the exhaust stroke. A part of the gas still burning in the clearance space ignites the incoming charge. Also if there are any pockets or small passages, such as the water-cooled pipe leading to the indicator cock, the gas in the passage or pocket is cooled to a point where it does not ignite readily. It becomes heated and ignites in the latter part of the pressure stroke, and continues to burn until the succeeding intake stroke when the incoming charge is ignited. The result of a back-fire is only the loss of the next power stroke, and usually a mis-fire at the second succeeding power stroke caused by the burning gas blowing back into the intake pipe and fouling the gas contained in it. The disturbance caused by pre-ignitions and back-fires is only momentary, and even when the engines are operating in parallel very little effect can be noticed. A muffler explosion is caused after a mis-fire, when an unburned charge of gas and air passes into the exhaust pipe and is ignited by the exhaust from the power stroke of another cylinder. It has no effect upon the operation of the engine, but makes a noise similar to that of a pre-ignition or back-fire.

Improper action of a gas engine is not shown nearly so clearly by the indicator card as it is in the case of a steam engine. For instance, the exhaust valve of a gas engine might be leaking and the only indication of the trouble would be low compression, yet the low compression might be caused also by badly worn piston rings or by packing in bad condition. The principal value of the indicator card is in adjusting the proportion of air and gas to give the most effective mixture, and for properly timing the ignition. To adjust the mixture it is desirable to put a steady load upon the engine, preferably that produced by a water box, and then indicate the engine and adjust the mixing valve until the card shows the maximum explosion pressure for a given compression, which is the condition existing when sufficient air for complete combustion is admitted with the gas, without excess.

Plant Performance.—Under this head, considering the class of service, reliability is of paramount importance. Details of the shut downs during the year are given by the author, and total 2 hours 45 minutes, the plant operating 24 hours per day. The failures were twice due to exciter, twice to suction of engine drawing water from the gasometer into gas main, shutting off gas supply and once each to belt of oil pump breaking, earthing on ignition wiring, operation of safety stop valve and unusual overload.

Second in importance to reliability are speed regulation and ability to operate successfully in parallel. The manufacturers guaranteed that from 25 per cent. to full-load the engine would govern within a maximum variation of 2 per cent. This condition is met as regards the mean speed on steady loads. When, however, a heavy load is suddenly thrown on the engine, or removed from it, a momentary swing of not exceeding 2 per cent. below or above mean speed for the given load occurs, which is due to over-reaching of the governor. While this swing in speed is not excessive, and is found to an equal or even greater extent in high-class reciprocating steam engines, it is rather remarkable that it is not far worse than the above figure in a four-cycle gas engine; for at the moment the load on the engine is changing, the governor has no control whatever upon the charge of gas next to be ignited.

It is generally supposed that the turning moment or angular velocity of a gas engine is uneven and characterised by periodic variations with each impulse, due to the fact that the initial cylinder pressures are extremely high as compared with those of steam engines. This would no doubt be the case with a single-tandem four-cycle gas engine, but with the twin-tandem engines having four double-acting cylinders eight impulses are given to the flywheel in two revolutions or one complete cycle. Therefore, as the cranks of the two sides are quartering, an impulse is imparted to the flywheel every 90 deg., or two impulses per stroke. The impulses thus overlapping tend to smooth out the variations that otherwise would occur, and permit of a far lighter flywheel than could be used with a single-tandem engine. The lighter flywheel is less sluggish and consequently promotes good parallel operation, but it is not too light to afford sufficient inertia practically to absorb the variations in crank effort

We have been convinced of the correctness of this statement by observing the behaviour of the alternators at various times when they were running in synchronism, with the engine cranks in almost every possible relation. No difference can be discerned in the action of the switchboard instruments, whether the cranks are in step or in any other possible position.

While the parallel operation of this engine would not be considered good in comparison with steam turbines operating at high speed, with alternators having from two to four field poles, it nevertheless compares favourably with the best type of reciprocating steam engines with alternators having the same number of field poles, viz., 60, which, of course, means that the variations in electrical degrees will be 30 times as great per degree of angular variation as would be the case in a turbine of the same capacity operating at 3,600 revs. per min. The temperatures of the alternators above room temperatures, so far as can be observed with the constantly varying load, do not indicate an excessive synchronising current, and there has never been any tendency on the part of the synchronous converters to fall out of step.

Cost of Operation and Repairs.—The load factor is poor, due principally to two conditions—first, the prevailing load for 20 hours per day is easily within the range of one unit, but the wide limits of variation make it necessary to operate the second engine on an average 10 hours per day; and second, from 12 o'clock night until 6 a.m one engine operates on practically no load at all. We estimate that with an increase in the load factor of 25 per cent. the additional output could be produced for an amount not exceeding 10 per cent. of the present cost. In the matter of cost of repairs, also, we expect a reduction rather than an increase in the near future. The largest item in the total cost of repair parts is the cost of an entire new equipment of exhaust valves, which amounts to about half of the total. These exhaust valves were put in, not on account of wear and tear, or breakage, but on account of the inferior design of the original ones. Four pistons have been taken out and fitted with new rings, the original rings having become broken when water leaks occurred in the cylinders due to defects in the castings of the piston water compartments. Broken rings almost invariably result from water leaks in a cylinder. In this case, new parts were furnished by the manufacturers without charge, and the labour was furnished principally from the operating force.

The least serious trouble that has been encountered, but one of the most annoying, on account of its occurring at most inopportune times, is the breaking on six occasions of the wedge adjusting bolts in either the crank or cross-head bearings.

The figures for the whole year are as follows: Units 3,355,907, engine-hours 12,403, pounds of coal 6,444,281, load factor 0·45. The load factor is given by $\frac{\text{Output}}{\text{Engine hours} \times \text{capacity of one engine}}$.

In addition to the coal, 260,292 lb. of coke were used in starting producers, of which amount 122,371 lb. were reclaimed, leaving the total net amount used 137,921 lb., equal in cost to 192,000 lb. of coal. The total coal consumption, therefore, is equivalent to 1·97 lb. per kilowatt-hour over the whole year.

Interest, depreciation, taxes, &c., are not included, as buildings, producers, &c., are provided for three units, although only two are installed.

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Details of Costs per Kilowatt-hour.

Coal	0·175d.
Power house labour	0·085d.
Producer labour	0·066d.
Oil for power house	0·032d.
Oil for producer	0·003d.
Waste and sundries, power house	0·006d.
Waste and sundries, producer house	0·002d.
Repair parts for engines	0·023d.
Repair parts for producers	0·003d.
Machine shop work, engines	0·008d.
Machine shop work, &c., producers	0·005d.
Water	0·035d.
Total	0·443d.

Producer Operation.—In starting a producer the generators are charged to a depth of 5 ft. with 72-hour coke, requiring about 6,000 lb. to each generator, or a total of 12,000 lb. The exhauster is then started and the coke ignited. The gas made during the first 40 minutes is too inferior to be of any use in the engine, and it is therefore blown out and wasted. As the coke in the generators burns and becomes hot, coal is charged at the top in small quantities and at frequent intervals. If coal is charged too rapidly, particularly in the early stages of the fire, it tends to coke, with the result that the draught will be unequally distributed over the fuel bed, finding its way down through holes and localising the heat to such an extent that the excessive temperature causes clinker to form, thus reducing the capacity of the generator and shortening by several days the time that the set can be run without shutting down for cleaning. When the fuel bed has attained a sufficiently high temperature the gas is admitted to the holder. Steam is introduced at the top of the charging doors and, together with the air, is drawn in by the exhauster, passing down through the generator, forming a mixed gas.

At intervals of 20 to 30 minutes, up and down steam runs are made in the generators in the following manner. The by-pass around the exhauster is opened, the charging doors of the generators closed, and steam is admitted beneath the grate bars of one generator, the gate valve of which is closed, for about 30 seconds. This steam passes up through the generator, moistens the ash, breaks up the fuel bed and cools the fuel at the point where clinker is forming, and which is not reached by the top steam before decomposition takes place. This steam leaves the generator through a connection at the top, passing over into the top of the second generator, down through the fuel bed and out through the other apparatus to the holder as a fixed gas. The direction of the steam is reversed on the next run, so that the generators are alternately treated in the same manner.

The hot gas leaves the generators at a temperature of about 1,200°C., and passes out through a brick-lined nozzle and water-cooled gate valve into the lower compartment of the vertical economiser, which is also brick-lined. A large part of the sensible heat of the gas is given off and goes to make steam which is used in the generators and for running the exhauster. From the top of the economiser the gas passes, at a reduced temperature, to the bottom of the wet scrubber where it is water sealed, and passing up through the wet scrubber, it works its way through several layers of coke over which water is sprayed from above. During its passage through the coke and water most of the dust and lampblack in the gas is removed, and its temperature is reduced to that of the atmosphere. In the top of the wet scrubber a thick layer of excelsior removes part of the moisture and most of the remaining lampblack. From the wet scrubber the gas goes through the exhauster, then to the dry scrubber, where two more layers of excelsior throughly dry it, thence it passes to the holder, a clean, dry, cool gas. It is very important that the gas should be reduced to atmospheric temperature in the wet scrubber by the use of a sufficient amount of cool water. About 4 to 6 gallons per horse-power-hour is required, depending upon the temperature of the water and that of the atmosphere.

The use of a large holder, such as the one installed in this plant (60,000 cubic ft.) is of great value in operation. It takes up the variations in load and allows the producer to be operated at an even rate; also, if the gas varies in quality over short intervals, which is unavoidable, the gases above and below the mean value are thoroughly mixed and a gas of uniform quality is supplied to the engines.

It may be of interest to describe a rather serious difficulty which was encountered, and the way in which it was remedied. A short time after the plant was put into operation, it was found that some of the tubes of the economisers were leaking. The tubes were rolled and the leaks stopped, but in a short time they were found to be leaking again. They were again rolled, but continued to leak, and when finally too thin to be any longer rolled they were taken out and replaced with new tubes. The old tubes when taken out were cut into sections and split open, and it was found that they were badly pited throughout their entire length, although the pitting was worse at the upper end; weighing the tubes disclosed the fact that they had lost nearly 25 per cent. of their original weight. After much surmising, the cause of the pitting of these tubes is believed to be as follows: In the usual design of plants of this kind, with two or more sets of apparatus, the various sets are absolutely independent of each other as far as the wet scrubbers, and as the gas is water-sealed in the wet scrubbers it is impossible for gas from one set to pass over into another. In this plant, however, in order to increase the flexibility of operation, the two economisers were connected together at the top by a horizontal header, and each one was cut off from the header by a gate valve. These gate valves coming in contact with gas at fairly high temperature expand and contract, and cannot be kept perfectly tight during steam runs. When the generators were under pressure leakage of these valves permitted hot gas to pass from the economiser in operation to the one shut down, and after passing down through this economiser to escape through the open generators. It was found that the economiser not in use sweated profusely on account of the difference in temperature of the room and the water in the economiser, keeping the tubes continually wet. This moisture, combining with the hot gas leaking through the apparatus, undoubtedly formed a strong acid and attacked the tubes. Since arriving at this conclusion, each time a producer is shut down the gates of the valves are thoroughly cleaned, the tubes are cleaned with a wire brush, the tube ends and tube sheet are painted with one coat of graphite paint, and the manholes at top and bottom of the economisers are left open, so that a circulation of air prevents sweating. Since adopting these measures, there have been no more leaky tubes, and it is believed that the trouble has been effectually remedied.

At another time an annoying occurrence was the development of numerous hot spots on the shells of the generators; these hot spots were caused by defects in the linings. It is found to be an advantage after cleaning a generator to wash the surface of the brick exposed to the fuel with fire clay grout, as the grout tends to form a cleavage plane between clinker and brick and greatly facilitates its removal. When cleaning the generators, it is not desirable to remove all the clinker, for in doing so a part of the brick would be chipped off each time, and greatly reduce the life of the lining. About 1 in. or 2 in. of clinker adhering to the brick is allowed to remain, and this coating affords great protection to the surface of the lining.

The author finally gives the theory of producer gas manufacture and combustion. He also questions whether the gas engine is adapted to the conditions of operation described above, unless in connection with a storage battery.

THE ELEMENTARY THEORY OF THE QUADRANT ELECTROMETER.

BY R. BEATTIE, D.SC.

Summary.—The author gives a simple proof of the theory of the quadrant electrometer. He also discusses its sensibility characteristics, and compares them with those of an alternate current moving coil galvanometer.

As is well known, the quadrant electrometer does not always obey the rules laid down for it in the text-books. According to the theory usually given, the sensibility is proportional to $\{V-(v_1+v_2)/2\}$, where V is the potential of the needle and v_1, v_2 are the potentials of the quadrants. Thus, with v_1 and v_2 small, the sensibility should be proportional to V. In point of fact, however, as was first shown by Hopkinson,* the sensibility generally reaches a well-defined maximum as the potential of the needle is raised. Much has been written with a view to elucidate this point, the chief Papers dealing with the subject being those of Gouy,† Ayrton, Perry and Sumpner,‡ Walker,§ and Orlich,‖ and in these Papers the development of a strict and full mathematical theory of the electrometer may be traced, and a satisfactory explanation of the peculiarity just mentioned may be found.

The purpose of the present Note is not to add anything to

* "Phil. Mag.," 5th Series XIX., p. 291, 1885.
† "Jour. de Phys." VII., p. 97, 1888.
‡ "Phil. Trans.," A. 182, p. 519, 1891.
§ "Phil. Mag.," 6th Series, VI., p. 238, 1903.
‖ "Zeit. für Inst.," XXIII., p. 97, 1903.

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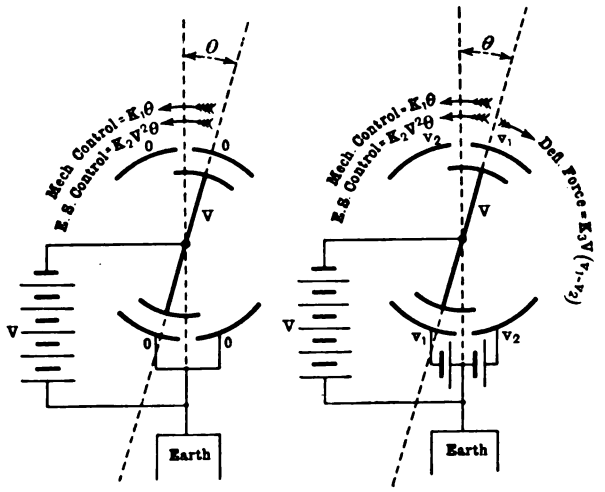
this theory, but rather to reduce it as far as possible to its purely physical elements and present it in its most elementary form. It has been felt that a simple explanation on these lines of the characteristics of the electrometer would be welcomed by many workers with the instrument who have neither the time nor the inclination to follow the mathematical arguments of the more complete theory.

The customary point of departure in establishing the theory of the electrometer is to write down an expression for the energy of the system in terms of the potentials and the position of the needle. From this, by differentiation, the value of the force acting on the needle is then obtained. It is safer,* however, and more direct, to start with the forces and equate, say, the controlling and deflecting couples acting on the needle; and this is the plan adopted in the following discussion. It is necessary, however, to be quite clear at the outset as to what is meant by the controlling couple and what by the deflecting couple. To prevent any misconception on this point, it may be advisable, therefore, to explain that the controlling couple on the needle in any given position is understood to mean the total couple on the needle from all causes when it is charged to its working potential V, the quadrants being at the same time earth-connected. The deflecting couple is the additional couple which comes on the needle when the quadrants are raised from zero potential to potentials v_1, v_2, the difference between which it is desired to measure.

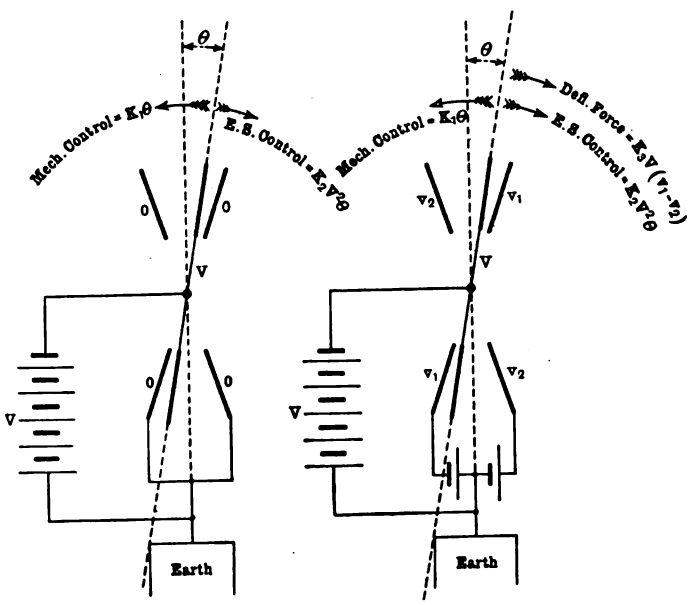


(a) Needle under controlling forces. (b) Needle under controlling and deflecting forces.

FIG. 1.—QUADRANT ELECTROMETER (POSITIVE ELECTROSTATIC CONTROL).

It should, further, be explained that in what immediately follows only a special case is considered—that of a symmetrical electrometer used to measure small potential differences, the needle being at a high potential, V, and the quadrants at potentials v_1, v_2 not far removed from zero. The deflections are also supposed to be small.

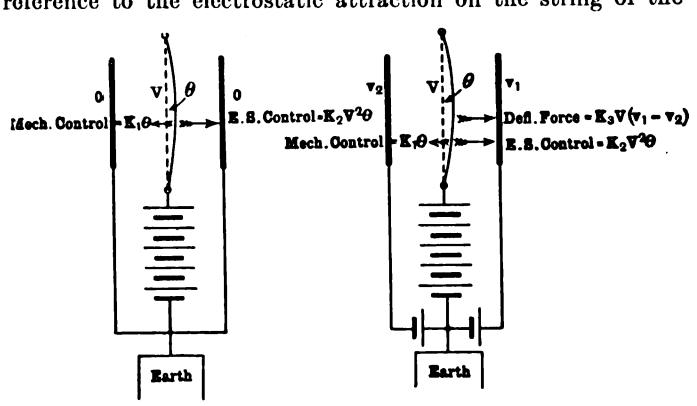
Controlling Couple on the Needle.—Any departure of the electrometer from the ordinary law is entirely accounted for by the fact that the controlling couple on the needle is not single (*i.e.*, is not due to the suspension alone, as is generally supposed), but is double, and arises partly from the suspension and partly from electrical causes. This will at once be clear on reference to Fig. 1, which represents diagrammatically an electrometer with its needle charged to potential V and its quadrants earth-connected. In an electrometer of this type, when the needle is displaced from its symmetrical position by a small angle θ, there are obviously two forces brought into play, both tending to bring it back again. There is, in the first place, the mechanical controlling couple due to the suspension. Being proportional to θ, we may represent this couple by $K_1\theta$, where K_1 is a constant. Next there is the electrostatic attraction between the needle and the quadrants, which, of itself, even if the needle were freely suspended, would suffice to pull it back to the symmetrical position. The restoring couple due to this latter cause—the "electrostatic control," as it may be called—is proportional to V^2 and to θ, and may therefore be represented by $K_2V^2\theta$, where K_2 is a constant. Thus the total controlling couple is $(K_1+K_2V^2)\theta$.



(a) Needle under controlling forces. (b) Needle under controlling and deflecting forces.

FIG. 2.—QUADRANT ELECTROMETER (NEGATIVE ELECTROSTATIC CONTROL).

We have considered a case where the electrostatic control, since it acts in the same sense as the mechanical control, must be reckoned positive. But cases may arise where the electrostatic control acts against the mechanical control, and must, accordingly, be reckoned negative. Evidently this is so in Fig. 2. Here the resultant electrostatic attraction brought into play by any displacement of the needle acts in the direction of that displacement; and the same holds good with reference to the electrostatic attraction on the string of the



(a) String under controlling forces. (b) String under controlling and deflecting forces.

FIG. 3.—STRING ELECTROMETER (NEGATIVE ELECTROSTATIC CONTROL).

string electrometer represented in Fig. 3. In both these cases the electrostatic control must be regarded as negative.

Electrometers can thus be classified into (1) those which possess positive electrostatic control, and (2) those which possess negative electrostatic control. In general, therefore, the total controlling couple on the needle will be represented by $(K_1 \pm K_2V^2)\theta$, the positive or negative sign being taken according as the electrostatic control is positive or negative.

Deflecting Couple on Needle.—Whenever an electrometer with its needle at potential V has the potentials of its quad-

* It is safer for this reason: If we express the energy of the system in the form $(A+B\theta+C\theta^2+D\theta^3+\&c.)$, where θ is the (small) deflection of the needle, and A, B, C, &c., are functions of the potentials, then we have to decide how many terms of the series it is necessary to retain. If we decide to retain two terms and then differentiate, we obtain one result; but if we differentiate first, and then decide to retain two terms, the result may be very different. It is really through omitting to retain a sufficient number of terms in the energy expression that Maxwell's proof ("Elec. and Mag.," Vol. I., §219) fails to disclose the now well-known peculiarities of the electrometer. In dealing with force expressions instead of energy expressions the liability to such an oversight is much less.

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rants raised from zero to v_1, v_2 respectively, the needle experiences a couple tending to deflect it. If v_1, v_2 are small compared with V, this deflecting couple will, for a given position of the needle, be proportional to $V(v_1-v_2)$, but will vary with the position. Provided the resulting deflection is small, we can always represent the deflecting couple as a function of θ by an expression of the form

$$K_3V(v_1-v_2)(1+a\theta+b\theta^2+c\theta^3+\&c.),$$

where K_3, a, b, c, &c., are constants. But from considerations of symmetry the electrostatic deflecting force must have the same numerical value when (v_1-v_2) and θ are simultaneously reversed. Hence all the terms in the above expression which contain odd powers of θ must vanish, leaving only terms involving the square and higher even powers. These we may neglect and take $K_3V(v_1-v_2)$ as a sufficiently exact expression for the deflecting couple.

The Sensibility.—By equating the deflecting and controlling couples as just determined we get

$$(K_1 \pm K_2V^2)\theta = K_3V(v_1-v_2)$$

or

$$\theta = \frac{K_3V}{K_1 \pm K_2V^2}(v_1-v_2).$$

For the particular case considered, this is the same result as that arrived at, though in a less direct manner, by the more complete theory. It shows that the sensibility of an electrometer is proportional to $K_3V/(K_1 \pm K_2V^2)$. Thus in electrometers with positive electrostatic control (like the ordinary quadrant electrometer) the sensibility reaches a maximum when $K_2V^2=K_1$—that is to say, when the potential of the needle is such that the electrostatic control is equal to the mechanical control. A typical sensibility curve for this type is shown in the lower curve of Fig. 4.

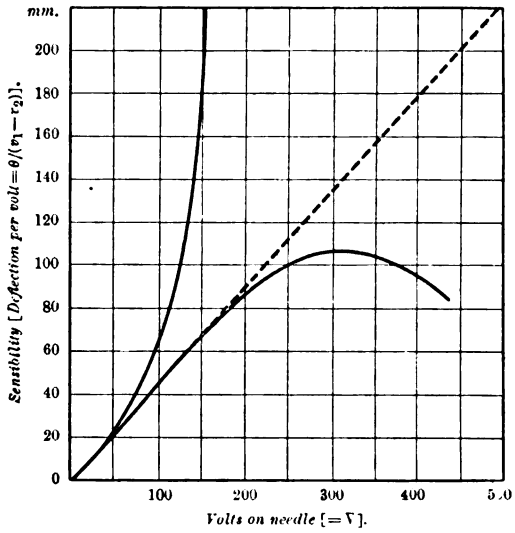


Fig. 4.—Characteristics of Quadrant Electrometer.

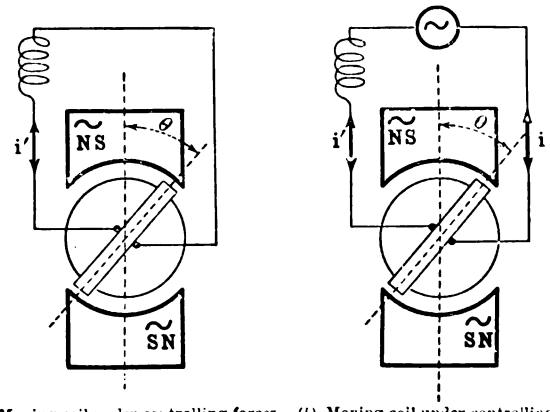
On the other hand, it is seen that in electrometers with negative electrostatic control (like the string electrometer) the sensibility becomes infinite when $K_2V^2=K_1$—that is to say, when the potential of the needle is such that the electrostatic control is equal to the mechanical control. If V exceeds this critical value the instrument is unstable. A typical sensibility curve for this type is shown in the upper curve of Fig. 4.

For any given electrometer there is thus a definite critical potential of the needle which corresponds either to maximum sensibility or to instability according as the electrostatic control is positive or negative. Theoretically it should be possible to construct an electrometer with zero electrostatic control. The instrument would then obey the ordinary law and would have a straight-line characteristic like the dotted line of Fig. 4. Practically it has been shown to be feasible to construct an electrometer in which the sensibility is proportional to V over a very wide range,* but ultimately such an instrument would probably reach either maximum sensibility or instability if only the potential of the needle were raised high enough.

Comparison of the Electrometer with the Moving-coil Alternating-current Galvanometer.—It may be pointed out in support of the idea of a double control which has been made use of to deduce the properties of the electrometer, that the moving-coil alternating-current galvanometer, though entirely different in construction and function, yet possess characteristics similar to those of the electrometer. This parallelism between two instruments so essentially different arises from the existence in each of a double control on its moving system—partly mechanical, partly electrical. The conditions in the alternating-current galvanometer are, however, more easily understood, there being no difficulty in distinguishing the electrical controlling forces from the electrical deflecting forces, whereas in the electrometer the electrical controlling and the electrical deflecting forces are liable to be confused.

In an alternating-current moving-coil galvanometer when the coil, suspended in an alternating magnetic field of strength H, is deflected by an angle θ, as in Fig. 5, there are two couples acting on it. One is due to the mechanical control and may be represented by $K_1\theta$; the other arises from the alternating current i' induced in the coil as a result of the alternating flux which traverses it in its deflected position. The action of the field H on this current produces an electromagnetic control which is proportional to H^2 and to θ, and may therefore be represented by $K_2H^2\theta$. This electromagnetic control may be positive or negative according to circumstances. If there is an inductance in the coil circuit the electromagnetic control is positive; if the inductance is replaced by a capacity it becomes negative. The total control may therefore be written

$$(K_1 \pm K_2H^2)\theta.$$



(a) Moving coil under controlling forces. (b) Moving coil under controlling and deflecting forces.

Fig. 5.—Moving-coil Alternating-current Galvanometer with Positive Electromagnetic Control.

When an alternating current, i, is passed through the coil from an external source, a deflecting couple, K_3Hi, is produced, so that the final position taken up by the coil is

$$\theta = \frac{K_3H}{K_1 \pm K_2H^2} \cdot i.$$

The sensibility of the galvanometer is thus $K_3H/(K_1 \pm K_2H^2)$. It therefore varies with the field strength H in exactly the same way as the sensibility of the electrometer varies with the potential V of the needle.

In pursuance of the analogy it may be noted that just as in the galvanometer the electromagnetic controlling couple on the coil arises from the current induced in it by the field, and the deflecting couple from the current injected into it by an external source, so in the electrometer the electrostatic controlling couple is due to the charges induced on the quadrants by the charge given to the needle, and the deflecting couple to the charges given to the quadrants by some external source.

* *Cf.* Ayrton, Perry and Sumpner, *loc. cit.* p. 554; also Chauveau "Jour. de Phys." IX., p. 524, 1900.

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The Sign of the Electrostatic Control.—Short of actually determining the sensibility curves, the nature of the electrostatic control in an electrometer can be arrived at in several ways. For example, if the periodic time of the needle is found to decrease when the needle is charged, the electrostatic control must be positive ; if the periodic time increases, the electrostatic control must be negative.

In general the sign of the electrostatic control is at once obvious from the construction of the instrument. In doubtful cases a consideration of the changes in the electrostatic field which result from a displacement of the needle will often assist materially in fixing the sign. For instance, with a needle completely boxed in, as in Fig. 6A, and free to move parallel to itself, the only electrostatic lines effective in producing motion are those which form the " fringes " at the edges of the needle. If the needle is displaced from its central position, the number of lines leaving the advancing edge must increase, owing to the edge approaching the side S of the box ; for a similar reason the number of lines leaving the retreating edge must decrease. On the whole the resultant force on the needle due to electrostatic causes is in the direction of the displacement, and the electrostatic control is therefore negative.

Again, in the arrangement of Fig. 6B, with a needle between parallel plates which are separated by very narrow gaps, the electrostatic forces on the needle tending to displace it parallel

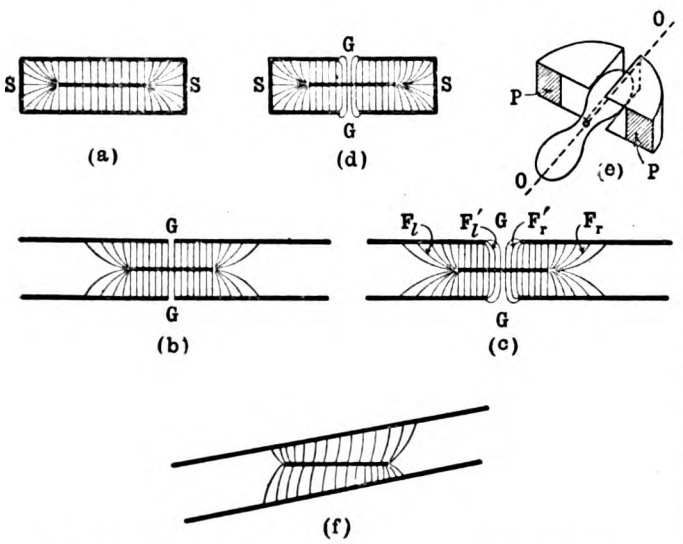

FIG. 6.—ILLUSTRATING METHOD OF DETERMINING SIGN OF ELECTROSTATIC CONTROL.

to itself are entirely the result of the fringes at the edges. If the gap G between the plates is very narrow, the fringes from the two edges will be similar in whatever position the needle may be placed, and will therefore always exert equal and opposite pulls. In this case the electrostatic control is zero.

But if the gap G between the plates is wide (Fig. 6C), we have fringes not only at the edges (F_l and F_r), but also at the gap (F'_l and F'_r). If the needle is displaced to the right the fringes F_l and F'_l are brought nearer together, and the lines in F_l are distorted in such a way as to exert a greater pull. At the same time the fringes F_r and F'_r are separated, and, as a result, the pull of the lines in F_r decreases. Thus the electrostatic forces brought into play oppose the displacement, or the electrostatic control is positive. This explanation is, of course, only a rough one, but it helps to make clear how the positive electrostatic control in the ordinary quadrant electrometer arises, and how it depends upon the width of the gap between the quadrants. Other things being the same, the effect of the gaps is obviously less the further they are removed horizontally from the sides of the needle.*

Such methods are not infallible, however, and often it may be impossible to predict the sign of the electrostatic control with certainty. Fig. 6D is a case in point. Here, if the sides S are far removed from the needle, the electrostatic control arises from the gaps G solely, and must therefore be positive. If, on the other hand, the sides are close up to the needle, the effect of the gap is relatively small, and the control becomes negative, as in Fig. 6A. But, except in these extreme cases, it is impossible to say whether the positive or negative control has the upper hand, and whether the resultant control is positive, negative or zero. This example serves to illustrate how readily a positive control may be converted into a negative by a simple structural alteration. In an ordinary quadrant electrometer a reversal in the sign of the electrostatic control may be effected by attaching plates PP, Fig. 6E, to the quadrants. These play the part of the sides SS of the box in Fig. 6D. and usually cause the electrostatic control to change from positive to negative, with a corresponding change in the sensibility characteristic.

Another way in which a negative electrostatic control may arise is through the non-parallelism of the needle and quadrants. From Fig. 6F, which represents an exaggerated case of this kind, it is clear that a displacement of the needle either to one side or the other causes the pull of the fringe of lines on its front edge to increase and that on its rear edge to diminish, the resultant electrostatic pull on the needle thus tending to increase the displacement. Even in the most carefully constructed instruments perfect parallelism cannot be secured, and therefore a certain amount of negative control must always be present. This can be magnified by suitably manipulating the levelling screws. Schultze* and Scholl† have, in fact, independently shown that in some electrometers it is possible to neutralise entirely the positive electrostatic control and obtain a straight-line sensibility characteristic merely by giving a small tilt to the instrument about an axis parallel to that of the needle in its zero position. But the necessary adjustments to secure this are rather tedious when only the usual levelling screws are available. If, however, electrometers were constructed so as to allow the whole quadrant system to be rotated through a small angle about the axis OO (Fig. 6E), the carrying out of this adjustment would be greatly facilitated, and a straight-line sensibility characteristic over a considerable range of needle potential could readily be secured. At very high potentials, however, owing to the existence of an electrostatic tilting couple, there would be a tendency for the inclination between the needle and the quadrants to increase, with an accompanying increase in the negative control. Thus an electrometer compensated on the " inclined quadrant " principle for low needle potentials would be over-compensated at high potentials and would ultimately become unstable.

Outline of General Theory.—A general electrometer formula which takes into account any want of symmetry as well as any contact potential differences that may exist between the quadrants, or between the needle and the quadrants, may be arrived at by supposing the resultant couple on the needle to be developed in a series of ascending powers of θ, say, $A-B\theta-C\theta^2-$&c. Assuming that the deflection is small, we may, by neglecting squares and higher powers of θ, reduce this expression to two terms only, the first of which, A, may properly be called the deflecting couple, and the second, $B\theta$, the total controlling couple. For equilibrium the resultant couple must be zero giving $\theta=A/B$. In the most general case that can be imagined both A and B are complete quadratic functions of V, V_1 and V_2, the potentials applied respectively to the needle and to the quadrants. Hence we may write as the most general expression for the deflection

$$\theta=\frac{a+\Sigma(bV^2)+\Sigma(cV_1V_2)+\Sigma(dV),}{a'+\Sigma(b'V^2)+\Sigma(c'V_1V_2)+\Sigma(d'V)}$$

where a a', b b', &c., are constants.

In the case of a symmetrical electrometer with V_1 and V_2

* This explains the absence of electrostatic control claimed for the special type of electrometer devised by Blondlot and Curie ("Jour. de Phys." VIII., p. 80, 1889).

* " Zeitschr. f. Instrumentenkunde," XXIV., 147, 1906.
† " Phys. Zeitschr.," IX., 915, 1908.

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small, and the contact potential differences negligible, this evidently reduces to

$$\theta = \frac{cV(V_1 - V_2)}{a' + b'V^2},$$

which is the result previously obtained.

Again, in an electrometer in which V_1 and V_2 are not small relatively to V, and in which the contact potential differences are not negligible, it can be shown (*see* Orlich, *loc cit.*, p. 152) that, when certain symmetrical conditions are complied with, the general expression for the deflection takes the form

$$\theta = \frac{(V_1 - V_2 + V_Q)(V - \frac{1}{2}V_1 + V_2 + V_N)}{A + B(V - V_1)(V - V_2) + C(V_1 - V_2)^2},$$

where V_Q and V_N denote respectively the contact potential difference between the quadrants, and between the needle and the quadrants, and A, B, C are constants.

In other cases the exact form taken by the general equation depends on the character of the adjustments, the method of connection, &c., and the values of the several constants which enter into the formula have to be determined experimentally. Orlich has discussed methods of doing this at length in the valuable Paper already alluded to, and he shows, among other things, that in direct-current measurements the effect of any dissymmetry or of any contact potential differences can be eliminated, and correct results obtained, by adopting a certain method of manipulation involving four readings produced by commutating the applied potentials.

In alternating-current measurements, on the other hand, contact potential differences have not to be reckoned with, and, therefore, two readings, obtained by reversing the connections either of the needle or of the quadrants, suffice to give correct results. This remark applies also to the use of the electrometer for measuring alternating-current power; but, as an inspection of the general formula will show, it is essential in this case that the electrostatic control should be negligible.

DISCUSSION ON RAILWAY ELECTRIFICATION.

The following communication has been sent by Mr. Philip Dawson to the Secretary of the Institution of Mechanical Engineers in connection with the discussion on railway electrification which took place at the recent joint meeting of that Institution and the American Society of Mechanical Engineers. An abstract of this discussion appeared in our last issue together with abstracts of the Papers read by Mr. G. Westinghouse, Mr. W. B. Potter and Mr. H. M. Hobart. Elsewhere in the present issue we give abstracts of the Papers by Mr. F. W. Carter and Mr. L. R. Pomeroy, which also deal with the subject of railway electrification.

Mr. Philip Dawson, in his written communication, says: I am very sorry that I was detained at London Bridge, and unable, therefore, to take part in the discussion of the Papers at the summer meeting in London. In consequence of my having only received the proofs of the Papers to be read two days before the meeting, it has been quite impossible for me to check the calculations and data given in the various Papers, and this will, therefore, prevent my making my portion of the discussion of these important subjects as interesting as it might otherwise have been. I will, however, make a few remarks which will practically represent those which I intended to make had it been possible for me to be present.

I will take Mr. Hobart's Paper first. Mr. Hobart assumes that the cost of the distributing system is the same in the single-phase and continuous current. This is quite inadmissible, and both Mr. Potter and Mr. Westinghouse in their contributions to this subject clearly state that the single-phase has the great advantage in having the cheaper distributing system. Mr. Hobart assumes that the output for the alternating current motor equipment is only 6 H.P. per ton in the cost of the Brighton equipments for which I am responsible. This is incorrect, firstly, because the weight of the electrical equipment is 36 tons and not 44 tons as wrongly assumed by Mr. Hobart. Secondly, six motors are quite sufficient to run the schedule time with ease, and, as a matter of fact, have often done so; in any case, it appears to me that the method of reasoning of Mr. Hobart is incorrect and really proves nothing. Mr. Hobart assumes the cost per ton of equipment; all those who have to purchase electrical apparatus know how erroneous such assumptions are. Mr. Hobart further assumes that the cost of electricity delivered to the railway is 0·7d. per B.O.T. unit. This is a great deal too high, and, as a matter of fact, the line with which I am connected will very soon reach a point which will only cost them ½d. per unit on their railway at the periodicity and at the pressure at which we use it. Mr. Hobart in his figures of cost of electrical energy per train-mile assumes that the electricity will cost us from 10d. to 15d. per train-mile; as a matter of fact, on the basis of the energy consumption which now exists and at ½d. per unit, this figure for our service only amounts to 4·83d. per train-mile. In this connection it must also be borne in mind that the South London line is a very bad line for running. It is full of short radii curves, and there is a rising gradient in each direction out to each station with the exception of the termini. Out to Victoria there is a gradient of 1 in 64 for a very considerable distance, and owing to the congested nature of the traffic, practically every train is stopped once or twice by signal both on entering London Bridge and Victoria.

Although I have no time to check Mr. Hobart's calculations, I believe there would be no difficulty in carrying out under the Southport conditions of distance between stations, gradients and curvature the services there running at the present moment with the Brighton equipments. Mr. Hobart's assumptions for charges for rolling stock I am entirely at a loss to understand, or his statement that the cost for electricity, plus individual charges, is 3d. higher for single-phase than for continuous current. I do not wish it to be thought that I am in any way criticising the continuous current, which gives such excellent results, and I think it is a pity that at this stage what amounts to an attempt to decrease the very great advantages possessed by single-phase should be attempted by engineers. In electrifying any portion of a main line railway system it must always be borne in mind that very large extensions may come about in the future, and even Mr. Hobart talks of a 30-mile radius. Under these circumstances it certainly appears to me that the single-phase system cannot be dismissed in the very simple way in which Mr. Hobart has attempted to do it.

Mr. Hobart suggests that the energy consumption on a test run on the train amounted to 79 watt-hours per ton-mile. Whilst these figures were those guaranteed by the manufacturers, the actual tests gave 66 watt-hours per ton-mile. That we have a very large amount of spare power on the trains on the South London line is shown by the fact that under ordinary running conditions it is quite possible to make up two minutes on the schedule run of 24 minutes. There are a great many other figures in Mr. Hobart's Paper which I should like to have taken exception to, and errors which I should like to have corrected, but as already mentioned, I only received the Papers two days before the meeting, and it has, therefore, been quite impossible for me to do this. In any case I think I have shown that Mr. Hobart's conclusions are entirely vitiated by the results obtained on the South London line.

I think Mr. Carter's Paper of great interest, but I should like to point out that the comparison of the cost as instituted by him between the South London and Tynemouth electrifications is entirely misleading, and that had I had to instal the third rail system on the South London line the cost of doing this would have been greater than the single-phase system; in any case, in advising the adoption, which I did in the case of the Brighton Railway, I had to bear in mind possible extensions as far as Brighton, and experience has certainly shown that the adoption of my advice has proved most satisfactory to the Brighton Railway Co.

As regards the very able Papers of Mr. Potter and Mr. Westinghouse, they are so full of figures that I had not time to criticise them very thoroughly. I should, however, like to point out that there is a very great discrepancy between the results obtained by these two eminent authors, who have had such vast experience in America, and who also have had the information and data of two such eminent manufacturing concerns as the Westignhouse Company and the General Electric Co., respectively, for whilst Mr. Westinghouse distinctly proves that the single-phase system is by far the most economical Mr. Potter succeeds in proving the reverse. I think this shows how easy it is to come to a false conclusion, unless every individual case is thoroughly investigated on its own merits by railway engineers. I should like to point out in this connection that the railway engineers of the various German States, Sweden and Switzerland, and many other railway engineers, after the most careful consideration, came to the conclusion that for the electrification of any portion of a main line railway, be it suburban, interurban or long distance, the only really satisfactory system to be employed is the single-phase. I do not give this as my own opinion, but only wish to refer to it as a general impression gaining ground in Europe.

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THE WORK OF THE PHYSIKALISCH-TECHNISCHE REICHSANSTALT IN 1909.

(*Continued from p. 639.*)

Self-Induction of Standard Resistances.—A formula for the self-induction coefficients of band resistances was determined similar to that used when measuring large alternating currents, and an electrical method was thought out for comparing these self-induction coefficients by means of high frequency currents. A large number of these resistances from 1 to 0·001 ohm were made, and their self-inductions calculated and measured. The results have been published.

Measurement of Small Alternating Currents.—An instrument fitted with Salomonson bridge connections was built up of constantan-manganin thermo-elements, the wires being only 15μ in diameter, while the smallest wires used up to the present have been 20μ. The most suitable length of an element was found to be about 13μ, and with a total resistance of about 100 ohms each arm of the bridge contained four elements, the thermo-electric power of the instrument being about 16 millivolts when a current of about 6 milliamperes was flowing. By the use of finer wire for the same total resistance there is a reduction in the number of elements, a simplification in the manufacture and a considerable increase in the sensibility being thus obtained.

A difference in the readings given by the instrument on continuous and alternating current occurred, as the resistance of the thermo-element in the neighbourhood of the junction has a considerable temperature coefficient. With continuous current the resistance of the element is, owing to the Peltier effect, different in the two directions, and the method of discharging the bridge galvanometer in the two current directions does not alone give the thermo-electric power of the elements, but is higher by an amount depending on the difference in resistance of the elements in the two directions. Attempts were made to avoid the troublesome reckoning of the difference, first, by a suitable arrangement of the connections and, secondly, by the use of thermo-elements with resistance material of small temperature coefficient.

The first was obtained in the following way: A resistance, A (Fig. 1), which could be short-circuited, was connected in series with the galvanometer G. The resistance was so adjusted with continuous current that the middle reading of the galvanometer was the same as when alternating current of the same effective value was employed and the resistance short-circuited. The percentage difference is, therefore, corrected for the whole scale, as it is a constant value independent of the load. The mean resistance of a thermo-element and of the whole bridge arrangement is, on account of the Peltier effect, higher with continuous than with alternating current. This difference was compensated by connecting a resistance, B, in the main circuit of the instrument, which is short-circuited with a plug when working with continuous current. The same plug, as mentioned above, may be used for the purpose. Two other resistances, C and D, which can be continuously altered, are connected in the galvanometer circuits. One of these is used for the compensation of the temperature coefficients of the sensitiveness of the instrument, and is provided with a scale divided into degrees Centigrade. The other resistance is provided to allow for any decrease in the sensitiveness which may occur in the course of the year, or due to overloads. The galvanometer is provided with a scale of milliamperes. Another resistance, E, is also provided to enable the total resistance of the instrument to be brought to any particular value. The instrument has shown itself to be useful by many repeated tests and researches.

As regards the removal of the temperature coefficient of the resistance in the thermo-elements it appeared best to weld the thin wire instead of to solder it, as all soldering material has a considerable temperature resistance coefficient. An instrument with this description of contacts was supplied by Messrs. Hartmann & Braun. The contact and the mechanical strength of the welded junction was good, the difference being somewhat smaller than in elements soldered with silver and amounting to about 1·1 per cent. The well-known phenomenon of a manganin wire becoming coated with a copper skin when heated was observed, a temperature coefficient of about 0·00015 per degree Centigrade being noted on these occasions. The manganin wire taken from store had only a temperature coefficient of some millionths per degree Centigrade, while the temperature coefficient of constantan wire was of the same value, but negative in direction. The temperature coefficient of constantan is not considerably affected by melting the wire. The copper covering on heated manganin wire can be sometimes washed off with nitric acid.

A clean manganin wire was heated to redness in a high vacuum, and in this case no copper skin appeared and the temperature coefficient remained small. There is, therefore, no danger that an accurate or only slightly inaccurate instrument will become very inaccurate if overloaded. Manganin and constantan can be electrically welded *in vacuo*, so that if elements have an inaccuracy exceeding 10 per cent. they are more than red hot. The phenomenon was not improved by melting the wire in pure hydrogen and thus preventing oxidation.

The difference was finally reduced by performing the welding in the following way. A manganin and constantan wire were twisted about 10 times and their ends were stretched out by two clamped-on screws (*ss*). The twisted part of this "bridge" was hung on two metal strips (*mm*) placed about 0·5 mm. apart (*see* Fig. 2). When a suitable voltage is applied the twisted parts are melted and burnt through. The other wire parts are cooled by dropping water at *ww*, so that immediately two elements are established. In this case the difference is about 5 to 7 per thousand with this arrangement. The melting occurs very accurately, so that a large number of elements can be set up in a short time and with a small expenditure of material. The melting places give good contacts and support a tensile stress quite well.

Standard Capacities and their Absolute Measurement.—Four standard air condensers made up of circular magnalium plates were erected, three being of 0·01 mfd. capacity with 73 plates, having a diameter of 20 cm., and one of 0·03 mfd. capacity with 101 plates, having a diameter of 30 cm. The plates were placed 2 mm. apart. These air condensers, which now have an aggregate capacity of 0·1 mfd., are used for the determination of the absolute value of self-induction standards and for the measurement of energy losses of condensers with solid and fluid dielectric.

These condensers were tested during the year in connection with the newly-constructed rotary interrupter. With the help of the speed indicator described in the 1908 report, the absolute value of capacity standards based on that of the international ohm could be determined with great accuracy, and the results of these measurements, as well as a detailed description of the air condensers, the rotary interrupter and the speed indicator, has been published.

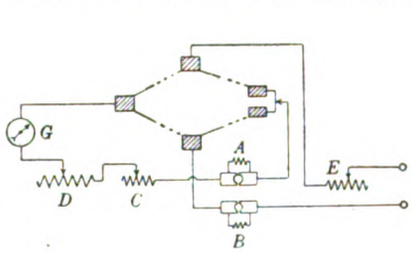

FIG. 1.

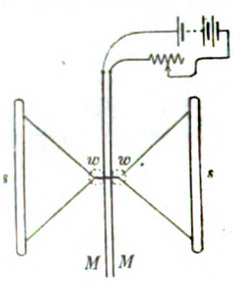

FIG. 2.

The Generation of Alternating Currents of Constant Frequency.—A rectified continuous current obtained by means of a rotating interrupter with a speed regulator is subject to some alteration in frequency during the period of one revolution, and is, therefore, unsuitable after it has been transformed into alternating current for absolute measurement with a slightly damped vibration galvanometer. If, however, it is produced by an electromagnet which is excited by a current having a frequency several times that of the mean interrupter frequency, resonance oscillations are set up and by means of a mercury contact, periodically interrupted direct current whose frequency is free from the oscillations mentioned above is generated. The alternating current mentioned above, generated with the help of this transformer, enables a higher accuracy of measurement to be obtained than was possible hitherto in self-induction and capacity measurements in which the zero position of a vibration galvanometer depends on the frequency.

(*To be continued.*)

PHYSICAL SOCIETY.

At the meeting held at the Imperial College of Science on July 8th, Prof. H. L. CALLENDAR, F.R.S., President, in the chair, a Paper entitled

"The Radio-balance: a Thermoelectric Balance for the Absolute Measurement of Radiation; with applications to Radium and its Emanation,"

was read by the President.

In this apparatus, which was first constructed in 1905, and was briefly described in an article on Radiation contributed to the "Encyclopædia Britannica," heat supplied by radiation is directly compen-

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sated by the Peltier absorption of heat in a thermo-junction through which a measured electric current is passed. In the simplest form of the instrument, radiation admitted through a measured aperture, 2 mm. diameter, falls on a small copper disc 3 mm. diameter by 0·5 mm. thick, to which two thermo-junctions are attached, forming a Peltier cross. One couple is connected to a sensitive galvanometer for indicating changes of temperature. The other is connected to a battery and rheostat in series with a milliammeter or potentiometer for measuring the current required to reduce the deflection of the galvanometer to zero. If A is the area of the aperture in square centimetres, Q the intensity of the radiation in watts per square centimetre, a the absorption-coefficient of the surface of the disc, P the Peltier coefficient in volts, C the balancing current in amperes, and R the effective resistance of the couple, the equation giving the value of the radiation in absolute measure is $aAQ = PC - C^2R$. The absolute value of P is the product of the absolute temperature by the thermoelectric power. The value of R, in the small correction term for the Joule effect, is readily determined by observing the neutral current, $C_0 = P/R$, for which the Joule effect balances the Peltier effect. In practice two similar discs with similar connections are mounted side by side in a thick copper box, and are balanced against each other in order to avoid changes of zero due to exposure to sunshine, or rapid variations of temperature.

The advantages of the disc radiobalance are that it is very simple to construct and easy to reproduce without material variation in the reduction constants. It is very suitable for measurements of solar radiation, or strong sources, but is insufficiently sensitive for weak sources; and the absorption coefficient a must be determined by comparison with a standard.

In the cup radiobalance, the radiation is received in a copper cup, .. mm. diameter by 10 mm. deep, so that the absorption coefficient is practically equal to unity. Greater sensitiveness is secured by employing a pile of several couples, insulated from the cup, in place of the single balancing couple. External disturbances are eliminated by employing a pair of cups, similarly mounted but oppositely connected, enclosed in a thick copper cylinder. The Joule effect, represented by the C^2R term in the equation, is automatically eliminated by passing the same current in series through the opposing Peltier junctions soldered to the bottom of the cups. The cup exposed to radiation is cooled, and the cup screened from radiation is heated by the Peltier effect, while both are equally heated by the Joule effect. A complete observation involves reversing the current and switching over the radiation screen, in order to eliminate any difference of sensitiveness of the two piles. By observing the neutral current, each cup can be used separately, as with the disc balance, but the disc balance cannot be used with the Peltier couples connected in opposition, unless the balancing couples are insulated from the discs. The cup radiobalance is sensitive to less than a tenth of a microwatt, and is very suitable for measuring the heat evolved by small quantities of radioactive substances.

A Paper entitled

"The Convection of Heat from a Body Cooled by a Stream of Fluid"

was read by Dr. A. RUSSELL.

Attention is directed to certain deductions made by Boussinesq from the mathematical theory of the conduction of heat in liquids. Complete proofs are given of Boussinesq's formulæ, stress being laid on their limitations, and some of their practical applications are pointed out. It is proved that when a hot body is immersed in a stream of liquid flowing with constant velocity, the cooling is proportional to the difference of temperature between the body and the liquid. Newton proved experimentally in 1701 that this law was true for the case of a hot body being cooled by a draught of air. He enunciated his law with reference to the forced convection of heat from a body, and not, as is often stated, to the natural free convection from it. Lorenz has shown that in special cases the natural convection of heat will vary as the 1·25th power of the difference of temperature. Provided that the velocity of the cooling draught is kept constant between certain limits, Compan has shown that Newton's law is very approximately true even when the difference of temperature is as high as 300°C. Another deduction from the formulæ proved in the Paper is that the cooling is very approximately proportional to the square root of the velocity of the convection current. The author gives the solution of the problem of the heating of a liquid flowing steadily, with a velocity less than the critical velocity, through a cylindrical tube which is maintained at constant temperature. It is shown that, in many practical cases, the heating power of the tube varies as $R\theta\sqrt{s\sigma k V l}$, where R is the radius of the tube, θ the difference of temperature between the tube and the liquid, s the specific heat, σ the density, k the conductivity, V the velocity of flow and l the length of the tube.

It is proved that if a wire be immersed in a stream of liquid with its length at right angles to the direction of flow, the electric current which will fuse the wire varies as the 1·25th power of the diameter of the wire. Finally, the effect on the cooling of an electrically-heated cylinder by a stream of liquid, of putting an insulating wrapping round it, is considered. It is shown that in certain cases the effect of this procedure is to lower the temperature of the cylinder, an effect which can be easily demonstrated experimentally. In order to simplify the mathematical work, only the case of incompressible fluids is considered. Experimental results, however, obtained by various physicists are quoted to show that some of the formulæ are approximately true for the cooling of heated bodies by convection with currents of air.

A Paper on

"Hysteresis Loops and Lissajous' Figures, and on the Energy wasted in a Hysteresis Loop."

was read by Prof. S. P. THOMPSON.

Attempts have been made to find an explanation of the forms of the looped curves which express the hysteresis exhibited by iron and steel when subjected to cycles of magnetisation. Physical explanations to account for their general shape have been given by Ewing and Hopkinson, and M. Pierre Weiss has put forward an electronic theory to account for the principal features. The author shows that any hysteresis loop can be analysed into a harmonic series of closed curves corresponding to the various terms in the analysis of the current wave, and their constituents are examined in the Paper. A number of examples of hysteresis loops were chosen and subjected to analysis. The loops chosen related to various kinds of iron and steel, hard and soft, solid and laminated, and taken by various methods. In carrying out the analysis the simple approximate method described by the author ("Proc." Phys. Soc., Vol. XIV.) was used. Details are given of the analysis of various loops, the effect of eddy currents on the size and form of the loops is discussed, and an account is given of the effect of the higher sine and cosine constitutents of the current wave.

Dr. RUSSELL thanked the author for his most interesting and instructive Paper. In connection with Dr. Thompson's orthogonal ellipse, he showed how an indefinite number of two-beaked loops similar to the hysteresis loop could be made up by quadrants of ellipses, each loop having the same height, the same area and the same breadth as the orthogonal ellipse. Two-beaked loops having equal areas, breadths and heights could also be made up from portions of any two curves provided that these curves were similar. He thought it would be of value to discuss the harmonics of the magnetising current, as deduced from the statical hysteresis loop, when the flux varied according to laws other than the harmonic law. F. J. Dykes had investigated the law according to which the flux must vary in order that the magnetising current might have a pure sine shape. To find the harmonics of the flux curve in this case and compare them with the harmonics of the current curve in the author's case would be of interest. A practical use of Dr. Thompson's rapid method of analysing the current wave into its harmonics was that it enabled us to compute approximately the eddy-current losses in iron in certain cases by utilising J. J. Thomson's and Heaviside's formulæ.

Dr. W. H. ECCLES, referring to the emphasis laid by Prof. Thompson on the hysteresis ellipse obtained by his ingenious mode of analysis of the hysteresis loop, suggested that other closed curves would be obtained if other normal functions were used in the analysis. In regard to the author's suggestion that his results affected our notions of the phenomenon called hysteresis, he thought no change was needed if we kept the term to its original meaning of a lag in state, in contra-distinction to (what is often implied) a lag in time.

A Paper entitled

"The Energy Relations of certain Detectors used in Wireless Telegraphy,"

by Dr. W. H. ECCLES, was taken as read.

The Paper is a record of the results of an experimental examination into the physical properties of the electrolytic detector, the zincite rectifier, the carborundum rectifier and a thermoelectric detector consisting of a light contact between graphite and galena. The conditions of the experiments have been generally identical with those arising in the ordinary employment of the detectors, and, in particular, the quantities of energy given to the instruments, in the form of electrical oscillations, have been of the same order in these experiments as in actual practice. Three ways of investigation are followed. The first way consists in applying to the detector an E.M.F. which is gradually increased, and measuring the current at each step. The second way is to fix the E.M.F. at some particular value, to send trains of oscillations of various energy values through the instrument, and to measure the intensity of the sound produced in the telephone on each occasion. The third way is to send trains of constant energy value through the instrument while the steady electromotive applied to it is varied, and to measure at each step the intensity of the sound produced in the telephone. These modes of investigation give curves that may be called respectively the steady current curve, the power curve and the sensitiveness curve. The chief fact brought to light is that the power curves of all the detectors are straight lines, which suggests that all the detectors are fundamentally thermal in their action.

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Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON
(ONLY ADDRESS.)
Tel.: Holborn **6363** (Two Lines). *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fifty-first issue of the Supplement was published (Gratis) with the number of "THE ELECTRICIAN" for July 22.

The "INDUSTRIAL SUPPLEMENT" is a comprehensive record of developments in Electrical Plant, Machinery, Apparatus, Accessories, Sundries and Materials, and of their proved suitability for various Industrial purposes.

MUNICIPAL FINANCE.

Recent events have emphasised the fact that the law relating to municipal corporations is rather complicated and that its intricacies are not understood or appreciated by ordinary laymen, such as those usually elected to municipal bodies in this country. Each session of Parliament sees some addition to the duties and obligations of local authorities, and it is not, therefore, surprising if such authorities occasionally find themselves in awkward positions. As a general rule it may be laid down that a corporation can only contract under seal, and that it can only perform those acts and things which it has been specially authorised to do, while occasionally compliance must be made with rather onerous conditions. This position is sometimes found too rigid by corporations with extensive business departments, such as electricity supply and gas undertakings, tramways, housing schemes, &c., and difficulty is experienced in complying with statutory requirements in such cases.

The position of West Ham, though somewhat exceptional, is a case in point, and members of local authorities and those who have business transactions with local authorities would do well to read carefully the judgment recently delivered by Mr. Justice NEVILLE in an action brought by the ATTORNEY-GENERAL (on the relation of the India Rubber, Gutta Percha & Telegraph Works Co.) against West Ham Corporation. The judgment was set out in full in our last issue. The facts of the case seem to be clear enough, but the position of the defendant Corporation was certainly adversely affected by the tardiness of the Local Government Board in granting sanctions to loans for electricity supply purposes.

Local authorities which possess electricity supply powers are entitled to borrow money for their undertakings on the

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terms laid down in section 8 of the Electric Lighting Act of 1882, but in doing so they must comply with the conditions set out in the schedule to that Act, and therefore they have to obtain the sanction of the Local Government Board and conform to the conditions laid down in sections 233 and 234 of the Public Health Act of 1875. West Ham Corporation appear to have experienced difficulty in obtaining the necessary sanction to loans for their electricity undertaking, and they therefore resorted to the expedient of an overdraft on their bankers in order to meet current requirements. This overdraft had been running for some years, and at one time it amounted to about £200,000. The India Rubber Co., as large ratepayers in West Ham, had a special interest in seeing that the undertaking of the Corporation was carried on in a prudent, businesslike manner, and naturally were dissatisfied with the loose and illegal method of bankers' overdrafts for financing the undertaking. They therefore brought an action for, amongst other things, a declaration that these overdrafts were unauthorised and illegal and that the Corporation were not entitled to levy a rate for paying off such overdrafts or interest thereon, and also for an order to compel the bank which made the advances to refund all interest already received on this account.

There is ample legal authority for saying that overdrafts, being in fact unauthorised borrowings of money, are *ultra vires*, and, as local authorities are trustees of public money, it is proper to insist that they should comply with the statutory requirements as to borrowing, more especially as these requirements have been made in the public interest. This is all the more necessary nowadays when local authorities have under their control extensive business undertakings, and it is reasonable to expect that they should carry on such undertakings in a businesslike way. If overdrafts were legalised, local authorities could easily evade the provisions which have to be made for repaying the capital expended on work by sinking funds or other means, and municipal accounts would get into a chaotic condition.

It appeared from the evidence in the case that West Ham Corporation had also erred by carrying forward deficits on their electricity undertaking instead of charging them upon, and paying them out of, the local rate as they arose each year, as provided by statute. We are afraid that West Ham is not alone in this respect, but the Local Government Board insist, and rightly so we think, upon provision being made for the payment of accumulated deficits before sanctioning fresh loans. The position of the West Ham electricity department had undoubtedly become very involved, and therefore it is satisfactory to find that the judgment has justified the public-spirited action of the India Rubber Co., who succeeded in obtaining a declaration that the overdrafts were *ultra vires*, and that if the Corporation raised money under borrowing powers they were bound to apply the money so raised to the specific objects for which such loans were sanctioned.

The judgment is not, however, so satisfactory from other standpoints, for the judge expressed the view that there were no means by which his declaration could be enforced; and the transaction may prove an unfortunate one for the bankers who obliged the Corporation with the overdrafts, as they have agreed, without admitting legal liability, to refund £7,000 which had been paid to them as interest. This course may be, and no doubt is, legally correct, but to an ordinary layman it is inequitable and may serve to emphasise the poor opinion of the law held by the average layman. The moral of the case is that those who propose to contract with corporations should first of all ascertain that what they propose to do is authorised by statute or by the common law.

There is, however, another phase of the question. It is becoming more and more apparent that if municipalities take up electricity supply they must be prepared to run such undertakings on commercial lines; they must push the sale of electrical energy and be ready to expand as rapidly as the demand may arise. In such a case as that of West Ham this means that a good deal of money may be required at comparatively short notice and that new plant must be put down without much delay. Now, it is well known that the procedure of the Local Government Board is not characterised by expedition. It may take the greater part of six months to obtain an inquiry, and a similar time before the result of the inquiry is known. If an undertaking is growing rapidly it may be a serious matter to add, say, nine months to the time required to get out plans, call tenders and lay down the plant. Consequently, the moral in this direction is emphatic that the L.G. Board should act in such manner as to facilitate the passing or rejecting of schemes, instead of requiring an absurdly long time in which to decide whether a scheme is, in the view of the Board, satisfactory or not.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electrical Installations of Electric Light, Power, Traction and Industrial Electrical Machinery. By RANKIN KENNEDY. Vols. IV. & V. (London: The Caxton Pub. Co.) Pp. viii. + 208; pp. viii. + 223. 7s. 6d. net each.

Vol. IV. opens with the subject of electrolysis. The theoretical sketch includes Grotthus', but not the dissociation, theory. A number of simple experiments as to quantity and quality of deposit are described, and the composition of one or two brassing baths. About a dozen pages are devoted to primary and secondary cells and electric furnaces, but contain little of real value. The author's homopolar machine is again referred to and figured, but we are still left in doubt as to its performance.

We are next switched back again to secondary cells, with descriptions of the principal types, including the Edison cell, which the author considers an important improvement. Electric furnace operations and welding are briefly described, after which a good deal of attention is devoted to thermopiles. Here the author rightly deplores the small amount of information available as to the thermal conductivity of metals and alloys, but considers work in this direction promising of fruitful results. Incidentally, Clamond is systematically given an extra m to his name, and other misprints or errors are somewhat common. In dealing with pyrometers, the Callendar form is quite ignored, but the thermo-junction and Féry radiation patterns are described.

The remainder of the volume is devoted to electric lighting, traction and transmission. Of course, each of these subjects

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is very sketchily treated, but no important errors are noticeable. One cannot help wondering somewhat at the author's selection of examples, but they, apparently, in many cases are those which have come under his own actual notice.

Vol. V., the last of the series, after dealing with train lighting and rectifiers, is mainly devoted to electric signalling. As to train lighting, the only system described is the Rosenberg cross-excited generator method, and the Stone system is not even mentioned. Rectifiers comprise the Nodon and mercury vapour forms, and the author incidentally introduces us to the Moore vacuum tube lamp. The description of the latter, is however, marred by the inversion of the block, which must leave a neophyte in doubt as to the functioning of the air valve.

A description of two new meters of the author's design is next sandwiched in. They are both of the motor type, the direct-current form resembling the early Chamberlain & Hookham meter, except that the field cuts the disc always in the same sense, and that a separate brake magnet is used. The author claims the latter as a great improvement, giving greater torque, but disregards the advantage of the combined motor and brake magnet in being nearly independent of variations in the strength of the magnet. If greater torque is aimed at, it should be possible to attain this with the additional magnets, without discarding the compensation principle. The alternate-current meter is of the induction type, and does not show any remarkable features.

Dealing next with dielectrics and cables, the author treats us to some remarks on electrostatics, in which we are informed that "when we charge any body we don't put anything into it or upon it, but we set up a field of force represented by radiating lines between it and all surrounding bodies." Apart from the vagueness of this idea, we should like to ask if the author has forgotten his earlier chapter on electrons.

The telegraphic section deals with the batteries and elementary circuits in a fairly clear manner. Why the reader should be told, however, that bridge duplex "works by opposing the P.D. of the batteries" we do not know; and the brevity of some of the descriptions makes them useless to one who is not already familiar with the apparatus. Railway and automatic signalling is fairly satisfactorily dealt with. Telephony is treated in a somewhat unequal manner, the illustrations being poor and exchange connections being given without those of a simple wall set. The KR law is given without any reservation.

A fair amount of space is given to wireless telegraphy. The author's ideas on induction coils, however, seem to be peculiar, and we are given a dissected diagram of a coil of his own design with interchangeable primaries, which may possibly work well in practice, but is certainly not based on sound principles as described in the book. As to wireless telegraphy itself, a few interesting descriptions are given, but a hopelessly garbled mathematical explanation of oscillatory discharges is given on p. 170, and the acoustical analogy is carried to the point of ignoring the transverse character of electromagnetic waves.

On the whole it must be said that, though the present volumes are a considerable improvement on the first edition, and contain much that is interesting and readable, they suffer from the very fault that the author criticises in technical colleges—the attempt to teach too much. If Mr. Rankin Kennedy will give us a few volumes dealing specially with parts of his undoubtedly useful ideas and experience we shall be much more grateful than for his attempt to cover the whole field of electrical engineering. C. V. DRYSDALE.

Alternating-Current Machines. By S. SHELDON, H. MASON and E. HAUSMANN. Vol. II. of "Dynamo-Electric Machinery." Eighth edition. (London: Crosby Lockwood & Son.) Pp. xi. + 353. 12s. net.

This is an American work, better known to English students in the days when electrical books were more scarce than they are at the present time. The new edition has been completely re-written; but, as there is no special preface for it, we assume that that for the seventh edition still holds. In this preface we read that the book has been written as a text-book "for students on other than electrical courses," because of "the growing tendency in many institutions to require more thorough and extended work in electrical subjects from such students." The authors, however, have made the great mistake, common to so many other writers, of trying to put a large amount of matter into a small space. The result is, as it always must be, unsatisfactory, for it can only give a smattering of the subject to any student.

On the other hand, it has several facts and formulæ which are very useful for the electrical engineer's private pocket-book, though this is clearly not the intention of the authors.

Starting with the Table of Contents, as a general rule this is probably the most deceptive part of a treatise of this kind. It may mean anything. For example, the section on the starting of converters might have well occupied several pages; actually it is compressed into a short paragraph.

Chapters I.–IV. are on alternating-current theory, Chapter V. on alternators, Chapter VI. on the transformer; Chapter VII. on motors: (*a*) induction, (*b*) synchronous, (*c*) single-phase commutator; Chapter VIII. on converters, and Chapter IX. on power transmission. Although the list of contents looks very full, yet on the whole the treatment is very superficial.

Several long and complicated formulæ appear for the inductances of various systems without any explanation of how they are obtained, while the derivation of the ordinary E.M.F. formula for an inductive circuit occupies four pages, and is treated very mathematically. And again, although vector diagrams, which are really necessary to the technical man, are passed over very cursorily, yet the theory of complex quantities is treated in such a very mathematical way that it is incomprehensible to the average student. Thus the treatise is very unequal at times.

The idea of giving problems at the end of the chapters is very good, and most of them are just what is wanted, but their utility largely disappears when it is found that the solutions are not given, nor any inkling as to the methods by which the student should tackle them.

The chapter on alternators is very short, but in it space is found to explain the reason of the shape of the saturation curve, which surely students who have advanced so far should be supposed to know.

Magnetic leakage is treated much more fully in the chapter on transformers, and the same method is applied to the slot leakage in induction motors. The tooth-tip, coil-end, &c., leakages, however, are derived more roughly, and several assumptions are made which the student has to take for granted without being shown any justification for them.

To obtain an *approximate* relation between the speed and efficiency of an induction motor, we find that the friction and windage and even all the stator losses are neglected. This is indeed sacrificing accuracy for the sake of simplicity.

The circle diagram is usually a puzzle to the student at first, and it is really very important, yet we can only class the pages devoted to it with those on vector diagrams.

On the whole, the book has several very good points, but we cannot consider it quite suitable as a text-book for alternating-current work at the present time, especially as it is the eighth edition. R. G. J.

POLYPHASE COMMUTATOR MACHINES.*

BY J. JONAS,

Summary.—The author discusses the necessity for and possibility of a polyphase motor with economical speed regulation. This leads to the introduction of the polyphase commutator motor, which is described, and its application in connection with machines of large output explained.

Whilst the development of the single-phase commutator motor has been prominently in the foreground during the last decade, practically little or no progress was made in the polyphase commutator motor; for since the first appearance of the latter motor at the Frankfort Exhibition in 1891 and the Paper by Görges in the "E.T.Z." in the same year, where the importance of the commutator as frequency changer was demonstrated, no important advance was made with these machines for a considerable time.

* Abstract, from the "Electrotechnische Zeitschrift," of a lecture delivered before the Electrotechnische Gesellschaft, Frankfort a.M.

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At the present time, however, the polyphase motor promises to become an important addition, the reason for this being chiefly the necessity of having a polyphase motor with an economical speed regulation.

Previously, efficiency was often sacrificed for regulation, and the imperfect method of inserting resistance in the rotor circuit was largely adopted. With the advent of machines of large output, however, such as are used for driving rolling mills, winding gears, fans, &c., the question of economy becomes of the utmost importance. But these large outputs were also the chief difficulty militating against the introduction of polyphase commutator motors, for the experience gained with continuous-current machines could not be used directly with these motors. Consequently it was a happy thought that led Krämer to supply only that power to the commutator motor which would otherwise be consumed in rotor resistances. This resulted in the patent D.R.P. 169,453 of the Felten & Guilleaume-Lahmeyerwerke, where a polyphase commutator motor is placed in cascade with the induction motor, and the power supplied to the commutator motor is given back to the shaft (*see* Fig. 5).

Scherbius solved this problem in a similar manner—D.R.P. No. 179,525—whereby the energy taken from the rotor of the asynchronous motor is supplied to an auxiliary commutator motor which drives a generator, so that the energy given out by the latter can be returned to the mains (*see* Fig. 6).

In this way it is possible to regulate the speed of a large motor by means of a comparatively small commutator motor, which has only to take a relatively small part of the total power.

Coming now to the description of the polyphase commutator motor, this machine has a fixed winding consisting of a number of coil-groups corresponding with the number of phases, just like the stator of an ordinary induction motor; these groups of coils being displaced in space by an angle corresponding to the displacement

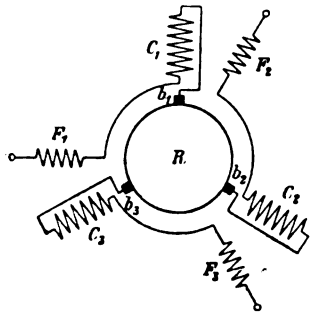

FIG. 1.—THREE-PHASE SERIES MOTOR WITH SEPARATE EXCITING WINDING.

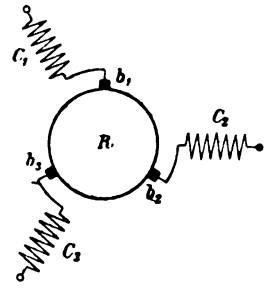

FIG. 2.—THREE-PHASE SERIES MOTOR WITH COMBINED EXCITING AND COMPENSATING WINDING (GÖRGES).

of the several phases from one another; thus, in a three-phase winding, they are separated by 120 deg. The revolving part of the motor is wound like a continuous-current machine and provided with a commutator. It is the commutator which distinguishes this motor from the ordinary induction motor. The difficulty of regulating the speed of induction motors hitherto was that no means were known whereby the low frequency of the rotor currents could be transformed to that of the mains. It was only the knowledge that the commutator always transformed the slip-frequency to that of the motor field—thus to that of the supply—that made this possible, for, since the commutator can be directly connected to the network, energy can be given or taken according to the conditions of working. Thus, whatever the speed of the rotor, the frequency of the pressure at the commutator brushes remains unaltered whilst its value only depends on the speed of the rotor.

We must now see how such a motor derives its torque. Torque is given by the product of field and current, whereby it is assumed these are perpendicular to one another. The field axis is determined by the position of the exciting winding, the current axis by the position of the brushes. Though both winding and brushes are fixed, yet the field and current axes rotate at synchronous speed. Since, however, they always retain the same angle between them, the torque is not affected.

The problem of building a three-phase commutator motor, therefore, falls into two parts; first, the production of the field, secondly, supplying the energy current to the rotor.

Production of the Field.—The field of a polyphase commutator motor is produced by the exciting winding, which is fed by a current or pressure. If the energy current of the motor is used as exciting current, the rotary field produced will not be constant, but will depend on the output of the motor. Thus, if the exciting winding F is connected in series with the energy winding C + R (Fig. 1) the motor will have a series characteristic, the speed being a function of the torque. On the other hand, if the exciting winding F is fed from a constant pressure (Fig. 3) the field will be constant, independent of the load. This motor possesses a shunt characteristic and runs at approximately constant speed. In addition to these, combinations can also be made to give compound characteristics.

It will be presently seen that in addition to the exciting winding there is also a compensating winding C on the stator, and it is possible to combine this with the exciting winding to form a single winding on the stator (*see* Figs. 1 to 4). In a series motor (Fig. 1) the exciting winding F is at 90 deg. to the compensating winding C. The combination of F and C gives a winding somewhat displaced from the brush axis. This is the Görges motor, and is shown in Fig. 2. By varying this angle between the axis of the winding and that of the brushes, the component producing the field can be varied without affecting the series characteristic of the motor.

Likewise an exciting winding fed with constant pressure can be combined with the compensating winding and the rotor winding by supplying the exciting pressure to one of the latter (Fig. 4). The phase of exciting pressure, however, must always be such that the axis of rotary field is always perpendicular to that of the energy current. In Fig. 3, for example, the axes of the exciting and compensating windings coincide, so that the exciting winding would have to be fed from a pressure having the same phase as the motor pressure, in order that the exciting current and flux are displaced 90 deg. from the energy current. In Fig. 4 the exciting pressure is supplied to the compensating winding; this pressure is also the energy pressure.

Supplying the Energy Current to the Rotor.—To supply the motor with energy current, counter E.M.F.s have to be overcome. Of these there are both useful and harmful. Of the useful there is chiefly the back E.M.F. induced in the rotor by rotation in the motor field, for the output of the motor is proportional to the product of this E.M.F.

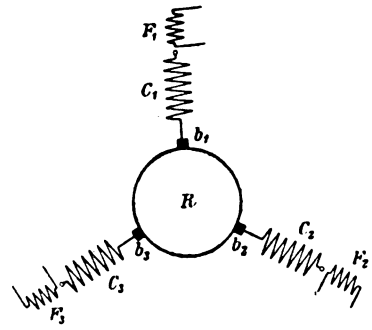

FIG. 3.—THREE-PHASE SEPARATELY EXCITED OR SHUNT MOTOR WITH SEPARATE EXCITING WINDING.

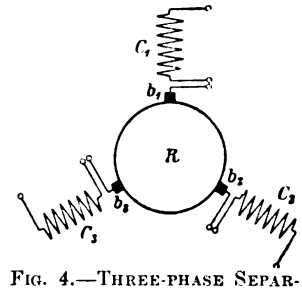

FIG. 4.—THREE-PHASE SEPARATELY EXCITED OR SHUNT MOTOR WITH COMBINED EXCITING AND COMPENSATING WINDING.

and the energy current. On the other hand, the counter E.M.F. of self-induction of the rotor winding is injurious, and can practically prevent any appreciable energy current flowing. It is, therefore, absolutely necessary to neutralise the inductance of the rotor winding along the brush axis and reduce the inductive pressure to a minimum. This is accomplished by means of a compensating winding on the stator, the axis of which is arranged along the brush axis. This winding is traversed by the rotor current or a current proportional to this, and serves to neutralise the armature field (*see* winding C in Figs. 1 to 4), the effective ampere-turns being adjusted to secure this result. The neutralisation of the rotor inductance, however, is not quite so simple as it seems, for in addition to the effective ampere-turns being equal, it is also necessary that the phase of the current in the compensating winding must be such that at every point along the periphery the resultant phase of the compensating winding is the same as that of the armature winding, otherwise local fields will be formed, which make the motor useless. Thus, in a two-phase commutator motor, it is necessary to have either a continuous-current winding for the compensating winding or a winding distributed over the whole circumference, if the rotor inductance is to be completely neutralised. With a three-phase motor this arrangement is not necessary, for in this case the equality of the resultant phases of the two energy windings takes care of itself. Thus we see that the compensating winding is an essential part of the polyphase commutator motor, and the same can either be a separate winding or combined with the exciting winding (*see* Figs. 1 to 4).

Speed Regulation.—It has been mentioned above that a counter E.M.F. is induced in the rotor due to rotation in the motor field. This pressure maintains equilibrium with the pressure supplied to the energy winding, and it is indifferent whether the energy pressure is supplied to the rotor winding or to the compensating winding or

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to both. For the internal E.M.F. of the rotor is made up of two parts, e_2 being the pressure applied at the brushes and e_i induced in the rotor by the stator field. The counter E.M.F. e_r must maintian equilibrium with the sum of these, *i.e.*, $e_r = e_2 + e_i$ (of course, e_2 and e_i may have negative values).

The speed regulation of the polyphase *series* commutator motor is similar to that in continuous-current machines. Let $e_r = k_1 F_1 n$ and $k'_1 = 1/k_1$, where n = speed, F_1 = motor field and k_1, k'_1 are constants; then $n = k'_1 \frac{e_i + e_2}{F_1}$. For a given definite torque, that is, for a given motor current, n can be adjusted then by either altering $e_i + e_2$, or the flux F_1; $e_i + e_2$ is varied by altering the motor pressure, for example, by means of a variable ratio transformer. The flux F_1 can be varied in motors with separate field windings by varying the number of exciting turns or altering the exciting pressure. In the

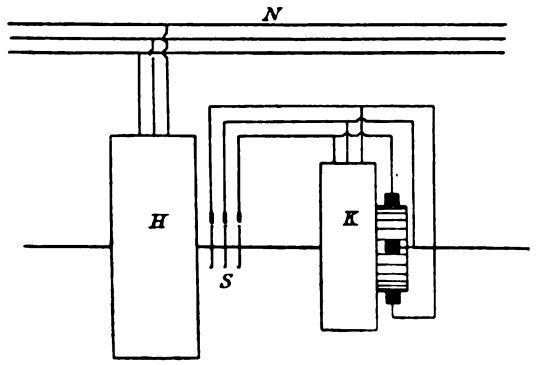

Fig. 5.—Speed Regulation with Auxiliary Motor D.R.P. 169453 (Krämer).

Görges motor, where the windings are combined, the field can be varied by shifting the brushes. In this case, however, the compensating component is also varied, so that the motor will not behave equally well in all positions. To overcome this Osnos proposed using two sets of brushes, one of which is fixed and the other movable.

To regulate the *shunt* motor we have the no-load speed from the relation $e_r = e_i + e_2$ as follows: Dividing the equation by e_i and putting $\frac{e_r}{e_i} = \frac{k_1}{k_2} \frac{F_1}{F_1} \frac{n}{\sim}$, where the ratio k_1/k_2 can be made equal to unity. Then $\frac{e_r}{e_i} = \frac{n}{\sim}$, where n = no-load speed and $\sim$ = synchronous speed. Then $\frac{n}{\sim} = 1 + \frac{e_2}{e_i}$, or $n = \sim\left(1 + \frac{e_2}{e_i}\right)$ is the general expression for the no-load speed of the shunt motor. When $e_2 = o$, *i.e.*, with the brushes short-circuited, $n = \sim$, and the motor runs at synchronous speed.

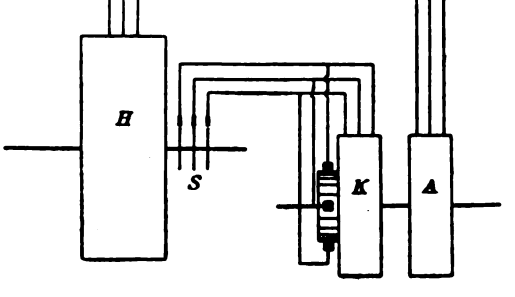

Fig. 6.—Speed Regulation with Auxiliary Converter D.R.P. 179525 (Scherbius).

When $e_i = o$, that is, when the energy pressure is only supplied to the rotor, the flux will be zero and the speed would be ∞. n can now be altered in a variety of ways, for $e_i = e_1 \frac{Z_2}{Z_1} v'_1$, where e_1 is the stator pressure, z_2 the number of energy turns on rotor, z_1 the number of energy turns on stator and v'_1 the resultant leakage coefficient. Hence $n = \sim\left(1 + \frac{e_2}{e_1} \frac{z_1}{z_2} \frac{1}{v'_1}\right)$. Thus the speed can be altered by altering any of these five variables, either singly or together.

Regulation by Means of Auxiliary Motor (Krämer).—This is shown in Fig. 5. The auxiliary commutator motor has only to be dimensioned for the output corresponding to the slip of the main motor. Thus, for a 10 per cent. speed regulation the auxiliary motor has only to be designed for 10 per cent. of the total output. The auxiliary motor is fixed to the same shaft as the main motor, and the latter machine takes entirely the character of the former. If, for example, the commutator motor is a series machine, then the main motor will have a series characteristic, or if a shunt, then a shunt. All the methods for regulating speed can be used with this aggregate and the no-load speed as shunt with this arrangement will be

$$= \frac{\sim}{1 + \frac{p_2}{p_1} \frac{e_2}{e_1} \frac{z_1}{z_2} \frac{1}{v'_1}}$$

where p_1 = number of poles for main motor, p_2 = number of poles for auxiliary motor.

Since the frequency supplied to the commutator motor is always low, it is better to vary $\frac{z_1}{z_2}$ than $\frac{e_2}{e_1}$. With this arrangement the total energy minus the losses is given to the shaft, so that the overall efficiency is very high.

Regulation by Means of Auxiliary Converter (Scherbius).—This arrangement also permits of all the above-mentioned methods of speed regulation being adopted. The polyphase commutator motor, K, (Fig. 6) drives an auxiliary generator, A, which pays back energy to the line. The machine, A, can be either synchronous or asynchronous

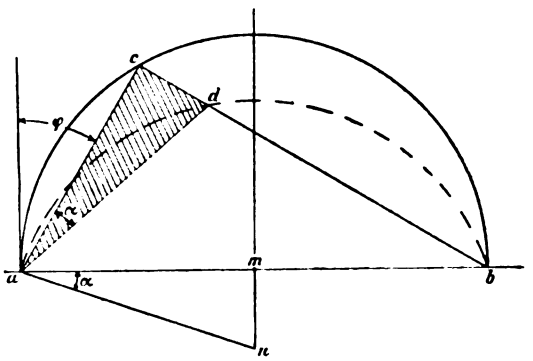

Fig. 7.—Diagram of the Ordinary Polyphase Series Motor.

or a commutator machine. Except in the last case, the speed of the auxiliary set will be approximately constant, being practically the synchronous speed of the auxiliary generator. The no-load speed of the main motor will be

$$n = \left(1 - \frac{\frac{p_2}{p_3}}{1 + \frac{e_2}{e_1} \frac{z_1}{z_2} \frac{1}{v'_1}}\right)$$

where p_2 = number of poles of commutator motor, p_3 = number of poles of the asynchronous or synchronous auxiliary generator.

A disadvantage of this system is that for a given main motor we can only regulate at constant torque, so that the output decreases with the speed. If constant output is required the main motor must be designed for the maximum torque. The efficiency of this arrangement is somewhat lower than that of the former.

For *starting* either of the above arrangements the main motor can be run up to speed independently, as an ordinary induction motor, and afterwards placed in connection with the auxiliary motor.

Sparkless Running.—With a large range of speed regulation the effect of the rotary field on the short-circuited coils (which is a minimum at synchronism) can become considerable, so that it is necessary to have suitable carbons to keep down the short-circuit currents. If these alone are not sufficient there are several other means, amongst which the use of resistance connections between armature winding and commutator and of commutating poles may be mentioned.

Phase Compensation.—Whilst two windings perpendicular to one another have no inductive action on each other in a single-phase motor, in a polyphase motor the relative position of the two windings does not have much effect on the magnitude of the mutual induction. This forms the chief difference between the two types of motor. If both windings are traversed by the same current in the polyphase motor, two rotary fields will be produced having the same angle in

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space as the windings. If the rotor revolves in both fields, two E.M.F.s will be induced, which are displaced from one another in time by an angle equal to the space angle between the windings.

It is possible, however, to compensate a polyphase motor by means of a leading E.M.F., this E.M.F. being produced by letting the rotor revolve in a field—in addition to the motor field—which leads the motor field by 90 deg. in space. The leading field, however, has the axis of the energy winding and the phase of the energy current and also the sense of the rotor ampere-turns. If then a polyphase motor is under-compensated, so that a flux exists along the energy axis in phase with the energy current, the power factor of the motor is improved. This is seen from the diagram. Fig. 7 shows the method of working of the ordinary uncompensated polyphase commutator series motor. The diagram is developed in the same way as in a single-phase commutator motor.

$ac = i(L_1 + L_s + L_2 - 2M)$,
$cd = i\Sigma\omega$,
$db = e_r$ = counter E.M.F. due to rotation in motor field,
ab = E = applied pressure.

The angle acd is a right angle and the locus for the motor current vector is a circle acb, whose centre lies in the mid point of ab. By dividing all the vectors by $L_1 + L_s + L_2 - 2M$ then ac denotes the motor current directly and $ab = \frac{E}{L_1 + L_s + L_2 - 2M}$ is the ideal short-circuit current of the motor, and

$$\tan\alpha = \frac{cd}{ac} = \frac{\omega}{L_1 + L_2 + L_s - 2M} = \text{constant}.$$

If now a second E.M.F. is induced in the rotor by rotation in a field in the energy axis and proportional to the energy current, we get

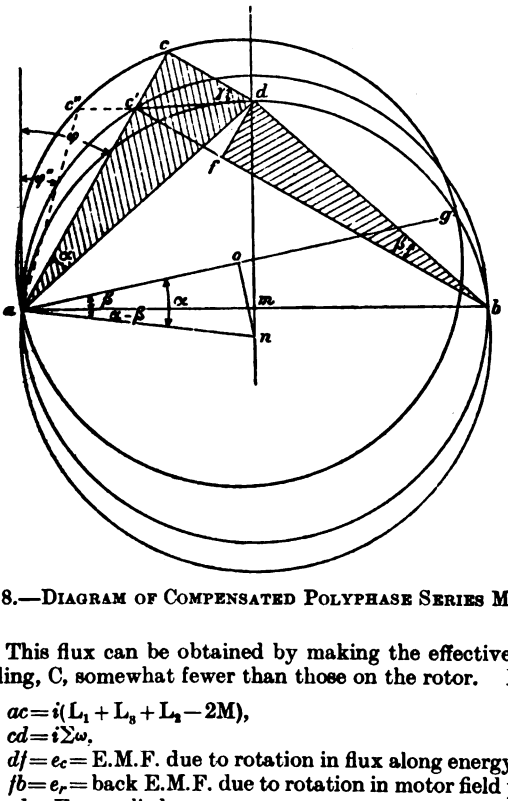

FIG. 8.—DIAGRAM OF COMPENSATED POLYPHASE SERIES MOTOR.

Fig. 8. This flux can be obtained by making the effective turns of the winding, C, somewhat fewer than those on the rotor. In Fig. 8.

$ac = i(L_1 + L_s + L_2 - 2M)$,
$cd = i\Sigma\omega$,
$df = e_c$ = E.M.F. due to rotation in flux along energy axis,
$fb = e_r$ = back E.M.F. due to rotation in motor field proper,
ab = E = applied pressure.

To find the locus of c we first find the locus of d. This point lies on a circle whose chord is ab and angle $adb = 90 - \beta + \alpha$. For

$$\angle adb = \angle adf + \angle fdb = \angle\alpha + 90 - \beta,$$

where $$\tan\alpha = \frac{cd}{ac} = \frac{\omega}{L_1 + L_s + L_2 - 2M} = \text{constant}$$

and $$\tan\beta = \frac{fd}{fb} = \frac{F_H}{F} = \text{constant},$$

where F_H = flux proportional to current along main axis, F = motor flux proper along exciting axis.

Hence $\angle 90 - \beta + \alpha$ is also a constant angle and d lies on a circle whose centre n is the point of intersection of the perpendicular from the centre of ab and the line through a at angle $\alpha - \beta$ to ab. The locus for c is then easily found when it is remembered that the $\triangle adc$ always remains similar, so that ac and ad enclose a constant angle α also ac bears a constant ratio to ad. c then also lies on a circle whose diameter is displaced from the diameter of the d-circle by $\angle\alpha$ and is in the ratio ac/ad. If then we set off ag at $\angle\alpha$ to an to cut the d-circle in g, then ag is the diameter of the c-circle, and the centre o is the point where the perpendicular from n cuts ag. As seen from Fig. 8, for the same input as in Fig. 7, the point c moves to c'' and the $\angle\phi$ to ϕ'', thus improving the power factor.

For the speed n we have

$$\tan\gamma = \frac{l_c}{i\Sigma\omega} = \text{constant}\frac{in}{i} = \text{constant} \cdot n.$$

The power factor of the shunt motor can also be improved by simple means, but this will be further explained in a later article.

THE ELECTRIFICATION OF TRUNK LINES.*

BY L. R. POMEROY.

It is assumed, from a physical and mechanical viewpoint, that electric traction can meet all the demands and requirements of railroad service. Therefore, whether electricity will replace steam traction or not is entirely a commercial problem.

It may be stated at the outset that, whatever system of electrification is adopted, a very large outlay has to be faced, and no case for electrification can be made out unless an increase in net receipts can be secured more than sufficient to pay interest on the extra capital involved. This increase may be brought about either by decreasing the working expenses for the same service, by so modifying the service as to bring in a greater revenue, or by a combination of these. The fundamental principle, based on the present state of the art, seems to be that if you cannot accomplish something by means of electricity that is now impossible by steam traction there is nothing to justify the change; the substitution of one kind of power for another merely to obtain the same result is not commercially warranted. In heavy work the limiting feature of the steam locomotive is the boiler, and the maximum adhesion can be utilised only at low speeds. For example, a 2-8-0 locomotive with 180,000 lb. on the drivers has a tractive force at 10 miles per hour of about 40,000 lb., or 4·5 to 1. At 30 miles per hour the tractive force becomes 13,250 lb., or 13·5 to 1. As tractive force governs the tonnage hauled, the ability of the electric locomotive to utilise almost indefinitely power proportional to the maximum adhesion and produce a drawbar pull entirely independent of the critical speed of a steam locomotive, as limited by the boiler, is a marked feature. In heavy gradient work the ability to increase the speed shows up favourably to the electric locomotive as enlarging the capacity of a given section, but here also the business has to be sufficient to absorb the increase in fixed charges. With steam locomotives a coal consumption, when running, of 4 lb. to 5 lb. per indicated horse-power-hour really means 6 lb. or 7 lb. at the rail, when the losses due to firing up, laying by in yards and sidings, blowing off at the pops, and consumption of the air pumps, are taken into account. Whereas, under electric operation, with an efficiency of 65 to 70 per cent. between the power house and the rail, a coal consumption of 4 lb. per kilowatt-hour at the rail can be counted on. The writer considers 1d. per kilowatt-hour at the rail a conservative figure, and will use this cost in the following computations. The relative difference in the cost of coal at the rail is represented by the following figures:—

Electric power station $\frac{2{\cdot}5 \text{ lb.}}{50\% \text{ eff.}} \times 6\text{s.}$ ..... 30s.
Steam locomotive $7 \times 9\text{s.}$ ..... £3. 3s.

or 50 per cent. in favour of electricity. The following results of the Mersey tunnel operation are pertinent: Under electric operation 1 ton of coal at 9s. yields 2·29 ton-miles at 22½ miles per hour, while with steam 1 ton of coal at 15s. yields 2·21 ton-miles at 17¾ miles per hour. The difference, amounting to 55 per cent., is in favour of the electric operation. On mountain gradients or in heavy freight service, where the boiler of the freight locomotive is forced to the limit, and the boilers are designed for this particular purpose, the showing is still more favourable to the electric side. Especially is this true when the steam locomotive is detained on side tracks for as long a period as it takes to make the run, which is very frequently the case, since under these conditions the cost for fuel becomes a larger proportion of the total operating expense. The cost of a unit of power with the steam locomotive becomes relatively higher under maximum than minimum boiler demands, while with electricity the cost per unit is at a uniform rate, whether working under extreme or light power demands.

* Abstract of a Paper read on July 29th at the joint meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers. An account of the joint discussion on this and other Papers appeared in our last issue.

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Thus, the cost per 1,000 ton-miles is 4s. 9d. for a 2-8-0 locomotive and 3s. 6d. for an electric locomotive. In this connection an article by Mr. C. L. de Muralt is referred to.

It is claimed that, with electric operation, greater mileage is possible with the electric locomotive and that fewer units are necessary to perform the same service. Great stress is laid on the fact that the ordinary freight locomotive makes only 3,000 miles per month, or 100 miles per day, against which is put forward the ability of the electric locomotive to perform practically continuous service, suggesting the propriety of comparing electric and steam operation on the basis of ton-miles per annum each is able to make, and also the relative weight on driving wheels and not their total weight. The operating efficiency of a steam locomotive in freight service is so low, averaging about 3,000 miles per month, that it is generally thought due to limitations, *per se*, in the locomotive, whereas it is mainly due to operating and traffic conditions, which limitations would apply with equal force to the electric locomotives, so that, barring some increase in speed, the electric locomotive can make no greater mileage than its steam competitor in equivalent service, consequently its splendid ability to perform almost continuous service cannot be realised in practice for reasons aforesaid. The time usefully spent is only 28 per cent. of the whole; 22 per cent. is spent in the shops and 50 at terminal yards, side tracks, &c., ready for use. The only case where electric operation is commercially justified is in congested local passenger situations where the conditions closely approach those of a "moving sidewalk," and the records show that these cases have been profitable only when a large increase in business has been realised.

In the annual report of the P.R.R. (1903) the president states "that the congested condition of your system has brought about a large increase in the ton-mile cost, which for 1903 was 25 per cent. greater than for 1899. In order to prevent the increase in ton-mile cost it is necessary to move freight trains faster in places where traffic is dense, and for such purposes the electric locomotive is most efficient." With steam locomotives the most economical average speed for freight service is 12 to 15 miles per hour, where there is ample track space for the free movement of trains. With a dense traffic this free movement can only be obtained by a higher speed, and, if the large train tonnage be maintained, more horse-power is required of the engine and boiler. It is difficult to increase the size of steam freight locomotives without resorting to the Mallet compound articulated type, and here we have the equivalent of two locomotives in one machine. With the electric locomotive it is possible to develop a much greater horse-power and a large percentage of overload at the time when needed, and do it more economically than with steam. The New York Central electric locomotive has a maximum peak horse-power of 3,000, which is 25 per cent. above normal. This maximum is about double the power which can be obtained from the New York Central standard Atlantic type locomotive. Similar proportions can be obtained for electric freight locomotives, and their size and power are not limited by boiler capacity. If the steam locomotive is capable of developing 30,000 t.f. at the drawbar at 12 miles per hour, or 960 H.P., and it is required to increase the speed of the train to 20 miles per hour and maintain the same tonnage, then 1,600 H.P. will be required, which means the employment of a much larger locomotive or double heading. The advantage of the overload capacity on short mountain gradients or for strategic peaks is one of the strong points in favour of the electric machine, and would make electric operation applicable to special cases rather than a universal substitute, in the broad light of commercial considerations.

The author's conclusion, from this survey of the situation, is that the rapid development of suburban passenger traction by electricity will require large power houses at large cities, and these can gradually be made sufficient for working the line on further stretches in each direction, handling congested terminals, or used where commercially practicable, until it may be desirable to electrify the entire division. Electric operation as compared with steam shows to greatest advantage in urban and suburban passenger service. Here, if multiple unit trains are employed, so that a considerable fraction of the total weight is carried on the driving wheels, thus permitting a high rate of acceleration to be used, a schedule speed quite impracticable in steam operation can be maintained. Moreover, a more frequent service can be given without a proportional increase in expense, whilst in times of light traffic small trains can be run, the energy consumption per train in such service being almost in proportion to the number of coaches. The law of induced travel, however, applies to urban and suburban passenger service, but does not hold for trunk lines, and especially freight service.

In conclusion, a number of examples are given of the financial benefits derived from electrification.

ASSOCIATION OF CONSULTING ENGINEERS.

As the objects of this Association have apparently been somewhat misunderstood in various quarters, the committee have prepared a memorandum setting forth in detail the aims and objects of the Association.

This memorandum we reproduce below :—

OBJECTS OF THE ASSOCIATION OF CONSULTING ENGINEERS.

One of the principal objects of the Association is to secure that municipal and other public works shall be supervised by duly qualified consulting engineers. In order that this may be done, it is necessary to know who is a qualified consulting engineer. There appear to be no means of ascertaining this at the present time. It is hoped that the register of the Association will give this information.

The Association will not be antagonistic to the principle of specialisation, as the intention is to include in the Association all branches of the profession—Civil, Mechanical, Electrical, Gas, and possibly others. It is not suggested that every member should possess a knowledge of all branches, or even more than one. Every member will be as free to specialise as he is now. All that is proposed is that every member shall be a properly trained and qualified engineer, and that he shall be acting solely in a professional capacity—that is, as a consulting engineer.

It is not intended to encroach in any way on the authority of the councils of the leading institutions which deal with the different branches of engineering. In fact, it is hoped that these councils will support the Association as acting in the interests of those of their members who are consultants.

Although the existing institutions are thoroughly representative of the profession of engineering as a whole, their province is to deal with the science and problems of engineering which are of equal interest to all engineers. The Association does not propose to deal with these matters at all, but only with the professional status and conduct of those engineers who have adopted consulting work as their profession, and who represent a comparatively small percentage of the engineering body as a whole.

The bye laws governing professional conduct issued by the Institution of Civil Engineers, and now adopted also by the Institution of Electrical Engineers, require that the members of these institutions when acting in a "professional capacity"—that is, as consulting engineers—shall conform to certain rules. The above institutions can make no distinction between their members, and are, therefore, not able to say to which of their members the rules are applicable. As the rules stand, a member can act in one capacity one day and in another the next. There is, or should be, as clear a distinction between the work of a consulting engineer and that of other members of the engineering profession as there is between the work of a barrister and that of a solicitor in the legal profession. The Association of Consulting Engineers has been formed to define clearly the above distinction. If it succeeds, it is believed that it will be acting in the interests of the existing institutions.

The register of the Association will, it is hoped, form a complete list of the qualified consulting engineers to whom the professional conduct rules above referred to will be applicable at all times. This register will be open to inspection by the authorities responsible for spending public money, as well as to anyone else requiring the advice of a consulting engineer.

The rules of the Association, which are now under consideration, will be based on the professional conduct rules of the Institution of Civil and of Electrical Engineers, to which it is intended to add other rules applicable to consulting engineers only. These rules will be submitted to a general meeting in the autumn. It is hoped that all the leading men in the profession will be willing to give their advice and help, so that nothing may be done that would be detrimental to the interests of the existing institutions or of the public.

At present membership is confined to those who are corporate members of the Institution of Civil Engineers and also of the Institution representing the particular branch of the profession in which they practise. The Institution of Civil Engineers has taken the lead in establishing examinations for admission, and has in many other ways taken great pains to improve the status of the engineering profession. The Association is not prepared at the present time to accept the responsibility of considering the qualifications of engineers other than those mentioned above, but it will no doubt be able to do so in the future, should it receive the support it desires from all members of the profession. A provisional list of members is now being drawn up. This list will be revised after the constitution and rules of the Association have been settled.

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It is hoped that all consulting engineers in sympathy with the objects of the Association will send their names to the honorary secretary, Mr. A. H. Dykes, of 1, Victoria-street, Westminster, London, S.W., so that notice may be sent to them of the general meeting which will be called in the autumn to consider and decide on the rules and constitution of the Association.

CERTAIN CHARACTERISTICS OF DRY CELLS.*

BY C. F. BURGESS AND C. HAMBUECHEN.

In spite of the fact that 40,000,000 or thereabouts represents the number of dry cells manufactured each year in the United States, little scientific work has been done in the way of making a detailed study of the various individual factors which influence the quality of the cell, if we may judge by the meagre publications. On the other hand, much scientific work has undoubtedly been done, if we may judge by the marked improvements which have been effected in the product. It appears that dry cell manufacturers who are doing the larger part of this work do not feel inclined to discuss analytically dry cell construction.

Perhaps 80 per cent. of the dry cells made and used are of the so-called No. 6 size, being in cylindrical form, the zinc container 6 in. high and 2½ in. in diameter. As far as the cylindrical zinc container is concerned, there is striking uniformity in dimensions and construction, the principal difference being in the thickness of the zinc, which may be found to vary from No. 7 to No. 11 sheet zinc gauge.

All cells employ a carbon rod for the cathode plate. In some forms of cells this rests on the bottom layer of paper, and in others it is raised ½ in. from the bottom. It extends up through a pitch seal, and a brass cap or brass screw attached to the top constitutes the positive terminal of the cell. Some of the carbons used are of smooth cylindrical shape, while others are corrugated or fluted to give greater contact surface to the filling material. Another striking similarity in most of the dry cells is the list of materials which are introduced into the zinc container. Similarity then ceases, and we encounter variations in the quality of the materials, the proportions and in the methods in which the materials are introduced into the container. The writers are unable to refer to published formulæ which are descriptive of the better type of cells at present in use. The following list and proportion of materials may be taken as fairly representing the filling mixture in well-known types of cells: 10 lb. of manganese dioxide, 10 lb. of carbon or graphite, or both, 2 lb. of sal ammoniac, 1 lb. of zinc chloride. Sufficient water is added to give proper amount of electrolyte to the cell, and the most suitable quantity depends upon the dryness of original materials, fineness, quality of paper lining, &c. While these are the essential elements, other materials are frequently added—such as starch or other forms of paste, to improve contact of electrolyte to zinc and promote distribution of action throughout the charge. Mercury is occasionally added to effect amalgamations and prolong life of the zinc.

With the materials as above listed and in the proportions named the resulting cells may be good or they may be practically worthless, depending upon various factors. It is generally believed that purity of materials is the pre-eminent requisite. Commercial conditions, however, prohibit the use of chemically pure materials. The customary specifications for manganese dioxide call for a granulated or powdered material having about 85 per cent. of MnO_2 and less than 1 per cent. of iron. This is a specification which can readily be complied with, and by careful selection and concentration it is possible to get as high as 92 per cent. Physical qualities, porosity and size of grains are likewise important. The amount of available MnO_2 differs according to the chemical test employed, and "available MnO_2" by test may not be the available MnO_2 under the conditions existing in the cell. In storage batteries PbO_2 is an active material only when in suitable contact or proximity to the grid or framework of the positive plate; and MnO_2 in a dry cell is active to a degree, depending upon its contact with the conductive carbon constituting the negative electrode. It is evident that penetration into the interior of a piece of MnO_2 is necessary if the entire mass is to be active; and porosity seems therefore to be important.

Sal ammoniac of a very pure grade is generally employed and in addition to purity, the physical qualities of dryness and freedom from lumps are requisite to ensure proper mixing with the carbon and manganese. The zinc chloride is also required to be of high purity and to be free from iron. Sheet zinc constitutes the anode and serves at the same time as a container. Purity is naturally of importance. The purchaser does not have, however, a variety of grades of zinc to choose from.

*Abstract of a Paper read before the American Electrochemical Society.

This anode makes contact with the electrolyte in the form of paper saturated with solutions of zinc and ammonium chlorides. Ideal conditions call for a corrosion of zinc only in amount equivalent to the current delivered to the external current. Excess of corrosion above this amount is caused by local action, and one of the principal problems in dry cell manufacture is to reduce such local action to a minimum.

There are numerous possible causes of local action—*e.g.*, iron or copper in the zinc, manganese dioxide getting between the paper and the zinc, or inequalities in the zinc itself.

It is evident, when we consider the numerous possible sources of trouble leading to faulty cells, that the making of a good dry cell requires care. Amalgamation of the zinc is occasionally resorted to, but it is doubtful whether material advantage accrues through the use of mercury in the dry cell. It is customary to consider the carbon rod as the cathodic electrode, and there are, therefore, arguments favouring the large corrugated and fluted shapes over the smaller cylindrical shapes, in that greater active electrode surface is thereby attained. It is doubtful, however, whether the surface of this rod is to an appreciable extent an active electrode surface. It makes contact with and is surrounded by a mass of material—carbon, graphite and manganese—possessing metallic conductivity even though moistened by electrolyte. It would, therefore, be more accurate to consider the active cathode surface as that portion of the mixture just within the paper. While this may be the main cathode surface, it is not exclusively so, and the active surface progresses inward as the action of the cell goes on. The cathode is a compound one, consisting of an intimate mixture of conductive carbon and graphite in contact with manganese oxide, and the E.M.F. of the cell is the summation of the electrode potentials, 0·56 volt for the zinc and about 1 volt for the carbon-manganese oxide mixture, or a combined voltage of 1·56. While the cell delivers current to the external circuit this voltage decreases, the rapidity depending upon the amount of current drawn. If it were not for the manganese dioxide the drop in the voltage would be very rapid, and the value of the cell is therefore dependent largely upon the active manganese oxide or depolariser. This manganese oxide is consumed. As commonly stated, it is reduced to Mn_2O_3, and in undergoing this change it becomes inactive both as a depolariser and as a conductor. It is probable that the MnO_2 possesses sufficient metallic conductivity to contribute something to the conductivity of the cell, and when changed to the lower oxide it loses this conductivity. It thus becomes inert and occupies valuable space. It is natural to assume that the MnO_2 in the outer portions near the paper is the first to become reduced, the action progressing inward to a certain depth, this depending upon various factors, such as the intimacy of contact between the carbon and MnO_2, the purity, fineness and porosity of the latter, &c. If the MnO_2 possesses metallic conductivity and makes contact with conductive carbon and both are moistened with electrolyte, there is a possibility that a certain amount of chemical action occurs owing to the voltaic couple thus produced.

A study of what actually takes place, chemically and electrically, inside of the dry cell while in action, and while standing in storage, offers an excellent subject for analytical research. While the chemical reactions which take place in the dry cell or other cells of the Leclanché type are frequently explained in a simple manner in text-books, a careful study will show that simplicity does not exist.

It is very commonly believed that the increase in resistance is due to the drying out of the cell, but the drying is of very minor importance as compared with other factors. One of these is the increase in resistance due to the partial reduction of the MnO_2. Another is the accumulation, on the surface between the paper and the zinc, of non-soluble impurities of the zinc and the various basic salts and double salts resulting from the electrolytic corrosion. When a cell is first made up the paper is saturated with a solution of zinc and ammonium chlorides. More zinc chloride is added as a result of the corrosion of the zinc. The increasing concentration of the $ZnCl_2$ in the presence of the ammonium chloride gives just the conditions which are needed for the production of various double chlorides, some of which are much less soluble than the single chlorides. These insoluble double chlorides occupy the pores and spaces in the paper, crowding out the electrolyte and increasing the resistance. If ammonia is liberated, it may react with the $ZnCl_2$ to form a precipitate of ZnOH, which likewise clogs the cell, unless sufficient ammonia be present to re-dissolve this precipitate. That this clogging action occurs at the paper and proceeds inward toward the carbon rod is evident, since in taking apart a run-down cell there is usually found a hard crust of ⅛ in. or more in thickness just inside the paper.

It is no doubt true that improvement in dry cell construction must come through reducing this accumulation of insoluble non-conductive materials. It may be suggested that this precipitation due to double chlorides might be delayed by using only NH_4Cl in the electrolyte to

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begin with, and, in fact, a somewhat greater ampere-hour output can be obtained in this way. But it involves the more serious disadvantage of shortening the life of the cell on open circuit. The presence of $ZnCl_2$ in the electrolyte decreases in marked degree the local action.

There is no doubt that marked improvement has been made in dry cells during the past few years, and there is no reason to believe that perfection has yet been approached. The field for research in the study of this important device has by no means been fully occupied. From the technical point of view the need for, and possibility of, improvement are equally great. The common and grossly inadequate methods of rating dry cells in terms of the number of miles they will run the ignition device on automobiles, or the number of months they will stand up on telephone service, or the number of sparks that they will produce, all of which are dependent upon the kind of device and the nature of the same in connection with which they are used, should give way to rating by energy output. This can only be done after determining and generally adopting the standard methods for conducting tests.

DISCUSSION.

Mr. CARL HERING said that the Paper stated that the E.M.F. of the cell was the sum of the two electrode potentials, 0·56 volt for the zinc and about minus 1 volt for the carbon-manganese oxide mixture, giving the combined voltage as 1·56. It seemed to him that there must be something wrong in this. It credited the greater part of the energy to the reduction of the manganese oxide, whereas the energy came chiefly from the oxidation of the zinc. He would like to ask, therefore, how it was determined; If it was determined by measurement, was not the method faulty? It seemed that no one had yet been able to measure the absolute single potential of an electrode by a method which was really beyond question. Calculation would show that the zinc gave the greater part and the manganese oxide the lesser part of the energy. Generally, the energy contributed by the depolariser was very small. The Paper also said it would seem better to reduce the formation of the insoluble compounds—that is, that it would seem better to have them soluble. The question arose whether that was really desirable. There was only a very small amount of water in the battery, and that small amount had to do a great deal of work: it seemed to him that if the products were soluble rather than insoluble, the water would be used up more rapidly, by having to hold in suspension the products that were formed; it would, therefore, not be available any longer as water. If this were correct, it seemed to him that it was rather a desirable thing to arrange to have the chemical products formed insoluble, so that they would deposit out and leave the water there to keep the cell wet.

Mr. CHARLES L. PARSONS asked if in their experiments with dry cells the author had made any experiments in the use of bromates as depolarising and oxidising agents. In some work done during the last year bromates certainly showed wonderful oxidising power at low temperature. He would be interested to know whether these bromates had been worked with to any extent in dry cell construction.

Prof. BURGESS, in reply, said as to bromates, chlorates and many other oxidising compounds, the use of these in most instances would increase the voltage of the cell and increase the amount of current output, but in general his experience had been that the soluble oxidising agents were detrimental to the life of the cell—that is, they increased the local action.

CONTACT DIFFERENCE OF POTENTIAL IN A MAGNETIC FIELD.*

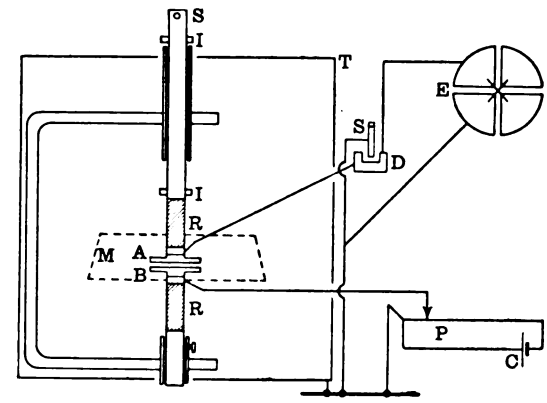
BY E. P. ADAMS.

Summary.—The author first discusses the theory of the contact difference of potential between pairs of metals, and then describes some experiments carried out two years ago which showed no change in the potential due to the introduction of a magnetic field. More recent experiments of M. Posejpal, however, show such a change: but these experiments are considered by the present author to be indecisive.

It seems well established that the contact difference of potential between metals in air is a chemical effect, the result of differential chemical action between the metals and condensed air films on their surfaces. There is, however, another way of looking at the subject. The fundamental thing to be explained is that the potential of an insulated metal differs from that of the surrounding air; and that this difference of potential varies from metal to metal. Let us assume that each unit area of the surface of the metals emits in unit time N electrically-charged particles, each of mass m and charge e. The metal is further supposed to be coated with a thin film of condensed air, or other substance, with the very high transverse electric resistance R per unit surface. The charged particles must be supposed to be emitted from the metal with an initial velocity sufficient to carry them through the film. A difference of potential V is thus set up between the two sides of the film. In the steady state the electric current due to the flow of charged particles from the metal through the film is balanced by the conduction current, the result of the difference of potential V and the conductivity 1/R of the film. Therefore, $Ne = V/R$, or $V = NeR$. Both N and R may be supposed to vary with the metal; thus each insulated metal will be at a definite potential above or below that of the surrounding air.

Suppose next that the metal in the form of a disc is placed in a magnetic field parallel to its plane. The charged particles will tend to describe circular paths whose radius of curvature is given by $mv^2/\rho = Hev$, v being the velocity of the particle and H the magnetic force. If this radius of curvature is small enough some of the particles will be prevented from getting through the film; the difference of potential between the two sides of the film will be diminished, and thus the contact difference of potential between a pair of metals, which is all that can be measured, will be changed. About two years ago the writer made some experiments to verify this, but the results were decisively negative (the sensitiveness of the method employed was such that a change of 0·001 volt in the contact difference of potential could have been observed). Very recently, however, M. V. Posejpal* has published the results of some experiments, a part of which bear upon this same problem. Contrary to the results of the writer, M. Posejpal, who used a different method, finds that the contact difference of potential between iron and zinc is changed in a magnetic field.

The compensation method devised by Lord Kelvin was employed by the writer. In the accompanying diagram A and B represent the two metal discs the contact difference of potential between which is to be measured. These are screwed on to the brass ends of the hard rubber insulators R, R, which are carried on brass rods, and these in turn freely slide through fixed brass tubes, as shown. The lower rod is fixed in position, its height being adjusted by means of a set screw. The limits of motion of the upper rod are controlled by the adjustable collars I, I.



The upper disc is permanently connected to one pair of quadrants of the electrometer E. By means of the mercury key D, this pair of quadrants may be connected to earth. When the rod S is raised, the earth connection is broken. The other pair of quadrants is connected to earth. The lower disc B is connected to the slider of the potentiometer P, so that it may be kept at any desired potential. Strings are attached to S, S by means of which the earth connection of the first pair of quadrants may be broken and the upper disc raised at the observing telescope. The determination of the contact difference of potential is made as follows: the electrometer quadrants being earthed, the two discs are brought close together, but not touching. Electrically they are of course in contact. The earth connection is then broken and the upper disc raised. A deflection of the electrometer needle, in general, results. The potential of the lower disc is then changed until on repetition of the above process no deflection of the electrometer results. The potential applied to the lower disc is then the contact difference of potential between the two discs.

Experiment showed that when the contact difference of potential between the discs was balanced by the potential applied to the lower, a change of 0·001 volt in the latter produced a distinct deflection. The pole-pieces of the electromagnet, one of which is shown in section at M, projected through holes cut into opposite sides of a zinc box T, which completely shielded the interior. As a further precaution against outside electrostatic disturbances the pole-pieces themselves were earthed. The electrometer connections were run through earthed brass tubes. The electrometer used was of the Dolezalek type, and had a sensitiveness of about 8,000 divisions per volt, and the needle was kept at a potential of about 80 volts by means of a battery of small storage cells.

The discs used were made of iron, zinc, and gold- and platinum-

* Abstract of an article in the "Physical Review."

* "Annales de Chimie et de Physique," August, 1909.

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plated brass. After the discs were cleaned and screwed into position the contact difference between them changed rapidly; but after the course of an hour or so it became so constant that no change could be detected during a period of 10 to 15 minutes. During this stage the contact difference was measured, then the magnetic field was applied and the contact difference again measured, and a final measurement was made after the magnetising current was broken. Many repetitions of this were made, using the combinations gold-zinc, platinum-zinc and gold-iron, but in no case was the slightest effect of the magnetic field observed. The magnetic force was measured by a calibrated bismuth spiral and was approximately 4,800 electromagnetic units.

The experiments of M. Posejpal differed in at least three important respects from those just described. In the first place, he used a direct deflection method, instead of a null method, which necessarily involved greater possibility of error. In the second place, the two discs were allowed to come into actual contact with each other before separation. It seems possible that the observed effects resulted from this actual contact. The contact difference of potential between metals is extremely sensitive to changes in their surfaces. If one of the discs is allowed to fall on the other considerable changes in the contact difference are almost certain to result. The writer has observed that if the initial distance between the two discs was made so small that on dropping the upper disc it touched the lower one, due to a lack of rigidity in the support, a distinct change in the contact difference was found on the next measurement. M. Posejpal found that the contact difference was by no means constant and sought to get correct values by taking the average of many results. Now when a magnetic field is applied this mechanical effect would be altered, particularly in M. Posejpal's experiments, since he used only the combination zinc-iron. The iron, unless very firmly held, would be certain to move in the magnetic field, and thus a secondary effect of the magnetic field on the contact difference of potential might be expected to result. Furthermore, when two unlike metals are separated from contact one would expect a production of frictional electricity, which, of course, would be added to the electricity set free by the true contact difference of potential. In the magnetic field, due to mechanical action on the iron, the amount of frictional electricity would be altered, and thus a change in the apparent contact difference of potential would result.

The third difference between the two methods lies in the position of the two discs with respect to the magnetic field. In M. Posejpal's experiment the lower disc remained in the region of strong magnetic force, while the upper disc was pulled into a region of comparatively weak magnetic force. In the writer's experiment, the pole faces of the magnet were of such a size that both discs remained in a fairly uniform field even after the upper disc was raised. Whether an explanation of the results obtained lies in this fact or not can be tested only by experiment. Unfortunately, M. Posejpal does not state the strength of the magnetic field he employed, nor the diameter of the discs. But the large effects he obtained, combined with the comparative insensitiveness of his method (his electrometer gave only 60 divisions for a volt), make it improbable that his positive results were due to using a magnetic field of much greater strength than that used by the writer.

ELECTRIC FURNACE PLANT OF THE UNITED STATES STEEL CORPORATION.*

When in February of last year the United States Steel Corp. adopted the Héroult electric furnace for steel refining, it was decided to erect, as a beginning, two furnaces, each of 15 tons capacity, one at the South Chicago works of the Illinois Steel Co. and the other at the Washburn & Moen plant of the American Steel & Wire Co., at Worcester, Mass. At South Chicago the electric furnace is used for refining molten metal from the Bessemer converter, at Worcester for refining molten metal from the basic open hearth. The object of the combination of the ordinary acid-lined Bessemer converter and the electric furnace (South Chicago) is to produce steel of open-hearth steel quality, or better, at less cost. The object of the combination of basic open-hearth and electric furnace (Worcester) is to produce steel better than the best acid open-hearth steel in quality, at a slightly advanced cost.

The undertaking of the United States Steel Corp. involved some interesting and important novel points. The largest Héroult furnaces installed before that time had a capacity of 5 tons. In the Héroult furnaces of the Steel Corp. this capacity was trebled. Further, the Héroult electric furnace had been used before on a commercial scale with cold charges, and with molten metal from the open-hearth furnaces; but in South Chicago it was adopted for the first time in America on a large scale in combination with the Bessemer converter. Finally, while in the past the Héroult process had been used essentially as a substitute for the crucible steel process for the manufacture of high-grade tool steels, &c., it entered into a much wider field of usefulness at South Chicago and Worcester, where it is used for large-tonnage products, like rails, axles, and wire.

The South Chicago plant has been in continuous operation since May of last year, while the Worcester plant was started in the beginning of this year. The South Chicago plant is perhaps the more interesting of the two, since it includes the more involved metallurgical process of both dephosphorisation and desulphurisation of the steel in the electric furnace, while the metal charged from the basic open-hearth into the electric furnace at Worcester is already largely dephosphorised.

The combination of the electric furnace with the Bessemer converter seems a matter of momentous commercial importance. For a number of years the cry of the consumer has been for better steel for many purposes, like rails, &c. As a result, there has been a decided tendency away from the converter and toward the open hearth. If the electric furnace in combination with the Bessemer converter can make as good or better steel at the same or less cost than the open hearth alone, it means that the electric furnace gives a new lease of life to the converter. From this viewpoint the results obtained with electric refining at South Chicago are of broad commercial significance and importance.

That the Héroult furnace at South Chicago is a commercial metallurgical apparatus and no longer in the experimental stage is proved by the regularity with which the heats follow each other. The furnace is in continuous operation during the whole week, and operation is discontinued only on Sunday. On the average 12 heats are made a day. Figures given for a particular day show that current was on for 18 hours and 5 minutes, so that the intervals between the successive heats amounted to 33 per cent. of the whole time. The average specific energy consumption on that day was 88·4 kw.-hours per 1,000 lb. net weight, or 194·5 kw.-hours per net metric ton. In this case the electric furnace treatment involved both desulphurisation and dephosphorisation. If the charge supplied to the electric furnace is already low in phosphorus, the specific energy consumption is, of course, less. Figures given in this connection show the average specific energy consumption to be 47·2 kw.-hours per 1,000 lb. net weight. Electrical energy is generated by means of gas engines, operated with blast furnace gas, and the two plants of the Steel Corp. at South Chicago, Ill., and Gary, Ind., are electrically connected in parallel. The power generation is highly economical. The charge for energy supply, made to the electric furnace plant, is 0·25d. per kw.-hour consumed.

The regularity of operation which makes the Héroult furnace at South Chicago a thoroughly commercial apparatus is due in no small degree to the simplicity and compactness of construction of the Héroult furnace and the total absence of any complications whatsoever, either electrical or otherwise, with the possible single exception of the electrodes at the top. The simplicity of the construction results in great convenience of repairs of the furnace proper. During the whole period of operation at South Chicago, since May, 1909, there has never been any necessity to stop the Héroult furnace for the sake of repairs. The lining is kept in good condition by throwing some shovels of broken burnt dolomite into the furnace upon the corroded portions of the hearth. This is done between successive heats, and requires not more than a few minutes. The consumption of dolomite for repairs is given as 10 lb. of dolomite per ton of steel. The silica roof has been generally repaired or replaced during the regular stop on Sundays. The last roof, however, lasted 129 heats. The cost of repairs is very low, about 3d. per ton.

As to the electrodes, their consumption is given as averaging 6 lb. per ton of steel, and this figure is stated to be true both for graphite and for amorphous carbon. This item, it is expected, can be very materially reduced in future. The original intention was to use amorphous carbon electrodes, but it was found very difficult to make very large homogeneous carbon electrodes. Graphite electrodes are now doing the service very satisfactorily, but are more costly. The electrodes as used at present are made up of Acheson graphite rods, 48 in. long and 8 in. in diameter. Three such rods are butt-connected to a total length of 144 in., and three such 144 in. rods are arranged side by side to form a single electrode. A water-cooled jacket is provided around each electrode, just above the openings in the roof.

Simply to try what can be done with the electric furnace, a very severe test was made some time ago. The worst kind of scrap (plate scrap, rusty nails, &c., in fact, the sweepings of the works)

*Abstract of an article in "Metallurgical and Chemical Engineering."

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was used. The specification was to produce steel; C., 0·35 to 0·45; S., 0·04; P., 0·04; Mn., 0·35 to 0·50. The steel produced analysed: C., 0·46; S., 0·037; P., 0·024; Mn., 0.34. There were charged in this test 9,000 lb. hot pig iron, 12,000 lb. rail ends, and 9,000 lb. stove-plate scrap, "the worst stuff to be found." The product was 31,800 lb. of steel. The energy consumption during this remarkable test was 14,450 kw.-hours.

As to the mechanical tests of the steel now being made by the Héroult-Bessemer electric process at South Chicago, the following data were given at the mechanical testing plant of the Illinois Steel Co.: Elastic limit, 35,000 lb. to 47,000 lb.; tensile strength, 60,000 lb. to 70,000 lb.; elongation, 25 per cent. to 30 per cent.; reduction of area, 43 per cent. to 60 per cent. As to the difference between this electric steel and acid open-hearth steel it was stated that the same tensile strength is obtained with the electric steel with lower carbon than with open-hearth steel. For example, an 0·10 C. electric steel averages the same tensile strength as an 0·15 C. to 0·17 C. acid open-hearth steel.

THE NATIONAL TELEPHONE CO. AND THE TRANSFER.

We have received the following lengthy communication from the pen of a gentleman who duly sends us his name, but who desires that his identity should not be disclosed. We have the strongest objection to anonymous communications when they attack an individual or a company, but as the communication is only one of a number, to withhold it on the ground of anonymity would serve no useful purpose, and we have, therefore, given it the necessary space in our columns.

Without any desire or intention to speak for the National Telephone Co., whose directors and officials are quite well able to speak for themselves, we consider that many of the statements by "Telephonist" are either beside the point or demonstrably unfair. The speech delivered by Mr. Franklin at the half-yearly meeting of the National Company we consider to have been a perfectly accurate statement of the company's case, as it affects the shareholders' position, and we cannot understand why the position of the company, financial or otherwise, should be better known to employés and ex-employés than to the directors and leading officials, who have been associated with the company for very many years, and are much more likely to know where the shoe pinches than either a present or past employé. It is perfectly true that the company's stocks and shares are at a considerable premium, and it is also true that friction has arisen over what has been termed the telephone monopoly, but taking the service as a whole, and judging public companies as such bodies must be judged by the public, we deny that the National Company merits any serious attack. The company has worked, as all companies work, for the ultimate benefit of the shareholders, and not being based on philanthropic lines no other course would meet the circumstances. That the company's reserve fund has reached a large total is not a point against the management, but is one, surely, to its credit. Knowing for many years that the period of its existence was limited, the directors have put by a sum for possible and actual depreciation which now amounts to, say, 20 per cent. of its total paid-up capital. This is not, in our opinion, one shilling too much.

With regard to the "water" in the company's capital account, we speak with an outside knowledge of the company's affairs from the very start of the telephone industry, and we venture to say that the amount of water in the capital, under all the circumstances, is small. The company has had many critics, but we do not remember any particular point having been made at any time regarding this alleged "water."

With the question as to how far the company has, since the more imminent expiry of its licence has drawn near, neglected its duty to the public in regard to spending money on capital account, we are not impressed with "Telephonist's" statement. The Post Office authorities have not, as far as we are aware, complained, and complaint lies almost entirely with the Post Office authorities.

We have, as we have said, given space to this letter for the reason that the points are temperately put, and form, as far as they go, a criticism on matters of public interest. The seventh, eighth, ninth and tenth paragraphs deal with matters which are partly *sub-judice* and cannot possibly be discussed at the present stage, as nothing is settled concerning most of them. We sincerely hope that "Telephonist" is in error in his assumption concerning the effect of the present policy of the company and the consequences of the transfer upon the staff. We fear that in so large a transaction as this transfer there has been already and there will be some hardship to individuals, however wisely conceived the arrangements for the staff may be, but that the National Company and the Post Office between them will act fairly by their officials, staff and employés generally is our sincere belief.

The letter referred to is as follows:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to a statement recently appearing in the Press as a result of a speech by the President of the National Telephone Co. at the half-yearly meeting of that company as to the alleged injustice and hardship which is being caused the shareholders of the National Telephone Co. (Ltd.), by the action of the Government in terminating the licence of the company and transferring the whole of the telephone monopoly to the direction of the Post Office Department.

As an ex-employé of the N.T.C., I desire to encroach upon your valuable space to deal with the facts as they really are and as are probably only known by the employés and ex-employés of the company.

As to the alleged hardship, the present prices of the company's stocks and shares as quoted by this morning's papers, each class of which shows a considerable premium upon the par value, from a financial standpoint is a sufficient answer to any alleged injustice which it has been suggested will be done, and on turning to the recently published report of the company it is seen that a 6 per cent. dividend has been paid on all classes of shares, and further that the reserve fund of the company has reached the enormous sum of £3,705,127, which, when it is considered that the total captial of the company is but £16,000,000, suggests that the possibility of any loss in connection with the sale of the plant has been adequately provided for.

Those who know something of the manner of the formation of the National Telephone Co. as a telephone monopoly and the way in which the various local companies were bought out and the huge sums paid them for "good will" and of the other directions in which the capital of the company has been watered, will be in a position to appreciate the fact that the company's shareholders, instead of fearing a grave loss as a result of the transfer are, on the other hand, in expectation of a considerable appreciation of the value of their holdings which would not have accrued had the company's licence been extended for an indefinite period necessitating the raising of further large amounts of capital to provide for the expansion and replacements of the plant which would have immediately resulted.

As a matter of fact, the shareholders are deserving of but little sympathy in connection with this transfer, as the manner in which they have treated the public and, more especially, the way in which they have made their own staff, to whose exertions and loyalty they owe the present prosperous condition of the company, feel the whole consequence of the altered financial considerations which are necessitated by the near approach of the termination of their licence, renders them rather the subjects for criticism than for sympathy.

It should be understood that as the period for which the company had a licence to conduct the telephone service ends at Dec. 31, 1911, the ordinary preparations which are made by a telephone undertaking for the development of their system to meet the demands of the public for connections must be considerably modified, and whereas in the ordinary course of business the company would be carrying on their constructional works and be providing for the replacement of the more antiquated of their exchanges by the modern central battery system, they are now closing down all these constructional works and dismissing and placing upon "short time" those of their staff who would have been employed upon these very necessary works.

Proposals have been made by the Postmaster-General which, if accepted by the company, would have allowed of the uninterrupted carrying on of such works and have allocated to the company and to the Post Office due proportions of the cost according to the benefit derived by the parties from the new plant erected and the plant replaced, but the shareholders, acting through their board of directors in pursuit of the "cent. per cent.," have refused these offers, and have thereby caused extreme hardship to their staff, many of whom are threatened with years of unemployment after having served the company faithfully for periods of 5, 10 and 20 years, and are also disregarding the public interest, which demands that the telephone system should be intelligently expanded to meet the demands upon it as occasion arises.

In 1912 and 1913 it will be found, unless some immediate action is taken, that the spare plant at the disposal of the Post Office department for new telephone lines will be altogether insufficient to meet the requirements of the trading community if the telephone system continues to expand at the same ratio as during the past five years. In this connection it must be remembered that the time taken to enlarge a telephone exchange or reconstruct underground or aerial line routes varies from 12 months to two years, according to the size and character of the job.

The position of the staff is particularly hard when it is remembered that the telephone industry is a virtual monopoly, and that, therefore, those men who have spent their lives' service in the telephone undertaking who are thrown into the ranks of the unemployed by the policy of the shareholders of the National Telephone Company are rendered, as far as the United Kingdom is concerned, unskilled workers, and thereby help to swell the already over-crowded ranks of the unemployed of this character. A further serious consequence to the country and to the public will result in the fact that when the Postmaster-General is in a position to do the necessary constructional work himself, after 1911, the skilled staff which will be required to take in hand the construction work will have been dispersed, and it will be found impossible to gather together a sufficient number of practical men to satisfactorily cope with the arrears of work due to the present policy of the company.

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It may be said that the telephone men discharged by the company will be employed by the Post Office, but it is obvious that until such time as the Post Office take into their own hands the telephone system of the country they will not have that work at their disposal upon which the men can be employed. It may be possible after a period of some 18 months for these men to be employed by the department, but at the cost of starvation and broken service during the intervening period.

I think when these things become known to the general public it will appreciate the fact that any sympathy which may be felt in this matter should rather be with the staff than with the shareholders of the company, who are at the present moment causing untold hardship to their hitherto loyal servants, and, what is of course more important to the public, seriously crippling the future efficiency of the British telephone system, upon which the prosperity of the business community, and therefore the country, has become so dependent.—Yours, &c.,

London, Aug. 9. TELEPHONIST.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An electrical fitter is required for the Gold Coast Government Waterworks. Age between 25 and 40, preferably unmarried. Salary £300 a year, rising to £350 by annual increments of £10, with free single quarters and second-class passage out and home. Applications to Messrs. Middleton, Hunter & Duff, 17, Victoria-street, London, S.W., up to August 18. See also an advertisement.

An electrical engineer is required by the British Westinghouse Electric & Mfg. Co. (Ltd.), Trafford-park, Manchester, for calculating and laying out winding engines and rolling mills. See advertisement.

The Council of the University of Birmingham invite applications for the appointment of assistant lecturer and demonstrator in electrical engineering. Candidates must be graduates, and must have had experience in the test room of first-class electrical engineering firm. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by Sept. 17.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

Mr. P. M. Hampshire, A.R.C.S., A.I.E.E., chief assistant in the physics and engineering department at Blackburn Municipal Technical School, has been appointed lecturer and practical instructor of engineering subjects at the Municipal Institute, Walsall, at a salary of £160 per annum, rising by annual increments of £10 to £200.

Mr. Hampshire, who is a native of Leeds, won a Science and Art National College scholarship, valued at £100 per annum and tenable for three years. From college he went to Messrs. Crompton's, at Chelmsford, where he obtained further practical engineering experience, and from there he passed to Faraday House, where he worked in the test room. Then he went to Finsbury Technical College, and for three years was lecturer in electrical engineering subjects. In Sept., 1906, he received his present appointment at Blackburn, where he has had charge of the theoretical and practical classes in mechanical and electrical engineering.

Mr. J. F. Chapman, of Swinton, has been appointed assistant in the mechanical and electrical engineering department of the Halifax Municipal Technical School, and Mr. N. Wolstenholme, of Morecambe, has been appointed lecturer in mathematics.

Mr. A. H. Lawrence, B.Sc., A.M.I.E.E., late of the Sunderland Technical Institute, has been appointed science master at Huish Grammar School, Taunton.

Mr. B. Wood, of the A.E.G., Berlin, has taken up the position of first assistant engineer to Messrs. Staerker & Fischer, the agents of the A.E.G. in Melbourne, Australia.

Mr. C. F. Butler has been appointed resident electrical engineer to the Uitenhage (Cape Colony) Electric Lighting & Power Co.

EDUCATIONAL NOTICES.

University of London, University College.—The 1910-11 session begins on Monday, Oct. 3. Complete courses of study, extending over three years, are arranged in mechanical, electrical, civil and municipal engineering. Students desirous of entering the faculty of engineering with the view of taking a full degree or diploma course must have passed the matriculation examination or some other examination accepted in its stead. Students who have already attained a sufficient standard may enter for a course occupying less than three years, and may obtain a general certificate of engineering after not less than two consecutive sessions. Graduates in science or engineering, or students who have done the work equivalent to a degree, may be admitted to special courses of study or to prosecute original research. Intending students should communicate with the Provost as soon as possible, and in any case not later than Sept. 20. Full particulars from the secretary, Mr. Walter W. Seton, M.A., Gower-street, London, W.C.

King's College (University of London).—In the Faculty of Engineering complete courses of study, extending over three or four years, are arranged in civil, mechanical and electrical engineering for the engineering degrees of the University of London and for the diploma and certificate of the College. There will also be special courses of advanced lectures on "Internal Combustion Engines" and "The Theory and Practice of Construction." The entrance day for new students is Tuesday, Oct. 4.

University of Birmingham.—The session 1910-11 commences on Monday, Oct. 3. The full courses in the engineering department extend over four years, and students who enter after matriculation and who pass successfully the examinations at the end of each year will be entitled to the degree of Bachelor of Science in the branch of engineering to which they devote themselves. The technical engineering classes include lectures on the strength of materials, theory of steam, gas and other heat engines, hydraulics, machine design, strength of structures and distribution of power, design of tools, prime motors, dynamos, &c. The courses in civil engineering cover a wide range. Lectures and demonstrations are given on all branches of electrical engineering and the electrical laboratory work comprises the testing of c.c. and a.c. machinery, instruments, meters, lamps and batteries and insulation and magnetic testing. The courses also include mathematics, physics, chemistry, geology and metallurgy. Syllabus, &c., from the Secretary.

University of Manchester.—The session commences on Oct. 4. Complete theoretical and practical training is given in this university to students preparing for the higher positions in the electrical engineering profession. The subject may be taken as part of the courses preparing for the B.Sc. degree in both the honours schools of engineering and physics. The John Hopkinson laboratories and dynamo house are well equipped, and offer good facilities for educational and research work. Prospectuses from the Registrar.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

Glasgow and West of Scotland Technical College.—The day classes begin on Tuesday, Sept. 27, and the evening classes on Thursday, Sept. 22. The diploma of the College is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, building and textile manufactures. The courses of study for the diploma usually extend over three sessions, and holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. Preliminary examinations begin on Sept. 19. There are new and well-equipped laboratories in the departments of physics, chemistry, mechanics, motive power and electrical engineering, &c., and facilities are afforded for research. Copies of calendar (price 1s. 4d.) and prospectus (gratis) can be obtained from the Secretary.

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Northampton Polytechnic Institute (London).—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Monday, Oct. 3.

The courses in mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include specialisation in radio-telegraphy. The entrance examination takes place on Sept. 28 and 29. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in engineering at the University of London. There are full and part time courses in all branches of technical optics. Particulars as to fees, &c., can be obtained at the Institute, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Borough Polytechnic Institute.—We have received a copy of "The Borough Polytechnic Institute; its Origin and Development," by Mr. Edric Bayley, M.A., with an introduction by Mr. Sidney Webb. The work is really a record of the history of the rise and development of one of the most useful of London's educational institutions. There is no one more fitted to deal with the interesting history of the Polytechnic than Mr. Bayley, who has been from its start an able and generous supporter of every movement tending to increase the institution's usefulness. The present work, which is a complete record of the leading events in the career of the Polytechnic, is well printed and illustrated, and is published in royal 4to, cloth gilt, by Mr. Elliot Stock at 6s. net.

Sunderland Technical College.—We have received a copy of the prospectus of the day classes at this College for the 1910-11 Session, and also copies of pamphlets giving details of the evening courses.

The head of the electrical engineering department is Mr. W. T. Maccall, M.Sc., A.M.I.E.E., and Mr. G. F. Bellwood is lecturer in telegraphy and telephony. There are also complete courses of instruction in civil, mechanical and marine engineering, mathematics and physics, chemistry, mining, building, naval architecture, commercial subjects, &c. Particulars of the scholarships for apprentice-students in engineering and naval architecture, tenable at the college, are given in a separate pamphlet.

BRITISH NOTES.

Brentwood.—The Lighting committee has been asked to report upon a request for the assent of the Council to an application for a provisional electric lighting order.

Cavan.—The District Council are desirous of being vested with the powers of an urban authority so as to adopt electric lighting for the town of Killeshandra.

Dublin.—On Monday the City Council were informed by the Lighting committee that the electricity department was making satisfactory progress. Between March 31 and June 30 about 170 new consumers were connected, the number for the corresponding three months of 1909 being 92.

The committee state that they are continuing their policy of endeavouring to postpone any extension work not urgently required although sanctioned by the L.G. Board. A portion of the South Circular-road extension (estimated to cost £5,500) will be carried out at once, and as soon as the South Dublin Guardians wire their premises, cables will be extended to the area around the Union premises at a cost of £2,350.

Eastbourne.—From Oct. 1 the following reductions of charges for electric current will take place:—

Where consumption exceeds 10,000 but does not exceed 30,000 units, ½d. per unit; exceeding 30,000 but not exceeding 50,000, ¼d.; exceeding 50,000, ¼d.; flat rate consumers, 5½d. to 5d.; double tariff consumers, night rate charge, 5½d. to 5d.; supply for heating and cooking, 1d. per unit. Where two or more meters are hired by the same consumer in respect of the same premises, the charge for hire of each meter is to be reduced from 10s. to 6s. per annum.

Electric Pumping Plant.—At the meeting last week of J. Grayson, Lowood & Co. (Ltd.) the chairman (Mr. C. B. Stuart Wortley, K.C., M.P.) said the result of the year's working was unfavourable, owing to a continuance of the difficulties with water in the gannister mine at Deepcar. The directors had come to the conclusion that the existing steam arrangements were inadequate, and had decided to instal an electric pumping plant.

Engineering and Machinery Exhibition.—We are informed that the Marquis of Graham, G.V.O., will formally open the Naval, Mercantile Marine, and General Engineering and Machinery Exhibition at Olympia (London, W.) on Sept. 1.

Many of the latest inventions in connection with all branches of engineering practice will be on view for the first time, and machine tool makers are particularly well represented. The exhibitors include several of the leading firms of manufacturers and engineers in London and the provinces, and the exhibits comprise metallurgical processes and raw materials, castings, machine tools, shop tools and appliances, lifts and lifting appliances, mechanical stokers and conveyors, engineers' stores, lighting, sanitary and ventilating apparatus, dockyard plant, and gas, steam and oil engines, &c. Special meetings of several engineering and scientific societies will be held at Olympia during the period of the exhibition. Preparations for the exhibition are well advanced, and the management are aiming at having the show absolutely complete on the opening day. The exhibition will run from Sept. 1 to Sept. 26 inclusive.

Finchley.—The salary of the electrical engineer (Mr. E. Calvert) has been increased to £525 per annum.

A small show room, for the display of electric motors, fittings, &c., is to be opened at the electricity works.

Hereford.—The L.G. Board have sanctioned the borrowing by the Council of £2,000 for mains and £1,500 for services, the period of repayment being 25 years and 15 years respectively.

The Board of Trade have made an order under sec. 6 of the Electric Lighting Act, 1909, to permit the Corporation to supply electricity to residences outside the present area of supply.

Hornsey.—A dispute has arisen between the Council and the North Metropolitan Electric Power Supply Co. in regard to the supply by the company of electricity to a cinematograph theatre in Hornsey but near the Municipal boundary.

The Council suggested that as a matter of general principle as regards supply of electricity to border cases the profit made (as agreed between the Borough Electrical Engineer and the Engineer-in-Chief of the company) should be apportioned between the Hornsey and Tottenham areas according to the rateable values in the respective districts of each of the premises supplied, the non-supplying authority receiving a moiety of the profit earned within its own area. The company, however, do not agree with this suggestion, and the Council are taking counsel's opinion on the position.

Light Railway.—The Board of Trade have confirmed the Llanelly and District Light Railways (Revival and Extension of Time) Order, 1910, and the Bacup Corporation Light Railway Order, 1910.

Lydney (Glos.)—The Rural Council have authorised Chepstow Electric Light & Power Co. to supply certain houses at Tutshill with electric current by overhead cables, provided the rights of the Gloucestershire Electric Power Co. are not interfered with, and that, if required, the cables are removed on six months' notice.

Municipal Wiring.—A deputation from the local contractors recently waited upon Dundel Town Council with regard to the proposal of the electricity department to support the Municipal Electrical Association in the steps they were taking to secure powers for local authorities to supply electrical fittings and wires on consumers' premises.

The city electrical engineer (Mr. H. Richardson) pointed out that it was an illogical position to allow the gas department to supply fittings, &c., while they denied the same privilege to the electricity department.

Mr. LOWDEN, for the deputation, contended that if the Council obtained powers to hire out motors, &c., and to do wiring and other work it would diminish private contractors' business. These traders were ratepayers, and were entitled to the protection of the Council. They denied absolutely the statement put out from the electricity department that only 10 per cent. of the increase in business was due to contractors' canvassing, while 90 per cent. was due to the department's canvassers. The combined capital of the local contractors was £50,000, and they employed 218 men. Gas and electricity were not on the same footing. So far as heating and cooking were concerned, electricity was a luxury, and therefore there was not the same excuse for the Corporation to go in for trading.

Mr. RICHARDSON said that the various corporations who had not obtained these powers would very soon be severely handicapped if they did not do so. He denied that electricity was a luxury; it was a necessity. It had never been a luxury to the same extent as gas had been in its early days. As to the percentage of new business brought in by private and corporation canvassers, the real figures were 92 per cent. brought in by corporation canvassers, and only 8 per cent. by contractors' canvassers. If the corporation ordered him to drop the present policy of the department, then, of course, he could not be expected to have any responsibility for its success.

An amendment to refer the matter to the committee for further consideration was carried.

Wimbledon Council have agreed to make a contribution (not to exceed £25) towards the expenses of the movement for obtaining Parliamentary powers to authorise all municipal electricity undertakers to provide, let for hire, and fix, repair and remove (but not manufacture) electric fittings, motors and other apparatus for lighting and power.

Barnes Council have referred back a recommendation to contribute a sum (not to exceed £50) towards the expenses of promoting the bill suggested by the Municipal Electrical Association.

Nelson.—The Council have agreed to supply electricity in bulk to Brierfield Council until March 31, 1914, and application is to be made to the Board of Trade for an order authorising the supply.

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New Acts of Parliament.—Royal Assent has been given to the following New Acts of Parliament :—

Mines (Rescue and Aid), Electric Lighting Orders Confirmation (Nos. 1, 2 and 4), Tramways Orders Confirmation, Metropolitan District Railway, London United Tramways, Bradford Corporation, Middlesbrough Corporation, Rhondda District Council (Tramways Extensions, &c.)

Newcastle-on-Tyne.—The Tramways committee recommend the Corporation to obtain Parliamentary powers to construct additional tramways, including extensions of the present system from Scotswood Bridge to Blaydon, Lemington and Newburn, extensions at Heaton, and in all probability to the sea coast via Benton. Powers will be taken for opening up these districts by trackless trolley cars and then, if desirable, by the ordinary system.

Newspapers and the Law of Libel.—We can wish nothing but success to the efforts of Mr. Walter Judd (Messrs. Heywood & Co. (Ltd.) in his efforts to secure an amendment of the law of libel. As things stand at present (as we very well know) any impecunious plaintiff, even with an imaginary grievance and with the aid of a solicitor ready to undertake speculative work, can cause heavy loss of time and money to the proprietors of newspapers and particularly of trade journals. Mr. Judd will have rendered good service to the Press if he can secure the amendment of the law he seeks. We fear, however, that he has an uphill task. Our experience is that juries are more disposed than judges to sympathise with the newspaper press and its trials.

Presentations.—On July 26 Mr. F. J. Walker, general manager and secretary of the St. James's & Pall Mall Electric Light Co., was entertained at dinner (at the White City, London), and presented by Mr. Frank Bailey (on behalf of the members of the Association of Chief Officials of London Electric Supply Companies) with a personally signed memento engrossed on vellum, in recognition of the active part taken by Mr. Walker in securing combined action by the London electricity supply undertakers in protecting their interests, and opposing projected competitive electric power schemes.

The members present included Mr. E. Cunliffe Owen, C.M.G., Mr. H. B. Renwick, Mr. E. Wilmot Seale, Sir Alexander Kennedy, and others.

Mr. T. G. Gregory, who has relinquished his position with the Mansfield Tramway Co., has been presented by the staff with a smoker's cabinet.

Provisional Order Revocation.—The Board of Trade have revoked the Gainsborough Electric Lighting Order, 1904, as from July 22.

Sheffield.—The Electric Light committee recommend the Corporation to adopt a revised scale of discounts for consumers of the electricity department.

To any consumer who uses electricity for lighting as much as possible throughout the year during daylight or long hours, mostly when the output is not at its maximum, and provided that the consumption (based on the estimated maximum demand) does not fall below 100 units per annum per 60-watt lamp or equivalent, a discount of 50 per cent. from the tariff of 4d. per unit.

Accounts will be rendered weekly, monthly or quarterly, at the option of the committee, and the discounts will be adjusted according to the average daily rate of consumption as shown between successive readings. No discount will be allowed unless the account is paid before the next account is due.

The committee reserve the power, in special cases where they deem it an advantage so to do, to make such terms as they think fit, provided, of course, that in any such case similar terms shall be allowed to other customers in similar circumstances.

Wimbledon.—The L.G. Board has sanctioned the borrowing by the Council of £3,400 for mains, £1,600 for house services and £1,600 for meters.

The Council offer to supply Mr. J. B. Mulholland (owner of theatre, lock-up shops, &c., now being erected at the junction of Merton-road) with energy for incandescent lighting and for arc lamps, limelights and similar apparatus at 2½d. per unit, provided a minimum consumption of 30,000 units per annum is guaranteed. Energy will also be supplied to a skating rink between 4 and 9:30 p.m. at the ordinary lighting rates and at other times at 1d. per unit.

Wireless Telegraph Notes.—We learn that the trials of the recently established wireless telergaph station at Cadiz have given satisfactory results, telegrams having been exchanged between Teneriffe (Canary Islands) and the Eiffel Tower, Paris. The electrical staff are satisfied, and the new station is shortly to be opened for the public service.

The Irish mail boats belonging to the City of Dublin Steam Packet Co. have now been equipped with wireless apparatus on the Marconi system, the first boat to leave Holyhead being the "Connaught."

The "Daily Mail" on Tuesday contained reference to some experiments with the Lepel system of wireless telegraphy of a novel character.

It is announced that the North German Lloyd has given an order for 15 of their vessels on their Eastern Asian and Australasian routes to be equipped with Telefunken wireless apparatus. Several other of the leading German lines are to be similarly equipped.

The Glasgow Chamber of Commerce will unanimously oppose the Wireless Telegraphy Bill now before Parliament on the ground that for vessels carrying 50 persons, inclusive of the crew, to be compelled to carry wireless telegraph equipments will impose a great hardship upon owners of purely cargo boats.

Wireless telegraphy is being used on a large scale in connection with the operations in different parts of the country in which the Territorial units are engaged.

The "Contractors' Record" statesthat the Chilian Government is about to instal a wireless telegraph station in the penal island of Fernandez Juan (Alexander Selkirk's island) to facilitate navigation and communication with the Continent.

COLONIAL AND FOREIGN NOTES.

Australasia.—At a recent conference of municipal representatives at *Melbourne* resolutions were carried in favour of the local tramway systems being carried on and developed as one metropolitan municipal system, and at an early date the conference is to consider the terms under which municipalities adjacent to Melbourne are to be included in the system.

The Melbourne Tramway & Omnibus Co.'s lease expires in 1916.

The "Australian Mining Standard" says at a recent public meeting at *St. Arnaud* (Victoria) a committee was formed to collect particulars concerning electricity supply and the cost of public electric lighting. Messrs. W. McLean & Co., of Melbourne, estimate that generating plant would cost about £2,000.

A recent directors' report of the *Charlton* (Victoria) Electric Light & Power Co. states that a consulting engineer is about to be appointed and a site for the power house is to be purchased.

The wages board, which has been dealing in *Sydney* with the conditions of labour of electrical workers employed by the Railways and Tramways Department and the City Council, has fixed the wages of electrical mechanics in the Railways and Tramways Department at 9s. 6d. per day, electrical fitters 11s., leading hands 12s.; electrical fitters employed by the City Council at 11s. 4d., mechanics 12s., and cable jointers—11s. 4d., with leading hands 1s. extra, and other employés 7s. 6d. to 8s. 6d. per day.

Camberwell (Victoria) Council recently decided to withhold their consent to a proposed application by Melbourne Electric Supply Co. for an order-in-council to authorise them to supply current for light and power in the whole of the municipal district.

The award of the Arbitration Court at *Perth* (W. Australia), with respect to the dispute on the city tramways, fixes the hours at 96 per fortnight for conductors and motormen, the minimum pay being 1s. per hour, and time and a quarter for overtime. Each employé is also to receive an annual holiday of seven consecutive days (including Sunday) on full pay, and an additional week without pay, if desired.

Footscray (Victoria) Gas Co. has asked the City Council to pay £2. 2s. per lamp per annum for street lighting. The average cost for the last three years has been £1. 9s. 9d., and for the last two years £1. 13s. 3d. The city surveyor regards the demand as monstrous, and Councillor Caldecott expressed the hope that it would induce the people to go in for electric lighting.

Shire Council are making inquiries as to the cost, &c., of an electric lighting scheme for *Swan Hill* (Victoria).

The *Yarrawonga* (Victoria) Shire Council are also discussing the relative merits of electric and gas lighting.

In a report to *Emu Bay* (Tasmania) Council on a proposal to adopt electric lighting in Burnie, Mr. G. H. Lofts discusses five hydro-electric schemes, but does not recommend either, on the ground of excessive cost. He recommends a local plant, and puts forward four propositions: (*a*) steam plant, capital cost £5,867, calculated to produce an annual credit balance of £275; (*b*) gas plant, cost £6,262, balance £186; (*c*) oil plant, £6,712, balance £270, and (*d*) steam locomobile set £6,312, balance £314.

At a conference of the Municipal Councils of *Coburg* and *Brunswick* (two suburbs of Melbourne) on June 25 it was resolved to convene a conference of the authorities of Brunswick, Coburg, Northcote, Preston and Broadmeadows to discuss the question of electricity supply and tramways for their districts.

Chili.—The 1909 report of Consul E. F. Hudson states that imports to the Iquique district included steel rails to the value of £1,265 (compared with £8,885 in 1908) from the U.K., £11,283 (£7,853) from Germany and £12,549 (£9,040) from Belgium; electric light machinery £45 (£217) from the U.K., nil (£1,350) from Germany and £1,125 (£7,621) from U.S.A. Other machinery £8,587 (£58,604) from the U.K., £22,997 (£30,109) from Germany, £7,847 (£5,601) from Belgium and £2,334 (£11,016) from the U.S.A.

China.—A Chinese company has been formed with a capital of $300,000 (£25,000) for lighting *Chungking* electrically. Machinery and equipment have been obtained from Europe, and a foreign engineer has been engaged in erecting it. It is expected that work will

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be completed before the end of the present month. The plant will be capable of lighting 16,000 16 c.p. metallic filament lamps. A movement is on foot to instal electric lighting plant in *Chengtu*, and a company was promoted for the purpose during 1909. Plant was purchased in Europe, and supply to about 100 lamps began in February last.

Customs Decisions.—It has been decided that radium bromide and X-ray apparatus consisting of screens for cell applicators and rubber caps for applicators (either from the British Dominions or foreign countries) can be imported duty free into New Zealand.

Germany.—A report by Vice-Consul Graham (*Emden*) states that the harbour extension works which are supplied with electrical energy by a line from Wiesmoor (near Aurich) were by the beginning of 1910 connected with the same generating station by a new (reserve) cable. The use of peat in the generation of electricity in the Government works at Wiesmoor appears to have been very successful. Current is transmitted to Emden by overhead conductors. Emden has grown in importance as a landing station for the German submarine telegraph cables, &c.

The report of Consul R. Bernal on the *Stettin* district states that electricity stations have, during the last few years, been erected in Pomerania for supplying electric current to neighbouring towns, villages, estates and farms. The largest station is at Beswitz and the distributing network is over 116 miles in length; the second in size is situated at Lottin with over 83·2 miles of distributors and feeders. Two smaller stations are at Crüssow with 4·1 miles of cables, and Schmolsin with 6·8 miles. Additional stations are projected or in course of erection at Schajow, Belgard and at Anklam. These electricity works are principally controlled by associations formed by landed proprietors, and sums have been voted by the Provincial Representative Chamber to assist them. Great value has been attached to supplying small farmers and artisans living in the country with electric light and power at a cheap rate. Practical applications of electricity has lately made such progress that in the next few years the cultivation and treatment of agricultural produce will be undertaken by this means. It is already possible to plough and thresh, saw timber, clean grain, and cut turnips and beetroot by electrically-driven machines, and electricity is also extensively used in dairy farms, distilleries, factories, carpenters' shops, smithies, limestone factories, &c.

Greece.—A report by Consul MacDonell states that the electric tramway company at *Athens* have continued the electrification of their lines, only one (an alternative line between Phalerum and Piræus) being still worked by horse traction. The entire system was expected to be working this month.

Japan.—In a recent issue of the "Japan Chronicle" (Kobe) it is stated that considerable progress has been made in the arrangements for the formation of the Kinugawa Hydro-Electric Power Co. The concern was to have had a capital of 13,500,000 yen under the joint interest of British and Japanese capitalists. As, however, the British capitalists could not secure suitable terms for the concession, the Japanese promoters have decided to float the company without the help of foreign capital.

Korea.—We have received from Mr. E. Ogita, Secretary of the Imperial Japanese Residency-General in Korea, a copy of "Recent Progress in Korea," which contains a most interesting and well-written history of recent events in Korea, and particularly of the progress made by the Japanese in improving the administration and reforming the financial and industrial resources of the "Hermit Kingdom." Some useful information concerning the public undertakings, means of communication, education, &c., is also given. The work has been compiled by H.I.J.M.'s Residency-General.

Spain.—Application has been made by the Soc. Anón. los Tranvias de Barcelona for a concession for the construction and working of electric tramways in Barcelona. One line of metre gauge and another of 1·43 metre gauge.

Sweden.—Vice-Consul Amnen states that a new transformer substation of about 2,000 H.P. has been erected in *Hudiksvaal* for supplying power transmitted from the Arbra Elektricitetsverk (about 33 miles distant) to several factories in the town and neighbourhood and also for lighting.

At Forssan (about 9 miles from Hudiksvall), a new wood-pulp mill and a cardboard factory are both now run by electric power from Arbra.

To facilitate discharging (and transport) of coal and chemicals from Stocka to the sulphite mill at Ström (about 15 miles from Hudiksvall) an electric derrick crane has been erected at Stocka and an electric railway built between these places.

Vice-Consul Carrick (at *Gefle*) says the Stora Kopparbergs Bergslags Aktiebolag of Harnäs is completing a large power station at the Buller Waterfall, near their ironworks at Domnarfvet. The company expects to obtain about 24,000 H.P. to be used partly for the driving of the large paper mill at Qvarnsveden and partly for the generation of electricity for smelting steel at Domnarfvet. The electric smelting furnace is said to be technically and commercially successful.

Sydney (N.S.W.)—The report of the city electrical engineer (Mr. H. R. Forbes Mackay) on the City Council's electricity supply undertaking for 1909, states that capital expenditure was £534,280 (compared with £435,105 at Jan. 1, 1909).

Revenue was £118,275, working expenses £52,976 (plus £14,362 payments to purchased companies). Depreciation at 3 per cent. and sinking fund 1 per cent. required £19,273, leaving £46,026 profit, before deducting amounts paid to purchased companies. The maximum load was 6,040 kw. (compared with 4,300 kw. in 1908), and the load factor 31·11 (14). There were 2,945 (2,219) customers, and motors connected were 10,978 H.P. (8,290 H.P.) Units sold were 11,914,720 (8,673,942). Average revenue per unit sold was 1·132d. (1·38d.).

Turkey.—A report on the trade of Constantinople and district for 1909 states that an electric tramway system is occupying the attention of the local authority at Adana.

The town of Tarsus, though formerly larger than either Adana or Mersina, has lost ground somewhat. Quite recently, however, electricity generating plant driven by water turbines has been established, and the streets are now lighted electrically. Electric power will shortly be used in the spinning factory at Tarsus, and there is a private scheme under consideration for transmitting electric power from Tarsus to Mersina.

At Beirut the gas company has obtained an electric lighting concession and imported machinery from Europe. It was expected the works would be in operation by about now.

United States.—A report by Consul-General Nugent states that the value of *Chicago* manufactures in 1909 was £367,282,280 (compared with £319,723,472 in 1908), including electric supplies £8,796,200 (campared with £7,828,000), machinery £7,004,000 (£5,871,000), boilers £1,161,840 (£968,200), cars, bridges, lifts, &c., £8,219,400 (£7,148,200).

During 1909 the Illinois Steel Co. installed the first Héroult electric furnace of large capacity at S. Chicago, Ill., that has been built in the United States. The furnace has been producing electrically refined steel at the rate of about 3,000 tons per month, and experimental lots of rails made under the process have been supplied to some of the Western railroads. The cost of electrically refined steel is stated to be higher than that of steel made by the ordinary processes.

Vice-Consul Meredith (*Detroit*) says the tunnel under the Detroit river between the U.S.A. and Canada is practically completed, and the third rail system of electric traction will be used in the tunnel. Bench walls in the tunnel carry a large number of ducts for power, telephone, telegraph and electric light cables.

Exports from *Boston* to the United Kingdom in 1909 included electrical appliances £20,632 (against £19,891 in 1908), electrical machinery £49,868 (£21,793), engines £239 (£747), and boilers and parts of engines £7,142 (£10,916).

Consul-General Hearn (*San Francisco*) says electric power is used extensively in California, the consumption in that State being 555,177 kw. for 1909, against 163,904 kw. for Washington, the next highest of the western districts.

Vice-Consul Mortimer, reporting on the trade, &c., of *Los Angeles*, (Cal.), says all the tramways in this city are worked by electricity. There are five systems with 275 miles of track in the city. The Pacific Electric Railway Co. are working tramways in the city and vicinity on 559 miles of track. The Los Angeles Pacific Co. have 175 miles working. These tramways connect Los Angeles with the surrounding towns, using the streets and country roads, and in some instances private rights of way. The tracks are well laid and the cars run at a high rate of speed—about 45 miles an hour. The electric supply companies supplied 245,797,449 units of current for lighting and power in 1909. In San Francisco alone there is a delivery of electric energy amounting to 275,000 H.P., and in Los Angeles 135,000 H.P. On the electric railways in California there are 2,516 cars, while the number of miles of standard gauge electric track is 1,653. The electric power generated by steam plants is more than equal to that generated by water power in the State. The increase of electric power plants throughout the State has had a marked effect in the mining regions. The numerous mountain streams furnish the original source of power, and this is distributed by electricity throughout the mining districts. This has had the effect of materially cheapening mining operations and has rendered possible the working of mines which were formerly idle. The electric iron smelter on the Pitt river (Shasta County, Cal.) has proved a success, and in August, 1909, was producing pig iron at the rate of 25 tons per day without the use of any blast or coke. The iron was delivered to a foundry at Redding at $25 (£5. 4s. 2d.) a ton, or less than the ordinary price at tidewater. It is pronounced to be of the finest quality for casting purposes.

Venezuela.—The report of Vice-Consul H. Tom on the trade of the *Caracas* district for 1908-9 states that the tramways of Caracas are owned by the United Electric Tramways Co. of Caracas (Ltd.), of London, but a local company (the Compañia Anónima Tranvias Eléctricos de Caracas) was formed to meet the requirements of Venezuelan law. The company's concession is for 99 years, and the service was opened March 15, 1908. There are about 15 miles of

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single track of 3 ft. 6 in. gauge, with crossings. There are 41 cars and on an average about 300,000 passengers a month are carried. The power, generated by water power about 10 miles from the city, is taken from a local company. The company has a reserve plant of three Diesel engine sets of 240 H.P. each, and a storage battery capable of carrying the entire load for one hour. The local electric power company is now erecting a new generating station, and the fall of the same river will be utilised to run the new station.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Barnes.—The capital expended on the electricity undertaking at March 31 was £65,201, an increase of £1,586 during the year.

The annual revenue was £10,921, including £8,382 from the sale of current for private lighting and power, and £1,968 from public lighting. Expenses were £4,052, leaving a gross profit of £6,869. Interest came to £1,964 and instalments of principal to £2,446. £1,451 was placed to reserve, and £716 devoted to meeting expenses of executing the order which are not chargeable to capital. £5,300 was carried forward, against £4,980 in 1908-9. 1,024,131 units were generated, 232,607 units were supplied to public lamps (266½ amperes Nernsts and 231 metal filaments), and 692,693 sold to private consumers. The total maximum supply demanded was 505 kw.

Beckenham.—The accounts of the electricity department for the year ended March 31 show a net deficit of £131.

The chairman of the Electricity committee (Mr. SJOLLEMA), in moving the adoption of the accounts at the last meeting of the Council, said that the most satisfactory feature was the important reduction in generation expenses, a reduction compared with the previous year of no less than £2,214. 0s. 3d., of which coal was responsible for £2,056. 3s. 9d. After making provision for interest and sinking fund charges the accounts showed an improvement over the previous year of £1,168. 2s. 10d., not sufficient, however, to ensure a profit because of savings effected by consumers, who had actually paid £536. 19s. 5d. less for current, although 184 more had been supplied. The revenue from tramway current was up by £112. They had appointed two canvassers and had opened showrooms in order to push the sale of electricity. They could supply 500 more customers without increase of plant.

Darwen.—The accounts of the tramways department for the year to March last show capital expenditure £85,609, amount borrowed £86,100, redeemed £21,100.

Total revenue was £13,723, working expenses (less depreciation) £8,825, depreciation £1,050, and capital charges £4,308, the net deficit being £658. Passengers carried were 2,562,218, car miles run 246,501, and units used 422,805 (1·71 per car mile). Total revenue was 13·36d. and working expenses (including power cost and depreciation) were 9·61d. per car mile.

Eccles.—The income of the electricity department for the year ended March 31 was £9,682, including £9,016 from the sale of electrical energy for private and public lighting and traction.

Total expenses were £5,286, and the gross profit £4,397. Interest absorbed £1,353, sinking fund contribution and repayment of loan (£1,681), other charges £145, leaving a balance of £1,218 which has been transferred to capital account for expenditure in excess of L.G. Board sanction. The gross capital outlay is £51,241, an increase of £2,040. £9,361 has been paid off. 309,575 units were sold to private consumers, 764,778 units supplied to the tramways department and 88,754 for public lighting.

Greenock.—The profit on the past year's working of the electricity undertaking was £3,250, which is a higher figure than in any previous year.

Halifax.—The total revenue of the tramways department for the past year was £89,270, against £86,157 in the previous year.

After deducting working expenses, interest, sinking fund and other charges, the net profit was £13,065, compared with a net loss of £13,542 in 1908-9, and of £9,605 in 1907-8. The route mileage of the tramways worked by the Corporation is now 37 miles 697 yds. The receipts from parcels have increased to £1,803. 5s., against £1,528. 15s. 8d.

Ilford.—The capital expended on the electricity department at March 31 was £181,326, the same as in 1909.

Total revenue was £29,747 (against £28,721), including £16,773 for current sold for private lighting and power, £7,305 for public lighting, and £4,577 from the tramways. Working expenses were £16,806 and £75 was carried forward to provide for irrecoverables, leaving a gross profit of £12,866 (7·42 per cent. on capital), against £10,679 (6·57 per cent.) Interest came to £5,754 (against £5,676), and repayment of debt charges £5,543 (against £5,002), leaving net profit £1,569, against £1 in 1908-9. The number of units sold for private supply was 1,553,133 (against 1,433,711), for traction 976,513 (against 1,020,960), and for public lighting 622,945 (against 780,405), a total of 3,152,591 (against 3,235,076). The average price per unit sold was 2d. against 1·87d. There were 3,545 consumers, an increase of 243. The maximum load was 1,665 kw. (against 1,675 kw.), and the load factor 21·61 against 22·05 per cent. The total costs were 1·03d. per unit (against 1·11d.), but coal showed a decrease of 0·14d. (0·48d. against 0·62d.) There are 106 arc and 1,570 incandescent lamps for public lighting.

Norwich.—The income of the electricity department for the year ended March 31 was £37,632 (including £35,876 for sale of current), increase £443.

The expenses were £16,524, compared with £19,070, leaving a gross profit of £21,109 to meet interest and sinking fund (£15,146), so that the net profit was £5,963. After crediting £126 from 1906, placing £2,000 to depreciation account, and devoting £360 to purchase of Duke-street property, £3,728 was carried forward. On the wiring account there was a profit of £271, but depreciation has only been calculated on a 20 years' basis. The outlay on free wiring during the year was £1,472, making the total £12,444. Units sold for private lighting were 2,008,167, an increase of 154,259 over 1908-9, for public lighting 42,598 units (increase 731), and for power 2,062,432 units (decrease 108,662). The total works costs were 0·943d. per unit against 1·062d.

Perth.—It was reported to the City Council on Monday that the revenue of the electricity department for the past year was £7,935. After meeting expenses, and paying interest, transferring £1,037 to sinking fund, and putting £475 to reserve, there was a balance to be carried forward of £67.

The receipts of the tramways department were £8,516, and the expenses £5,362, leaving £3,153 to meet interest and sinking fund charges (£3,166). In addition, the interest and instalment on purchase price required £1,157, and the net deficit on the year's working was consequently £1,470.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published

TENDERS INVITED.

Tenders are invited up to Sept. 20 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA (Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone insulators to the Postmaster-General's Department in all the States of the Commonwealth of AUSTRALIA. Tender forms, &c., may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Sept. 27 for the supply of electric lamps to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W. See advertisement.

LONDON County Council invite tenders for the covering with asbestos tape of certain electric cables in manholes in the south of London. Specification, drawing, form of tender, &c., from the Clerk of the Council, Spring Gardens, S.W. Tenders by 11 a.m. Aug. 30.

LONDON County Council also invite tenders for wiring and fitting for electric lighting of the second section of the central car repair depot, Woolwich-road. Specifications, &c., from the Clerk of the Council. Tenders by 11 a.m. Tuesday, Aug. 30.

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NEWPORT (Mon.) Electricity and Tramways committee invite tenders for supply of carbon filament electric lamps, radiator lamps (British made), flame arc lamp carbons for Excello and Oliver type lamps, and a.-c. and d.-c. two-rate and prepayment meters, during the ensuing 12 months. Specification and schedule from the borough electrical engineer and tramway manager, Mr. H. Collings Bishop, M.I.E.E. Tenders to the Town Clerk, Town Hall, Newport, Mon., by first post Aug. 15.

OLDHAM Surveyor's and Tramways committee require tenders by Aug. 17 for materials and labour (except electrical equipment) required in construction of a tramway. Forms, &c., from the Borough Surveyor.

CHELMSFORD Education committee want tenders by Aug. 31 for electric light wiring at Trinity-road school. Forms, &c., from Mr. W. H. Pertwee, London-road, Chelmsford.

SALFORD Tramways Committee want tenders by 10 a.m. Aug. 15 for supply of 500 tons of steel tramway rails. Specification, &c., from general manager.

BOURNEMOUTH Tramways committee want tenders by Aug. 31 for reconstruction of 2½ miles of tramway permanent way and supply of 450 tons of rails, with fastenings. Specifications, &c., from the General Manager.

Tenders are wanted by 5 p.m. Aug. 25 for supply of telephone apparatus and cable (main central battery system and metallic circuit telephone switchboards, &c.) for the Lancashire County Asylum, RAINHILL. Specification, &c., from the Clerk.

SOUTH DUBLIN Guardians want tenders by noon Aug. 24 for wiring and fitting the workhouse for electric lighting. Specifications, &c., from the Clerk on payment of £1. 1s.

ROCHDALE Electricity committee want tenders by noon, Aug. 31 for 12 months' supply of paper insulated cables. Specification from the engineer and manager.

HACKNEY (London) Council want tenders by 7 p.m. Sept. 15 for extension of main switchboard. Specification, &c., from the Town Clerk.

KETTERING Council require tenders by noon Aug. 22 for the supply and fixing of three steel chain independent coal elevators. Specification, &c., from the Electrical Engineer.

SKIPTON Council require tenders by Aug. 17 for supply of a gas engine and dynamo and for the wiring, &c., for electric lighting at the Town Hall.

POPLAR (London) Guardians want tenders by 6:30 p.m. Aug. 31 for 12 months' electrical supplies, ironmongery, packing and jointing, &c. Forms, &c., from the Clerk.

IPSWICH Corporation want tenders by Aug. 22 for one year's supply of underground cables. Specification from the Chief Engineer.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W., and also from Messrs. R. W. Cameron & Co., 23, South William-street, New York, and Mr. H. Stephenson Smith, 244, California-street, San Francisco, Cal. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

Tenders are invited for supply to the Corporation of the City of MELBOURNE of 4,840 yds. single conductor lead-covered cable, suitable for use on a circuit having a working pressure of 460 volts, and 880 yds. concentric lead-covered cable for use on a circuit having a working pressure of 2,000 volts. Specifications, forms and conditions from Messrs. McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter Square-buildings, London, E.C., to whom tenders by noon Tuesday, Aug. 23.

Tenders are invited up to Sept. 7 for supply of battery material and glassware to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Official Secretary in Great Britain of the Commonwealth of Australia, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, BRISBANE, will receive tenders until noon Sept. 7 for supply of glass cells, corks and tubes and porous cups for batteries, battery material, chemicals, &c. Specifications, &c., from the High Commissioner for the Australian Commonwealth, London. Local representation is necessary.

The Deputy Postmaster-General, MELBOURNE (Victoria), will receive tenders until 3 p.m. Aug. 30 for supply of electrical sundries, insulators, wire and sulphate of magnesia. Local representation necessary. Further particulars from 72, Victoria-street, London, S.W.

The Ministry of Public Works, CAIRO, require tenders for electrical installations and refrigerating plant for the lunatic asylum in course of construction at Khanka. Specifications from the Chief of the Administrative Service, Ministry of Public Works, Cairo. Stamped paper for tenders is obtainable from Mr. A. L. Webb, Westminster, S.W. Tenders by noon Oct. 20. Legal domicile at Cairo is necessary in the case of this contract, and to obtain temporary domicile British firms must, before electing such domicile, formally advise the Consulate at Cairo of intention to do so, formally authorise the Consulate on their behalf and inform the Consulate of the address to which documents should be forwarded.

The Burgemeester en Wethouders van AMSTERDAM announce that on Aug. 22, 1910, the Corporation will receive tenders for delivery and erection of a 6,000 kw. steam turbo-generator unit for the Corporation electricity works. Specification (in German), price Fl.2.50, and further particulars from the Gemeente-Electriciteitswerken, Hoogte Kadyk 200, Amsterdam, Holland.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The Italian State Railways Administration, 16, Via Ludovici, ROME, want tenders by Aug. 22 for supply of 584,000 common carbons for arc lamps. Only firms on list kept by administration are generally allowed to tender. Local representation is practically necessary.

Tenders will be received at the offices of the municipality, Gorodskaia Uprava, ST. PETERSBURG, up to 11 a.m. Aug. 2/15 for supply and installation of switchboards for the extension of the St. Petersburg telephone system. Particulars from the telephone station, Morskaia 22, St. Petersburg.

MOSTAR (Austria-Hungary) municipality will receive tenders until Oct. 1 for the installation of electric generating plant.

TENDERS RECEIVED AND ACCEPTED.

Manchester Council have accepted the tender of the Union Cable Co. for service cables at £1,500.

The chairman of the Electricity committee (Mr. Howarth) explained to the Council that the lowest British tender was £2,750. The Union Co. proposed to erect works in Essex.

An amendment to refer the matter back in order to consider the question of accepting a British tender was rejected.

Stockport Council have accepted the following tenders for annual supplies:—

Morgan Crucible Co., carbon brushes; British Insulated & Helsby Cables, overhead line materials; T. Richardson, rubber blocks; H. Hollingdrake & Son, bolts, nuts, &c.; McClure & Whitfield, two commutators for motors.

Sheffield Council have accepted the following tenders:—

British Insulated & Helsby Cables, 2 miles of figure 8 bronze trolley wire 8½d. per pound (less 2¾ per cent.); W. T. Glover & Co., 10 tons of h.c. copper wire to be made up into cables during two years; Gilbert Heathcote & Co., constructional steelwork for extensions to boiler house at Neepsend station, £6,355. 3s. 7d.

Salford Council have accepted the following tenders:—

Lightfoot Bros., telephonic installation at Sanatorium, £27. 10s.; British United Road Traction Co., 28-34 H.P. Halley petrol power wagon, £670; T. Robinson & Son, moulding machine, £66. 1s. 8d., and grinding machine, £19. 10s.; C. Churchill & Co., lathe, £58; Selsor Engineering Co., shaping machine, £68.

Walsall Council have accepted the tender of H. G. Richardson & Co., for l.t. switchboard and altering a switchboard at £88. 10s., and that of the Union Electric Co., for three h.t. isolation switches at £19. 10s.

Warrington Council has accepted the tender of George Wallington for concrete foundations for the turbo-alternator and condensing plant, and the erection of a building for switchboard extensions at £300.

Sydney City Council are recommended to accept the tenders of the Australian General Electric Co. for the supply of switchboards and transformers, and Noyes Bros., British Insulated & Helsby Cables and Jas. Connolly for other electric lighting materials.

Motherwell Council have accepted the following tenders:—

Chamberlain & Hookham, meters; Balcke & Co., cooling tower, £818; Callender's Cable & Construction Co., cable, £530; Siemens Bros. Dynamo Works, switchboard extension, £305.

Belfast Harbour Commissioners have accepted the tenders of Siemens Bros. Dynamo Works for a dynamo, and that of Jas. Howden & Co. for a steam engine to be direct coupled to the dynamo.

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Folkestone Council has accepted the tender of E. Morgan at £69. 15s. for supply and fixing electric fittings at the Corporation offices.

Ashstead Council have accepted the tender of the Leatherhead & District Electricity Co. for lighting 54 public lamps at £2. 17s. 6d. each per annum.

Stretford Council have accepted the tender of the Tudor Accumulator Co. for alterations to and extensions of the existing storage battery at £784. 9s.

Leith Corporation have accepted the tender of the British Westinghouse Co. for a 500 kw. mixed pressure turbine and d.c. generator, condensing plant and cooling tower at £4,775.

Fareham Asylums Committee of Southampton County Council have accepted the tender of Shalders & Davis, for electrical machinery at £1,715.

Eccles Council have accepted the tender of E. M. Evans & Sons for wiring the new secondary school at £460.

Torquay Council has placed an order with Ferranti Limited for the annual supply of meters.

The contract for the electric lighting of the new Hamilton Academy has been secured by Wm. Torrance at £1,500.

Bury (Lancs.) Council have accepted the tender of Siemens Bros. & Co. for the supply of e.h.t. trunk mains.

Folkestone Council have accepted the tender of E. Morgan for electric fittings at £69 for the municipal offices.

Electric Lift Contracts.—A. W. Penrose & Co. have secured the contract for the electric lifts required in the new head post office, Edinburgh, the contract amounting in all to about £4,000. The firm have also other work in hand for the P.O. authorities, including three 30 cwt. goods lifts for the new western district post office, three a.c. lifts for Sheffield, one passenger lift for Leeds, and one passenger lift for Newcastle-on-Tyne.

BUSINESS NOTICES.

Messrs. J. Parkinson & Co., Post Office Chambers, St. Nicholas-street, Newcastle-on-Tyne, have been appointed by Messrs. Tetley & Co. their sole agents for Newcastle and district.

Mr. Alf. E. Croager, Norfolk House, Laurence Pountney-hill, London, E.C., has been appointed London representative to Messrs. Joseph Williamson & Co., screwing machine makers, of Manchester, for all sizes from $\frac{1}{8}$ in. to 36 in. diameter.

The works of the Telegraph Condenser Co. (Ltd.) have been removed to Vauxhall-street, Kennington Oval, S.E.

Mr. P. P. Kipping has removed from 71, Queen Victoria-street, to Midland Bank Chambers, Queen Victoria-street, E.C. Telegrams, "Peelcontel London." Telephone, London Wall 673.

Sale by Auction.—Messrs. Horne & Co., 35, Old Queen-street, Westminster, S.W., will sell by public auction at the Royal Arsenal, Woolwich, on Thursday, 25th inst., at 11 a.m., unserviceable and obsolete stores, including quantities of iron and steel, brass, copper, gunmetal, lead and antimony alloy, zinc, mixed metal and turnings, &c., dynamo, drums of cable, lathes and other machine tools, telegraph and electric light fittings and instruments, electric lamp bases, &c. The lots may be viewed at the Royal Arsenal, Woolwich, on Monday, Tuesday and Wednesday, previous to and on morning of sale. Catalogues from the War Office, Whitehall; the Ordnance Office, Tower; and the Ordnance Office, Royal Arsenal, Woolwich See also an advertisement.

Patents Development.—The proprietor of letters patent No. 28,542/1907, relating to "Electrical induction furnaces," desires to enter into arrangements for exploiting same. Communications to Messrs. J. E. Evans-Jackson & Co., 19 and 20, Holborn Viaduct, London, E.C.

The proprietor of patent No. 23,491/1902, relating to "Magneti. wheels" desires to dispose of same, or to grant licences for working in this country. Applications to Messrs. Cruikshank & Fairweather (Ltd.), 65 and 66, Chancery-lane, London, W.C.

Electric Clocks.—Electric time service is making rapid strides. The Synchronome Co. inform us that they are installing their system of electrical impuls dials in a number of public buildings, works and factories, &c.

Conduit and Conduit Accessories.—The General Electric Co. announce that they will shortly be issuing a new catalogue for conduit and conduit accessories, pending the publication of which all former list prices and quotations are withdrawn as and from July 21. In the meanwhile the company will supply customers with net quotations for anything they may require.

National Telephone Directories.—The new edition (July, 1910) of the National Telephone Co.'s directories for the United Kindgom

ELECTRICITY SUPPLY TABLES AND DATA.

This Valuable Set of Tables and Engineering Data relating to Electricity Supply and to Electric Traction on Railways and Tramways in the United Kingdom, the Colonies, and some important places abroad, is now ready, and can be obtained complete in handy book form, price 6s. 6d. post free, or on very hard paper for rough or constant use, price 8s. 6d. post free. A complete Index is included

have just been issued. The two volumes into which the complete directory is divided continue to increase in bulk, indicating a steady growth in the number of subscribers to the company's system. There is nowadays no business house of importance without telephone facilities. Vol. I. contains sections 1 to 26 of the directory, and comprises the important London area, and the Midland, Southern and Western Provinces; Vol. II. includes sections 27 to 55 and embraces Scotland, the North-Western and Northern Provinces and Ireland. The published price of the set is 30s., or 15s. each volume. The directories can also be obtained in the smaller sections. The London directory can be obtained price 2s.; the Midland Provinces Sections (2 to 9 inclusive) complete 5s., or 1s. each separate section. As a rule, each of the sections can be obtained for 1s. each, but the price of some 16 of the smaller provincial sections is only 6d. each.

Touring in Bucks.—The Great Central Railway Co. has prepared a convenient pocket guide book which gives illustrated details of a number of cycling tours in Buckinghamshire. By taking the Great Central to certain stations the cyclist can find his way through the most picturesque byways and reach some other point on the railway from which to return to town. The most intricate turnings on the various routes are indicated by photographs, and these, in conjunction with the letterpress, make it impossible to lose one's way. The booklet is interspersed with interesting notes of the principal places en route. Copies can be obtained, post free 3d., from the Great Central Railway Publicity Dept., 216, Marylebone-road, London, N.W.

CATALOGUES, &c.

"Butt" Arc Lamp.—We have received from the General Electric Co. an advance copy of a pamphlet they are issuing dealing with a new flame arc lamp shortly to be placed on the market. It is suitable for both direct and alternating current, and is self regulating. There is no clockwork and no shunt coils. It can be run on alternating current of 25 cycles per second. It is made in three types: short hour, having a life of 8–10 hours, long hour 16–18 hours, and the double carbon lamp 32–38 hours.

G.E.C. Switchgear.—The General Electric Co. have also sent us a couple of pamphlets dealing with iron clad switchgear of the Salford type, and Witton switches. The latter of these was described in the last issue of The Electrician, while with regard to the former it may be said that they are all good standard patterns with cases and designs suitably protecting the switches from dust and damp. A pamphlet describing this firm's well-known Flamgold arc lamps has also come to hand.

"Tricity" Cookers.—We have received from the Berry Construction Co. an illustrated catalogue showing the latest type of their well-known "Tricity" cookers. These can be provided with extensions so that from small beginnings a large and efficient cooking apparatus can easily be built up.

Clyde Capstans.—A pamphlet from Messrs. Bruce Peebles & Co. describes in detail the operation of the Clyde patent electric capstan.

Litholite Insulators.—Litholite (Ltd.) send us a number of sheets giving sectional drawings and details and dimensions of the insulating equipment made by them.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during June, 1910, and (*b*) during the current year from Jan. 1 to July 31, with the increases or decreases compared with the corresponding periods of 1909:—

Electrical machinery (*a*) £43,712 (decrease £13,448), (*b*) £323,144 (increase £33,217); telegraph and telephone cables (*a*) £7,250 (decrease £3,086), (*b*) £79,697 (increase £6,886); telegraph and telephone apparatus (*a*) £10,504 (decrease £1,682), (*b*) £99,606 (decrease £5,435); other electrical wires and cables, rubber insulated (*a*) £21,080 (decrease £2,632), (*b*) £120,395 (increase £67,647), with other insulations (*a*) £2,785 (increase £1,969), (*b*) £47,360 (decrease £37,264); carbons (*a*) £10,183 (decrease £1,073), (*b*) £78,216 (increase £1,383); glow lamps (*a*) £51,162 (increase £20,263), (*b*) £320,727 (increase £72,590); arc lamps and electric searchlights (*a*) £224 (increase £160), (*b*) £2,025 (decrease £6,865); parts of arc lamps and searchlights (other than carbons) £4,549 (decrease £1,063), (*b*) £40,192 (increase £6,853); primary and secondary batteries (*a*) £3,368 (increase £815), (*b*) £23,939 (decrease £3,147). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £120,264 (increase £16,237), (*b*) £841,091 (increase £102,526).

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Exports.—The exports of electrical machinery, material, &c., (*a*) during July, 1910, and (*b*) during the current year from Jan. 1 to July 31, and the increases and decreases compared with the corresponding periods of 1909, are as follows :—

Electrical machinery (*a*) £172,252 (increase £49,689), (*b*) £891,675 (increase £61,451); telegraph and telephone cables (*a*) £129,999 (increase £106,446), (*b*) £1,030,093 (increase £595,220); telegraph and telephone apparatus (*a*) £18,167 (decrease £31,783), (*b*) £100,134 (decrease £73,310); other electrical wires and cables, rubber insulated (*a*) £28,960 (increase £6,312), (*b*) £228,323 (increase £78,898), with other insulations (*a*) £25,450 (decrease £2,234), (*b*) £169,946 (decrease £5,377); carbons (*a*) £1,199 (increase £211), (*b*) £9,861 (increase £4,673); glow lamps (*a*) £9,548 (increase £3,802), (*b*) £72,365 (increase £31,399); arc lamps and searchlights (*a*) £1,602 (decrease £764), (*b*) £11,022 (decrease £889); parts of arc lamps and searchlights (other than carbons) (*a*) £1,293 (increase £790), (*b*) £8,032 (decrease £921); primary and secondary batteries (*a*) £16,870 (increase £7,314), (*b*) £70,036 (increase £3,982). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £269,895 (decrease £118,905), (*b*) £1,962,689 (increase £688,253).

LIQUIDATIONS.

A summary of the liquidator's accounts in the matter of the Phosphor Bronze Co. (Ltd.) has been issued, covering the period from Dec. 14, 1909, to June 14, 1910. The whole of the creditors have been paid in full, the debentures have been paid off (or amount provided for same), and there is a balance of £12,697. 16s. 3d. to the credit of the company.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

April 30, 1910.

10,693 KOOPMAN & PONTELEC WELDING PATENTS. Supports for electric conductors.*
10,694 KOOPMAN & PONTELEC WELDING PATENTS. Electric heating machines.*
10,705 BROWN, GOURLAY & GOURLAY. Electric conduit threaders.*
10,706 GODFREE. Electro-mechanical separator. (Date applied for, 28/5/09.)*†

May 2, 1910.

10,717 HARRIS. Safety recessive shell for detonation for blasting purposes when fired by electric current. (Addition to No. 225/09.)
10,718 HALL. Electric ignition apparatus.
10,728 TAYLOR. Instantaneous switches for alternating and direct-current circuits.
10,745 HURD. Telegraphic slip winder.
10,748 LIDDLE. Motor-driven capstans.
10,749 LANCASHIRE DYNAMO & MOTOR CO. & MASON. Electrically operating planing machines and the like reciprocating tools.
10,771 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Circuit breakers.*
10,772 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Electric circuit controllers.*
10,773 SIEMENS BROS. DYNAMO WORKS. BATE & GLADDY. Electric lamp holders.
10,774 BALDWIN. Sound-reproducing devices of the telephone-receiver type.
10,788 LANZAROTTI & CRESFI. Systems of telegraphy from trains and the like.
10,799 RANSCH. Temporarily short closing of electrical currents.*
10,817 FESSENDEN. Wireless signalling. (Date applied for, 19/7/09.)*†
10,820 ZAHRINGER. Device for operating magneto-electric ignition machines.*
10,829 B.T.-H. Co. (G.E. Co., U.S.) Electric conductors of refractory metal.*

May 3, 1910.

10,842 CHRISTMAS. Duplicated reversing sparking plugs.
10,843 MORSE. Power-transmission mechanism. (Date applied for, 15/12/08. Comprised in No. 28,923, dated 10/12/09.)*
10,945 NICHOLLS. Attachment to telephones to note telephonic communications.
10,869, 10,871, 10,873 and 10,874 HARRISON. Manufacture of filaments for incandescent electric lamps.
10,870 and 10,872 HARRISON. Exhaustion of incandescent electric lamps.
10,913 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Regulation of the power factor in the external circuit of polyphase electric machines.*
10,917 FRANTZEN. Electric furnaces. (Date applied for, 5/5/09.)*†
10,919 COX. Electrical switches.
10,932 WEEKES. Combined installations for power generation and industrial heating.
10,943 & 10,955 LAKE. (William Edward Clark, U.S.) Arc lamps.*
10,961 PARTINGTON. Multiple fusible cut-out for electrical circuits.*
10,964 & 10,965 GRAHAM. Telephonic systems and apparatus.*
10,970 ZWEIGBERGK. Dynamo-electric machines.
10,972 HAZLEHURST & LONGSTRETH'S. Automatically breaking the charging circuit of a secondary battery.

May 4, 1910.

11,013 MURRAY. Heating interiors by means of electric radiators.
11,021 FISH & PARKER. Shade-holders for electric lamps.
11,024 AKT.-GES. BROWN, BOVERI ET CIE. Driving dynamo-electric machinery. (Date applied for, 5/5/09.)*†
11,031 DUNNITHORNE. Production, control and application of currents of electricity which vary periodically in intensity.
11,048 BOULT. (International Telechronometer Co., U.S.) Telephone apparatus.*
11,051 LOBEL & BRITISH EVER READY ELECTRICAL CO. Holders or fittings for electric incandescent lamps.*
11,054 SIEMENS SCHUCKERT WERKE G.M.B.H. Searchlight apparatus. (Date applied for, 10/5/09.)*†
11,072 PEFLOW, HEYN & LEYLAND. Electric signalling lamps carried on bicycles and the like.
11,085 BROWN. Telephone relays or transmitters.

May 5, 1910.

11,105 GUNNER. Earthing device for electrical conduits.
11,107 KRAUSE. Manufacture of electric metal filament lamps. (Date applied for, 6/5/09.)*†
11,137 MITCHELL. Holders for electric glow-lamps.
11,145 FLURY. Operating electric switches and the like.
11,146 FENNER. Arc lamps.
11,154 & 11,155. FESSENDEN. Wireless signalling. (Date applied for, 29/1/10.)*†
11,157 MUNR & RAILLESS ELECTRIC TRACTION CO. Trolley-poles for electric traction systems.
11,175 SEWARD, KUGELGEN & BIDDER. Electrolytic production of light metals and particularly sodium. (Date applied for, 10/5/09.)*†
11,184 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Motor controllers and like electric switches.*
11,186 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Starting devices for electric motors.*
11,188 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Electromotor-controllers and like electric switch.*

May 6, 1910.

11,251 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Telephone exchange circuits.
11,260 THORNTON. (John Tefft Clarke, U.S.) Circuit closers.*
11,275 BAKER & LONGSTRETH'S. Electric couplings.
11,277 EVERSHED & VIGNOLES, EVERSHED & PAYNE. Binding screws or terminals for electrical purposes.*
11,281 MCKENZIE & HOLLAND & WOOD. Electric contact makers.*

May 7, 1910.

11,294 GOLDSCHMIDT. Production of high frequency currents for use in wireless telegraphy and telephony.*
11,333 HOWARD & COAD. Telephone mouthpieces.*
11,356 GARCIN. Dynamo-electric machines. (Date applied for, 8/5/09.)*†
11,359 MARCONI'S WIRELESS TELEGRAPH CO. & PRINCE. Portable apparatus for wireless telegraphy.
11,360 MARCONI'S WIRELESS TELEGRAPH CO., BANGAY & PRINCE. Carrying portable motors and dynamos on horseback.

May 9, 1910.

11,385 CROSSLEY & HAMER. Cord grips for incandescent lamp-holders.
11,415 KITSEE. Metallic filaments for electric lamps.*
11,429 YOUNG. Starting and controlling electric motors.
11,437 DAALEN. Actuation of controllers for electric machinery. (Addition to No. 15,203/09.)*
11,439 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controlling electric motors.*
11,494 REID. Electric clocks.

May 10, 1910.

11,559 WALTERS. Stage arc lamps.
11,564 PEARSON. Electric switches.
11,569 CHADWICK & CLARKE. Detachable power handle for use on electrical controllers on tramcars, motor cars, trains and the like.
11,581, 11,582 and 11,583. HEIMANN & SCHAFFER. Working arc lamps in series with incandescent lamps. Addition to No. 747/10. (Date applied for, 2/8/09, 10/10/09, 10/1/10.)*
11,600 BOSCH. Terminals for electric cables. (Date applied for 23/7/09.)*†
11,602 FESSENDEN. Telephone transmitters and relays.
11,614 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Alternating-current magnets.*
11,626 GRAHAM. Telephonic apparatus.*

May 11, 1910.

11,644 FAHN. Electric lighting of motor vehicles.
11,658 ATKINSON. Guiding apparatus for electric trolley wheels for tramways and the like.
11,671 IRWIN. Selective signalling.
11,707 B.T.-H. Co. & WEDMORE. Electric switch mechanism.
11,708 B.T.-H. Co. (G.E. Co., U.S.) Electric switches.
11,716 THOMSON. Electric furnaces. (Date applied for 13/5/09.)*†
11,717 THOMSON & FITZGERALD. Electric furnaces. (Date applied for, 13/5/09.)*†
11,718 FITZGERALD. Electric furnaces. (Date applied for, 13/5/09.)*†

May 12, 1910.

11,746 KERNAN. Electric lamp or like switches.
11,756 LACY. Electrical circuit breakers, fuse bridges, cut-outs, distribution boards and the like.
11,781 STERN. Electrical accumulators. (Date applied for, 12/5/09.)*†
11,792 BEAVER, SWENDOWER, PREECE & CLAREMONT. Electric cable.
11,812 MACBRAYNE. Power transmission plants.
11,830 ZWEIGBERGK. Controllers for dynamo-electric machines.*
11,837 ESTELLE. Depolarising agents for electric batteries. (Date applied for, 13/5/09.)*†

May 13, 1910.

11,854 AIKEN. Controlling electric lights and apparatus therefor.
11,885 CLARK. (Brown Spin-Wright Co., U.S.) Power transmission apparatus.
11,896 SIEMENS BROS. DYNAMO WORKS & PICKERING. Armature windings of dynamo-electric machines.*
11,903 FESSENDEN. Signalling by electromagnetic waves. (Date applied for, 18/5/09.)*†

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

6,758 DURTNALL. Electrical transmission of power and speed regulation.
10,680 KILROY & EVERSHED & VIGNOLES. Starting of electric motors.
10,757 ELICSON. Electric Switches.
10,860 MARTYN. Junction boxes for electric wires and cables.
11,172 B.T.-H. Co. (G.E.Co., U.S.) Electric heating devices.
11,242 SHARMAN. Master switches for radio-telegraph and radio-telephone stations.
11,282 GROTE. Arc lamps.
11,285 B.T.-H. Co. & WEDMORE. Electric distribution systems. (Cognate application, 12,048/09.)
11,295 LEAKE. Electrical transmission of signals and the like.
11,302 and 11,303 VON ZWEIGBERKG. Electric controllers.
11,304 VON ZWEIGBERGK. Protection of high-tension direct-current motors in series.
11,402 GODDARD. Prepayment electricity meters.
11,445 DAWSON & PYNE. Control of electric motors.
11,482 DAVY. Arc lamps.
11,539 B.T.-H. Co. (G.E. Co., U.S.) Rectifying apparatus for electric currents.
11,540 LAURIE-WALKER & NIBLETT. Ploughs for electric tramcars.
11,843 COWPER-COLES. Compound anode and cathode bars.
11,981 PEASE. Flexible protection for electric cables and the like purposes. (Cognate application, 25,920/09.)
12,005 NICHOLSON & HIGHAM. Forming and transforming cipher messages for telegraphic and other purposes.
12,139 IRELAND. Controlling and indicating the condition of control of electrically propelled tramcars and other vehicles.
12,146 VERNIER. Electrical conductors.
12,395 ELECTRIC CONTROL, MACMILLAN & DRYER. Electric switch-operating mechanism.
12,607 SMITH & WATSON. Trolley-heads for electrical tramcars.
12,677 BENKÖ. Carbon electrodes for galvanic elements.
12,689 B.T.-H. Co. & HOLDEN. Electric meters.
13,831 ABRAHAM & BRITISH PNEUMATIC RAILWAY SIGNAL CO. Electric relays for railway signalling and other apparatus.
14,674 WEAVER. Controlling arc lamp carbons.
14,790 PEARSON. Ironclad electric switches.
15,006 KELVIN & JAMES WHITE (LTD.) EVANS & WILSON. Terminals for "shunts" and other electrical apparatus.
15,075 MACKENZIE. (Sundh Electric Co.) Electric circuit closing contacts.
15,115 REGNART. Electric reflector lamps.
15,151 LYNESS. Contact finger for electrical controllers and switches.
15,193 SOC. FRANCAISE D'INCANDESCENCE PAR LE GAZ (SYSTEME AUER). Preparation of filaments suitable for incandescent electric lamps. (Date applied for, 18/7/08.)
15,802 BROOKS & ALSTON. Electric ignition apparatus for internal-combustion engines.
15,881 JABURG. Arc lamps. (Date applied for, 1/7/08. Originally included in No. 7,471/09.)
16,292 MESSENIE & SLAUGHTER. Arc lamps.
16,331 MORRISON. Electric transmission for motor vehicles.

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16,709 Nobel's Explosives Co. & Evans. Electric igniting apparatus for fuses and the like.
16,934 Siemens-Schuckertwerke Ges. Arc lamps. (Addition to No. 15,605/09.)
17,106 Munro & Railless Electric Traction Co. Crossings and junctions for electric traction systems.
17,326 Munro & Railless Electric Traction Co. Hangers and the like for electrical conductors.
17,960 Felten & Guilleaume Lahmeyer-Werke Akt.-Ges. Metal filament lamps. (Date applied for, 2/1/09.)
18,665 Vandervell & Middley. Switch mechanism.
18,836 Weber. Metallic filaments for incandescence electric lighting.
18,863 Kraus. Electric pocket lamps.
21,285 Zschocke. Metal filament incandescent electric lamps.
22,922 Siemens & Halske Akt.-Ges. Electrical energy meters. (Date applied for, 8/10/08.)
22,926 Szubert. Arc lamps.
23,302 Gillies & McPhee. Electric fuses for blasting.
25,190 Pedersen. Transmitting apparatus for electric signalling.
25,542 Compagnie Generale Radiotelegraphique Carpentier, Gaiffe, Rochefort. Wireless telegraphy or wireless telephony. (Date applied for, 13/11/08.)
25,590 Felten & Guilleaume-Lahmeyerwerke Akt.-Ges. Transporting mechanism. (Date applied for, 22/1/09.)
26,021 Sykes & Cooke. Electric conduit joints and joint boxes.
26,046 Allgemeine Elektricitats Ges. Polyphase alternating current commutator machines. (Date applied for, 11/11/08.)
26,266 Harden. Electric furnaces.
26,574 Verney. Electromagnetic couplings. (Date applied for, 16/11/08.)
26,845 Helfenstein. Electric furnaces.
27,689 Amalgamated Radio-Telegraph Co. (Von Bronk.) Detection of thermal or electrical energy.
28,545 Erdmann. Wireless telegraphic signalling apparatus. (Request under section 19 not granted.)
28,849 Binet & Guenne. Arc lamp casings. (Date applied for, 11/12/08.)
29,239 Gravius. Electrodes for electric arc lamps. (Date applied for 1/7/09.)
30,579 Thorrowgood. Polarised relays for selective electric signalling.

1910 Specifications.

466 Siemens Bros. & Co. & Riber. Telephone receivers.
3,118 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Telephone exchanges.
3,400 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Telephone exchanges.
3,926 Lundberg, Lundberg & Lundberg. Boxes for switches or other accessories.
7,019 Tanner & Claremont. Distribution of electric energy. (Date applied for, 8/4/09.)†
7,211 B.T.-H. Co. (G.E. Co., U.S.) Telephone systems.
7,468 & 7,470 Stone & Co. & Darker. Electric lighting, heating, cooling and ventilating of railway carriages and other vehicles. (Date applied for, 27/3/09.)
7,471 J. Stone & Co. & Darker. Electric lighting, heating, cooling and ventilating systems for railway carriages and other vehicles. (Date applied for, 27/3/09.)

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"A Treatise on Electro-Metallurgy." By W. G. McMillan. Revised by W. R. Cooper. 3rd edition. (London: Charles Griffin & Co.) 12s. 6d. net.

"General Foundry Practice." By W. Roxburgh. (London: Constable & Co.) 10s. 6d. net.

"The Calculus for Beginners." By J. W. Mercer. (Cambridge University Press.) 6s.

"Elementary Experimental Electricity and Magnetism." By W. T. Clough. (London: Methuen & Co.) 2s. 6d.

"The Theory of Ionization of Gases by Collision." By J. S. Townsend. (London: Constable & Co.) 3s. 6d. net.

"Commercial Year-Book of Leeds Chamber of Commerce, with Classified Trade Index of the Members of the Chamber." Edited and compiled by the secretary, Rhodes K. Calvert.

"Dictionary of Metallurgical and Chemical Machinery, Appliances and Material." 2nd edition. (New York: "Metallurgical and Chemical Engineering.") 50 cents.

"Science Abstracts." Vol. XIII., Part VII., No. 151. Section A. Physics. Section B. Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

"Handbuch der Telephonie." By Dr. Robert Weber. 2nd edition. Edited by Ing. Johannes Zacharias. (Leipzig: A. Hartleben.) M.12.

"Travaux du Laboratoire Central D'Electricité." Vol. I (1884-1905). (Paris: Gauthier-Villars.)

"Die Dampfturbinen." By A. Stodola. 4th edition. (Berlin: Julius Springer.) M.30.

"Die Herstellung von Hochprozentigem Ferrosilizium in elektrischen Ofen." By W. Pick and W. Conrad. (Halle-a-S.: Wilhelm Knapp).

"Encyclopédie Electrotechnique": "Les Machines Electriques." By L. Barbillion. "Le Courant Electrique." By Eng. Vigneron. "Magnétisme and Electriomagnetisme." Parts I. and II. By Eng. Vigneron. (Paris: L. Geisler.) Fr.2.50 each.

"Schriften des Naturwissenschaftlichen Vereins für Schleswig-Holstein." Vol. XIV. Part II. (Kiel: Lipsius & Tischer.) M.4.

"Das Elektrische Kabel." By Dr. Phil. C. Baur. 2nd edition. Berlin: Julius Springer.) M.12.

"Elektromotorische Antriebe für die Praxis bearbeitet." By B. Jacobi. Vol. XV. of "Oldenbourgs Technische Handbibliothek." (Berlin: R. Oldenbourg.) M.8.

COMPANIES' MEETINGS AND REPORTS.

BARBADOS ELECTRIC SUPPLY CORPN. (LTD.)—At the statutory meeting on Wednesday Mr. L. W. Hawkins stated that the electric lighting order to acquire which the company was formed was sanctioned by both branches of the Barbados Legislature in May. The reports from the company's manager and the consulting engineer as to the demand for electrical energy were encouraging. The greater part of the plant and materials required for the equipment of the undertaking had been ordered. A site had been secured, and it was anticipated that construction would shortly commence.

BROWN, BOVERI & CO., (BADEN) A.G.—The net profit for the past year was 2,142,122 fr., against 2,752,809 fr. in the previous year, and a dividend of 8 per cent., against 11 per cent., was declared. The directors' report states that in spite of some revival in demand prices fell steadily throughout the year, and are still unsatisfactory. Every order is keenly fought for, and quotations are approaching levels which leave no margin of profit. The German market is particularly bad in this respect. The prices of steam turbines are poor, and the company have curtailed their output in the department. The French branch of the company has just received an order for six 20,000 H.P. turbines for the generating station in Paris. The company is engaged in working out simpler and cheaper models, which they think will prove satisfactory. Little or no progress is being made with the electrification of the Swiss railways, and but few generating stations are now being erected in Switzerland. The Prussian State Railways have ordered one of the company's electric locomotives and have shown great interest in their single-phase a.c. system, which is being largely adopted by mining companies.

CENTRAL LONDON RAILWAY CO—At the meeting last week the chairman (Sir Henry Oakley) said that during the past half-year their business had gone on steadily. They had earned £4,597 more and had saved in working £1,974. They had recommended 3 per cent. on ordinary stock and 4 per cent. on preferred ordinary stock, after providing for the interest on debenture stock, and they carried forward £40,000 for the dividend for the first half-year on the deferred stock. They were, therefore, for the time, in a happy and comfortable position. They were gaining slowly. They had carried an increased number of passengers (1,675,787) in the half-year, but as the fares were so small it took a great many millions of passengers to earn a substantial sum. The increase in the number of through-booked passengers to and from their line and other tubular lines was encouraging. They carried 420,000 more through-booked passengers in the last six months than in the corresponding period. The penny passengers had increased by 2,290,390. They charged 1d. for three stations, and the policy adopted had certainly developed a large local traffic. They had gained nearly 9 per cent. in passengers, but only 2 per cent. in money. Their capital expenditure was partly in replacing the original wooden platforms with stone and improving some of their machinery at Shepherd's Bush, so as to lessen, as far as possible, the cost of working and generating power.

ELECTRIC WELDING CO. (LTD.)—The accounts for the year ended Nov. 30 show a loss of £2,028 (including £1,176 for debenture interest), increasing the debit to balance of profit and loss account to £31,458.

GREAT CENTRAL RAILWAY CO.—At the meeting on Friday the chairman (Sir Alex. Henderson) said that there was a moderate increase in the number of passengers carried, though a larger increase had been anticipated in view of the improved business of the country. He had reason to believe that improved telephone service had affected railways, as journeys upon business by rail had become less necessary than formerly. There had been an increase in the number of season tickets issued, and a total increase under the head of passengers of £8,888. There were also increases in goods, parcels and minerals. In regard to the Altrincham line, which was a joint line belonging to the L. & N.W. and G.C. Cos., they had for some time past been considering with the L. & N.W. Co. whether it would be advisable to electrify the line. They had not yet quite decided what to do. The proprietors knew perhaps of the success which had attended the efforts of the Brighton line to get back traffic which had been taken by the tramway company, and it might be that other companies would follow suit.

HENDON ELECTRIC SUPPLY CO. (LTD.)—At the recent meeting it was reported that the result of the working for 1909 was a credit balance of £1,095. 1s. 7d., and after providing for interest and taking into account the debit balance from the previous year (£1,479. 9s. 3d.), the total debit was £1,970. 9s. 3d. On Dec. 31, 1909, 830 houses (with 23,055 33-watt lamps) were connected (against 343 houses and 12,058 33-watt lamps in 1908, and applications were in hand for 287 houses with 5,123 lamps.

HONG KONG & SINGAPORE TRAMWAYS.—At the recent meeting of the Yangtse Valley Co. (Ltd.) the chairman (Mr. Edmund Davies) said the company's principal interest remained in the Electric Traction Co. of Hong Kong, and, owing to the proposals passed by the shareholders in that company, the nominal value of the shares which the Hong Kong Company held would be reduced from £1 to 5s. each, and the debenture issue of the company would be increased from £195,000 to £205,000, as it was necessary to raise additional capital to provide further rolling stock and a site for the erection of car accommodation. The receipts show satisfactory increases, and from Jan. 1 to July 16 they were to $268,824, compared with $244,610 in the same period last year.

The receipts of the Singapore Electric Tramways from Jan. 1 to July 16 were $277,452, comparing with $269,470 for the corresponding period of last year.

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LIVERPOOL OVERHEAD RAILWAY CO.—At the meeting on Tuesday Sir Wm. Forwood said the directors were gratified in being able to produce a slightly more favourable report for the past half year. The expenditure of the half year had been reduced by £524, and with an increased revenue of £824 there was an improvement of £1,348. The directors had been able to pay the 5 per cent. dividends on both classes of preference shares, leaving £5,916 to be carried forward. That was the first time since 1907 that they had been able to pay a dividend for that half-year on the second preference shares.

LONDON, TILBURY & SOUTHEND RAILWAY CO.—At the meeting last week the chairman (Mr. A. L. Stride) said that electric traction was very satisfactory, and 41,000 additional car-miles had been run. It was thought they had done well in 1909, when they ran a service at 2·77d. per car-mile; but for the half-year just ended the car-miles were run at 2·39d., or ⅞ths of a penny per mile less cost than last year.

METROPOLITAN DISTRICT RAILWAY CO.—At the meeting on Wednesday the chairman (Sir Geo. S. Gibb) said that they had carried 36,000,000 passengers during the past half-year, or an increase of 3,250,000; the passenger receipts were £280,000, an increase of £26,000 (about 10½ per cent.) The average receipt per passenger has been 1·86d. The season ticket revenue continued to show a good increase (£8,389, or 29½ per cent.), and the increase of traffic was again general throughout the system. They had had an increase at practically every station except a few of the stations on the east side of the City. The working expenses show a decrease of 3¼ per cent. Train working showed a decrease, mainly due to the very large saving in the cost of electric current. On the last occasion he mentioned that they were arranging an alteration of the supply agreement in regard to the depreciation fund. The power-house depreciation was originally arranged on the basis of 2½ per cent. on the total capital expended, including machinery, land and buildings. Now that the depreciation fund amounted to £148,000, it was plain that the figure set aside was substantially in excess of any reasonable calculation for depreciation. Therefore, they had arranged, with the sanction of the trustees for the power house debentures, that in future the amount to be set aside should be a fixed sum of £20,000 per annum instead of an average of about £35,000 per annum at present. The main factor in the saving was that they had got rid of the Westinghouse steam turbines that were originally installed at the power-house, and had installed in their places Parsons' steam turbines which were giving most excellent results. The cost of coal had not contributed to the saving, because in the half-year the average price of coal had been slightly higher than in the corresponding period of 1909. With regard to train working, the net result was a decrease of £1,500, and the total working expenses showed a net decrease of £4,765. After dealing with the various items in the accounts he gave a sketch of the steady progress made during the last 4½ years. Their capital account now showed a credit of £99,980, the renewal reserves amounted to £30,452, and there were unissued Prior Lien Debentures which could be issued for any necessary expenditure. Therefore, they might regard the financial position of the company with equanimity. In the last nine years the District Co. had been saved from wreck, and he could say with confidence that, except with regard to the rolling stock—which he did not like to permit himself to praise—the proprietors possessed one of the finest underground railways in the world.

MIDDLETON ELECTRIC TRACTION CO. (LTD.)—At the recent meeting it was reported that the revenue for 1909 was £17,273 and the expenses (including £2,000 for debenture interest and £1,000 for renewals) £15,680. The balance was £1,593, added to £1,507 brought forward.

PEARSON FIRE ALARM (LTD.)—The report for 1909 states that there was a profit on sales, rent of installations, &c., of £5,105, against £5,964 in 1908. After meeting expenses, paying debenture interest, &c., and allowing for depreciation, &c., there was a deficit of £2,677, against £39 in 1908.

TYNESIDE TRAMWAYS & TRAMROADS CO.—At the meeting on Tuesday the chairman (Dr. J. T. Merz) moved the adoption of the directors' report for the half year ended June 30, which stated that the profit was £3,656. 5s. 5d., which, with the balance forward (£521. 5s. 4d.) made £4,177. 10s. 9d. Deducting interest, &c. (£1,033. 2s. 11d.), the available balance was £3,144. 7s. 10d. After paying preference dividend the directors recommended a dividend on the ordinary shares at the rate of 1 per cent. per annum, and £643. 13s. 8d. is carried forward. The traffic receipts showed an increase for the half-year of £145. 9s. 11d.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

C. H. HARE & SON (LTD.) (110,911.)—Reg. July 21, capital £12,000 in £1 shares, to carry on the business of mechanical, electrical, sanitary, lighting, heating, water-supply, civil and general engineers, &c., and to adopt an agreement with the Caribonum Co. (Ltd.), Sophia R. Hare and F. C. Hare. First directors, F. C. Hare, Sophia R. Hare and C. H. Mortimore, R. Clark and J. M. Evans.

JOHN RATTRAY & SON (LTD.) (7,609)—Reg. in Edinburgh, on July 12, capital £4,000 in £1 shares, to take over the business of gas-fitters and electrical engineers, &c., carried on by John Rattray & Son, Glasgow. Private company. First directors, G. McKinlay and H. R. Hayes.

M. & G. TRUCK & ENGINEERING CO. (LTD.) (111,131.)—Reg. Aug. 2, capital £5,500 in 5,000 preference shares of £1 each, and 10,000 ordinary shares of 1s. each, to carry on the business of electric and tramway, railway, constructional and general engineers as formerly carried on by Mountain & Gibson (Ltd.) at Elton Fold Works, Bury, and to adopt an agreement with Hobdell, Way & Co. Private company. First directors W. F. Hobdell (chairman) and I. E. Winslow (both permanent).

T. F. SYND. (LTD.) (111,205.)—Reg. Aug. 6, capital £2,000 in £1 shares, to carry on the business of manufacturers of and dealers in and agents for metal filaments for electric lamps, electricians, electric lamp and accessory manufacturers, suppliers of electricity, &c., and to adopt an agreement with the Deutsche Glühfahdenfabrik (Berlin), R. Kurtz and Dr. F. Eisner (the partners therein), and others. Private company. First directors, E. C. Churchword, Dr. F. Eisner, J. Wertheim and T. F. Wilson. Reg. office, 341-5, Birkbeck Bank Buildings, London, W.C.

TITAN ELECTRIC CO. (LTD.) (111,191.)—Reg. Aug. 5, capital £80,000 in 7,998 shares of £10 each, and 20 shares of £1 each, to carry on the business of engineers, &c., and to adopt an agreement with S. de Szepczynski for the acquisition of a business of manufacturers of electric batteries and accessories. Reg. Office, 792, Salisbury House, London Wall, E.C.

STATUTORY RETURNS.

CALLENDER'S CABLE & CONSTRUCTION CO. (LTD.)—In return to July 18 capital is £500,000 in 60,000 ordinary and 40,000 preference shares of £5 each. 35,000 ordinary and 40,000 preference shares taken up. £5 per share called up on 15,000 ordinary and 40,000 preference. £275,000 paid. £100,000 considered as paid on 20,000 ordinary. Mortgages and charges, £300,000.

EASTERN & SOUTH AFRICAN TELEGRAPH CO. (LTD.)—In return dated May 25 capital is £600,000 in £10 shares. All shares taken up. £600,000 paid. Mortgages and charges, £199,500.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) By return, dated May 20, capital is stated at £3,000,000 in £10 shares. All shares taken up and paid for in full. Mortgages and charges, £752,400.

LEEDS ELECTRIC CO. (LTD.)—Return to May 20 gives captial £10,000 in £1 shares. 6,104 shares taken up. £2,800 paid and £3,304 considered as paid. Mortgages and charges, nil.

SOUTH LONDON ELECTRIC SUPPLY CORPN. (LTD.)—Return dated March 29 gives capital as £260,000 in 65,000 shares of £4 each. All shares taken up. £260,000 paid. Mortgages and charges, £100,000.

WEST COAST OF AMERICA TELEGRAPH CO. (LTD.)—Return to May 24 gives capital as £132,520 in 53,008 shares of £2. 10s. each. 45,008 shares taken up. £2. 10s. per share called up on eight. £20 paid. £112,500 considered as paid on 45,000. Mortgages and charges, £170,000.

WESTERN TELEGRAPH CO. (LTD.)—According to return dated May 25 capital is £2,500,000 in £10 shares. 207,930 shares taken up. £10 per share called up on 130,000. £1,300,000 paid. £779,300 considered as paid on 77,930. Mortgages and charges, £815,175.

MORTGAGES AND CHARGES.

G. W. CLARKE & CO. (LIVERPOOL) (LTD.)—Particulars of £1,000 debentures, created July 12, have been filed, the whole amount being now issued. Property charged: Company's undertaking and property, present and future, including uncalled capital. No trustees.

I. T. C. (LTD.)—Particulars of £3,000 debentures, created April 23, have been filed, the whole amount being now issued. Property charged: Company's undertaking and property, present and future, including uncalled capital. No trustees.

RAIL-LESS ELECTRIC TRACTION CO. (LTD.)—Issue on July 20 of £750 debentures, part of a series of which particulars have already been filed.

CITY NOTES.

MEMORANDA (Aug. 11).—Bank rate 3 per cent. (since June 9, 1910). Price of silver, 24⅞d. per oz. Consols 80⅞—81⅛ for money; 81—81⅛ for account. Consols Pay Day, Sept. 1; Stock and Shares Continuation Days, Aug. 29 and Sept. 13; Ticket Days, Aug. 30 and Sept. 14; Pay Days, Aug. 12 and 31; Mining Shares Carry Over Day, Aug. 26.

PRICES OF METALS (London).—*Copper*, cash, 55½; three months, 56⅛. *Lead*, English, 12⅞—13; foreign, 12⅝—12¾. *Spelter*, 22½. *Tin*, English, 150½—152½; foreign cash, 152½; three months, 152¾. *Iron*, Cleveland, cash, 49/11, three months, 50/8.

COMPANY REGISTRATIONS IN 1910.—The last issue of the "Investor's Guardian" contained a review of the company registrations of the first six months of 1910:—The number of companies registered (3,744) created a record, and, compared with the first six months of 1909, showed an increase of 31 per cent. The capital was £131,323,000, a sum more than double the average of the past five years. The capital of the rubber companies registered was £36,628,000 and of the oil companies £24,880,000. Mining registrations also show revival, the capital being the largest for five years. Engineering registrations have been steady, but electrical enterprises are still very depressed; motor and carriage registrations have also dropped to the lowest level.

METALITE (LTD.)—It is announced that the first batch of letters of allotment and regret for the recent issue of capital by this company has been posted.

WASTE HEAT & GAS ELECTRICAL GENERATING STATIONS (LTD.)—The directors have decided to pay an interim dividend at the rate of 5 per cent. (less tax) in respect of the half-year ending July 31.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 4	1,680	— 78	9	13,889	— 76
Airdrie	July 29	172	— 12	30	6,513	+ 81
Anglo-Argentine	Aug. 5	43,541	+ 4,896	31	1,367,296	+ 160,361
Ayr Corporation	„ 6	504	— 10	12	5,025	+ 221
Barnsley	July 29	169	..	30	5,095	+ 140
Barrow	„ 29	333	+ 47	30	7,814	+ 1,121
Bath Electric Trams, Ltd...	Aug. 3	1,288	+ 58	31	24,725	+ 1,220
Birmingham Corporation ..	„ 6	7,078	+ 467	18	123,539	+ 299
Birmingham & Midland....	July 22	861	+ 11	29	24,300	+ 230
Blackburn Corporation	Aug. 3	1,071	+ 21	‡19	20,475	— 778
Blackpool and Fleetwood ..	„ 6	2,566	+ 119	..	..	..
Bolton Corporation.....	„ 7	2,515	— 141	19	44,272	— 372
Bombay	July 8	2,630	+ 259	27	73,261	+ 5,083
Bournemouth Corporation..	Aug. 3	2,618	+ 38	18	34,865	+ 4,004
Bradford Corporation.....	„ 6	5,706	+ 103	19	95,190	+ 3,145
Brighton Corporation.....	„ 8	2,243	+ 88	§18	19,133	— 52
Bristol Trams & Carriage ..	„ 5	8,254	+ 490	5	33,099	+ 1,791
Burnley Corporation	„ 6	1,303	— 80	5	6,383	+ 24
Burton Corporation	„ 7	318	— 13	18	4,993	— 45
Bury Corporation	„ 7	1,208	— 150	§18	22,053	— 378
Calcutta Tramways Co.....	„ 6	₹53,470	+ ₹4,828	5	₹261,474	+ ₹11,177
Camborne-Redruth	„ 6	118	— 15	31	3,662	— 136
Cardiff Corporation.....	..	..	..	..	..	..
Cavehill.....	July 29	83	— 4	30	2,734	+ 215
Central London Railway ..	Aug. 6	5,092	+ 457	5	27,726	+ 1,546
Chatham & Dist. Lt. Rys. ..	„ 4	1,305	+ 179	31	25,753	+ 1,127
City & South London Rly...	„ 7	3,143	+ 159	5	15,530	+ 94
City of Birmingham	July 29	2,853	+ 69	30	85,568	+ 1,846
Colchester Corporation	Aug. 3	319	+ 31	..	..	..
Cork Electric Trams Co.....	„ 4	536	— 51	41	14,983	+ 1,649
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams ..	July 29	428	+ 60	30	12,367	+ 1,509
Dover Corporation	Aug. 6	358	+ 26	18	4,065	+ 73
Dublin & Lucan Railway ..	„ 5	211	— 3	5	890	+ 24
Dublin United	„ 5	6,530	— 467	5	30,963	+ 385
Dudley-Stourbridge	July 29	854	+ 32	30	22,760	— 7.0
Dundee Corporation	Aug. 3	1,181	+ 18	§11	14,056	+ 313
East Ham Council	„ 6	1,234	+ 102	¶18	19,280	+ 388
Exeter Corporation.....	„ 5	433	— 23	18	6,016	— 651
Gateshead & Dist. Trams ..	July 29	1,032	+ 21	30	29,350	— 209
Glasgow Corporation	Aug. 6	17,091	+ 351	10	168,482	+ 10,286
Glossop Trams.....	„ 6	123	— 8	31	3,622	— 209
Gloucester Corpn.....	„ 3	421	+ 33	4	1,616	+ 43
Gravesend-Northfleet.....	July 29	252	+ 26	30	6,068	+ 28
Great Northern & City Rly..	Aug. 6	1,243	+ 68	5	6,502	+ 152
Greenock & Port Glasgow ..	July 29	694	+ 34	30	18,444	+ 2,590
Hartlepool Tramways	„ 29	312	+ 54	30	7,792	+ 375
Hastings Elec. Trams Co. ..	Aug. 4	1,921	+ 70	5	6,599	+ 3
Hong Kong	„ 6	$8,763	+ $589	5	$44,857	+ $3,993
Huddersfield Corpn.	„ 6	1,969	+ 146	18	32,506	+ 1,852
Hull Corporation.....	„ 6	2,928	+ 82	18	49,510	+ 3,014
Ilford District Council.....	„ 6	706	+ 87	18	9,995	+ 510
Ilkeston District Council ..	„ 3	164	..	18	2,335	— 114
Ipswich Corporation	„ 6	780	+ 176	18	8,101	+ 493
Isle of Thanet Co.	..	..	..	..	..	..
Jarrow	July 29	139	+ 19	30	3,638	+ 209
Keighley Corporation.....	Aug. 3	188	+ 25	18	3,256	+ 124
Kidderminster & District ..	July 29	124	— 2	30	3,074	+ 64
Kilmarnock Corporation ..	Aug. 6	169	+ 8	12	1,946	+ 37
Lanarkshire Trams Co.	„ 4	1,317	— 77	31	42,587	+ 3,788
Lancashire United	„ 3	1,572	+ 145	31	40,307	— 215
*Leamington	July 29	196	— 8	30	4,792	— 190
Leeds Corporation	Aug. 6	7,859	— 124	18	131,752	+ 4,921
Leicester Corporation.....	„ 6	2,659	+ 14	..	..	..
Leith Corporation	„ 6	676	— 16	12	7,822	+ 140
Lincoln Corporation	„ 6	133	— 4	19	2,367	— 70
Liverpool Corporation	July 30	11,534	+ 391	30	333,527	+ 12,856
Liverpool Overhead Rly. ...	Aug. 7	1,707	+ 48	6	8,974	+ 37
Llandudno&ColwynBayRy.	..	..	..	..	..	..
*London County Council	July 27	41,445	+ 5,347	¶17	711,507	+ 98,399
London Elec. Ry. Co.....	Aug. 6	11,500	+ 605	5	60,970	— 310
London United	„ 6	9,594	+ 644	31	196,921	+ 10,073
Lowestoft	„ 6	491	+ 85	45	7,667	+ 410
Maidstone Corporation	„ 6	277	+ 8	18	3,310	— 194
Manchester Corporation....	„ 6	16,338	+ 387	18	285,018	+ 5,454
Mersey Railway	„ 6	2,033	+ 27	5	9,951	+ 139
Merthyr	July 29	206	— 2	30	6,101	— 205
Metropolitan Dist. Railway..	Aug. 6	9,892	+ 1,062	5	53,396	+ 3,384
Metropolitan Elec. Trams ..	July 29	7,636	+ 1,184	30	219,319	+ 39,289
Middleton	„ 29	334	+ 4	30	9,370	— 563
Nelson Corporation.....	Aug. 6	170	+ 3	§18	2,697	+ 75
Newcastle-on-Tyne Corp. ..	„ 6	4,558	+ 603	¶18	74,003	+ 822
Newport (Mon.)	„ 6	837	+ 44	19	13,215	+ 498
Northampton Corporation..	„ 6	753	+ 14	§18	9,255	+ 13
Oldham, Ashton & Hyde ..	July 29	570	+ 10	30	16,514	— 69
Oldham Corporation	Aug. 7	1,857	— 195	19	36,039	— 1,013
Perth (N.B.) Corporation ..	„ 3	205	+ 2	§11	2,063	+ 143
Perth (W.A.) Elec. Trams ..	..	..	..	..	..	..
Peterborough	July 29	130	— 1	30	3,362	— 49
Portsmouth Corporation ..	Aug. 6	3,328	— 332	18	38,918	— 1,727
Potteries	July 29	1,793	+ 7	30	52,279	— 498
Preston Corporation	Aug. 3	751	+ 22	18	13,261	— 228
Rotherham Corporation....	„ 4	720	+ 87	18	11,232	+ 392
Rothesay	July 29	556	+ 47	30	5,755	+ 198
Salford Corporation	Aug. 8	4,827	— 125	‡19	87,699	+ 857
Sheerness	July 29	69	+ 13	30	1,435	— 40
Sheffield Corporation	Aug. 7	6,162	+ 276	¶19	115,528	+ 6,548
Singapore Trams.....	„ 6	$10,098	+ $328	5	$39,670	+ $3,136
South Metropolitan.....	July 29	818	+ 11	30	24,090	+ 1,216
South Staffs.....	„ 29	870	+ 46	30	24,749	+ 61
Southend Corporation	Aug. 3	1,253	+ 292	18	10,972	+ 893
Southport Tramways	July 29	343	+ 3	30	8,548	+ 230
Stalyb'dge,Hyde,&c.,Jt.Bd.	Aug. 6	825	— 43	¶18	13,394	— 1,099
Sunderland Corporation....	..	..	..	..	..	..
Sunderland District	„ 3	670	— 80	40	17,014	— 1,284
Swansea Trams	July 29	1,159	+ 151	30	31,509	+ 3,738
Swindon Corporation	Aug. 5	197	+ 28	..	..	..
Taunton	July 29	45	+ 2	30	1,235	+ 124
Tynemouth and District....	„ 29	380	+ 5	30	6,981	+ 481
Tyneside Trams Co.	Aug. 3	650	+ 108	5	2,589	+ 206
Wallasey District Council ..	„ 6	1,337	+ 73	§18	17,870	— 118
Walsall Corporation	„ 6	668	+ 23	31	16,594	+ 754
Warrington Corporation....	..	..	..	..	..	..
West Ham Corporation	July 28	2,482	+ 168	17	42,272	+ 1,332
Weston-super-Mare	„ 29	264	+ 15	30	3,449	+ 119
Wolverhampton Co.	„ 29	427	+ 3	30	12,568	+ 262
Wolverhampton Corpn.	Aug. 3	1,147	+ 190	18	17,250	+ 2,618
*Worcester	July 29	322	+ 1	30	8,162	+ 181
Wrexham	„ 29	99	+ 2	30	2,868	+ 14
Yorkshire W.R. Trams	Aug. 7	1,698	— 204	32	39,459	..
Yorkshire Woollen District..	July 29	1,186	+ 67	30	29,288	+ 2,594

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	NAME.	Price Wed., Aug. 10.	Rate per cent. Yielded.	Dividend Due.	Business Week to Aug. 10. Highest.	Business Week to Aug. 10. Lowest.
		Electricity Supply.		£ s. d.			
10	6/0	Bournemouth & Poole Elec. Sup. Ord.	9 —9¼	5 15 6	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.....	9¼—9½	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10¼—10½	5 11 6	Feb, Aug	10⅜	10¼
St.	4¼%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	102½	102
5	5/6	Brompton & Kensington Elec. Sup. Ord. ..	7¼—7⅝	6 11 0	March....	7⅝	7½
5	3/6	Do. 7 per Cent. Pref.....	7 —7½	4 13 6	Mar, Sept	7⅞	7⅝
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¼—4	6 5 0	Feb, Aug	3½	3⅜
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 14 6	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99½—101⅛	4 8 6	..	101	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¾—4⅛	5 9 6	Jan, July	3 1/16	..
5	2/6	Chelsea Electric Supply Ord.....	3¾—4¼	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	†City of London Electric Lighting Ord.	11¼—11⅝	6 8 6	Feb, Aug	11⅞	..
10	6/0	† Do. 6 per Cent. Cum. Pref.	11½—12¼	4 18 0	Jan, July	11⅛	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 —124	4 0 6	June, Dec	121	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99½—102½	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.....	1¼—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾—3¼	7 14 0	April, Oct	..	..
10	4/0	†County of London Elec. Supply Ord.	7⅜—7⅝	6 7 6	Feb, Aug	7⅝	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½—11	5 9 0	Mar, Sept	10⅞	10½
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104 —107	4 4 0	Jan, July	106¼	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	102	101½
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4½	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	101 —104	4 6 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.....	7 —7⅛	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.....	7 —7⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅞—6¼	4 18 0	Jan, July	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	5⅛—5⅜	5 13 0	Mar, Sept	5⅜	5⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	90	..
5	2/6	Metropolitan Electric Sup. Ord.	3¼—3⅜	6 2 0	April, Oct	3⅛	3⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.....	4 —4¼	5 0 0	Jan, July	4⅛	4⅛
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95⅛—97⅛	4 12 6	June, Dec	..	..
5	1/6	†Newcastle Elec. Supply Ord.....	3¼—4¼	4 14 0	Feb, Aug	..	..
5	5%	†Do. 5 per Cent. non Cum. Pref.	4¼—4½	5 5 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	100	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	5⅜—6⅛	5 3 0	March	..	..
5	5/0	†St. James' & Pall Mall Elec. Ord.....	7⅜—8⅛	6 1 0	Feb, Aug	7⅞	..
5	3/6	†Do. 7 per Cent. Pref.....	6¼—7⅛	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2⅛—2⅜	6 18 0	April	..	..
St.	5%	Do 5 % 1st Mort. Stock (red.).....	99 —102	4 18 0	..	101½	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅞—1	..	..	..	..
1	0/8⅓	Do. 7 per Cent. Cum. Pref.	1⅛—1 1/16	6 12 0	Feb, Aug	1	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.).....	98 —101	4 9 0	April, Oct	99	98
5	2/6	Urban Electric Supply Ord.	½—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	†Westminster Elec. Sup. Ord.....	6⅛—6⅜	5 16 0	Mar, Sept	8⅜	8⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5⅛	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	94 —96	4 3 6	Jan, July	95	..
1	..	Bath Elec. Trams Pref. Ord.....	⅛—3/16	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	1/16—⅛	6 12 9	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.).....	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	81½	80
10	6%	†Bristol Tramways & Carriage Ord.	6¼—6⅝	8 18 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7⅛—7⅜	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¼ —1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅛—3⅛	..	Feb, Aug	2 1/16	..
St.	5%	Do. 5 per Cent. Perpetual Debs.....	86 —90	5 11 0	April, Oct	89⅛	86
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	68 —73	6 3 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	66 —68	4 9 0	Feb, Aug	67	..
St.	4%	Do. 4 per Cent. Pref. Stock	86 —88	4 11 0	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	94 —96	4 4 0	Jan, July	94½	94
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5¼	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	†City & South London Rly. Con. Ord. ..	27⅛—28⅛	5 5 0	Feb, Aug	28	27⅛
St.	5%	†Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	†Do. (1896)	102 —104	4 16 0	Feb, Aug	101	100
St.	5%	†Do. (1901)	99 —102	4 18 0	Feb, Aug	101	99½
St.	5%	†Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.....	99 —101	3 19 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.....	13 —14	4 5 9	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8⅛—9⅛	4 14 0	Feb. Aug	8⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 —96	4 4 0	Jan, July	95	93½
5	..	Hastings & District Elec. Trams, 6% C. P.	⅝ —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3¼—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1 1/16—1⅛	4 4 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	67 —72	5 11 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9 1/16—10 1/16	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —86	5 16 0	Jan, July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	67 —71	5 12 6	Jan, July	69⅛	68⅛
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.....	⅞—15/16	..	..	1/16	⅞
1	..	Do. Deferred	1/16—⅛	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	5 9 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	96 —99	4 11 0	Jan, July	..	..
St.	..	Do. 5 per Cent Db. Stk	94½—96½	..	..	96½	..
St.	1½%	†Metropolitan Railway Consolidated.....	38 —38½	2 18 0	Feb, Aug	38⅜	37⅛
St.	2½%	†Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	66½	66
St.	3½%	†Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	87½	..
St.	3½%	†Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	84½	84
St.	3½%	†Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	..	..
St.	3½%	**Do. 3½ per Cent. Debenture Stock .....**	91 —93	3 15 6	Jan, July	91½	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

Google

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Electric Railways and Tramways—*Continued.*

Shre.	Last Dividend	Name	Price Wed. Aug. 10	Rate per Cent. Yielded (£ s. d.)	Dividend Due	Business Week to Aug. 10 Highest	Business Week to Aug. 10 Lowest
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	90 —92	3 15 6	Jan, July	91½	90½
St.	..	Metropolitan District Railway Ord.	20 —20½	..	Feb, Aug	20½	20
St.	..	Do. Extension Pref. (5 per Cent.)	69 —71	..	Feb, Aug	70½	70
St.	3½%	†Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	70 —72	4 17 0	Feb, Aug	71½	70½
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	75½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	99 —102	3 18 6	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	102 —104	3 17 0	Mar, Sept	103½	102½
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	140 —142	4 4 6	Jan, July	141½	141
St.	4%	Do. 4 per Cent. Ditto	94 —96	4 3 6	Jan, July	95	..
1	4½d.	Potteries Electric Traction Ord.	[illegible]	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	[illegible]	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock	82 —85	5 5 3	May, Nov	82	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	[illegible]	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoup5	37 —39	..	June, Dec	39	36½
..	5%	Do. 5% Prior Lien Bonds	102½—103½	4 16 6	..	..	..
..	4½%	Do. 4½% Bonds with coup. 6	87 —89	5 1 0	..	88	87
..	4%	Do. 4 per Cent 1st Power Ho. Dbs.	98 —100	4 0 0	..	99½	99½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	[illegible]	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	77 —80	5 12 6	Jan, July	..	..

Electric Manufacturing, &c.

Shre.	Last Dividend	Name	Price Wed. Aug. 10	Rate per Cent. Yielded (£ s. d.)	Dividend Due	Business Week to Aug. 10 Highest	Business Week to Aug. 10 Lowest
St.	4½%	Ancho Cable Co. 4½ % Deb. Stock	99½—101½	4 8 6	..	..	..
1	..	Aron Electricity Meter Ord.	[illegible]	..	..	..	..
1	1/9½	Do. 6% Cum. Pf.	[illegible]	6 16 3	April, Oct	5[illegible]	5½
1	3/2½	Babcock & Wilcox Ord.	5½—5½	5 7 6	April, Oct	..	..
1	0/7½	Do Pref.	1⅛—1⅛	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7½	6 18 0	July, Feb	7½	6[illegible]
5	3/0	†Do. 6 per Cent. Pref.	5½—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	103½	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	[illegible]	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	99½—101½	5 19 0	..	100½	100½
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	61 —63	3 3 6	Jan, July	..	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	23 —27	16 12 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9 —10	7 10 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4½—5½	4 15 0	Jan, July	4½	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	100½—102½	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.	[illegible]	5 0 0	May, Nov	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.)	104 —107	4 4 0	Feb. Aug	..	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅛	5 19 0	March ..	..	..
1	0/7½	Consolidated Electrical Co.	[illegible]	5 18 0	August ..	..	..
1	0/6	Consolidated Signal Co.	[illegible]	5 12 9	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	[illegible]	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	[illegible]	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	84 —87	5 15 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¾—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	1 —1½	5 7 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1½	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	[illegible]	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1½	9 3 0	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	[illegible]	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—1½	..	May, Nov	..	..
St.	4½%	Do 4½ per cent. 1st Mort. Deb. (red.)	75 —76	5 18 0	Jan, July	76	..
2	..	Electric Construction Co.	[illegible]	..	Jan, July	[illegible]	..
2	2/9½	†Do. 7 per Cent. Cum. Pref.	1½—1½	4 13 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs	59 —61	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	12 —12½	5 17 6	Feb, Aug	12½	..
5	2/3	Do. 4½ per Cent. Pref.	4½—5½	4 5 9	Feb, Aug	5[illegible]	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105 —107	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works	14½—15	6 12 0	Feb, Aug	15½	..
10	5/0	Do 5 per Cent. Cum. Pref.	10½—10½	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	98½	..
1	..	National Elec. Construction Co.	[illegible]	..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	[illegible]	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	33½—35½	3 19 6	Mar, July	35½	34½
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99½—101½	3 18 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord	2⅛—2⅛	4 5 0	..	2½	2
1	0/6	Do 5 per Cent. non-Cum. Preference	1⅜—1½	4 0 0	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 3	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	104 —106	4 14 3	..	104½	..
10	10%	J. G. White & Co. 6% Cum. Pref.	12½—13½	7 8 0	..	12½	..
1	..	Willans & Robinson Ord.	[illegible]	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1½—1½	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	60 —70	5 14 0	May, Nov	..	..

Telegraphs.

Shre.	Last Dividend	Name	Price Wed. Aug. 10	Rate per Cent. Yielded (£ s. d.)	Dividend Due	Business Week to Aug. 10 Highest	Business Week to Aug. 10 Lowest
10	..	Amazon Telegraph	3½—3½	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan, July	..	..
St.	15/0	†Anglo-American	64½—66½	5 9 0	F,My,Ag,N	..	..
St.	30/0	†Do. Preferred	106½—108½	5 11 0	F,My,Ag,N	107½	106½
St.	25/0	Do. Deferred	26½—26½	4 14 0	F,My,Ag,N	26[illegible]	25
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	84 —86	4 13 0	Jn,Ap,Jy,O	85	83½
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 15 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3½—3½	5 14 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	99 —101	4 19 0	Jan, July	..	..
20	6/0	†Direct United States Cable xd & bonus	14½—15½	5 18 0	Ja,Ap,Jy,O	15⅛	14½
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.)	99 —101	4 10 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	132 —135	5 4 0	Ja,My,Jy,O	134½	132½
St.	17/6	Do. 3½ per Cent. Pref. Stock	84 —86	4 1 6	Ja,My,Jy,O	85½	84½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	102 —104	3 16 0	May, Nov	..	..
St.	2/6	Eastern Extension	12½—12½	5 15 0	Ja, Ap,Jy,O	12½	12[illegible]
100	4%	†Do. 4 per Cent. Deb. Stock	99 —102	3 18 0	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	100 —102	3 18 0	May, Nov	..	..
10	5/0	G.N (of Copenhagen), with Coupon 80	29½—30½	5 15 0	Jan, July	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	54½	..
100	5%	Mackay Companies Common	84 —88	5 14 0	Ja,Ap,Jy,O	..	..
100	4%	Do. Preference	74 —73	5 2 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	[illegible]	..	April	[illegible]	[illegible]
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	96½—98½	4 2 0	June, Dec	..	..
[illegible]	[illegible]	West Coast of America	1½—1½	3 12 9	May	..	..
[illegible]	[illegible]	[illegible] per Cent. Debs.	96½—98½	4 2 0	Jan, July	..	..
[illegible]	[illegible]	[illegible] Panama	[illegible]	..	May, Nov	[illegible]	..
[illegible]	[illegible]	[illegible] 1st Pref.	8½—9	6 12 6	May, Nov	..	..
[illegible]	[illegible]	[illegible]	8 —9	6 13 6	May, Nov	..	..
100	[illegible]	[illegible] Debs.	99½—101½	4 19 0	Jan, July	..	..
10	3/0	Western [illegible]	[illegible]	5 0 0	Mr,Jn,O,D	13½	..
St.	4%	Do. 4 per [illegible] Deb. Stock (red.)	[illegible]	4 19 0	June, Dec	..	..
–	4%	Western Union [illegible]	[illegible]	[illegible] 15 3	[illegible]	..	..
..	4½%	Do. $1,000 4½% [illegible]	[illegible]	[illegible]	[illegible]	..	..

Telephones.

Shre.	Last Dividend	Name	Price Wed., Aug. 10	Rate per Cent. Yielded (£ s. d.)	Dividend Due	Business Week to Aug. 10 Highest	Business Week to Aug. 10 Lowest
100	2$	Amer. Telephn. & Telegh. Cap. St.	135 —138	5 16 6	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	91 —93	4 6 0	Jan. July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	103 —105	3 16 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —103	4 17 0	Mar, Sept	..	..
5	5/0	†Chili Telephone	9 —9½	4 4 0	August ..	9½	..
1	0/7½	Monte Video Telephone Ord.	[illegible]	5 9 0	Nov	[illegible]	..
1	0/6	Do. 5 per Cent. Pref.	[illegible]	5 13 9	May, Nov	..	..
St.	6%	National Co. Pref. Stock	107 —108½	5 11 0	Feb, Aug	103½	106½
St.	6%	Do. Def. Stock	126½—128½	4 13 3	Feb, Aug	128½	126½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10½—11	5 9 0	Feb. Aug	10½	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10½—11	5 9 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5½—5¾	4 7 0	Feb, Aug	5[illegible]	5¾
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	97½—99½	3 10 6	June, Dec	99½	99½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	98½—100½	3 19 6	Jan, July	99½	98½
.	4½%	New York Telephone Co. 30 yr. Bnds.	98 —99	4 11 0	..	..	..
1	1/0	Oriental	1[illegible]—1[illegible]	4 15 0	April, Oct	..	..
1	0/7½	Do 6 per Cent Cum. Pref.	1⅛—1⅛	4 11 6	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	80 —86	4 11 0	Jan, July	87½	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	98 —100	4 10 0	Jan, July	..	..
5	5/0	†United River Plate Ord. ex rights	6½—7½	5 12 3	July	7½	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅛	4 14 9	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.	101½—103½	4 7 0	Jan. July	102½	..

Financial, Investment, &c.

Shre.	Last Dividend	Name	Price Wed., Aug. 10	Rate per Cent. Yielded (£ s. d.)	Dividend Due	Business Week to Aug. 10 Highest	Business Week to Aug. 10 Lowest
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	2½—3½	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10½—10½	5 8 3	Sp,DcMrJu	10[illegible]	10⅛
10	3/0	Do. 6 per Cent. Pref.	13 —13½	4 9 0	Sp,DcMrJu	13½	13[illegible]
10	6%	Submarine Cables Trust (Cert.)	129 —132	4 12 0	April, Oct	..	..

Colonial and Foreign Electric Railways, Tramways, &c.

Shre.	Last Dividend	Name	Price Wed., Aug. 10	Rate per Cent. Yielded (£ s. d.)	Dividend Due	Business Week to Aug. 10 Highest	Business Week to Aug. 10 Lowest
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4[illegible]—4[illegible]	5 10 0	April, Oct	4[illegible]	4[illegible]
5	2/6	Do. 5% Cum. 2nd Pref.	4½—4½	5 14 0	Jan, July	..	..
St.	4%	Do 4% Deb. Stock	90 —91½	4 7 6	June, Dec	91½	90½
St.	4½%	Do. 4½% Deb. Stock	93½—96½	4 13 6	..	95½	94½
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	103 —105	4 15 3	Jan, July	..	..
5	4/6	Brisbane Electric Trams. Invest. Ord	6½—6½	4 11 3	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4½—5½	4 15 0	May, Nov	5[illegible]	4½
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	99 —102	4 8 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	141 —146	5 12 0	Mar, Sept	..	..
St.	£3	†Do. Pref. Ord. Stock xd & bonus	123 —127	4 14 6	May, Nov	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	108½—111½	4 11 0	Jan, July	111	109½
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	103½—105½	4 0 0	..	105	104½
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99 —102	4 18 0	Mar, Sept	100	..
St.	6%	†Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	..	..
5	2/6	Calcutta Tramways (1 to 137,610)	4 —4½	5 0 0	Mar, Sept	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4½—4½	5 2 6	Jan, July	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red)	96 —99	4 11 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	[illegible]	..	..	..	..
5	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5½—5½	4 5 0	F,My,A,N	5[illegible]	3[illegible]
St.	4%	Do 4 per Cent. Deb. Stock	98 —101	4 0 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	95 —98	5 2 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	96 —99	5 1 0	Feb, Aug	98½	..
1	..	Kalgoorlie Elec. Trams Sh.	[illegible]	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	92 —95	5 5 0	Jan, July	94½	..
5	6%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	Lisbon Elec. Trams. Ord.	1½—1½	4 8 0	July	1[illegible]	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1½—1½	4 16 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	97½—101½	4 18 6	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	..	..
100	5%	Manaos Trams and Lt. Co. 5% Debs	87 —88½	5 13 0	..	87½	..
..	5%	Manila Elec. Ry. $1,000 Gold Bonds	98 —103	5 2 0	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	118 —120	5 17 0	..	120½	118½
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	99 —100	5 3 0	..	99½	98½
St.	6%	Do. 6% 50 yr. Mort. Bds.	97½—98½	6 2 0	..	98½	97½
St.	4½%	†Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	100 —102	4 8 0	Feb, Aug	..	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	103½	103½
1	0/6	Perth Elec. Trams Ord.	[illegible]	5 15 5	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5½—5½	5 2 6	..	5½	5½
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	101½	101
100	$1½	Rio Janeiro Tram, Lt. & P. Co.	90 —92	4 12 3	..	91½	88½
..	5%	Do. 30 yr. Gold Bnds.	97½—98½	4 1 6	..	98½	97½
100	5%	Do. 50 yr. Mt. Bnds	88½—89½	5 12 0	..	89½	88½
..	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	142 —144	7 2 6	..	144½	143
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102½	101½
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	101 —103	4 7 6	Feb, Aug	..	..

Colonial and Foreign Electricity Supply, &c.

Shre.	Last Dividend	Name	Price Wed., Aug. 10	Rate per Cent. Yielded (£ s. d.)	Dividend Due	Business Week to Aug. 10 Highest	Business Week to Aug. 10 Lowest
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—5½	5 2 0	Mar, Sept	..	..
10	6/0	†Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 11 0	..	..	..
St.	4½%	Do 4½ per Cent. Deb. Stk. (red)	93 —95	4 15 0	Jan, July	94½	93
..	5%	Do 5 per Cent. 2nd Mort. Deb. Stock	97 —99	5 1 0	..	98½	..
5	4/9	Calcutta Elec. Supply Ord.	6½—6½	6 6 0	April, Oct	..	..
100	7/2½	Canadian Gen. Elec. Co. Com. St.	103 —107	6 8 6	..	106	105½
100	$3½	Do. 7% Cm. Pf. Stock	122 —125	5 12 0	..	123½	122½
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
500	5%	Elect. Development Co. of Ontario	85 —88	5 12 6	..	86½	85
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—1½	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	8 0 0	April, Oct	..	..
..	5%	Kaministiquia Power Co.5% Gold Bnds.	100 —102	4 18 0	..	101½	..
5	..	Madras E. S. Corp. Ord.	2½—3	..	..	..	..
St.	..	Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock	90½—92½	5 9 0	..	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	85 —86	5 16 0	..	85½	85
St.	$1	Mexican Lt. & Power Co. Com. St.	77 —79	5 1 0	..	78½	79
St.	$3½	Do. 7% Cum. Pref. St.	101 —103	6 16 0	..	102½	102
500	5%	†Do. 5% 1st Mort. Gold Bnds.	93 —94	5 5 0	..	93½	92
100	$1½	†Montreal Lt. Ht. & Power Co. Cap. St.	128 —132	5 6 0	F,My,A,N	131½	..
St.	£9	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	218	..
St.	6%	Do. 6 per Cent. non-Cum. Pref. Stk.	105 —115	5 5 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
5	3/0	Rosario Ele . Co. Ord.	8½—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
5	3/0	Do 2nd Pref.	8½—8½	6 14 6	..	..	..
100	$1	Shawinigan Water& Power Co.Ca	97 —98	4 2 0	..	99½	..
..	5%	Do. 5 per Cent. Bds.	106 —108	4 12 6	Jan, July	108	107
St.	4½%	Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	101½	..
St	4½%	Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	101½	100
..	6d.	Victoria Falls Power Co. Pref.(1 to 808,000)	[illegible]	5 6 6	Jan, July	..	..
1	..	Do. (803,081 to 1,700,000)	[illegible]	..	..	..	..

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,683. [No. 19. Vol. LXV.] FRIDAY, AUGUST 19, 1910. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

International Electrotechnical Commission.

THAT the deliberations of the International Electrotechnical Commission have so far been productive of but small results, at any rate of a practical nature, is doubtless largely due to the comprehensive nature of the Commission, most of the important countries of the world being now represented at its Conferences. Progress, however, is nevertheless being made; and from our report of the proceedings at the unofficial Conference held at Brussels last week it will be seen that several decisions of considerable importance to electrical engineers are likely to be reached at the formal meeting of the Commission next year. In fact, the proceedings were so harmonious that the various proposals discussed will probably be adopted, without any serious alterations, by the various national Committees, and further matters will, doubtless, come up for consideration at the formal meeting next year after these proposals have been officially promulgated.

ONE of the most important subjects dealt with by the members last week was the question of symbols. The great disparity shown in those adopted by authors in different countries, and even in the same country, leads to much confusion, so that uniformity is much to be desired. In this connection it will be seen that, besides suggesting definite principles as to the use of capital, small and script letters, and in the use of the suffix "*m*," the Conference proposed the adoption of eight symbols, subject, of course, to the approval of the various Committees and of the official delegates next year. It may at first seem curious that μ is not included in the list of symbols, as it is practically universally used to denote permeability, but in view of the fact that its use in this connection will probably continue, and that it would form an exception to a principle likely to be introduced at a later date—viz., that Greek letters should be reserved for angles—it was considered desirable to omit μ from the list of symbols at present suggested. The proposed adoption of a standard direction of rotation for vectors is also worthy of note. We believe that opinion generally favours the anti-clockwise direction, which is in keeping with trigonometrical notation, although several writers have adopted the opposite method of representation.

ONE result of the unofficial Conference is that the full meeting of the Commission, which it had been arranged should be held at Berlin next year, will probably take place at Turin at the same time as the Electrical Congress which is to be held in connection with the Turin Exhibition. Members of the Commission will appreciate the courtesy of the German Committee in falling in with the proposed alteration in the place of meeting. An Electrical Congress is frequently associated with an international exhibition, but does not usually receive adequate official recognition; it is to be hoped, therefore, that co-operation will be possible between these two electrical bodies, to the advantage of both.

WE may also draw attention to the fact that a special invitation was issued to the secretary of the Engineering Standards Committee to be present at the meeting last week. In this connection, it will be remembered that Sir JOHN GAVEY and Dr. R. T. GLAZEBROOK were recently nominated to represent the Engineering Standards Committee upon the British Committee of the Electrotechnical Commission. This is extremely gratifying, for it evidences a desire on the part of the British Electrotechnical Committee to work in harmony with the Engineering Standards Committee. It may therefore be pre-

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sumed that the excellent work already carried out by the Electrical Section of the latter body will be of great utility in forming the basis of the recommendations of the British section of the Commission when electrical machinery is under consideration. Moreover, it should further the recognition of the work of the Engineering Standards Committee.

The Association of Consulting Engineers.

THE chief bone of contention at the present moment in regard to the formation of the Association of Consulting Engineers is the question of qualification for membership. For the moment, membership is restricted to those who are corporate members of the Institution of Civil Engineers and also of the institution representing the particular branch of the profession in which they practice. In our correspondence columns this week Mr. H. LAWS WEBB questions the wisdom of such a rule, and this point has also been raised in other quarters. On a previous occasion we have expressed the view that any such rule would not be rigorously enforced, and we think it is only necessary for us to refer our readers to the official memorandum published last week, wherein it is stated that "*at present*" the membership is confined to those so qualified, for confirmation of our views. Mr. WEBB very rightly states that the man who has spent his life in some special line of work is better qualified than the average corporate member of the "Civils"; and we do not doubt that this point is in the minds of those most closely connected with the new Association. Obviously, the specialist should be welcomed by the Association; we would go further, and say that the specialist should give his whole-hearted support to the movement, for it is only by unanimous co-operation that the greatest benefit will result, and the profession of consulting engineering be given a proper status in this country.

IF only the critics of the rule in question will look at the matter broadly, we think they will find some wisdom in the course that has been followed. Reading between the lines of the official statements, it will be gathered that the required qualifications were so framed in the first instance as to make selection, or rejection as simple as possible. It may be contended that the experience and examination required by the "Civils" really count for very little in such a case. There may be some truth in this contention; but, in combination with other qualifications, they postulate a certain breadth of training, and the fact remains that most of the leading consultants *are* corporate members of the "Civils." It should be remembered that the formation of a society of this kind is not an easy matter, and that the elected committee have barely got to work. It would have been a fatal mistake to begin with a low standard, whereas to begin with a high standard (even if somewhat arbitrary), and then to adjust matters so that no injustice is done, is by far the safest course. For the success of the Association it is essential that the whole body of members should be satisfied that the members admitted are in every sense desirable; and, in working towards that ideal, we think the provisional committee were wise in adopting a rule which can, and must, be relaxed as soon as the Association gets into working order.

Brussels Exhibition Fire.

THE latest reports from Brussels as to the cause of the recent disastrous fire at the International Exhibition afford a complete refutation of the early report that the conflagration was of an electrical origin. The well-worn phrase, "the fusing of an electric wire," has been given very little prominence in the daily papers, and they must be complimented upon the exercise of a reserve which can only be characterised as remarkable, particularly in view of the magnitude of the electrical installation at the Brussels Exhibition, and the necessarily temporary nature of all the work. This reticence was, however, not imitated by our gas contemporaries, who, accepting a hurried and meagre report, announced to the skies the dangers of electric lighting. We deal with the details of the fire in another column, and it will be seen to reveal a sad, not to say criminal, lack of organisation in the Exhibition Fire Department, while they hint strongly at extreme laxity in the enforcement of the regulations regarding smoking in the buildings.

IT is unfortunate that such heavy loss has been inflicted on British exhibitors, especially as the majority of them had been persuaded to exhibit in the British section by the efforts of the Board of Trade Exhibition Department. The Commissioner-General, Mr. WINTOUR, and his assistants are to be commiserated on so untimely an end to their splendid efforts in making a thoroughly representative collection of British industrial and art exhibits. Still, the disaster has its lessons, dearly as they have been purchased. One of the most important of these, and one which strongly impresses itself upon us, is the folly—it can be given no other name—of massing the exhibits of a number of countries into what is virtually a single building. The Belgian, French, British and Italian exhibits were under cover of a contiguous series of buildings, and an outbreak of fire, unless promptly dealt with, would, as it has done, involve the entire series of structures. Absolute independence is the only safe plan upon which buildings should be laid down in exhibitions. The Germans adopted this method at Brussels, and their entire exhibit, self-contained and practically standing in its own grounds, remains to-day a striking monument either to their good luck or good judgment—more probably the latter. Had the British section been similarly dealt with there would be no national loss to mourn at this moment, and on parsimonious Government policy to deplore. However, no such calamity must overtake the British section at the Turin Exhibition to be held next year, and no doubt the Commissioner-General will see that there is no possibility of it.

Street Lighting in Westminster.

IT will be remembered that a month or two ago the Westminster City Council entered into fresh contracts with the Gas Light and Coke Company for the illumination of certain streets within the city area. Most of these streets are already lighted by gas, but one, Regent-street, has for some time been illuminated by a modern type of flame arc lamp. The electricity supply authorities were, it is true, also asked to tender for the lighting of the areas concerned, but the prices sent in by them were consider-

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ably higher than those of the gas companies for an equal candle-power, and on these grounds, therefore, the tenders were not successful. At the time we went carefully into the question and formed the opinion that the prices quoted by the gas company not only left them no margin of profit but would involve them in a heavy loss—only 5½d. per 1,000 cubic feet being charged for gas, or about one-fifth of the *standard* price. It was evident, in fact, that they were determined to retain the street lighting at all costs, and to do this were willing to expend a large sum on what was really a form of advertising. These conclusions have turned out to be well founded, and during the last few days inspired paragraphs have been appearing in the daily papers stating that gas is to *supplant* electricity as a street illuminant in the business thoroughfares of the City of Westminster, except in the parish of St. George's, Hanover-square, and that this supersession is due to the fact that gas is from 30 to 50 per cent. cheaper than electricity. The insidiousness of these statements is evident; obviously it is not possible to supplant what was never there. In the whole area referred to something less than 100 arc lamps are to be removed in favour of gas, and, further, this form of lighting is only from 30 to 50 per cent. cheaper than electricity when the prices given in the Westminster tenders are taken as a basis of comparison.

A paragraph of the kind mentioned above, appearing in a widely read daily paper, is likely, and is probably intended by its inspirers, to cause a good deal of harm to the progress of electric lighting. It is, therefore, well that supply engineers and others who cater for public needs in the matter of electric light should be acquainted with the real nature of the campaign now being conducted by the gas interests, and should be prepared to controvert with figures such statements as those to which we have called attention. Our gas friends desire to have it both ways. They are willing, and are being allowed, to light Regent-street and Piccadilly with high-pressure gas at a wholly unremunerative price purely for the sake of advertisement. At the same time they wish it to be believed that they are doing this work at a profit, and are consumed with anxiety to persuade an unsuspecting public that some recent wonderful inventions in gas mantles have made this possible. But the "unsuspecting public" must be disillusioned. It is the duty of all who wish to further the cause of electricity supply to adopt for the nonce the rôle of the Ancient Mariner; and under those ghastly mantles which, unfortunately, we shall soon see in Regent-street, inform the world at large that this wonderful illuminant, of the supposed cheapness of which we hear so much, is only cheap when the customer is the street authority, and is both inefficient and expensive to the private individual.

Multiple Reflections of Short Electric Waves.—In a recent issue of the "Physical Review" Messrs. L. E. Woodman and H. W. Webb describe an investigation of the multiple reflections of short electric waves between two or more reflecting surfaces. The conclusions reached are summarised as follows:—(1) A Righi vibrator of small dimensions mounted with no oil holder surrounding the balls and with as little dielectric as possible in front of the aperture of the mirror and placed at the focus of a paraboloid of revolution acts very nearly like a point source and gives very nearly a parallel beam of energy. (2) The tuning curves as well as the wave-length curves show that the radiation from a Righi vibrator consists of a short spectrum of wave-lengths, and that the maximum on the tuning curves is governed within the limits of this spectrum by the peculiarities of the receiver. (3) The non-selective receiver is far superior for all work involving the determination of wave-lengths or the tuning of resonators pasted on screens and placed in the path of the incident energy. (4) The intensity of the transmitted and reflected energy passes through a series of maxima and minima as the distance between the reflecting surfaces is increased through a small number of wave-lengths (this agrees well with the theory as worked out for optics). (5) A screen of resonators acts like a selectively reflecting surface for waves very nearly in resonance with the resonators. This was tested by determining the wave-length of the transmitted beam as well as of the reflected beam. These were found to check at least qualitatively with what one would expect from a consideration of an assumed emission curve for the vibrator combined with an assumed transmission curve for the screen of resonators. (6) With a tuned receiver *extra-transmission* may be expected for plates of glass of the proper thickness and of the proper dielectric constant and for wave-lengths within proper limits. (7) The transmittivity of a glass plate of a given thickness and given dielectric constant depends upon the wave-length of the incident energy. (8) The change of phase due to reflection is not a constant, but varies with the length of the resonators pasted on the reflecting surface.

Electric Traction in Pittsburg.—Following on his report on this subject, a summary of which was published in our issue of August 5th, Mr. B. J. Arnold has now issued some further notes after a consideration of the various problems involved. The questions discussed are mostly to do with traffic, and include the author's view on how best the municipal authorities, the public and the tramway company can work together to obtain the most satisfactory service. His conclusions are: The public should learn to recognise that empty seats cost as much to operate as occupied seats, that a seat for every passenger during the rush hours must mean the curtailment of the service during the non-rush hours, and that new cars and new tracks cannot be furnished until the old rolling stock has been in service a reasonable length of time. The company should adopt the policy of trying continually to please the public, and should arrange their schedules and routes to accommodate the greatest number. If the best service can be rendered by establishing through routes and giving transfers, these methods should be adopted in an effort to increase gross earnings by making it easy to ride. The municipal authorities should co-operate with the company on street traffic regulation, widening the streets where necessary and issuing permits for extensions and new connections which are absolutely necessary for the best routing system. Unnecessary taxes and the burden of paving maintenance should be removed in the interest of allowing more money for better service. The property owner should recognise that the general prosperity of the entire district is not only vital to him but to others, and that routes and extensions cannot be controlled for his particular benefit. The financier must realise that the day for exploitation of established enterprises has passed, and that the fixed charges on such properties must be reduced to a fair return on the actual investment. New capital which is absolutely necessary for the continued life and usefulness of any public utility must be furnished, and this flow of new blood should be supplied in advance of actual needs, if it is to have a strengthening influence on the system. Economy and a continuation of an equitable balance dictates efficient management, and the setting aside out of earnings each year of a fund to provide for renewals. These conclusions are not unworthy of general attention in this country, where the tramway company is too often bled by the local authority, and the service conducted irrespective of the requirements of the public.

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Constantinople.—The Chirket-i-Hairie Co., of Constantinople, have decided to rebuild and re-equip their shipbuilding yard and engineering works, to bring them up to date. The new buildings will cover an area of some 12,000 sq. yds. Two new slipways are to be erected in the yard, and new machine tools to be installed throughout, including two 20-ton overhead travellers and some 40 to 50 electric motors. The whole of the works will be electrically driven while the yard will be electrically illuminated. Gas engines and gas producer plant will be installed, and the whole of the equipment is to be ordered from England.

Accidents in Mines.—The annual report for the year 1909 of Mr. R. A. S. Redmayne, Chief Inspector of Mines, which was issued last week, shows that the total number of fatal accidents in the coal mines of the United Kingdom last year was 1,182, compared with 1,138 in the year 1908. These accidents involved the loss of 1,453 lives, as against 1,308 in the previous year. Only 11 of the accidents, involving the death of 13 persons, are attributed to electrical causes. Electrical accidents are accountable only for about 1 per cent. of the total number of fatalities, and in all cases they occurred underground. The number of deaths in 1908 due to electricity was 15, four of these being above ground. Last year's electrical fatalities therefore show a decrease of two compared with those of 1908. As regards non-fatal accidents, 153,306 persons were disabled for more than seven days, compared with 141,851 in the previous year. Of this large total, electrical causes account for 38 cases of injury to persons working underground, and in 18 cases to workmen above ground, the figures for last year being 22 and 12 respectively. The proportion of accidents attributable to electricity is therefore 0·4 per cent. In the case of metalliferous mines, no fatal accidents and one instance of injury are stated to be due to electricity, the total number of accidents in this class being 40 killed and 1,434 persons injured. The third heading under which accidents are classified is "In and about quarries"; 84 deaths and 4,856 cases of injury are recorded, electricity being in no instance responsible.

On the Decrease of Velocity of the β Particles on Passing through Matter.—Mr. W. Wilson recently discussed further details of this subject before the Royal Society, having in a previous Paper shown that the velocity of β-particles suffered an appreciable decrease on passing through matter. The present experiments were undertaken with a view of directly confirming this result. Homogeneous beams of rays were separated by means of a magnetic field from a heterogenous beam given out by the active deposit from radium. These homogeneous rays passed into another magnetic field, where their velocity was measured. Sheets of aluminium were then placed in the path of the rays between the two fields, and the velocity of the emergent rays was found to have decreased by an appreciable amount. From consideration of the law of absorption found to hold for homogeneous rays, the decrease of velocity of the rays as they passed through matter could be calculated, and was found to agree with the results obtained experimentally. The results obtained were in agreement with the equations $E = k(a-x)$ and $E^2 = k'(a'-x)$, where E was the energy of the rays, x the thickness of the matter traversed and k and a constants. The agreement was rather better in the former case than in the latter: but the range of velocities considered was not sufficient to differentiate sharply between them. Although the change in velocity observed was only from $2{\cdot}85 \times 10^{10}$ to $2{\cdot}25 \times 10^{10}$ cm. per second, yet the change of the properties of the rays with respect to absorption was very large, the absorption coefficient of the former being $4{\cdot}9^{-1}$ cm., while that of the latter was $35{\cdot}2^{-1}$ cm..

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910
Bonny—Duala	Aug. 3, 1910
Hong-Kong—Macao	Aug. 15, 1910

Electric Power on the Rand.—In a recent issue the "Transvaal Leader" gives some particulars of the power station being erected at the Rosherville Lake for the supply of electrical energy and compressed air to the mines of the Eckstein and Rand mines groups. It is stated that the station when completed will be the largest turbine installation in the world, its capacity being about 106,000 H.P. Considerable use is to be made of compressed air and huge pipe mains for the transmission of the air are being laid. Each of the four turbine-driven compressors will deliver about 600 cubic metres of air at a pressure of 140 lb. per square inch, whilst the five A.E.G. turbo-generators will each be of a capacity of 12,500 k.v.a. at 5,700 volts. Eight Babcock & Wilcox boilers are being installed in each of the three boiler houses, which are situated at right angles to the engine room, whilst eight 80 ft. chimney stacks have been erected. It is expected that a supply of electrical energy will be available by the end of the present year, and several of the mines will by that time be ready for electrical operation.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. C. M. Dowse contributes an article on "The Use of Thermo-junctions for High-frequency Current Measurements."

An unofficial conference of the International Electrotechnical Commission was held at Brussels last week. Several important proposals have been put forward for consideration by the various committees.

We give a description of the new Post Office Telephone Exchange at Glasgow, which was opened on Saturday last.

It is stated that the disastrous fire at the Brussels Exhibition was due either to the imprudence of a smoker or to malevolence. The suggestion that it was caused by an electrical short-circuit has been dismissed.

An interesting report on the Wigan tramway undertaking has been made by Mr. C. W. Mallins, general manager of the Liverpool Corporation tramways.

New Technical School Regulations have been issued by the Board of Education.

In a recent invitation for tenders for electric power plant at Maribyrnong (Victoria) it was a condition that the plant must be of Australian manufacture. The contract has been let at £7,459 to the lowest tenderer.

The results of through tramway working between the London County Council and Croydon Corporation tramways are shown in a set of interesting figures on another page.

Interesting statistics of the trade of the United Kingdom with the Argentine Republic are given.

The development of the telephone in Denmark in recent years has been so rapid as to put that country relatively in the front rank of telephone users.

Contracts have recently been let in New Zealand for the work of clearing the bush to enable an extensive hydro-electric enterprise to be carried out.

Legal.—An unusual claim under the Workmen's Compensation Act was part heard before Judge Scully at Hastings last week.

Companies' Meetings, &c.—At the meeting of the London Electric Railway Co. last week Sir Geo. Gibb gave particulars of the progress made by the three tube railways of the Company. Each of the railways showed an increase of traffic, while the expenses had decreased.

The directors' report of the Underground Railway Co. of London states that the result of the past year's working shows a substantial improvement.

The directors' report of the Mersey Railway Co. for the half-year ended June 30 states that further progress has been made, the receipts having increased while the expenses show a decrease.

The directors' report of the Compania Alemana de Electricidad gives particulars of the rapidly increasing demand for electricity in Buenos Aires.

INSTITUTIONS AND SOCIETIES.

UNION INTERNATIONALE DE TRAMWAYS ET DE CHEMINS DE FER D'INTERET LOCAL.—The congress of this Society will be held at Brussels during the week September 5th to 10th, when a number of interesting tramway Papers will be read.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION.

An unofficial Conference of this Commission was held at Brussels last week from August 8th to 13th, the gathering numbering about 50.

The Conference was opened by Col. R. E. Crompton, C.B., after which Prof. Eric Gerard, of the Institute Montefiore, Liège, gave an address of welcome to the delegates and representatives, and said the Commission was to be congratulated upon the success with which it was meeting in the various countries. He explained that the present conference was in no way official, but was intended as a preparation for the official meeting it was proposed to hold in Berlin next year. The Belgian committee, he said, offered a very hearty welcome to the representatives from the various countries, and trusted that the Conference would fulfil its object and enable the Commission to show practical proof of its utility. The Conference, being unofficial, no definite resolutions would be come to; on the other hand, he hoped most useful propositions would emanate from the Conference to be placed before the various electrotechnical committees.

The question of nomenclature was first considered. Dr. E. Budde, representing the German committee, put forward a list of about 80 terms. This aroused much discussion. It was fully recognised that the work already carried out by the British, French, Italian and other committees who had for the past year or two studied the question of an electrotechnical vocabulary, was of great value, and that the question of the vocabulary was one which was and would always form part of the work of the Commission. At the same time, in order to facilitate progress, the Conference decided to recommend to the various committees the idea underlying the proposal of the German committee, viz., to take a certain leading idea, for instance, an electric generator, and to describe its various parts, each committee being subsequently asked to give the term in French and English and in their own language for each particular part described. Each committee are to send their replies to the central office before March 1, 1911, and delegates from the British, French and German committees will meet before the following September in order to prepare a list of agreed definitions to be put before the Commission at its next meeting.

The conference also suggested that the French and Belgian committees working together should be requested to undertake the preparation of the logical list of fundamental ideas in such a manner that one definition leads naturally to the next. These definitions will be gathered into groups, certain leading ideas being taken as the starting point for each group.

The French representatives next put forward certain principles in regard to the question of symbols. These proposals, which are of great importance, came in for much discussion, but finally it was agreed that the following five principles should be submitted for the consideration of the various electrotechnical committees: (1) That small letters be reserved for instantaneous values of electrical quantities varying with the time; (2) that capital letters be reserved for effective or constant values of electrical quantities; (3) that capital letters followed by the suffix "m" be reserved for the maximum values of periodical electrical quantities; (4) that capital script letters be reserved for magnetic quantities, constant or variable; (5) that capital script letters accompanied by the suffix "m" be reserved for the maximum values of magnetic quantities.

The conference also agreed to suggest the following eight symbols:—

Electromotive force	E, e
Electrical quantity	Q, q
Inductance	$\mathcal{L}$
Magnetic force	$\mathcal{H}$
Magnetic flux density	$\mathcal{B}$
Length	L, l
Mass	M, m
Time	T, t

The omission of μ for permeability is noticeable. In view of proposals likely to be introduced at a later date, however, it was decided not to include permeability at the present stage especially as the use of μ for permeability is practically universal.

The question of the direction of rotation in the case of vectors was brought to the notice of the Conference by the American representatives. Dr. Kennelly read at the recent convention of the American Institute of Electrical Engineers a Paper dealing with this subject, and the convention have requested the Electrotechnical Commission to consider this with a view to giving an early decision on the matter. At the present unofficial meeting no recommendation was made to the electrotechnical committees on account of the many authorities who ought to be consulted in the various countries. The Conference, however, thought it was desirable that each committee should send to the central office a short report on the subject after consultation with those interested in the question.

A preliminary suggestion as to the rating of electrical machinery was finally put forward by the American representatives, but the Conference felt that they could not adopt the proposal as it stood. Feeling, however, the necessity of taking some step in this direction they suggested for the consideration of the various committees that the output of an electrical generator should be defined as the power available at the terminals, and that of a motor as the power available at the shaft; and, further, that electrical and mechanical power be expressed in international watts.

It may be remarked that in making the above expressions of opinion the Conference was unanimous.

The question of electrical congresses was also discussed. The Italian representative, Mr. Guido Semenza, drew attention to the international exhibition to be held at Turin next year, and to the fact that he had received a communication in regard to holding an electrical congress there. He said he was sorry the Commission was going to meet at Berlin and that there should be an electrical congress at Turin at the same time, for the Commission and the congress were doing much the same thing—working for the good of the electrical industry.

Dr. Budde, the German delegate, with the courtesy which has always distinguished his attitude at the meetings of the Commission, stated that although the German committee would certainly be extremely sorry if the Commission did not go to Berlin, it was certainly inopportune to hold a congress in Turin and for the Commission to meet in Berlin. If, therefore, it should be decided to hold an electrical congress at Turin, the German committee would be quite willing to waive their claim and to agree to the Commission holding its meeting at Turin.

The Belgian committee had made extensive preparations for the entertainment of the members of the Commission who attended the Conference, and their kindness was much appreciated. The programme included a lunch at the Exhibition, excursions to Liége and from there by boat to Cockerill's works, an excursion to the Société Electrique Charleroi and to two coal mines where an interesting electrical haulage on the Ward-Leonard system was inspected, a 30-ton flywheel equaliser being installed.

On the last day of the conference the members were most cordially received by the Burgomaster at the Town Hall of Antwerp. The proceedings concluded with a lunch, at which a very cordial telegram was received from the King of Belgium, who it is well known has strong leanings towards science of all kinds.

THE MOORE LIGHT.*

BY W. WEDDING.

The German Moore Light Co. asked the author to report on the installation they have erected in one of the public halls in Berlin. But as this was not very convenient in view of the many instruments and the large amount of apparatus that would be necessary, they installed the light in one of the large workrooms in the Charlottenburg Polytechnic, and the present report is based on the results so obtained.

D. McFarlan Moore first described his methods to the American Institute of Electrical Engineers on April 24, 1896,

* Abstract of an article in the "Elektrotechnische Zeitschrift."

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and lighted the lecture room with 27 Geissler tubes, made in accordance with his methods. On this occasion he used tubes 2 metres long and 5 cm. in diameter. In 1903, using tubes 4·5 cm. in diameter, and 17·5 metres long, he carried out the lighting of some business premises in New York. He used a special type of alternate-current machine for producing a sudden change in the voltage: this is described in his German patent, No. 130,123 of January 21, 1900. At the present moment in America there are tubes 66 metres long. He now uses ordinary alternate current of a frequency between 40 and 60, relying chiefly on the German patents No. 150,095 of June 5, 1902, and No. 187,649 of May 3, 1906. The latter patent, which is the more important of the two, describes a method of preventing a variation of the vacuum in the tube. It is well known that this variation ordinarily takes place, unless means are taken to prevent it, and this constitutes the so-called "hardening" of the tube. Unless the vacuum is maintained at a steady value, the conductivity of the tube varies, and with it, of course, the light emitted. The device consists of a method by which a decrease of vacuum in the tube increases the conductivity; this causes an increase of current to react on the primary circuit, producing a similar increase there, with the result that a mercury-sealed valve is momentarily opened, allowing gas to pass into the tube, till equilibrium is restored.

Ordinarily the installation is built up out of 2-metre lengths of glass tubing, which are fused together *in situ*, the whole being suspended from the ceiling by insulated supports. Moore gives a good deal of detailed information in his last-mentioned patent, and there is much to be learnt from his lecture before the American Institute of Electrical Engineers on April 26, 1907, where he speaks of tubes up to a length of 70 metres. In the present case now under examination, the length of the tube was, in all, 37·5 metres. The walls of the tubing are 2 mm. thick, and its external diameter 44 mm. The

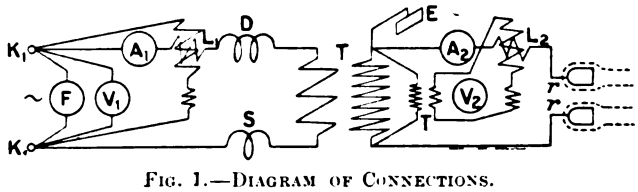

Fig. 1.—Diagram of Connections.

tube was suspended at a distance of 1 metre from the ceiling, and a Weber photometer was installed at this height for purposes of observation. In the first instance, central strips of the tube, 1 cm. broad, and of varying lengths, were examined, and it was found that, to all intents and purposes, the lengths of the exposed portion of the tube varied as the light emitted. The primary pressure was 220·6 volts, and that of the secondary 12,926 volts; with a frequency of 50, the light emitted per square centimetre was 0·21 hefner c.p. Similarly the light emitted through a circular aperture in a direction perpendicular to the length of the tube was roughly proportional to the radius of the aperture, the maximum value of which was about the same as the width of the tube. This leads to the question as to the extent to which the light is absorbed in its passage through the gas. This was determined by placing two arms of the tube immediately one behind the other, and finding the candle-power given out by the one alone, and then by the two together. In this way it was found that no light was absorbed by the column of the gas, which is therefore completely transparent, this being precisely the opposite effect to that produced by the ordinary bat's-wing gas burner. This effect can be observed by looking down the tube from one end, when the light seems almost as bright as that of a small arc lamp, whereas looked at from the side in the usual way it appears quite dull.

The question of the efficiency was examined with the connections as shown in Fig. 1. At the terminals K alternate current is taken from the mains, the tube being shown on the secondary side at *r*. L_1 and L_2 are wattmeters, E is an earth connection, D is a choking coil and S the solenoid working the automatic valve, which is placed in the primary circuit for greater safety in working.

The candle-power emitted through a circular aperture with a diameter of 1 cm. was found to be 0·571 hefner c.p., which gives a candle-power of 57·1 for the length of a metre. The total length of the tube was 37·5 metres, and the total power absorbed was 3,286 watts. Therefore, 87·6 watts correspond to 57·1 hefner c.p., or 1·53 watts per hefner candle-power. The overall efficiency between the primary and secondary terminals was 0·877, the frequency 50, the primary and secondary voltages 220 and 12,790 respectively, and the primary current 23 amperes, with a power factor of 0·647. If the losses which take place in transformer, choking coil, copper and iron are neglected, as having no real connection with the efficiency of the light, we find that 1 hefner c.p. is produced by 1·34 watts. This is very similar to the result produced by the metal lamps, and is still far from the ideal heatless light. The tube feels only slightly warm to the touch, but the radiation is, of course, spread over an immense surface, amounting in all in this case to 5·18 sq. metres. The effect of change of frequency in the given lamp was very marked. The primary voltage, which had to be kept constant, was therefore very low. The valve keeps the primary current constant, and the secondary voltage falls as the frequency rises. The watts absorbed by the secondary also sink, and with this is bound up the corresponding fall in the candle-power. Thus, with a constant primary voltage of 153 or thereabouts, and with a rise in the frequency from 36 to 60, there was a fall in the candle-power per metre length of 24·3 to 5·2. Owing to the insufficiency of the secondary voltage, the light flickered somewhat at the higher frequencies, and under these circumstances the higher frequencies require higher voltages. It must be said that the light shows a certain sluggishness in adapting itself to any change. When switched on it lights up at once, but after that any change in the conditions only makes itself felt slowly.

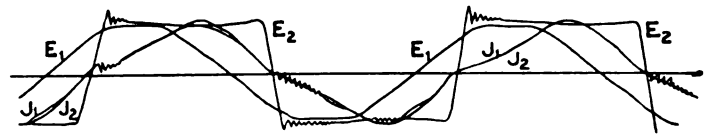

Fig. 2.—Oscillograms showing Primary and Secondary Voltages and Currents, the Secondary Waves being shown displaced through 180°.

Thus, a series of observations carried out at a given voltage does not always necessarily give the same mean result, as was found experimentally. This can probably be traced to the effect of changes slowly taking place in the conditions, but this sluggishness has its advantages in the fact that such changes as take place are quite unnoticed by the ordinary observer.

A series resistance has to be used with the Moore light just as with an arc lamp, and for this purpose a choking coil is used, which is provided with five terminals to meet the various cases that may arise. If the number of turns on the choking coil is increased the secondary voltage falls, and with it also the candle-power. On the other hand, if the choking coil is completely cut-out the flickering is such that it is impossible to use the photometer. Normally, the choking coil was found to take 140 watts, which is 4 per cent. of the total taken by the primary.

A series of oscillographic records is given, showing that the primary and the secondary currents are of almost exactly the same wave-shape, if differences of amplitude are neglected. There is no phase-displacement whatever between the waves of secondary voltage and current, thus showing that the gas column is free from anything of the nature of capacity or self-induction. There is no trace of any back E.M.F., and the tube may be said to constitute a simple inductionless resistance. The shapes of the curves are shown in Fig. 2, but the secondary waves have here been shifted back through 180 deg. in order to compare their shapes with those in the primary. The curves show that the gas column itself produces the sudden change in the secondary voltage which Moore supposed originally would require a special machine for the production of the primary wave. The shapes of the secondary

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waves are shown very clearly in Fig. 3, and they are seen to be very similar to those obtained in the ordinary alternate-current arc lamp. The Moore arc lamp may therefore be considered as a type of the simple arc lamp, 37·5 metres long. Some further oscillographic records show the effect produced by a variation of the amount of self-induction in the primary. The most noticeable result is the effect produced upon the time taken by the secondary current to pass through its zero value, which is so prolonged in the case where the choking coil is almost cut out that photometric readings become impossible owing to the flickering. The valve also works n this case very unsteadily. In one instance the light broke down altogether, and this was probably due to the too rapid admission of air through the valve, with the result that it was not entirely freed from oxygen by its passage over the phosphorus.

A further experiment was made by lighting the same room with an installation of tantalum lamps, which were carefully adjusted to take the same amount of energy as the Moore tube. The room was 4·75 metres high, 17·4 metres long, and 8·6 metres broad; 41 tantalum lamps were required, each of 50 c.p., and one of 25 c.p. When the tantalum lamps were alight, the illumination was carefully mapped out over a number of points at a height of 96 cm. from the ground, a magnesia plate being used as the reflecting surface. The same was also done for the Moore tube at 26 points in the room, about six or eight readings being made at each point. The readings varied from 29·4 hefner c.p. to 48 hefner c.p., the mean value being 37·3, for the tantalum lamps; while for the Moore tube, the readings varied from 32·4 to 46 hefner c.p., with a mean value of 39·4. The uniformity of the distribution

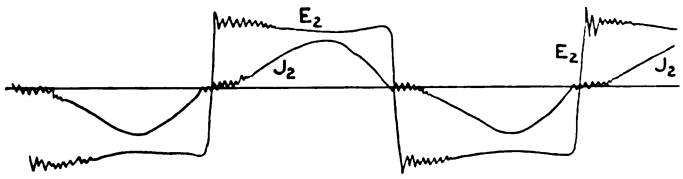

Fig. 3.—Oscillograms showing Secondary Voltage and Current, there being no difference of phase between the two.

was therefore slightly greater in the latter case, owing doubtless to the fact that the light-emitting surface is much more extended, whereas the tantalum lamps are, as it were, so many bright specks. This is one of the great advantages of the newer form of light, in that it tends to produce a well-diffused illumination, this object being to some extent attained in incandescent and arc lamps by the use of frosted bulbs and globes, which, however, shut off at least 10 per cent. of the light.

Further, the Moore tube gives a warm rosy light, which is very agreeable in a room. It must remain a matter for experiment as to whether nitrogen can be more profitably replaced by another gas. The cost of an installation must be compared with those using the ordinary method, and no doubt there is likely at first to be some difficulty in getting a sufficient number of experienced workmen, just as in the case of any other novelty of a similar kind. The high voltage ought not to be in itself a source of danger, seeing that the tube itself can be handled without any risk. Repairs are another matter. In case of breakage, a piece of tube would have to be cut out; but the Americans have to some extent foreseen these points, and arranged suitable apparatus for the purpose. Whether the supply companies will approve of the lag in the primary cannot be foretold; at present, a power factor of 0·6 is not unknown in the case of some power users. Its first application is likely to be found in lighting some of the larger buildings, but even so, some sort of stand-by would seem to be necessary. There are doubtless other points requiring further consideration, but the lamp may be taken as an interesting example of the attempt to convert energy into light without the manifestation of heat.

ON THE USE OF THERMO-JUNCTIONS FOR HIGH-FREQUENCY CURRENT MEASUREMENTS.

BY C. M. DOWSE.

Summary.—The author describes a form of thermo-junction suitable for radio-telegraphic measurements in technical colleges. "Eureka"-copper junctions have been found very suitable for the purpose. The particular construction adopted is described and tests are given showing that such junctions are reproducible and are reasonably permanent.

One of the most sensitive methods of measuring small alternating currents of high frequency is that in which the heat developed in a short, fine wire raises the temperature of a thermo-junction soldered to it, and the resulting thermo-E.M.F. is detected by a galvanometer of suitable resistance connected to the junction. If the diameter and length of the wire are kept small, variations in the effective resistance with frequency will be negligible.

Prof. Fleming and others have used and developed apparatus based upon this principle, and it is also embodied in the highly sensitive thermo-galvanometer of Mr. Duddell, where, however, the heating wire is not in contact with the junction. For use in the practical classes in radio-telegraphy at the Northampton Polytechnic Institute, it was found desirable to have some inexpensive, portable instrument for high frequency current measurements, having as long a range as possible, so that, if necessary, the same apparatus would serve for the determination of resonance and damping as well as currents up to 1 or 2 amperes. A suitable series of thermo-junctions in conjunction with a Paul unipivot galvanometer has been found to meet all requirements, and experiments will be described which indicate the possibility of standardising these junctions for general laboratory use.

Materials.—The table below gives some of the most suitable combinations, with the approximate thermo-forces. The differences between the values given by different observers for various samples of wires are so large that it is useless to give more exact results. In most cases, also, they refer to mean temperatures considerably lower than that employed in the case under consideration, and the thermo-forces will accordingly be different at the higher temperatures of the heating wire, except in the case of those materials for which the lines on the thermo-electric diagram are nearly parallel.

Materials.	Mean thermo-E.M.F. Micro-volts per deg. C. 0—150°C.
Antimony-bismuth	104
Copper-constantan	40
Constantan-iron	51
Nickel-iron	31
Copper-Eureka	41

The antimony-bismuth junction is very sensitive, but the mass of metal, and therefore the heat capacity, of the junction is fairly large, the high resistance of bismuth seriously reduces the galvanometer current, and the soldering is difficult and so unsatisfactory that the joint is liable to fracture by even a slight jar, and it is therefore better to use a more robust but less sensitive combination, and raise it to a higher temperature. Copper is a good material in conjunction with constantan or Eureka, as its resistance is low, and W. P. White * has shown that its thermo-electric properties are constant. The well-known alloy constantan has been largely used on account of the high thermo-E.M.F. against iron, but the properties of this substance are liable to serious variations in different samples, although there is no evidence of important secular changes in a junction containing it. A striking example of the variations referred to was met with when an attempt was made to obtain a second sample of a constantan wire having a remarkably low temperature coefficient, and a thermo-force against copper which was 35 per cent. higher than that usually obtained. This material is No. 9 in the list of properties of

* "Phys. Rev.," Vol. XXIII.

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resistance alloys observed by Mr. Jolley and published * in a Paper by Dr. Drysdale. On testing the wire supplied by the manufacturers as the same material, the thermo-force against copper was found to be only 42 micro-volts per degree C. and not 57 micro-volts. A more serious difference is shown by the figures for this thermo-force given in a Paper by Mr. R. D. Gifford, M.Sc.,† where the remarkably low value of 17·7 micro-volts is recorded.

The iron-constantan couple is more difficult to solder effectively, but it has a much greater sensitiveness than a similar copper-constantan junction. This is clearly shown by the curves in Fig. 1, which were obtained by calibration, with a continuous current, of two similar junctions of copper (diameter 0·02 mm.) and iron (diameter 0·02 mm.) with constantan (diameter 0·016 mm.). The last-mentioned wire was used in the heating circuit, and the resistances of this and the junction circuits were adjusted to equality. The greater sensitiveness of the junction with iron is partly due to the low thermal conductivity of this material as compared with copper.

Nickel and iron junctions are not very sensitive and are troublesome to solder, but these materials have no neutral point above 0°C., and the lines on the thermo-electric diagram

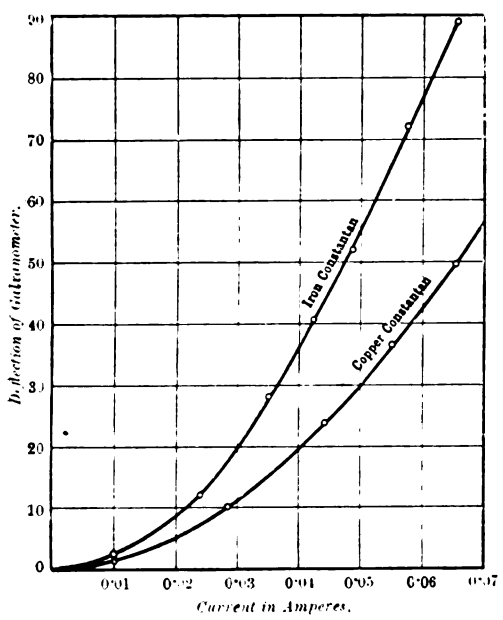

Fig. 1.

are almost parallel, so that the E.M.F. developed is fairly proportional to the difference of temperature. This is also the case with iron and german silver, and copper and constantan or Eureka. Eureka wire has been found from experience a very satisfactory material for this work. The thermo-force against copper is high, and has been found to vary but little in different samples.

The following experiments were performed in order to test this point. Three samples of Eureka wire with diameters of 0·13 mm., 0·33 mm., and 0·71 mm respectively, were each soldered to lengths of copper wire (diameter 0·27 mm.), and two of these junctions were immersed in an oil bath, the copper wires connected to a reflecting galvanometer, and the remaining ends of the two Eureka wires were soldered together and placed in another oil bath which was kept at a constant temperature. On raising the temperature of the oil surrounding the copper-Eureka junctions, any observed deflection would be due to a difference in the thermo E.M.F.s developed. Errors due to stratification were avoided by stirring constantly. In order to ascertain the sensitiveness of the arrangement, one copper-Eureka junction was transferred to the cold bath, and the deflection noted for a small known difference of temperature. From this, by assuming strict proportionality between E.M.F. and difference of temperature, the deflection for the highest difference of temperature can be obtained.

* The Electrician, October, 1907.
† "Electrical Engineer," Vol. XLV., p. 3.

The results are given in the accompanying table, and it will be seen that the differences are very small. One experiment was made with two junctions of the *same* wire with copper, and in this case the difference is even smaller.

Junctions in hot bath.	Difference of temp.	Deflection.	Calculated deflection for given difference.	Variation. %
Copper – Eureka ..... (d. = 0·27mm.) (d. = 0·33mm.) Copper – Eureka ..... (d. = 0·71mm.)	151°C.	10·0 divs.	1,033	1·0
Copper – Eureka ..... (d. = 0·71 mm.) Copper – Eureka ..... (d. = 0·13 mm.)	144·5°C.	9·5 divs.	1,034	0·9
Copper – Eureka ..... (d. = 0·71 mm.) Copper – Eureka ..... (d. = 0·71 mm.)	136·0°C.	1·5 divs.	3,040	0·05

Construction.—Although it is well known that the sensitiveness of a thermo-electric junction is considerably improved by placing it in an exhausted vessel, this refinement is not advisable in an instrument for general testing purposes, as repair is difficult and the resistance and decrement are necessarily high. The most convenient arrangement has been found to comprise two junctions mounted close together on a wooden or ebonite base.

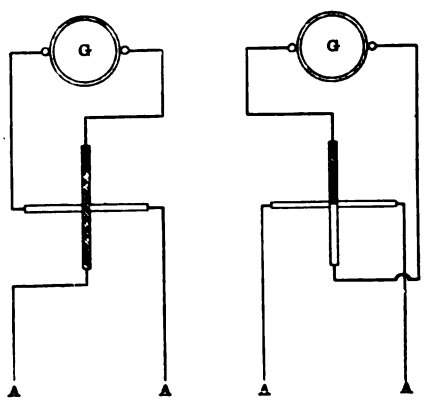

Fig. 2A. Fig. 2B.

The junctions may be adjusted to equal sensitiveness, when they may be used for differential tests, or they may have different ranges of sensitiveness to suit the conditions of the circuit.

The ends of the heating and junction wires are soldered to small copper wires which can be clamped in position, and a wooden cover with a glass lid prevents disturbance by air currents.

There are two ways in which these junctions can be made, which are indicated in Fig. 2, A and B. The first method has been used largely on the Continent and is the only type mentioned in Zenneck's well-known treatise.* Wires of two different materials are stretched between opposite terminals and soldered at the centre. The circuit in which the current is to be measured is joined to AA, and a galvanometer is connected to the remaining terminals, both circuits being composite. There are two disadvantages in this method of construction. In the first place, the hottest part of the high-resistance wire is not at the junction, and, secondly, it is necessary to take readings with reversed currents when calibrating, because of the Peltier effect. The magnitude of the difference in the resulting E.M.F. with the current in different directions in the case of a "crossed" junction of copper (diameter 0·07 mm.) and Eureka (diameter 0·05 mm.) is evident from Fig. 3. It will be seen that the cooling effect actually over-balances the ohmic heating for low currents. In the

* "Elektrische Schwingung und Drahtlose Teleg.," p. 777.

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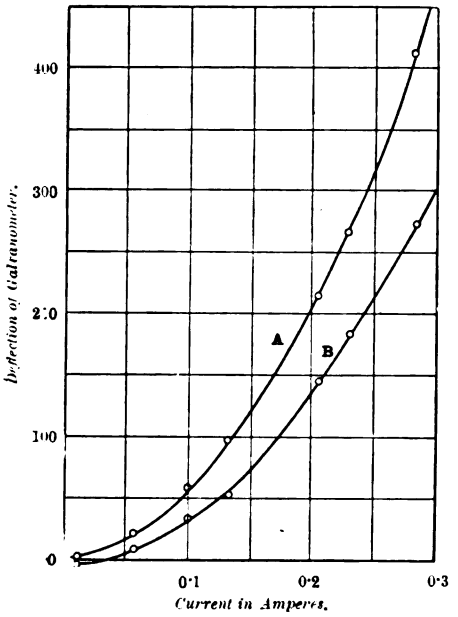
case of copper and Eureka, a crossed junction is not more than two-thirds as sensitive as one constructed in the second manner. In this case, a heating wire carrying the current to be measured is stretched between opposite terminals, but the junction wires are in a separate circuit and the two ends are soldered to the centre of the heating wire, as shown in Fig. 2 B. No part of the heating current now passes through the junction, but there is a possibility of an error in calibrating if the junction wires are not at the same point on the heating wire. This type is more difficult to construct than the crossed type, but it is much more satisfactory from every other point of view.

The chief trouble is in effectually soldering the three wires, as this cannot be satisfactorily done with an ordinary soldering iron when fine wires are used. After some unsuccessful attempts to effect the joint by passing a current through the heating wire, it was found that uniformly successful results could be obtained by the use of a small platinum heater shown in Fig. 4. Two stout copper rods, A, A, are fixed in grooves in a rectangular piece of ebonite, and the ends are bridged by a strip of platinum foil, B, bent into an arch. A current of



Curve A, Peltier effect assisting ohmic heating.
Curve B, Current reversed. Peltier effect opposing ohmic heating.

FIG. 3.

about 10 amperes from a few secondary cells is sufficient to raise the foil to a red heat, and the joint can be made without touching the wires.

The usual method of procedure is as follows: The wires to carry the tested current are soldered to two opposite lugs, and any slackness made up by sliding the lug through the terminal. The junction wires are also fixed to the remaining pair of copper lugs, and cut off to the required length. This should allow a little arch to be made in each, so that there is no strain on the joint owing to the expansion of the hot wire. The position of the ends of the wires is adjusted by moving the rods through the terminals, and they should be finally clamped so that the wires meet on the heating wire at the same point, with a slight downward pressure. The joint is now treated with a few drops of a solution of resin in pure alcohol, and a tiny fragment of solder placed on the point of contact. The red hot platinum foil is then placed under the junction and the solder will melt to form a sound joint. The process can be watched by means of a lens, and no difficulty has been found in carefully adjusting the positions of the junction wires while the solder is plastic. If properly done, no difference in deflection will be obtained on passing a current in different directions through the heating wire. Much depends on absolute cleanliness of the materials, but with care, wires of copper, Eureka and constantan, with diameters as small as 0·016 mm., can be soldered in this way, and of the 50 or more junctions which have been made—in some cases by students—not one has broken at the joint on account of mechanical injury.

Iron cannot be satisfactorily soldered with resin, and it has been found necessary to use a solution of zinc chloride as a flux. In this case, the junction is washed with sodium carbonate after soldering, and finally with distilled water. It is, however, very probable that the zinc chloride would lodge in microscopic pockets inside the joint and eventually cause corrosion of the material.

Messrs. Hartmann & Braun supply very fine wires of constantan, iron and other metals, but they are difficult to handle, because of a tendency to curl. This can be prevented by holding a piece of the wire above a small bunsen flame until it is raised to a red heat, after which it can be pulled straight with ease. The film of oxide can be removed by immersion in dilute nitric acid and washing.

Standardisation.—Since momentary rushes of current are liable to occur in adjustable resonating circuits, and it is practically impossible to protect these fine wires by fuses, it seemed advisable to determine how far it was possible to accurately reproduce junctions having approximately similar calibration curves, and which could be relied upon for permanence under normal and overload conditions for a reasonable time.

In this connection three questions must be considered:—

1. The similarity in properties of various specimens of the same material.

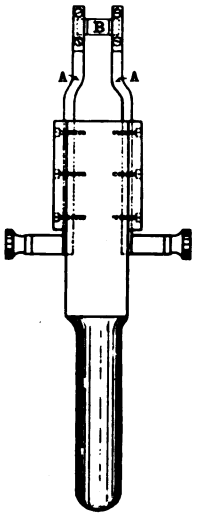


FIG. 4.

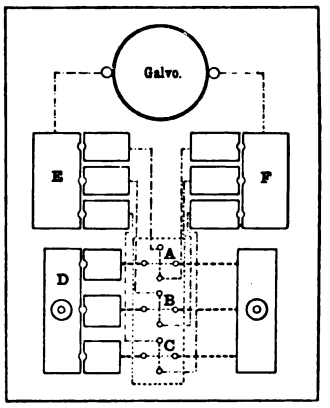


FIG. 5.

2. The most satisfactory size and form in order to secure accurate reproduction.

3. The constancy of the calibration under varying conditions of use.

Experiments have already been described which show the properties of Eureka wire to be fairly constant, and the writer would therefore recommend the use of that material in preference to constantan. For this special purpose, sensitiveness must be sacrificed for constancy and reliability, and iron and constantan are therefore not admissible.

The size of the heating wire must depend upon the maximum current it will carry, but as the properties of Eureka, and indeed of most alloys, are changed when they are submitted to temperatures above 500°C.—600°C. for any considerable time, the maximum temperature must be kept low. For standardised junctions the joint should be hard soldered, if possible, as there is less danger of melting the solder or of changes in the thermo-force. The length of the wire must be kept as small as possible to reduce the inductance, but conduction to the terminals will reduce the sensitiveness, and the best length for the heating and junction wires can be found by trial. After a little practice, it was found quite easy to reproduce a number of junctions having calibration curves which differed by not more than 1 per cent. at any part of the scale. The heating wires were adjusted to the same resistance, and the lengths of the junction wires made equal. On solder-

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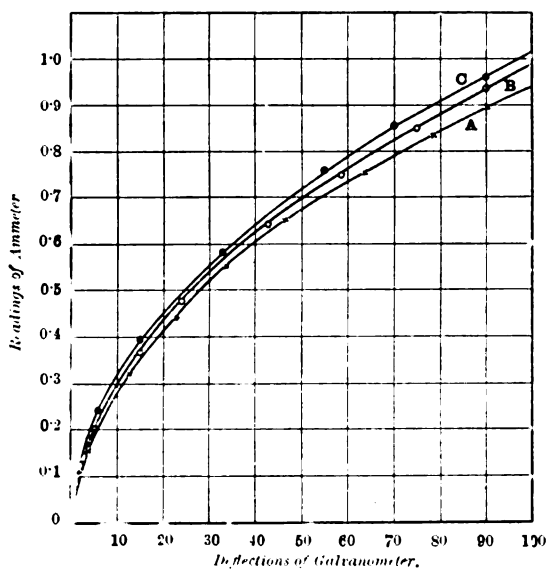
ing and testing, any differences due to varying mass of solder at the junction were compensated by varying the length of the Eureka junction wire, and this has been successfully done with wires of 0·016 mm. diameter where the mass variation is very important.

Since it is undoubtedly possible to reproduce standard junctions, the only remaining question is that of permanence. It is true that continued heating at excessive temperatures renders most materials brittle, and changes would certainly occur in the thermo-E.M.F., but the writer is of the opinion that the unreliability of junctions of suitable materials has been exaggerated, and experiments have shown that with proper precautions serious variations can be avoided.

Two similar combinations of copper (diameter 0·035 mm.) and Eureka (diameter 0·05 mm.) were made up and a continuous current of 0·7 ampere was passed across the heating wire of one, while the deflection of a galvanometer attached to the junction was compared at intervals with that obtained from the second junction which was not continuously in circuit. The heating wire was of Eureka (diameter 0·1 mm.) and the current passed was 75 per cent. of that required to cause a dull red glow, but no change in deflection could be detected after the current had been flowing for three weeks. The current was then increased until the segments of the heating wires between the junction and the terminals showed a dull red glow at the centre, and this temperature was maintained for half an hour.



A, Continuous current. B, $n = 2{\cdot}3 \times 10^6$. C, $n = 3{\cdot}1 \times 10^6$.

FIG. 6.

The deflection at the end of this time was 2·8 per cent. lower than before for the former current, and this is very satisfactory considering the severity of the overload.

Junctions have been used on high-frequency circuits for long periods, and no serious changes in their calibration have been observed, provided that the wire was not overheated. We may therefore conclude that copper-Eureka junctions are reliable, reproducible and fairly permanent, and are very suitable for high frequency measurements. As a result of these experiments it is evident that an accurate instrument of considerable range and flexibility can be constructed by combining a series of standardised junctions with the necessary plug switches and a suitable galvanometer. The arrangement is seen in Fig. 5, where A, B and C represent three junctions which can be placed separately in circuit by the plug switch D. The junction wires are joined to the galvanometer by the plug switches E and F.

The circuit including the heating wire is as straight and short as possible, and the connections should be made with stranded wire. The whole junction circuit may be examined by means of a sliding base, and in the event of a junction being burnt out it can be quickly replaced by another having the same calibration. The galvanometer might have three scales, or the calibration curves could be placed inside the lid.

Such an instrument has several advantages over the ordinary hot wire instrument.

1. The range is easily varied.
2. The energy consumption is smaller.
3. Action is less sluggish.
4. The readings are independent of frequency.

It is difficult to determine theoretically the variation in resistance of a small wire, because the value of $\sqrt{h}$ in the formula given by Prof. Fleming,* $\frac{R'}{R} = \frac{1}{2}\sqrt{h} + \frac{1}{4}$, where $h = \frac{(\pi d)^2 n}{\rho}$, comes out less than 5 for most cases, and the formula cannot be applied. The error with wires up to 0·4 mm. must be very small, and currents up to 2·5 amperes can be measured in this way. Prof. Fleming has recently shown † that it is possible to measure larger currents accurately by diminishing the inductance of the heating circuit by suitably spacing the wires. In order to test the behaviour of the junctions in circuits of varying frequency, the readings on a junction of copper and Eureka with a heating wire of Eureka (diameter 0·33 mm.) were compared with the indications of a hot wire instrument on the expansion principle, by Johnson & Phillips. The range of this ammeter was from 0·1—1 ampere, and readings were first taken between these limits with continuous current.

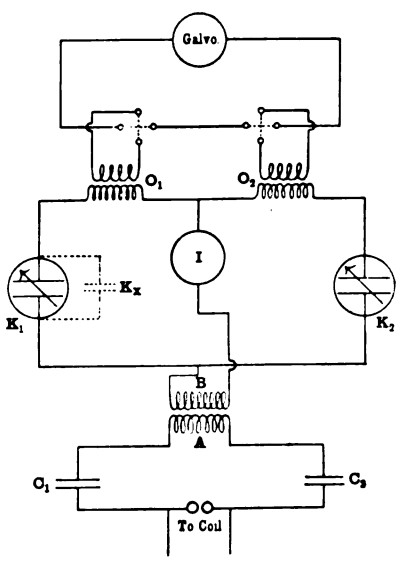


FIG. 7.

The two instruments were then joined in series in a circuit containing a standard inductance and a variable capacity, and the calibration repeated with oscillating currents with frequencies of $2{\cdot}3 \times 10^6$ and $3{\cdot}1 \times 10^6$. The current was varied by changing the length of the spark-gap and the frequencies were measured by means of a Fleming cymometer. The curves in Fig. 6 show the higher readings of the ammeter at the higher frequencies, the maximum error being about 6 per cent. The resistance of the ammeter was 1·11 ohms, and that of the thermo-junction 0·53 ohm, but the most serious defect of the former was its sluggish action. The galvanometer connected to the junction came back to zero in 3 seconds from switching off the maximum current, but the ammeter took 22½ seconds to return under the same circumstances. The calibration of the two instruments was again checked with continuous current after these experiments and found to be unaltered. The uses of the instrument described above may be extended to measurements of magnetising currents of small transformers and the currents in dielectrics, but it has the largest scope in radio-telegraphic experiments where the possibility of rapid variations in sensibility is almost a necessity.

* THE ELECTRICIAN, Vol. LXIV., p. 382.

† THE ELECTRICIAN, *loc. cit.*

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Many useful applications can also be made of the differential action of two equally sensitive junctions, and the writer has developed the method shown in Fig. 7, which enables low capacities to be balanced with ease and accuracy. A coil, A, which is in an oscillation circuit with capacities C_1, C_2 forms the primary of an oscillation transformer, the secondary B of which can be moved so as to vary the coupling. Connected to the terminals of B are an indicating instrument, I, and a pair of similar circuits each containing a variable condenser, K_1, K_2, and the primary coil of a small oscillation transformer, O_1, O_2. The secondary coils are in very close coupling and are joined to the terminals of the heating wires of two similar thermo-junctions. The junctions are in opposition and are connected to a sensitive galvanometer. The deflection is reduced to zero by balancing the variable capacities K_1, K_2, and the sensitiveness adjusted by varying the coupling between A and B. The indicating ammeter I shows the value of the current in the main circuit, and experiment will easily show the maximum value that can be reached without burning out the junctions. After noting the readings of the variable capacities, the capacity K_x to be measured is joined in parallel with one of the variable condensers, and this latter varied until the deflection is again reduced to zero. The difference in the readings gives the capacity of the condenser K_x. It is advisable to partially withdraw B before inserting the test condenser in order to avoid overheating the junctions, and in case of differences in the calibrations of the junctions the heating circuits may be exchanged and the mean value taken. This precaution is unnecessary if the inductances of O_1 and O_2 are small, as the process is similar to the double weighing method of eliminating error. In an experiment made by this method, the capacities C_1 and C_2 were Leyden jars with capacities of 0·0012 mfd. each, and the coils A and B were of No. 16 copper wire wound on tubes 6 cm. and 4 cm. in diameter. C_1 and C_2 were moving sector variable air condensers, and the oscillation transformers in the condenser circuits were of No. 16 copper wire—primary eight turns, secondary four turns, one winding over the other. The junctions were of iron and constantan, and a Paul unipivot galvanometer was used. A change of 0·8 per cent. in the capacity was easily detected, and with a reflecting galvanometer this sensitiveness could be considerably increased.

The writer wishes to express his indebtedness to Dr. Drysdale and Mr. Jolley for their encouragement and valuable suggestions.

MAGNETIC AND ELECTRICAL PROPERTIES OF IRON-SILICON ALLOYS.*

BY C. F. BURGESS AND J. ASTON.

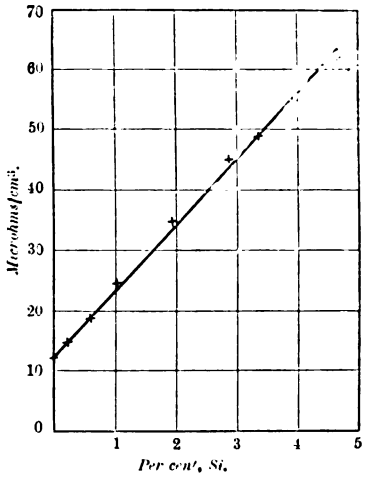
The belief was held for a long time that, as far as magnetic properties were concerned, purification was the method to be looked to for improvement of iron. That this is not true is now, of course, common knowledge. The work of Barrett and Brown, in 1901,† on alloy steels, made by Hadfield, gave for irons with additions of 2¼ per cent. of aluminium or 2½ per cent. of silicon permeabilities excelling those of pure iron; investigations of the authors have shown this same effect by additions of about 2 per cent. of tin or about 4 per cent. of arsenic. It is not probable that the influence of these elements, all non-magnetic, is directly, or in a strict chemical sense, the cause of the marked improvement of magnetic quality. It is more likely that the effect is due indirectly to some change in the physical structure of the iron itself. This supposition is seemingly confirmed by the influence of the heat treatment of high-purity iron. Annealing at lower temperatures (about 700°C.) results in improvement of quality throughout the entire magnetisation curve, due to the removal of all cooling and forging strains; while annealing at the higher temperature of 1,000°C. results in a deterioration of quality in the upper ranges, and a higher permeability at low magnetising forces.

From the above investigations have resulted the present-day materials so largely used in transformer work, in which the percentage of silicon varies from about 3 to 6 per cent. In these silicon steels the heat treatment is of importance comparable with that of the silicon content, and the practice seems to be annealing at high temperatures. The result is a material of very high permeability for the lower magnetising forces; the saturation limit is reached at comparatively low densities, however, and beyond this point the quality is not exceptional. This characteristic makes the steel particularly suited to alternating-current working, where low working densities are the rule. The low hysteresis losses, together with the added benefits of high electrical resistance and slight deterioration due to ageing, are the special features of the silicon steels.

Our investigations covered tests of 15 iron-silicon alloys, with from 0·233 to 4·655 per cent. of silicon. Electrolytic iron of high purity (99·9+) formed the basis of the alloys. All effects noted, therefore, may be ascribed, as far as due to chemical composition, to the added element alone. The results of the tests are given in tables and curves by the authors. Four heat treatments were adopted: Forged, annealed at 675°C., annealed at 1,000°C., and quenched at 900°C. Comparison is made with a standard bar of electrolytic iron of high magnetic quality.

In the unannealed condition all the curves fall considerably below the standard, particularly in the upper ranges; the best results are obtained with bars of lower silicon content, and the lowest with those of highest silicon; but the latter for very low values of H have the highest permeability of the series.

Annealing at 675 deg. raised the maxima of all curves, but the comparative order is about as in the previous condition. Second annealing at the higher temperature of 1,000 deg. resulted in a falling off



ELECTRICAL RESISTANCE OF IRON-SILICON ALLOYS.

of the permeability for the bars of lowest silicon content. But for three bars of highest percentage of silicon (2·83, 3·33 and 4·66 per cent.) there was a considerable improvement of quality at the lower magnetising forces, with but little change for the upper ranges. Here the curves fall below those of lower silicon, and all are well below the standard. Quenching at 900 deg. resulted in a deterioration of quality, particularly in the lower ranges, with but little change at higher magnetising forces.

In general, the coercive forces become less with annealing, and reach a minimum after heating to 1,000 deg. The very low value of 2·7 reached by a bar with Si 4·66 per cent., after annealing at 1,000 deg., confirms the previous deductions of high permeability for this alloy at low magnetising forces.

Summarising, the results of these tests do not show a general improvement of permeability due to the presence of silicon in electrolytic iron, but the experience of practice is confirmed in that a high-silicon alloy after annealing at high temperature is of high permeability for very low magnetising forces and densities such as are used in transformer design. The improvement is not so great in our tests as it is in commercial materials; it may be that the effect of the silicon is more pronounced in the presence of certain impurities or after special heat treatment. For the purpose of comparison, results of tests on commercial silicon steels obtained from steel and electrical manufacturers are given by the authors.

A feature of steels for transformer working, second only to the magnetic quality, is a high electrical resistance, to reduce the eddy current loss. In this respect the silicon steels are an additional advantage. The curve herewith shows the effect of increasing the amount of silicon.

* Abstract of an article in "Metallurgical and Chemical Engineering."
† "Journal" Inst. Elec. Engrs., Vol. XXXI., p. 675.

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NEW POST OFFICE TELEPHONE EXCHANGE AT GLASGOW.

The telephone system in Glasgow enjoys the distinction of having been the centre of a great controversy and one which raged fiercely for a number of years. With the opening of the new Post Office common battery exchange a fresh epoch is marked in telephone progress in this country. The inauguration of the new service is a fitting climax to the events of the past, and is a matter for all-round congratulation. As far as the past is concerned it is probably best dismissed by the old phrase, "let bygones be bygones." Our friends in the northern capital may now rest content upon the knowledge that their latest telephone achievement is as up-to-date as electrical enterprise can make it, and, further, they have the supreme satisfaction of being in possession of an equipment which is the result of British enterprise and is the product of British labour.

FIG. 1.—NEW POST OFFICE BUILDING, GLASGOW.
The New Telephone Exchange is installed on the second floor, the whole of which it occupies.

The new exchange presents a large number of entirely distinctive features. The first of these is the installation of the entire equipment upon a single floor. This applies to the power plant, test room, subscribers' sections and staff quarters. This convenient arrangement of the equipment is made possible by the ample dimensions of the magnificent new Post Office building in Waterloo-street. The imposing nature of this structure will be gathered from Fig. 1, which is an exterior view of the building, and shows the south and west fronts. The telephone exchange is situated on the second floor, and it will be noticed that there is ample lighting provision made. The position of the pillars supporting the roof allows ample space for the switch sections.

It will be remembered that the call-wire system was adopted some years ago in Glasgow. The object of this system was to do away with indicators, but progress in the design of telephone exchange equipment has proved that the method, while simple in principle, is complicated in practice. It has accordingly come to be regarded as obsolete. This is not to be wondered at, when it is considered that an operator can only deal daily with 40 per cent. of the number of calls which she can handle in a modern exchange. During the busier times of the day special operators had to be put on, and it was not unusual for a messenger to be requisitioned to find and clear a connection which could not be dealt with by any other means. When the Post Office acquired the telephone plant of the Glasgow Corporation it was not unnatural that the call-wire system was abandoned. The new exchange is the first to supersede a portion of the existing call-wire equipment of some 5,000 subscribers' circuit which have been gradually transferred. At the same time the new plant makes provision for an additional 5,000 lines, making a total of 10,000 in all for the exchange just opened.

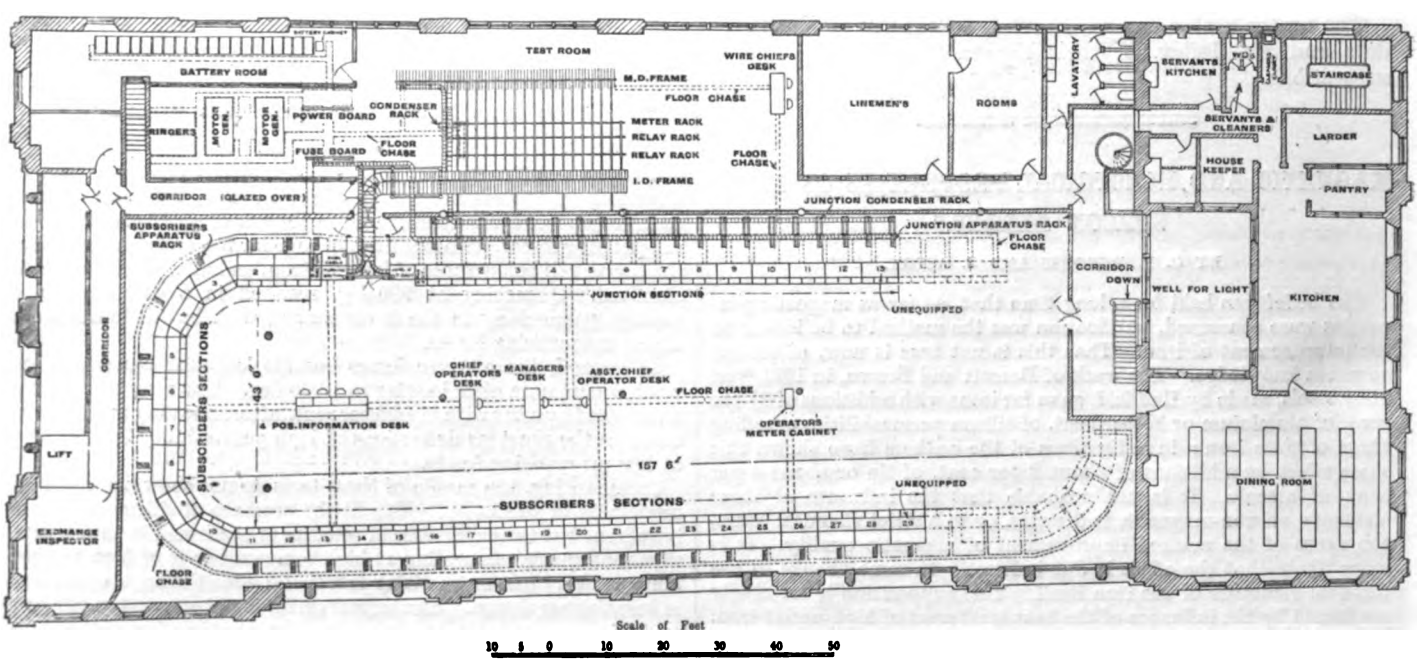

FIG. 2.—FLOOR PLAN—POST OFFICE CENTRAL EXCHANGE, GLASGOW.

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We have already remarked that the latest equipment is of British design and manufacture. The entire work has been carried out by the Peel-Conner Telephone Works (Ltd.), who made the whole of the apparatus at their Salford factory, and subsequently erected it in the exchange. A general idea of the nature of the undertaking will be gathered from the plan to a 30 kw. generator. These are of standard "Witton" design, and were made at the Birmingham works of the General Electric Co. A general diagram of the power circuits is shown in Fig. 3. In addition to the two main motor generators, there are two ringers belt-driven from motors each of 4 H.P. One of these motors is direct-connected to the 250-volt line of the Cor-

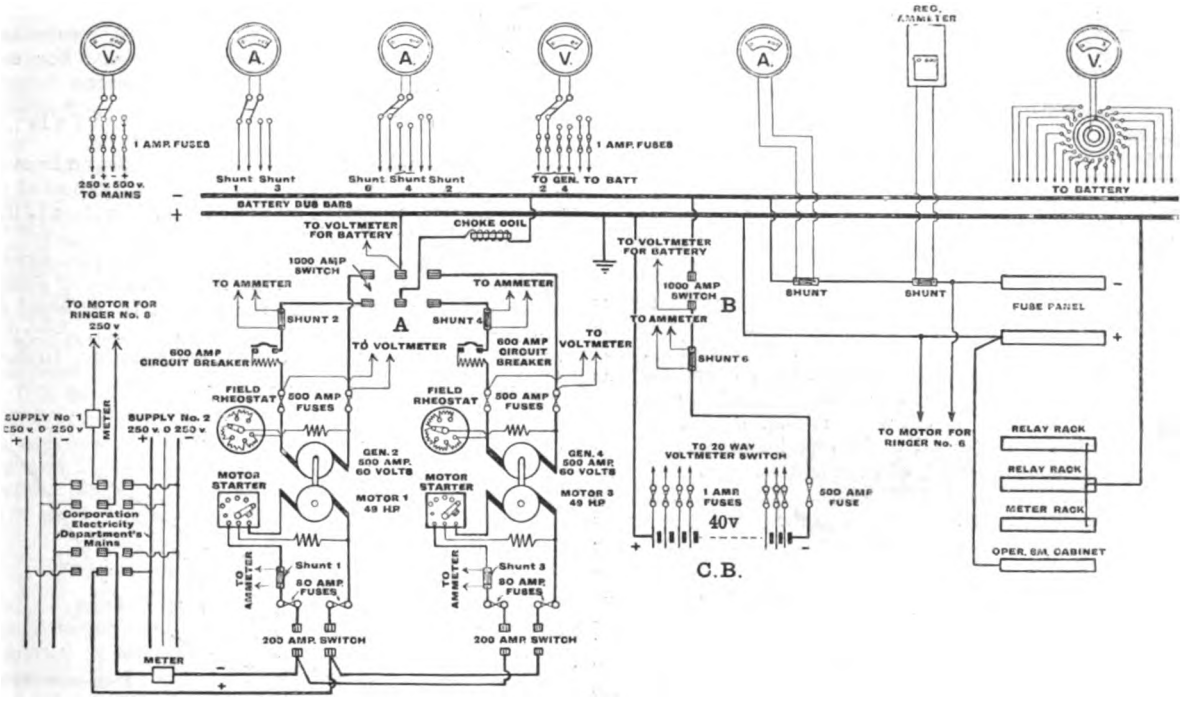

FIG. 3.—GENERAL DIAGRAM OF POWER CIRCUITS IN NEW EXCHANGE.

view of the exchange which is shown in Fig. 2. This serves to illustrate the convenience of placing the whole of the equipment on a single floor. It is particularly noticeable in the position of the power plant, which is immediately adjacent to the switch-room. Usually this portion of the equipment must

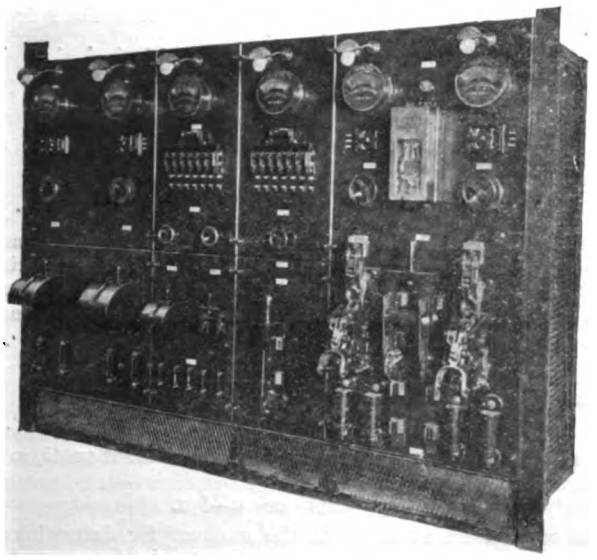

FIG. 4.—GENERAL VIEW OF POWER SWITCHBOARD.

perforce be placed in the basement or in some other position at a considerable distance from the main boards.

For the supply of energy to the exchange two distinct direct current three-wire services have been laid in from the network of the Glasgow Corporation electricity department. From these a supply at 500 volts is given to the motor generators. A switch is provided so that the mains of either service may be coupled to the machines. There are two main motor-generators, each consisting of a 49 H.P. motor direct-coupled

poration service, and the other motor is operated at 40 volts from the 60-volt generator 'bus bars, a choke coil being used to reduce the pressure. The common battery shown at CB on the diagram comprises 20 Chloride cells having an ultimate capacity of 3,230 ampere-hours at a 9-hour discharge rate. The initial equipment of plates provides for a capacity of 2,720 ampere-hours at the same rate. As there are two independent supplies of energy, the battery has not been arranged in duplicate. A 1,000-ampere two-pole double-throw switch, shown at A in the diagram, is provided for connecting either generator to the battery. The battery is protected by a 500-ampere fuse

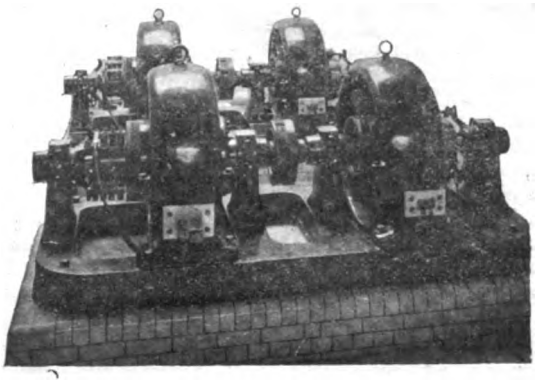

FIG. 5.—WITTON MOTOR GENERATORS INSTALLED IN NEW TELEPHONE EXCHANGE.

enclosed in an air-tight cabinet, and erected near the end cell on the negative pole. The negative battery lead can be disconnected by means of a 1,000 ampere switch shown at B on the diagram. This switch can only be used when the battery is disconnected from service. In this case one of the generators would have been previously coupled up for supplying current direct to the exchange. The power board and motor generators are illustrated in Figs. 4 and 5.

(To be continued.)

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LIBRARY OF THE UNIVERSITY OF CALIFORNIA

COHERERS.*

BY W. H. ECCLES, D.SC., A.R.C.S.

(*Concluded from p. 727.*)

Summary.—A method of investigating detectors is developed with special reference to the relations between the energy given to the detector in the form of electrical vibrations and the energy delivered by the detector, as direct current, to the circuit of the indicating instrument. The response of the detector was measured by comparing the sound in its telephone with the sound produced in the same telephone by interrupting a measurable direct current. The results of experiments on coherers made of oxidised iron wire dipping into mercury, and on coherers made of a clean iron point touching an oxidised iron plate, are recorded. The author puts forward the hypothesis that the properties of an oxide coherer may arise solely from the temperature variations caused in the minute mass of oxide at the contact by the electrical oscillations and by the applied E.M.F. He examines the hypothesis mathematically and shows that most of the phenomena recorded can in this way be accounted for as perfectly as the present state of the measurements permits.

A Hypothesis of Coherer Action.—The experimental results described above lead me to offer a simple hypothesis of the mode of operation of the class of coherers in question. When an oxidised wire is dipped into mercury or touched against a conductor, the oxide dielectric between the conductors is so thin and so extended that a considerable current, relatively speaking, can be passed through it. The films of oxide used in the experiments had a thickness of the order of a wave-length of light and an electrical resistance usually between 50 and 2,000 ohms. When a current is passed through the film, heat is generated in the film and raises its temperature. The rise of temperature may be considerable if the mass heated is small, but is limited by the escape of heat to the surrounding metal. If the rise of temperature does not affect the resistance of the heated material appreciably, the relation between the applied E.M.F. and the consequent current will be a linear one; but if the resistance of the material varies with its temperature the relation between E.M.F. and current will not be linear. A direct experiment on a film of oxide of iron showed that its resistance coefficient was negative and nearly 1 per cent. per degree Centigrade. Calculation shows that a resistance-temperature coefficient of this magnitude can cause the voltage-current curve to deviate considerably from a straight line. The equation of the curve is deduced below.

If a train of electrical oscillations be passed through the minute mass of oxide traversed by the steady current, its energy appears as heat in the oxide. The resistance falls in consequence, and the equilibrium of the direct current in its circuit is disturbed. Since the rise of current enhances the heating of the oxide, the subsidence of the current to equilibrium is somewhat prolonged when, as in the case of iron-oxide, the resistance-temperature coefficient is negative. Hence the effect on a telephone diaphragm, whose natural period of vibration must be regarded as great in comparison with the duration of a train of oscillations, may be very large. It remains to be seen whether the disturbance of the direct current, caused by a small variation of resistance, can account for the phenomena disclosed in the course of the above-described experiments.

Let W_1 be the fraction of the energy of a single train of oscillations given to the variable resistance ρ of the detector; let $\rho=\rho_0(1-\alpha\theta)$, where ρ_0 is the value of ρ at the temperature of the surroundings. Then $kW_1=(\delta c)c-(\delta\rho)c^2\rho_0\alpha$, where k is a constant involving Joule's equivalent and the specific heat and the mass of the oxide. This initial disturbance $(\delta\rho)$ of resistance is accomplished in less than $\frac{1}{10000}$ second and gives rise to the perturbations of current to be traced immediately.

Let the direct-current circuit of the detector comprise a total invariable resistance r (which includes the resistance of the telephone), the variable resistance ρ of the detector, and the inductance L of the telephone. Let c be the current at any moment and ϵ the applied E.M.F. Assume that the rate of loss of heat from the warmed mass of oxide to its surroundings is $m\theta$, where, as implied above, θ is the temperature of the oxide above the temperature of the surroundings, taken as zero. Then at any time t

$$\frac{d\theta}{dt}=k\rho c^2-m\theta, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and

$$L\frac{dc}{dt}+(r+\rho)c=\epsilon. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Since $\rho=\rho_0(1-\alpha\theta)$, (1) becomes:

$$\frac{d\theta}{dt}+k\rho_0\alpha\cdot\rho c^2+m\rho\cdot m\rho_0. \quad . \quad . \quad . \quad . \quad . \quad . \quad , \quad (1')$$

* Paper read before the Physical Society. A short account of the discussion following the reading of this Paper appeared in THE ELECTRICIAN, April 1, 1910, p. 1021.

The simultaneous equations (1′) and (2) contain the complete history of the fluctuations of c and ρ from any assigned equilibrium condition. We need only investigate here small fluctuations. First, however, let us obtain equilibrium value of c, say c_1, corresponding to a given value of the applied E.M.F. ϵ. Put $dc/dt=0$ and $d\rho/dt=0$ in (1′) and (2) and eliminate ρ. We get

$$\epsilon=\left(\frac{m\rho_0}{m+k\alpha\rho c^2}+r\right)c. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This equation agrees perfectly with the results of numerous experiments on the iron-oxide-iron coherer. For example, the experimental curve of Fig. 7 has the parameters

$$r=390 \text{ ohms}, \rho_0=970 \text{ ohms}, \frac{k\alpha}{m}=3{\cdot}7\times10^6.$$

In general it would appear that the curves drawn from experiments on detectors should fall into the two classes indicated in Fig. 8 by curves I., III., separated by the case II. In class I. the curve has two vertical tangents; the condition for this is $\rho_0>8r$. If when the coherer is in use the values of ϵ and c pass those corresponding to the lower bend of the curve, the original values of c and ϵ can only be regained by interrupting the current by external agency: the coherer is not "self-decohering." In class III. $\rho_0<8r$: there is no vertical tangent, and the coherer is self-restoring. In case II. $\rho_0=8r$. All these cases can be realised, with patience.

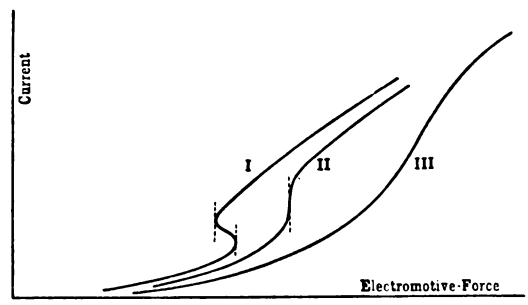

FIG. 8.—IDEAL CURVES SUGGESTED BY THEORY.

To return to the problem of the small fluctuations of the current from its equilibrium value when the arbitrary small variation $(\delta\rho_1)$ is imposed on the system by the arrival of a train of oscillations at the time $t=0$. Equations (1′) and (2) become

$$L\frac{d\delta c_1}{dt}+(r+\rho_1)\delta c_1=-c_1\delta\rho_1 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and

$$\frac{d\delta\rho_1}{dt}+n\delta\rho_1=-2(n-m)\frac{\rho_1\delta c_1}{c_1}. \quad . \quad . \quad . \quad (5)$$

Here

$$n\equiv k\rho_0\alpha c_1^2+m, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

and ρ_1, c_1 are corresponding equilibrium values of ρ and c.

Equations (4) and (5) give

$$L\frac{d^2\delta\rho_1}{dt^2}+(Ln+r+\rho_1)\frac{d\delta\rho_1}{dt}+\{n(r+\rho_1)-2(n-m)\rho_1\}\delta\rho_1=0, \quad . \quad (7)$$

which can be written in the form

$$[D^2+aD+b]\delta\rho_1=0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Here a is essentially positive. The quantity b has the same sign as $d\epsilon/dc$, as may be seen by differentiating (3) and comparing (7) and (8). Since my experiments have been for the most part confined to self-restoring coherers, b has been in practice always positive. Thus (8) yields

$$\delta\rho_1=Ae^{-m_1't}+Be^{-m_2't}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where

$$m_1', {}_2'=\frac{a}{2}\left(1\pm\sqrt{1-\frac{4b}{a^2}}\right).$$

It appears later that a^2 is always much greater than $4b$, so that, approximately,

$$m_1', {}_2'=b/a \quad \text{or} \quad a-b/a.$$

The only datum available at the moment for determining the arbitrary constants A and B in (9) is that the initial value of $\delta\rho_1$ is $(\delta\rho_1)$. Therefore

$$(\delta\rho_1)=A+B. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Using (9) in (4),

$$L\frac{d\delta c_1}{dt}+(r+\rho_1)\delta c_1=-c_1(Ae^{-m_1't}+Be^{-m_2't});$$

whence

$$\delta c_1=-\frac{c_1}{L}\left[A\frac{e^{-m_1't}-e^{-\frac{r+\rho_1}{L}t}}{\frac{r+\rho_1}{L}-m_1'}+B\frac{e^{-m_2't}-e^{-\frac{r+\rho_1}{L}t}}{\frac{r+\rho_1}{L}-m_2'}\right], \quad . \quad (11)$$

which vanishes at $t=0$.

Let the work done in the telephone by the fluctuation of the current through it be w_1, and let the effective resistance of the

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telephone be P. Thus the rate at which the telephone current is working at any moment is Pc_1^2, and, therefore,

$$w_1 = \delta P \int_0^\infty c_1^2 dt = 2Pc_1 \int_0^\infty \delta c_1 dt.$$

Equation (11) now gives

$$w_1 = -r + \frac{2P}{r+\rho_1} c_1^2 \left\{ \frac{A}{m_1} + \frac{B}{m_2} \right\}$$

$$= -\frac{2P}{r+\rho_1} \cdot \frac{c_1^2}{m_2} \left\{ (\dot{\epsilon}\rho_1) + A\left(\frac{m_2}{m_1} - 1\right) \right\}, \quad . \quad . \quad (12)$$

by using the condition (10).

Now, as stated before, $(\dot{\epsilon}\rho_1) = -k\rho_0 a W_1$, where W_1 is that portion of the energy of a single train of oscillations usefully converted to heat in the detector. Therefore (12) becomes

$$w_1 = \frac{2Pk\rho_0 a}{r+\rho_1} \cdot \frac{c_1^2}{m_2} \left(W_1 - \frac{A}{k\rho_0 a}\left(\frac{m_2}{m_1} - 1\right) \right). \quad . \quad . \quad . \quad (13)$$

The experiments have shown that the term involving the arbitrary constant A is always positive. Hence, if A be positive, m_2 must be greater than m_1; moreover, (10) shows that B must be negative when, as was always the case, $(\dot{\epsilon}\rho_1)$ is negative. These considerations applied to equation (9) imply that $\delta\rho_1$ runs through a series of diminishing negative values, passes through the value zero, and becomes positive. This is not possible. On the other hand, if A be negative, m_2 must be less than m_1, and B may be either positive or negative. If B be positive, (10) shows it must be numerically less than A, and then the condition $m_2 < m_1$ implies that $\delta\rho_1$ in equation (9) changes sign once during its history. Rejecting this case we are left with A and B both negative and $m_2 < m_1$. The quantity m_2 must, therefore, be given the value b/a and m_1 must equal $a - b/a$. Put $A = -f^2$, and (13) becomes

$$w_1 = \frac{2Pk\rho_0 a}{r+\rho_1} \frac{ac_1^2}{b} \left(W_1 - \frac{f^2}{k\rho_0 a}\left(1 - \frac{b}{a^2 - b}\right) \right). \quad . \quad . \quad (14)$$

This equation, regarded as an equation between the energy W_1 spent in the detector and the energy w_1 delivered by the detector to the telephone, is precisely of the form required by the experimental curves of Figs. 4 and 5. Those curves may be regarded, in fact, as determining the constant of integration f^2. The methods of measurement are not yet sufficiently refined, however, to make it worth while to examine this intercept term in detail. The coefficient of W_1, on the other hand, may be profitably enquired into.

In this coefficient P, k, ρ_0, a and r (which includes P, of course) are to be taken as constants, while ρ_1, a, b have values dependent on the square of c_1, the direct steady current passing round the detector circuit. By aid of equations (6), (7) and (8) the part of the coefficient which varies with c_1 may be expressed in terms of the quantity n defined by (6). This quantity n, it should be noticed, is itself a function of the square of c_1, and therefore the following discussion applies equally to positive and negative steady currents through the detector. It will be found that

$$La = Ln^2 + m\rho_0 + rn$$

and

$$Lb = n^2 r - mn\rho_0 + 2m^2\rho_0, \quad . \quad . \quad . \quad . \quad . \quad (15)$$

when, as implied by (3), we remember that

$$m\rho_0 = n\rho_1.$$

Now if (3) be differentiated (15) will be seen to become

$$Lb = n\frac{d\epsilon}{dc}.$$

Hence the coefficient of W_1 in equation (14)

$$\propto (n-m)\left(\frac{Ln}{rn + m\rho_0} + \frac{1}{n}\right)\frac{dc}{d\epsilon}. \quad . \quad . \quad . \quad . \quad (16)$$

It is convenient to think of c_1, the impressed current through the detector, as the independent variable. It is, of course, readily connected with ϵ, the impressed voltage by equation (3) or by Fig. 4.

Then as c_1 is varied the factor $n - m$ has as graph a parabola with its vertex at the origin and with the tangent there horizontal. This parabola rises only slightly within those values of the current ever passed through detectors. The second factor has as graph, when values of c_1 are again taken as abscissæ, a slowly falling curve. As a rule the graph of the product of these two factors appears to be a slowly rising curve. Now the third factor $dc/d\epsilon$ is the gradient of the ϵ, c curves shown in Figs. 7, 8. Hence, for a self-restoring coherer we expect that if we draw curves connecting w and ϵ—that is, the watts in the telephone, and the voltage applied steadily to the detector—we expect to find w rising to a maximum at a value of ϵ rather beyond the steepest part of the steady current ϵ, c curve. This deduction is amply borne out by the experimental curves of Figs. 2 and 6. I am not able at the present moment to enter into an exact numerical examination of the whole matter, but such rough values as have as yet been obtained leave little room for doubt that the quantitative adequacy of the above reasoning is as perfect as its qualitative sufficiency. It may be remarked, in closing, that the term subtracted from W_1 in the bracket of equation (14) has its maximum at about the same value of c_1 as gives the maximum gradient in the ϵ, c curve of the detector. This deduction also has to some extent been experimentally confirmed, but the lability of coherers is so remarkable and the difficulty of carrying a coherer through a variety of experiments without altering its internal state is so great, that full confirmation will only be attained by selection of the best from a very large number of observations.

I have to thank the Royal Society's Government Grant Committee for a grant of money to defray the cost of construction of the apparatus used in the above experiments.

INCANDESCENT LAMPS AS PHOTOMETRIC STANDARDS.*

BY C. H. SHARP AND P. S. MILLAR.

For use as photometric standards well-selected lamps should be employed that have been in service for such a length of time that the change in candle-power at constant voltage throughout a considerable period is inappreciable. In regard to the seasoning of the lamps in any given lamp, when the vacuum character of the surface of the filament and the transparency of the bulb are unaltered, the candle-power depends directly upon the watts expended in it. During the early life of the lamp the watts expended in the lamp at constant voltage change on account of a decrease in the resistance of the filament. When the filament has become stable—that is, when its resistance no longer decreases, the candle-power at constant volts no longer decreases. Now, the measurement of electrical resistance is the most precise, as well as the most convenient, measurement which can be made; the method, therefore, has been adopted to measure the change in resistance of the filament at full voltage rather than the change in candle-power. The total change in resistance of a lamp in the period between its initial and peak-candle-power is, roughly speaking, 0·5 per cent. To obtain a satisfactory determination of the exact point at which the seasoning process should be interrupted, the change in electrical resistance should be measured to something like 1 per cent. or 2 per cent. It is necessary, therefore, that the electrical resistance should be measured accurately to one part in from 10,000 to 20,000. There are two available methods for measuring this resistance change. One is to measure the voltage and current. It is, however, a matter of some difficulty to measure the current through a lamp to one part in 10,000.

For measuring the resistance, use is made of the Wheatstone bridge method, which is easily capable of yielding results to the required precision, and which does not require an absolutely steady applied voltage. In using this method the lamp is connected in series with a manganin rheostat, the resistance of which is approximately equal to that of the lamp when hot, and comparisons are made by means of a sensitive galvanometer. The useful life of an incandescent lamp standard is greatly increased when it is used at constant watts rather than at constant volts.

In most commercial photometric work carbon-filament lamps of the ordinary oval anchored type, standardised whilst rotating, form acceptable standards. For work of higher precision, and for stationary standards in general, use is made of a special type of lamp consisting of two hairpin loops, one within the other, and lying in the same plane. The idea of this form of construction is to render it possible to determine the distance between the photometric centre of the lamp and the photometer screen with the highest degree of precision. In the oval anchored type the different parts of the filament lie at different distances from the photometer screen; hence this distance cannot be determined with high accuracy. The filaments of the parallel filament type of lamp, lying as they do in the same plane at right angles to the axis of the photometer bar, enable the operator to ascertain this distance very exactly. Moreover, in this style of lamp the variation of the candle-power involved in a false adjustment of the lamp, whereby it is not placed with its filaments exactly at right angles to the bar, is very small, and the consequences of a mistake of this kind are minimised.

Ordinarily, in the interests of long life, carbon-filament lamps are standardised at about 4 watts per candle. This involves the disadvantage that the light of the lamp is somewhat redder in hue than that of most of the lamps which are to be compared with it, though this disadvantage is not a very serious one until metal filament lamps are reached. The comparison of a tungsten lamp at 1·25 watts per candle with a carbon lamp at 4 watts per candle involves very great uncertainties on account of colour difference. For this reason there

* Abstract from the "Electrical World" of a Paper read before the New York Section of the Illuminating Engineering Society.

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has been established a set of tungsten standards, the candle-power of which is known in terms of the carbon standards. The colour difference difficulty, having been met once for all, is eliminated in future work with tungsten lamps by the use of tungsten standards.

A great deal of attention has recently been given to the question of standardising tungsten lamps, since this type of lamp, being very little subject to change in candle-power, would seem to make an ideal standard for the photometering, not only of tungsten lamps, but also carbon lamps. In the latter case the tungsten standards would be standardised at a sufficiently reduced voltage to bring their colour to the right quality. It has been found that the ordinary commercial type of tungsten lamp does not admit of very accurate standardisation. The difficulty seems to be that a variable cooling is introduced by the contacts between the filament and the anchoring wires. To meet this difficulty there has been developed a type of parallel filament tungsten lamp, in which the anchor wires are dispensed with and all variable contacts are removed. This type of lamp is available only for low voltages, but from all indications furnishes a reliable standard. Another type of tungsten lamp standard has been developed, in which the filaments are in the form of straight pieces welded to wires at both the top and the bottom. This plan obviates the variable contacts and enables the construction of lamps for the range of E.M.F. between 100 volts and 130 volts. In precision standards an error of not exceeding 0·1 per cent. is obtainable. In commercial standards the error is kept within 0·25 per cent. The latter degree of accuracy, being greater than is obtained in much commercial photometric work, is sufficient in many cases.

DISCUSSION.

Dr. E. B. Rosa remarked that themethods formerly used for ascertaining when lamps submitted to the Bureau of Standards had not been fully seasoned required observation of the performance of the lamps over a considerable period of time in order to detect any change in the light given by the filaments. At the present time use was made of measuring instruments at least 10 times as sensitive as formerly, and an observer could ascertain within 10 minutes if the lamps were not properly seasoned by noting some change in the resistance of the filament during that period. An idea of the constancy and reliability of incandescent lamp filaments as primary reference photometric standards could be gained from the fact that accurate estimates showed that if well standardised properly seasoned carbon filament lamps were used regularly as reference standards for 100 years the change in light given at a certain wattage at the end of that time would be only a few hundredths of 1 c.p.

PROBLEMS IN POWER TRANSMISSION.*

BY H. W. BUCK.

Summary.—The author discusses the following subjects: The advantages of steel towers, length of span, suspension insulators, anchoring the conductors, the practical limit of pressure, voltage regulation, frequency, lightning arresters and interruptions of supply.

The rise in the price of wood and the reduction in the cost of fabricated structural steel have naturally led to the substitution of steel towers for the old wooden poles on many lines. Such steel construction enables higher supports to be used, and consequently longer spans with resulting economies. Steel supports also eliminate the fire risk. The question of depreciation in a steel tower, due to corrosion, even if galvanised, has, however, not yet been definitely determined, for most tower lines have been in service for only a few years. If the steel legs of the tower are installed directly in the ground it is questionable whether the life of this part of the tower will be any longer than that of a wooden pole. The strength of a tower with its legs in the ground is also uncertain, since the quality of the soil varies to a great extent. If the legs of the towers are concreted in the ground the tower is greatly strengthened and corrosion is practically eliminated, but the cost per tower installed is thereby in some cases as much as doubled. Unless, therefore, the amount of power used in transmission is very large, so that the cost per horse-power of the line is reduced, steel-tower construction is almost prohibitive in cost. In order to reduce this cost it is common practice to make the smaller members of the tower not more than 0·125 in. in thickness. The life of steel members of this small section, even if galvanised, has yet to be determined, although the results on windmill towers are encouraging.

The lengthening of the span on transmission lines has been an obvious result of the introduction of steel towers. It reduces the number of insulators and consequently the opportunity for breakdowns, and has other advantages, but the lengthening of the span has introduced certain difficulties. With the old-fashioned short-span construction common on wooden pole lines the question of sag and strength of conductor was of very little importance. Lines could be installed slack, using soft-drawn conductors, and the strains on insulators and supports could be reduced to a minimum. Conductors on this account seldom broke. The sag was small in any case, and a foot or so more or less made very little difference. With long spans, however, there is a radical difference in requirements. In order to reduce the height of towers, since their cost increases almost as the square of the height, the conductor must be drawn up to the maximum possible tension. This has eliminated the use of soft-drawn metal for conductors and has necessitated the development of commercial hard-drawn copper and aluminium of very high elastic limit. The long span also requires the stringing of the wire with the greatest care with accurate observations as to temperature and tension. The high-working stress in conductors necessary in modern long-span lines has introduced new mechanical problems in insulator joint cross-arm designs. Furthermore, the conductor is stressed so near to its elastic limit at times of low temperature and high wind that a short-circuit on the line is almost certain to burn it enough to cause it to part from a reduction in cross-section. When a conductor does part under these conditions the high initial mechanical tension is likely to cause considerable damage to adjacent insulators, cross-arms, &c., from recoil. A further difficulty in the case of very long spans has resulted from vibration of the conductor and its crystallisation and ultimate breakage at the point of attachment. In such cases it has been found necessary to make the attachment more or less flexible. The suspension type of insulator is specially favourable for this reason. The economical span length for steel construction under present conditions ranges from about 300 ft. as a minimum to 750 ft. maximum, depending upon a large variety of conditions peculiar to each line.

For E.M.F.s up to about 60,000 volts the standard type of pin insulator construction gives very satisfactory results. With the rise in transmission voltage above this figure, however, mechanical difficulties are encountered due to the large size of pin insulator required. The cost of this type of insulator increases nearly as the cube of increase in voltage, above 60,000 volts, and the necessary height of the pin imposes on the cross-arm tensional strains which are objectionable. Probably the most important and radical improvement which has taken place in recent years in energy transmission has been the development and introduction as a commercial success of the so-called suspension insulator construction. It superseded the pin type almost immediately for the very high voltage lines and now is standard for voltages above about 80,000. Its advantages and its successful performance have been definitely established on a number of important transmission systems already in operation. The suspension insulator requires a higher tower than does the equivalent pin insulator. This is a disadvantage, but it is offset by the simplification of the cross-arm possible with the suspension insulator and the elimination of torsion on the arms and head of the tower. The hardware used in connection with the suspension insulators of various forms is not altogether satisfactory, and there is a field for development and improvement here.

Where pin insulators are used the ordinary method of construction consists in drawing the conductor up to tension over the top of the cross-arms or through the groove in the top of the insulator. Since each pin insulator is a fixed point on the line, the conductor when up to tension can be tied in at any insulator and fixed until the next few spans are drawn up, and so on. With suspension insulators the method is not so simple. Usually the wire is slung in snatch-blocks, one hung from each cross-arm and a mile or so of conductors drawn up to tension. The cable is then fixed to some tower with an auxiliary clamp. After this operation it is necessary to transfer the cable from each snatch-block to the suspension clamp on each insulator, and ultimately the auxiliary clamp must be removed. The extra labour involved puts the suspension insulator at a disadvantage in cost of construction. There are possibilities for improvement here, especially in training linemen to this special work, which is new to most of them. Experience is specially necessary for the tying-in of conductors at dead-end insulators where the operation is quite complicated.

There has been considerable discussion as to the best method of securing conductors on suspension insulator lines. Probably the most satisfactory is to place at regular intervals along the line, one mile or so apart, extra strong towers where dead-end insulators can be installed and the line fixed at these points. These towers should be strong enough to withstand any strain likely to occur on the line. The intermediate towers should be equipped with suspension insulators, but with the conductor clamped thereto so that it can slip through in case of breakage. The intermediate towers need then be only just strong enough to carry the actual weight of the conductors and to resist the overturning moment across the line due to wind. At angles, dead-end insulators should, of course, be used with extra strong towers. Italian engineers carried this principle to an extreme

*Abstract of a Paper read before the National Electric Light Association.

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several years ago by using flexible towers as intermediate supports. The arrangement has special merit in connection with suspension insulators, and has recently been taken up actively in this country. It gives promise of economy, especially from the viewpoint of the cost of tower assembly and erection.

The success with suspension insulators on the recent 100,000-volt lines in this country has been remarkable, and such lines have actually given less insulator trouble than the early 20,000-volt lines when they were first installed. Since the degree of insulation with suspension insulators can be increased to almost any desired extent without involving prohibitive difficulties, there seems to be no reason in the insulator itself why much higher voltages should not give satisfactory results. There are, however, other considerations which will probably limit line E.M.F. to approximately 100,000 volts for some time to come. The insulation of the line itself is a much easier problem than that of transformers, lightning arresters and sub-station equipment, and these devices cannot be considered entirely satisfactory even at 100,000 volts in the present state of the art.

Oil switches become of enormous proportion at this voltage and involve the use of large quantities of oil under conditions where the fire risk is considerable. Furthermore, the spacing necessary between phases at 100,000 volts is so great that sub-station buildings are necessarily very large and expensive. It is questionable whether the economy in conductor cost in raising the voltage from 100,000 volts to 150,000 volts would not be more than offset by the increased cost of insulator towers, sub-stations and operating equipment. There are other problems incident to the very high line voltages which have not yet been solved. The line-charging current is a serious element on long lines even at 100,000 volts, and the atmospheric discharge loss increases rapidly above this voltage. The spacing between conductors for the latter reason will have to be largely increased as the voltage goes up, and it will probably be necessary to increase artificially the diameter of conductor to reduce the discharge loss. This will increase the wind strains on towers and increase their cost. It is provable that 110,000 volts is as high a voltage as is justified on a large commercial scale under the state of the art as it is at the moment. It would be well for electrical engineers to be conservative in this regard in the best interests of permanent advancement, since a too rapid rise in line voltage applied commercially is certain to result in unforeseen difficulties and unsatisfactory service, which can only retard legitimate development.

Voltage regulation under the variable load on very long high voltage lines cannot be considered satisfactory under present conditions. This result is attributable principally to the great inductive drop and the excessive charging current, both of which are exaggerated at 60 cycles. For instance, the wattless leading current in a 100,000-volt 60-cycle single-circuit line 150 miles in length is approximately 50 amperes, or equivalent to 8,650 k.v.a. This requires a very considerable generator equipment to operate the line even at no-load. This charging current magnetises the generator field so that the voltage will automatically build itself up until a condition of high saturation in the generators is reached. In order, therefore, to maintain normal voltage under these conditions the generator direct-current field excitation must be reduced almost to nothing. The combination is highly unstable. As the load comes on, if it is inductive, such as induction motors, the line-charging current may be neutralised or the resultant may actually be a lagging current. The generator fields must then be strengthened to a point which on the no-load saturation curve of the machines would correspond to a voltage much above normal. Assume, then, that some circuit-breaker on the system opens, thereby cutting off a large block of power load and also part of the compensating lagging current; the resultant current at the generators immediately changes from lag to lead, the line-charging current again predominating, and the generator voltage may rise as much as 50 per cent. This serious rise in voltage is caused by momentary speed rise due to reduction in load and armature reaction due to change from lag to lead, and in addition there is the boost of voltage over the line inductance due to the leading current. Other motor users on the system which remain connected to the lines under these conditions will suffer from the disturbance.

This problem in regulation can be solved only by the installation of shunt inductance placed at intervals along the line permanently connected thereto, and so adjusted as to neutralise the line-charging current regardless of conditions in the various receiver circuits. If it becomes necessary to neutralise the lagging currents of the receiver circuits, use should be made of rotary condensers. It is not feasible, however, to neutralise the lagging currents in the receiver circuits with the line-charging current if a good line regulation is required, since one is a constant and the other is a variable.

While a frequency of 60 cycles does not compare favourably with one of 25 cycles for line conditions alone, on account of the increased charging current and inductive drop at the higher frequency, 60 cycles is coming into more general use on the large transmission systems. This result is due somewhat to the necessity of operating in conjunction with existing plants; but there is justification for it in the reduced cost and size of the transformers, which are large and expensive in any case at high voltages. One of the strong arguments formerly used in favour of 25 cycles for transmission is its benefit in rotary converter operation. On account of poor voltage regulation however, it is no longer usual practice to instal converters on long lines, since independent voltage control of the motor-generator set is required. Furthermore, the general adoption of 25 cycles for single-phase railway operation does not look as probable as it did a few years ago; so that greater advantages for overhead work seem to be in the 60-cycle system. Where extensive underground cable networks are involved a frequency of 25 cycles is desirable in order to reduce the cable eddy current and dielectric losses and to lessen the charging current.

Good progress has been made in lightning arresters through the development of the electrolytic type. If a disturbance takes place on a line, thereby causing a wave of high voltage, the electrolytic arrester allows the surge to pass through it satisfactorily and absorbs its energy. Under these conditions current from the generator does not follow and the arrester is not overheated. If, however, the actual voltage on the line rises for reasons previously discusssed, the arrester breaks down and the current in the circuit is actually generator current at the higher voltage, and here the heat generated in the electrolyte is apt to cause an explosion with consequent ejection of liquid, oil, &c., and permanent damage to the disc units.

It is not likely that lightning itself will be as troublesome at 100,000 volts and over as it is on the lower voltages. The insulation of the entire transmission system is so high that the potentials due to lightning are not so likely to cause a puncture, and a point should ultimately be reached where all the apparatus will have sufficient insulation to be practically lightning proof. Arresters are really of use more for protection from so-called surges than from lightning. Even these should be reduced as line voltages increase, since the reaction due to any sudden change in the line current is proportional to the square of the line current. The higher the voltage, of course, the less the current for a given power, so that the tendency should be to lessen disturbances. The steel guard wire installed along the top of many recent transmission lines has given promising results, and the general opinion is that it is a benefit as a protection from lightning. It has an additional mechanical advantage in tying all the towers together and an added electrical use in connecting all the towers so that all must be at the same potential. If it is then necessary to work on a conductor on the line, this conductor can be earthed to any tower and brought thereby to the same potential with every tower, so that work can be safely carried on without danger from shock.

So long as overhead transmission lines exist as they are under the present state of the art, occasional interruptions to service will necessarily occur. It is better to recognise this fact and make provision to reduce the duration of interruption. An interruption once or twice a year, lasting a few minutes, will cause very little inconvenience even to the most exacting public utility. The real problem in satisfactory service is to design switching arrangements and provide spare circuits and apparatus so that when trouble does occur it can be located rapidly, isolated and service resumed at once. Resumption of service should never wait upon repairs.

One of the most important elements in case of trouble is effective telephonic communication between the various parts of the transmission system. The practice lately has been to remove telephone wires entirely from transmission towers, so that they will not be subject to trouble from the high-tension conductors. This arrangement is especially necessary on the very high-voltage lines because of static induction. The latter is more difficult to eliminate satisfactorily than is magnetic induction, which can usually be overcome by transposition.

The largest field for future evolution in energy transmission is toward high-voltage direct current. Its advantages over alternating current from the standpoint of the line itself would be very great. The effective voltage would coincide with the maximum, and the insulator problem would be reduced by 30 per cent. The number of conductors would be reduced to at most two, and possibly one with earthed return would be satisfactory. Line-charging current and self-induction would cease to exist, and the question of power-factor would be eliminated. The whole problem of energy transmission would be vastly simplified, and costs for construction would be reduced. Such a development would undoubtedly double the practicable transmission distance. The problem is not one in energy transmission but one in electromagnetic machinery, and it would involve radical developments and probably some new discoveries. The complications now necessary for the generation and utilisation of high-voltage direct current are such that its general adoption would not be commercially practicable.

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Editorial, Publishing and Printing Offices,

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(ONLY ADDRESS.)

Tel.: Holborn **6363** (Two Lines). *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."

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THE IDEAL ELECTRIC LIGHT.

What constitutes the ideal electric light is largely a matter of opinion. There are many sides to the question, efficiency being the one that is seldom overlooked. But economy is not the only thing to be aimed at; the colour of the light and its even diffusion are equally of importance. Daylight is usually regarded as the natural standard by which colour and diffusion should be judged; but in both respects the standard so set up is purely arbitrary. It is, indeed, conceivable that, in so far as the effects on the human eye are concerned, daylight may have too much red or blue; in other words, a light of a different character ought not necessarily to be put out of court if its physiological effects on the brain alone are considered. The mercury arc lamp is extremely efficient, in the sense in which the word is used in engineering circles; it is also said by those who have used it to be very pleasant to work by. No complaints have ever been made, in so far as we are aware, of any injurious effect that has been produced by it on the human eyesight, though it has been in continuous use in certain places for lengthened periods. Yet the character of this light, spectroscopically considered, is notoriously different from that of daylight, which seems to show that the arbitrary spectroscopic standard of daylight may, perhaps, admit of a good deal of variation, when looked at from the physiological point of view, without ill effects.

We publish in this issue an abstract of the report by Prof. WEDDING, of Charlottenburg, on the Moore light, and this

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is probably the first independent statement that has been made on the subject as the result of careful photometric tests. The pertinacity with which Mr. McFarlan Moore has laboured during the 15 years he has devoted to the development of his idea is worthy of all praise. The outside man has, however, to examine the result in the light of cold reason. The obvious fact must be admitted that the diffusion produced by the source of light is in many respects an advance, which could only be produced with other illuminants by the use of frosted globes or by inverting the lamp, or otherwise hiding in one of many ways the source from which the light directly proceeds. Using the word "efficiency" in the usual sense, the light is inferior in this respect to others at present in common use, though for many purposes this would not be held to be a deciding issue. In spite of all the special pleading that has been heard from time to time, we cannot say that the difficulties connected with the installation itself have been altogether disposed of; in fact, we fear that the more we come to close quarters the less will these things loom in the distance like so many unconsidered trifles to be easily overcome. The immense voltage to be applied to the tube through a transformer can scarcely be regarded as a trifle, even by the most optimistic householder; the "glass-plumbing" that has to be undertaken in case of a fracture or repair will need the development of a new type of workman, and make the cost of repairs very serious at any distance from headquarters; the light itself is indivisible, which means that the whole of a room or hall must be lighted, and not a corner that might meet the needs of the case; some sort of a stand-by seems necessary in case of a breakdown, meaning that the installation must be duplicated in some way; the power factor is not likely to be much higher than 65 per cent., so that the lamp is likely to receive rather a cold welcome from the central station engineer; added to this, little or nothing seems publicly known as to the cost of installation, although a good deal of work has been done in America, a country in which the arts of advertisement are not lost on either buyer or seller, and must be taken into account in pioneer installations of this kind, where cost is not altogether a final factor.

Taking these as the most serious items in the case that can be made out against the lamp, the main thing urged on the other side is with regard to the nature of the illumination and the colour of the light. On neither point do we feel altogether convinced. A well-diffused light is not unknown to electrical engineers, and this, too, with a reasonable efficiency. As to the colour of the light, this, of course, depends on the nature of the gas through which the discharge passes. Nitrogen seems to be the usual gas, though with carbon dioxide a whiter light, more nearly approximating to daylight, can be produced at a lower efficiency. Taking the nitrogen light, the colour is described as warm and rosy, and this agrees with previous reports, which described the light as containing a considerable excess of red. It may be of a pleasant colour, but it is certainly different from daylight. The carbon dioxide lamp has been used in places where the matching of colours is an important part of the day's work; but we do not hear the same of the nitrogen tube, which seems to be the commercial article. Prof. Wedding says nothing about the flicker, which has been noticed with ordinary frequencies, such as 60. With a frequency of this order, there has been noticed by other observers to be a well-marked flicker, which produces strange effects when things exposed to the light are moved rapidly to and fro. Users of the lamp are said not to complain of this, and it may be that one easily gets accustomed to it.

On the whole, we are far from rivalling the phosphorescence of the firefly. Not more than 10 per cent. of the power put into the most efficient illuminant with which we are acquainted is turned into light; usually we have to be content with about 2 or 3 per cent. Still, we cannot help feeling that Mr. Moore has quite unconsciously taken up arms against a sea of troubles, an unequal form of struggle at best. He has successfully grappled with the problem of keeping the vacuum constant, or at any rate he has discovered a workable solution. But whether his persistence will overcome the dogged obstinacy of the human mind, which is only too willing to bear the ills it has, remains to be seen.

REVIEWS.

(Copies of the undermentioned works can be had from The Electrician Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

The Gas, Petrol and Oil Engine. By Dugald Clerk. Vol. I. (London: Longmans, Green & Co.) Pp. ix. + 313. 4s. 6d. net.

For now nearly 30 years the name of Dugald Clerk has been permanently associated with the development of the gas engine, not only from the practical side, but also from the interest which he has taken in the elucidation of many difficult problems that have been brought to light by the study of the internal combustion engine.

Any work by this distinguished authority will only be too eagerly read by the student, and all those interested in the development of power. The work in question was published many years ago, and Clerk has now brought it up to the most recent knowledge on the subject. It may be said at once that those who already have a familiar knowledge of the internal combustion engine will find a great deal of modern and interesting information in the work. Those, however, who are approaching the subject as pure learners, and who have not got a knowledge of gas engine practice, such, for example, as the multitude of engineers who are now being educated in the various technological centres, will, we fear, find this work far from easy to master. It labours under the disadvantage of so many recent works on applied science that the logical order of the subject, which is so important to the student, is not strictly followed. The subject matter is all there, and is well treated, but the subjects do not lead from one to another in the order in which the student can most readily assimilate the information. We venture to suggest that those proposing to write technological works which will appeal to seekers of information—and these, after all, are by far the largest class of readers—would do well to study such standard text-books as those of Rankine, Cotterill and Ewing, in which the subject matter is presented in a form suitable for the student to follow readily the various steps.

Clerk adheres in the body of his work to the standard cycles based on air as a working medium (specific heat being assumed as constant), no doubt being largely influenced by the committee of the Institution of Civil Engineers, who after weighing the subject decided, for the sake of simplicity, to recommend as a standard an engine working on a simple fluid like air, and ignoring all the evidence that has been accumulated on the variability of the specific heat with temperature.

The experiments of Holborn and Henning in 1907 proved beyond all question that the specific heat of the permanent

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gases varies with the temperature, according to linear law, and that further, both water vapour and carbon dioxide follow a law which is still more complicated than the linear form. It is, of course, quite open to suppose that experiments conducted at the high temperatures of 1,400°C. are subject to serious error, and that therefore the absolute values of Holborn and Henning may be uncertain, but we venture to suggest that no treatment of the internal combustion engine may be considered as at all satisfactory which does not take into account the variability of the specific heat.

The phenomena of afterburning, or what is termed "Nachbrunen," have given rise to much speculation as to what takes place during the expansion curve of an internal combustion engine. Clerk himself has long been an advocate of the theory of disassociation, that is, that chemical combination does not take place at the very high temperatures, and that the carbon and hydrogen atoms may exist uncombined in an atmosphere of free oxygen. Other authorities have considered that it is possible for the wall action to account for the apparent contradiction of the raising of the expansion curve above the adiabatic. If, however, the variability of the specific heat be admitted, the whole of these phenomena are most readily explained, as it will be found that the true form of the adiabatic curve as compared with the expansion curve is always above, and never below. We ourselves have plotted a large number of expansion curves in combination with the true adiabatic, taking for the specific heat of the gases the values of Holborn and Henning, Holborn and Austin, and the still later results of Millard and Le Chetalier, the latter of which are admittedly incorrect.

It will be found that during expansion the charge behaves as a perfect gas, and that there is a loss of heat. Moreover, if the heat additions be calculated up to the point of maximum temperature, the whole heat of the charge will be approximately accounted for, a result pointed out in the first instance by Slaby. These experiments, although made as far back as 1887, are still full of information.

In conclusion, we would strongly recommend all those interested in the internal combustion engine to read this work. If they are careful to take out from the vast mass of information which it contains that which is useful they will profit; but we would wish that Clerk had had sufficient time and inclination to re-write the work entirely, and to put before his readers exactly what is his own opinion as regards the phenomena which take place. F. W. BURSTALL.

Finanzierung und Rentabilität deutscher Strassenbahnen. By Dr. FR. HERMES. (Jena: Gustav Fischer.) Pp. vi.+63. M.2·50.

Although the present volume deals exclusively with German tramway finance, it contains a great deal of information which will prove very interesting reading to managers of English tramway undertakings. The subject is well presented and scientifically treated. Only company controlled tramways are considered, municipal undertakings being excluded.

In the introductory portion the author gives a brief but interesting survey of the growth of electric traction in Germany. Chapter I. deals with the question of electrification, and contains remarks on the various groups of interested parties, the electrical companies, trusts, the financial dependence of tramways and divided guarantees. In Chapter II. the author discusses the considerations underlying the granting of tramway concessions, the influence of the town on the length of the line and the tramway fares, the taxes to be paid to the town and their basis of computation, and the length of the term of the concession. Several examples are cited. Chapter III. details the methods of raising capital, which is further examined in Chapters IV. and V. Chapter VI. is on revenue (receipts, fares, competition, expenses, &c.). A large amount of statistical data is also given in tabular form at the end of the book.

The Protection of Railroads from Overhead Transmission Line Crossings. By F. F. FOWLE. (New York: D. Van Nostrand Co.) Pp. vi.+68. $1·50.

The present little volume is the publication in book form of a Paper prepared by the author for the twenty-seventh Annual Convention of the Association of Railway Telegraph Superintendents at Montreal, June 24 to 26, 1908, and deals exclusively with the methods of protecting railroad property and the lives of railway employés at overhead crossings of high-tension lines. The subject is an important one, and deserves the close attention of all engaged in high-tension transmission work. The principles involved are carefully explained, and the protective devices in use are critically examined. It is a book which distinctly fills a gap in the literature of this branch of electrical engineering, and should prove of value. A special feature of the book is the number of excellent illustrations it contains of high-tension lines, which show in a very striking manner the effects of failures which commonly occur in actual practice.

The book starts with an exposition of the dangers consequent upon the use of high potentials and the effects of failure at a railroad crossing; examples of line construction and actual cases of failure are given. The screen protection is next explained, and several types of screen construction are illustrated. The method is restrictive rather than preventive, and for this reason the author does not favour it except as a last resort. Bridge and catenary type of reinforced crossings are also explained and criticised, and underground crossings are considered. Under the heading "Discussion of Proposed Type of Crossing," the points which are vital in drawing up a specification are given, crossings are classified according to voltage, and sleet load, wind pressure, temperatures and factors of safety are considered, together with structures, foundations, insulators, conductors, distance apart of conductors, dead ending and tying, ground cables and low-voltage circuits on the high-tension line. A typical crossing for a high-tension line carrying two 22,000-volt three-phase circuits is then fully illustrated, and a number of useful references are given to the transactions of the American Institute of Electrical Engineers on the subject. In conclusion, we feel sure that a book dealing with the whole subject of high-tension protection by the author would be welcomed by the engineering profession.

LOCATION OF FAULTS IN UNDERGROUND HIGH-TENSION CABLES.*

BY W. A. DURGIN.

Summary.—The author discusses the methods of fault location adopted on the high-tension underground cable system of the Commonwealth Edison Co. of Chicago. A special slide-wire bridge designed for Murray and Varley loop tests is described.

Prompt location by test requires that each terminus of high-tension lines should be provided with a device for short-circuiting the phases of a faulty cable. For a three-phase line, three short lengths of flexible cable, joined at one end and provided at the other with spring clips adapted to clamping the phase terminals firmly, answer admirably. The addition of a longer cable from the common junction increases the usefulness of the device by making a convenient arrangement for earthing, which is further facilitated by installing a permanent earth wire with wing-nut connectors near each cable terminus. A 100 to 200 volt source of direct current should also be available at each terminus. With these devices available, fault location by test resolves itself into four main divisions: (*a*) Analysis of original fault; (*b*) reduction of fault resistance; (*c*) approximate location by predictive tests; (*d*) final location by exploration tests.

Much time may be saved and many errors avoided in predicting locations by analysing the original fault thoroughly. A sensitive voltmeter, a lead from one side of the direct-current source with a lamp socket in series, and some form of bridge for measuring resistances from 0·1 to 300 ohms, are all the apparatus necessary in addition to that noted above. The voltmeter is used to measure insulation resistance by the well-known series method, and should preferably have a resistance of at least 500 ohms per volt, although satisfactory results can generally be obtained with instruments of 200 ohms per volt. The procedure is as follows:—

1. With both ends of all phases clear, measure the insulation of each phase by reading the deflection of the voltmeter when one terminal is connected to the phase conductor and the other to the unearthed side of the direct-current source through a 32 c.p. lamp. If E_2 = voltmeter deflection, E_1 = pressure of direct-current source, R = voltmeter resistance, then insulation resistance = $R(E_1 - E_2)/E_2$.

* Abstract from the "Electric Railway Journal" of a Paper read before the National Electric Light Association.

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2. If a fault on either phase has low resistance, apply the lead from the lamp directly to this phase, and if the lamp glows measure the fault resistance with the bridge, reverse the battery and re-measure, taking the mean of the two bridge measurements as the true resistance.

3. Test for crosses between such phases as show the same insulation by earthing one and re-measuring the insulation of the other, using first the voltmeter and then, if a low cross exists, the bridge.

4. Have the short-circuiting device applied at the distant end of the line, caution being used to make firm low-resistance contacts on all phases.

5. Measure the resistance of all uncrossed loops with the bridge, checking the result against the resistance computed from the known size and length of line.

6. If either loop shows high resistance, determine the insulation on the far side of the "open" over a clear phase, and unless that is much lower than the insulation on the test side of the "open" proceed with No. 7.

7. Measure the insulation of the test side of the open phase when the far side is earthed over a clear phase, thus getting a minimum limit for the resistance of the path across the "open." If in No. 6 the insulation resistance of the far side is low, No. 7 is practically covered by No. 6.

8. If all the loops show "open," check continuity by having the short-circuiting device earthed at the distant end of the line and applying the voltmeter to each phase. If one phase is then shown continuous and has fair insulation, apply No. 7 to the other two phases.

This procedure gives a clear picture of fault conditions. If the analysis shows all faults or crosses of more than 100 ohms resistance, the next step is to reduce one to this or preferably to a lower magnitude. The apparatus for "breaking down" faults depends largely on the size of the system concerned. In any system, pressures from twice that of the normal transmission to a few volts, and current of at least 5 amperes, will be required at the fault, while for long lines excess current capacity must be provided to supply charging current at the higher pressures. When special apparatus is to be provided for a moderate-sized system, the most satisfactory results will probably be obtained from a single-phase testing transformer of ample capacity supplied from the regular low-tension system and controlled through a water rheostat. Provision should be made for following fault conditions with ammeter, voltmeter and wattmeter connected to the transformer, and for quickly checking the fault resistance at frequent intervals during the reduction process by series direct-current voltmeter readings.

The procedure in this reduction process varies with the conditions at the fault. The object is always to carbonise a sufficient amount of paper to carry a current of 1 ampere to 2 amperes for several hours, as it is practically impossible to produce any form of metallic path from sheath to conductor in the presence of paper. If the paper at the fault is dry, a current of 1 ampere continued for 5 to 10 minutes will generally produce a carbon path of less than 10 ohms resistance, which is stable for currents of a few amperes; but with damp paper a 3 to 5 ampere current is required for about 10 minutes for drying, followed by a 1 ampere current for five minutes for carbonising. With a fault submerged in water, no manipulation will produce carbonisation. These fault conditions can frequently be deduced from the behaviour of the voltmeter and ammeter. Thus a submerged fault has a resistance to direct current of from 1,000 ohms to 3,000 ohms, and requires 2,000 volts for any alternating current from 1 to 5 amperes. Furthermore, the frequent interruption of the arc at the fault by water gives both meters a peculiar kicking swing. A similar swing is also observed at first with a damp fault, but lessens perceptibly after one or two minutes; and when the arc is once established, the pressure required rapidly diminishes. With a dry fault very little swinging occurs, and if the current is held constant the pressure drops very rapidly to zero. The lower the resistance produced the easier it will be to make accurate locations, but, unless the reduction is carried below 100 ohms, a 1,000 ohm fault is nearly as satisfactory as one of intermediate resistance. It is important to work always on a single-phase or loop, for if two or more phases are earthed, or more than one cross exists, a successful exploration test depends on reducing the resistance of one fault much below that of the others, and, on the other hand, a successful predictive test depends on preserving the unfaulted phases intact for use as normal standards.

Resistance forms the basis of most predictive tests, for this quantity is easily measured to an accuracy of one-tenth of 1 per cent., and proportionality to length is approximately realised. Of the many resistance methods only two are generally applicable to power cables—the Murray and the Varley loop tests. Both these tests are special applications of the Wheatstone bridge principle, and in consequence a modified bridge is required. The essential features can be shown by describing the apparatus illustrated in Fig. 1, which, although apparently crude, has been found to answer all requirements. This consists of a slide wire, C-SL, mounted over a paper scale divided into 100 parts, numbered in two ways, the inner scale 0-100-0 and the outer 0-50-100. Between SL and the posts LL, 5 and 20 are mounted three coils, the first having a resistance exactly equal to the slide wire (about 0·75 ohms), and the second and third 5 ohms and 20 ohms respectively. The key K serves to control the connection between the binding post E and the chisel blade P, which is used as contact on the slide wire. Connections to the cable under test are made through 6 ft. lengths of large flexible leads, equipped with clamps capable of gripping firmly any form of switch part which may serve as the cable terminal; the resistance of these leads in terms of equivalent lengths of the various sized cable conductors is tabulated for use in correcting measurements. A portable galvanometer, having a resistance of about 30 ohms and a sensibility of 0·4 millivolt per division, and a box containing eight dry battery cells, complete the equipment.

The resistance to be measured is connected between posts 20 and C, the galvanometer between posts SL and C, and two or three cells of battery between posts 20 and E. The point of zero galvanometer deflection is found with P on the slide wire, when, if S = reading on the outer scale, the resistance equals $20S/(100-S)$ ohms. If the resistance is less than 7 ohms, the connections are transferred to post 5 from post 20 and the measurement repeated, 5 ohms being substituted for 20 in the formula. In practice, the values of $20S/(100-S)$ and $5S/(100-S)$ are plotted against S in the form of curves, so that resistances are read off directly for any given value of S. For values between 0·1 and 200 ohms the apparatus gives sufficient accuracy to check the continuity of conductors or to provide the data for a Varley loop location. The loop tests are applicable only when the faulted conductor is continuous—that is, when its resistance from terminus to terminus is entirely unaffected by the fault, and when at least one unfaulted conductor is available in the same or a parallel cable. For either test, the phase which has the lowest resistance fault is joined to a clear conductor at the distant terminus with the short-circuiting device described above, using every precaution to make the connection of negligible resistance to insulate it well from the ground.

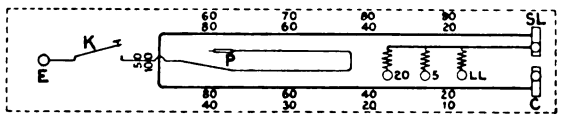

FIG. 1.—SIMPLIFIED SLIDE WIRE BRIDGE.

In the Murray loop test the two ends of the cable loop thus formed are then connected to the ends of the slide wire at the posts SL and C, the galvanometer also being connected between these posts. When an "earth" is to be located, the lead from the earthed direct-current source used for insulation measurements with the 32 c.p. lamp still in series is connected to post E, and the point of balance is found with P. If the galvanometer is not sufficiently sensitive, a second 32 c.p. lamp may be connected in parallel with the first, care being taken to make and break contact at K rather than P. If S = slide wire reading on inner scale expressed as decimal part of 1·00, L = cable length = equivalent length of single connecting lead from slide wire to cable terminus, then $S(L+1)-1$ = distance of fault from testing end of cable. A check measurement is next made by reversing the connections of the cables when the point of balance is found on the opposite side of the slide wire, and a second check by transferring connections from post SL to post LL. With this latter connection the slide wire is one-half of the measuring loop, and S is read on the outer scale with twice the precision of the former measurements. No check reversal can be made with this connection, as the faulted phase must be connected to C in order that the balance point may fall on the slide wire. The mean of the three measurements is taken as the Murray loop location.

The standard Varley loop test differs from the Murray loop merely in using a fixed ratio for the balance arms of the bridge, represented by the slide wire, and in inserting between one end of the balance arms and the faulted side of the cable loop a variable resistance which is adjusted until zero galvanometer deflection is obtained—that is, until the inserted resistance plus the resistance of the cable up to the fault bears the same ratio to the resistance of the remainder of the cable loop as one balance arm of the bridge bears to the other. The true Varley test cannot be made with the slide wire bridge, but a modification which combines features of both loop tests can be performed by connecting the cable loop between posts 5 and C—the faulted side to 5—with galvanometer between posts SL and C. This

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places the 5 ohm coil in series with the faulted side of loop, and leads to a new point of balance on the slide wire. Then, if S = slide wire reading on outer scale expressed as decimal part of 1·00, Lr = resistance of one conductor of cable, lr = resistance of one connecting lead from slide wire to cable terminus (2Lr + 2lr = resistance measured by loop bridge), and X = location of fault in per cent. of cable length from testing end; then

$$X = \frac{(2Lr + lr) - S(5{\cdot}00 + 2Lr + 2lr)}{Lr}.$$

It has been assumed throughout that the faulted cable is made up of a single-sized conductor, and that a clear phase in this cable is used to complete the loop. If, however, the line is composed of known lengths of different sized conductors, or if a clear conductor of known length and size in a parallel cable is used, it is only necessary to remember that the percentage length obtained by either test is in reality a percentage of total resistance and to make the necessary computations to reduce this resistance measurement to percentage length.

The procedure has been outlined as applying to an "earth" fault, but the only change necessary to adapt it to the location of crosses is to treat one of the crossed conductors as "earth," connecting the direct-current source between it and the contact blade of bridge, the other conductor being considered the faulted phase.

The essential points in any satisfactory exploration test are to produce a large difference in some electrical condition on the near and far sides of the fault, and to provide a detector which shall only be affected by this condition. With sheaths bonded at frequent intervals to prevent electrolysis, the path of a signalling current from an "earth" to the sending station will divide first at the fault and further subdivide at each bonding point. A similar effect will result, even though the sheath is unbonded, if the duct line is damp or any other form of distributed earth connection exists. Hence, a continually diminishing portion of current will return over the sheath toward the sending station, while another continually diminishing

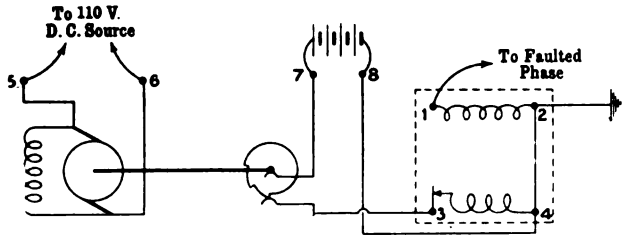

Fig. 2.—Vibrating Interrupter.

portion will continue along the sheath to more distant bonds. Any detector, therefore, which responds equally well to current flowing in a conductor or in the sheath will continue to indicate beyond the fault until the point is passed, where the last trace of signalling current leaves the sheath. Furthermore, any detector which responds at all to sheath currents will give most confusing signals due to railway and other stray currents.

These considerations lead to the development of a longitudinal exploring coil to be used with a telephone receiver. When the magnetic circuit of the coil is parallel to the axis of the sheath, and the winding, therefore, at right angles thereto, no effect is produced by sheath currents alone, but with conductors spiraled as in all high-tension cables a loud signal is produced by current flowing over the loop circuit formed by the conductor up to the fault and the sheath back toward the sending station. When the fault resistance can be reduced to a few ohms, so that currents of 8 and 10 amperes can be produced with a 115 volt direct-current source, very satisfactory signals may be obtained by using such a current sharply interrupted from 50 to 100 times a minute. Any form of "flasher" is adapted to the purpose, which gives a quick break and is capable of operating with certainty for a sufficient period to permit the exploration of the entire length of the longest line should location by the explorer method alone be necessary. In many cases, however, it is extremely difficult to reduce the fault resistance below 50 or 100 ohms, and in some instances even when so reduced the "earth" quickly burns off under currents of more than 2 or 3 amperes.

Such conditions are well met by an interrupting vibrator. This, as shown in Fig. 2, consists of a small 110 volt shunt wound motor, which, through reduction gearing, drives a three-point cam switch controlling the battery connection to the primary of an induction coil. The vibrating spring of the coil breaks contact about 200 times a second, and as the cam switch makes irregularly spaced interruptions of the vibration increase, the words "Hur-ry—up," repeated once a second, result. These irregularly spaced interruptions of the vibration increase the life of the vibrator contacts and battery, and give a distinctive signal. With eight dry cells connected to the primary, currents from 0·4 to 0·2 amperes can be forced through resistances from 0 to 100 ohms. Direct currents of this magnitude interrupted at low frequencies produce no sensible sound in the detecting apparatus, but the exploring coil and receiver are so much more sensitive to high-frequency currents that the signal from the 0·2 ampere current of the vibrating interrupter is quite as loud as that which would be obtained from a 15 ampere "flasher" current.

The sensitiveness of the explorer and receiver are such that with high-frequency currents the displacement of the conductor due to spiraling is sufficient to cause a signal when the explorer is parallel to the sheath axis, even though the sheath carries no return current. For complete silence the explorer must be absolutely parallel to the conductor axis, and, when used on a cable, to the sheath axis as well. This condition may be attained by connecting the vibrator between earth and all cable conductors in parallel. Charging current then flows out over all conductors, but as these are disposed symmetrically about the cable axis the combined effect is strictly equivalent to that of charging current flowing along a single straight conductor at the centre, the sheath also being equivalent to such a central conductor. The signal from charging current, then, is entirely eliminated by adjusting the explorer accurately along the cable axis, if the charging currents are approximately equal for all phases. Such approximate equality will exist unless the resistance of the faulted phase up to the fault is a considerable percentage of the fault resistance—that is, in general power work—unless the fault resistance is less than about 10 ohms. As no interference from charging current is experienced with the single-conductor connection on very low resistance faults, the entire range from 0 to 100 ohms is covered by using the multiple-conductor connection from 100 to 10 ohms, and the single-conductor connection below 10 ohms.

THE PRACTICAL CONDUCTANCE OF ELECTROLYTES.*

BY J. W. RICHARDS AND W. S. LANDIS.

Under the above title is discussed the actual conductance of the electrolyte in electrolytic refining tanks as they are ordinarily set up and operated. In almost all refining tanks the edges of the anode and cathode plates, usually of the same size, are at some distance from the sides and bottom of the tanks. The free space, that not directly included between the plates, is a field through which stray current flows, the current lines being usually curved. It adds considerably to the conductance of the electrolyte. The authors have endeavoured to measure experimentally the conductance of these lateral or bottom prisms of electrolyte in order to see to what extent they influence the conductance of the electrolyte as a whole.

The experimental method used was to place two electrodes of pure copper in a neutral copper sulphate solution against the ends of a glass cell which they completely covered. Readings of current and voltage allowed the calculation of the conductance of the cell as a whole to be arrived at, repeated readings being taken at different values of current and voltage until accurate values were obtained for the conductance. The plates were then raised by intervals of 1 cm. and the conductance of the cell determined each time as before. From the conductance of the cell as a whole, as thus measured at each interval of rise, was subtracted the calculated conductance of the prism of electrolyte directly between the plates, thus leaving the conductance of the bottom prism. The conductance of the bottom prism was then compared with its full calculated conductance, and the percentage which the former formed of the latter recorded. Similar experiments were made with cells of different dimensions. It was found that while the conductance of the bottom prism was different for different lengths between the plates, its percentage conductance as calculated above was practically constant for any given ratio of depth of solution under the plates to length of solution between the plates. We have therefore plotted from our most reliable experiment the percentage conductance of prisms below the plates, taking as ordinates the ratio of depth to length and as abscissas the percentage conductance as calculated above. (*See* Fig.)

For zero ratio the conductance is, of course, 100 per cent., and for an infinite ratio 0. An interesting observation is that for a given conductance between the plates the actual (not percentage) conductance of the prism below the plates reaches a maximum at a finite increase in depth, and thereafter remains constant. In several of our experiments this maximum conductance was reached with a ratio of depth to length of approximately 0·8.

In order to determine whether the conductivity (specific conductance) of the electrolyte affected the values determined as above,

*Abstract of a Paper read before the American Electrochemical Society.

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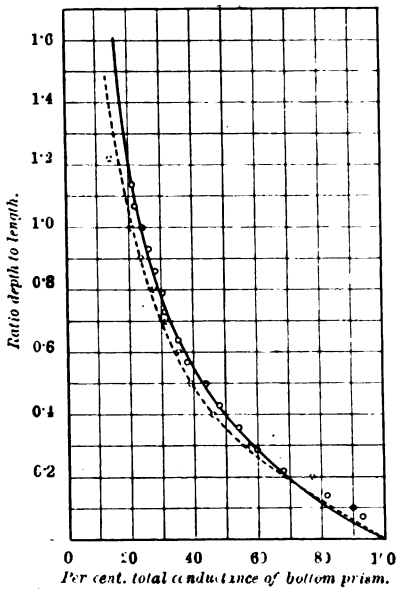
the authors tested electrolytes of widely varying conductivity with approximately identical results, and furthermore tested sheets of copper tinfoil and zinc; the most careful experiments being made with zinc and the ratio determined from it practically duplicated the ratio obtained from the copper sulphate electrolyte. The results obtained with zinc are shown by the dotted curve.

In cells in which the electrode covered only a portion of the ends we also attempted to determine the conductance of the prism of electrolyte not directly underneath the electrodes, but to one side, and which may be assumed as having connection with the electrodes only at their corners. In making these determinations, electrodes were used smaller than the ends of the cells and were also raised up by successive centimetres, leaving besides the prism directly between the plates, the side prism between the edges of the plates and the side of the tank, the bottom prism between the bottom edges of the plates and the bottom of the tank and the diagonal bottom prism. The conductance of the cell as a whole being measured for each successive withdrawal of the plates, the sum of the calculated conductances of these prisms, between the electrodes, at the side of the electrodes, and directly under the electrodes, was subtracted from the measured conductance of the whole cell in order to determine the residual conductance ascribable to the bottom diagonal prism. The number of factors to be considered in this measurement left the determination of the conductance of this bottom diagonal prism rather unsatisfactory. From three or four carefully conducted experiments, however, it can reasonably be concluded that the conductance of a relatively large diagonal prism, such as would be encountered in practice, does not appear to add sensibly to the conductance of the cell as a whole.



There results from this study the conclusion that the practical conductance of the electrolyte situated between the two electrodes (including that directly, laterally and beneath the electrodes) can be calculated by adding to the conductance of the portion between the plates the virtual conductances of the side and bottom prisms. These latter are to be determined in each case by calculating from the respective total conductances of the prisms (as if between parallel plates) and the use of the percentage conductance as given in the curve herewith. It is necessary to reckon the ratio of depth (distance from edge of plate to side or bottom of tank) to length (distance between the plates), refer to the curve and find for this ratio the percentage of the total conductance of each prism actually available. The conductance of the diagonal bottom prism may be neglected in all cases in actual practice.

For practical purposes, where the ratio of depth to length happens to be greater than 0·8, the conductance of the prism of electrolyte beneath or alongside the electrodes may be considered as constant, and calculated as equal to the total conductance (between parallel end plates) of a prism of electrolyte of the length concerned and one-quarter as deep as it is long. Or, in other words, the maximum conductance of these lateral or bottom prisms of electrolyte is reached when their depth (measured away from the plates) is over 0·8 of their length (distance between the plates), and may be calculated as the total conductance of a prism of solution whose depth is one-quarter of its length.

There are various other more complex problems in this connection, particularly in tanks used in electro-plating where the plates are not against the ends of the tank, or between uneven surfaced electrodes, but the infinite variety of such cases makes a satisfactory study of them impossible. We have worked out the simplest case such as we think will assist the electrochemical engineer in the design of ordinary metal refining tanks.

The fact that there is reached a maximum conductance after a given depth, holding for both electrolytes and metals, is important as showing the uselessness of increasing the depth of the electrolyte underneath or at the sides of the electrodes past a certain point, such increase in dimensions adding nothing to the conductance. The uselessness of increasing the depth (width) of an electrical metallic conductor conducting between points of contact at the two ends on the same side, beyond a certain depth which is approximately the ratio of depth to length of 0·8, is quite as important for the electrical engineer in the design of equalising bars and heavy bus bars of short lengths, and shows the great importance of making contact over the whole end or face of the conductor in order to get the full utilisation of the metal contained in it. Connection should never be made simply along an edge or at the corners.

CORRESPONDENCE.

THE ASSOCIATION OF CONSULTING ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will the Association of Consulting Engineers be a truly representative body if its membership is to be confined to "those who are corporate members of the Institution of Civil Engineers?" There must be a number of consulting engineers, thoroughly competent in their own speciality, who would be excluded by this restriction; and it is open to question whether they or the new Association would be the poorer for their exclusion.

Certainly in some special lines of work, as, for example, telephony, the man who has spent his life in the work is better qualified than the average corporate member of the Civils.

It is to be hoped that in justice to those who for a variety of reasons have not been able to join the Civils the proposed restrictions will not be maintained.—I am, &c.,

Westminster, August 15. HERBERT LAWS WEBB.

[We comment upon this letter in the Editorial Notes.—ED. *E.*]

THEORY OF THE QUADRANT ELECTROMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The usual formulæ, as well as those given by Mr. Beattie in your current issue, express the sensibility in terms of the *absolute* potential of the needle. Now this has always seemed to me to be unreasonable, for the absolute potential is a mere mathematical convention, useful enough in its proper place, but a thing whose value can never be known. It is also my opinion that the common use of this function in connection with the electrometer leads to confusion of thought and hides the real actions.

The forces acting in an electrometer do *not* depend on the absolute potential of the vane by itself, as generally stated, but on the *difference* between that potential and that of the quadrants. Essentially, an electrometer consists of a condenser having one, or both, coatings movable, and forces act on the parts in such a way that any motion they produce increases the capacity. For a given position these forces are proportional to the square of the potential difference between the two coatings; for a given P.D. and different positions they are proportional to the increase of capacity per unit displacement. If the vane be surrounded by several conductors at different potentials, each system must be worked out by itself and the resultant of their several effects found. The potential of the instrument relative to earth is only of importance when earthed bodies have an effective capacity with the vane.

Thus, a quadrant electrometer has two fixed systems, pulling the vane in opposite ways, since the capacity of one is increased and that of the other diminished by any motion. If the

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potentials of the quadrants be V_1 and V_2, while that of the vane is V_v, then

The torque due to the first is $\frac{1}{2}\frac{dc_1}{d\theta}(V_v-V_1)^2$.

That due to the second is $\frac{1}{2}\frac{dc_2}{d\theta}(V_v-V_2)^2$.

And the total torque is $\frac{1}{2}\frac{dc_1}{d\theta}(V_v-V_1)^2+\frac{1}{2}\frac{dc_2}{d\theta}(V_v-V_2)^2$, or

$$k\vartheta=\frac{dc_1}{d\theta}(V_2-V_1)\left\{V_v-\frac{(V_1+V_2)}{2}\right\}+\left(\frac{dc_1}{d\theta}+\frac{dc_2}{d\theta}\right)(V_v-V_2)^2.$$

Hence,

$$\frac{\theta}{(V_2-V_1)}=\frac{\frac{dc_1}{d\theta}\left\{V_v-\frac{(V_1+V_2)}{2}\right\}}{k-\left\{\left(\frac{dc_1}{d\theta}+\frac{dc_2}{d\theta}\right)\Big/\theta\right\}(V_v-V_2)^2}.$$

If we have perfect symmetry, which requires the central part of the periphery of the vane to be circular and concentric with the suspension, and also that the needle shall be narrow enough and the quadrants wide enough to make the edge effects negligible, then $\frac{dc_1}{d\theta}=-\frac{dc_2}{d\theta}$ and we get the usual formula; but it ought to be retained in the form showing differences of potentials. If the symmetry be not perfect, the relation between the two parts of the deflecting couple due to the electrostatic forces may be anything at all according to the shape of the vane and its position relative to the quadrants. For example, the Nalder "Ohmer" is a quadrant electrometer having no mechanical control, but in which the vane is able to find a position in which the one part of the couple balances the other; this position depends on the ratios of the two P.D.s, and not on their actual values, which is the necessary condition for an ohmmeter.

Mr. Beattie's division of the total electrostatic couple into a controlling and a deflecting couple is a little unfortunate, and his assumptions that the former part is independent of the potentials of the quadrants and proportional to the displacement, quite unjustifiable. Its variation with the displacement is usually erratic.

The highest curve of Fig. 4 corresponds to an increase of the total capacity being produced by a deflection, while the lowest is for the case in which the total capacity is diminished. The exact shape of these curves, however, will depend on the rates of increase of capacity, and the net rate of increase is not usually proportional to the capacity.—I am, &c.,

DAVID ROBERTSON.

Merchant Venturers' Technical College,
Bristol, August 16.

THE ELECTRIC PROPULSION OF SHIPS.*

BY ATHOLL BLAIR AND J. F. WILSON, B.SC.

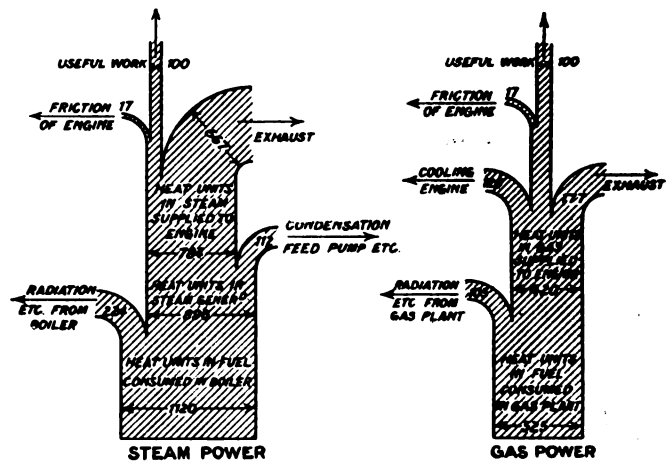
Summary.—The authors consider a cross-Channel vessel, the s.s. "Londonderry," and give particulars of the suggested equipment for electrical propulsion. Suction gas plant is proposed for generating current for the electrically-driven auxiliaries, whilst high-speed turbines would be employed for the main generators. Details of the equipment are given.

The authors here propose to take an actual vessel, to consider the equipment best suited for electrical propulsion, and to compare the suggested scheme with the vessel as at present equipped. For this purpose their choice has fallen on the Midland Railway Co.'s steamer "Londonderry." Several reasons led to this choice. In the first place, the authors have full particulars of this vessel; secondly, it is a vessel with steam turbines of modern design; and thirdly, anything pertaining to local affairs should arouse more attention.

The details of the s.s. "Londonderry" are as follows: Length 330 ft., breadth 42 ft., depth 25½ ft. There are two double-ended boilers 22 ft. long and 11½ ft. diameter, and one single-ended boiler 11½ ft. long and 11½ ft. diameter. The total heating surface is 12,500 sq. ft., and grate area 400 sq. ft., whilst the working pressure is 150 lb. per square inch. Forced draught on the closed stokehold system is fitted, the fans for this purpose being driven by direct-current electric motors. There are three turbines—one high pressure and two low pressure—driving three shafts, with a three-bladed propeller to each. With the low-pressure turbines, operating the wing shafts, are incorporated the reversing turbines, which run in vacuo when not in use. Complete condensing plant is installed. All the propellers are 5 ft. diameter and 4½ ft. pitch. The speed of the central shaft is 750 revs. per min., and of the wing shafts 670 revs. per min. The power developed is about 6,300 shaft horse-power at a speed of 21 knots. A mechanical efficiency for the turbines of 92 per cent. gives 6,850 I.H.P.

The steam turbine is in several ways an ideal motor, for it has few working parts, and, above all, gives a uniform torque; its outstanding feature, however, is that it becomes more efficient the higher the speed. Now we know the screw propeller to be most efficient at low speeds, and the question is how to utilise both most efficiently. Various mechanical gear boxes of ingenious design have been suggested, but electrical methods only are considered here. By adopting such a system we are enabled to run our steam turbines at a much higher speed than what would be desirable where they are coupled direct to the propeller shaft, and so to obtain a saving in turbine weight as well as an economy in steam consumption.

We have met with a number of suggestions much to be admired, but we have not yet seen any system, carried out in detail for any particular vessel that would comply with actual conditions. We cannot couple to the propeller shaft a motor of large diameter that will enable the propeller shaft to be at a feasible depth below the water surface; neither can we place our motor far aft, and thus economise in shafting, for the lines of the vessel will not allow of it.



* FIG. 1.—HEAT EFFICIENCY DIAGRAMS 250 B.H.P.

Hence we see the engine room will be situated in much the same position as it is at present. It is our intention to drive all auxiliary machinery by electric motors, including all pumps, hoists, capstans and steering engines. In the "Londonderry" the forced draught is motor driven, and in her sister ship, the s.s. "Manxman," motor steering gear is employed, whilst there is not any one element in the whole ship for which we cannot substitute an existing motor-driven machine.

Suction Gas Plant for Auxiliary Power.—We propose to generate our supply for the lighting and all auxiliaries by a single prime mover, with a duplicate set as a standby. For this we have full confidence in putting forward the claims of suction gas plant, coupled with a three-phase generator. Our reasons for adopting the gas plant are twofold. In the first place, we can vary our load in a few minutes to suit the conditions and yet maintain its full efficiency; and, secondly, we can show it is one of the cheapest and most economical prime movers applicable to such a case. The power taken by the auxiliaries is rarely correctly estimated. The lengthy steam pipes to winches and steering engines, giving rise to great radiation and condensation, account for losses far greater than the average chief engineer would admit. We have fixed upon a set of 250 B.H.P., which is about 4 per cent. of the total power of the main engines. As to the relative efficiency of suction gas and steam plants, we have selected a heat unit diagram of efficiency in both cases (*see* Fig. 1*), representing up-to-date practice. We see that the suction gas plant is twice as efficient as the steam plant. As to the distribution of power to the auxiliaries, in the case of the "Londonderry" each auxiliary element is driven direct by its own steam engine, and we

* Abstract of a Paper read before the Belfast Association of Engineers.

* Fig. 1 is reproduced from "Producer Gas" (Dowson and Larter), by permission of Messrs. Longmans, Green & Co.

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may gather at once that the over-all efficiency of the auxiliary engines is not to be compared with a single steam unit of equal power. To balance against this, there is a loss in the electrical transmission and generation in the suction gas plant amounting to about 25 per cent., whereas in the distribution for the steam plant there would, under very favourable conditions, be a loss of 50 per cent. The efficiency of the coupled motors would be about the same as the existing efficiency of each auxiliary engine. Hence, again, we have a balance in favour of the gas plant of 25 per cent. Thus we may sum up the over-all gain as 50 per cent. for consumption and 25 per cent. for distribution.

The whole producer plant would occupy just the same space as the single-ended boiler and the turbo lighting set installed on the "Londonderry." The weight of the over-all gas plant would be very approximately the same as the existing steam plant. The conditions vary so much that no hard and fast rule could be laid down, nor could we make a direct comparison, as no data exist. The same remark applies to costs, it only being a question of going into detail of such designs of sizes of auxiliaries to suit the requirements of the "Londonderry." To be on the safe side, we will content ourselves with an extra 10 per cent. cost in the gas plant installation, an outlay that would be fully recovered by the saving in consumption in the first 12 months.

The Electrical Proposal.—Direct-current working is outclassed at once on account of sparking difficulties; in fact, at the present day, direct-current machinery is only adaptable to comparatively small work. So far it has been found impossible to construct a direct-current turbo-generator of over 2,000 kw. capacity, whilst turbo-alternators of large power are quite common. Another point, and really the main consideration, is that the minimum price for direct-current turbo sets is 18s. per kilowatt, compared with 13s. per kilowatt for alternating-current sets for any capacity up to 1,500 kw.

In regard to the motor, the size required is in the neighbourhood of 3,000 H.P. (one motor on each shaft, twin screw). Anything of the nature of a rubbing surface carrying such a large power would be a tremendous drawback on board ship, so that we may consider continuous current out of the question, both from the generator and the motor point of view. Turning our attention to the alternating-current side, we find the induction motor would suit our purpose very well. It has one drawback over its direct-current rival. It exhibits its best properties at a high speed; but, as we shall see later, we can afford to sacrifice a few per cent. in efficiency, and in a ship the main point is simplicity of construction. We have two main types of induction motor. Hitherto we have favoured the type having a wound rotor and slip-rings in preference to the squirrel-cage rotor. The reason for this preference is primarily that the slip-ring motor can start up against load by introducing resistances into the rotor circuit, and we may control its speed by the same device. For a large motor this would entail the same troubles as in our direct-current motor. In the squirrel-cage motor, however, note the compactness, durability, ease of repair, great mechanical strength, ease with which it gets rid of heat, practically constant speed and low cost.

The authors next describe the three-phase system of supply and the operation of a three-phase motor. As pointed out, however, the squirrel-cage armature has one fault which has not made it a favourite in land work. It starts badly against a load. Now one of the beauties of ship propulsion is that the motor is not required to start against a load—*i.e.*, the torque or turning effort at starting on the propeller is just the resistance to churning of the water, and once the motor has got a start it has no difficulty in reaching its full speed. To show what can be done in starting and running large squirrel-cage motors, we may instance the Simplon Tunnel locomotives. The motors, of which there are two, are three-phase squirrel cage, with pole changing devices on the stator. The difficulty of starting torque is overcome by starting with the winding of 16 poles, then changing over to 12 poles, then to 8, and finally to six poles. The pole-changing devices are operated pneumatically, and the rotor winding is constructed of thick copper tubing. The starting current necessarily raises the temperature of the rotor, and this reaches 492°F. In consequence, the stator windings are completely enclosed to prevent radiation from the rotor. This was also required because of the extremes of temperature (in winter on the north side the temperature is sometimes 13°F., while the southern half is 82°F.). The air is full of water vapour, consequently the locomotives emerge dripping wet. The rotor is cooled by allowing air to pass right through it. It must be agreed that such a motor is eminently suitable for marine work.

To return to our own case, we require to run our turbine at a high speed for the sake of economy. Our motor, however, is limited to a rotor diameter of 7 ft. At first we worked out a design, on the particulars given of 1,500 revs. per min. for the turbines and 180 for the shafts, and found ourselves confronted with the following difficulties: If we advocated, for the sake of a good generator design, a four-pole machine, that meant we must adopt 50 cycles. Hobart has shown that a 25 cycle, two-pole 1,500 revs. per min. turbo-generator is almost as heavy as a 25 cycle four-pole 750 revs. per min. machine, so that there is much to be gained by keeping the cycles high. This is borne out by S. P. Thompson's data, given in his Howard Lectures on "High-speed Electric Machines." There you will find only 117 watts are available from a cubic inch of active material in the two-pole 1,500 revs. per min. machine, while a four-pole 1,500 revs. per min. machine would provide from 212 to 288 watts, or more than double the output per cubic inch.

Now in regard to the motor. As we said, the dimensions of the vessel limit our rotor diameter to 7 ft., and this with the motor in the engine room. Placed aft, to save three lengths of shafting, this would mean reducing the diameter to 4 ft. A frequency of 24 cycles would mean 16 poles on the motor, and 48 cycles 32 poles, for 180 revs. per min. With an available circumference of 22 ft. this would mean that the poles would be so inconveniently near to one another in the 32 pole machine that it would result in a poor electrical design. With 3,000 H.P. and a diameter of 7 ft., even with 16 poles and frequency 24, such a long armature ($5\frac{1}{4}$ ft.) makes the power factor 0·9; whilst 32 poles and a frequency of 48 brings it down to under 0·85—*i.e.*, produces an increase in current of at least 15 per cent., and a consequent increased heating loss of 32 per cent., an increase over the 16 pole design of 11 per cent. Therefore there is much to be gained by keeping the cycles low and raising the speed of the motor. This accounts for us compromising between the two requirements and fixing upon a propeller speed of 300 revs. per min. The motor will, therefore, have 16 poles and the generator 4, with speeds of 300 and 1,200 revs. per min. respectively.

So far we do not think that anyone has gone seriously into the matter of the design of these motors and turbines, but all with one accord are struggling for devices to give a variable speed. In the present case, with the cross-Channel boat, this seems unnecessary, as the speed may be controlled for running out and in port, where economy does not particularly concerns us, by adjusting the speed of the turbine. Throughout its entire range—or at least as far down in speed as we wish to go—a 1,200 revs. per min. turbo and 300 revs. per min. shaft will give a 4 to 1 gear ratio.

In this country there have been two main systems proposed to overcome this difficulty of obtaining variable speed on the alternating current motor without wasting power. As to Mavor's system, in which a spinner is employed, Mr. Durtnall has pointed out that such a combination is not only liable to mechanical troubles, but the rotor is really the driving element. This means that the outside of the spinner and the stator are occupying most valuable space on board ship. The rotor would have to be of small diameter and long, making a most inefficient motor. Again, the drawback to the Paragon system* (of Mr. Durtnall) obviously lies in the excessive diameter of the motor to get a suitable design for the large number of poles. Another point is that the four-pole generator has to be large enough to supply the motor when running at lowest speed, and yet on the other speeds it is only required to produce the fields—*i.e.*, it is practically running idle. A breakdown on the four-pole machine would also stop the ship.

A more reasonable scheme to obtain a large reduction ratio would seem to be to adopt a similar arrangement to Ziehl's double-field generator, which also uses the idea of the revolving field produced by three-phase currents. Let the revolving field of such a rotor be supplied as in the Durtnall scheme, but this time from a separate small rotary converter; then run up the turbine to twice the speed of this field, but in the opposite direction. The field will thus be equivalent to one travelling in the same direction as the shaft, but with only half the speed—*i.e.*, we get a generator which gives us half the frequency that the ordinary type would give us for the same speed and the same number of poles. The three stator terminals of the motor would then be connected direct to the turbine generator terminals, and both starting and intermediate speeds would be obtained by running between half speed and full speed of turbine, on the stop valves of the turbine itself.

Last year a new motor, called the Hunt Cascade motor, manufactured by the Sandycroft Foundry Co., appeared. This may prove the solution of our difficulty. The arrangement is similar to the ordinary induction motor—a short-circuited rotor without slip-rings, but with a double winding. From published tests it seems that greatly increased power factors are obtained at remarkably low speeds, using high frequencies.

If the maximum economy on intermediate speeds was required,

* Described by the authors in their Paper. A four pole (excited by a small generator) and a 12 pole machine are assumed on the turbo shaft, and a 60 pole induction motor on the propeller shaft.

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then recourse must be had to the windings mentioned in the Simplon Tunnel equipment. Suppose that two equal sized turbo-generators be put in to supply the 3,000 H.P. to each motor independently, and that one of these turbo-generators broke down, then the windings of the motors could be rearranged for half speed, and the two motors run in parallel off the other turbo. As, however, the total power is reduced to one-eighth at half vessel speed, this turbo would only run at one-quarter load or thereabouts. Now, if we introduced some arrangement to get four-fifths speed out of the motor the power used

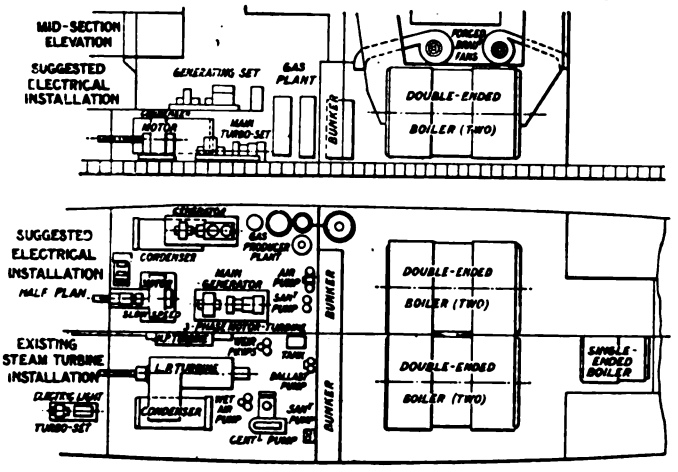


FIG. 2.—DIAGRAM SHOWING THE PROPOSED LAY-OUT OF S.S. "LONDONDERRY," AND THE EXISTING INSTALLATION.

would be approximately reduced to one-half, and one set would do it economically. Such an arrangement can only be obtained by a double winding, such as a 16 pole on top speed and 20 pole at four-fifths speed. This would be more costly, but it would perhaps pay for itself, as it would form a stand-by in the event of a winding breaking down.

There has been much discussion in the Press on the question of voltage. If we consider for a moment existing voltages on board ship, the Board of Trade would not permit more than 250 volts. Such a pressure would mean an enormous current; the cables would have to be very large to keep down the heating losses, and the designs would also be unworkable. If these schemes are to come into operation, the Board of Trade would raise their limit, and allow at least 2,000 volts. As this pressure is now quite common ashore, and the cables are to be confined to a short length in the engine room, there would be no risk.

The sizes of the electrical plant may then be summarised as follows:—

Turbo-generators.—Two sets of 2,400 kw. four-pole machines, 40 frequency and speed 1,200 revs. per min., 2,000 volts, 800 amperes per phase at a power factor 0·9, steam pressure at stop valve 150 lb. per square inch, 100°F. superheat, consumption 11 lb. of steam per indicated horse-power-hour, weight of turbine, generator and bed-plate complete 30 tons each set. Rotor diameter 3 ft. 9 in., length 3 ft. 4 in., external diameter of stator 5 ft. 6 in., efficiency of generator 96 per cent.

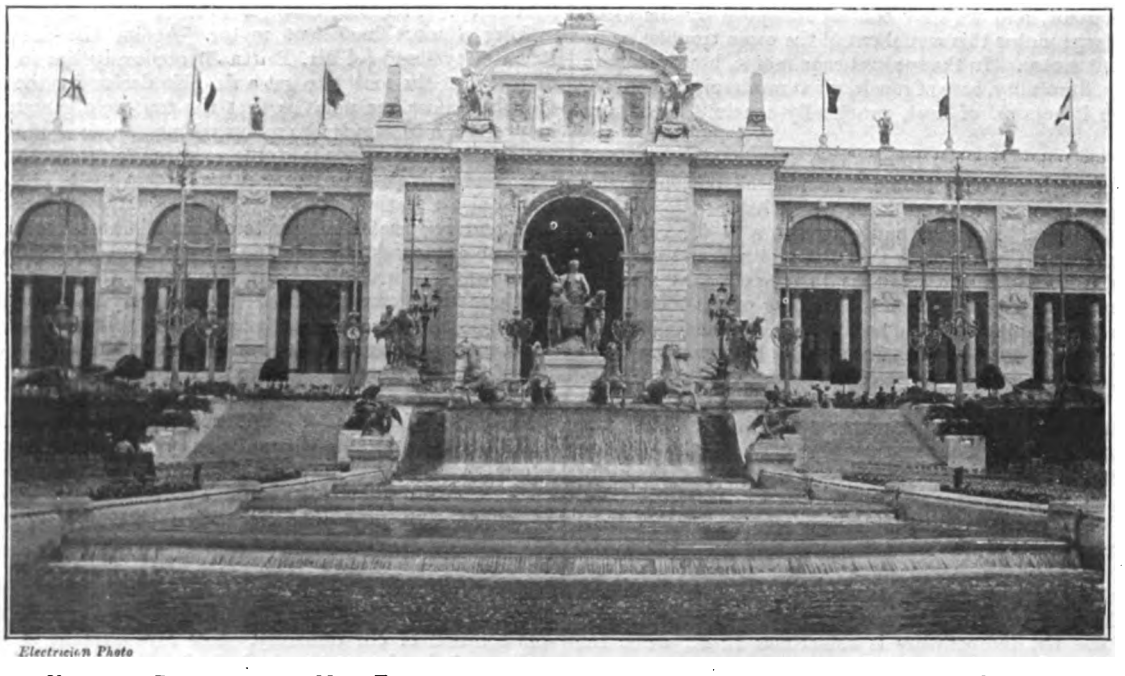
Propeller Motors.—Two 2,870 B.H.P. three-phase 16 pole 40 frequency at 300 revs. per min., 96 per cent. efficiency at power factor of 0·9, rotor diameter 6 ft. 3 in., and length 4 ft., external diameter of stator 8 ft. Weight of each motor, with thrust block complete, 35 tons.*

Fig. 2 shows the proposed arrangement and the existing installation.

The authors finally give figures of the estimated results with the electric drive, but were unable to state the actual cost figures for the s.s. "Londonderry" with the existing installation, so that the saving by adopting the electric drive could not be put forward.

DISASTROUS FIRE AT THE BRUSSELS EXHIBITION.

On the 14th inst. a fire broke out in the Belgian section of the Brussels Exhibition, and owing to the flimsy nature of the buildings it spread so rapidly that in a few hours practically the whole of the Belgian, British, French and Italian portions were gutted. The daily papers have dealt very fully with the fire, so that our readers will be well acquainted with the main details. In accordance with the custom now prevailing of reporting all large conflagrations, the cause of the fire was attributed to an electrical source, but, strangely enough, these rumours have not been accepted with the usual avidity, except, of course, by the gas journals, and the majority of the daily papers have refrained from definitely attaching blame to the electrical installation. Reports received at the moment of going to press give an emphatic denial to these early rumours, but the matter is being sifted by the authorities, and, we understand, particularly by the British Commissioner, Mr. U. F. Wintour, and his staff. We extend our sympathies to Mr. Wintour and to his assistants for this untimely end to their splendid efforts on behalf of British industries at the Exhibition.



Electrician Photo

VIEW OF A PORTION OF THE MAIN FRONT OF THE EXHIBITION, BEHIND WHICH WAS THE BRITISH SECTION.

* According to the Oerlikon Co., the motors (single speed, 300 revs. per min.) would weigh about 40 tons and cost about £3,000 each.

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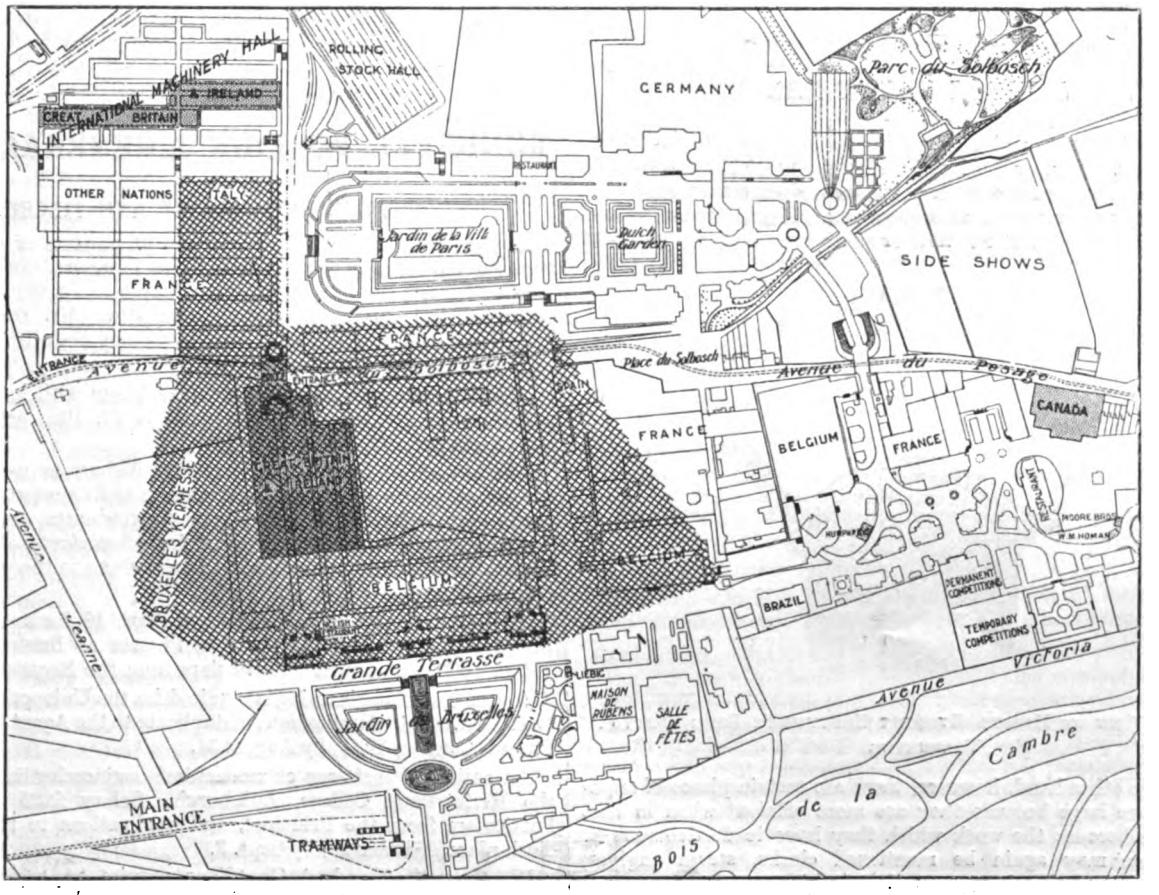
The British section proper, which adjoined the Belgian building, has been entirely wiped out, and many important exhibits of electrical instruments and apparatus were consumed by the flames. The section contained no heavy machinery exhibits, as these were displayed in the International Machinery Hall, which is situated beyond the Italian section, and was not reached by the fire. Among the electrical and allied firms exhibiting in the British section were Kelvin & James White, the Morgan Crucible Co., the Reflector Synd., Cambridge Scientific Instrument Co., Gambrell Bros., Nalder Bros. & Thompson, John Dugdill & Co., Faraday & Son, R. W. Paul, British Aluminium Co., J. J. Griffin & Sons, Thermal Synd., Doulton & Co., and the Synchronome Co. The last named had equipped the whole of the British section with their well-known system of electric clocks, and the company suffers considerable loss in that its exhibit was not covered by insurance.

The daily press is loud in its complaints against the Exhibition authorities for the inadequacy of the water service and inefficiency of the fire brigade. Continental practice in fire fighting does not appear to come anywhere near British standards, judging by the reports received. On the occasion of the recent visit of our representative with the British Press delegates to the Exhibition the fire which occurred in the Café Monico about the middle of July was fresh in every one's mind, and the conduct of the fire staff was generally the subject of criticism. The interference of officials, who either refused to allow water to be turned on or insisted upon its being turned off, was the cause of the spread of the fire and nearly occasioned a general outbreak. The extent to which this official interference was carried may be gathered from an amusing incident. One of the British exhibitors in the International Machinery Hall, which is not far from where the Café Monico stood, is showing an internal combustion pumping plant. A feature of the exhibit is the actual raising of water to a given height from which it falls into a feed tank, being constantly circulated. No regular demand is made upon the water mains, but the water may be seen falling in a large stream from the delivery to the feed tank. When the Café Monico was burning the order was given to turn off the water from those exhibits which regularly required it, but an official noticed that this particular exhibit was still in operation and that water was issuing as usual from the delivery tank. Although he was assured that the same water was being used over and over again, he insisted upon the plant being shut down, as he felt sure that this course would materially assist the efforts of the brigade in putting out the fire.

It is always easy to be wise after the event, but disasters of this kind constitute that class of bitter experience from which it is usually possible to profit. An examination of the adjoining plan of the buildings of the Brussels Exhibition will show the circumscribed character of the British exhibit, and it is easy to see how difficult it would be to save this section should fire break out in the adjoining buildings. While considerations of ground space must, of course, be taken into account in the planning of a large international exhibition, at the same time the possibility of fire should exercise some influence on the general scheme adopted. For this reason it would appear to be a wise plan to isolate buildings as much as possible, so that anything in the nature of a general conflagration could be prevented by concentrating the efforts of the fire brigade upon the particular structure affected. The German section of the Exhibition is standing at the present moment mainly upon this account. It is entirely separated from the main buildings, as reference to the plan will show, and the wisdom of collecting the whole of the German exhibits in a distinct group of buildings has been fully justified by events.



PLAN OF BRUSSELS INTERNATIONAL EXHIBITION, SHOWING PORTIONS DESTROYED BY FIRE.

The disaster will cast a shadow over the Exhibition, and will probably militate against its success as a financial venture. Practically no damage has been done to the Machinery Hall, so that engineers who contemplated visiting the Exhibition may still do so without fear of disappointment. On the other hand, the Belgian, British, French and Italian sections proper each contained special exhibits of engineering and electrical interest, and these exhibits, unfortunately, have been involved in the flames.

STREET LIGHTING AT FINSBURY (LONDON).

It has been announced in the public journals that Finsbury (London) Borough Council havegranted a 10 years' contract to the Gas Light & Coke Co. for the lighting of all the streets in the borough by gas, and the statement has been further made that this decision has been come to after careful inspection and consideration of the latest examples of gas and electric lighting and their relative cost.

As usually occurs where gas and electric lighting interests are involved, statements are made which are not in accordance with the facts. One of the publications in which the statement we have referred to has appeared is the "Municipal Journal," and Mr. H. B.

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Renwick, general manager and secretary of the County of London Electric Supply Co., has written to that journal the letter set out below. It is well that the public should have the exact facts before them in regard to the subject of public lighting :—

My attention has been called to a paragraph appearing in your issue of the 29th ultimo relative to the contract recently entered into by the Finsbury Borough Council with the Gas Light and Coke Company for the lighting of the borough. You state that "this decision was taken after the latest examples of gas and electric lighting had been carefully inspected and relative costs compared."

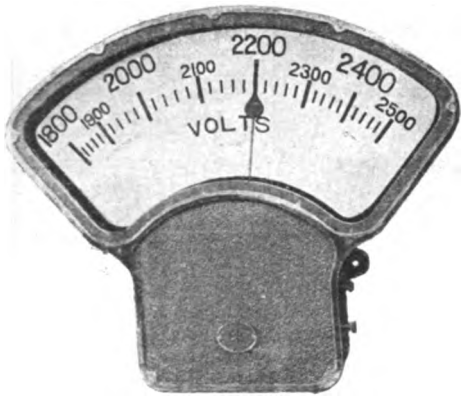
I am not in a position to say what were the latest examples of gas and electric lighting inspected by the Council, but I do know that my company offered to submit examples of electric lighting free of expense to the Council, but this offer was declined.

With regard to the question of relative running costs, my company submitted a tender for lighting which gave an illuminating power three times as great as the existing gas lighting, and, moreover, showed a saving in running costs as compared with gas of over 14 per cent. In spite of this, however, the company's offer was declined.

In view of the mistaken impression which the paragraph in question is likely to convey to your readers, I trust you will find space for this letter in your next issue.

A LARGE VOLTMETER.

A large instrument or piece of equipment may owe its size to one of two things. It may be large and even unwieldy because its manufacture has not reached a very high state of perfection, or because the making of its parts is not an easy matter. Clocks, steam engines, electric motors have all at one time or another been examples of this



General View of Messrs. Everett Edgcumbe's Large Sector Voltmeter.

law. On the other hand, however, there are certain pieces of apparatus that are large because they are more efficient when in that condition or because the work which they have to do demands it. Among these may again be mentioned clocks, steam engines, electric motors and also, it appears, electrical instruments.

For Messrs. Everett, Edgcumbe & Co. inform us that they have lately been supplying a few extra large patterns of sector voltmeters, especially designed for central station work. The accompanying illustration shows one of these instruments, which is, it is claimed, the largest that has ever been supplied either in this country or abroad.

The actual length of the scale is 2 ft. 1 in., and these instruments are intended to be employed in large central stations, so that the engine driver will be able to see from any position in the station the exact voltage of the system. In one particular central station, where there is both alternating and continuous current, two voltmeters have been supplied, one for use on the alternating-current side and the other for use on the continuous-current side.

As will be readily understood, the designing of an instrument having this extremely long scale was rather special when the size and weights of the moving parts are taken into account, but Messrs. Everett, Edgcumbe & Co. inform us that these instruments are quite as dead-beat as an ordinary 6 in. dial instrument, and every whit as efficient.

Railway Station Lighting.—The Lancashire & Yorkshire Railway Co. is making steady progress with the work of substituting electric for gas lighting at the stations on the Southport line. The last station to benefit from the change is Waterloo, where the increased illumination is a great improvement.

LEGAL INTELLIGENCE.

Workmen's Compensation.

At Hastings County Court on Monday, before Judge Scully, Wm. Remane claimed compensation from the Hastings & District Tramways Co. for loss of his employment as a motorman through defective eyesight, alleged to have been caused by the flashes and sparks that flew from under the cars, which are worked on the Dolter surface contact system on a portion of the route.

Applicant stated that he had been in the German Navy and the English mercantile marine, and had not suffered from any trouble with his eyes. On Feb. 1 last, while driving a car up a hill, he had an accident through a mist suddenly coming before his eyes. Afterwards he noticed that the mist came after he passed other cars that were flashing and sparking on the Hastings Front, where the surface contact system was operated. So, having seen a doctor, he informed the general manager of the company that his eyesight was defective and left the company's service. He denied that he had had previous trouble with his eyes, but admitted that once when he went to the East Sussex Hospital the doctor told him he was short-sighted. Both at Bristol (when employed on the tramways there) and at Hastings he had passed eye tests quite satisfactorily.

His Honour adjourned the hearing, remarking that he had heard of no similar case.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the vacant position of assistant lecturer in the physics department of the Technical College, Sunderland. Commencing salary £150 per annum. Particulars from the assistant clerk to the Education committee (Mr. Herbert Reed), 15, John-street, Sunderland. Applications by Sept. 10. See also an advertisement.

A shift engineer is wanted for power house with h.t. alternating and d.c. plant. Salary £2. 5s., rising to £2. 10s., per week. See advertisement.

The Council of the University of Birmingham invite applications for the appointment of assistant lecturer and demonstrator in electrical engineering. Candidates must be graduates, and must have had experience in the test room of first-class electrical engineering firm. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by Sept. 17.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

A professor of engineering is required for the University of Queensland (Australia). Applications in duplicate to the Agent-General, 409, Strand, London, W.C., by August 31.

An assistant professor of mechanical engineering is required for the Heriot-Watt College, Edinburgh. Salary £225 per annum. Particulars from the Principal, and applications to the Clerk, 20, York-place, Edinburgh, by Sept. 3.

Wandsworth (London) Guardians require an engineer and an assistant engineer. Salaries £2. 17s. 8d. and £2. 2s. per week respectively. Applications to the Clerk, St. John's Hill, S.W., by Oct. 31.

The Governors of Faraday House have appointed Mr. E. A. Nash, A.C.I.S., A.I.E.E., as secretary and business manager of the Electrical Standardising, Testing and Training Institution, in place of Mr. Howard Foulds, who has recently secured an appointment in Birmingham.

The following appointments have been made by the Council of the University of Manitoba :—

Mr. J. W. Dorsey to be lecturer in mechanical and electrical engineering; Mr. Geo. Halstead, M.Sc., lecturer in materials and hydraulics; Mr. J. R. Thomson, B.A., B.Sc., lecturer in drawing; Mr. Lloyd A. H. Warren, M.A., lecturer in mathematics; Mr. T. A. Neelin, B.A., demonstrator in physics; and Mr. B. Olson, B.A., demonstrator in chemistry.

The Walsall Electrical Co. have appointed Mr. C. F. Thompson, Glenbank, Woodland Park, Newport (Mon.), as their sole agent for Gloucester, Monmouthshire and South Wales.

EDUCATIONAL NOTICES.

University of London, University College.—We have received a copy of a pamphlet which gives particulars of the faculty of engineering and school of architecture. The faculty includes the departments of mechanical, electrical, civil and municipal engineering, and

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provides students wishing to devote themselves to engineering with a systematic training by means of lectures, tutorial classes, drawing, laboratory and practical classes, in the application of scientific principles to industrial purposes.

The courses are also suited to the requirements of students who intend to enter for appointments in the Indian Public Works Department, engineering department of the G.P.O., department of the director of engineering and architectural works in the Admiralty, Patent Office and other similar services, or of those who intend to become patent agents, architects, technical teachers, chemical engineers, &c. The engineering departments have been recognised by the Board of Trade as providing suitable technical training for marine engineers, and a student who has satisfactorily attended a three years' course may be exempted from two of the four years' workshop training required.

The Pender Professor of Electrical Engineering is Prof. J. A. Fleming, M.A., D.Sc., F.R.S. (Dean of the Faculty), and he is assisted by a capable staff of assistants. The courses of instruction are arranged to cover: (1) Ordinary and special training for the profession of electrical engineering by lecture and laboratory courses; (2) undergraduate lecture and laboratory courses covering the range of study required in preparation for graduation (B.Sc. in engineering) in the University; and (3) special advanced research and post graduate work. A special feature is the electrical research laboratory, which is fully equipped for teaching and research in connection with radio-telegraphy and high-frequency currents. The lecture accommodation is good and the plant and apparatus at the laboratories are up to date.

In the mechanical and civil engineering departments the courses of instruction are so designed that engineering students receive a thoroughly sound practical and scientific training.

Facilities are also provided in each department for post-graduate and research work in all the subjects.

Intending students should communicate with the Provost or the Dean of the Faculty, not later than Sept. 20.

University of Manchester.—The new session commences on Oct. 4. New and enlarged engineering laboratories have been erected. Prospectuses, giving particulars of the lectures, laboratory and drawing courses in engineering and physics, &c., may be obtained from the Registrar.

University of Bristol.—At this university complete courses of instruction in electrical, mechanical and civil engineering are given, and also instruction in the evening classes. The 1910-11 session in the faculties of arts, science and medicine will commence on Oct. 3, and in the faculty of engineering on Sept. 13. Particulars and prospectuses from the registrar, Mr. James Rafter.

Merchant Venturers' Technical College.—The faculty of Engineering of the University of Bristol is provided and maintained at the Merchant Venturers' Technical College. There are complete courses of instruction in civil, mechanical, electrical, mining and motor car engineering. Calendar (6d.) or prospectus (1d.) may be obtained from the Registrar.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

University College, Dundee.—The new Peters electrical engineering laboratory will be opened on Oct. 6, when Prof. E. Rutherford will deliver an address.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

Glasgow and West of Scotland Technical College.—The day classes begin on Tuesday, Sept. 27, and the evening classes on Thursday, Sept. 22. The diploma of the College is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, building and textile manufactures. The courses of study for the diploma usually extend over three sessions, and holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. Preliminary examinations begin on Sept. 19. There are new and well-equipped laboratories in the departments of physics, chemistry, mechanics, motive power and electrical engineering, &c., and facilities are afforded for research. Copies of calendar (price 1s. 4d.) and prospectus (gratis) can be obtained from the Secretary.

Technical School Regulations.—Revised regulations of the Board of Education for technical schools, &c., have been issued, together with a memorandum by the Permanent Secretary to the Board (Sir R. L. Morant).

The changes introduced are mainly for bringing out more clearly the intention of those regulations and guarding against irregularities which have been apt to grow up in practice. Largely owing to the activities of local education authorities and other bodies, various new types of school and class have come into existence since the passing of the Education Act of 1902 which were not directly contemplated when the regulations were framed. The Board hope, therefore, to issue before the end of the current year a body of new regulations, which will come into force on Aug. 1 next and will make more adequate provision for the co-ordination of continuation schools by local education authorities, for the grouping of subjects into organised courses and the improvement of the attendance of students. It will be necessary to provide simpler and more suitable means of allocating the grants payable under the regulations of the Board of Education to institutions of university rank, and for co-ordinating these grants with those paid to the same institutions by the Treasury. Separate regulations will accordingly be arranged for this purpose. The Board must be satisfied that the courses provided are adequate in range and length, and that the students are regular in their attendance, but it is hoped that these requirements can be secured without interfering with the freedom of universities to work out their curricula in the ways best suited to their individual needs. It is required that the attendances of students shall in future be recorded in registers supplied by the Board. This requirement, however, will not necessarily apply to technical institutions of university rank recognised under the regulations. The present regulations are limited to those determining the conditions of grant. The Board have under consideration certain changes as regards the science and art examinations, the national competition and the awards to students.

BRITISH NOTES.

Aberdeen.—On Monday the City Council decided to establish on all the tramway routes a series of ½d. fares for a maximum of 740 yds.

Carmarthen.—Public electric lighting was inaugurated on 1st inst. by the Carmarthen Electric Supply Co., which is supplying current to 238 public lamps from temporary plant by overhead cables.

The company has secured a 14 years' contract from the Council, who are making a saving of £200 a year by the change from gas to electric lighting. When the generating station has been completed there will be an official inauguration of the scheme by the mayor (Ald. Walter Lloyd). The generating plant consists of two 50 H.P. gas engines and two 35 kw. d.c. dynamos, with a battery of Tudor cells.

Carnarvon.—The National Eisteddfod Pavilion is being wired for the electric light at a cost of £40.

Caversham.—Reading & District Electric Supply Co. have notified the Council of their intention to extend their electric supply mains into this district.

Darlington.—An unopposed inquiry was held last week into the Council's application for sanction to borrow £1,500 for extensions of the plant at the electricity works.

Dunfermline.—The Council have been in communication with the Board of Trade in regard to the transfer of the Dunfermline provisional electric lighting order to the Fife Electric Power Co.

The Board refuse sanction to the arrangement for the transfer, as the clause in the agreement providing for the purchase of the undertaking by the Corporation between 30 and 40 years hence is deemed practically worthless. The agreement provided that the lighting customers of the company should be transferred to the Corporation on certain conditions, but that users of electric current for power (except where the current consumed did not exceed 4 H.P.) should be retained by the company, the object being that the company might retain their large consumers. The Council is asking the Fife Co. to submit terms more acceptable to the Board of Trade.

Electricity in Blasting.—At inquests on three men who lost their lives as the result of an explosion at a limestone quarry in Penmon, Anglesey, on 11th inst., the jury found that the explosion was an accident, and that it might have been caused by a smouldering fuse in the hole which the men were at the time charging with gunpowder. The manager (Mr. George Finsland) accepted a sug-

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gestion from the inspector of mines, to use electricity instead of ordinary fuses, the inspector stating that electricity was much safer.

Electricity in Mining.—In his annual report H.M. Inspector of mines for the Southern District (Mr. J. S. Martin) states that the use of electricity has been increased at South Crofty Mine (Cornwall) and it has given general satisfaction throughout the year. At the various mines where electric plant has been in operation it has been continued, except (he believed) at Wheal Busy, where those responsible for its adaptation had not in any way benefited themselves nor anyone else by the manner in which things were carried out.

The principal installations are at Great Dowgas, Wheal Jane, Wheal Vor, St. Ives Consolidated, &c. East Pool and South Crofty, &c., have been taking their supply of electric energy with mutual satisfaction from the local power company, the former for conveying the mineral to its Tolvadden dressing floors. Dolcoath Mine (Ltd.) has during the year concluded a contract with the Cornwall Electric Power Co. and the Urban Electric Supply Co. for the supply of power to the mine generally, and considerable saving in fuel consumption and wages is anticipated. It has been decided to adopt plunger pumps (electrically-driven) in Williams' shaft. This pumping installation will be very compact, everything will be in duplicate, and the several parts will be interchangeable.

Grassington (Yorks).—At a meeting of the Grassington Electric Supply Co. last week it was reported that the demand for electric current was increasing and negotiations were proceeding for adopting electricity for street lighting.

Hospital Lighting.—Hyde Council have agreed to wire the borough infectious hospital.

Huddersfield.—The salary of the tramways manager (Mr. R. H. Wilkinson) has been increased from £375 to £400 per annum.

Launceston.—The Council are in negotiation with Mr. J. A. Purves as to the supply of electricity. At present a provisional order for the district is held by the Electric Supply Corpn., but there is no provision for a transfer.

Leeds-Morley Tramways.—A scheme has been arranged between Leeds Tramways committee and Morley Corporation for the extension of the Leeds municipal tramways to Morley, about 7 miles distant. Morley Council possess parliamentary powers to construct the lines and Leeds will construct and lease them.

Light Railway.—The Light Railway Commissioners have submitted for confirmation to the Board of Trade an order reviving the powers granted by the Wolverhampton and Cannock Chase Railway (Light Railway) Order, 1907. Objections to the Board by Aug. 31.

The Board of Trade have recently confirmed the order of the Light Railway Commissioners for the construction of a light (electric) railway from Bacup to Shawforth. The line, which will be constructed at once, will make connection with the Rochdale tramways.

London and Croydon Through Tramway Booking.—We have received particulars of the results of the first year's working of the through bookings on the tramways between Croydon and London from the opening of the L.C.C. Streatham to Norbury tramway extension on July 31, 1909, to July 30, 1910 (inclusive).

On the Norbury and Purley route 1,058,696 car-miles were run and 10,448,687 passengers were carried. The total receipts amounted to £39,558. 13s. 7d., an increase of £13,831. 8s. 2½d., the average weekly increase being £265. 19s. 9d. The through bookings issued were: By London County Council, 508,504; by Croydon Corporation, 569,548; total, 1,078,052. Croydon issue over L.C.C., 61,044. The values were: By London County Council, £6,025. 0s. 4½d.; by Croydon Corporation, £7,111. 2s. 2d.; total, £13,136. 2s. 6¾d. The Croydon value over L.C.C. system was £1,086. 1s. 9½d. The proportions due are: To London County Council, £8,948. 7s. 1d.; to Croydon Corporation, £4,187. 15s. 5½d.

Notts and Derbyshire Tramways.—The light railways in the Ripley district, which form part of the scheme of the Nottinghamshire & Derbyshire Electric Tramways Co., are shortly to be constructed.

Patent Decisions.—It is announced that an order has been made by the Controller-General of Patents revoking the letters patent granted to Harry Wharton for an invention for "Improvements connected with pulley blocks, cranes and other hoisting gear," No. 20,342 of 1902.

An order has been made restoring the letters patent granted to John Schade, jun., for "Improvements in spring terminal clips for electric conductors," No. 17,879 of 1904.

Personal.—Mr. W. Perren Maycock, M.I.E.E. (who has recently completed an 18 months' engagement with the Int. Corres. Schools), is resuming his consulting and literary work. For some time Mr. Maycock has been engaged on a new edition of "Electric Wiring, Fittings, Switches and Lamps." This will be published by Messrs. Whittaker & Co.

Presentation.—On the occasion of his marriage Mr. T. H. Saul, of the Acton electricity staff, has been presented with a canteen of cutlery and a silver sugar bowl.

Rawtenstall.—The Council have obtained authority to construct an additional tramway from Waterfoot to Water. Six new single-deck cars are to be purchased.

Reigate.—A committee of the whole Council has reported that they have approved the adoption of Diesel oil engines at the generating station.

The chairman of the Electric Light committee (Ald. BARNES) explained that for the year ending March 31, 1909, the revenue was £5,812 and the expenditure £3,453, leaving a net profit of £2,358.

Dr. COLMAN hoped that smaller householders would be able to obtain electric current in the same way as they were at present supplied with gas.

School Lighting.—Abertillery Education committee have decided to wire the Aberbeeg and Brynhyfoyd schools.

Stockton-on-Tees.—The local Chamber of Commerce have invited Sir Clifton Robinson to meet them in order to discuss extensions of the local tramways.

Sunderland.—The chairman of the Electricity committee and the borough electrical engineer (Mr. A. Blackman) have been authorised to visit Marylebone (London) electricity supply department for the purpose of obtaining information as to the methods adopted for increasing the number of consumers of electricity.

Ald. BRUCE stated at the last meeting of the Council that, owing to the decrease in the units for lighting, which was not due to any loss of customers, but entirely to the fact that metal filament lamps would give an equal light with a decrease of units, the committee felt that the time had come when they should do something in the way of canvassing. Marylebone had a system of canvassing in operation which had resulted in turning a debit of £3,090 in 1909 to a credit balance of £8,482 in 1910. The promoters of an electrical exhibition which was to be held in Sunderland in September and October had asked the committee to make a small contribution to the exhibition and supply them with current free of charge. As the committee thought the local undertaking would reap the greatest advantage by it, and it would be a splendid advertisement, they proposed to support the exhibition as desired.

The report was adopted.

Tramway Fares.—On the London United Tramways a new scale of fares has been introduced. Each route is now divided up into sections, any consecutive three of which may be traversed for 1d., six for 2d., and so on; the charge for one additional section is ½d., i.e., four consecutive sections for 1½d., seven for 2½d., &c.

On the tramways in the Potteries district the ¼d. "fair fare" system is to be abolished on Sept. 1, and ½d. stages introduced.

Tramway Provisional Orders.—In the 1910 session of Parliament only three applications were lodged with the Board of Trade for provisional orders under the Tramways Act, 1870 (from Huddersfield and Rawtenstall Corporations and Milnrow Urban Council). Each of the applications was for power to construct additional tramways. The aggregate length of the proposed tramways was 2 miles 7 chains of double line and 4 miles 63 chains of single line, and the estimated cost was £67,376. Orders were made and confirmed in every case.

Tramway Workers' Conference.—At the annual delegate meeting of the Amalgamated Association of Tramway and Vehicle Workers at Manchester on Friday the following resolution was passed:—

That the time has arrived when the following alterations in the conditions of labour should be conceded by the tramway authorities throughout the country:—(1) An allowance of not less than 30 minutes per day for booking on and off duty; (2) That all spare men be guaranteed not less than 48 hours per week; (3) That all time from signing on duty to signing off duty be paid for except such time as may be mutually agreed upon as reasonable for the purpose of meals.

Underground Telegraph Wires.—The Postmaster-General has decided to lay underground telegraph wires between Leeds and Hull.

Ventilation of Buildings.—The Medical Officer of Health of Westminster, London, in his annual report states that it is not uncommon to see in restaurants and business places electric fans at work having no communication with the outer air. These fans do not act as ventilators, but merely agitate the air, probably already heated and vitiated. Experiments have been carried out by two French doctors (MM. Sartory and Filassier) proving that these fans cause draughts, stir up the dust and distribute it through the rooms, so that, after running for one or two hours the number of organisms and dust particles in the air is enormously increased. They therefore recommend that all shafts and tubes used for bringing or taking off air should be frequently cleansed.

Wigan.—The general manager of the Liverpool Corporation tramways department (Mr. C. W. Mallins), who was recently called in to report on the position of the Wigan tramways, has issued his report.

The gross capital expended on the tramways at March 31 last was £508,073, 8s., but from Ince Council, for purchase of lines within their area, there had been received £24,033. 14s., leaving the expenditure £484,039. 14s., less loans redeemed and sinking fund amounting to £90,705. 19s. 11d., or net £393,333. 14s. 1d. The total length of route was 23 miles 6 fur. 126 yds., and the cars in stock 67. From the amount

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expended on capital account, the undertaking appeared to be considerably over-capitalised, accounting to some extent for the loss in working the concern. Nothing had been set aside for renewals, which would become very urgent in the not distant future. Mr. Mallins was convinced that the loss would have been much greater but for the economies which had been practised by the committee responsible for the undertaking. As regarded the permanent way, it was most unfortunate that two gauges should have been introduced on one system. The narrow gauge should be abolished as soon as the financial position warranted. £305,208 seemed to have been expended on the permanent way (£9,877 per mile), which seemed excessive against £6,132 per mile expended on 15 typical municipal tramways throughout the country. That gave an excessive capital expenditure of £115,730, and a corresponding excessive payment of annual interest and sinking fund of £6,292. The £57,421 and £1,858 per mile expended on overhead equipment appeared also excessive, compared with £1,524, the average cost on 15 other tramways. Under that head an excessive capital expenditure of £10,329 had been incurred, involving £561 for interest and sinking fund. On car sheds, buildings, &c., the capital expenditure of £1,234 per mile of track was above the average (£1,054). That gave as excess £5,864, which involved £319 for annual interest and sinking fund. On rolling stock Mr. Mallins states that the £792 per car is above the average of £672, the total excess being £8,047, or £437 for interest and sinking fund.

In regard to the question of over capitalisation, Mr. Mallins observes that one way of dealing with the matter would be to expend a further sum for doubling the lines wherever possible through the system. If, however, the committee did not feel justified in expending the large amount necessary for this, he believes that £51,000 approximately would be sufficient to correct the mistakes which had been originally made in planning the track and in the kind of rolling stock purchased. This amount would provide 50 additional passing places, the lowering of the surface under 11 bridges, the committee's proportion of construction of three junctions for through running with adjoining tramways, and additional junctions and lines in market-place, &c., as also 40 new double-deck cars. The improvements should be introduced gradually, and he was not without hope that if £23,416 were spent for these purposes the system could be made a paying concern. The second moiety of the improvements could be carried out later, subject to the success of the smaller scheme. The alternative would be to lease the lines to a company who would relieve the Corporation of all further liability.

Mr. Mallins considers that great care must have been exercised by those responsible for the control of the traffic department; indeed, had the other departments of the undertaking been managed as economically there would have been no loss on the concern. The traffic prospects in Wigan appeared to be fairly good on most of the routes. General expenditure in the engineering departments amounted to 0·892d. per car-mile, which compares favourably with other undertakings, but had electric current been supplied at the same price per unit as the average there would have been a considerable saving.

Mr. Mallins makes the following recommendations:—

1. The appointment of a general manager, responsible to the Tramways committee for the whole undertaking, with the possible exception of the permanent way. 2. That the maintenance charge on overhead equipment, rolling stock, car sheds and workshops should be reduced to the average. 3. That the cost of electric current be reduced to the average of tramway undertakings. 4. The cost of maintenance of permanent way reduced to the average. 5. An improved service. 6. A system of through running. 7. The contract for advertising on the cars be looked into, as to whether better terms could be arranged. 8. A rearrangement of the present stages and fares. 9. A more up-to-date type of rolling stock; and 10. The standard gauge be substituted for the narrow gauge portions of the routes.

Wireless Telegraph Notes.—The great usefulness of wireless telegraphy in connection with seafaring matters is now firmly established. An instance of its utility in combination with the submarine cable is now reported from Durban, Natal. The British warship "Hermes," whilst at sea off the coast of Natal, by means of a wireless message became acquainted with an accident which had happened to a ship, the "Combermere." After rendering assistance and supplying the "Combermere" with some spares, the "Hermes" communicated news of the accident to Durban by wireless, and a message was sent over the cables of the Eastern & South African Telegraph Co. to the owners of the "Combermere" in London, so that within a few hours of the accident becoming known on board the "Hermes," London was informed of an event which had occurred on the high seas to a vessel six days out from Port Elizabeth.

In regard to the grounding of the British armoured cruiser "Duke of Edinburgh" on the Atherfield Ledge, off the Isle of Wight, between Ventnor and Freshwater, four miles west of St. Catherine's Point, in a fog on Saturday last, it is announced that immediately the accident occurred the Commander-in-Chief at Portsmouth was communicated with by wireless for assistance, and immediately the cruiser "Furious" and a number of dockyard tugs were despatched to the assistance of the "Duke of Edinburgh," which, however, was successfully refloated with very little outside help. It is calculated that if the worst had happened to the ship the timely notification of the occurrence and the prompt response would have prevented any loss of life.

The Marconi Company have made an offer to the Portuguese Government to establish wireless telegraph stations in the Portuguese colonies. It is stated that the Portuguese Government are favourably disposed to the offer.

In connection with the establishment of radio-telegraph stations in the Pacific, the following information from the "Australian Mining Standard" is of interest:—

Taking for granted that the Commonwealth and the New Zealand Governments will construct the Sydney and Doubtless Bay stations at their own expense, the cost of the remainder is estimated at £42,000, of which the Imperial Government's proportion would be £23,334, the Commonwealth's £12,833, New Zealand's £2,333 and Fiji's £3,500. The annual cost of maintenance was estimated at £13,820, to which Great Britain would contribute £7,716, the Commonwealth £4,234, New Zealand £748 and Fiji £1,122. There is, however, good ground for thinking that the cost of construction will be well below the estimate, the contracts of the Commonwealth for its Sydney and Fremantle stations each having a range of 1,250 miles, having been let for £4,150 each to the Australasian Wireless (Ltd.). In addition to this general scheme the Commonwealth Government will establish medium-power stations at Port Moresby and Thursday Island, so that Australia and Papua may be connected; specifications are now being prepared for these, and tenders will be invited at an early date. A telegram from Port Darwin, received last week, stated that the Governor of Timor purposes to visit Melbourne for the purpose of conferring with the Commonwealth Government on the question of connecting that island by wireless with Port Darwin.

COLONIAL AND FOREIGN NOTES.

Argentina.—H.M. Consul (Mr. H. M. Mallet), reporting on the trade and commerce of the consular district of Rosario for 1909, states that a number of foreign travelling agents now constantly visit the district, while their efforts, with the careful study of requirements and methods of trade, assist them to obtain large and profitable orders.

Competition for trade is keen, and agents and travellers from abroad are constantly on the watch to meet requirements, and merchants, on account of the less trouble it gives them, frequently avail themselves of this opportunity to replenish their stock. Among the more important items likely to be required are electrical fittings, hardware, agricultural machinery and implements, iron girders, &c.

Another large grain elevator (electric) has been erected at the port for a British firm.

Formerly (continues the report) British capital alone monopolised the construction of public works, such as railways, ports, trams, telephones, electric lighting, &c. At present, however, foreign capital (chiefly French, German and Belgian) is competing for such works, and has been successful in securing several profitable concessions hitherto worked with British capital. The valuable concession (a monopoly) held by a British company for providing electric light, &c., to the city of Rosario is about to pass into foreign hands.

The official value of the electrical appliances imported into Rosario during 1909 was $76,567 (gold), compared with $166,916 (gold) in 1908, the figures for railway and tramway rolling stock, engines, &c., being $10,100,006 (gold) and $14,670,349 respectively.

Buenos Ayres Western Rallway has asked Congress to grant a concession for the construction of a tube (electric) railway between Once and the Port, to be used for freight only, passenger traffic being catered for by the Anglo-Argentine Tramways Co., who propose to construct another tube railway.

The "Review of the River Plate" recently published statistics showing the proportion of the trade of Great Britain, United States and Germany in the leading imports into the Argentine Republic in 1908, from which we abstract the following:—

Railway cars, $6,029,924 (gold): U.K. 69 per cent., U.S. 14 per cent.; galvanised iron, $5,395,047 (gold): U.K. 86 per cent.; railway material, $4,987,187 (gold): U.K. 70 per cent.; machinery, $3,726,786 (gold): U.K. 34 per cent., Germany 33 per cent., U.S. 11 per cent.; locomotives, $3,394,498 (gold): U.K. 81 per cent.; steel sleepers, $3,183,193 (gold): Germany 57 per cent.; bar and sheet iron, $3,133,634 (gold): Germany 35 per cent.; galvanised iron wire, $1,680,510 (gold): Germany 64 per cent., U.S. 14 per cent., U.K. 13 per cent.; electric cables and wire, $1,511,155 (gold): Germany 59 per cent., U.K. 25 per cent.; steel columns and joists, $1,392,554 (gold): Germany 54 per cent.; bolts and nuts, $1,332,159 (gold): U.K. 41 per cent.; boilers, $582,707 (gold): U.K. 71 per cent., U.S. 19 per cent.; dynamos and motors, $576,823 (gold): U.K. 48 per cent., Germany 30 per cent., U.S. 11 per cent.; electrical goods, $508,463 (gold): U.K. 45 per cent., Germany 34 per cent.

Australasia.—Mr. Buchanan Black has again submitted his scheme for leasing the Creswick (Victoria) Council's water reserves for utilisation in the generation of electric energy for lighting and power on a large scale.

Mr. Black is reported to be acting on behalf of a syndicate formed to provide funds for preliminary expenses, and he is confident that if the necessary powers be granted the capital for the whole scheme will be forthcoming. The main proposal is to increase very largely the storage capacity at Bragg's Flat, and to utilise the water power to generate electricity for supplying energy in bulk to large consumers for power and other purposes. Subsidiary plants at other points might increase the

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supply. It will be necessary to bring a bill into the State Parliament, and the co-operation of the Council is sought.

A new 750 kw. low-pressure A.E.G. turbo-generator is being put down at the Golden Horse Shoe mine, Kalgoorlie.

Mr. J. H. D. Brearley (Messrs. Noyes Bros.) has reported on the proposal to construct an electric tramway to connect certain of the southern and eastern suburbs of Melbourne. The line will be about 2½ miles in length and double track throughout. The total cost of construction is put at £27,450, including £17,800 for permanent way and overhead construction, and £7,700 for rolling stock.

A conference of the municipalities interested in the proposal to purchase the local cable tramways, and to electrify and extend the system, has been held, but consideration of the matter has been adjourned.

Contracts have been let to fell the bush along the transmission line between Waihi and Wairongami (N.Z.). The work of excavating, &c., is making satisfactory progress at Horahora Falls, and it is anticipated that there will soon be available at Waihi 6,000 H.P. to 7,000 H.P. for operating the various mining plants now being driven by steam. With a cheaper power the mining management will be in a position to handle and treat a large tonnage of lower grade materials; the period of paying working of the mines will be extended by the employment of electric power in this way.

Hobart City Council has entered into an agreement with the Complex Ores Co. for the supply of electricity for public and private lighting in the city.

Brazil.—A contract was recently entered into between the State and Mr. Henry J. Conill for the construction of a railway from the Bay of Camamou to Salto Grande de Jequitinhonha, on the boundary between the States of Bahia and Minas Geraes. Steam or electric traction may be used, and the concessionaire has the right to construct any necessary telegraph or telephone lines.

Santa Catharina State Government has contracted for the electric lighting of the capital for £32,500. The generating plant is being supplied by a London firm, and it is anticipated that current will be available by the end of August.

The value of the whole of the electrical appliances imported into Santos during 1909 was £102,106, against £77,087 in 1908 and £97,138 in 1907. Reports deplore the falling off of British interest in these imports.

Chile.—In the "Diario Oficial" of June 8 a decree was published authorising Mr. Owen L. McDermott to construct an electric railway between Antofagasta and Mejillones. Work must be commenced within 12 months and the line completed in two years from May 28 last.

Several other public works, including a railway between Puerto Montt and Taena (897 miles), are projected. Five concessions for the construction of 480 miles of railway have been made recently.

China.—The value of the electrical material imported into Canton during 1909 was £9,210, against £6,799 in 1908; engine and boiler fittings £2,454, against £6,446; machinery £19,054, against £15,212.

Denmark.—In the report for 1909 on the trade and commerce of Denmark Mr. Consul Liddell states that the use of the telephone in Denmark has become general with extraordinary rapidity. Not to find a telephone in the towns or even the country districts is rather the exception than the rule. In 1881 the Telephone Co. of Copenhagen had only 22 subscribers, but at present the number is about 33,000. This rapid increase has not been confined to Copenhagen alone, but has spread to the provinces, and Denmark, comparatively speaking, now possesses the most extensive telephone service of all European countries, having 33·2 telephones per 1,000 inhabitants, whereas Sweden has 31·7 per 1,000, Norway 23·3, Switzerland 22·8 and Germany 14·1.

Exhibitions.—The commission appointed by the Spanish Government to consider the expediency of holding an exhibition in Madrid have decided in favour of a Universal Exhibition being held there in 1913. Tenders for carrying out the undertaking are invited (from both Spaniards and foreigners), and must be sent in to the organising committee before Sept. 15. The committee's decision will be given before Oct. 30. The work must be begun before Jan., 1911, and be completed by March, 1913.

A Fibre Congress and Exhibition will be held at Sourabaya, Java, in July, 1911.

Germany.—H.M. Consul at Stettin (Mr. R. Bernal) reports that Brown-Boveri steam turbine and dynamo of about 3,000 k.w. will be installed at a cellulose factory being erected at Cavelwisch, near Stettin.

Italy.—The "Gazetta Ufficiale" of Aug. 2 contains a decree giving particulars of 21 telephone lines which are to be erected by the Government. The Rome to Naples section will be 161 miles, the Genoa-Milan section 108 miles, Venice-Udine section 79 miles and the Catania-Messina section 63 miles. The other sections are shorter.

In order to cope with the increased traffic on the railway between Milan and Varese, and in order that some of the heavy trains now run by steam can be worked by electric traction, the Italian Minister of Public Works is making arrangements for the purchase of a number of additional electric locomotives.

Rio de Janeiro.—It is reported that the Rio de Janeiro Power & Light Co. have started to supply current to 2,000 arc lamps for street lighting under their new contract with the municipality.

Russia.—In the report for 1909 on the trade of Russia and of the consular district of Moscow Mr. Consul H. M. Grove states that there was an increased demand for foreign iron and steel goods, including dynamos, locomobiles, gas engines, hand tools, &c. The increase in the total exports for 1909 was wholly due to the increased output of rails, of which 141,000 tons were exported in 1909, against 82,000 tons in 1908.

A new grain harbour at Odessa is projected. It is probable that electric cranes and elevators will be erected and the quays will be lighted electrically. The estimated cost of the scheme is £1,636,000.

Spain.—In his report for 1909 on the trade and commerce of Barcelona Mr. Consul-General Roberts states that the local electric light, tramway and gas companies are in German and French hands. The electric supply company is a German concern, which supplies about 40,000 H.P. in the city and its environs. The company uses German coal, shipped from Rotterdam by the Westphalian Synd.

A concession has been granted for the construction of a new tramway up the mountain situated at the back of Barcelona to Rabassada, a favourite suburban resort about 6 miles distant.

The electric light and power business is in the hands of two companies—one known as the Barcelonesa and the other as the Catalana. The former is a German undertaking. Electric light, although in very general use, is expensive, the charges being 1 peseta per unit for domestic purposes and 30c. for power.

A British company has purchased from the Spanish holders a concession for the construction of dams across the river Ebro at certain points, and are about to build a dam at a point some 20 miles from Mora del Ebro, at a cost of about £200,000. The water thus impounded will give from 30,000 H.P. to 50,000 H.P., and enable the company to supply all the towns and villages for 150 miles around with electricity. The total cost of the scheme is estimated at over £1,000,000.

The British Chamber of Commerce for Spain, which was started in April, 1903, is doing useful work for British trade and commerce.

The electrical material imported into Barcelona during 1908 weighed 1,434 tons (of which only 3 tons were from the United Kingdom), against 444 tons in 1908 and 1,689 tons in 1909.

Copper is imported into Spain in the form of bars, wires and tubes, mostly from France and Germany. The quantities of wire for electrical purposes are of relative importance, but British prices are stated to be too high to admit of British goods being imported. The United Kingdom takes the lead in the export of machinery, chemicals, coals, the total exports showing an increase of £75,000 over 1908.

Sweden.—The report for 1909 of H.M. Consul at Gothenburg (Mr. J. A. Duff) states that, though the general trade of the country was depressed during the year, electrical engineering made some progress.

The supply of power by one of the largest companies (Sydsvenska Kraftaktiebolaget) began in the course of the year. The Trollhattan Works, which began its delivery of power in 1908 from its provisional establishment, extended its lines in 1909 to Gothenburg, Alingsas and Skofde, and began supplying the last-named town with power. The Hemsjo Co. also started its new power station at Torsebro during the year. In Norrland only one large power station (the Ungers Industriaktiebolags power station at Arbra) was opened. Stora Kopparbergs Bergslags power station at Bullerforsen is still in hand. The power station of the Uddeholm Co. at Forshult and the Vasterdalalfvens Kraftaktiebolags power station at Mockfjard have commenced work, and Hellefors Bruks Aktiebolag have commenced the work of harnessing four of its waterfalls in Svartalfven. The town of Umea has begun the construction of a power station at Klabbole on the Umea River. The large steam turbine station at Gellivare was ready to start work at the close of the year.

The Swedish Water Power Association, which was formed in 1909 for the promotion of a rational use of the water power, has on its programme several questions of great importance for the economy of water power, such as better water legislation, control of rivers and lakes, &c.

In the iron trade the most important event was the completion of the experiments in iron ore reduction in electric furnaces of different types at the Domnarfvet iron works in which the victory fell to the Aktiebolaget Elektrometall. Thanks to the decision of the Swedish Iron and Steel Institute to devote 250,000 kr. to set up experimental works on a large scale at Trollhattan, this important matter for the Swedish iron industry has been brought much nearer to the commercial stage.

In the report for 1909 of Mr. Vice-Consul Neess (Landskrona) it is stated that electric supply was inaugurated during the year. Power is transmitted by overhead cable from the River Lagan (about 62 miles away).

Uruguay.—Extensive improvements are to be carried out at the harbour of Montevideo, including the provision of cranes, electric light and motor power plant, dock railway lines, &c. The text of the Government bill authorising the work has been published, and the total cost of the scheme is put at £2,808,000.

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ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Birkenhead.—For the year ended March 31 the total receipts of the tramways department were £56,817, including £55,759 from passenger receipts.

The total working expenses came to £33,757, and after allowing for bad debts, &c., the gross profit was £22,683. Interest amounted to £9,984, sinking fund charges to £9,317, and interest on amount applied to redemption of debt £1,742, and the balance (£2,357) was transferred to renewals fund. The capital expended was £366,419, an increase of £2,990 during the year, but the outstanding loans only amount to £282,442. 12,283,344 passengers were carried and 1,201,476 car-miles run, against 12,124,297 passengers and 1,278,015 car-miles in 1908. The receipts per car-mile were 11·32d., against 10·53d.

Halifax.—The accounts of the electricity department for the year ended March 31 show a total income of £36,329.

Receipts included £18,823. 10s. 5d. from supply of current for private lighting, power and heating, £15,195 from traction, and £1,718 from public lighting, less £1,044 for discounts. Total working expenses were £20,060, which included £11,337 for generation, £3,256 for distribution, and £2,664 for management expenses and general establishment charges. Gross profit was £16,269, and after paying interest on loans, &c. (£7,922), sinking fund charges (£6,349), income tax (£115), the net profit was £1,883. After crediting balance brought forward (£156) and bank interest, and voting £1,000 in relief of rates, the balance (£1,158) was carried forward. The total capital expended on the supply department is £107,133, an increase of £2,671 during the year. There are 1,855 consumers (with the equivalent of 174,994 8 c.p. lamps) connected, against 1,797 consumers and 163,578 8 c.p. lamps in 1909. 5,477,369 units of electrical energy were sold, including 1,865,715 units for private lighting and power, 3,545,007 for traction and 66,647 for street lighting. There are 63 public arc lamps, and the public maximum supply demand was 2,870 kw. against 2,850 kw. in 1909.

The total receipts of the tramways department were £89,270, against £86,158 in 1908-9. Passenger traffic was £86,285 against £82,219, the luggage and parcel receipts were £1,625, and advertising on cars £972, against £2,314. Working expenses were £53,898 against £60,145, and gross profit £35,372, against £26,013. After deducting special expenditure (£762, against £17,982), interest (£11,861, against £12,201), sinking fund (£9,562, against £9,200) and preliminary charges (£122, against £172) there was a net profit of £22,307, against a deficit of £13,542. Total working expenses came to 6·947d. per car-mile (against 7·95d.) which included power expenses 1·869d. (against 2·095d.) per car-mile. The charge for current during the past year was 1d. per unit against 1¼d. in 1908-9. The car-mileage run was 1,862,068 against 1,815,692, and the units of electrical energy consumed for traction were 3,479,464 against 3,580,224. 16,323,755 people were carried, against 16,413,434 in 1908-9.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone insulators to the Postmaster-General's Department in all the States of the Commonwealth of AUSTRALIA. Tender forms, &c., may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Sept. 27 for the supply of electric lamps to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Oct. 5 for the supply of 5,000 porcelain insulators to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Oct. 4 for the supply of telephone material to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See advertisement.

LONDON County Council invite tenders for the covering with asbestos tape of certain electric cables in manholes in the south of London. Specification, drawing, form of tender, &c., from the Clerk of the Council, Spring Gardens, S.W. Tenders by 11 a.m. Aug. 30.

LONDON County Council also invite tenders for wiring and fitting for electric lighting of the second section of the central car repair depot, Woolwich-road. Specifications, &c., from the Clerk of the Council. Tenders by 11 a.m. Tuesday, Aug. 30.

BOURNEMOUTH Tramways committee want tenders by Aug. 31 for reconstruction of 2½ miles of tramway permanent way and supply of 450 tons of rails, with fastenings. Specifications, &c., from the General Manager.

Tenders are wanted by 5 p.m. Aug. 25 for supply of telephone apparatus and cable (main central battery system and metallic circuit telephone switchboards, &c.) for the Lancashire County Asylum, RAINHILL. Specification, &c., from the Clerk.

CHELMSFORD Education committee want tenders by Aug. 31 for electric light wiring at Trinity-road school. Forms, &c., from Mr. W. H. Pertwee, London-road, Chelmsford.

SOUTH DUBLIN Guardians want tenders by noon Aug. 24 for wiring and fitting the workhouse for electric lighting. Specifications, &c., from the Clerk on payment of £1. 1s.

ROCHDALE Electricity committee want tenders by noon, Aug. 31 for 12 months' supply of paper insulated cables. Specification from the engineer and manager.

POPLAR (London) Guardians want tenders by 6:30 p.m. Aug. 31 for 12 months' electrical supplies, ironmongery, packing and jointing, &c. Forms, &c., from the Clerk.

WEST HAM Guardians want tenders for 12 months' supply of electrical fittings, engineers' oil, &c. Tenders to the Chairman of the Board, at 11 a.m., Sept. 1.

The COMMISSIONERS OF H.M. WORKS AND PUBLIC BUILDINGS invite tenders for 12 months' supply of electrical accessories. Tenders by 11 a.m., August 24, to the Secretary, Storey's Gate, London, S.W.

The directors of the Powell Duffryn Steam Coal Co. (ABERDARE) invite tenders for stores, including electrical goods. Tenders to London office (101, Leadenhall-street, E.C.) by Sept. 12.

HACKNEY (London) Council want tenders by 7 p.m. Sept. 15 for extension of main switchboard. Specification from Town Clerk.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W., and also from Messrs. R. W. Cameron & Co., 23, South William-street, New York, and Mr. H. Stephenson Smith, 244, California-street, San Francisco, Cal. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

Tenders are invited up to Sept. 20 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA (Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 7 for supply of battery material and glassware to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Official Secretary in Great Britain of the Commonwealth of Australia, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, MELBOURNE (Victoria), will receive tenders until 3 p.m. Aug. 30 for supply of electrical sundries, insulators, wire and sulphate of magnesia. Local representation necessary. Further particulars from 72, Victoria-street, London, S.W.

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Tenders will be received (up to 3 p.m. Sept. 13) by the Deputy Postmaster-General, MELBOURNE, for supply of 8,510 telephones. Local representation necessary.

Tenders will be received up to noon Sept. 1, at the offices of the chairman of the Board of Control, WINNIPEG (Manitoba, Canada), for supply and installation of 46,000 ft. of 13,000-volt three-core cable. Deposit of $1,000 (about £205) required. Specifications and forms from the Power Engineer, Winnipeg. Copy of specification and conditions may be seen by British makers at 73, Basinghall-street, London, E.C.

The Ministry of Public Works, CAIRO, require tenders for electrical installations and refrigerating plant for the lunatic asylum in course of construction at Khanka. Specifications from the Chief of the Administrative Service, Ministry of Public Works, Cairo. Stamped paper for tenders is obtainable from Mr. A. L. Webb, Westminster, S.W. Tenders by noon Oct. 20. Legal domicile at Cairo is necessary in the case of this contract, and to obtain temporary domicile British firms must, before electing such domicile, formally advise the Consulate at Cairo of intention to do so, formally authorise the Consulate on their behalf and inform the Consulate of the address to which documents should be forwarded.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

MOSTAR (Austria-Hungary) municipality will receive tenders until Oct. 1 for the installation of electric generating plant.

TENDERS RECEIVED AND ACCEPTED.

The tender of G. Weymouth Proprietary (Ltd.) has been accepted for the supply and erection of the electric power plant, &c., required for the cordite factory at Maribyrnong, Victoria.

There were seven tenders, and it was stipulated that the plant must be of Australian manufacture, importers being, therefore, precluded from the competition. It was further stipulated that the plant must be placed in position within 20 weeks from the date of acceptance of tender. The lowest tender (at £7,459) was accepted. The plant consists of duplicate air compressors, hydraulic machinery, refrigerating plant, cold water and pneumatic circulating systems, feed pumps, electric motors and electric distributors.

Belfast Harbour Commissioners have accepted the tender of the British Insulated & Helsby Cables for the supply and delivery of 3¼ miles of 7/18 h.t. cables, paper insulated, lead covered, bound with a layer of jute, compounded, suitable for a 3,000 volt continuous current), and ½ mile of 7/18 rubber insulated cable to sample.

Sunderland Corporation have accepted the following tenders:—

W. Rickard (Ltd.), supplying cable for stock; W. G. Farrow & Co., w.i. piping and bends; and British Westinghouse Co., for a three-phase transformer.

Bury (Lancs.) Council have accepted the tender of Siemens Bros. & Co. for e.h.t. trunk mains.

Clacton-on-Sea Council have accepted the tender of I. Frankenburg & Sons for 440 yds. of cable at £29.

Wigan Council have placed an order with D. A. Ablett for extending the electricity station buildings.

Messrs. Dorman, Long & Co. have placed an order with the A.E.G. (Berlin) for a complete electric power plant, consisting of three mixed pressure turbo-alternators and one live-steam turbine (each of 1,280 kw.), which will generate three-phase current at 3,000 volts 40 cycles. There will also be three 600 kw. direct coupled generators, two 600 kw. transformers, an induction motor coupled to a 150 kw. d.c. generator, switchboard, &c.

BUSINESS NOTICES.

Messrs. Arthur Joppling & Co. have opened a branch office and stores at 16, Park-lane, Leeds, to deal with their business in the north of England, and Mr. A. Pyman has been appointed manager for the Leeds district.

The Melbourne (Australia) offices of the India Rubber, Gutta Percha & Telegraph Works Co. have been removed to 21 and 23, Elizabeth-street.

Messrs. W. G. Watson & Co. (Ltd.) has been formed to acquire the New South Wales business of J. A. Newton & Co. Proprietary (Ltd.).

The Welsbach Light Co. of Australasia has been appointed sole agents in Australasia for the Electric Construction Co. of Wolverhampton and London.

Messrs. Henry Wm. Davis and Harry Walter Hosier, electrical and surgical instrument makers, 43, Grafton-street, London, W.C. (trading under the style of H. & W. Davis), have dissolved partnership as from July 16. Debts by H. W. Davis, who continues.

Messrs. Kurt, Wm. Bacher, Hugh C. Taylor and Jas. R. F. Smith, electrical and mechanical engineers, of Hounslow, Middlesex, have dissolved partnership.

Siemens "Onewattlite."—A new development introduced some months ago by Messrs. Siemens Bros. Dynamo Works, Tyssen-street, Dalston, London, N.E., when placing their 100 c.p. lamps on the market, is now generally known to the trade as the "Onewattlite." Particulars of this have been widely circulated by the firm, and it is worthy of consideration by the contractor who is more particularly interested in supplying shop keepers and trade establishments. It consists of a 100 c.p. "Onewatt" lamp used in conjunction with a suitable design of "genuine" Holophane glass reflector fitted to a gallery which brings the lamp into true focus and obtains the best possible illumination effects. Holophane glassware is now widely known for its special reflecting capacity, and used in conjunction with the "Onewatt" drawn tungsten lamps, provides a cheap and efficient method of illuminating the display windows and interiors of shops. Contractors are specially asked to note that when ordering "Onewattlite" the price quoted is inclusive of glassware, gallery and 100 c.p. "Onewatt" lamp complete, with the exception of the lamp holder, and is readily fitted to any existing lamp holder which may be installed. In the case of new installations, however, it would be necessary to order lamp holders extra. The firm will be pleased to supply full particulars of this speciality to all contractors who are interested in the class of work mentioned.

"Metalik" Lamps.—With the lighting season now fast approaching, attention may be called to the advantages claimed by Messrs. G. M. Boddy & Co. for their "Metalik" lamps. Among these may be mentioned the fact that these lamps do not blacken with use. Messrs. Boddy also claim that their lamp infringes no existing patent, and that they indemnify all users from legal attack.

CATALOGUES, &c.

B.T.H. MOTORS.—We have received from the British Thomson-Houston Co. two lists, the first of which deals with motors designed for driving sewing machines, and the second with continuous-current motors and generators of the DG type. These are made in several styles, one of which has a flange fitted to the motor so that the latter can be connected with an air duct and thus be kept supplied with fresh air.

SIEMENS METERS.—Messrs. Siemens Bros. Dynamo Works send us a pamphlet giving details of their watt-hour meters. This meter, it is claimed, marks a distinct step forward in the construction of this class of instrument, as all the working parts can be replaced without tools, and the replacement of all or any parts does not necessitate recalibration.

ST. HELENS CABLES.—From the St. Helens Cable & Rubber Co. we have to acknowledge a catalogue, on the front of which are some illustrations showing the use of this firm's cables in pre-historic times. We confess we did not know the use of the electric drive had advanced so far in the days of the Ancient Britons. Various electrical accessories made by the firm are illustrated in the interior of the catalogue, the advantage of which is brought before the senses of the reader by means of rhyme quatrains.

CONTA LAMPS.—The Regina Arc Lamp Works, of Cologne, have sent us two catalogues dealing with their well-known "Conta" lamp, the advantages of which were recently set out in the pages of THE ELECTRICIAN. Full details of the operation and prices of these lamps are given.

BANKRUPTCIES, LIQUIDATIONS, &c.

The discharge in bankruptcy of Albert Clapham, trading in partnership with James W. Hunter at 101, Kirkstall-road, Leeds, under the style of the Yorkshire Motor Car & Electrical Engineering Co., has been suspended for two years.

The National Lighting Corpn. (Ltd.,) 35, Cock-lane E.C., is being wound up, and the first meeting of creditors and contributories will be held on Aug. 23, at 33, Carey-street, London, W.C.

A meeting will be held at 61½, Fore-street, London, E.C., on Sept. 13, to receive an account of the winding up of the Crystalate Mfg. Co. (Ltd.)

The Russian Engineering Co., Ltd., is being wound up voluntarily. Mr. G. Hagger, 16, Gt. George-street, London, S.W., is liquidator. Meeting of creditors on 29th inst.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

*NOTE.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

May 13, 1910.

11,904 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controllers for alternating-current electric motors.*
11,931 STODD. Incandescent electric lamps.*
11,951 HERBERTS. Electrical impedance switches and regulators.

May 14, 1910

11,978 VANDERVELL. Armouring for electric wires or cables.
12,026 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Control of electric motors.*
12,059 GROTE. Direct producing continuous-current dynamos and motors.

May 17, 1910.

12,077 BIRAM. Telephone systems.
12,089 JOHNSTON. Cord-grip lampholders and like electric fittings.
12,120 TAYLOR. Limiting the current on a short circuit.
12,122 TAYLOR. Localising faults on high tension alternating-current circuits.
12,133 KUHN. Sparking plugs.*
12,149 BISSON & BERGES. Arc lamps.*
12,174 MIDGLEY & VANDERVELL. Dynamo-electric machinery. (Addition to No. 16,447/09.)

May 18, 1910.

12,184 JOHNSON. Electric switch.
12,192 BENTLEY. Electrical lampholders and shade carriers.
12,214 HIORTH. Electric induction smelting furnaces. (Date applied for, 22/5/09.)*†
12,229 KAISER. Oxidising nitrogen by means of electric discharges. (Date applied for, 19/5/09.)*†
12,248 THOMPSON. (Deutsche Telephonwerke G.m.b.H., Germany.) Selectors for automatic telephone exchange systems.
12,259 LUGARD. Electromagnetic clutches.*
12,265 B.T.-H. Co. (G.E. Co.) Electric motor control systems.
12,269 TAYLOR. Electrical switchgear.

May 19, 1910.

12,299 FIELD & FERRANTI (LTD.). Dynamo-electric systems and the like.
12,300 FIELD & FERRANTI (LTD.) Electric motor starters.
12,322 NEWITT & FLETCHER. Electrical heating appliances.
12,342 BULLERS (LTD.) & TWISS. Electric insulators.
12,347 LAITTE & SAFETY LIGHT (LTD.). Electric switch.
12,355 BERRY. Electrical transformers.

May 21, 1910.

12,357 WILSON. Low-tension make-and-break electric safety lamp-lighter.
12,368 TRIN. Electric safety lamp.*
12,408 DROOP. Relays for telephone circuits. (Date applied for, 21/5/09.)*†
12,427 BERRY. Switch apparatus.
12,428 CLARKE, CHAPMAN, & CO. & HARRIS. Electric resistances.
12,430 ELEKTROMETALL. Regulating the electrodes in reverberatory electric furnaces. (Date applied for, 21/5/09.)*†

May 23, 1910.

12,483 SIEMENS-SCHUCKERT WERKE G.M.B.H. Arc lamps. (Date applied for, 24/5/09.)*†
12,489 & 12,490 DEY. Electric switches. (Date applied for, 21/10/09. Comprised in No. 24,208, dated 21/10/09.)*
12,497 COWPER-COLES. Electro-deposition of zinc.
12,522 SCHULTZ. Electric switches. (Date applied for, 24/7/09. Comprised in No. 17,274, dated 24/7/09.)*

May 24, 1910.

12,576 VICKERY. Electric signalling and like systems.
12,594 BLATHY. Dynamo-electric machines. (Date applied for, 27/5/09.)*†
12,601 SERPEK. Improvements in electrical resistance furnaces.*
12,609 FREIBERG. Electric lamp-holders.*
12,614 AMERICAN AUTOMATIC TELEPHONE CO. & GOODRUM. Automatic telephone systems.*
12,616 BALSILLIE & BRITISH RADIO TELEGRAPH & TELEPHONE CO. Detecting electrical oscillations.
12,625 SALOM. Negative plates for storage batteries and in processes for the manufacture thereof.*
12,627 FESSENDEN. Utilising radiant energy. (Addition to No. 28,577/09.)
12,651 LEHMANN, ROSS-HARVEY & INRIG. Variable-speed dynamo.
12,664 BROWN. Telegraphy.

May 25, 1910.

12,682 LAWSON & DENT. Universal electric rotary indicator.
12,701 ADAMS & ADAMS MFG. CO. Electric change-over switches.
12,708 ELECTRIC & ORDNANCE ACCESSORIES CO. & COLLINS. Time-limit or retarding devices.*
12,724 SIEMUND. Electric welding and repairing. (Date applied for, 3/6/09.)*†
12,739 SCHWARZHAUPT. Auxiliary telephone receiver.*
12,754 PAKENHAM & "Z" ELECTRIC LAMP MFG. CO. Machines for making incandescent electric lamps.
12,757 B.T.-H. Co. (G.E. Co., U.S.) Alloys useful as electric resistance conductors.*
12,758 B.T.-H. Co. (G.E. Co., U.S.) Composite wires.

May 26, 1910.

12,783 DUNCAN. Portable electric lamps.
12,787 MARCHANT & MARCHANT. Armatures for dynamo-electric motors and generators.
12,791 AIKEN. Controlling electric lights and apparatus therefor.
12,814 MILLER. Combined interrupter and switch.
12,815 TAYLOR. Localising faults on high-tension alternating-current systems.
12,856 LAMPLOUGH. Sparking plug.
12,859 WARWICK MACHINERY CO. (1908) (G.E. Co., U.S.) Turbine vanes or buckets.*

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

12,047 B.T.-H. Co. & KINGWELL. Control of electric motors.
12,442 HAMILTON. Combined section insulator and double action quick-break switch for electric trolley conductors.
12,585 WEEKES. Fuse switches.
12,937 HOUGHTON, ALLMAN & GRAY. Electric power traction systems.
13,080 EVERSHED & VIGNOLES & EVERSHED. Electric energy meters.
13,220 SIEMENS BROS. & CO., HANDCOCK, DYKES & RAWLINGS. Sheathing of insulated electrical conductors. (Cognate application, 24,683/09.)
13,228 BASTIAN. Incandescence electric lamps.
13,238 LAURIE-WALKER & NIBLETT. Ploughs for electric tramcars.
13,265 FRANCIS. Stage arc lamp.
13,295 NATHUSIUS & WESTDEUSCHE THOMASPHOSPHAT-WERKE GES. Electric furnaces. (Addition to No. 7,188/08.)
13,391 CLARKE. Incandescent electric lamps of the "Nernst" type.
13,442 BERRY. Electric switches and switch fuses.
13,573 MARKS. (Milton.) Electric interrupters for ignition purposes.
13,771 ADAMS-RANDALL. Telephones.
13,827 BASTIAN. Transformation of electrical energy into heat energy.
13,834 TUBBS. Magazine electric arc lamps.
14,248 HADFIELD. Tramway points.
14,660 THUM. Electrolytic apparatus.
15,251 LODGE & LODGE. Sparking plugs.
15,282 FELTEN & GUILLEAUME-LAHMEYERWERKE AKT.-GES. Driving mechanism for petrol electric apparatus. (Date applied for, 1/7/08.)
15,438 HOOKHAM. Electricity meters.
15,496 JAHODA. Manufacture of metallic filaments for electric incandescent lamps. (Date applied for, 10/5/09.)
15,803 BROOKS & ALSTON. Electric ignition systems of internal-combustion engines.
15,981 LERTOURNE. Producing synchronism between the rotation of a controlling machine and the rotation of one or more electrically-driven machines.
16,520 TATTERSALL. Telephone and other similar mouthpieces.
16,811 SIEMENS BROS. DYNAMO WORKS & KIEFFER. Alternating-current electric induction motors.
17,101 HIRST & COATES. Insulating device for electric lamp-holders.
17,189 MIDGLEY & VANDERVELL. Dynamo-electric generating systems.
17,761 DEUTSCHE ELECTRO-SPARLICHT GES. Closed circuit transformers. (Date applied for, 31/7/08.)

COMPANIES' MEETINGS AND REPORTS.

CLAUD HAMILTON (LTD.)—The accounts for the past year show an available balance (including £932 brought forward, of £6,207. After placing £400 to preference shareholders' reserve, the directors recommend a dividend of 7½ per cent., carrying forward £1,797.

COMPANIA ALEMANA TRANSATLANTICA ELECTRICIDAD—The directors report further increase in the business of the company during 1909, and although the capital has been increased from 72,000,000 marks (£3,600,000) to 80,000,000 marks (£4,000,000), and the debenture issue from 15,000,000 marks (£750,000) to 17,000,000 marks (£850,000), the dividend has been increased from 9½ per cent. to 10 per cent. At the recent meeting the chairman announced that they had secured the contract to supply electrical energy to the Anglo-Argentine Tramway Co., and it was expected that the tramways in Monte Video would shortly show better results. The directors did not propose to increase the capital at present, but if found necessary it would take the form of debentures. In Buenos Aires the output of current for the year amounted to 128,514,152 units, compared with 110,895,317 units in 1908. Out of that total the energy consumed was 100,826,968 units in 1909, against 86,355,995 units in 1908, an increase of 16·8 per cent. The profit amounted to 14,756,652 marks (about £737,830), compared with 12,430,763 marks (£621,538). The new connections in 1909 were as follows: 96,154 incandescent lamps (equal to 5,110 kw.), 1,011 arc lamps (924 kw.), 1,028 motors (4,037 kw.), 566 ventilators, &c. (363 kw.), and 631 kw. increased output to other stations. These increases represent 11,065 kw., equivalent to an increase of 16·05 per cent. over 1908. At the end of 1909 the connections comprised a total of 732,484 incandescent lamps, 6,972 private arcs (equal to 44,990 kw.), 1,427 street arcs and 543 in the port (equal to 1,146 kw.), 6,783 motors, 9,569 ventilators, &c. (equal to 33,248 kw.). Sales to other stations were equivalent to 1,524 kw.: tramways about 15,190 kw. The company had 26,074 clients and 28,666 meters, against 21,489 clients and 24,402 meters in 1908. The total length of mains was 2,492 km. (about 1,545 miles), and the total capacity of the power houses was 46,710 kw. The construction of the station at Dock Sud was well in hand at the end of the year, and at present 30,000 kw. was available.

GREAT NORTHERN, PICCADILLY & BROMPTON RAILWAY CO.—At the meeting last week Sir Geo. Gibb said that the meetings of the three tube railways were consolidated into one for the purpose of his remarks. He expressed regret that the proposal for the extension of the Charing Cross line from its present terminus (under the S.E. Railway) to the Embankment did not pass the committee of the House of Lords. Each of the three railways had shown an increase in traffics, and the total value of the additional traffic for the half-year was £10,940. The working of all the railways had shown a satisfactory decrease in expenditure. The traffic was a growing one, and the facilities were being more and more appreciated by the general public. The Charing Cross, Euston & Hampstead Co. had maintained its dividend at the rate of ¾ per cent. on the ordinary stock. The Piccadilly Co. paid a dividend at the rate of 1½ per cent., an increase of ½ per cent., and the Baker Street & Waterloo Co. paid a dividend at the rate of 2 per cent., an increase of ½ per cent.

MERSEY RAILWAY CO.—The train-mileage run during the half-year ended June 30 was 330,307, compared with 384,962 during corresponding six months of 1909, and the number of passengers conveyed was 5,948,152 (against 5,818,759), exclusive of season ticket holders. Total receipts were £54,652. 18s. 2d., compared with £53,227. 18s. 10d. Working expenses (exclusive of charges for pumping, ventilation and lifts) were £29,916. 4s. (equal to 54·74 per cent.), against £30,810. 9s. 10d. (57·88 per cent.). The charges for pumping, ventilation and hydraulic lifts amounted to £3,279. 11s. 9d. (6·0 per cent.), compared with £3,659. 11s. 11d. (6·88 per cent.).

MEXICAN LIGHT & POWER CO. (LTD.)—At the recent meeting (at Toronto) it was announced that the storage capacity had been increased, and 20,000,000 cubic metres of water were now on hand. The business prospects for the present year were excellent. The net revenue for the past year was $2,426,811. After paying fixed charges, and dividends of 7 per cent. on the preference shares and 4 per cent. on the common stock, $149,385 was carried forward.

MEXICO TRAMWAYS CO. (LTD.)—At the recent meeting it was stated that there was every prospect of improvement in the receipts of the company. The Xocohimilco line was now in full operation and the receipts were satisfactory. The net revenue for 1909 (in gold), after paying all expenses and fixed charges, amounted to $922,457·95, to

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which must be added $371,350·17 brought forward. Four quarterly dividends at the rate of 6 per cent. per annum had been paid, $300,000 carried to reserve, leaving $416,344·12 to be carried forward.

TURNER, ATHERTON & CO. (LTD.)—The directors' report recommending a dividend of 12½ per cent. for the half-year (making 10 per cent. for the year) on the ordinary shares, was approved at last week's meeting.

UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)—The directors' report states that the result of the past half-year shows a substantial improvement. The net revenue from investments and properties (deducting general expenses) amounted to £96,767. 14s. 1d. The net income from the operation of the power house was £45,416. 19s., but the interest on £1,000,000 4 per cent. first power house debentures, and a proportion of commission, discount and expenses incurred in connection with the issue, required £20,870, leaving a surplus from the power house of £24,546. 19s., making a total revenue of £121,314. 13s. 1d. After meeting the service of the £1,000,000 5 per cent. prior lien bonds, and of the £2,818,700 4½ per cent. bonds of 1,933, and the payment under the guarantee on Metropolitan District Railway assented extension preference stock the surplus was £26,392. 13s. 1d. Interest at the rate of 1 per cent. on £4,928,050 6 per cent. income bonds of 1,948 required £24,640. 5s., income tax thereon £1,437. 6s. 11d., leaving £315. 1s. 2d. for reduction of accumulated revenue deficiencies. Since the closing of the accounts £54,652. 5s. was received from the estate of the late C. T. Yerkes on account of unpaid calls on shares and interest. The traffic of the railway companies in which the company is interested is increasing satisfactorily, and a notable feature is the decrease, in each case, in the working expenses, notwithstanding increase in receipts.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, AND RECEIVERSHIPS.

NEW COMPANIES.

BRYANT & SONS (LTD.) (111,261)—Reg. Aug. 11. capital £3,000 in £1 shares, to take over the business carried on by E. T. Bryant at Bristol, and to carry on the same, and the business of mechanical and electrical engineers, &c. Private company. First directors, E. T. Bryant, J. J. Ballard, O. E. Bryant and S. W. Bryant. Reg. office, 42, Queen Anne-road, Bristol.

LUMINATOR WATER CO. (FOREIGN PATENTS) (LTD) (111,214)—Reg. Aug. 8, capital £5,000 in £1 shares, to take over a business of engineers, electricians, machinists, manufacturers of and dealers in electrical and other machinery, &c. Private company.

ORIZABA TRAMWAYS SYND. (LTD.) (111,297)—Reg. Aug. 12, capital £3,150 in 3,000 ordinary shares of £1 each and 3,000 deferred shares of 1s. each, to carry on the business of tramway, railway and omnibus proprietors, manufacturers of and dealers in tramways, accumulators, locomotives, dynamos, &c., and to acquire any tramways in Orizaba, Mexico. Private company. Provisional directors, M. E. Williams and J. E. Stevens.

SALERNO SYND. (LTD.) (111,301).—Reg. Aug. 12, capital £8,300 in 8,000 shares of £1 each and 6,000 shares of 1s. each, to obtain concessions, licences, or powers for the construction, maintenance and working of railways, tramways and other public works in the province of Salerno, Italy, or elsewhere. Private company. First directors, B. W. Bennett and L. Dini. Reg. office, Cross Keys House, Moorgate-street, London, E.C.

SIRENO CO. (LTD.) (111,315)—Reg. Aug. 13. capital £3,000 in £1 shares, to carry on business as manufacturers of and dealers in electric warning signals, motor horns, projectors, switches, taximeters and all kinds of accessories used in connection with motor cars, boats and aeroplanes. Private company. S. F. Tyler is permanent governing director. Reg. office, 46, Brewer-street, London, W.

STATUTORY RETURNS.

ALERT ELECTRICAL CO. (LTD.)—Return (dated Jan. 27) filed July 2, gives capital £2,000 in £1 shares. 708 shares taken up. £708 paid. Mortgages and charges, nil.

BRECKNELL, MUNRO & ROGERS (LTD.)—In return dated May 24 capital is £30,000 in 2,000 preference shares of £5 each and 20,000 ordinary shares of £1 each. 14,829 ordinary and 958 preference shares taken up. £1 per share called up on 767 ordinary and £5 per share on 958 preference. £5,557 paid. £14,062 considered as paid on 14,062 ordinary shares. Mortgages and charges, £7,600.

CAMBORNE ELECTRICITY SUPPLY CO. (LTD.)—The capital in return to May 18 is £10,000 in £1 shares. 607 shares taken up. £1 per share called up. £605 paid, leaving £2 in arrears. Mortgages and charges, nil.

CANADIAN ELECTRIC TRACTION CO. (LTD.)—Return to Dec. 31, 1908, (filed June 21, 1910), gives capital as £120,000 in £1 shares. 68,007 shares taken up. £53,000 paid on 53,007, leaving £7 in arrears. £15,000 considered as paid on 15,000 shares. Mortgages and charges, nil.

GORSEINON ELECTRIC LIGHT CO. (LTD.)—According to return to June 6 capital is £4,000 in £1 shares. 2,000 shares taken up and £1,998 paid. Mortgages and charges, £800.

INTERNATIONAL DOWSING ELECTRIC HEATING & APPLIANCES CO (LTD.)—The capital in return to Dec. 31 is £20,000 in £1 shares. 18,107 shares taken up. £7 paid. £18,100 considered as paid. Mortgages and charges, nil.

LEATHERHEAD & DISTRICT ELECTRICITY CO. (LTD.)—In return dated June 2 shows capital £35,000 in £1 shares. 34,200 shares taken up. £34,200 paid. Mortgages and charges, nil.

LISBON ELECTRIC TRAMWAYS (LTD.)—Return dated May 11 shows capital £1,250,000 in £1 shares. 634,026 ordinary and 425,553 preference shares taken up. £134,026 paid on 134,026 ordinary. £925,553 considered as paid on 425,553 preference and 500,000 ordinary. Mortgages and charges, £499,400.

LLANDUDNO & COLWYN BAY ELECTRIC RAILWAY (LTD.)—Return to March 14 gives capital as £100,000 in £1 shares. 99,400 shares taken up. £77,900 paid. £21,500 considered as paid. Mortgages and charges, £75,000.

LLANGOLLEN & DISTRICT ELECTRIC LIGHT & POWER CO. (LTD.)—Return to July 16 gives capital as £6,000 in £1 shares (2,500 preference). 1,754 ordinary and 360 preference shares taken up. £1 per share called up. £2,110. 15s. paid, leaving £3. 5s. in arrears. Mortgages and charges, £2,000.

W. LUCY & CO. (LTD.)—In return to July 4 capital is £15,000 in £10 shares (250 preference and 1,250 ordinary). 250 preference and 1,030 ordinary shares taken up. £10 per share called up and paid on 250 preference and 781 ordinary. £2,490 considered as paid on 249 ordinary. Mortgages and charges, £7,000.

PETERBOROUGH ELECTRIC TRACTION CO. (LTD.)—Capital in return to May 16 (filed July 19) is £60,000 in 6,000 ordinary and 6,000 preference shares of £5 each. 4,000 ordinary and 4,400 preference shares taken up. £42,000 paid. Mortgages and charges, £21,000.

MORTGAGES AND CHARGES.

THOMAS L. SCOTT & CO. (LTD)—Particulars of £3,500 debentures, created Aug. 20, 1909, have been filed, amount of present issue being £500. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

RECEIVERSHIPS.

ACCESSORIES MFG. CO. (LTD.)—Mr. H. A. McCann, King's House, King's-street, London, E.C., was appointed receiver on July 29.

MAGNETO CO. (LTD.)—C. H. MacPherson, 35, Newhall-street, Birmingham, ceased to act as receiver or manager on July 20.

CITY NOTES.

MEMORANDA (Aug. 18).—**Bank rate 3 per cent. (since June 9, 1910). Price of silver,** 24½d. per oz. Consols 80¾—81 for money; 80¾—81 for account. **Consols Pay Day, Sept. 1; Stock and Shares Continuation Days, Aug. 29 and Sept. 13; Ticket Days, Aug. 30 and Sept. 14; Pay Days, Aug. 12 and 31; Mining Shares Carry Over Day, Aug. 26.**

PRICES OF METALS (London).—*Copper*, cash, 55⅝; three months, 57¼. *Lead*, English, 12⅞—13; foreign, 12½—12⅝. *Spelter*, 23. *Tin*, English, 151½—153½; foreign cash, 154½; three months, 153¾. *Iron*, Cleveland, cash, 50/0, three months, 50/9.

BERLINER STRASSENBAHN GESELLSCHAFT.—The general manager of the A.E.G. (Herr E. Rathenau) has been appointed a member of the board, with a view (it is stated) of putting an end to the quarrel between the municipality and the company. The Berliner Electricitäts Werke, which supply power to the Strassenbahn is to be acquired by the Council.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the five weeks ended July 1 were 995,992, compared with 865,897 in the corresponding five weeks of 1909.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The warrants in payment of the dividends on account of 1910 on the preference and ordinary shares have been posted.

W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)—The directors have declared interim dividends on the preference shares and at the rate of 10 per cent. per annum, tax free, on the ordinary shares for the half-year ended June 30, both payable Sept. 1.

LIVERPOOL DISTRICT LIGHTING CO. (LTD.)—An interim dividend for the past half-year at the rate of 4 per cent. per annum has been declared.

MATHER & PLATT (LTD.)—An interim dividend on the ordinary shares at the rate of 5 per cent. (tax free) for the half-year ended June 30 (at the rate of 10 per cent. per annum) has been declared.

METALITE (LTD.)—Letters of allotment and regret have now been posted.

NORTHAMPTON ELECTRIC LIGHT & POWER CO. (LTD.)—The directors are paying an interim ordinary dividend at the rate of 5 per cent. for the half-year to June 30.

SOUTH AMERICAN LIGHT & POWER CO. (LTD.)—The directors have declared a dividend of 5 per cent. for the past year, have placed £1,500 reserve and carried forward £628.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have been requested to appoint a special settling day, and to grant a quotation to £1,240,563 4 per cent. preference stock and £3,791,106 4 per cent. debenture stock of the *London Electric Railway Co.* (in lieu of the securities of the Baker Street and Waterloo, Charing Cross, Euston and Hampstead, and Great Northern, Piccadilly and Brompton Railways), and the further issue of £184,375 *Metropolitan District Railway* guaranteed stock (4 per cent.)

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 10	1,669	— 198	10	15,558	— 274
Airdrie	„ 5	202	— 11	31	6,715	+ 70
Anglo-Argentine	„ 13	43,059	+ 6,089	32	1,410,335	+ 166,450
Ayr Corporation	„ 13	572	+ 70	13	5,598	+ 292
Barnsley	„ 5	216	+ 42	31	5,311	+ 182
Barrow	„ 5	436	+ 137	31	8,250	+ 1,229
Bath Electric Trams, Ltd...	„ 10	991	— 41	32	25,716	+ 1,179
Birmingham Corporation ..	„ 13	6,198	+ 231	19	129,737	+ 530
Birmingham & Midland....	July 29	883	+ 43	30	25,183	+ 273
Blackburn Corporation	Aug. 10	1,239	— 168	‡20	21,714	— 924
Blackpool and Fleetwood ..	..	..	..	..	..	..
Bolton Corporation.....	„ 14	2,585	— 2	20	46,858	— 373
Bombay	July 15	2,627	+ 400	28	75,888	+ 5,483
Bournemouth Corporation..	Aug. 10	2,484	— 132	19	37,350	+ 3,872
Bradford Corporation.....	„ 13	5,401	— 24	20	100,491	+ 3,121
Brighton Corporation.....	„ 14	1,373	— 69	§19	20,507	— 123
Bristol Trams & Carriage ..	„ 12	6,116	+ 172	6	39,215	+ 1,963
Burnley Corporation	„ 13	1,339	— 78	6	7,722	— 54
Burton Corporation	„ 14	288	— 11	19	5,281	— 56
Bury Corporation	..	..	..	..	..	..
Calcutta Tramways Co.....	„ 13	₹52,904	+ ₹4,504	6	₹315,378	+ ₹15,681
Camborne-Redruth	„ 13	137	+ 6	32	3,899	— 130
Cardiff Corporation.....	July 30	2,341	— 211	18	39,278	+ 388
Cavehill.....	Aug. 5	102	— 40	31	2,836	+ 174
Central London Railway ..	„ 13	4,716	+ 414	6	32,442	+ 1,960
Chatham & Dist. Lt. Rys. ..	„ 11	996	— 114	32	26,750	+ 1,014
City & South London Rly...	„ 14	2,990	+ 4	6	18,520	+ 98
City of Birmingham	„ 5	3,190	+ 84	31	88,758	+ 1,930
Colchester Corporation	..	..	..	..	..	..
Cork Electric Trams Co.....	„ 11	555	— 35	42	15,538	+ 1,614
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams ..	„ 5	560	+ 108	31	12,927	+ 1,618
Dover Corporation	..	..	..	..	..	..
Dublin & Lucan Railway ..	„ 12	185	+ 4	6	1,075	+ 28
Dublin United	„ 12	6,082	— 253	6	37,045	+ 37
Dudley-Stourbridge	„ 5	1,524	+ 82	31	24,284	— 617
Dundee Corporation	„ 10	1,173	— 65	§12	15,240	+ 241
East Ham Council	„ 13	1,020	— 29	¶19	20,299	+ 367
Exeter Corporation.....	„ 12	382	— 31	19	6,398	— 683
Gateshead & Dist. Trams ..	„ 5	1,139	+ 65	31	30,490	— 144
Glasgow Corporation	„ 13	18,118	+ 787	11	186,600	+ 10,962
Glossop Trams.....	„ 13	120	— 22	32	3,742	— 231
Gloucester Corpn.....	..	..	..	..	..	..
Gravesend-Northfleet.....	„ 5	340	+ 27	31	6,408	+ 55
Great Northern & City Rly..	„ 13	1,230	+ 55	6	7,732	+ 207
Greenock & Port Glasgow ..	„ 5	727	+ 31	31	19,171	+ 2,621
Hartlepool Tramways	„ 5	429	+ 85	31	7,521	+ 462
Hastings Elec. Trams Co. ..	„ 11	1,712	— 78	6	8,311	+ 75
Hong Kong	„ 13	$8,132	+ $623	6	$52,989	+ $4,616
Huddersfield Corpn.	„ 13	1,826	— 176	19	34,332	+ 1,677
Hull Corporation.....	„ 13	2,671	+ 6	19	52,181	+ 3,020
Ilford District Council.....	„ 13	526	— 7	13	10,521	+ 502
Ilkeston District Council ..	„ 10	129	— 27	19	2,465	— 141
Ipswich Corporation	„ 13	587	+ 33	19	8,688	+ 518
Isle of Thanet Co.	..	..	..	..	..	..
Jarrow	„ 5	188	+ 17	31	3,826	+ 226
Keighley Corporation.....	..	..	..	..	..	..
Kidderminster & District ..	„ 5	336	+ 49	31	3,410	+ 113
Kilmarnock Corporation ..	„ 13	147	+ 5	13	2,094	+ 43
Lanarkshire Trams Co.	„ 11	1,474	— 122	32	44,061	— 3,666
Lancashire United	„ 10	1,377	— 299	32	41,686	— 510
*Leamington	„ 5	303	— 3	31	5,095	— 193
Leeds Corporation	..	..	..	..	..	..
Leicester Corporation.....	„ 13	2,252	+ 43	..	..	..
Leith Corporation	„ 13	702	— 113	13	8,524	+ 128
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	„ 6	12,373	+ 396	31	345,896	+ 13,248
Liverpool Overhead Rly. ..	„ 14	1,573	+ 26	7	10,547	+ 63
Llandudno&ColwynBayRy. ..	„ 12	821	— 19	36	9,236	+ 5
*London County Council	„ 3	45,956	+ 7,569	¶18	757,463	+ 105,969
London Elec. Ry. Co.....	„ 13	10,325	+ 460	6	71,295	+ 770
London United	„ 13	7,111	— 929	32	204,032	+ 9,144
Lowestoft	„ 13	477	+ 27	46	8,144	+ 436
Maidstone Corporation	„ 13	202	— 24	19	3,511	— 219
Manchester Corporation....	„ 13	15,021	— 769	19	300,039	+ 4,522
Mersey Railway	„ 13	1,847	+ 10	6	11,798	+ 149
Merthyr	„ 5	305	— 12	31	6,406	— 21
Metropolitan Dist. Railway..	„ 13	9,040	+ 778	6	62,346	+ 415
Metropolitan Elec. Trams ..	„ 5	9,938	+ 1,694	31	229,257	+ 40,984
Middleton	„ 5	404	+ 40	31	9,774	— 523
Nelson Corporation.....	„ 13	165	+ 2	§19	2,862	+ 77
Newcastle-on-Tyne Corp. ..	„ 13	3,837	+ 23	¶19	77,840	+ 815
Newport (Mon.)	„ 23	710	+ 4	20	13,925	+ 502
Northampton Corporation..	„ 13	517	+ 23	§19	9,772	+ 10
Oldham, Ashton & Hyde ..	„ 5	614	+ 40	31	17,128	— 29
Oldham Corporation	„ 14	1,909	— 89	20	37,948	— 1,102
Perth (N.B.) Corporation ..	„ 10	203	+ 7	§12	2,266	+ 150
Perth (W.A.) Elec. Trams ..	..	..	..	..	..	..
Peterborough	„ 5	181	+ 6	31	3,544	— 44
Portsmouth Corporation ..	„ 13	3,018	— 195	19	41,850	— 2,007
Potteries	„ 5	2,019	— 80	31	54,298	— 577
Preston Corporation	„ 10	80	— 71	19	14,123	— 300
Rotherham Corporation....	„ 11	629	+ 41	19	11,852	+ 433
Rothesay	„ 5	542	— 45	31	6,298	+ 153
Salford Corporation	„ 15	4,826	+ 55	†20	92,525	+ 808
Sheerness	„ 5	100	+ 25	31	1,505	— 15
Sheffield Corporation	„ 14	5,937	+ 418	¶20	121,365	+ 6,966
Singapore Trams.....	„ 13	$10,392	+ $1,263	6	$50,052	+ $4,399
South Metropolitan.....	„ 5	1,226	+ 63	31	25,316	+ 1,279
South Staffs.....	„ 5	1,155	+ 26	31	25,904	+ 87
Southend Corporation	„ 10	1,062	+ 119	19	12,035	+ 1,012
Southport Tramways	„ 5	482	— 16	31	9,030	+ 214
Stalyb'dge,Hyde,&c., Jt.Bd.	„ 13	704	— 188	¶19	14,098	— 1,287
Sunderland Corporation....	„ 14	1,393	— 25	20	23,140	— 458
Sunderland District	„ 10	475	— 77	41	17,489	— 1,361
Swansea Trams	„ 5	1,757	+ 209	31	33,266	+ 3,947
Swindon Corporation	„ 10	175	— 8	19	2,683	+ 119
Taunton	„ 5	59	+ 4	31	1,294	+ 128
Tynemouth and District....	„ 5	727	+ 40	31	7,708	+ 521
Tyneside Trams Co.	„ 10	570	+ 38	6	3,159	+ 244
Wallasey District Council ..	„ 13	1,098	+ 5	§19	18,969	— 113
Walsall Corporation	„ 13	524	— 15	32	17,102	+ 738
Warrington Corporation....	„ 11	382	+ 9	19	7,482	+ 146
West Ham Corporation	..	..	..	..	..	..
Weston-super-Mare	„ 5	647	— 119	31	4,096	..
Wolverhampton Co.	„ 5	632	+ 30	31	13,200	+ 293
Wolverhampton Corpn.	„ 10	1,060	+ 267	19	19,310	+ 2,885
*Worcester	„ 5	502	+ 9	31	8,664	+ 190
Wrexham	„ 5	133	+ 3	31	3,601	+ 18
Yorkshire W.R. Trams	„ 14	1,592	+ 272	33	41,051	..
Yorkshire Woollen District.	„ 5	1,101	+ 122	31	30,389	+ 2,715

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST

Share	Last Dividend	NAME.	Price Wed., Aug. 17	Rate per cent. Yielded.	Dividend Due.	Business Week to Aug. 17. Highest.	Lowest.
		Electricity Supply.		£ s. d.			
10	6/0	†Bournemouth & Poole Elec. Sup. Ord.	8¾ —9¼	5 16 0	Mar, Sep	..	..
10	4/6	†Do. 4½ per Cent. Cum. Pref.....	9 —9⅝	4 12 6	Feb, Aug	..	..
10	6/0	†Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 13 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord. ..	6¾ —7⅛	6 9 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.....	6 13/16 —7 1/16	4 14 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	†Charing Cross (W. End & City) El. Sup. Co.	3⅜ —3⅝	6 5 6	Feb, Aug	..	..
5	2/3	†Do. 4½ per Cent. Pref.	4¼ —4⅜	4 14 0	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	100½ —102½	4 8 0	..	102½	101
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅜ —4⅛	5 9 6	Jan, July	93	..
5	2/6	Chelsea Electric Supply Ord.....	3¾ —4⅛	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	†City of London Electric Lighting Ord.	11¼ —11⅝	6 8 6	Feb, Aug	..	..
10	6/0	† Do. 6 per Cent. Cum. Pref.	11⅛ —12⅛	4 18 0	Jan, July	11⅝	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 —124	4 0 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99½ —102½	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.....	1⅝ —2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾ —3¼	7 14 0	April, Oct	..	..
10	4/0	†County of London Elec. Supply Ord.	7⅛ —7¼	6 7 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½ —11	5 9 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104 —107	4 4 0	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼ —4⅜	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	..	..
St.	4½%	†Do. 4½ 1st Deb. Stock (red)	99 —100	4 10 0	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.....	7 —7⅛	5 9 0	April, Oct	..	..
5	4/0	†Kensington & Knightsbridge Ord.....	6¾ —7⅛	5 6 9	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5¼ —6⅛	4 18 0	Jan, July	..	..
St.	4%	†Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜ —2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	5 1/16 —5 3/16	5 13 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/6	†Metropolitan Electric Sup. Ord.	3⅛ —3⅜	6 14 0	April, Oct	72/6	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	4 —4⅛	5 0 0	Jan, July	85/-	82/6
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	84	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95⅛ —97⅛	4 12 6	June, Dec	..	..
5	1/6	†Newcastle Elec. Supply Ord.....	3⅛ —4⅛	4 14 0	Feb, Aug	..	..
5	5%	†Do. 5 per Cent. non Cum. Pref.	4⅛ —4⅜	5 5 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6⅜ —6⅝	5 2 0	March	..	..
5	5/0	†St. James' & Pall Mall Elec. Ord.....	7⅛ —8⅛	6 1 0	Feb, Aug	..	..
5	3/6	†Do. 7 per Cent. Pref.....	6¼ —7⅛	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1¼ —2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2⅛ —2¼	6 18 0	April	..	..
St.	5%	Do 5 % 1st Mort. Stock (red.).....	99 —102	4 18 0	..	101½	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	7/8 —1	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1⅛ —1 1/8	6 12 0	Feb, Aug	1	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.).....	98 —101	4 9 0	April, Oct	99	98
5	2/6	Urban Electric Supply Ord.	1 —1⅛	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	†Westminster Elec. Sup. Ord.....	7⅛ —8⅛	5 16 0	Mar, Sept	6⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5¼	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	94 —96	4 3 6	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.....	⅛ —7/16	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	11/16 —12/16	6 12 9	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.).....	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	..	..
10	6%	†Bristol Tramways & Carriage Ord.	6½ —6⅝	8 18 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7⅛ —7½	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	½ —1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅝ —3½	..	Feb, Aug	2⅛	..
St.	5%	Do. 5 per Cent. Perpetual Debs.....	86 —90	5 11 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	68 —73	6 3 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	64 —66	4 11 6	Feb, Aug	64⅛	..
St.	4%	Do. 4 per Cent. Pref. Stock	84 —86	4 14 6	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	94 —96	4 4 0	Jan, July	..	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4⅛ —5⅛	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	†City & South London Rly. Con. Ord. ..	27 —28	5 6 0	Feb, Aug	28⅛	..
St.	5%	†Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	†Do. (1896)	102 —104	4 16 0	Feb, Aug	..	..
St.	5%	†Do. (1901)	99 —102	4 18 0	Feb, Aug	101⅛	..
St.	5%	†Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.....	99 —101	3 19 0	May, Nov	100⅜	..
10	6/0	†Dublin United Trams, 6 per Cent. Pref....	12⅛ —13½	4 6 6	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾ —1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8⅛ —8⅞	4 15 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	94 —96	4 4 0	Jan, July	..	..
5	..	Hastings & District Elec. Trams, 6% C. P.	⅞ —1⅛	..	Mar, Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	‡Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3¼ —4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1⅛ —1⅜	4 4 0	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	69 —73	5 17 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9 1/16 —10 1/16	5 18 9	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —86	5 16 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	67 —71	5 12 6	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.....	25/32 —27/32	..	..	..	..
1	..	Do. Deferred	1/8 —¼	..	April	..	..
1	0/6	†Do. 5 per Cent. Cum. Pref.	½ —⅝	5 11 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	95 —99	4 11 0	Jan, July	97½	..
St.	..	Do. 5 per Cent. Db. Stk	94½ —96½	..	..	96	96
St.	1½%	†Metropolitan Railway Consolidated.....	38 —38½	2 18 0	Feb, Aug	38½	38½
St.	2½%	†Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	65½	..
St.	3½%	†Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	..	..
St.	3½%	†Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	84½	..
St.	3½%	†Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	86	84½
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	July	..	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed. Aug. 17	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to Aug. 17. High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*					
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	90 —92	3 15 6	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.....	21 —21½	..	Feb, Aug	21⅞	21½
St.	..	Do. Extension Pref. (5 per Cent.).....	75 —77	..	Feb, Aug	76½	75½
St.	3½%	†Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	70 —72	4 17 0	Feb, Aug	71½	70½
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	75½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	4 0 0	Jan, July	..	..
St.	4%	Do. Guar. Stock 4 per Cent.	84 —87	4 14 0	Mar, Sept	103½	102½
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	140 —142	4 4 6	Jan, July	141½	141
St.	4%	Do. 4 per Cent. Ditto.....	94 —96	4 3 6	Jan, July	95	..
1	4½d.	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅛—¼	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock.	82 —85	5 5 3	May, Nov	82	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—¼	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoup5	39 —41	4 16 0	June, Dec	40½	40
..	5%	Do. 5% Prior Lien Bonds.....	102½—103½	4 16 6	..	..	..
..	4½%	Do. 4½% Bonds with coup. 6	88 —90	3 19 6	..	89½	88
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	98 —100	4 0 0	..	99½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	¼—½	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Anchor Cable Co. 4½ % Deb. Stock	99½ —101½	4 8 6	..	..	..
1	..	Aron Electricity Meter Ord.....	⅜—⅝	..	..	..	..
1	1/9½	Do. 6% Cum. Pf.	⅜—⅝	6 16 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.....	5⅞—6⅛	5 7 0	April, Oct	..	..
1	0/7½	Do Pref.....	1⅞—1⅞	3 16 3	..	7⅛	..
5	6/0	British Insulated & Helsby Cables Ord...	6½—7½	6 18 0	July, Feb	..	..
5	3/0	†Do. 6 per Cent. Pref.....	5½—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	101 —104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	101 —104	4 6 6	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	⅛—⅜	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	99½—101½	5 19 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	61 —63	3 3 6	Jan, July	61	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	23 —27	16 12 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9 —10	7 10 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	4½—5½	4 15 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	100½—102½	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.....	2½—2½	4 19 6	May, Nov	57⅝	53/-
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb. (red.)..	104 —107	4 4 0	Feb. Aug	107	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅛	5 19 0	March ..	..	..
1	0/7½	Consolidated Electrical Co.....	⅛—¼	6 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.....	⅛—⅛	5 12 9	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	⅛—⅛	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	¼—½	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	84 —87	5 15 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅛—1⅛	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	1 —1½	5 7 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	1 —1½	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United (" A " Sh.) (£3 pd.)	⅜—⅝	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅜—⅝	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1¼—1½	..	May, Nov	..	..
St.	4½%	Do 4½ per cent. 1st Mort. Deb. (red.)..	75 —78	5 15 6	Jan, July	76	..
2	..	Electric Construction Co.....	⅛—¼	..	Jan, July	..	..
2	2/9½	†Do. 7 per Cent. Cum. Pref.....	1¼—1½	4 13 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	59 —64	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7⅜—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	12 —12½	5 17 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 5 0	Feb, Aug	5⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105 —107	4 4 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works....	14½—15	6 12 0	Feb, Aug	..	..
10	5/0	Do 5 per Cent. Cum. Pref.	10½—10¾	4 12 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	..	..
1	..	National Elec. Construction Co.	¼—½	..	April ...	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—½	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅜—½	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	76 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance..	33½—35½	3 19 6	Mar, July	..	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	99½—101½	3 18 6	Jan, July	..	..
1	1/0	†Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 5 0	..	41/9	41/2
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅜—1⅝	4 0 0	..	..	..
St	5%	†Do. 5 per Cent. non-Cum. Preferred ..	107 —110	4 12 0	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	..	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	104 —106	4 14 3	..	105	..
10	10%	J. G. White & Co. 6% Cum. Pref.	12½—13½	7 8 0	..	12½	..
1	..	Willans & Robinson Ord.....	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1½—1¾	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅜—3½	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan. July	..	..
St.	15/0	†Anglo-American	6½—6⅝	5 9 0	F,My,Ag,N	..	..
St.	30/0	†Do. Preferred	10⅝—10¾	5 11 0	F,My,Ag,N	10⅞	..
St.	25/0	Do. Deferred	2⅝—2⅝	4 14 0	F,My,Ag,N	2⅝	..
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	84 —86	4 13 0	Jn,Ap,Jy,O	85⅜	84½
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 15 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅛—3½	5 14 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	7⅛—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	99 —101	4 19 0	Jan, July	..	..
20	6/0	†Direct United States Cable xd & bonus ..	14½—15½	6 2 3	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½%Rg.Do.(rd.).	99 —101	4 10 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	132 —135	5 4 0	Ja,My,Jy,O	133½	132½
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	84 —85	4 1 6	Ja,My,Jy,O	85½	84½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	102½—104½	3 17 9	May, Nov	..	..
St.	2/6	Eastern Extension	12½—12¾	5 15 0	Ja, Ap, Jy, O	12⅝	12⅜
100	4%	†Do. 4 per Cent. Deb. Stock	99 —102	3 18 0	Feb, Aug	101	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	100 —102	3 18 0	May, Nov	..	..
10	5/0	G.N (of Copenhagen), with Coupon 80 ..	29½—30½	5 15 0	Jan, July	30½	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	54½	..
100	5%	Mackay Companies Common	84 —88	5 14 0	Ja,Ap,Jy,O	..	..
100	4%	Do. Preference	74 —78	5 2 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜—½	..	April	..	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	96½—98½	4 2 0	June, Dec	..	..
2½	1/3	West Coast of America	1½—1⅝	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.....	96½—98½	4 2 0	Jan, July	..	..
10	..	West India & Panama	⅛—⅜	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9	6 12 6	May, Nov	..	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.....	99½—101½	3 19 3	Jan, July	..	..
10	3/0	Western Telegraph.....	13¾—14½	5 0 0	Mr,Jn,O,D	13⅝	..
	4%	Do. 4 per Cent. Deb. Stock (red.).....	100½—101½	3 19 3	June, Dec	..	..
	4%	Western Union Telegraph. $1,000 4% Bds	105½—106	3 15 3	..	..	..
		Do. $1,000 4½% Edc. & Rl. Est Gd Bnds	101½—102				

Share	Last Dividend	Name	Price Wed., Aug. 17	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to Aug. 17. High-est.	Low-est.
		Telephones.					
100	2$	Amer. Telephn. & Telegh. Cap. St.	138 —141	5 18 0	..	..	..
	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —96	4 5 0	Jan. July	..	..
St.	4%	†Do. 4% Cons. Bonds 1936	103 —105	3 16 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101½—103½	4 19 0	Mar, Sept	..	..
5	5/0	†Chili Telephone	9½—9¾	4 4 3	August ..	..	..
1	0/7½	Monte Video Telephone Ord.....	⅛—⅜	5 9 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅛—⅜	5 13 9	May, Nov	..	..
St.	6%	†National Co. Pref. Stock.....	104 —105½	5 1 0	Feb, Aug	104½	104
St.	6%	Do. Def. Stock	123½—125½	4 16 0	Feb, Aug	124	123½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 8 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 8 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref....	5⅛—5⅜	4 8 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)....	97½—99½	3 10 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	98½—100½	3 19 6	Jan, July	..	..
	4½%	New York Telephone Co. 30 yr. Bnds....	98½—99½	4 12 0	..	99½	98½
1	1/0	Oriental	1⅛—1⅛	4 15 0	April, Oct	..	..
1	0/7½	Do 6 per Cent. Cum. Pref.	1⅛—1⅛	4 11 6	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock.....	86 —88	4 11 0	Jan, July	87½	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	98 —100	4 10 0	Jan, July	..	..
5	5/0	†United River Plate Ord. ex rights	6⅞—7⅛	5 12 3	July	7⅛	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 14 9	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.....	101½—103½	4 7 0	Jan. July	103	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2⅜—3⅛	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10¼—10½	5 8 3	Sp,DcMrJu	10½	10⅛
10	3/0	Do. 6 per Cent. Pref.	13 —13½	4 9 0	Sp,DcMrJu	..	..
10	6%	Submarine Cables Trust (Cert.)	129 —132	4 12 0	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅜	5 10 0	April, Oct	91/3	90/7½
		Do. 5% Cum. 2nd Pref.....	4⅛—4⅜	5 14 0	Jan, July	85/7½	..
		Do 4% Deb. Stock	90 —91½	4 7 6	June, Dec	91½	91
		Do. 4½% Deb. Stock	93½—96½	4 13 6	..	95⅝	94½
St.	4%	Auckland Elec. Trams. 5% Deb. (red.)....	103 —105	4 15 3	Jan, July	..	..
		Brisbane Electric Trams. Invest. Ord	6 —6½	6 0 0	May	..	..
		Do. 5 per Cent. Cum. Pref.	4⅛—5¼	4 15 0	May, Nov	..	..
		Do. 4½ per Cent. Db. Prov. Certs.....	99 —102	4 8 6	Jan, July	..	..
St.	4%	British Columbia El.. Rly. Df. Ord.	144 —148	5 10 6	Mar, Sept	..	..
St.	8%	†Do. Pref. Ord. Stock xd & bonus	124 —128	4 13 9	May, Nov	111	..
St.	£3	Do. 5% Cum. Perp. Pref. Stock.....	109 —112	4 10 3	Jan, July	..	..
St.	5%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
	4½%	Do. 4½% Perp. Con. Deb. St.	104 —106	4 1 0	..	104½	104½
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db.	99 —102	4 18 0	Mar, Sept	97½	..
St.	5%	†Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	..	..
St.	6%	Calcutta Tramways (1 to 137,610).....	4 —4½	5 0 0	Mar, Sept	..	..
		Do. 5 per Cent. Cum. Pref.	4⅛—4⅜	5 2 9	Jan, July	97/6	..
		Do. 4½% 1st Deb. Stock (red).....	96 —99	4 11 0	Jan, July	..	..
		Cape Electric Tram Shares	¼—½	..	..	..	..
St.	5%	†City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 6 0	F,My,A,N	..	..
		Do 4 per Cent. Deb. Stock.....	98 —101	4 0 0	June, Dec	99½	..
		Colombo Tr. & Ltg. 5% 1st Mt. Db.....	96 —99	5 1 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	97 —100	5 5 0	Feb, Aug	..	..
		Kalgoorlie Elec. Trams Sh.	⅜—½	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock.....	92 —95	5 5 0	Jan, July	..	..
100	5%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	†Lisbon Elec. Trams. Ord.	1⅛—1⅛	4 8 0	July	1⅞	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	4 16 0	Jan, July	23/c	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	97½—101½	4 18 6	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	87	..
100	5%	Manaos Trams and Lt. Co. 5% Debs	87 —83½	5 13 0	..	..	..
100	$12½	Manila Elec. Ry. $1,000 Gold Bonds.....	98 —100	5 2 0	Feb, Aug	121	..
100	5%	Mexico Trams Co. Com. St.	119 —121	5 16 0	..	..	..
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	99 —100	5 3 0	..	99½	99½
		Do. 6% 50 yr. Mort. Bds.....	98 —99	6 5 0	..	93½	98
		†Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	100 —102	4 8 0	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 3	..	103½	103½
		Perth Elec. Trams Ord.	⅜—½	5 15 5	May	..	..
		Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	..	..
5	5%	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅜—5⅞	5 2 6	..	5⅛	5⅛
		Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	101½	101
		Rio Janeiro Tram, Lt. & P. Co.....	93 —95	4 12 6	..	94½	92½
100	$1½	Do. 30 yr. Gold Bnds.	98 —99	5 4 0	..	95½	98
100	5%	Do. 50 yr. Mt. Bnds	89 —90	5 14 0	..	89½	89½
	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	143 —145	7 1 6	..	144½	143
500	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102½	101½
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	101 —103	4 7 6	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5⅛—5⅜	5 2 0	Mar, Sept	..	..
10	6/0	†Bombay E.S. & T. 6% Cm. Pf.....	10½—11	5 11 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red).....	93 —95	4 15 0	Jan, July	..	..
	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock..	97 —99	5 1 0	..	..	..
1	$2½	Calcutta Elec. Supply Ord.	⅝—⅞	6 6 0	April, Oct	105½	..
100	7/2½	Canadian Gen. Elec. Co. Com. St.....	104 —108	6 14 0	..	..	..
100	$3½	Do. 7% Cm. Pf. Stock	122 —125	5 12 0	..	..	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
		Elect. Development Co. of Ontario.....	85 —88	5 12 6	..	89½	..
500	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
St.	5%	Indian Elec. Sup. & Trac. Co.	1½—1¾	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅛—¼	8 0 0	April, Oct	..	..
100	$1	Kaministiquia Power Co.5% Gold Bnds..	100½—102½	5 0 6	..	131½	..
5	3/0	Madras E. S. Corp. Ord.....	2½—3	..	..	..	..
5	3/0	Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
500	5%	Do. 5% 1st Mortg. Deb. Stock.....	90½—92½	5 9 0	..	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	85 —86	5 16 0	..	85½	84½
100	$1	Mexican Lt. & Power Co. Com. St.	78 —80	5 4 0	..	79½	79
St.	$3½	Do. 7% Cum. Pref. St.	103 —105	6 17 0	..	104½	103½
500	5%	†Do. 5% 1st Mort. Gold Bnds.	93 —94	5 5 0	..	94	..
100	$1½	†Montreal Lt. Ht. & Power Co. Cap. St.	132 —138	5 5 0	F,My,A,N	135½	135½
St.	£9	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	2/6	..
St.	6%	Do. 6 per Cent. non-Cum. Pref. Stk. ..	105 —115	5 5 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
5	3/0	Rosario Ele . Co. Ord.	8½—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
100	$1	Do 2nd Pref.	8½—8¾	6 14 6	..	..	..
		Shawinigan Water& Power Co.Ca	99 —101	4 4 0	..	..	..
		Do. 5 per Cent. Bds.	105 —108	4 12 6	Jan, July	..	..
		Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	102½	..
		Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	..	..
		Victoria Falls Power Co. Pref.(1 to 808,000)	⅛—¼	5 6 6	Jan, July	..	..
		Do. (808,081 to 1,200,000)	⅛—⅜				

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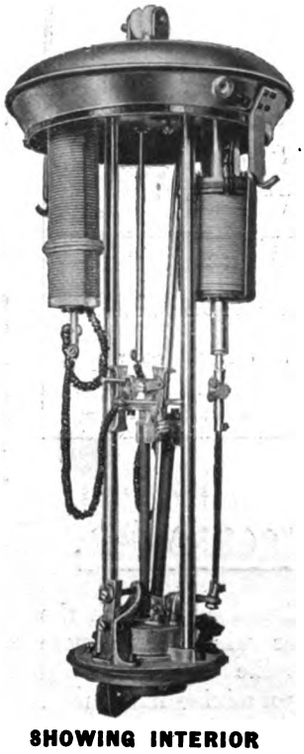

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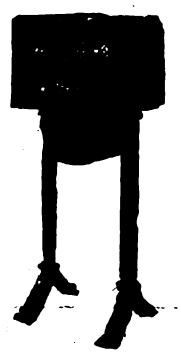

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Helsby Mining Accessories.

THERE is no doubt that a direction in which the application of electric power will become more and more extended, and at the same time will increase in usefulness, is in the driving of mining machinery. The strides that have been made, even during the past 12 months, in the installation of electrical machinery in mines are very great, all of which goes to show that the undoubted advantages of this class of apparatus for underground working are fully appreciated.

It may be taken for granted that the be-all and end-all of electrical working in a mine is the motor. But, in order that this may operate successfully, it is necessary that the transmission lines should be well designed, and that the intermediate apparatus, such as switches, controllers and fuses; should be capable of doing their work. This part of the scheme has been taken in hand by the British Insulated & Helsby Cables with the result that they have designed a series of excellent mining accessories.

It is only natural, before electrical working can be adopted in a mine, that supply cables must be run down the shaft. This is an operation of some difficulty not to say danger, and to minimise the attendant risks the Helsby Co. have designed the hand-driven cable winch shown in Fig. 2. The driving gear consists of a machine-cut worm and wheel and a machine-moulded spur and pinion; the worm gear prevents any possibility of the drum "running wild," and a special brake gear is therefore unnecessary. The purchase can be modified to cover a wide range of load. Current is conveyed to the cable by means of a special slip-ring collector gear enclosed in a ventilated weather-proof case. The stands are of strong construction, well stayed and bolted together, and the drums can be supplied in deal, oak, or wrought steel.

Attention may next be called to a range of three-phase joint boxes designed to meet all ordinary colliery and mining requirements. In the design and manufacture of all types of joint boxes the Helsby Co. claim they have an unrivalled

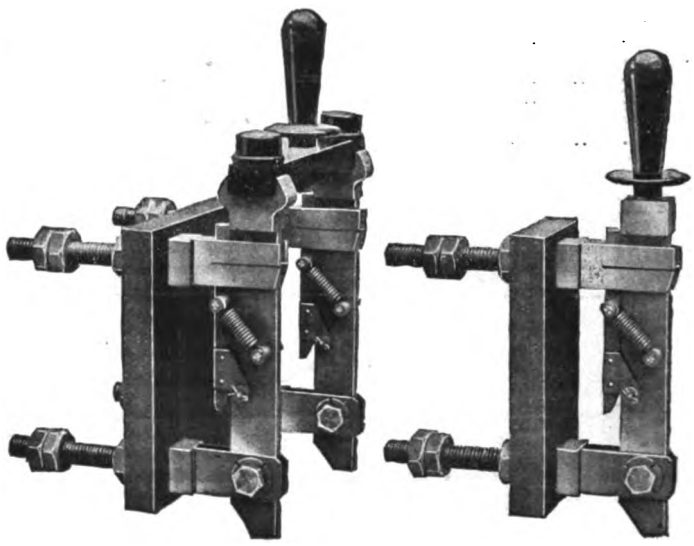

Fig. 1.—Helsby Mining Switches.

experience extending over 20 years; and although these special boxes are designed for colliery work and to meet the Home Office Regulations they are equally suitable for general use. The cast-iron boxes are gas and water-tight, and are of heavy construction to withstand rough usage. Practically all the boxes can be supplied with either a single or double bond. The single bond is intended for

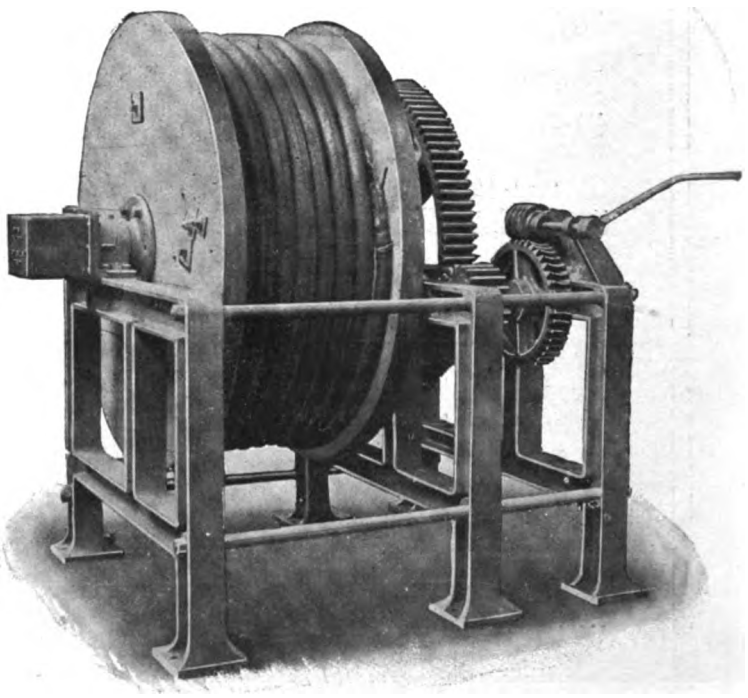

Fig. 2.—Hand Driven Cable Winch.

use with wire-armoured bitumen cables, where it is only necessary to provide a secure attachment for the armouring wires. This type can also be used with lead-covered and wire-armoured cables, and in such instances a special copper clamp is provided for bonding the lead sheathing to the cast-iron box. The double bond is, however, recom-

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mended for lead-covered cables as it affords a secure anchoring for the armouring wires and positively earths the lead sheathing to the cast-iron box. The cable fittings are made

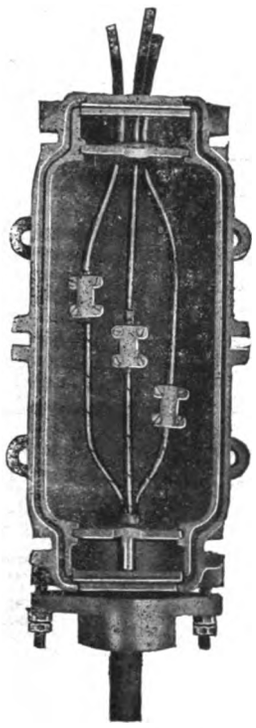

Fig. 3.—Straight Through Non-Disconnecting Box.

of copper and are of sufficient section to carry the maximum current continuously without undue heating. In all the boxes the conductors are secured to the various terminals by mechanical joints, but for non-fiery mines boxes with sweating fittings can be supplied if specified. The non-disconnecting boxes, except terminal boxes, are provided with spreaders to keep the conductors and fittings well apart; in disconnecting boxes the terminals are securely

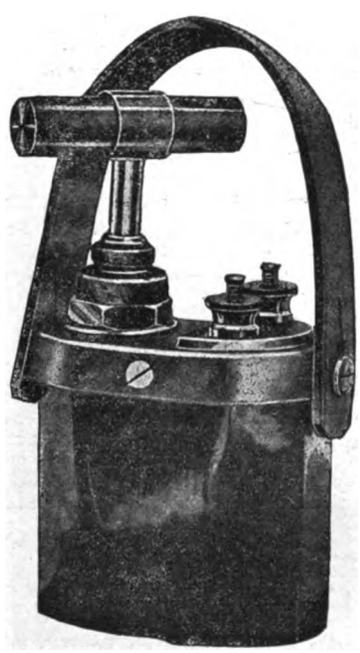

Fig. 4.—Helsby Pocket Magneto Exploder.

fixed to insulating bases, and fittings of different polarity are separated from one another and from the cast-iron box by insulating partitions. All non-disconnecting boxes should be fitted in solid with compound, care being taken that the subsequent shrinkage of the compound is made good by further pouring. Disconnecting boxes should be filled in with compound to just underneath the disconnecting terminals. To prevent sparking when making or breaking a connection, these boxes can be filled with oil above the level of the compound. Fig. 3 shows an example of straight-through non-disconnecting joint box, made in accordance with the above condition. Our illustration shows the box with the cover removed. The box is intended for use with standard size of three-core wire-armoured three-core cables, connected to the three single insulated cables. It is designed to be employed on pressures up to 3,000 volts. Fig. 5 shows a three-way disconnecting joint box for three-wire armoured cables. Two examples of Helsby switches

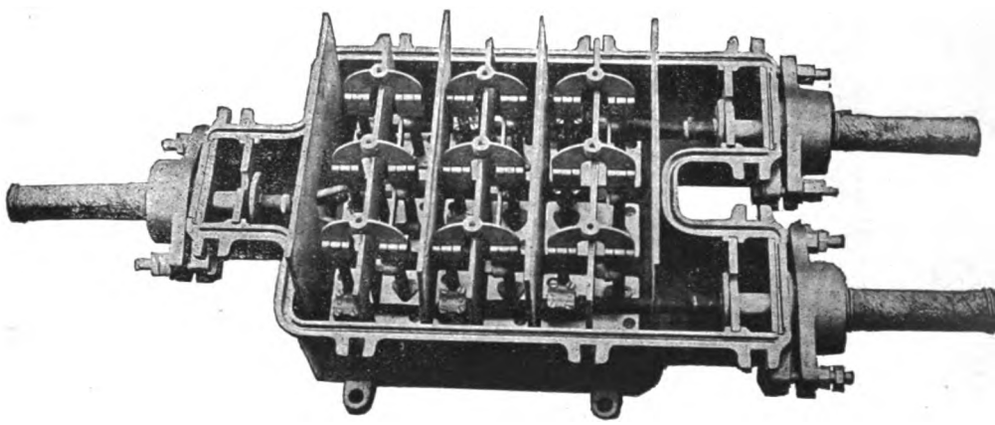

Fig. 5.—Three-Way Disconnecting Box.

for this class of work are given in Fig. 1. They are fitted with a long break and positive action, all parts of the switch carrying current being made of high conductivity

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copper of ample section. The blades of the double and triple-pole switches are connected to a polished ebonite cross bar. These switches are made in several sizes up to a maximum capacity of 1,000 amperes.

In cases where several mines are fed from one power station it is becoming usual to employ overhead lines for the transmission of power. An insulator, known as the Sinclair-Aitken No. 1 leading-in insulator. is employed by the Helsby Co. It has been designed for dealing with the difficult problem of preventing leakage at points where underground cable wires are connected to open wires, or where open wires are led into buildings by means of covered wire. The inner shed, which is provided with a groove and a coarse screw thread on the outer surface, is first screwed on to the bolt and then the rubber-covered leading-in wire is laid in the groove, the outer shed being screwed on to the inner one so as to clamp the rubber covered wire in position as shown. One end of the covered wire is soldered to the line wire, the other end being connected to the underground cable or led into the building, care being taken to prevent the covered wire touching the lips of the porcelain sheds. The Sinclair-Aitken insulator is, it is claimed, not only thoroughly effective in maintaining insulation, but it has the advantage that it can be fitted and the necessary connections made by any ordinary lineman in a remarkably short time.

Fig. 4 shows a useful type of instrument known as the Helsby magneto pocket exploder. It is claimed that this type is highly efficient, and will fire two shots in series simultaneously. Further, it is compact, and is fitted with a leather carrying strap and a detachable handle. The handle is gripped in the palm of the right hand, with the stem between the fingers. The exploder is held by the left hand, and when the wires have been attached to the terminals, the action of sharply rotating the handle half a turn fires the shots. There is no key to press.

Fortiter Three-Phase Motor Starters.

IN these days of high-tension power transmission on the three-phase system it is not surprising to find that the line of least resistance is being taken, and that three-phase motors are being extensively employed. The starters for these motors require special thought and care in their design and manufacture, while at the same time they must conform to those safety conditions which are becoming more and more to be recognised as necessary in industrial electrical work. The Union Electric Co. have paid great attention to all these points.

The starters designed by them are generally intended for motors having the rotor windings connected to slip-rings. In the operation of starting, a resistance is inserted between these rings, and as the revolution rate of the motor increases this resistance is gradually cut out and the rings short-circuited. No arrangements are usually made on the standard starters for making and breaking the stator circuit, therefore it is necessary to provide in each case a switch for this purpose. The resistances are normally rated to start the motor with full load, and cannot be used for speed regulation unless specially designed for this condition. The rotor pressure—that is to say, the pressure between two slip-rings at starting—must be accurately known, so that the resistance may be correctly rated. If this information is not obtainable, the following values are assumed: With motors up to 3½ H.P. the rotor pressure will be 80 volts; up to 10 H.P., 100 volts; up to 15 H.P., 150 volts; up to 20 H.P., 200 volts.

A type of three-phase starters with the contacts and resistances under oil, and which has been specially designed for

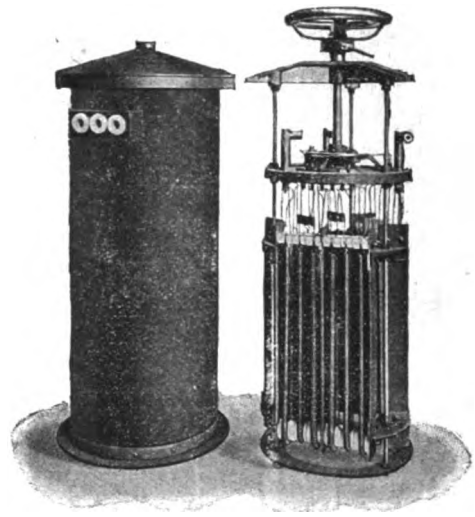

Fig. 1.—Oil Immersed "Fortiter" Starter.

use in mines, is shown in Fig. 1. These starters are enclosed within vertical cylindrical casings of sheet steel, the contacts being arranged upon slate or marble bases fixed in the upper portion of these cases and above the oil-immersed resistances. The terminals are fitted upon these bases, and the connecting cables are brought in through porcelain bushes. Access to the contacts can be obtained only after the metal covers of the cases have been removed. As with

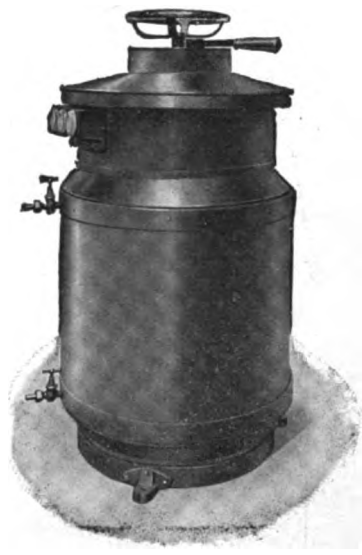

Fig. 2.—Oil Immersed and Water Cooled "Fortiter" Starter.

the smaller patterns, the starters are operated by nickel-plated hand wheels. Starters with oil-immersed resistances will carry large overload currents for short periods. In cases where the motor has been started several times in succession with short intervals of rest, it is necessary to allow sufficient time for the oil to cool down, otherwise it will reach boiling point. The resistances are rated to start

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the motor under full load torque. These starters are made in 15 standards sizes, varying in capacity from 6 H.P. to 250 H.P.

Another type of starter which is intended for use where the starting conditions are extremely severe is shown in Fig. 2. The resistance is oil cooled, as before, but the starter is also fitted with a water jacket, through which circulating

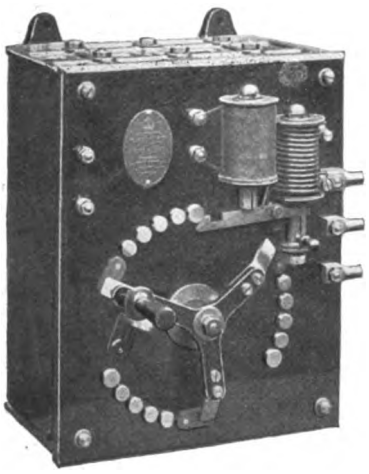

Fig. 3.—Standard Three-Phase Starter.

water can be passed. Where motors are connected to high-tension circuits suitable interlocking gear between the starters and the stator oil-break switches can be arranged.

A rather different starting equipment for use in places where protection against the surrounding atmosphere is not necessary is shown in Fig. 3. These starters are of the plain open type with black enamelled slate fronts, and starting resistance capable of passing approximately full load current on the first contact, and of carrying 50 per cent. overload for one minute or 100 per cent. for 30 seconds. They can be used in connection with any alternating-current motor having standard values of slip. They are fitted with both overload and no-volt releases, the former being placed

Fig. 4.—"Fortiter" Liquid Starter.

in the rotor circuit, which is broken on all three phases. No provision is, however, made for breaking the stator circuit, and a separate switch must be used for this purpose. The "no-volt" release acts, it is claimed, as a most efficient interlocking arrangement between the main switch and the starter, as it operates and places the starter in the "off" position directly the switch is opened.

An example of a liquid starter made by the Union Electric Co. is shown in Fig. 4. For continuous-current motors the starters are provided with two, and for two or three-phase motors with three, cast-iron tanks mounted upon a substantial cast-iron framework, and supported upon porcelain insulators. Iron plates are gradually lowered into these tanks by means of suitable worm gear, which is operated by a hand wheel. In the operation of starting the motor it is impossible in lowering these plates to exceed a certain rate. Contacts are arranged to connect metallically each plate

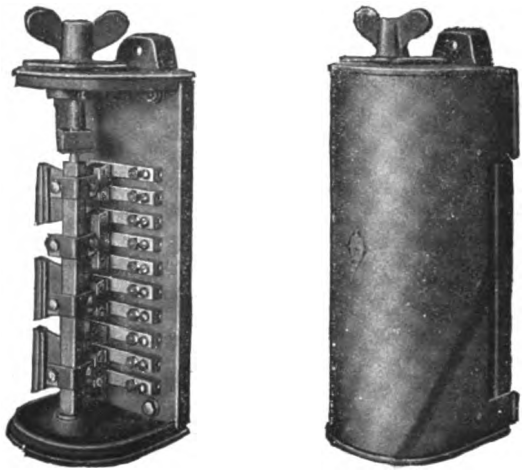

Fig. 5.—Star-Mesh Switch for Machines with Short-Circuited Rotors.

with its respective tank when the lowest or full on position is reached. The starters are designed for starting only, and not for speed regulation. The tanks should be partly filled with a solution of soda or sal ammoniac in water.

For starting such motors as have short-circuited rotors the star-mesh switch shown in Fig. 5 is used. These switches are of simple and durable construction, and suited to severe working conditions; the contacts are arranged with quick make and break to minimise sparking and consequent damage to the current-carrying parts. A ratchet device is provided to prevent the controller shaft being operated in the wrong direction. With the switches in the "off" position the motors are completely isolated from the circuits. The switches are supplied in two sizes, the larger for motors up to 20 H.P. and the smaller for motors up to 10 H.P.

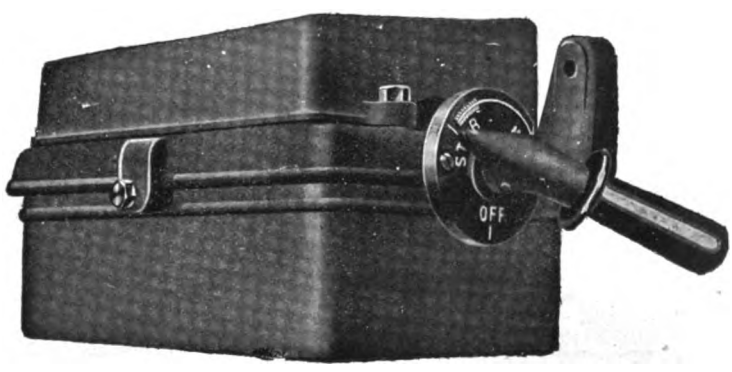

Fig. 6.—Oil Cooled Drum Starter.

Fig. 6 shows an oil-cooled starter of the drum type which can be employed with motors with short-circuited rotors.

The above description is sufficient to show that the Union Electric Co. have paid special attention to the design of starting regulating apparatus for three-phase motors. It is desirable indeed that much care should be taken in this respect for this class of motors is now being widely used in explosive places like mines, so that protection of the current carrying parts from the surrounding atmosphere is a necessity.

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ISSUED MONTHLY with "THE ELECTRICIAN"
Telegraphic Address "ELECTRICIAN NEWSPAPER LONDON" Telephone No. 949 HOLBORN.

All communications should be addressed to the Editor, "The Electrician" Industrial Supplement, 1, 2 and 3, Salisbury Court, Fleet Street, London, E.C.

Copy for Text or Advertisement pages for next issue, publishing on **September 16th, 1910,** *should reach the above address by Tuesday,* **September 6th 1910.**

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

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The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

The Proper Driving of Machine Tools.

There is no doubt that the proper driving of machine tools is a subject to which more attention might be paid than is at present the case. In the days when it was usual to drive one, or even more, shops by means of a single central engine a proper supervision of the power demanded was difficult, while to determine the actual amount of energy wasted in the various belts and shafting was an intricate matter. Now that the employment of the electric motor has become general, these measurements are much easier, and, owing to the subdivisions thus obtained, it is quite possible to keep a close watch on the energy consumed by the tool, and thus to nip in the bud any cause of waste that may arise. The size of motor required to drive any particular machine is too often determined in a wholly empirical manner, or from the data of past experience. While the latter of these may in nine cases out of ten give quite accurate results, yet it may happen that local conditions to some extent vitiate former conclusions and lead to mistakes being made. It is only possible to rectify such mistakes by a close inspection of the machine during operation, by taking readings of the energy consumed and thus discovering whether the tools are really working under the most economical conditions.

The results of this type of ordered inspection will be found on another page of this issue. As might be expected, they emanate from America, and while it appears that sometimes the margin of power allowed in the first instance was too large, and in others it was a minus quantity, yet in a third class there does not seem always to have been good reason why any change should have been made.

Taking the results in detail, the first is rather a glaring case, a 30 H.P. motor being replaced by a 7·5 H.P. motor. In this instance the original designers were evidently of the opinion that all the three machines would be working at full load simultaneously. This is certainly not (as it is, in fact, very seldom) the case, and the large motor has been replaced by one of only one-quarter its output. In this connection it is well to note that about one-third of the output of the new motor is taken up by driving the line shafting and in overcoming the friction of the machinery when running light. The length of shafting in this case is evidently short, but the results obtained are enough to show what great economies have been effected by the use of the divisible electric drive.

The second case is of the same *genus* as the first, but in the third, one may perhaps be permitted to wonder why it was necessary to substitute alternating-current motors for continuous-current motors of the same output. This change would certainly be viewed with disgust by some eminent engineers, and it rather seems that the change was made for the sake of changing, or perhaps with a view to obtaining certain advantages of a somewhat visionary nature. The fourth case is of the reverse kind, the motor which was replaced being overload to a small extent, but evidently sufficiently to vitiate its usefulness and make a change an economical necessity.

We need not go in detail through the remainder of the cases, for the figures are sufficient to show that the designers sometimes overshot the mark in one direction and sometimes in the other. Some of the variations are of the kind that might easily have arisen in the course of working. As the machines settle down to the work or wear their power requirements alter, while a modification in the work they have been doing would certainly be sufficient to cause the small variation in the power taken noted in some of the above instances.

The results given of this investigation tend to show that money may be saved by keeping a close watch on the energy consumed by each machine. If the power plant has been well designed in the first instance, the alterations should not need to be very severe; but there may be isolated cases where a serious slip has been made, and where a drastic change becomes necessary. This "craze for measurement" marks a step forward in workshop practice and is to be commended.

Rates and the Metal Filament Lamp.

It will be remembered that, when some three years ago the metal filament lamp was beginning to make its influence felt on the loads of electricity supply stations, certain engineers suggested that an increase in price would be necessary in order that they might preserve the soundness of their financial condition. Wiser counsels have, however, prevented this rash act, and, as far as we know, there is not a single instance of the prices for electrical energy having been raised from this cause. It does not, however, follow that the present rates are in every way the best for dealing with the new situation, and, as is well known, various attempts have been made to formulate a system of charging which shall be simple, intelligible and equitable—not at all an easy matter.

One suggestion after another has been made, among the latest being one due to Mr. S. Bingham Hood, which he brought forward at a recent meeting of the Canadian Elec-

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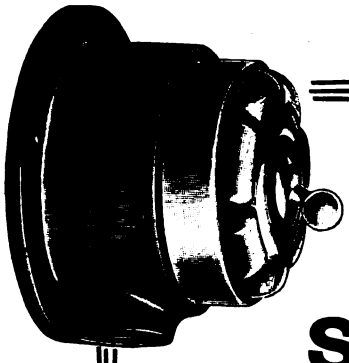

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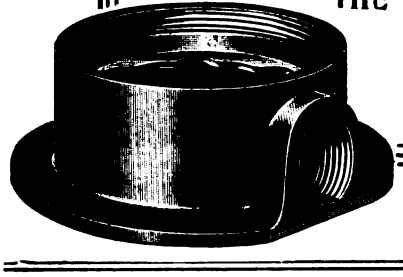

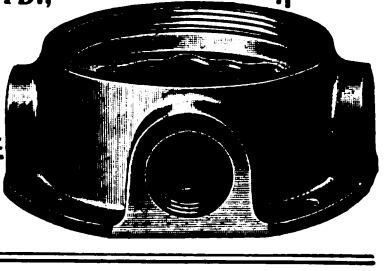

trical Association. The system he evolves is of the differential type, and consists of three parts: A "readiness to serve" charge, a consumers' charge and a meter charge. The first of these is obtained by dividing the sum of all annual fixed and operating charges which vary with the size of the plant by the total kilowatt capacity of the generating equipment. The consumers' charge includes all those expenses which vary directly with the number of consumers connected to the system. The total of these expenses divided by the number of consumers connected to the system will give the charge, which is made to every consumer irrespective of his demand or the character of his load. The kilowatt-hour charge covers all expenses which vary directly with the kilowatt-hour output of the system. For residence lighting the demand of the consumer is arrived at by considering the floor space lighted, only that portion of the room requiring light being taken into account.

Looking at these suggestions from the English point of view, though it may be admitted that this system is equitable, it cannot be called simple, neither is it at once intelligble. It only goes to show how difficult it is to bring into the rate charged the consumer every item which goes to make up the production costs. The case is so different from that of the ordinary commodity. It is then generally easy to trace each item of cost from the producer to consumer, and to allow each such item its proper influence in the determination of the selling price. But this is not the case with the sale of "electricity."

The question then arises: Which system are we to follow? Are we to postulate that the true price "of anything is just as much as it will bring," and to charge as much, or as little, as we can get, or are we to work out laboriously the true proportion of the total cost to be borne by each consumer, and thus evolve a truly scientific rate?

If we adopt the first method we are commercial, but not scientific; while, on the other hand, the intricacies of the scientific, but complicated, system will certainly not be intelligble to the majority of consumers. On the whole, we are inclined to believe that the best way at present is to stick to unscientific methods until we have had time to educate both the public and the Board of Trade. The latter would be certain to raise objections, for it expects that consumers of the same class to be charged on the same scale, and it would be difficult to persuade them that two householders, possessing the same number of lights, but having a different area of floor space lighted, should be charged in two separate ways. While the two householders themselves might also mutually bicker.

In our opinion, then, a system of charging consisting of a fixed charge per annum, based on the consumer's maximum demand together with a charge per unit consumed, could be arranged to cover all the various items of cost met with in central station work, while at the same time the system is easily intelligible, and the variations between two almost similar consumers would not be great enough to cause any trouble.

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Elliott's Instruments.

A FIRM which is well known and justly celebrated for the manufacture of instruments of all kinds is Messrs. Elliott Bros., of Lewisham. Several catalogues recently issued by this firm sufficiently well indicate their catholicity in this connection, for they include descriptions of ordinary electrical instruments of potential and current transformers, of photometers, station keepers, accelerometers, galvanometers, and distance recorders. Details of some of the equipment mentioned in this list will doubtless be of interest.

Fig. 1 shows a voltmeter of Messrs. Elliott's well-known moving-coil type, whose operation, it is claimed, is both dead beat and accurate. The pivots and jewels are carefully selected, and the springs and magnets are well aged to secure permanence of calibration. They are contained in neat japanned iron cases, and meet the demand for an instrument of moderate price yet possessing the high-class workmanship of the better form of instruments. They are made for back connections only, and are extremely useful for motor circuits, small switchboards and anywhere where space is a consideration. Every instrument is carefully checked before being sent out.

Fig. 1.—Elliott's Moving Coil Instrument.

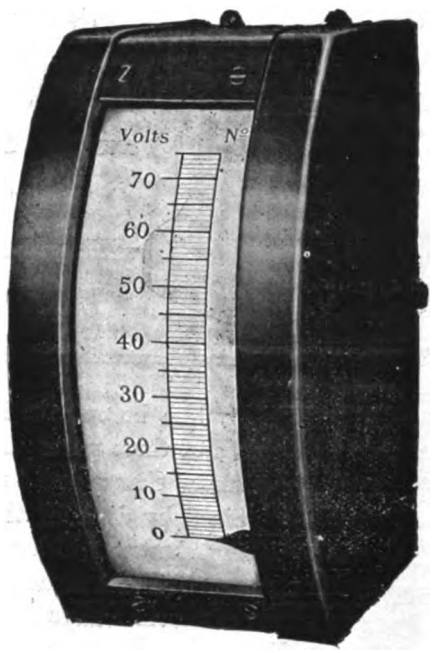

Fig. 2.—Sector Voltmeter.

Another type of moving-coil instrument of the edgewise shaped pattern is shown in Fig. 2. These have been placed on the market with a view to meeting the demand for reliable instruments at low prices, as far as is consistent with sound mechanical and electrical principles. They are contained in neat japanned iron cases without nickel facings, and are arranged either for back or front connections. The movements are on Elliott's well-known moving-coil system, dead beat and accurately balanced. The springs, pivots and jewels are carefully selected, and the magnets well aged and tested to ensure permanence of calibration. Each instrument is checked against standards, and no instrument is allowed to pass unless it satisfies the requisite degree of accuracy. Each instrument carries with it a guarantee for one year in respect of material and workmanship, and Messrs. Elliott undertake to check the calibration against their standards at any time for a period of three years from date of purchase, provided the customer pays carriage both ways.

An interesting type of portable potential transformer is shown in Fig. 3. The current transformers are of the taped coil pattern, and are mounted in teak carrying cases. They are suitable for working a maximum of two recording and three indicating instruments. The secondary or instrument terminals are provided with a short-circuiting switch, which enables the instrument to be disconnected while current is still passing through the primary winding, and prevents any risk of damage to the transformer itself by so doing. For voltages above 750 volts the transformer boxes are provided with ebonite feet, and although this is sufficient insulation in the great majority of cases, Messrs. Elliott advise that the transformers be placed upon an insulating stand or mat as an additional precaution. As in the case of the switchboard pattern current transformers, the secondary or instrument winding is the highly insulated one. Generally speaking, for currents of 400 amperes and upwards, the primary winding consists of a copper bar, but for multiple range current transformers and transformers for special requirements this is not always the case. When one instrument is to be used with several current transformers in turn, it is advisable to use a special change-over instrument switch.

The potential transformers are of the core type with thoroughly laminated iron circuits and imbricated joints. They are mounted on teak bases in teak carrying frames, the high-tension terminals being placed on the transformer base and protected by the carrying frame. The windings are of the taped pattern, and the standard secondary voltage is 100. These transformers are wound in two styles, for frequencies of 50 and 25 respectively. The 50 cycle transformers are suitable for all frequencies from 40 to 100 periods. From 39 to 23 periods the 25 cycle transformers must be used.

Another interesting instrument, which we show in Fig. 4, is the Harrison universal photometer. This instrument can be used to measure the illumination from, or candle-power, of a lamp of any nature in a test room, ordinary room or in the street. It should not be used to calibrate standard lamps, for the reason that the instrument itself depends for operation on the sub-standard lamp it contains. For practical purposes, in the hands of an intelligent operator, it can be relied upon to measure within 5 per cent. the illumination derived from, or candle-power, of any lamp.

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The chief novelty of the instrument is the embodiment of a flicker disc, rotated by a blast of air under the control of the operator. This enables the instrument to measure lamps of all types of which the spectrum varies considerably, at the same time providing a light, portable and inexpensive instrument, equal in efficiency to the clumsy and expensive apparatus so far available for the purpose. The instrument is provided with a small milled head screw (painted white), accessible by opening the large side door of the photometer. By carefully turning this the flicker disc may be clamped so that one of the rotating sectors occupies half the field of view of the eye-piece, the other half of the field of view is occupied by the adjustable screen. In making a measurement by the direct comparison method, the adjustable screen is moved by means of the pointer on the left side of the case till the illumination throughout the field of view of the eye-piece is uniform. The illumination can now be read directly on the scale against the tip of the pointer. The attachment for measurement of total horizontal illumination consists of a horizontal screen of white paper having specially prepared surface, with a hole through the centre. This screen is covered with a cap provided with a bayonet joint, and when removed the white horizontal screen is exposed. With the cap in position, the arrangement forms the eye-piece of the flicker head. As before, the direct comparison of illumination is obtained against that of the adjustable screen. The instrument is arranged for two-standard

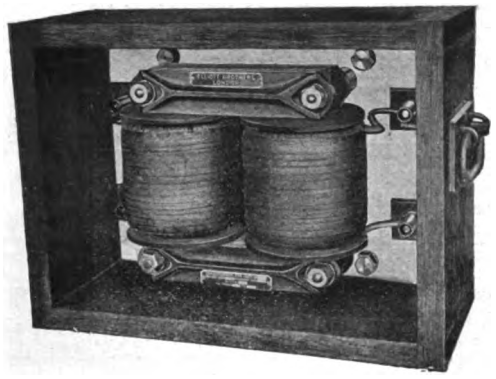

Fig. 3.—Current Transformer.

illuminations, giving two ranges, corresponding to the two scales on the instrument. Either range may be used at will by means of the two-way plug switch.

The stock instrument has scales of 0 to 0·5 and 0 to 5 candle-ft. The double range that this instrument possesses is found to be a great advantage, as it allows of measurements of illumination to be made under practically every condition. The instrument is, it is claimed, suitable not only for ascertaining the illumination due to high-power lamps in the streets and large spaces, but also when erected in offices, showrooms, &c. Moreover, it has been found that many operators can use the instrument more accurately when the screens are highly illuminated than when they are poorly illuminated, as is generally the case when making measurements at the usual distance from a street post. Thus, with a lamp giving from 50 c.p. to 100 c.p., the photometer can be erected at any convenient distance from about 40 ft. down to 4½ ft. from the lamp. Measurements at any distance from 40 ft. to 15 ft. being made with the low candle-power standard, and from 15 ft. to 4½ ft. with the high candle-power standard. Measurements can also be made consecutively with each standard to check results. The instrument is provided with a self-contained accumulator battery of two cells. This should be kept fully charged, but before taking measurements the standard lamp should be connected for about 10 minutes in order to obtain a constant potential. It is advisable to slide the battery, &c., from the case when charging, care being taken to keep the sector disc clean.

To make a measurement, the instrument is set up with the opening, with the sector disc exposed and pointing directly towards the light, so that the light falls at right angles on to the sector disc. The distance of the lamp from the disc can be measured by the knob on the side of the instrument placed there for the purpose. The sector disc can be rotated by means of the air-pressure bulb provided, and the standard lamp having been lit by inserting the plug through the hole in the side of the case, the pointer is moved until a position is found when the operator, looking through the eye-piece, can see no flicker. The pointer then indicates the illumination in candle-feet at that distance from the light, and at the angle of incidence shown by the clinometer.

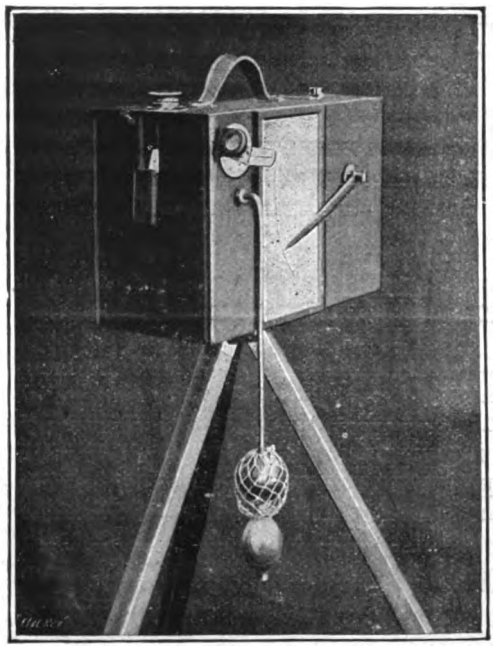

Fig. 4.—Harrison Photometer.

The Forbes distance recorder and Elphinstone speed indicator for ships is a useful instrument by which, it is claimed, the correct registration of the distance travelled by a ship can be obtained, while the actual speed in knots is indicated. The apparatus fixed in the ship consists of a sea cock or valve fitted in the bottom, preferably about one-third of the length of the ship from the bows. Through this sea cock can protrude, when indications are required, a manganese bronze tube having an opening facing forward for the admission of water as the tube is carried forward by the ship, and another opening facing aft to allow the water to escape. Between these two openings is a propeller operating the transmitting mechanism, so designed as to make a certain definite number of revolutions while the ship travels one mile. The whole of the tube which protrudes through the ship's bottom can,

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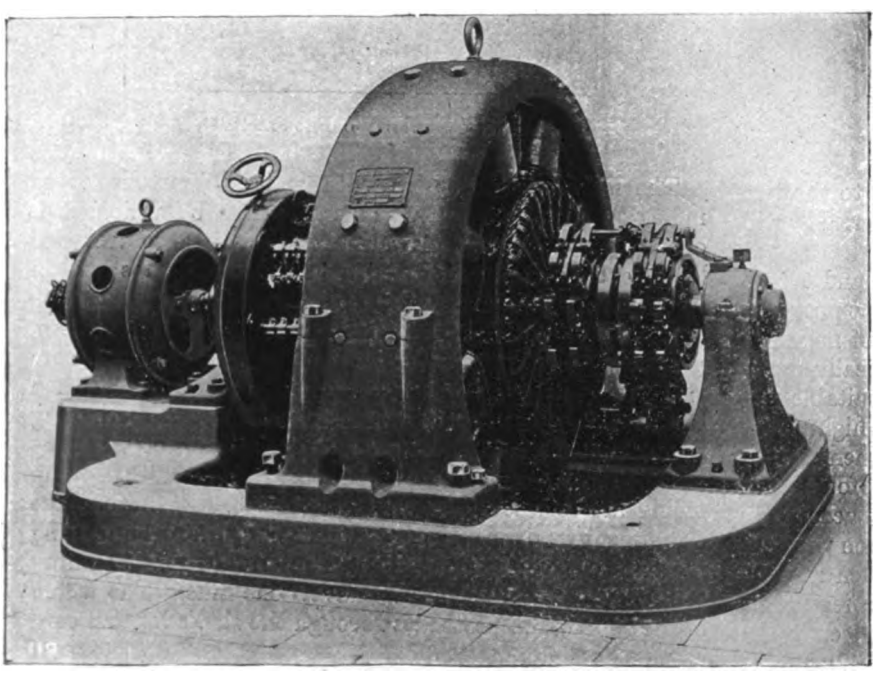
at any time, be drawn up into the interior of the ship, and then, after the sea cock is closed, the whole apparatus can be removed for examination and for cleaning if necessary. Guide rods are provided attached to the casting of the body of the sea cock to keep the tube in position when drawn into the ship, and also to keep the openings in the tube facing correctly fore and aft when the tube is pushed down.

At the top of the tube is fixed a casing, in which are two entirely separate pieces of apparatus, viz., a commutator for transmitting electric signals to the distance recorder, which is arranged so that 100 electric signals are made while the ship travels 2,027 yds., or one nautical mile; and a magneto generator, which generates current at a pressure proportional to the speed at which it revolves, this current being led to a voltmeter having its scale marked in knots, and which, accordingly, serves as an indicator of the speed of the transmitting apparatus, and therefore of the ship through the water. Both the above pieces of apparatus are driven by means of gearing from a shaft rotated by the propeller in the tube, and an arrangement of change wheels is provided so that corrections or adjustments can readily be made. It should be noted that any alteration of the change wheels affects both the distance recorder and the speed indicator, so that the indication of these two instruments maintains a consistent relation one to the other.

Vickers' Electrical Plant.

ALTHOUGH Messrs. Vickers, Sons & Maxim are known to the public at large for the work they have done in the design and manufacture of large guns, yet it must not be forgotten that they also operate in more peaceful directions and do their share towards propagating the use of electrical machinery.



350 kw. Vickers' Rotary Converter with Starting Motor.

At the Japan-British Exhibition at Shepherd's Bush they are, in fact, showing a selection of their electrical plant, among which may be mentioned a rotary converter. Its capacity is 300 kw. and its synchronous speed 750 revs. per min. when supplied with alternating current of 50. A similar set of 350 kw. output is shown in the accompanying illustration.

We may also mention a Vickers' "F" type semi-enclosed shunt-wound variable-speed motor fitted with interpoles, to give an output of 30 B.H.P. at 220 volts with speed range from 280 to 840 revs. per min., and a Vickers' semi-enclosed induction motor of the slip-ring type, which is designed to give 40 B.H.P. when running at 730 revs. per min. and supplied with three-phase current at 220 volts and a frequency of 50.

Holden & Brooke Centrifugal Pumps.

FOR many years centrifugal pumps have been used for dealing with large quantities of water against low lifts, but it is only comparatively recently that these pumps have been used to any large extent for working against high lifts. At the present time, however, they are in use for lifts equal to those dealt with by any reciprocating pump. Strength of materials is the only factor which limits the head against which these pumps can work. When it is remembered that a head of 1,600 ft. means a pressure of about 700 lb. per square inch in the pump it will beat once realised with what difficulties the designer has to contend.

As might be expected from what has been mentioned above, there has been a tendency to divide these pumps into two distinct main classes, namely, "high lift" and "low lift" types. These two classes, particularly the former, are again divided into centrifugal pumps, turbine pumps, and pumps known by their own particular trade names, but it will be seen later that although these pumps may differ very considerably in design and construction yet in principle they are all identical. It is unfortunate that such a division should have been made, for it is often the case that "low lift" is only another name for a crudely designed and cheaply made pump. Undoubtedly there is a demand for this class of pump owing to the fact that they, more often than not, form only an auxiliary part of an installation such as a circulating pump in connection with an engine and condensing plant where the initial cost is a more serious matter than the loss due to inefficiency. On the other hand, the "low lift" type also includes those large pumps, dealing with enormous volumes of water in connection with dock work, land drainage and irrigation work, in which the design, the construction and efficiency are quite equal to those of any so-called "high lift" pump.

"Single stage" and "multiple stage" would not be amuch better division, since single stage pumps have been made for pumping against heads of as much as 800 ft., and are obviously "high lift" pumps. It is preferable, therefore, not to attempt to divide the centrifugal type of pump into such sub-divisions, but rather to regard the application to high lifts as the natural development of the earlier uses.

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It is not a matter of surprise that such a development should have taken place in these pumps, for they possess many advantages over other types. The initial cost is low, and at the same time good efficiencies can be obtained, as will be seen from the table given below, which shows the relative prices of, and power required to drive, a few actual reciprocating and centrifugal pumps.

Centrifugal pump and motor.				Reciprocating pump and motor.	
Gallons per minute.	Head in feet.	H.P.	Price.	H.P.	Price.
			£		£
167	750	60	280	55	510
300	400	52	180	55	480
300	100	14	110	20	310
700	607	190	390	180	1,640

The number of wearing parts is small. They are suitable for dealing with water containing solid matter in suspension as they have no valves. The high rotative speed necessary makes direct driving by electric motors an ideal arrangement. The space occupied by the plant is small and only light foundations are required. Transport and erection are comparatively small items.

Much use has been made of this type of pump in the unwatering and drainage of mines. The small space occupied by a pump and motor capable of dealing with large quantities of water, the ease with which power can be conveyed to the electric motor and the fact that only one pipe—the delivery pipe from the pump—is required, make them admirably suitable for slinging in mine shafts.

A firm who have paid great attention to the design of these pumps are Messrs. Holden & Brooke, of Manchester. The shaft inside their pump is completely covered either by the impellers themselves or by gun-metal bushes, thus preventing any corrosion taking place. The end thrust, and in the case of a vertical pump, the weight of the impellers and shaft, is completely balanced hydraulically and automatically, thus absolutely dispensing with thrust bearings of any description. The pressure on the back of the last impeller is automatically regulated to that required to balance the end thrust by allowing the shaft with its impellers and a balance valve to have a slight end movement which, in actual operation, enables it to take up such a position that the amount of leakage past the face of the balance valve is of such an amount that it requires the necessary pressure on the back of the impeller to force this water past the small orifice shown in the flange of the delivery end bearing. The amount of water required for balancing does not exceed a fraction of 1 per cent. of the total amount passing through the pump. It will be noticed that this design of balancing arrangement is independent of any wear which may take place on the face of the balance valve, and, as wear takes place on the impeller neck rings the amount of balance water required actually decreases. It should also be noted that the delivery end bearing, the balance valve, and the renewable valve seating ring can be taken out of the pump without disturbing the main bodies or the pipe connections.

The pump is fitted with the necessary air-cocks, drain cocks, priming cock and tundish. Provision is made on the suction and delivery branches for attaching gauges which are supplied as extras. Owing to the special design of covering which is cast with the bodies the pump presents, it is claimed, a neat external appearance without the use of any sheet metal covering, which soon becomes rusted and damaged.

Recently much stress has been laid upon the value of pumps giving a so-called "self-regulation" when working with varying heads. The effect of this is that the power required to drive a pump running at a constant speed does not exceed a certain limit, however much the head is reduced. Undoubtedly cases arise in which it is beneficial to instal pumps having this property of self-regulation, as for example in sinking or unwatering mines. It should be borne in mind, Messrs. Holden & Brooke point out, however, that in all cases this property is obtained at the expense of efficiency at the normal duty of the pump. This must be so from the very nature of the method by which the self-regulation is obtained. Although one pump *without* self-regulation may have a maximum efficiency of, say, 65 per cent., while another of a different size *with* self-regulation may have a maximum efficiency of 70 per cent., yet of two pumps built on the same lines, for the same output, the one *without* self-regulation would have the higher efficiency when dealing with its normal output. It will be seen, therefore, that this property has its limitations, and that whereas in some cases it may be desirable to make use of it, in other cases, where the head is practically constant, it is preferable to instal pumps without self-regulation in order to obtain the maximum efficiency under the normal working conditions. The effect being obtained by means of impellers specially designed but without small nozzles, which are so liable to become choked up when dealing with dirty water.

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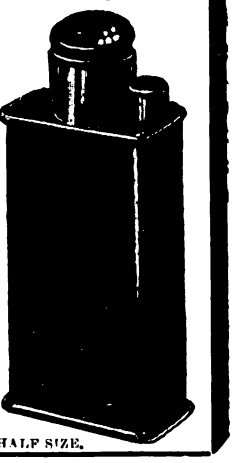
HALF SIZE.

"Tricity" Cookers.

ALTHOUGH the present summer has not provided any days of very great heat, the weather has been sultry enough to justify the claims made for electrical cooking apparatus as regards its hot weather advantages. Not only is electrical heating simple, easily regulated and perfectly controlled, but the heat produced therein is localised and applied just where it is wanted, and does not heat the surrounding atmosphere.

A cooker for which all these advantages are claimed is that known as the "Tricity," made by the Berry Construction Co. Fig. 1 shows a "Tricity" duplex cooker, from which it will be seen that the body of the cooker is surmounted by a circular iron plate. This plate, on which the various utensils are placed, is raised to a dull red, or lesser heat, which is controlled by means of two switches. One switches the current "on" or "off," the other regulates

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the temperature to "high" or "low." The handle of the switch indicates its position, and when pointing to "low" the heat obtained is one-quarter of that when the handle points to "high." Current is brought to the cooker through a flexible steel-covered cable, thus ensuring, it is claimed, absolute safety. Three types of cookers are made: The duplex, with two hot plates; the single, with one hot plate; and the extension, also with one hot plate. This latter is intended for use as an extension to the duplex cooker, or for

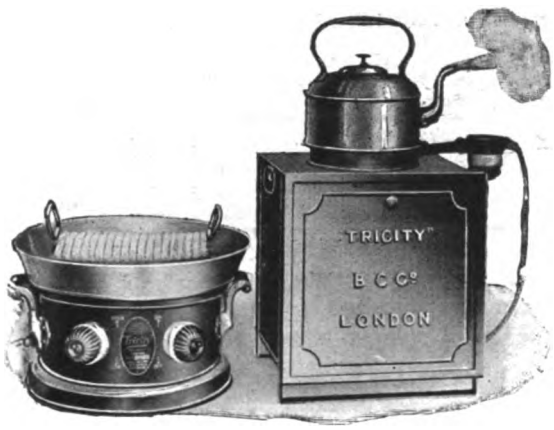

Fig. 1.—No. 1 "Tricity" Range.

oven top heat with single and duplex cookers, or again, it is useful alone for boiling, stewing and similar simple operations. The combination of the duplex with one or more extension plates provides a wide range of utility, and permits a variety of cooking processes to be carried out simultaneously.

The oven is made in two sizes, and is placed on the top of the cooker, so that the hot plate projects into the oven. To obtain a top heat, so essential for browning purposes, the extension cooker is inverted and placed on the top of the oven, with its hot plate projecting into the oven. An oven

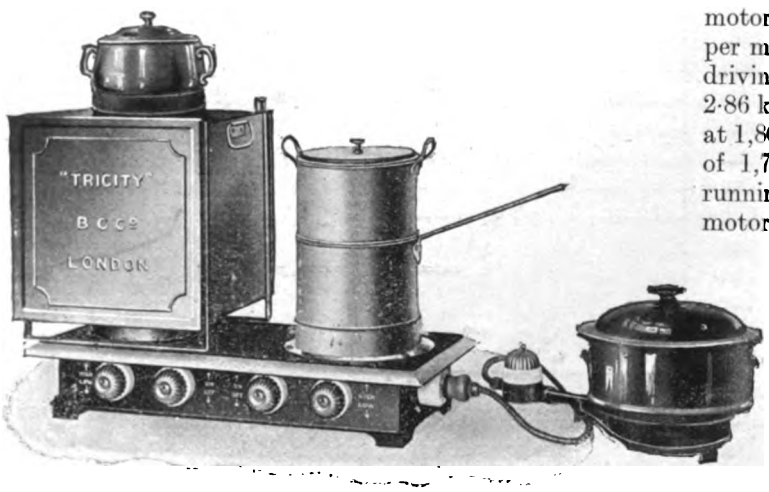

Fig. 2.—"Tricity" Range.

set on the table with the extension plate arranged for top heat only forms a useful hot cupboard for keeping food warm, or warming plates, &c.

Special grills, saucepans and other appliances have been designed and arranged for use with the "Tricity" cooker. To all outward appearances they are, with the exception of the grill, exactly similar to the utensils to which you are accustomed, but special care is taken with every one to make the bottom as flat as possible, so as to obtain good contact with the hot plate of the cooker, and so, by avoiding loss of efficiency, make the cooking rapid and economical. The utensils cost only a few shillings each. There are no wires attached to any of them, the only wire is the steel-covered one previously referred to, attached to the cooker. No harm can come to the cooker by being left "on," and whether there are any utensils on it or not there is, it is claimed, nothing to destroy or to burn. Of course, "Tricity" utensils will no more stand being boiled dry or used empty without suffering than the utensils in use on any kitchen range, but if they are destroyed accidentally, or through carelessness, it is only a matter of a few shillings to replace them, and no damage will have been done to the cooker.

Re-Powering Machine Tools.

ONE of the greatest advantages of the electric drive is the facility with which the power requirements of different tools and machine combinations can be tested from time to time for the purpose of securing the most positive and efficient operation of the plant. By means of a few electrical measurements data may readily be secured to determine the power necessary to operate the machine. In the following paragraphs which are taken from the "Electrical World," are given the results of a number of tests of this kind in a large foundry, with the changes determined by simple voltmeter and ammeter readings. The data illustrates the need of going over machine-tool installations from time to time to find out whether the conditions of power supply and utilisation require a readjustment of the motors in relation to the tools, a substitution of group for individual driving, or vice versa.

All motors in service were of the direct-current type, wound for 500 volts, and were replaced by 550 volt three-phase motors. One 30 H.P. motor, running at 650 revs. per min., driving a line shaft and three rattlers, light took 2·2 kw.; driving one rattler loaded it took 3·5 kw. The motor was replaced by a 7·5 H.P. motor running at 1,200 revs. per min. One 7 H.P. motor, running at 950 revs. per min., driving a suction fan for rattlers, with the usual load, took 2·86 kw. The motor was replaced by a 5 H.P. motor running at 1,800 revs. per min. One 3 H.P. motor, with a rated speed of 1,700 revs. per min., driving a sand conveyor, when running unloaded took 0·9 kw. A 3 H.P. alternating-current motor, running at 1,800 revs. per min., was substituted for this motor. One 2·5 H.P. motor, with a rated speed of 1,620 revs. per min., driving a double grinder, with the grinder idle took 0·68 kw., with the motor driving the grinders, two men grinding light castings, it took from 1·1 kw. to 1·8 kw. A 2 H.P. 1,800 revs. per min. motor was substituted. One 2 H.P. motor, running at 1,280 revs. per min., driving a 36 in. exhaust fan, removing gases from the core room and ovens, with normal load took 1·8 kw. It was replaced by a 3 H.P. motor running at 1,800 revs. per min. One 5 H.P. motor running at 1,200 revs. per min., driving a sand mixer, when running light took 0·92 kw.; and when running loaded took 1·84 kw. This motor was replaced by a 4 H.P. 1,200 revs. per min. alternating-current motor.

One 2·5 H.P. motor running at 1,700 revs. per min., driving a rattler, when running light took 2·2 kw. A 3 H.P. 1,800 revs. per min. motor was substituted for this motor. One 40 H.P. six-pole motor, rated at 975 revs. per min. when running light and at 840 revs. per min. when loaded, driving a Roots blower, one hour after starting took 0·26 kw. A 35 H.P. 900 revs. per min. motor was substituted for this

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motor. One 2·5 H.P. 1,800 revs. per min. motor, driving a 36 in. band saw, a 14 in. bench saw and a 7 in. lathe showed the following conditions: Motor driving shaft light took 0·66 kw.; motor driving band saw, 2 in. pine stock, took 1·1 kw.; motor driving band saw, with 2 in. plank on bench saw, took 3·3 kw. This load was so excessive that motor speed was reduced to 70 per cent. of normal speed. The motor was replaced by a 5 H.P. 1,800 revs. per min. motor. One 2 H.P. motor was running at 2,000 revs. per min. connected to a 3 in. by 24 in. planer. This motor was unable to plane wide stock at the desired speed. It was replaced by a 5 H.P. motor running at 1,800 revs. per min.

B.T.-H. Motors and Generators.

THE latest type of continuous-current motors and generators made by the British Thomson-Houston Co., of Rugby, embody some new features in their design, though the construction of this class of equipment has become so standardised that it seems that little more can be done, except in improving comparatively minor details.

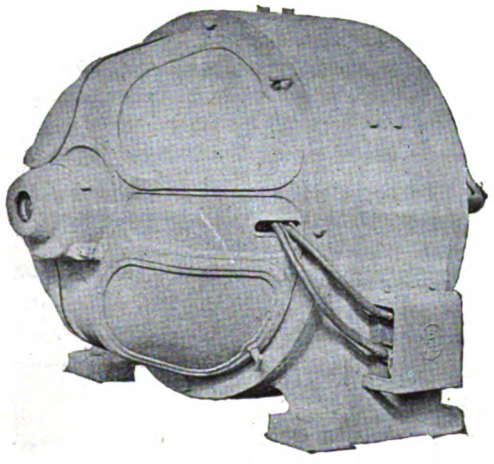

Fig. 1.—B.T.-H. Motors with Solid Covers.

Turning to the details of these motors, which suffice to show how certain excellent results are obtained, only the best quality of material is used in the insulation of the armature and field coils. Special attention is given in the process of manufacture to the removal and permanent exclusion of moisture from the insulating material of the coils. To this end the insulated conductors of which the coils are formed are subjected to a drying process and then treated with a special moisture-proof compound. The coils are subjected to a high potential test of alternating current at a pressure of 1,500 volts applied between the coils and frame for a period of 60 seconds while the machine is hot.

The core consists of laminations of sheet steel of high permeability slotted on the periphery to receive the windings, and clamped under pressure between substantial end flanges. To minimise losses due to eddy currents the laminations are coated with an insulating compound before assembly. The cores are provided with radial ventilating ducts to allow of the free circulation of air through the body of the armature. At the ends of the armature, and also in each ventilating duct, steel spacers are provided to support each tooth. This construction, it is claimed, prevents the vibration which may occur with unsupported teeth.

The armature consists of form wound coils which are carefully insulated and then inserted in the slots of the armature core, which are insulated to receive them. The coils themselves consist of high conductivity copper conductors, and are secured by binding bands calculated to resist the centrifugal force at the maximum speeds with an ample factor of safety.

Fig. 2.—B.T.-H. Protected Motor.

The commutator is built up of hard-drawn copper segments of ample wearing depth insulated from one another by means of carefully selected mica, and from the clamping rings and shell by means of cones and a sleeve of specially prepared mica. The commutator shell is forced into position and rigidly keyed to prevent any relative movement between the armature winding and the commutator. The commutator shell is provided with ventilating ducts and the commutator has ample cooling surface.

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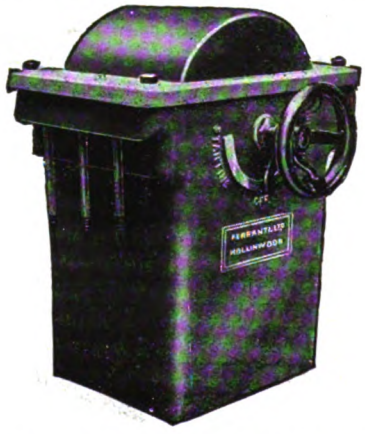

THREE-PHASE
AUTO-TRANSFORMER
STARTERS.
TOTALLY-ENCLOSED. 245

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The magnet frame is of cast iron, and has inwardly projecting poles rigidly bolted thereto. The main poles are built up of laminated steel, and can be removed with the field spools without any displacement of the armature being necessary. The field coils are wound on substantial bobbins and are held in position by means of the projecting pole-tips. They can be readily taken off when the poles have been removed from the frame.

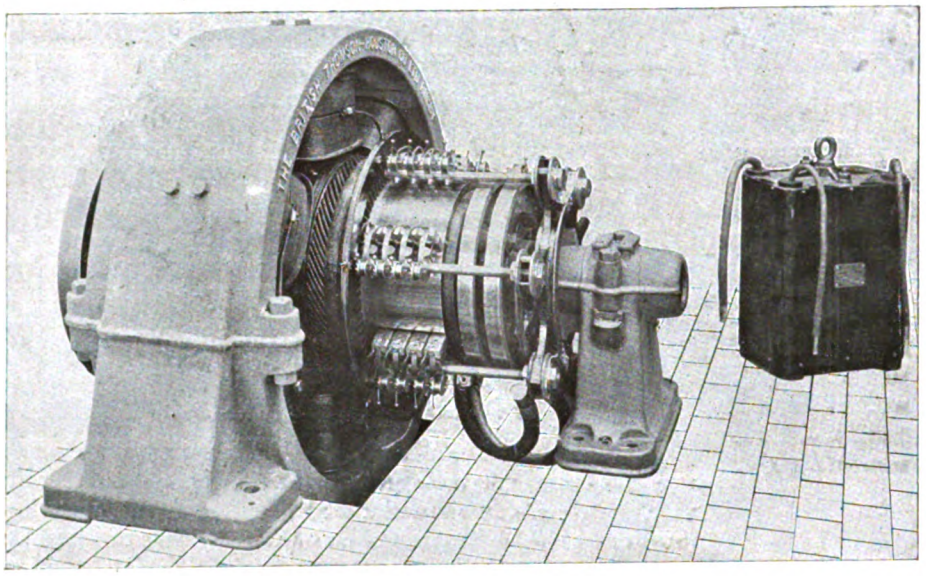

Fig. 3.—Three Wire Generator with Neutral Compensator.

The bearings are carried either in end shields, or in pedestals when such are required. In the former case a special mechanical feature is the provision of adjusting screws on the end shields, by which the bearings can be readily re-centred when it becomes necessary; this re-centreing can be done on belt-driven machines without removing the belt. In the former case the bolts are so spaced that the end shields and bearings can be turned through 90 deg. or 180 deg., thus allowing the motor to be mounted on the floor, wall or ceiling. Standard slide rails

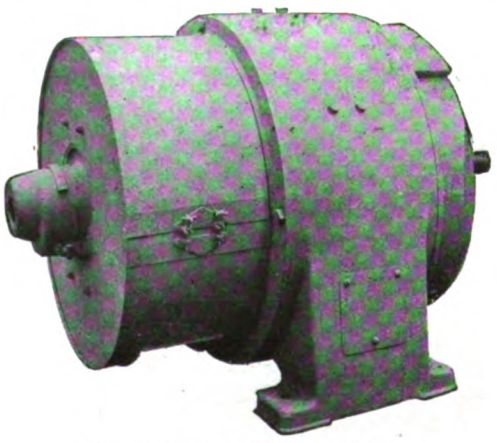

Fig. 4.—Totally Enclosed Motor.

are suitable for floor use only. For ceiling or wall suspension special rails will be required. The bearings are of the self-oiling type, the lubrication being effected by means of loose rings on the shaft dipping into large oil wells. The bearings are of cast iron with linings of white metal and are self-aligning. The length of bearing is three times the diameter of the shaft.

The brushes are of carbon and are carried in brush holders of the clock spring type, so constructed that the tension of any brush is uniform throughout the life of the brush, and is readily adjusted without removing the brush from the commutator, and without the use of any tool. Any brush can be removed while the machine is in operation without disturbing the others and without removing the holder from the stud. Flexible connections are employed for carrying the current direct from each carbon brush to the body of the holder, thus making a positive connection between the two. The brush studs are securely locked to prevent rotation due to vibration.

All these B.T.-H. machines will stand full load for six hours with a temperature rise (by thermometer) not exceeding 40°C., and will stand 25 per cent. overload for one hour and 50 per cent. momentarily, without injurious heating or sparking. The temperature rise, measured by thermometer, is based on the assumption that the mean temperature of the surrounding air (measured within 3 ft. of the machine) does not exceed 25°C. If at the time of test the mean temperature of the surrounding air is higher than this temperature, the observed temperature rise on the machine must be reduced by ½ per cent. for each degree centigrade, the mean temperature of the surrounding air exceeds 25°C.

As regards speed regulation, stand and shunt-wound machines without commutating poles may be increased in speed up to 5 per cent. above the normal by varying the excitation and without causing injurious sparking. If a greater speed variation than this is required commutating poles must be used. This variation of B.T.-H. motor is wound for the standard voltages of 200, 220, 250, 400, 440, 500 and 530. The accompanying illustrations are examples of the types made.

Electricity in Excavation Work

AT the present day, when the time which is allowed for construction work must be reduced to a minimum, electricity is finding a wide application, due to its inherent advantages, and in many places the electric motor is supplanting the steam engine. Electrical apparatus is especially serviceable to contractors, and will be found to result in a great saving in time and money. The electrical equipment is always ready for instant use, thus eliminating the loss of time in getting up steam when a steam engine is used.

Its use results in a reduction of expense, as one pays only for the power which actually does work. There is no consumption of power when the motor is not in operation. This eliminates the expense resulting from the consumption of fuel in order to keep up steam while the equpiment is not in operation and to enable work to be resumed at any desired moment. Any person of ordinary intelligence can operate an electrical equipment, and thus the high wages of a licensed engineer are saved.

The operation of an electrical equipment is not attended with objectionable and annoying features. There is no fire hazard due to flying sparks or live coals accidentally dropped from the boiler fire box, nor is there the nuisance

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of smoke, ashes and dust. The operator is not burdened with the responsibility of keeping sufficient water in the boiler, maintaining a hot fire to keep up steam, shovelling coal, removing ashes, &c. Its use eliminates the danger of water pipes and cylinders freezing and bursting in the winter time.

It is a very simple matter to instal it, and it can be changed from place to place at will Its position is not determined by features which limit its installation to certain points, as in the case of the steam-driven equipment, where steam or water supply pipes limit its location. After it has been moved to its new position the wires can be readily changed.

A good example of the use of electricity in contracting work is the recent work on the Champlain Barge Canal, which has been recently described in the "Electrical Review and Western Electrician."

This installation is unique in being one of the first to be equipped with induction-motor drive, and also to employ dynamic braking. The bucket is controlled by two cables, which are operated by a double-drum hoist. This double-drum hoist is driven by a 90 H.P. 550 volt high-torque three-phase induction hoist motor working at a frequency of 40. The excavator is mounted on a circular track permitting its rotation through a complete circle, and making it possible to dump the bucket wherever desired within quite a large radius. The hoist for accomplishing this movement is driven by a 22 H.P. 550 volt high-torque three-phase inductionhoist motor.

The controlling apparatus consists of a group of contactors, interlocks, current-limit relays and a motor controller for the operation of the main drum hoist motor and the control of the speed of hoisting and excavating by a varying resistance inserted in the motor circuit. This type of control, known as magnetic control, is essential in work of this class owing to the severe conditions. The operator is able to give a jerky movement to the bucket in order to shake clay and sticky mud from its bottom.

The motor is protected from overloading by a triple-pole circuit-breaker adjusted to trip at about 50 per cent. above normal full-load current. This protection is necessary, since the bucket may strike a rock or other hard substance embedded in the soil being excavated. The motor which rotates the excavator is also protected by a triple-pole circuit-breaker, and is controlled by a drum-type controller with a bevel gear and lever device instead of the ordinary handle.

The two drums for hoisting and digging are each provided with an air brake for retarding the movement of the bucket or boom when these are being lowered. This equipment consists of an air compressor of 19 cub. ft. displacement driven by a 6 H.P. 550 volt induction motor, and controlled by an automatic pressure governor which starts the motor when the pressure falls below a certain value. As soon as the required pressure is restored, the controller automatically stops the motor. For controlling the air brakes two valves of the type designed for electric car service are provided.

Two of these excavators are employed. Power at a pressure of 6,600 volts and a frequency of 60 cycles was purchased from the Hudson River Power Co. and stepped down to 550 volts for operation of the motors by a bank of three 60 kw. transformers.

A triple-pole oil switch and a lightning arrester, both designed for operation on a 6,600 volt system, are installed in the temporary building beside which the transformers are located. The transformers and buildings are mounted on skids to facilitate moving the apparatus as the work progresses.

W. & W. Motor-Generators.

A WELL-designed and built series of motor-generators, by which one continuous current can be transformed into another of either higher or lower voltage are now being made by Messrs. Wright & Wood. A variation of the generator voltage is provided, the set consisting of two direct-coupled shunt-wound machines mounted on cast-iron bed-plates.

The bearings are of the journal type and are provided with automatic oil ring lubrication. Both field and armature windings are of the interchangeable former type, and before mounting are vacuum dried and impregnated with the best insulating varnish, thus ensuring, it is claimed, complete immunity from breakdown. All insulating material is of the best quality and ample ventilation is provided. Carbon brushes only are employed, and the machines are so proportioned that absolutely sparkless running is secured. Mechanical balance and freedom from vibration may be mentioned as noteworthy features. All openings in the machine can be provided with ventilated covers if required, and all terminals are protected by a cast-iron cover. The temperature rise on load does not exceed 75°F. after a six hours' run.

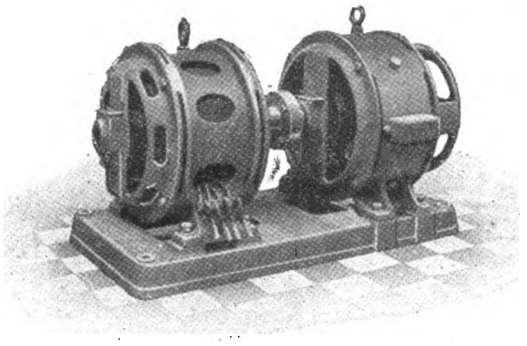


Fig. 1.—W. & W. Motor-Generator

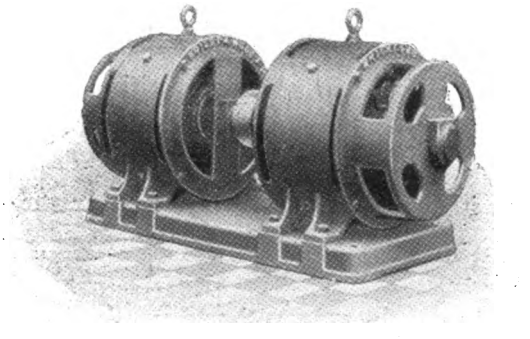
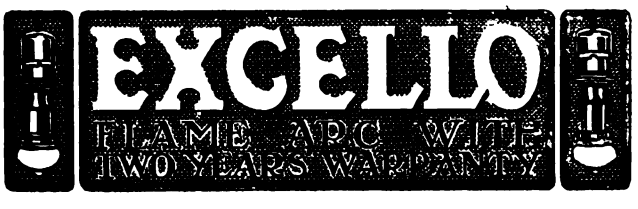


Fig. 2.—Another View of the same Machine.

The overall efficiency varies from 42 per cent. for the 240-watt set to 85 per cent. for the 25 kw. size.

Induction motor-generators are also made and these transform single, two, or three-phase alternating current to continuous. The motors are all of the squirrel-cage type, wound for a frequency of 50, but other frequencies can be



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adopted when necessary. The efficiency of the two and three-phase sets is equal to that of the continuous-current type, but the single phase is 10 to 15 per cent. less. No brush gear of any description is required on the motors, which are of the most substantial design.

Single field motor transformers for direct current only, in outputs varying from 0·9 to 5·75 kw., consist of a standard magnet frame and an armature provided with high and low-tension windings and two commutators. These machines have a higher efficiency than the motor-generator sets, but the voltage on the generator side cannot be varied, having a value in fixed proportion to the supply voltage. Rotary transformers for converting direct to alternating single, two or three-phase current are also a speciality with Messrs. Wright & Wood, and can be supplied to specification.

Star Delta Switches.

A SERIES of oil-break switches entitled as above are now being placed on the market by Messrs. Siemens Brothers Dynamo Works. They are of the oil, immersed drum type, and may be used for currents up to 50 amperes at 3,300 volts, 100 amperes at 2,200 volts, and 300 amperes at 650 volts.

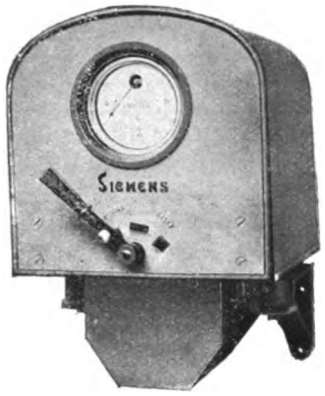

Fig. 1.—Star Delta Switch with Ammeter arranged for Wall-Fixing.

A stop is provided at the star position to prevent the switch from over-running this position, and to allow the motor to attain a suitable speed before switching in to the delta position. It is impossible to put the switch into delta position without previously passing through star position. Provision is also made to prevent the switch from being left in any but the delta or off positions.

Fig. 2.—Star Delta Switch with Cover removed.

Fig. 3.—Star Delta Switch arranged for Floor-Fixing.

When the switch is in the off position the motor is completely cut off from the mains.

The contact fingers are made adjustable to ensure a good contact pressure between them and the contact rings on the drums. The copper contact rings are mounted on insulating discs carried on the drum shaft. The terminals consist of copper rods carried through porcelain insulators, the latter being cemented to the cast-iron top-plate of the switch. If desired, special protected terminals encased in fibre tubes can be supplied. The sheet-metal oil tank may be readily removed for inspection of the drum and contact fingers. These switches can be supplied non-automatic suitable for wall fixing, or automatic, fitted with overload and no-voltage releases, suitable for either wall fixing or floor fixing; in the latter case, tubular columns are provided through which the cables may be led to the switch.

The amount of oil required for these switches is $2\frac{1}{2}$ gallons, the weight being $8\frac{3}{4}$ lb.

Renold's Silent Chain.

A VERY useful method of driving machinery is that due to Messrs. Hans Renold (Ltd.) The original silent chain, of which system we speak, was introduced by Mr. Hans Renold in 1895, and while the principle of the gearing has remained unaltered there have naturally been many changes in the construction. The first chains were made up of thin plates threaded alternately right and left

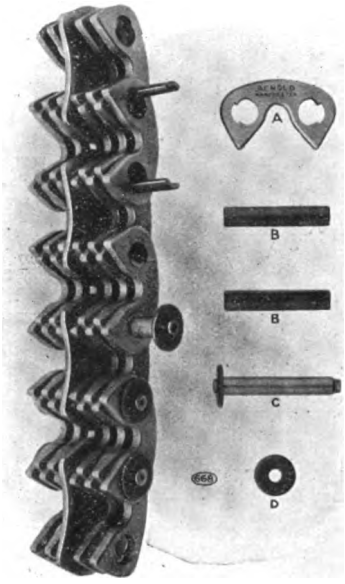

Fig. 1.—Liner Silent Chain.

on to hardened studs. The bearing surface on each side of the stud was thus only half the stud length and was broken up into a number of separate bearings, each as long as the thickness of the plate. These plates could not be hardened and the wear on the chain joints was found to be very considerable. In 1900, an improvement was made by placing several plates together and inserting hardened bushes in the end holes. In this way increased durability was obtained on the wearing surface, but there were certain difficulties of manufacture, so that this type was eventually succeeded by the block silent chain. In this new idea hardened blocks ranging from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. wide were used instead of groups of bushed plates. This pattern was very durable, but was not so strong as the earlier arrangement, as the blocks were sawn from drawn steel bars, which were necessarily milder than the rolled strips from which the thin plates were punched. Experiments then led to the introduction of the patent liner silent chain, which was introduced in 1904.

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The new feature of this arrangement was the introduction of hardened segmental liners at the chain joints. These are fixed in the chain plates and give an increased and continuous bearing on the pins. This chain is shown in detail in Fig. 1. The liners are fixed in the plates and bear on the studs. They extend over the whole width of the chain and consequently the wearing surfaces obtained are the maximum possible, while the wear of studs is evenly distributed owing to their freedom of rotation. These bearings can be easily lubricated as the spaces between the liners allow the oil to reach the bearings readily. Each hole in the plate has one small and one large recess the small gripping the liners and the large ones giving them clearance, and so allow the plates to swing on the studs. In a new series of liner chains, made with thick plates, the shape of the hole has been improved, so that the chain can now be bent almost as far backward as forward. This arrangement is shown in Fig. 2. An inner and outer combination of plates is thus formed at each joint and the

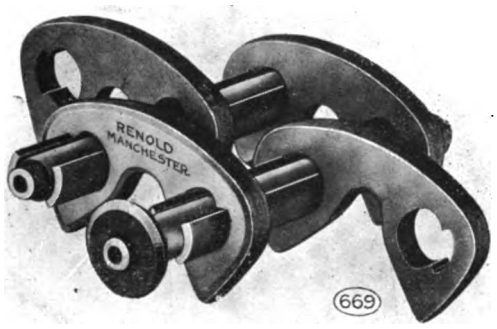

Fig. 2.—Skeleton showing construction of Liner Silent Chain.

liners in one combination can move through the clearance recesses of the other sufficiently to allow the chain to encircle the smallest sprocket used. The liners, being at the outer ends of the plates, bear on the studs when the chain is in tension.

In 1909, owing to the difficulty of manufacturing the patent liner silent chain in very small sizes, Messrs. Hans Renold again introduced the principle of the old bushed link silent chain mentioned above. The new chain is made from single plates of heavy gauge instead of groups of thin plates, the holes being lined with glass-hard circular bushes. This chain is shown in Fig. 3. The bushes are slightly longer than the thickness of the plates and project a little on each face of the latter, and so prevent them from binding against each other. This reduces the bending friction to a minimum and considerably improves the lubrication. It is pointed out that since the bearing surfaces of the points are well hardened the chain is very durable, and the little wear which takes place is evenly distributed owing to the studs being free to rotate.

The type and size of chain to be used depend on a number of considerations, viz.: Nature of the drive—whether the load is steady or impulsive, &c.—the speed required, the power to be transmitted, the relative position of driver and driven shafts, the shaft centre distance, the speed ratio and other more general conditions.

About 1,300 ft. per minute is a normal maximum speed for silent chains up to 1·5 in. pitch inclusive, and 1,200 ft. per minute for larger sizes. These speeds may, of course, be exceeded, but then it is advisable to provide an oil bath chain case, especially with the larger chains, and to erect the gear very substantially. With these provisions, though at the cost of reduced life, silent chains may be run up to 1,800 ft. per minute in the smaller sizes and 1,500 ft. per minute in the larger.

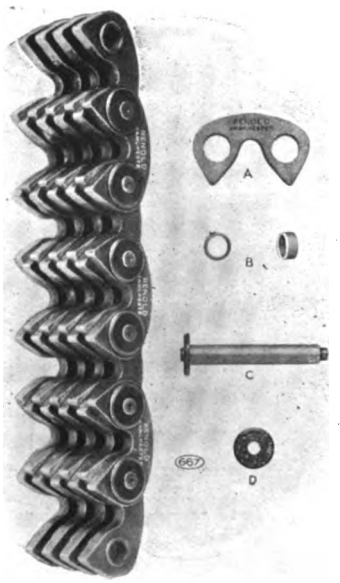

Fig. 3.—Bush Silent Chain.

The factor of safety may vary from 30 for 1·75 in. pitch chains to 50 for 0·5 in. pitch chains at the maximum speed. These factors are not needed to ensure safety but to obtain a reasonable bearing pressure on the studs. As regards the position of drive, inclined or horizontal positions, with the tight side of the chain on top, are the best. When the slack side is above, the action on the small wheel is not quite so smooth. If a vertical position is necessary, adjustment of the centre distance is very important and must be carefully attended to, as otherwise the chain may fall out of gear with the lower wheel.

The normal minimum distance between the shafts should be equal to 50 pitches of the chain used; it would thus be 4 ft. 2 in. for a drive using 1 in. pitch chain. The distance may, however, be reduced until the wheels only just clear, but the life of the chain decreases out of all proportion to the decrease in centre distance. Greater distances than the minimum are advantageous, as they give more chain over which to distribute the wear. The maximum centre distance is about 15 ft. to 20 ft., but, on account of the weight of the chain between the wheels, it largely depends on the rigidity with which the gear is mounted.

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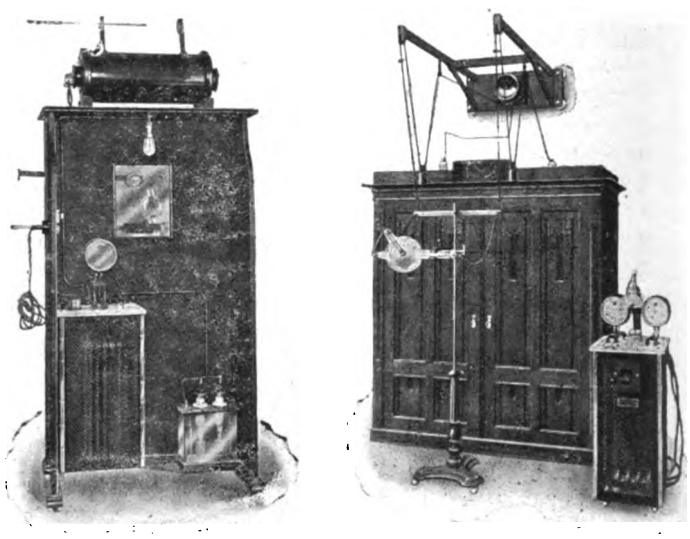
Wherever possible some means of adjusting the centre distance should be provided. Slide rails are not always necessary, although they are very convenient; for motor to lineshaft drives, adjustment may be obtained by means of packings or slotted holes in the motor feet. A short or vertical drive requires nicer adjustment than one running in an oblique or horizontal position, where the chain acts to a certain extent as an automatic adjuster. This is, however, insufficient if the centres are short and the load impulsive, and in such cases if adjustment of centre distance is not possible, it is necessary to fix a jockey wheel on the slack side of the chain. The jockey is an ordinary chain wheel as large in diameter as possible, and must gear with the inside of the chain, thus forming a triangular drive. It must further be placed in such a position that at least three teeth mesh with the chain. A jockey wheel must on no account be used on the back of a chain. It burrs over the edges of the links, making the joints stiff, and may also bend the chain backwards at a sharper angle than is permissible with the liner type chain. The chain should be run at a tension which would be considered just too slack for a leather belt, the correct adjustment allowing it a slight sag.

The silent chain gear is, it is claimed, a well-finished and accurate piece of mechanism, and to obtain the best results must be carefully erected. Although the chain has a certain amount of lateral flexibility, and gives satisfaction where the conditions are far from ideal, as on motor cars, erection cannot be too substantial if the maximum life is to be obtained. Shaft bearings should be rigid and sprockets should run true, and be mounted near a bearing if on light shafts liable to spring under load. If the drive is from an electric motor the end-play of the armature shaft must be kept down to a minimum, say from $\frac{1}{16}$ in. to $\frac{1}{8}$ in., according to the centre distance of the wheels and the size of the chain. Greater exactitude in alignment is necessary than with belts. It is not sufficient that the chain is running centrally on both driver and driven wheels, as this result could be obtained by a combination of disalignment in two planes, and yet the chain might be racking itself to pieces. The shafts must be both level and parallel and the wheels should be tested for alignment. Whilst the setting up of chain drives does not require the degree of accuracy necessary for double helical spur gears, it is not too much to say that fully three-fourths of the failures of silent chain drives have been due to faulty alignment, generally aggravated, it is true, by insufficient lubrication. Of the remainder, lack of lubrication alone, Messrs. Hans Renold consider, accounts for the greater part.

Siemens Electro-Medical Apparatus.

THE subject of the application of electricity to medical work has lately been brought prominently before the public by the death of Mr. H. W. Cox. Mr. Cox, like many others, was the victim of ignorance of the conditions under which the X-ray works, and through his experience it has been possible to devise apparatus for the prevention of like disasters.

Messrs. Siemens Bros. & Co. are a firm who have paid a great deal of attention to this class of work, and the apparatus shown in Fig. 1 represents a complete outfit with 16 in. spark induction coil, switch table and Wehnelt interrupter. The apparatus is arranged on a protecting screen. In fact: in order to avoid the harmful effect which may be produced by frequent application of the X-rays, it is necessary that not only the patient but also the physician, and all those persons who are entrusted with the use of the X-ray outfit, should be protected as far as possible against secondary



Figs. 1 and 2.—Two Examples of Siemens X-ray Outfits.

radiation of the tube. For this purpose, only that pencil of the X-rays should be allowed to come into contact with human beings which is required for application to a part of the body, that is to say, the application of the X-rays should be confined as far as possible to that part of the body only which requires treatment, and the physician as well as those persons entrusted with the use of the X-ray apparatus must be protected from all radiation. The patient himself is protected from accidental subjection to the rays by the use of diaphragms and protective devices. The most suitable means for protecting the physician and his assistants has been proved in practice to be a cabinet, the walls of which are lined with lead. This cabinet contains the controlling and regulating apparatus, and the physician is able to observe the tube and the patient through lead glass windows let into the sides.

An X-ray outfit of rather a different kind is shown in Fig. 2. It possesses the great advantage of being capable of being used direct on either a single-phase or three-phase supply. The demand for these new X-ray outfits was

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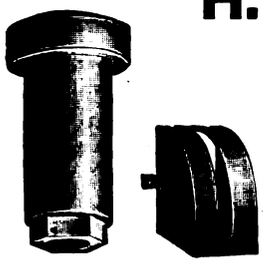

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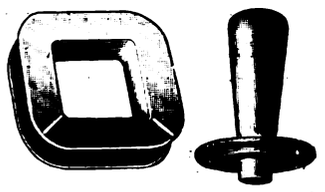

determined by the necessity for generating absolutely unidirectional current for working the tubes and for generating large amounts of energy, in order to be able to make rapid and instantaneous exposures and good radiographs, and for obtaining an absolutely steady bright image on the screen. An X-ray outfit of this kind consists of two parts, a generating plant in a cabinet form and a trolley switchtable or a switchboard.

The generating plant consists of the following principal parts: (1) A high-tension transformer for 100,000 to 120,000 volts with a capacity of 4 k.v.a., that is to say, an output which is greater than that of an induction coil. These transformers possess a special advantage in that both high-tension terminals are well insulated from body and from earth. (2) A rectifying apparatus, which converts the high-tension alternating current supplied by the transformer into continuous current, which serves to work the tube. Messrs. Siemens' rectifiers are, it is claimed, specially characterised by the fact that no insulating material is used for the spindle, which is of steel running in ball bearings; that no rotary discs and insulating screens are employed, so that rotating arms of good insulating material well spaced apart move freely with the current-carrying conductors. (3) A driving motor, which in the case of single-phase or three-phase current is of the self-starting synchronous type, and in the case of continuous current is combined with an alternating-current generator. These parts are mounted in full view in the interior of a cabinet, which is made sound-proof. In order to render the apparatus suitable as well for radioscopy and radiotherapy, a high-tension switch is attached which reduces the number of current impulses through the tube by one-half. In the case of single-phase and three-phase outfits, a special device is provided by which it is possible to determine the polarity of the high-tension continuous current before switching in the tube.

Fig. 3 shows a type of universal electro-medical switch-table, for connecting to continuous-current mains and capable of being used in the application of galvanisation, faradisation and galvano-faradisation.

The current for galvanisation and light is generated separately by a small dynamo, and, therefore, there is no danger of the patient or the doctor receiving electric shocks in consequence of earth connections. The machines are made of such a size that even the largest cauteries and loops may be used. Special attention has been given to simplicity in regard to attendance and convenience. By the attachment of a flexible shaft, this apparatus can also be employed for vibratory massage and for drilling, milling and sawing as required for surgical operations.

A high-frequency apparatus is shown in Fig. 4. It is frequently employed for the medical application of high-frequency currents. It is known as the Oudin resonator, and the illustration shows a type which has been improved in construction and efficiency by Messrs. Siemens. The apparatus is connected to an induction coil, which charges the four Leyden jars under the table. These discharge themselves through a spark-gap fixed above them and through the windings on the lower part of the revolving solenoid, the effective number of which may be adjusted by a sliding contact. According to the adjustment of the number of windings, the resonance is more or less defined so that thereby a good regulation is obtained of the strength of the brush discharges, which are produced at the end of the electrode connected with the resonator. These apparatus are also specially suited for the production of auto-conduction of the human body by means of a large solenoid.

Fig. 3.—Universal Electro-Medical Table.

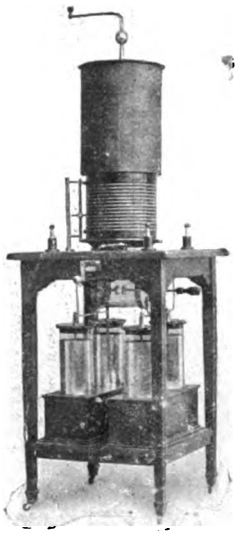

Fig. 4.—High Frequency Apparatus.

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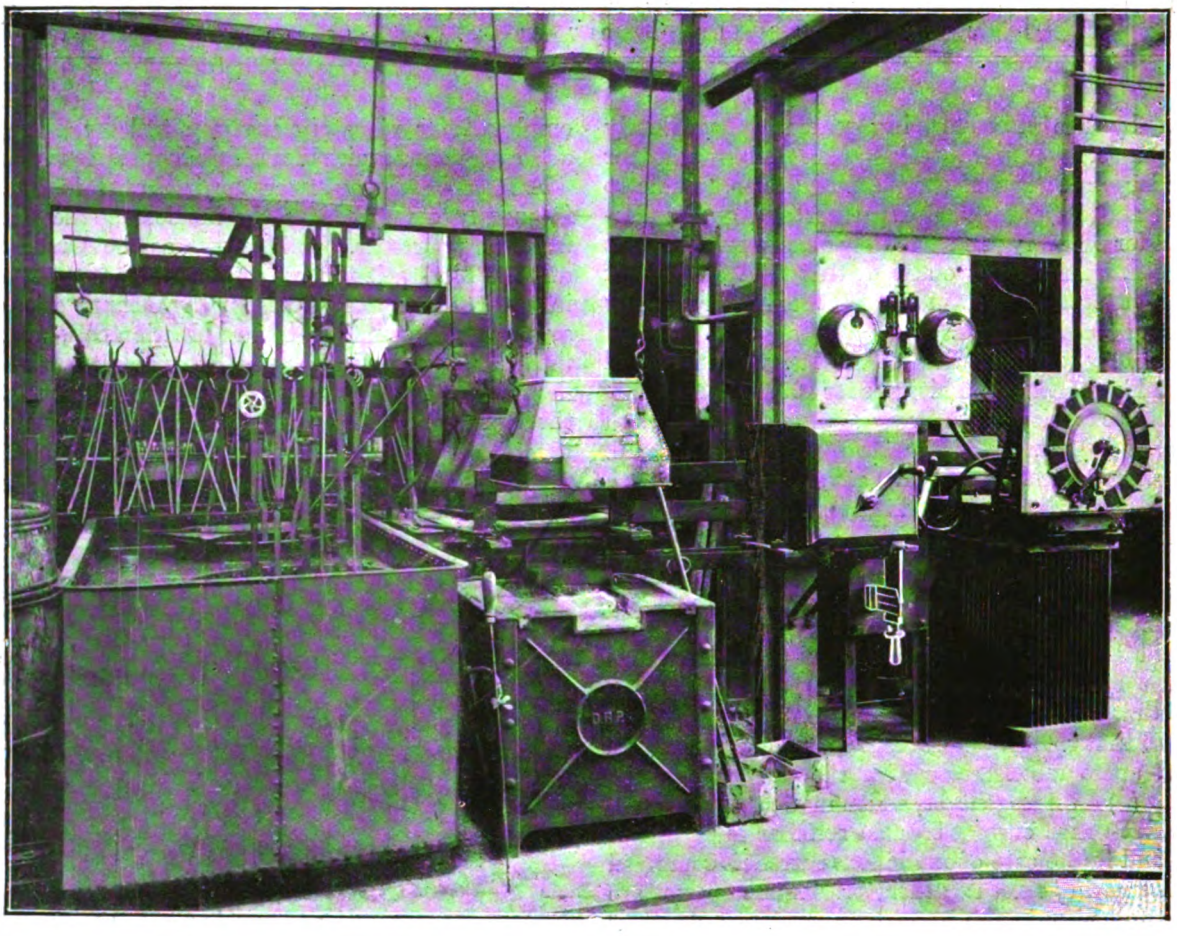

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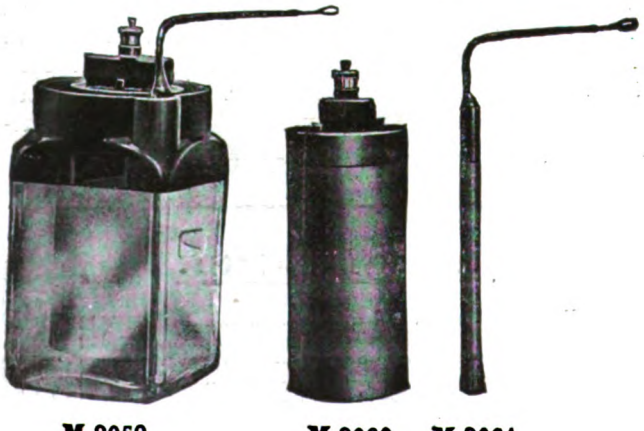

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,684. [No. 2n. Vol. LXV.] FRIDAY, AUGUST 26, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Provisional Order Applications.

THE Board of Trade have issued a revised code of rules with regard to applications for Provisional Orders under the Electric Lighting Acts, 1882 to 1909. The revision has been rendered necessary by the important and useful changes in the law relating to electricity supply introduced by the Electric Lighting Act of 1909. As many of our readers will be interested in the subject, we set out in another column extracts from the regulations, giving the principal modifications made and also the new rules of the Board in regard to applications for provisional orders for the constitution of joint (electricity) committees or joint boards, the supply of electricity in bulk, and the compulsory acquisition of land for generating stations. In regard to the purchase of land, these rules follow the procedure hitherto adopted in the case of bills and provide for due notice being given to the owners of the land to be taken, and also to owners and occupiers of land within 300 yards of the proposed generating station. Provision is also made for those cases where the Board have refused to grant a Provisional Order for the supply of electricity in bulk and it is intended to proceed by private bill. We are pleased to notice continued evidence in the rules of the Board's intention to insist that undertakers who have obtained orders should carry out their obligations within a reasonable time; and among other changes is the reduction of the fee from £50 to £35. The issue of the new rules marks a distinct step in advance in connection with electricity supply undertakings, and we believe that the cheapening and expansion of Provisional Order procedure will give an impetus to the development of electricity supply for power, lighting and industrial purposes in this country.

Glasgow New Telephone Exchange.

WHATEVER telephone troubles Glasgow has experienced in the past, they are, at all events, at an end now. Glasgow has always boasted of its municipal enterprise, and up to the time that the Corporation was seized with the idea of a municipal telephone system it could point to highly profitable undertakings under its control. Water, gas, electricity and tramways, when handled by the Corporation of Glasgow, were all so conspicuously successful that their management has been, and is, held up as a model for emulation by other municipal bodies. But municipal telephony in Glasgow was never able to compare satisfactorily, as a trading concern, with the other departments. There is a trite saying that "the man who never makes a mistake never makes anything," and the spirit of this must be also applicable to corporate bodies. The mistake of its municipal telephone system was, of course, shared by Glasgow with a number of other cities, but its experience with telephones in no way damped its ardour for municipal trading in those other departments mentioned for which it is evidently well suited. However, in the new Post Office Central Exchange the citizens of Glasgow and the people of the surrounding townships have facilities for telephone communication whose efficiency the now obsolete system of the Corporation could never have afforded them. The installation of the common battery system on so large a scale effects a considerable reduction in the list of call wire subscribers, and a complete change-over to common battery working is now merely a matter of time.

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THE magnitude of the undertaking of the new exchange will be gathered from the detailed description of the equipment which appears elsewhere in this issue. One of the most satisfactory features of the installation is the employment, for the first time, of plant which has been manufactured wholly in this country. So much of our large telephone exchange work has been entrusted to American firms that they have come to be regarded somewhat as monopolists in this field. The General Post Office, in its new Glasgow telephone exchange, however, gives the clearest possible indication of its faith in home enterprise by placing the entire contract with a British firm, who have completed the work without hitch of any kind. This gratifying result is worthy of special comment, because it emphasises the presence in this country of a manufacturing organisation which can be relied upon to uphold the reputation of the old country in telephone matters. The work of the installation of large exchange equipments is now highly specialised, and it speaks volumes for the abilities of the contractors for the new Glasgow exchange that they have provided plant which is in the forefront of telephone developments. We may express the hope that this project will be but the first of a long series of successes for British-made telephone exchange apparatus.

Suburban Railways v. Trams.

THE chairmen of our great railway companies have long been wont, in their speeches at general meetings, to bewail the loss of suburban traffic and to ascribe this disastrous state of things to rate-aided tramway competition. It is obvious, however, that no amount of subsidising could have had the smallest effect if it had not been for rapid developments in electric traction; and these very developments are now providing the railways with a powerful weapon by the aid of which they can win back their lost ground. The effect of tramway competition seems now to have reached its maximum, and if the railway companies seriously wish to find a solution of the problem, they can do so by introducing electric traction and running a frequent service on their suburban lines. Suburban electric traction is no longer a matter for doubt, as may be gathered from the regular and efficient working of existing lines under the most arduous service conditions. It is, for instance, not surprising to find that by running a frequent service of electrically-worked trains at cheap fares the London, Brighton & South Coast Railway have succeeded in considerably increasing their suburban traffic and practically counteracting the effects of tramway competition.

WHILE the trains are not so frequent as the trams and the passenger cannot alight at his own door, yet the actual running is speedier and the net time occupied on the journey less. Moreover, as the permanent way is under the complete control of the railway company, while the roads are open to all and sundry, it is possible to arrange and adhere to some form of fixed time table, an advantage which cannot fail to be appreciated by the man whose minutes are valuable. That the advantages of such a suburban service are recognised by other railway companies is shown by certain proposals emanating from the Manchester district, where the traffic conditions are not unlike those which now prevail in London, particularly as regards the London County Council tramways. The suburban train service in Manchester is infrequent and is overshadowed by the Corporation's trams, but we feel sure that some arrangement of electrical working of the local trains like that lately introduced in London cannot fail to be successful. So vast an industrial area as that of Greater Manchester cannot now afford to be behind the metropolis in the matter of its suburban train service, and we hope to see the recent project, which is after all but the revival of a scheme mooted some years ago, come speedily to a practical head. Such a satisfactory development would give the lead to other similarly situated towns and a much needed stimulus to suburban electric traction throughout the country.

Electric Traction in Switzerland.—"The Times Engineering Supplement" states that the new electric railway from Martigny to Orsieres through the Val d'Entremont, Canton of Valais, is completed, and that the inauguration has been fixed for the 27th inst. The line, which is about 11¾ miles in length, will in time be prolonged to the foot of the Grand St. Bernard Pass, via Bourg, and from the climber's point of view will open up a new district—a second Zermatt—crowned by the Grand Combin, Grand St. Bernard, and on the western side by the Mont Blanc range. The line up Monte Mottarone, 4,890 ft. high, in the Canton of Ticino, will be opened, it is hoped, next month. The mountain overlooks Lake Maggiore, and is situated about equidistant from Baveno and Stresa. The total length of the line, which is mostly on the rack system, is about 6 miles, the gradients vary from 5 to 20 per cent., and the motive power is electricity, the installation giving 600 H.P. The cost is estimated at nearly £100,000, and the line will be one of the most picturesque in Switzerland.

Preservation of Wooden Poles.—At the last meeting of the National Electric Light Association a report was presented on this subject, and contained much valuable information and statistics. At present it is estimated that there are required for renewals between 500,000 and 600,000 poles per year, and that during the next 10 years this number will be increased to in the neighbourhood of 900,000 or 1,000,000. As a result of direct inquiry from a large number of transmission companies, the life of various timbers when used for transmission poles was given as follows: Cedar, 13½ years; chestnut, 12 years; cypress, 9 years; pine, 6½ years; and juniper, 8½ years. The committee of the Association recommends strongly that the companies should keep accurate and complete records of poles and cross-arms and collect authentic statistics and literature pertaining to wood preservation. It also recommends the seasoning, and in most cases preservative treatment, of wood. It is claimed that a well-seasoned untreated pole will last at least 30 per cent. longer than an untreated green pole. Directions are given for seasoning, and illustrations show clearly how the poles should be piled. The theory and various methods of wood preservation are also described in considerable detail. No particular process is recommended for all conditions, although experience seems to indicate that coal-tar creosote gives the best results as a preservative, and that the high-pressure process of applying creosote is more flexible.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Assab—Perim	July 8, 1909 ...	—
Malta—Tripoli	April 20, 1910 ...	—
Reunion—Mauritius	May 20, 1910 ...	—
Latakia—Palura	May 26, 1910 ...	—
Obock—Djibouti	June 24, 1910 ...	—
Bonny—Duala	Aug. 3, 1910 ...	—
Hong-Kong—Macao	Aug. 15, 1910 ...	Aug. 22, 1910
Cape St. James—Doson	Aug. 23, 1910 ...	—

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Personal.—On the occasion of the 80th birthday of the Emperor and King, Francis Joseph I. of Austria and Hungary, a special honour was conferred upon Mr. Etienne de Fodor, general manager of the Budapest General Electric Co. The official gazette of Hungary brought the news that the King had with a renewed document confirmed and certified the ancient line of nobility from which Mr. de Fodor's family sprang, and before whose name the predicate "Varkony" is attached. These original papers and family documents were lost during the past wars and political disturbances, and on the 18th inst., in recognition of the scientific services which Mr. de Fodor has rendered, the King has been pleased to reconfirm by Royal Decree his family's pedigree.

Comparison of Arc Lamps.—In a Paper read before the National Electric Light Association and entitled "Magnetite and Flaming Arc Lamps versus Open and Enclosed Carbon Arc Lamps for Street Illumination," the author, Mr. W. d'A. Ryan, compared the 9·6-ampere open arc, the 6·6-ampere enclosed arc, the 4-ampere luminous arc, the 6·6-ampere luminous arc and the 6·6-ampere flaming-arc lamp with vertical electrodes. In the order here indicated, these lamps gave 0·8, 0·9, 1·1, 1·4, and 3·6 mean spherical candle-power per watt, or 1·2, 1·7, 1·7, 2·6 and 5·8 mean lower hemispherical candle-power per watt. The distances from the lamps at which equal illumination would be obtained are 250 ft., 285 ft., 315 ft., 475 ft. and 637 ft. Each of the above lamps was assumed to be operated at a normal E.M.F. of from 70 volts to 80 volts, direct current. In the most highly efficient lamp, use is made of specially treated carbon electrodes, which cost from £4 to £6 per year more than do the electrodes for the 6·6-ampere luminous-arc lamp.

An Electric Light Company and the Telephone.—From a recent issue of the "Electrical World" we gather that in some small installations in the United States there is distinctly friendly working between the electric light and telephone undertakings. There appears to be a small independent telephone exchange near Columbus, Ohio, which has had some trouble in the operation of its lines at night, owing to the proximity of the high-potential alternating-current circuits of the electric light company. It is said that, owing to induction, it is almost impossible to hear over some of the telephone lines because of the noise, but in spite of this the kindness of the electric company enables the telephone people to do some business. When a night call comes in for a physician, or any call which is believed by the operator to be urgent, she telephones the lighting company to shut off the supply of electricity in the village, while the conversation is being held. With this request the electric light company obligingly complies, and the conversation is uninterrupted. Evidently the users of light in that neighbourhood are both easily satisfied and very kindly-disposed folk.

Performance of an Electric Shunting Locomotive.—According to the "Railway and Engineering Review," the Hoboken R.R., Warehouse & Steamship Co. have had in operation since May, 1906, a 60-ton electric shunting locomotive which, it is stated, has given remarkably continuous and economical performance under varying and severe load conditions. Since the electric locomotive was placed in operation four years ago there has not been replaced a single contact on the switch group or a contact on the master switches or reverser, while on the control apparatus only two tips on the live switch have been replaced. The brushes that are in the motors at the present time have been operating 14 months, and it is believed that they will operate at least six months longer without replacement. No trouble has been experienced with broken brushes. Except that there has been replaced one pinion which was broken when a lock washer dropped into the gears, no repairs on the motor have been necessary. The cost of inspection and cleaning has been practically nil. Every Saturday morning the man operating the locomotive makes an inspection of the equipment. With compressed air he blows out the motor and the various parts of the control apparatus, and cleans any part that may need it with a piece of cloth. This work is not charged to maintenance, as the operator in doing it is simply filling in his time. No extra time is needed for maintenance or inspection. The locomotive has a running and a starting drawbar pull of 14,500 lb. and 30,000 lb. respectively, and has a normal speed of 12 miles an hour. It is fitted with four 100 H.P. slow-speed motors, a hand operated unit switch control, and air brakes and compressor.

Wireless Equipment of Lightships.—According to the "Electrical Review and Western Electrician," the United States Lighthouse Board recently furnished a statement of the amount of wireless apparatus that would be required for installation upon vessels belonging to the lighthouse establishment. Only such vessels as go out of sight of land are to be so equipped. There are at present about 20 lighthouse tenders which go out of sight of land and upon which a wireless apparatus could be installed. Besides this number there are 10 other lighthouse tenders which may possibly go out of sight of land occasionally. At the present time none of these tenders is equipped with wireless apparatus, but steps are now being taken to instal a plant of this character upon the tender "Kukui," which does service in Hawaiian waters. Wireless equipment is already in use on four lightships. Six lightships which are stationed 13 miles or more from the nearest land are not provided with wireless equipment and such apparatus might be installed upon these vessels. It is estimated that the cost of installing wireless telegraph apparatus on vessels of the lighthouse establishment would aggregate £700 for each vessel to be so equipped.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. D. Shirt contributes an article on "An Overlap Loop Test."

We continue our description of the new Post Office telephone exchange at Glasgow.

Mr. W. Winsborough gives particulars of the electrical installation at the Rose Bridge and Douglas Bank collieries, Wigan.

We analyse the electricity supply accounts of the Burton-upon-Trent Corporation.

In our correspondence columns Mr. R. Beattie replies to the criticism by Prof. D. Robertson of his article on the "Quadrant Electrometer."

Newcastle-on-Tyne Tramways Committee are considering the advisability of adopting the rail-less trolley system of traction.

The Lancashire & Yorkshire Railway Co. propose to extend their electrically operated train service so as to include the belt route between Liverpool, Ormskirk and Southport.

The Board of Trade have issued a revised code of rules with regard to applications for electricity supply provisional orders.

Loans for Electricity Undertakings.—The L.G. Board have sanctioned a loan of £40,000 for extensions of the Manchester electricity supply undertaking, without holding a local inquiry.

West Ham Corporation have also received permission to borrow sums amounting to £118,525 for their electricity department.

Inquiries have also been held at Peterborough and Bury St. Edmunds into applications for sanction to loans.

Dartford Council have applied for sanction to a loan of £11,000 for electricity supply extensions.

Directors' Report.—The report of the directors of the Yorkshire Electric Power Co. states that the company is making steady progress, and the receipts for the sale of current show a considerable advance over those of the corresponding half-year of 1909.

ARRANGEMENTS FOR THE WEEK

BRITISH ASSOCIATION.

WEDNESDAY, August 31st.

Meeting at Sheffield. Presidential Address, in the Victoria Hall, by the Rev. Prof. T. G. Bonney, Sc.D., F.R.S.

THURSDAY, September 1st.

Addresses by the Presidents of the various Sections. To Section A (Mathematical and Physical Sciences), by Prof. E. W. Hobson, F.R.S. To Section G (Engineering) by Prof. W. E. Dalby, M.A.

[A list of the various Papers to be read during the meeting, which lasts until Tuesday, Sept. 6th, was given in our issue of Aug. 5, p. 676. The actual days on which these Papers will be read will only be announced at the meeting.]

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BURTON-UPON-TRENT ELECTRICITY SUPPLY ACCOUNTS.

The progress made by the Burton-upon-Trent electricity undertaking is always watched with interest by electrical engineers. The annual report of Mr. P. J. Pringle, borough electrical engineer and tramways manager to the Corporation, for the year ended March 31st last, states that the surplus on the present occasion is the largest so far recorded by the electricity undertaking, viz., £1,474. This result is the more satisfactory in that although the output of electrical energy is practically the same as that recorded a year ago, the revenue has decreased, whilst the average price per unit sold is slightly less. It is evident, therefore, that considerable economies have been introduced in the costs of generation. We referred to this point at some length in our issue of May 13th, and further mention of it is made below.

Considering in detail the output of energy, the revenue obtained from private lighting shows a reduction of £206, as compared with last year's figure, due to the further introduction of metal filament lamps and to the effects of bad trade. It is actually less than the figure recorded seven years ago. On the other hand, an increase of £25 is recorded in the revenue obtained from the sale of heating and power units, and an increase of £38 due to an increased output for traction. The net result is a decrease of £149. The number of units sold for private lighting was 300,774, as against 317,129 in 1908-9; for motors 544,484, as against 533,390; and for heating, &c., 16,120, as against 15,159, whilst 1,190 units were sold for public lighting. The Corporation electric tramways required 617,199 units, an increase of 7,310 over the previous year's demand, whilst the Burton & Ashby Light Railways purchased 49,833 units, as against 51,084 units in 1908-9. The total sales, therefore, amounted to 1,529,600 units, an increase of only 1,759 units compared with the output for the previous year.

During the 12 months 53 new lighting consumers were connected to the mains, bringing the total number of lighting consumers to 605, whilst the number of power consumers increased during the same period from 67 to 76. It is interesting to notice that the increase in lamp connections is the lowest recorded for many years. This result is very different from the experience elsewhere, as the advent of the metal filament lamp has generally caused an acceleration in the rate at which lamps are connected to the mains. The unfortunate state of trade in Burton, however, is stated to be accountable for this slow progress.

The total horse-power of motors connected to the mains is now 933, the connections during the past year accounting for 156 H.P. of this total. As applications for 10 motors, representing 118 H.P., were in hand in April of the present year, it is evident that considerable expansion of output is likely to be recorded next year.

In view of the small change in the total output of units, it is not surprising that on the present occasion the maximum demand for lighting and power is almost identical with that recorded a year ago, viz., 500 kw. in 1909-10 and 504 kw. in 1908-9, the maximum traction demand in each year being 375 kw. The corresponding load factors naturally show little change, being 19·69 per cent. and 20·3 per cent. for lighting and power and traction respectively. The capacity of the generating plant remains at 1,710 kw.

In regard to the revenue, the average price obtained for lighting was 4·86d., the figure for the previous year being 4·61d.; whilst for power and heating units the average price obtained was 0·97d., as against 0·98d. last year. For the whole supply the average price was 1·875d.

One of the most interesting features of the Burton electricity undertaking is the restricted-hour power supply. On March 31st last, of a total of 933 H.P. in motors, no less than 744 H.P., or 80 per cent., was supplied on the restricted-hour system. During the 12 months the number of units sold on this system was 430,246, 94,736 of these units being charged at 1d., 76,412 at ⅞d., 58,796 at ¾d. and 200,302 at ⅝d., the average price, therefore, being 0·855d. As the expense of generating restricted-hour units is only about 35 per cent. of the revenue obtained, it is evident that the load must prove very profitable to the supply undertaking.

From the analysis of the expenditure below it will be seen that the total costs have been reduced during the year from 1·03d. to 0·92d., this excellent result being accounted for by a reduction in the fuel item from 0·38d. to 0·28d.; and the costs are now for the first time below 1d. per unit. The important economies introduced in the boiler house, together with the lower price of coal, have resulted in a reduction of £644 or 27·6 per cent. in the total cost of fuel, notwithstanding that the output was slightly higher during the year 1909-10. Of this reduction £418 is attributable to greater economy in working, the remaining £226 being accounted for by the lower prices of coal prevailing throughout the year. Taking into consideration the size of the undertaking, the figure of 0·28d. per unit for fuel reflects the greatest credit on Mr. Pringle and his staff.

We give below an analysis of the expenditure during the year ended March 31, 1910, together with the cost per unit sold for each item, the latter figure for the previous year being also included to facilitate comparison:—

		Cost per unit sold. 1909-10.	1908-9.
Generating Costs.			
Fuel	£1,811	0·28d.	0·38d.
Oil, waste, stores, &c.	362	0·06d.	0·06d.
Salaries and wages at station	1,236	0·19d.	0·19d.
Repairs and maintenance	812	0·13d.	0·14d.
Total Generating Costs	£4,221	0·66d.	0·77d.
Distribution Costs.			
Wages	£34	0·01d.	0·01d.
Repairs and maintenance of meters, motors, &c.	284	0·04d.	0·03d.
Total Distribution Costs	£318	0·05d.	0·04d.
Management Costs.			
Salaries	452	0·07d.	0·07d.
Printing, stationery, &c.	26	0·00d.	0·00d.
Insurance	36	0·01d.	0·01d.
Miscellaneous	117	0·02d.	0·02d.
Total Management Costs	£631	0·10d.	0·10d
Rates and taxes	£683	0·11d.	0·12d.
TOTAL COSTS (*ex.* capital charges)	£5,853	0·92d.	1·03d.
Capital Charges.			
Interest	£2,056	0·32d.	0·34d.
Sinking fund	3,091	0·49d.	0·45d.
Total Capital Charges	£5,147	0·81d.	0·79d.
TOTAL COSTS (*inc.* capital charges)	£11,000	1·73d.	1·82d.
TOTAL REVENUE (from all sources)	£12,474	1·96d.	1·96d.
Surplus	£1,474	0·23d.	0·14d.

This surplus has been allocated as follows:—To capital cost of meters, £166; to stock motors, £129; to capital cost of instruments at power station, £24; carried to renewals fund, £1,155. A further sum of £191 is being transferred to the renewals fund on account of a rebate of income tax for the years 1907-8 and 1908-9. This fund now stands at £4,441, or 5·3 per cent. of the total capital expenditure, which latter amounted on March 31st last to £83,395, an increase of £816 during the past year.

THE ELECTRICAL PROPULSION OF FRENCH SUBMARINES.*

BY J. BREGUET.

At a time when the application of electricity to marine propulsion is so widely under discussion, the following notes on the electrical equipment of the latest French submarines will be of interest to all engineers.

The "Mariotte," "Archimède" and "Amiral Bourgois" of the French 1906 programme have recently completed their tests. These vessels are of about 800 tons displacement, a total horse-power of over 2,000; they have a large radius of action, are habitable, and, in fact, war vessels for offensive operations.

Each vessel has two screws and on each shaft are mounted a thermal prime mover (gas or steam engine) and an electric motor.

* Abstract of an article in "La Lumière Electrique."

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During surface cruising the former drives the vessel and also recharges the accumulator batteries, the motors being meanwhile used as dynamos. When submerged, propulsion is wholly electrical, the maximum speed obtained being 10 knots, the maximum surface speed being about 14 knots. Each motor has practically continuous speed variation from rest to full speed, and, each shaft being controlled quite independently of the other, very quick manœuvring is possible. All manœuvring (such as coming alongside, entering and leaving port, reverse running, picking up course, &c.) is best done, even at the surface, by aid of the electric motors; this course is essential if gas engines be the prime mover and is highly admirable even with steam engines.

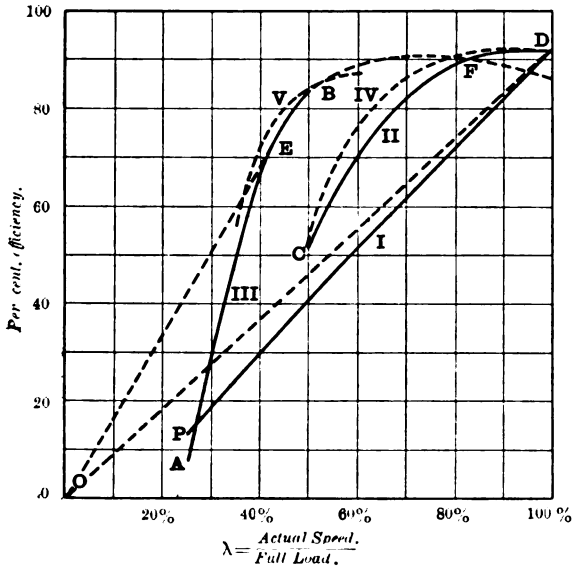
The motors having to fulfil stringent requirements, as regards insulation, heavy and variable duty and use as generators, must be robust and specially designed. A high efficiency is of the greatest importance since, on the efficiency, the radius of action between charging directly depends. Direct-current motors are invariably employed.

Methods of Speed Variation.—The methods used are

(*a*) By use of series armature resistance, reducing the effective applied voltage.

(*b*) By varying the field strength the terminal voltage being constant.

In case (*a*) commutation is good, the field strength being constant, while in case (*b*) special commutating arrangements are necessary since at low fluxes the armature reaction is proportionately high. Compensating windings and auxiliary poles have so completely over-



Efficiency Curves.

come the latter objection that the only practical disadvantages of method (*b*) are the slightly lower efficiency, the higher price and the greater complication. Weight and space considerations make the net balance incline to (*a*). The dimensions and weight of the motor required are, then, those of the standard motor giving P horse-power at N knots and U volts terminal pressure; on reducing U by the addition of armature resistance R_A the speed falls in proportion to the net terminal voltage E (φ being constant); the couple decreases in proportion to (speed)^2 hence the armature current remains constant.

Employing method (*b*), the weight and volume of the equipment depend directly on the minimum speed required with maximum field but no armature resistance. Let this speed be $N_3 = \frac{N}{3}$; then, by supplying the motor with full voltage at full flux, it would, at speed N, give three times the desired output. Such a motor would be unnecessarily costly, bulky and heavy and for this reason it is usual to compromise with a minimum speed of $N_2 = \frac{N}{2}$ at full flux.

Efficiency Considerations as affecting the choice of a speed regulating system:—

Case (*a*). Let N be the normal (maximum) speed,
I be the armature current (at speed N),
U be the voltage of supply,
E be the armature terminal P.D.

Then (U—E) = voltage absorbed by rheostat R_A,
and U = E at speed N.

Further let U × I = P watts,
P_e = Power dissipated in shunt field,
P_i = C^2R losses in armature, brushes, connections
P_p = Iron losses (eddy + hysteresis) + friction losses (bearings, brushes and windage).

Then P_e is constant: $P_i \propto I^2$, *i.e.*, $\propto$ (speed)^4 and the hysteresis losses $\propto$ speed; the eddy losses $\propto$ (speed)^2 and the windage losses $\propto$ (speed)^3 so that it is found that $P_p \propto$ (speed)$^{\frac{3}{2}}$.

If λ be the ratio of the actual speed N′ to the normal speed N and P'_e, P'_i, P'_p the corresponding losses, then

$$P'_e = P_e : P'_i = P_i\lambda^4 : P'_p = P_p\lambda^{\frac{3}{2}} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The armature terminal volts at N′ = E′ = Eλ, so that the rheostat loss $P'_r = (U - E\lambda)I'$ and E = U and $I' = I\lambda^2 \therefore P'_r = (1-\lambda)UI\lambda^2$, hence

$$P'_r = P(1-\lambda)\lambda^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In machines of about 200—600 B.H.P., 300 revs. per min., such as are here concerned, we have, at full load,

$$\left.\begin{aligned} P_e &= P \times 0{\cdot}015 \\ P_i &= P \times 0{\cdot}03 \\ P_p &= P \times 0{\cdot}04 \end{aligned}\right\} \text{(approx.)}. \quad . \quad . \quad . \quad (3)$$

Now the efficiency $\eta = \dfrac{P - (P_i + P_r + P_p)}{P + P_e}$, which, substituting from equations (1), (2) and (3) gives

$$\eta = \frac{\lambda^2 - (0{\cdot}03\lambda^4 + 0{\cdot}04\lambda^{1{\cdot}5} + (1-\lambda)\lambda^2)}{\lambda^2 + 0{\cdot}015},$$

i.e.,

$$\eta = \frac{\lambda^3 - (0{\cdot}03\lambda^4 + 0{\cdot}04\lambda^{1{\cdot}5})}{\lambda^2 + 0{\cdot}015}, \quad . \quad . \quad . \quad . \quad . \quad (4)$$

whence follow the results in Table I.

Table I.

λ	η	
1·00	0.916	Curve I. (*see* figure).
0·75	0·669	
0·50	0·412	
0·25	0·130	

For very small values of λ, η is negative, the equation (4) being only approximately true; over the whole practical range of λ the equation is sufficiently accurate. Owing to the variations in the losses, the current I follows a complex law of variation with λ; equation (4) is sufficiently accurate until the losses become comparable with the useful power; the true efficiency is actually somewhat greater than is given by Table I.

The shape of the efficiency curve (I. in figure) is significant; it is approximately linear and at half speed only 40 per cent. total input is available at the motor shaft, the bulk of the remainder is dissipated by R_A. Owing to this inefficiency the range of action is small, or for a given range the battery equipment is heavy; hence method (*a*) of speed regulation is now only of secondary importance.

Method (*b*).—Constant voltage; variable field. Let the minimum permissible speed at maximum field be N/2.

Let P = volt amperes absorbed by the armature,
P_p = Σ mechanical and iron losses,
P_i = C^2R losses in armature, series field, auxiliary poles and compensating windings,
P_e = C^2R losses in shunt field.

Then since I $\propto$ (speed)^1 $\therefore$ $P_i \propto$ (speed)^6,

i.e.,

$$P'_i = P_i \times \lambda^6. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

With decreasing speed the mechanical losses $\propto$ (speed)^1 ..... the magnetic losses increase on account of the stronger field but decrease on account of the lower frequency, so that the net variations of P_p over the present limits of field and speed are small. The losses are slightly greater at the minimum than at the maximum speed, and the loss curve has a minimum at a speed equidistant from the two extremes; for the present purposes, however,

$$P'_p = P_p. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The law of variation of P_e depends on the load characteristic of the machines; between the present limits of induction the characteristic may be taken as the arc of a hyperbola. The maximum flux

Table II.

λ	η	
1·00	0·916	Curve 2 (*see* figure).
0·75	0·860	
0·50	0·515	

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being at speed N/2, we may assume the asymptotes of the hyperbola to correspond to abscissa N/3.

Then $$P'_e = P_e \times \frac{2}{3\lambda - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and $$\left.\begin{aligned} P_i &= 0{\cdot}035P \\ P_p &= 0{\cdot}040P \\ P_e &= 0{\cdot}010P \end{aligned}\right\} \text{(approx.)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$\therefore \eta\left(=\frac{P - P(P_i + P_p)}{P + P_e}\right) = \frac{\lambda^3 - (0{\cdot}035\lambda^6 + 0{\cdot}04)}{\lambda^3 + \left(0{\cdot}01 \times \frac{2}{3\lambda - 1}\right)} \quad . \quad . \quad (9)$$

which gives the results shown in Table II.

The speed N/2 ($\lambda = 0{\cdot}5$) being the minimum obtainable by field regulation, lower values are secured by armature rheostats (much smaller than in case (*a*)). Henceforth the efficiency closely follows the line joining point C (0·50, 0·515) to the origin (0, 0). (*See* case (*a*)).

A comparison of curves I. and II. shows that method (*b*) secures much the better efficiencies particularly at high speeds; at half speed the advantage is very slight. Here the gain, possible by method (*b*), only that indicated by the relative position of curves I. and II.; the great increase in weight, cost and complexity entailed by (*b*) would hardly be justified. Though method (*b*) has been used in its simple form, it is dealt with here rather as an introduction to the most recent methods of speed control.

At point C the terminal voltage is E, and, N′ being = N/2, $\phi' = 2\phi$; if now E be reduced to E/2 only the original field ϕ would be required to preserve half speed. The speed being constant and the induction B being halved, the iron losses would fall in proportion to a power of B somewhere between 1·6 (hysteresis) and 2·0 (eddy), *i.e.*, P_p, which was originally 0·04P (*see* equation (8)) would then lie between $\frac{0{\cdot}04P}{4}$ and $\frac{0{\cdot}04P}{3}$, *i.e.*, would = 0·0115P (say) . (10).

The output being constant and V halved, C must be doubled . ·. P_i is quadrupled, *i.e.*, $$P_i = 0{\cdot}140P\lambda^6. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

The field induction has resumed its original full load full speed value, but $\lambda = 0{\cdot}5$, hence the new hyperbola asymptote is $\lambda = \frac{1}{2 \times 3} = \frac{1}{6}$

and $P'_e = P_e \times \frac{2}{6\lambda - 1}$ and $P_e = P \times 0{\cdot}01$

$$\therefore P'_e = \frac{0{\cdot}02}{6\lambda - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

so that $$\eta = \frac{\lambda^3 - (0{\cdot}14\lambda^6 + 0{\cdot}115)}{\lambda^3 + \frac{0{\cdot}02}{6\lambda - 1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

giving

Table III.

λ	η	
0·500	0·830	Curve 3 (*see* figure).
0·375	0·585	
0 250	0·575	

Note that curves II., III. lie somewhat below the actual test curves IV., V., so that equations (4), (9) and (13) can be relied upon as giving the minimum efficiencies likely to be obtained in practice.

Curves 2 and 3 simply illustrate, in a new connection, the well known advantages obtainable by series parallel control; in this case a submarine can run at half speed, a convenient and usual cruising speed, at practically as high an efficiency as at full speed. The simplest method of obtaining the requisite 2:1 pressure step at half speed would be to place two motors on each shaft, coupling the machines in series or parallel according as full or half speed be desired. The objection to having two motors per shaft when one would suffice is sufficiently serious in submarine work, but the vital disadvantage of the suggested simple series-parallel arrangement is, that if the slightest inequality in the field-strengths of the two machines be introduced during their regulation, one armature at once takes the whole load, the second acting as a generator feeding the first; heavy circulating currents flow, the armatures are overheated, if no worse, and the circuit breakers continually open.

The load distribution between the two rotors, mechanically compelled to the same speed, depends entirely on the relative fluxes in which they run and is so unstable that series-parallel operation of variable shunt field machines, on the above system, is impracticable.

Actual arrangement on board the "Mariotte."—Instead of connecting two armatures in series or parallel, the Breguet firm (responsible for the electrical equipment of the "Mariotte" and her sister vessels) have adopted the use of two half batteries connected in series or parallel at will. The efficiency as a function of the speed varies as follows: From full to ¾ speed the efficiency falls slowly from 92 to 85 per cent., from ¾ to ½ the efficiency falls rapidly, finally (at $\lambda = 0{\cdot}5$) being only 50 per cent. The two halves of the battery, hitherto in series, are now parallelled. The efficiency rises abruptly to over 80 per cent. in consequence of the halved voltage; between ½ and ¾ speed the efficiency remains good and then falls very rapidly to join, at ¼-speed, the efficiency curve obtained by the first method (series batteries). For speeds below $\lambda = 0{\cdot}25$ a series armature resistance is employed for speed regulation.

The efficiency-speed curve when running with constant field and variable pressure is practically a straight line through 0 (*see* notes on method (*a*)), hence it is economical to keep the field fixed and operate by series R_A at speeds below that at which the tangent to the field regulated efficiency curve passes through 0 (*see* point E in figure). Thus, contrary to what one might expect *a priori*, it is advantageous to regulate at low speeds by armature resistance, keeping a medium field strength, rather than by the use of abnormally strong excitation and constant supply pressure.

The dotted portion of curve III. of diagram has been supplied by calculated extrapolation; it shows the efficiency with the batteries *in parallel* to lie between 85 and 90 per cent. over the range $\lambda = 0{\cdot}5$, $\lambda = 1{\cdot}0$. The point of intersection F of II. and III., at about 0·85 × full speed, is clearly the theoretical point at which the conversion from series to parallel connection should occur. The armature current is then $I' = I \times (0{\cdot}85)^3 \times 2 = 1{\cdot}225$ I.

It is not advisable to work at so high a point of conversion as F because the field is then unduly weak as compared with the increased armature reaction; further, the armature heating is then excessive. By converting at $\lambda = 0{\cdot}75$, however, $I' = I \times (0{\cdot}75)^3 \times 2 = 0{\cdot}841$, *i.e.*, the current is less than its full load full speed value. A valuable gain in efficiency at speeds between $\lambda = 0{\cdot}5$ and $\lambda = 0{\cdot}75$ is thus obtained by the use of suitable R_A and field regulation, conversion from series to parallel connections being at ¾ speed.

The provision of sufficient field regulation to vary the speed from $\lambda = 1{\cdot}0$ to 0·75 enables the speed $\lambda = 0{\cdot}375$ to be reached simply by converting the battery sections from series to parallel connections; the tendency is, however, to provide as small an armature resistance as possible with a minimum number of stops, as low a speed (say, $\lambda = 0{\cdot}25$) as possible being obtained solely by field regulation. This course is dictated by operating conditions and not by efficiency considerations. . . . . (α)

At low speeds the efficiency is less dependent on the latter; the total power concerned is small and the useful energy may become less than the losses.

Actual arrangement on board the "Archimede."—Series-parallel armatures are adhered to on this vessel, while, to avoid the difficulties of instability of load, both windings are on one core, and hence, of necessity, always in equal fields. Two commutators are required and only one supply battery. Inherently the solution is no different from that employed on the "Mariotte," but the practical advantages are as follows:—

1. The current per commutator (in parallel) is only one-half its value in the "Mariotte" under the same conditions; commutator design and operation is thus facilitated.

2. Series-parallel connections between the switchgear and motors are very short, the boards being as near the motors as possible, whereas series-parallel leads from switchboards to accumulators are much longer, the latter being in a separate compartment, usually at the other end of the vessel.

3. Advantages in accumulator charging as below.

Charging Accumulators.—The electric motors which drive the submerged submarine act as charging dynamos during surface running; the prime movers of the vessel must be able to drive the latter at the desired maximum speed on the surface, meanwhile leaving a sufficient balance of power to recharge the battery within reasonable time.

Let the maximum surface and submerged speeds be N_t, N_e. The torque of a thermal engine being roughly constant at all speeds the output $P_t \propto$ speed,

so that $$P_t = P_{t\max.} \times \lambda, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

The power absorbed by the screw $\propto \lambda^3$

i.e., $$P_h = P_{t\max.} \times \lambda^3, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

hence the available surplus power on the shaft

$$= P_d = P_{t\max.}(\lambda - \lambda^3), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

which is a maximum when $\lambda = \sqrt{\frac{1}{3}} = 0{\cdot}576$, so that under the most favourable conditions the excess power available for cell charging is

$$P_d = 0{\cdot}384 \times P_{t\max.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

In the present instances the surface speed is about 40 per cent. > submerged speed, this necessitating a horse-power of prime mover = about 3 × horse-power electric motors.

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Then P_d is a maximum for a speed

$$= 0{\cdot}576N_d = 0{\cdot}576 \times (1{\cdot}4N_e) = 0{\cdot}8N_e \quad . \quad . \quad . \quad (18)$$

It is best to recharge all the cells in series, this ensuring the same current through all; the motors running as generators must be able to attain an E.M.F., say, 40 per cent. above the normal discharge voltage of the cells. The motor field should not be above 80 per cent. its full strength during charging, the efficiency having been shown to be poor at high excitation, besides which, the field coils become very hot if run fully excited for such long periods.

The normal maximum voltage E_m is obtained from the motors at a speed of $0{\cdot}5N_e$ with full excitation; hence, to secure ($E_m + 40$ per cent.) volts with a flux of only $0{\cdot}8\ \phi_{max.}$ requires a speed

$$N_e = \frac{0{\cdot}5 \times 1{\cdot}4}{0{\cdot}8} N_e = 0{\cdot}875N_e \quad . \quad . \quad . \quad . \quad . \quad (19)$$

clearly a fortunate coincidence with the requirements of equation (18).

Thus between $0{\cdot}8$ and $0{\cdot}9 \times N_e$, *i.e.*, at about $0{\cdot}6 \times$ the maximum surface speed, a good cruising speed, charging conditions are at their best.

If P_e be the maximum output of the motors then, since

$$P_{max.} = 3P_e \ : \ P_d = 3P_e \times 0{\cdot}384 \ (see\ (17)) = 1{\cdot}15P_e, \quad . \quad . \quad (20)$$

i.e., the charging load is rather above the maximum output of the motors on minimum flux, but quite within their capabilities at $0{\cdot}8\phi_{max.}$ excitation.

Time of Charging.—The batteries maintain an output of P_e kilowatt at a speed of $0{\cdot}715N_e$ during H hours;

$$\text{hence the charging period} = H' \text{ hours} = \frac{H}{0{\cdot}5 \times 1{\cdot}15} = 1{\cdot}75H \quad . \quad . \quad (21)$$

(assuming an overall efficiency for batteries, leads and generators of 50 per cent.). The charging period is 75 per cent. longer than the discharge period, but whereas discharge occurs with a vessel speed of $0{\cdot}715N_e$, charging takes place at $0{\cdot}6N_e$ (20 per cent. slower).

A double commutator motor allows of recharging at a lower speed of motors and vessel, for, by connecting the commutators in series, the requisite E.M.F. can be obtained at ½ speed (with maximum flux),

$$i.e., \ N''_e = 0{\cdot}25 \times \frac{1{\cdot}4}{0{\cdot}8} N_e = 0{\cdot}4N \ (see\ (18), (19)) \quad . \quad . \quad (22)$$

This ability to obtain a given charging voltage at half the speed otherwise necessary is a very valuable advantage in the present case.

Practical Difficulties; Future Developments.—The above considerations show some of the conditions and difficulties to be met with in the electrical equipment of submarines. Practical difficulties far greater than would appear from the above have to be overcome at every stage in the vessel's building and equipment; among the chief of these are:—

1. The very limited space available for motors.
2. The poor ventilation and cooling obtainable.
3. The humidity of the atmosphere and consequent insulation difficulties.
4. The complexity of the control gear, further hampered by space restrictions and the essential need for reliable and rapid operation. (The Védovelli Priestley controllers are used on the "Mariotte" and "Archimede.")

Future developments in the electrical equipment of submarines will probably be on the following lines:—

1. Higher voltages, probably 480 volts, will be employed in the main motor circuits only. This will lead to the saving of considerable space and copper, both in the motor rotor and in the armature rheostat, battery, leads, &c.

The difficulty of providing adequate insulation will be reduced by confining the high-tension circuits to the main motors. All lighting, contactor solenoids, field bobbins, starting resistances and, above all, the connections and contacts of the controllers would still be low-tension (120 v. or 240 v. = ¼ or ½ main battery respectively) and of normal insulation. The high-tension battery leads could be easily insulated, but the maintenance of the motor insulation, particularly in the armature, will involve

2. The use of completely enclosed motors in place of the present open type. Inspection doors for brush examination will be required as usual. Total enclosure will, in turn, involve:—

3. The use of water cooling, such as is already employed in high-tension transformers. Circulation of the water will be maintained naturally or by circulating pumps.

4. All main switches will be of the oil-break type; very strong and easily accessible. Their number will be reduced to a minimum by the reduction of the armature resistance (*see* note (α) above).

Minor contacts, then as now, will offer no difficulties.

Such are the tendencies in French submarine construction; the developments foreshadowed will be largely realised in the new vessels of over 1,000 tons displacement already under design.

DRY CELL TESTS.*

BY F. H. LOVERIDGE.

Summary.—The author gives some useful data regarding the fall of E.M.F. and increase in internal resistance of dry cells under ordinary working conditions. His figures embrace those obtained from tests carried out when cells were allowed to send currents for lengthy and continuous periods, as well as others obtained by causing the cells to send intermittent currents such as are required for ignition work.

If we are to judge by numerous inquiries from users of "dry cells" as to the electrical qualities which such cells possess, the conclusion is reached that ideas along this line are very indefinite.

It would seem to be a very desirable thing to have dry cells rated on an ampere-hour or watt-hour basis under some definite condition of energy discharge, but such a thing is practically unknown at the present time. The rating we now have is that of dimensions of the cell and its current. The first might be accepted as reasonable, but the second is misleading. Amperage ratings are high and apparently based on the instantaneous current a cell gives when short-circuited through a low resistance ammeter; such readings are of practical value in discovering defects, but so far as determining an energy output is concerned, they are of little value because the sustained current a cell can give has very remote relation to the short-circuit current. The voltage reading is also useful in discovering defects, but inasmuch as the cell may give out a very considerable part of its energy and cause only a small drop in this value it follows that such readings are not of much importance.

The "shelf test," or, in other words, the test made after a cell has remained for a certain time in storage, is one that serves a useful purpose, for the reason that it is desirable to know the change that takes place during such period. Very few cells go into service immediately after they are made, and during the delay more or less deterioration takes place. There is, however, the difficulty that if the test comprises readings of current with a low resistance ammeter, a decrease of 50 per cent. in its value would indicate only an insignificant increase in internal resistance, which would be unimportant with ordinary current drains. If current readings are taken with a resistance inserted in series, then the variation showing the change in internal resistance is correspondingly reduced. Where it is desired to take the current and voltage of a cell, it should be done by means of instruments that do not absorb a large part of the energy in themselves. Hence a high resistance voltmeter and a low resistance ammeter should be used—a minimum of 150 ohms for the voltmeter and a maximum of 0·01 ohm for the ammeter are found to be satisfactory values. Taking everything into consideration it appears that the best shelf test is one that compares the actual performance under working conditions of the cell after a certain length of time on shelf, with that of a new cell. In this way results are obtained that involve no factors of uncertainty. There is involved in this the using up of cells to find out what they will do on life test. Such procedure, however, seems necessary, since other methods involving tests not absorbing energy are not dependable and sample cells used up on life tests do not represent very great expense.

Deterioration is shown by an increase of internal resistance, inasmuch as voltage readings decrease very slightly on the shelf. It is impossible to give any exact data as to the increase of internal resistance on the shelf, because there is such a wide variation even in cells of the same make, but, roughly, it might be said that a reduction in the short-circuit current of 50 per cent. would be a fair average in one year at ordinary temperatures. The question of change in internal resistance from change in temperature is sometimes brought up. One test in which a decrease from 100°F. to 25°F. below zero produced an increase in internal resistance of only about 100 per cent.—even at this latter temperature the internal resistance was so low as not to interfere seriously with a light current drain. The indications in this test were that the increase of internal resistance was proportional to the decrease in temperature.

Life tests are often made on dry cells by connecting them permanently in circuit with a fixed resistance. This method is the easiest one to employ, as it requires no attention other than the taking of readings at the desired intervals. Such a test is of no great value, however, as the energy output is small and the life very short unless the current is kept low. Under these conditions the staying qualities of the cell are not demonstrated, and the ability of the cell to stand up under ordinary current drain after a considerable period on "open circuit" service cannot be predicted with safety.

In Fig. 1 is shown the result of tests made on dry cells of the standard 2½ in. by 6 in. size, in which the circuit is closed continuously through a fixed resistance, the resistance in each case being

* Abstract of a Paper read before the American Electrochemical Society.

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indicated by the figure on the curve. The ordinates give the P.D. at the terminals of the cell and the abscissæ the time in hours. It will be seen from an inspection of these curves that there is a very rapid drop in potential at the terminals of the cell when the resistance is small. As the resistance increases the length of time required to reach any given P.D. is increased. Thus after 10 hours the P.D. at the terminals of the cell has reached 0·5 volt where the resistance in circuit is 1 ohm, whereas with 10 ohms in circuit a value of 0·5 volt is reached after 285 hours.

There is a wide variation in the energy derived from cells under these varying conditions as would, of course, be inferred from the forms of the curves. The value of this energy output in the different cases has been figured to a point at which the P.D. has fallen to 0·5 volt and is found to be as follows:—

With	1 ohm	7 watt hours.	
,,	2 ohms	8	,,
,,	4 ,,	14	,,
,,	6 ,,	21	,,
,,	10 ,,	24	,,

These values would, of course, be modified if the integration were carried to lower points with the lower resistance, but inasmuch as 0·5 volt is only one-third the initial E.M.F., it is seen that we are carrying our energy drain to quite a low point and that the volume of current has fallen to one-third its original value. These curves show approximately what may be expected as the characteristic performance of dry cells under the above conditions.

As we have seen that the "closed circuit" test is not a safe one for "open circuit" work, the best test we can apply is the "open circuit" one in which the cell may be made to show what its life characteristics are when its energy is used over a relatively long period. Sample cells are generally taken for this purpose and tests should duplicate working conditions as nearly as may be. Some form of clock-controlled contacts are very well adapted to this purpose and may be made to control the open and closed circuit periods

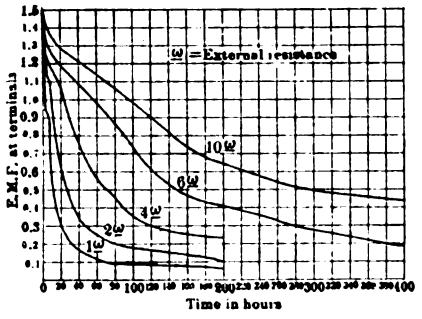

Fig. 1.

in any manner desired. It is also a good plan to use relays controlled by clock contacts for closing the test circuits. By this means, the master or pilot contacts on the clock are only used for light currents, and it is much easier to maintain them in good condition. The mechanism and contacts should be well made and reliable, as it is difficult at best to get consistent results. The shorter tests as a rule give results more satisfactory as regards uniformity than long ones, the chances for variable factors entering being greater with increased time.

In taking readings on dry cells, it is, of course, necessary in either "closed" or "open circuit" tests to have some form of voltmeter to measure the voltage. It is also desirable to use such an instrument for current readings employing the fall of potential method, as this enables current readings to be taken without disturbing circuit connections. If an ammeter is inserted in circuit from time to time, there is a tendency to vary contacts and resistance. Anything tending to introduce variations should be carefully avoided.

In Fig. 2 is shown a set of three curves representing the relation between E.M.F. (curve A), P.D. at the beginning (curve B) and P.D. at the end (curve C) of the closed circuit periods taken from an open circuit test of a standard dry cell. The E.M.F. is seen to be a gradually diminishing quantity, which, however, remains at a comparatively high level. At the instant of circuit closure the P.D. immediately falls and the divergence of curve B from curve A indicates the increase in internal resistance. Curve C also diverges from curve B, thus indicating polarisation during the closed circuit period. The lowest curve is in reality the one of greatest value, for it indicates the level at which the cell maintains its potential under severe conditions. These curves are also of interest as showing what may be expected in the way of internal resistance. The question is often asked as to the magnitude of the internal resistance of dry cells. From the above curves it is seen that there is a continual increase in this quantity as energy is given out. We know also that the internal resistance is very low when the cell is new, for the current on short-circuit is high; as the cell grows older on the shelf the resistance is continually increasing, though to a much smaller extent than when it is on even very light service. In attempting to answer the question, it is necessary to take both these factors into consideration. Hence the requirement for a definite answer is a definite statement of conditions.

In Fig. 3 four curves are shown which are plotted from the results of intermittent tests, each curve representing a special condition. The values are taken from the P.D. at the end of closed circuit periods. As will be seen from the data, curves A and B represent the same external resistance, which is about 1·6 ohms. Curves C and D represent the same conditions, but with 6·6 ohms. Curves B and C represent conditions where circuit closure averages about 0·5 hours per

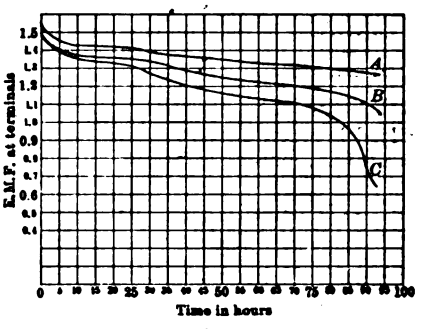

Fig. 2.

day and curves A and D represent an average of about 0·2 hours per day. An integration has been made to an arbitrary point where the P.D. has fallen to 0·7 volt. Where the resistance in circuit is low the watt hours are higher than with corresponding time conditions and high resistance. It seems from this that, down to the integration point taken, cells will give out more energy when allowed to do so at the high rate. At the low rate the energy, th ugh less in watt hours, extends over a longer period of time and the P.D. is maintained at a much higher level. In the tests in which the same resistances are used but the time varied, it will be noted that the watt hours are less with the smaller daily period. This is to be accounted for largely by deterioration taking place over a longer period of time. It is probable that it is due in large measure to the fact that when current is drawn from the cell the action is not uniform; this lack of uniformity would tend to set up P.D. in the cell itself. The result would, of course, be the setting up of local action which would deteriorate the cell to a degree determined by the unbalancing. A degree of unbalancing is to be expected which bears some proportion

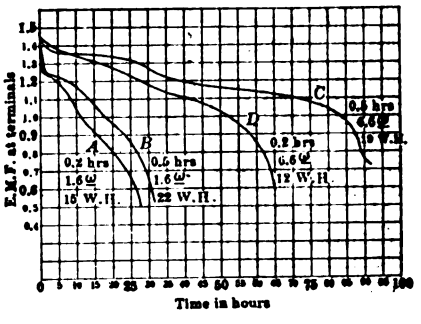

Fig. 3.

to the magnitude of current. The energy of curve A is less than of curve B by about the same amount that curve D is less than curve C, but C and D represent much longer periods of test, hence a smaller rate of deterioration.

In Fig. 4 are two curves which represent tests similar to that shown in curve D in Fig. 3. The conditions being slightly different from that of curve D, the two curves should be compared only with each other. The integration has been carried to 0·9 volt and shows 8·5 watt hours for the longer duration (curve B), as compared to 9 watt hours for the shorter (curve A); the energy, however, in these two cases may be considered as practically identical. We see here the same characteristic of longer duration and higher level with increase in resistance in the external circuit.

In Fig. 5 are shown two curves representing intermittent tests, which are similar to those in Fig. 3, with the exception that in

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curve A the resistance has been increased to 20 ohms. The duration of the test is approximately one year, and, considering this factor of time, the energy output is very good, the watt hours being about 16 when figured to 0·9 volt. The current drain being light, it is probable that there is small opportunity for irregular action. Curve B is for a still lower current, the resistance being increased to 25 ohms. Although the current is low, the time of closed circuit per day is comparatively long, thus bringing the watt hours up to the comparatively high figure of 30. In integrating curves of this nature, the true value of course lies as a mean between the P.D. at the beginning of the closed circuit period and the P.D. at the end. In these integrations, however, the P.D. at the end of the period has been used because the desire has been to show characteristic action rather than to give exact laboratory data.

Curve C in Fig. 5 represents the result of a test made on ignition service. As no attempt was made to determine the energy, no deductions of this nature can be made. It is, however, of interest as showing what seems to be the requirement for this class of work, and that it is a sustained high potential for the period of its useful life. There are difficulties to be overcome in arriving at any adequate idea of the energy requirements for ignition service. The resistance as well as adjustment of spark coils is very variable and the time of service, as for instance in automobile work, is apt to vary between wide limits. In striving to obtain the highest efficiency, it is necessary to know working conditions, such as current drain or resistance of circuit, and the frequency and duration of circuit closure. Knowing these factors, the proper arrangement for the required number of cells can be made to obtain the best results. It is frequently found that cells in parallel may be advantageously employed for the reason that excessive current drains may thus be avoided. The characteristic action of cells indicates that under heavy current drain the fall of potential is rapid and the energy obtained is small, hence the plan of placing "enough" cells in series may not be advisable;

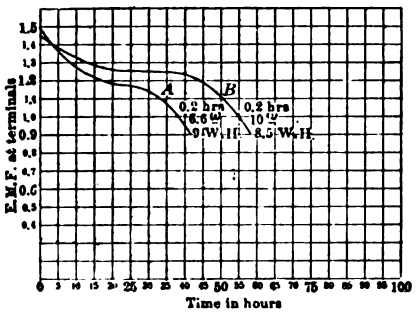

FIG. 4.

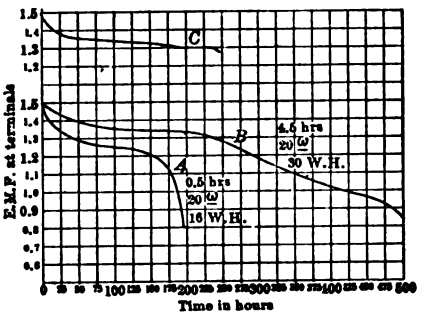

FIG. 5.

an excessive current is of no benefit and on the other hand draws energy in an inefficient way. A high potential may be maintained by placing cells in parallel so that the current drain on each will be light. Such a plan utilises the energy available in a far more efficient way, since we know that at high levels we obtain the greatest amount of energy.

Tests are sometimes made in which a fixed current is caused to flow, but in order to accomplish this, the resistance must be constantly changed. Such tests are interesting, but the conditions are not those ordinarily met in practice. A constant current flow is desirable, however, and a very close approximation to it may be made with dry cells, provided they are arranged for the high level rate of discharge.

One of the important factors in obtaining data from dry cell tests is the "cut-off" point, or, in other words, the value to which the P.D. of the cell may be allowed to fall before it is considered exhausted. The lower a cell is run, the greater will be the energy obtained, but this is offset by the greater variation in P.D. Hence a compromise must be made. A study of conditions must govern the selection of this point in various classes of service, but it should be remembered that it involves one of the most important elements in obtaining best results. The battery gauge is a factor in the situation that must be considered. As a rule, these instruments are constructed as a species of volt-ammeter, in that they are either high resistance ammeters or low resistance voltmeters. As they are not expensive, it can hardly be expected that they will compare favourably with Weston instruments in exactness of indications. The scale divisions generally indicate amperes, and the intention is to show what current would flow if the cell were short-circuited through a low resistance ammeter. The coil of the battery gauge being of only a few ohms resistance, there will be a variation in current depending on the internal resistance of the cell; the deflections of the needle will be approximately proportional to the current strength. When the internal resistance has increased to a considerable extent, the battery gauge is capable of giving a good indication of it. Thus when a cell is exhausted, a battery gauge is convenient and fairly reliable for indicating the condition of the cell. Battery gauges are not reliable for detecting small variations in the condition of a cell, nor for determining accurately any exact condition. Where exact conditions are desired, the best that can be done is to allow the normal working current of the cell to flow and then take a P.D. reading with a standard high resistance voltmeter. Such readings give the best indications of the stage a dry cell has reached in the period of its useful life.

IRON-BAR OVERHEAD CONSTRUCTION AT BROOKLYN.*

One of the most interesting and novel features of the overhead construction of the Brooklyn Rapid Transit System has been the invention and application on a wide scale of iron-bar overhead conductors.

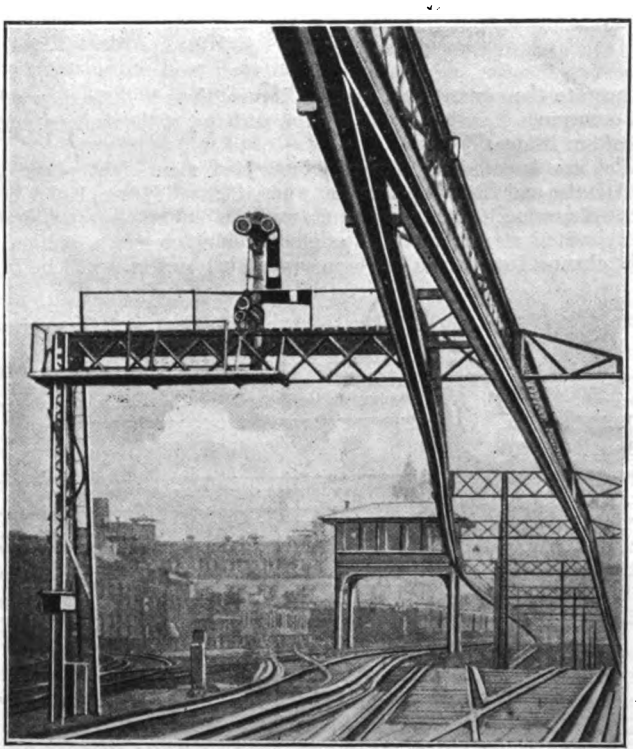

FIG. 1.—IRON BAR CONSTRUCTION ON BROOKLYN BRIDGE SURFACE CAR INCLINE.

These bars are used wherever traffic is heavy and at every important intersection under the elevated railway structure. The adoption of this practice meant a great deal more than the simple suspension of the bars, as it was necessary to design section insulators, expansion joints, frogs, diagonals, feed-in castings and other auxiliaries required to obtain a well-rounded and complete system of overhead construction, All of these details have been worked out with such

* Abstract of an article in the "Electric Railway Journal."

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success that the iron-bar overhead suspension, wherever used, has proved remarkably reliable and far easier to maintain than methods hitherto regarded as standard. Admitting the reliability of the iron bars for permitting a practically uninterrupted car service, the objection might be raised that they must be very hard on the trolley wheels. This drawback has not been an appreciable factor, however, because the bars are installed only in locations where the traffic is too heavy to operate the cars at high speeds. Hence, there is little chance for the occurrence of severe arcing, except, perhaps, at the inclines on the Brooklyn Bridge.

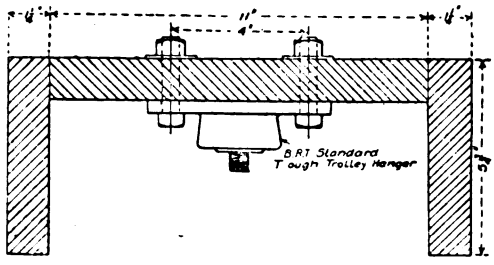


FIG. 2.—TROUGH WORK.

The iron-bar construction was first tried some eight years ago at Atlantic and Flatbush-avenues, where the trolley wire had a very short life owing to the heavy traffic and the limited clearance under the elevated structure. The original conductor was a section of light channel iron, which has been superseded by ⅜ in. by 2½ in. bars of round-edge iron. The latter have been found cheaper than the channels, can be more readily purchased in the open market, and are spliced and installed more easily. In cases of emergency, even a square-edge bar may be installed, leaving the trolley wheels to round off the bar in short order. The bars may be of any commercial grade of iron or steel.

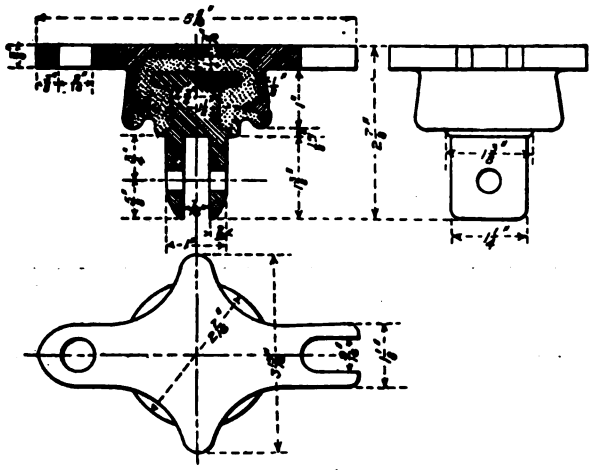


FIG. 3.—TROUGH BAR HANGER.

The bar suspension is also of the greatest value where clearances are so low that the trolley contact has to be offset 4 in. to 6 in. from the centre line in order to permit the cars to operate at all, considering the bending of the trolley poles. An idea of the durability of this work may be obtained from the statement that all the bars at the Brooklyn Bridge terminal on the Brooklyn side have been in use since April, 1908, without change, and are expected to last until February, 1911, at least, whereas even phono-electric wire was not serviceable for more than five months at the same location. At other places frogs and diagonals of the bar design last four to five times as long as those of the composition metal, and cost a great deal less.

All bars are made up in the line department's shops to standard lengths of 16 ft., and are suspended at intervals of 8 ft. Fig. 2 shows the latest form of trough used with this standard bar and hanger. The hanger design permits the use of a lighter bottom-board than heretofore and avoids boring a large hole for the insulating stud, thereby producing economy both in labour and material. The standard trough bar hanger is shown in Fig. 3. It does not differ from the Brooklyn Rapid Transit wire hanger except for the stud.

The composition iron-bar end casting for No. 00 wire illustrated in Fig. 5 is employed to join the overhead wire to the conductor bar.

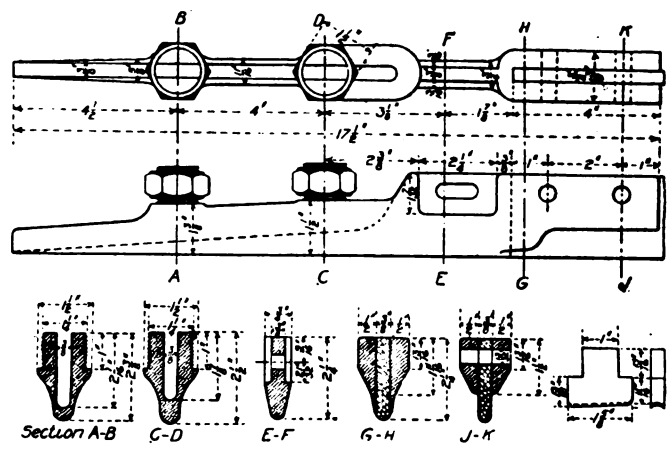


FIG. 5.—COMPOSITION IRON BAR END CASTING.

The casting is riveted to the bar. Means for suspending this casting from the trough are provided by a slotted hole, which allows for the expansion of the bar.

The standard right-hand iron-bar frog (Fig. 4) is designed as an entering frog, and operates properly with all types of cars, whether they have one or two poles, are single or double truck, &c. These frogs are made for standard overall lengths and can be inserted in the conductor bar by removing and replacing six rivets. It has not been thought desirable to use bolts, as the little extra time required to remove the rivets is not objectionable, because generally there is no need for removing the frogs in a hurry, and the changes can be made when it is most convenient. The rivets give better electrical contact than bolts, and none of them has ever been burned out in service.

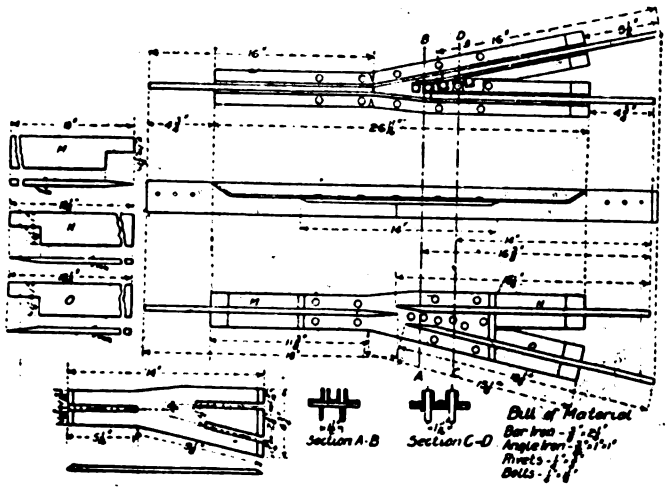
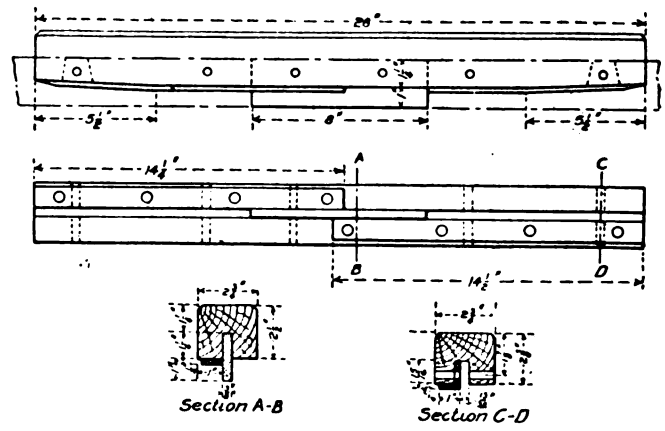


FIG. 4.—STANDARD IRON BAR FROG.



Note.—Wrought iron wearing strips to be fastened, as indicated, with 1-in. No. 10 flat-head screws, countersunk. Insulation—Hard fibre. Wood—Maple or oak.

FIG. 6.—IRON BAR SECTION INSULATOR.

The bar-iron section insulators are made with fibre centres, as indicated in Fig. 6. These devices have given a life exceeding 10 months

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over the most heavily travelled tracks in Brooklyn. At street intersections it is the practice to put bar section insulators into the trough work to avoid having insulated crossings or section breakers in the trolley wire. The bar method gives a more durable and reliable means of insulating the intersecting lines. The principle of the bar section insulator construction has been applied to the circuit-breakers of the electric automatic track switches operated by the company. These circuit-breakers have been found to last longer than the original designs furnished by the track switch manufacturers.

Side-feed taps are made into the conductor bar by means of a brass casting. This casting has two bolts for the connection to the bar. It is drilled in the upper part to receive a sleeve, into which the copper feed wire is wedged and soldered and then held in place by set screws.

A number of illustrations in the article show typical portions of the overhead construction. Fig. 1 gives a good idea of the equipment.

AN OSCILLATION DETECTOR ACTUATED SOLELY BY RESISTANCE TEMPERATURE VARIATIONS.*

BY W. H. ECCLES, D.SC.

Summary.—The author describes experiments on a detector of the crystal rectifier type as additional support for his hypothesis of the mode of action of electrical oscillation detectors.

In a recent communication to the Physical Society† the properties of a type of iron-oxide coherer were discussed. The Paper described experiments on coherers made by dipping a slightly oxidised iron wire into clean mercury, or by pressing a fine iron wire against a thinly oxidised iron plate, and the results were discussed mathematically. It was shown that in the case of the iron point and oxidised plate the whole of the experiments could be explained qualitatively on the assumption that the only electrical phenomena at play were the Joule effect and the resistance-temperature changes in the small mass of oxide between the metal electrodes.

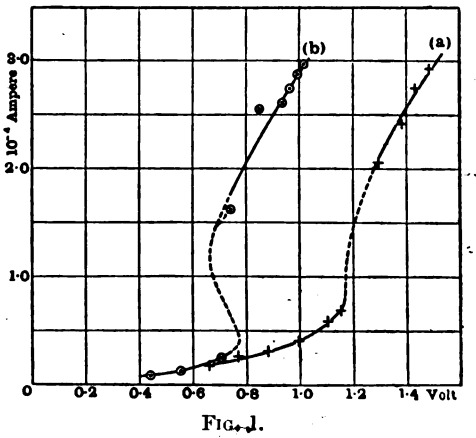

FIG. 1.

The hypothesis that was put forward by the author supposes that a train of oscillations, by yielding its energy as heat to the contact, raises the temperature there and disturbs the existing equilibrium of current and voltage. The dissipation of a train of oscillations is accomplished in a time of the order of a fifty-thousandth of a second; the ensuing fluctuation of the current causes the sound in the telephone. In the Paper cited, the energy w given to the telephone circuit was shown to be connected with the energy W delivered by the train of waves by the equation $w = m(W - a)$, where m and a are constants for any fixed value of the current. This theoretical conclusion agreed well with the experiments on an iron oxide coherer. The object of the present Paper is to show that the above hypothesis holds good for a very different type of detector.

All the well-known forms of "contact" detector consist of a contact between two substances that stand well apart in the thermoelectric series; and the thermoelectric force plays a very important part in their operation. They are usually classed as "rectifying detectors," to distinguish them from such detectors as the coherers. In seeking a "rectifying detector" that would illustrate the above hypothesis, substances that stand far apart in the thermoelectric series must be avoided, for such substances would introduce Peltier effects that would tend to mask the resistance-temperature phenomena we wish to isolate. Even in the iron : iron-oxide : iron coherer it is possible that thermoelectric forces arise owing to unequal heating of the two iron to iron-oxide junctions. It occurred to me, therefore, to construct a detector out of one substance only. Accordingly a search was made for a substance possessing high, but not too high, resistivity, with large negative temperature coefficient. Several such substances were found among the native crystalline oxides and sulphides. Most of these are ælotropic, and must on that account be avoided. Fortunately, galena, the native sulphide of lead, has fairly high resistivity, a very large negative resistance coefficient, and crystallises in the cubic system. A galena-galena detector was therefore constructed. Two pieces of galena cut from the same crystal were embedded in solder, mounted in a clamp and brought into gentle contact. It was put into a wireless telegraph receiving set, and was found to yield excellent signals when a current of proper magnitude was passed through it.

A few preliminary experiments showed that it was not easy to find two pieces of galena which, when placed together and submitted

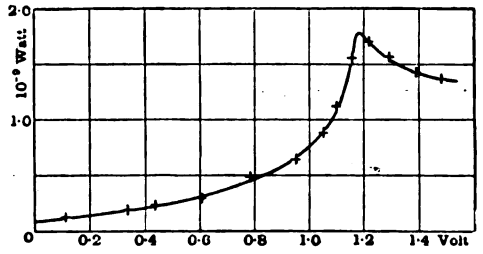

FIG. 2.

to positive and negative voltages in turn, exhibited perfect symmetry. The asymmetry is always small, and is probably due to the rise of thermoelectric forces at the contact when it becomes heated by the steady current, and these forces are probably caused by slight variations in the chemical composition of the galena from point to point in the crystal. When a contact that gives symmetrical voltage-current curves is found, it constitutes a detector that operates only when a current is passing through it. The efficiency of the detector is the same for each direction of the current, and appears to be practically independent of the shape of the galena surfaces at the contact.

The experiments here described were made on selected galena-galena combinations in precisely the same way as the earlier experiments on the iron-oxide detectors. The diagram of the apparatus employed is shown in Fig. 1 of the previous Paper,* and the mutual inductance between L and L′ was 2,500 cm. The detector was submitted to an E.M.F. which was varied in steps from zero to about 1 volt positive or negative. At each step an observation was made

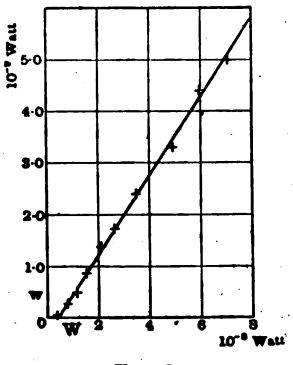

FIG. 3.

of the steady current through the detector, and of the intensity of the sound produced in the telephone. The intensity of the sound was measured by balancing the sound from the detector against that from the interrupter and the potential divider P_3. The curves of Figs. 1 and 2 herewith were obtained in this way. Fig. 3 was obtained by applying oscillations of various amplitudes to the detector while it is traversed by a suitable steady current, and measuring the intensities of the resulting sounds; and therefore expresses the relation between the energy given to the detector and that appearing in the telephone circuit. The curves given are selected out of a number as representative ones.

The most difficult observations to make were the steady current ones. The current-voltage curves obtained with increasing currents are very different from those got with decreasing currents, unless

* Abstract of a Paper read before the Physical Society. A short account of the discussion appeared in our issue of June 17, 1910.

† THE ELECTRICIAN, August 12 and 19, 1910.

* THE ELECTRICIAN, August 12, 1910, p. 724, Fig. 1.

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certain precautions are observed. Usually a decreasing-current curve lies above an increasing-current curve. The difference between the curves was found to depend greatly on the time allowed for a set of measurements, due to the temperature at the contact lagging behind the changes of current. This temperature lag may be expected to be more pronounced in detectors made wholly of substances of low thermal conductivity than in detectors consisting of a very thin film of oxide between metal electrodes. The phenomenon is very prominent in this new galena detector, though it escaped observation in the iron-oxide detectors, and therefore the former may be expected to work well as a rectifier of alternating currents of moderate frequency. Once the slow movements of heat through the galena had been observed the difficulties were overcome by allowing time for thermal equilibrium to be attained before the final galvanometer reading was taken.

Each setting of the two pieces of galena gives a different contact resistance, and therefore a different curve. Since very slight accidental vibrations can cause relative motion of the pieces of galena, it is almost impossible to perform a series of measurements yielding sufficient data for all the curves of Figs. 1, 2, 3, with full confidence that the contact has not varied.

The galena detector here investigated proves very good in practical wireless telegraphy. It has shown itself to be better than any coherer* known to me. This superiority is, according to the hypothesis here advocated, to be ascribed chiefly to the large negative temperature coefficient of resistivity of galena. By direct measurement of a cube of galena clamped between pieces of tinfoil the resistance was found to fall from 0·33 ohm at 12°C. to 0·10 ohm at 99°C.—a negative coefficient of 0·0079 per degree Centigrade. Pyrites has a coefficient about 0·006. Iron oxide has a coefficient somewhat lower than this last.

NEW POST OFFICE TELEPHONE EXCHANGE AT GLASGOW.

(*Continued from p. 771.*)

The lead covered paper-core cables are led into the building through 50 ducts, 10 from the north side and 40 from the south side. The cables are supported on bearers to the foot of a chute up which they pass to a mezzanine floor above the linesmen's rooms, thence they enter the test room about 3 ft. from the top of the main distribution frame and between the wire chief's desk and the nearest main wall. A general view of the distributing frame is shown in Fig. 6. The solid joints between the paper core cables and the silk and cotton core cables are staggered along a support which runs the whole length of the main distribution frame. This latter frame, together with the meter and relay racks, are designed and grouped for ready extension when necessary. This facility is ensured by arranging the apparatus vertically on both sides of the racks.

The line, or fuse, side of the main frame has a circuit capacity of 16,560 lines grouped upon 69 verticals of 240 each; the exchange side, accommodating the heat coils and lightning protectors, has a capacity of 13,800 circuits, comprising 69 verticals of 200 each. In cabling the main frame the lead is stripped from the silk and cotton core cables, and 12 groups of 20 pairs are formed for the 12 fuse mountings. The bunch of 40 wires pass behind and within the horizontal channel iron to which the mounting is fixed, and are accordingly protected from the cross-connection field. Fire risks are minimised by placing sheets of uralite underneath each horizontal layer of the cross connection field. The meter rack will accommodate 10,200 meters and each relay rack will carry 5,400 line and cut-off relays; the intermediate frame has a capacity of 12,400 circuits. To afford access to the main frame and racks travelling ladders are provided.

A diagram of the connection of the ringers is shown in Fig. 7, there being two belt-driven ringing generators, one connected to a 40-volt direct-current motor and the other to a 250-volt direct-current motor. Each generator shaft carries a divided ring from which the positive and negative pulsations are obtained for the operation of party lines. To the same shaft are also fitted two high-speed tone interrupters, giving respectively 400 and 133 vibrations per second; the former is employed for the busy back and plugging circuits, and the latter for trunk tone test upon incoming junctions. The diagram shows a number of slow-speed interrupters, which are driven at 1/30th the speed of the generator by means of gearing.

The transmission system adopted is illustrated by the diagram (Fig. 8). This will be noticed as a modification of the

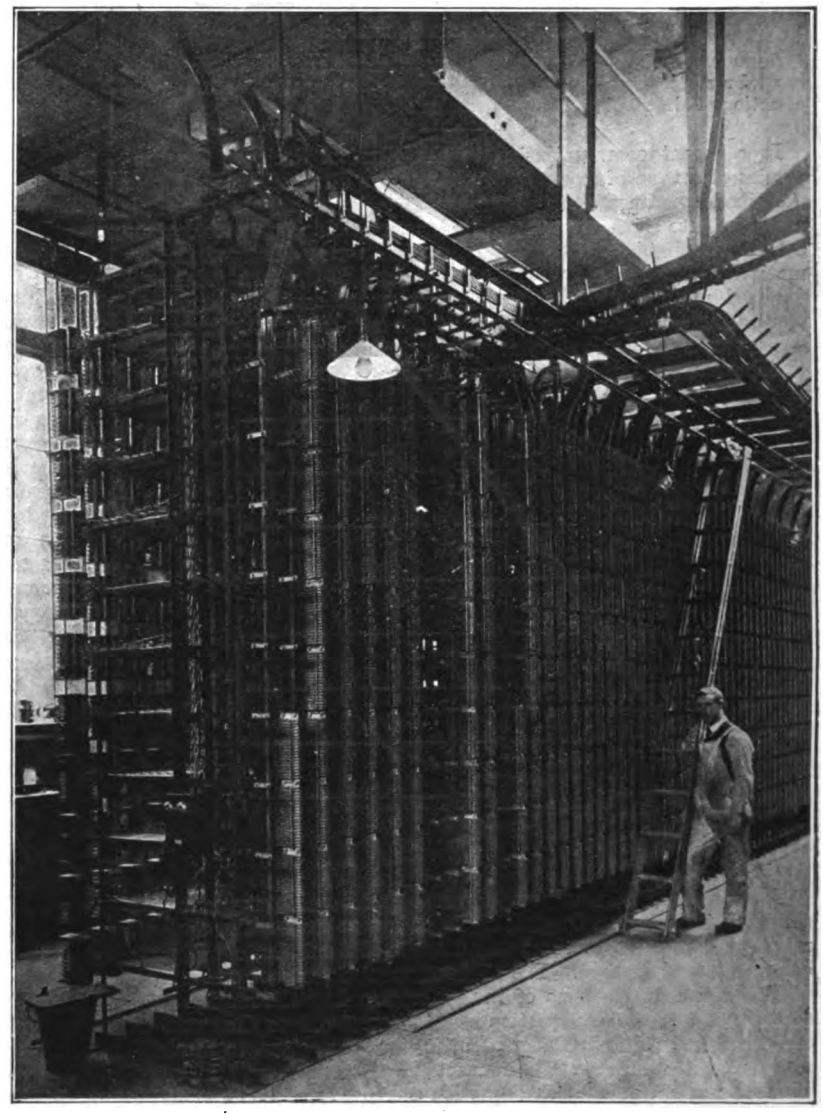

Fig. 6.—Distributing Frame.

method devised by Mr. J. S. Stone in 1892. The 40-volt common battery is coupled to the tip and ring conductors of both sides of the cord circuits by way of 200-ohm supervisory relay coils. The two 2-tip and two ring conductors of the plugs are connected through two 2-mfd. condensers. It is claimed that an exceptionally silent system is obtained by this method, and that greater sensitiveness in the relays is secured by the use of the higher voltage. Interesting new features in the subscribers' line circuit are the 40-volt line lamp, 50-ohm cut-off relay and the double coil line relay. In view of the fact that small private branch exchanges, which require current from the "B" wire exchange circuit, not being catered for in Glasgow, a 200-ohm line relay coil can be used between the nega-

* But not so good as certain "thermoelectric" detectors.

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tive pole and the common battery and the "B" wire of the circuit. For the same reason a 200-ohm supervisory relay coil in the cord circuit may be used to connect the common battery to each "ring" conductor. The composite diagram shown in Fig. 9 gives the subscriber's line and operator's keyboard connections. It was the original intention to provide a composite supervisory relay for each side cord circuit, but this was abandoned for the more simple arrangement shown. When the calling subscriber removes his receiver the line relay circuit is closed, and the 40-volt line lamp is connected across the multiple jack socket would have been at zero potential and no click would have been heard. The subscriber required is called by the insertion of the calling plug and the intermittent throwing of the ringing key. The cut-off relay of the circuit required is energised and the line relay and the line lamp of that circuit are cut out. While ringing continues the 36-volt supervisory lamp in connection with the supervisory relay will glow, and ringing is proceeded with until the supervisory lamp darkens. The removal by the called subscriber of his receiver closes the circuit for the calling supervisory

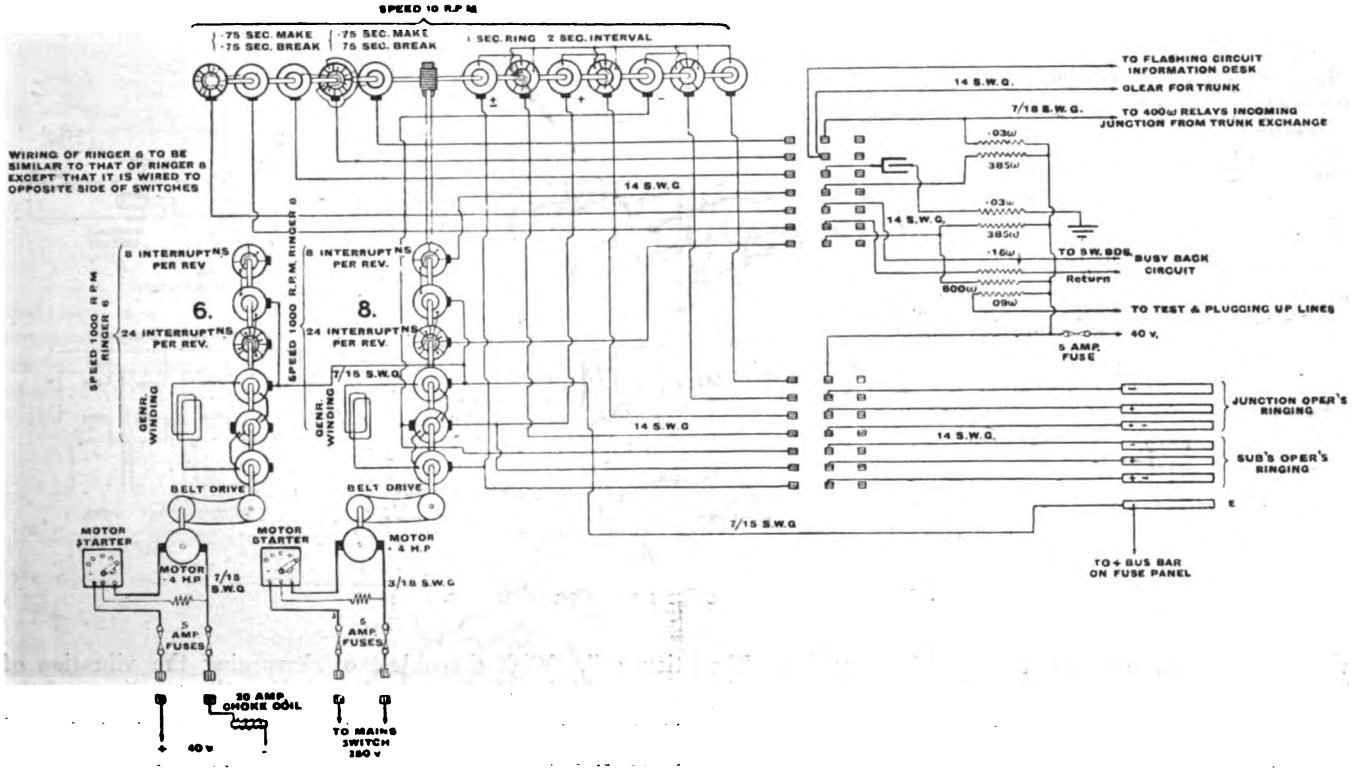

FIG. 7.—CONNECTION DIAGRAM OF RINGER CIRCUITS.

the common battery. The answering plug of the disengaged circuit is then inserted into the answering jack. The cut-off relay is then energised through a 400-ohm resistance in the cord circuit, and the line relay is disconnected from the calling subscriber's circuit. The circuit for the answering supervisory relay is also closed, and the 36-volt supervisory lamp actuated by this relay is disconnected. The number required is taken by the operator through the speaking key, and the tip of the calling plug is placed in the nearest multiple jack of the subscriber required. If engaged, a current will be flowing through the cut-off relay of this circuit, and as all multiple

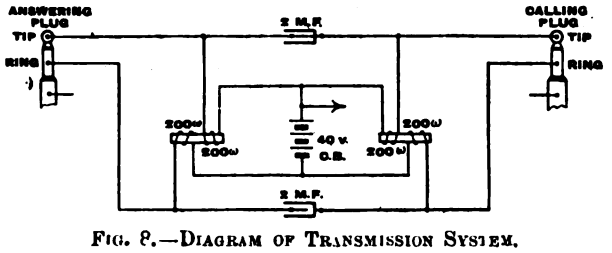

FIG. 8.—DIAGRAM OF TRANSMISSION SYSTEM.

jacks are in multiple with each other and the answering jack, a negative potential will exist at the jack sockets of each engaged circuit. When the speaking key is thrown, the tip of the testing plug being at zero potential, the charge in the condenser is proportional to the full voltage of the battery. When the tip of the testing plug and the socket of the engaged line are brought into contact, the voltage across the condenser is reduced and a discharge follows through the operator's receiver and an audible click is produced. If the circuit required had not been engaged relay. During the conversation both supervisory lamps are out, and the current consumption is thereby reduced to a minimum. The subscriber who originated the call controls the answering supervisory lamp, and the called subscriber the calling supervisory lamp, thereby affording double supervision. When both receivers are hung up the circuits of both supervisory relays are broken, both lamps glow, and the operator, after depressing the meter key for effective calls, disconnects the lamp circuits by removing the plugs from the jacks.

The arrangement of the meter circuits is similar to that employed by the Post Office department in London and Cardiff. The connections for these circuits are incorporated in the diagram (Fig. 9). The arrangement is distinctive in that no extra cells are required, the meters being operated from the common battery circuit. The meter circuit for effective calls is in two sections, one for the subscriber's line and the other for the answering side cord circuit; these are connected when the answering plug is inserted into the answering jack. A meter key is provided for effective calls for each answering plug, and an operator's or position meter with lamp is furnished for each "A" position. The resistance of the position meter is 0·5 ohm, and the low resistance winding of the subscriber's meter is 50 ohms. When the answering plug is inserted in the answering jack, current flows from the 500-ohm winding of the meter and also through the cut-off relay winding. Until the meter key is pressed the current in the 500-ohm winding is too weak to actuate the meter armature, but the depression of the key shunts the 400-ohm resistance and 36-volt lamp by the 0·5 ohm winding of the position meter. This increases the current in the 500-ohm winding six-fold, and the armature is attracted and the meter reading advanced by 1 unit. The movement

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of the armature also couples the 50-ohm winding in multiple with the 500-ohm winding, halving the resistance in series with the position meter, the latter causing the meter lamp to glow and adding 1 unit to the position reading. The position meter records all effective calls handled by the operator, and the subscriber's meter all effective calls originated by him. Provision is also made at each answering position for a special meter key and meter for the recording of ineffective calls.

The common battery is employed to supply current to the operator's transmitter, the necessary reduction of voltage across the transmitter being obtained by a 400-ohm retardation coil. With the object of sharpening the vibration of current in the 11-ohm primary winding, this winding and the transmitter are shunted by a 2-mfd. condenser. The combined action of this coil and the condenser shields the operator's telephone circuit from cross-talk and other disturbances. The existing practice of the department has been followed in the

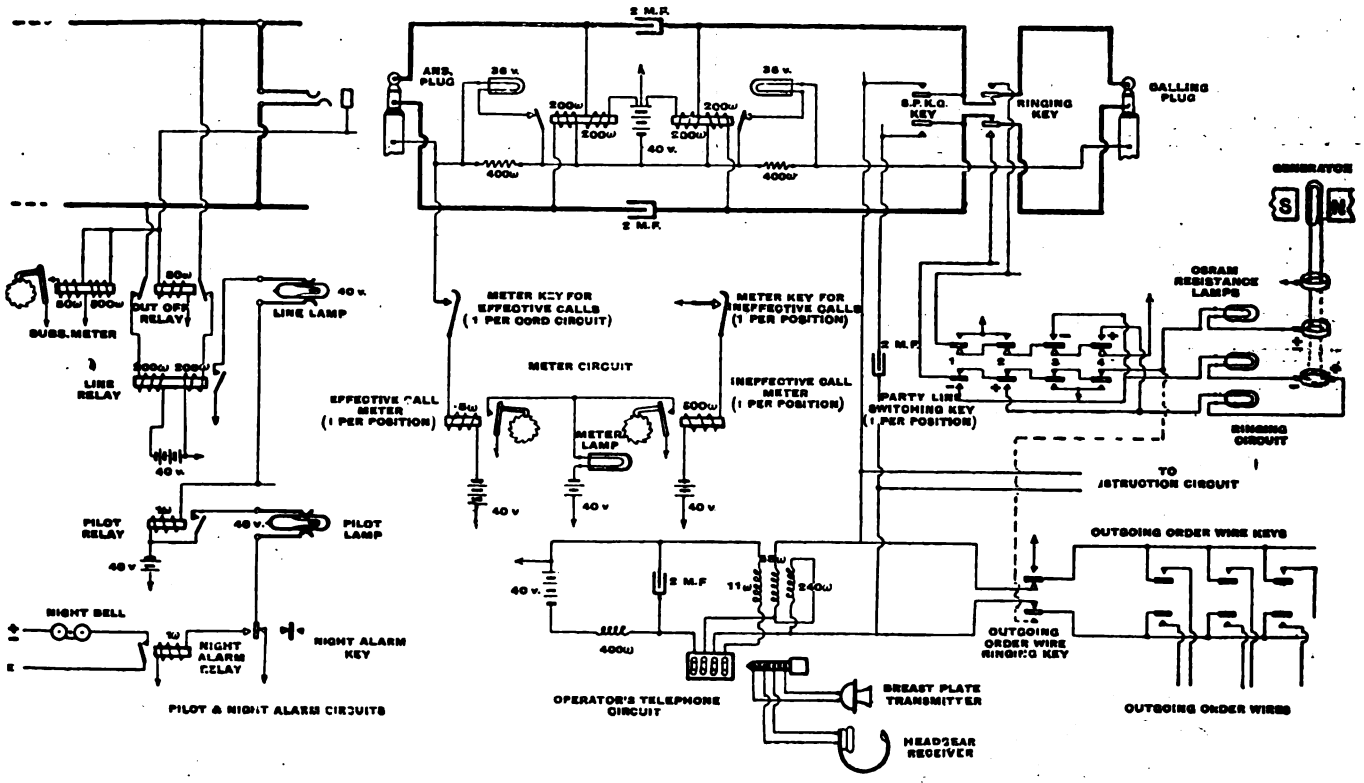

FIG. 9.—SUBSCRIBER'S LINE AND CORD CIRCUITS.

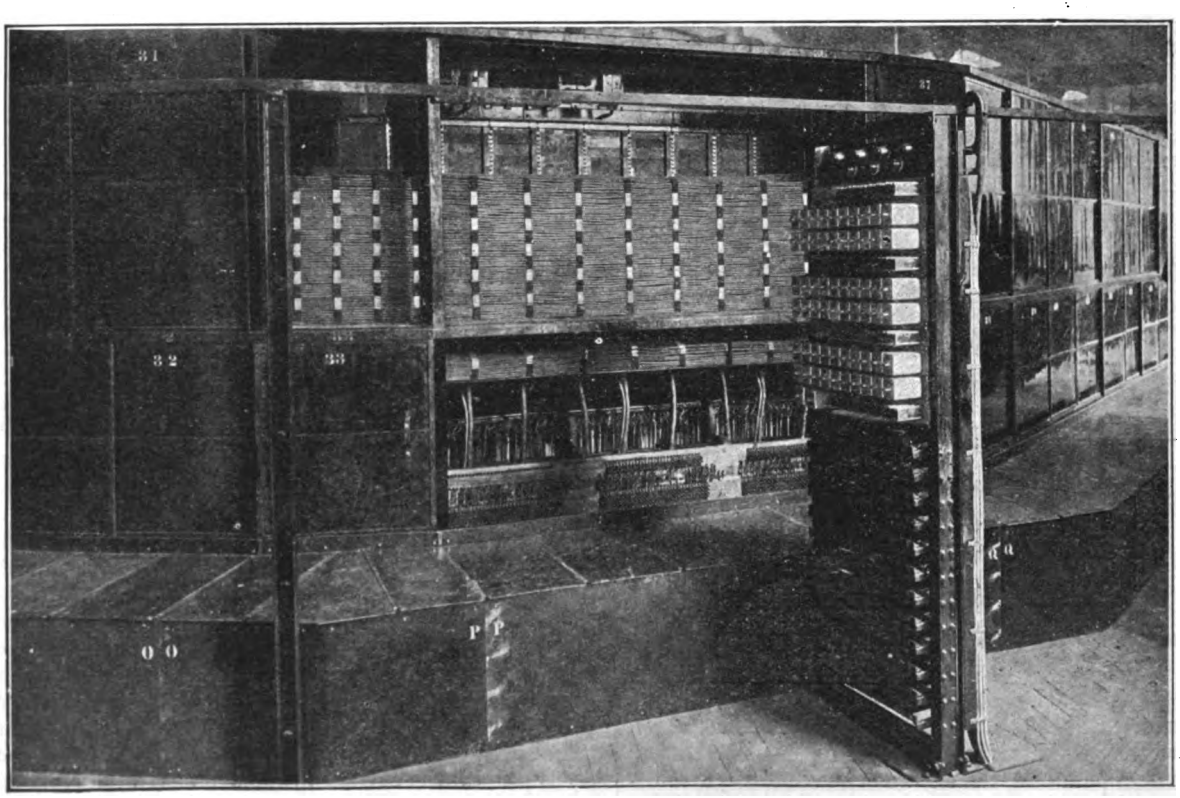

FIG. 10.—SUBSCRIBER'S BOARD, REAR VIEW

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method employed for the diminution of "side tone" in the operator's receiver. The 58-ohm or tertiary winding acts as the secondary winding, while the 240-ohm winding is coupled across the receiver, so that while its action assists the 58-ohm winding in the subscriber's circuit, it opposes that winding in the operator's receiver. Each operator's position is provided with a set of four-party line switching keys on the Thompson and Robe system. This system requires that between the pulsations the brushes bearing on an additional two-segment ring fitted to the generator armature and collecting the positive and negative pulsations respectively shall be

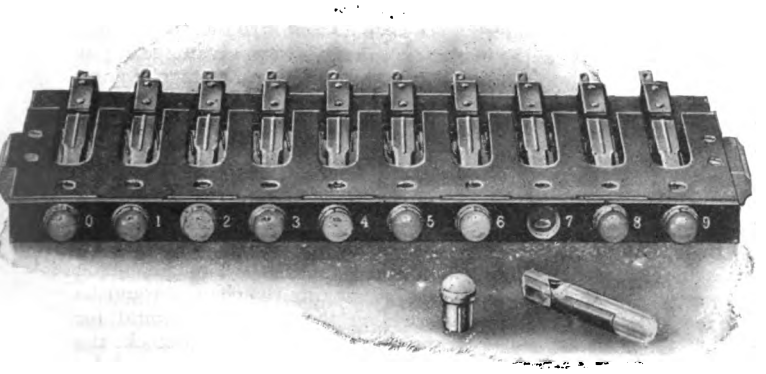

FIG. 11.—LAMP JACKS, SHOWING ONE OPAL CAP AND LAMP WITHDRAWN.

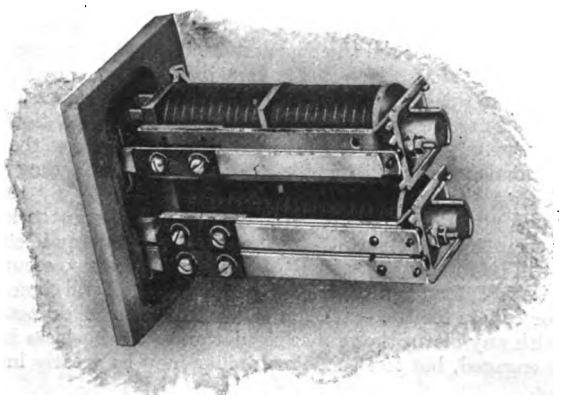

FIG. 12.—LINE RELAY (AT TOP) AND CUT-OUT RELAY.

connected to earth. This is done by coupling the spare segment of the divided ring to the earth ring by an internal insulated conductor. Three resistance lamps are fitted to each subscriber's position to prevent too great a demand being made on the ringing generator when this is coupled to a faulty circuit.

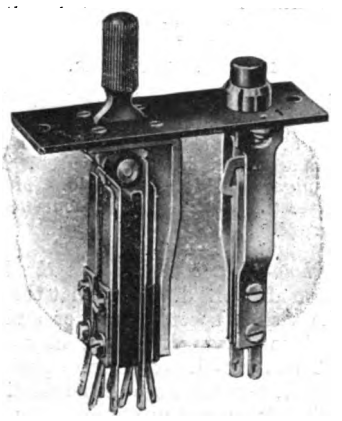

FIG. 13.—RINGING AND SPEAKING KEY.

Osram lamps, which have the advantage of a positive temperature coefficient, have been employed for this purpose. Fig. 10 shows a rear view of a portion of the subscriber's board.

The wiring of the subscriber's line circuit has been divided into nine important sections, representing connections at the main distribution frame, the relay rack, the intermediate distribution frame, the multiple junction board, the multiple subscriber's board, the meter rack, the fuse cabinet, the apparatus rack at the rear of the subscriber's board and the answering position. On the line side of the main frame the G.P.O. standard 3-ampere glass tube fuses are utilised. On the exchange side of the main frame are assembled the lightning conductors and the heat coils. The relay racks are erected between and parallel to the main and intermediate distribution frames, so that the 42-wire cables can be conveniently and economically terminated upon the relay rack instead of at the intermediate frame as was previously the practice.

Figs. 11, 12 and 13 show details of the most interesting items in the subscribers' sections.

(To be concluded.)

TWENTY FIVE YEARS OF CENTRAL STATION COMMERCIAL DEVELOPMENT.*

BY S. INSULL.

In 1885, when the National Electric Light Association was formed, the development of the central station business was confined almost entirely to a few companies established under the auspices of the Edison Electric Light Co. The companies forming our early membership were not engaged in what we understand to-day as central station business, but were either arc light manufacturers and supply men, or those companies who were engaged in series arc lighting, doing practically no other business, except in a very few cases a small amount of power and series incandescent business. At the Niagara Falls meeting, in 1897, I well remember the Paper read by Mr. T. C. Martin on the "Daylight Work of Central Stations." He started his Paper by stating that the central station industry had in some respects been a disappointment, that after nearly 20 years of work the companies restricted themselves injuriously by remaining mere lighting companies, and he asked the question, What would become of the central station companies if a new lighting medium came into vogue and we were deprived of our illuminating business entirely? To get statistics of the early days of the business is a difficult matter, but Mr. Martin showed that in 1886 there were 410 central stations in the country, that only 300 of these furnished any statistics, and that of these 226 were only doing a night business. Assuming that those who did not report were in the same class as the 226 doing only a night business, we find that out of 410 so-called central station companies 325 were doing business only between dusk and daylight.

It is probable that to say £2,000,000 represented the cash investment in the business in 1885 is naming a very liberal amount, whereas it is authoritatively stated that between £200,000,000 and £250,000,000 represents the total sum of the capital employed to-day in the central station industry of this country.

The commercial development of the business was of necessity in the early days hampered, amongst other things, not only by a lack of knowledge of conditions governing the relation of the true methods of selling electric energy to the cost of producing it, but also by the high capital cost of the plant used. The leading features which, from the technical and engineering side, have made the central station business of to-day possible, are the change from the two-wire system to the three-wire system; the reduction in the energy consumption of the incandescent lamp from 6½ watts per candle in 1882 to $3\frac{1}{10}$ watts per candle in 1890; the introduction in 1886 of the alternating-current system (making the central station business available for the small towns throughout the country); the building in 1890-1891 of slow-speed electric generators directly connected to highly economcal reciprocating engines (the first step in reducing the cost of central station investment and the operating cost of the energy produced), followed in 1896 by the introduction into this country of the use of high-tension alternating transmission lines operating sub-stations. The combination of the above forced, on account of the saving made, the abandonment of small generating stations and the massing of production on a very large scale. The limit of the size of units of power was reached by reciprocating engines at about 5,000 H.P., and the increasing demand for energy resulted in the development of very large steam turbo-generators, which operate to-day in units of upwards of 20,000 H.P., and which will within the next year be operating in units of 30,000 H.P. Moreover, within the last two years the introduction of higher efficiency incandescent lamps has greatly reduced the cost of light.

* Abstract from the "Electrical Review and Western Electrician" of an address delivered by the President of the Commonwealth Edison Co., of Chicago, to the National Electric Light Association at the celebration of the 25th anniversary of the starting of the Association.

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In the early days of the development of the central station business—from, say, 1881 to 1891—the customers of the central station companies looked upon our product as more or less of a luxury. Rates were very high and the result was that business was confined almost entirely to short-hour consumers, the interest and operating costs to the company being necessarily very high. It was not until the early nineties that any of the managers of the large central station properties of the country appreciated the fact that if they desired to place their business on the basis of a general public necessity it was necessary for them to rearrange their rates on such a plan as would give the long-time consumer the lowest possible price. The recognition of the necessity of meeting this condition may possibly have had as much to do with reducing operating cost and reducing interest and depreciation costs as have the wonderful work of the inventors and the marvellous skill of the engineers.

I am dwelling upon this subject, not with any idea of belittling the great achievements of inventors and engineers, but for the purpose of impressing, more especially upon the younger men connected with our organisation, the great importance of the commercial side of the business, and to point out to them the advantage alike to themselves and the business itself of their bestowing upon the commercial side of the business as much, if not a greater amount of thought than that which they bestow upon the technical operation and construction side of central station development.

The possibilities of central station business, while great to-day, must be far greater in the future, and in trying to point to what those possibilities are it might not be amiss to discuss what is the real function of a central station company. Is it simply to light the streets of the city, as most of the electric lighting companies thought was their function 25 years ago? Is it merely to do house-to-house lighting, as was (with the incidental power connected with it) the business inaugurated by the few Edison companies a little more than 25 years ago? Should a central station company be engaged merely in production of power for industrial purposes, or for railway purposes—whether the railway be urban, inter-urban, state or interstate? Or should the central station company embrace all of the functions stated above and produce all of the electric energy needed in a given community or a given area?

The maximum load of the electric lighting business in this latitude comes in December, and is accentuated by the industrial power load; the maximum load of the street railway business comes more often in January than in December, especially in the central west, owing to the conditions of temperature and consequently heating as well as traction. The maximum load of the steam railway business, so far as I have been able to figure it, comes in the middle of the summer in Connecticut and Massachusetts, towards the end of September around New York City, and in October around Chicago and St. Louis. The maximum load of a waterworks comes in a great many instances, if ample storage is at an elevation, at the convenience of the producer; and, in any event, it comes at a time of the year when the demand for total energy used in a given community for other purposes is by no means at its maximum. Why should all these operations for the production of energy be dealt with on a separate basis? Why not concentrate them all, and by so doing get low cost of production, low capital investment (because of the elimination of duplication of investment), and increased diversity of demand for energy, and, what is of vast importance, consequent low prices to all users.

What I am advocating is merely the extension of the central station idea. If you will apply the arguments that you use to persuade a possible customer to give up his isolated plant to the larger questions of manufacturing and distributing electric energy, you must come to the conclusion that our true function as central station companies is not only to supply the energy required in the community in which we live, but also to supply the energy required to carry us to the next community when we go to visit our neighbour, or, in any case, to carry us part way.

The vice-president of the New York, New Haven & Hartford Railroad recently said that, in his opinion, within the next 15 years the New Haven road between New York and Boston would be electrified throughout, and the towns on the way would have the opportunity of obtaining electric energy at a very low cost, the cost dependent upon the cost to the railway company of current, which, in his opinion, would necessarily be low because of the very large amount of business that they would have of their own. The work of the New York Central and Pennsylvania railroads in the way of electrification has gone hand in hand with the work of the New York, New Haven & Hartford Railroad, and if the steam railroad people look forward to current being supplied at very low cost throughout Connecticut, Massachusetts and Rhode Island as a result of the production of current in large quantities for the electrification of the steam railroads in those States, the same thing must necessarily happen throughout the whole of the densely settled portion of the United States if the reasoning of the vice-president of the New Haven Railroad be correct.

But it would seem to me that our functions as producers of electric energy should, with the tendency towards electrification of steam railroads, become very much broadened, and instead of its being the exception, as it is to-day, for a central station company to cover any large amount of territory outside of the municipality in which they are mainly established, their operations will become far more extensive; since, if the steam railroad men of the country want electric energy produced economically, they should find it to their advantage to come to us as specialists in electric energy, taking advantage of our experience in the best methods to pursue, taking advantage of combining their necessities for electric energy with the necessities existing in the communities in which we operate—which combination will result in economies which neither can obtain separately—and so leading to the establishment of large central station plants capable of supplying all the requirements in the way of electric energy for a large area of territory surrounding the centres of population. If our members will do their share towards working to such a desirable end the possibilities of electrification of steam railroads will be brought much nearer to us. The financial burden of making the change would be divided, the steam railroads providing the necessary capital for electrifying their right of way and changing their rolling stock, the central station companies of the country providing the capital for building the large generating stations and transmission lines to convey the electric energy to the railroads and other consumers along their right of way.

As to the relations of the central station business and the communities, the business in which we are engaged can be most successfully operated as a monopoly. If the communities which we serve are to get electric energy at the lowest possible cost, they can only expect to achieve this by preventing duplication of investment and by concentrating production under one organisation. It should be borne in mind that the more closely our business is supervised and regulated the greater are the chances of our being protected against ruinous competition, which to-day is mainly instigated by those who desire to take this means of acquiring our existing business. Whilst we may not care to be hampered by the rules and regulations established by commissions created to watch over our operation, the further these commissions go into our business the more will they be convinced that the best results can be obtained only by regulated monopoly, and that competition is alike as ruinous in the long run to our customers as it is to the central station company itself. The result will be that our monopoly of the business will be secured, our securities will stand in higher credit and new capital will come flowing into our coffers for the extension of our business. I do not myself view with any alarm the proper regulation of the business in which we are engaged, but feel that its stability may be greatly increased thereby.

President Insull next referred to the desirability of fostering a friendly feeling of relationship between the supply company and its customers, and concluded with an appeal to the young men to look upon their chances for success in the central station field as of the highest possible opportunity.

PHOTO-ELECTRIC PROPERTIES OF THE ALKALI METALS.*

BY F. K. RICHTMYER.

Summary.—In the first section of this article, which is a continuation of previous researches, the author describes experiments to ascertain the dependence of photo-electric current on the wave-length of the incident light, an acetylene flame being used. In the second part of the article he suggests useful applications of the photo-electric properties of alkali metals, such as the measurement of the decay of phosphorescence.

Dependence of Photo-Electric Current on the Wave-length of the Incident Light.—Soon after the discovery that the alkali metals were photo-active in the visible spectrum Elster and Geitel published some brief observations showing the sensibility of these metals for different colours. These data, however, were qualitative rather than quantitative, and as the exact nature of the relation between wave-length and photo-electric current would not only be of value in the theory of photo-electric phenomena, but would also help in correlating it with other phenomena, the writer has attempted the determination of this relation for sodium—which has a maximum of sensibility in the visible spectrum. The apparatus used has already been described in a former article,† the only modification

* Abstract of two Papers read before the American Physical Society.
† THE ELECTRICIAN, March 4, 1910, p. 859.

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being that the source was replaced by a spectrometer, whose movable telescope arm carried the source of light, the spectrum of which was to be thrown on the sensitive surface of the photo-electric cell. The spectrometer was calibrated by the lines from a mercury vapour lamp. The prism gave a spectrum about eight degrees in width. The widths of the two slits were equal and represented about 10 minutes of arc. As before described, the platinum wire leading to the sensitive surface was charged to such a negative potential as to reduce the leakage current, through the walls of the cell, to zero, thus making the photo-electric surface at zero potential with respect to the receiving Pt wire. Under these conditions the rate of deflection of the electrometer was proportional to the photo-electric current.

A Nernst glower was at first used as a source. Although this furnished a very intense light the glowers did not last long enough for making a good set of observations. An acetylene flame was then substituted and had a twofold advantage. Not only was it of constant intrinsic brightness, but also the energy distribution was known, having been recently determined by Profs. Nichols and Merritt.*

In order to make the results useful for comparison two corrections were made: First, due to the variable dispersion of the prism, it was necessary to reduce the observed photo-electric currents to what would have been obtained had the spectrometer slit included a constant number of wave-lengths at each observation. The slit width was such as to make it possible to do this by graphical means from the slope of the calibration curve of the spectrometer. Second, the final relation between wave-length and photo-electric current should show the current that would be produced by the same amount of energy at each wave-length. This correction was made

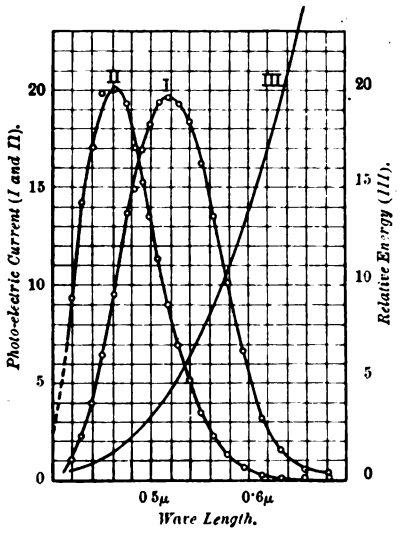

FIG. 1.

by dividing the observed currents by the relative energy for each wave-length in the spectrum of acetylene. As the above curve of Nichols and Merritt for the energy distribution extends only as far as 0·48μ, while the observations in this experiment extend to 0·42μ, a method of extrapolation was employed, using Wien's equation for the energy distribution in the spectrum of a black body,† a new energy distribution curve being obtained, extending to 0·42μ (*see* Fig. 1, curve III). The observed photo-electric currents, after making the correction for variable dispersion are divided by these energy values. The resulting currents are those which would have been obtained from a normal spectrum containing the same amount of energy for each wave-length. The results are shown in Fig. 1, curve I. being the observed curve, and II. the curve after making both the above corrections.

The significance of the exact shape and location of this curve for sodium is not at present apparent. The maximum occurs at about $\lambda = 0{\cdot}46\mu$, and yet $\lambda = 0{\cdot}46\mu$ does not seem to bear any unique relation to any of the known properties of sodium. Still some relation must exist. There must be some reason why a sodium surface shows a maximum at one wave-length, and rubidium, for example, at another. If such a relation could be established it would doubtless do much to explain not only photo-electric phenomena but also many questions connected with the structure of matter.

Whatever theory of the photo-electric discharge we accept the shape of the above curve is very strongly suggestive of resonance in some form or other, and that the expulsion of the electron is due to selective absorption of light. If such is the case the free period of the electron in the sodium atom in its solid state should be determined by the period of vibration for $\lambda = 0{\cdot}46\mu$, and metallic sodium ought to show selective absorption for this wave-length. But since the curve extends over a comparatively large range of frequencies, the question might be raised whether the frequencies of the electrons are correspondingly distributed, or whether all the electrons have the same frequency and the effect of light other than $\lambda = 0{\cdot}46\mu$ is due to vibrations of a semi-forced nature. Further experiments along this line are in progress.

Apropos of the present discussion as to whether the energy of the expelled electron comes from an atomic explosion under the influence of light or from the absorption of energy from the incident light,* it might be of interest to consider the energy changes involved. Unfortunately data are available for only the roughest kind of an approximation, but the magnitude of the quantities concerned can at least be shown. In a recent experiment by the writer† a sodium surface containing 10 square cms. was exposed to the radiation from a 2,000 c.p. arc at a distance of something less than 1·5 metres. If we assume the reflecting power of sodium as given by Drude (for white light?) to be 99·7 per cent., we obtain, after making due allowance for other absorptions and reflections, that approximately 400 ergs per second of light energy are absorbed by the sodium surface. Comparing the above distribution curve with the visibility curve we might conclude that 100 ergs per second of this energy fall within those wave-lengths which are capable of producing the discharge.

The photo-electric current resulting was 25×10^{-9} amperes, corresponding to 25×10^{10} electrons per second if we accept the value of e as 10^{-20}. In the article cited, Kunz has found the initial velocity of the electrons from a sodium-potassium alloy to be 6×10^{7} cm./sec.

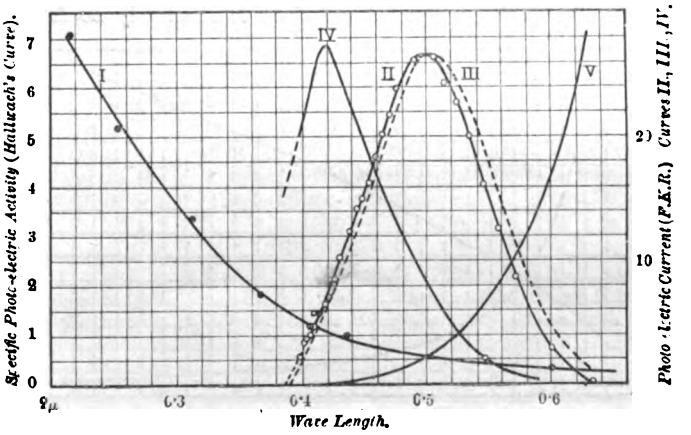

FIG. 2.

for $\lambda = 0{\cdot}42\mu$. The velocity of the electrons from the above sodium surface can hardly be more than 10×10^{7} cm./sec., giving as the kinetic energy per electron 3×10^{-12} ergs, where m is taken as 6×10^{-28} grams. This makes the total kinetic energy of the expelled electrons 0·75 erg per second, a quantity which so far as its magnitude is concerned could easily be supplied from the 100 ergs per second of absorbed energy.

Since the above was prepared for publication, Hallwachs‡ has published some data showing the "specific photo-electric activity" for potassium from 0·2μ to 0·6μ, using the lines of the mercury arc in quartz as the exciting source. Excluding the existence of secondary maxima, his data, when plotted as a smooth curve, take the form shown in curve I. Fig. 2. It was suggested to the writer that the radical difference between this curve and Fig. 1 (II.) might have been in part due to the use of a flint glass prism, which undoubtedly did absorb some of the energy in the blue and violet region. It did not seem possible, however, that this absorption could have been sufficient to account for the difference.

It is to be regretted that measurements of the energy distribution in the spectrum of acetylene in the neighbourhood of 0·4μ are almost impossible. However, to test in a qualitative way the influence of absorption, the flint glass prism was replaced by a carbon bisulphide prism, which is especially transparent to the blue and violet, and the measurements repeated. The results are shown in Fig. 2, curves II, III. and IV. Curve II. is plotted from the

* "Physical Review," Vol. XXX., p. 328.

† This method is, perhaps, not altogether justified, since we are not sure that acetylene follows Wien's law of radiation exactly. It was used, however, with the hope of checking it up later.

* *See* article by Jakob Kunz, "Physical Review," XXIX., p. 212.

† "Physical Review," Vol. XXIX., p. 212.

‡ "Ann. d. Ph.," XXX., p. 593.

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observed data without making any corrections. The ordinates, as in Fig. 1, are rates of deflection of the electrometer in millimetre per second. It is to be noted that the maximum ordinate is only a trifle over one-tenth of the corresponding ordinate in Fig. 1 (II.). This is due to smaller light intensity. A slight correction to curve II. is necessary on account of the rapid change of the index of refraction of CS_2 with change of temperature. Fig. 2 (III.) is the result of this correction, the points being omitted to avoid confusion. Finally, after reducing to a normal spectrum with equal energy distribution, we get Fig. 2 (IV.).

The maximum persists although, as might be expected, it is shifted somewhat toward shorter wave-lengths. Still it seems sufficiently prominent to call it a primary rather than a secondary maximum, the exact location of the crest being somewhat in doubt. In other words the use of the flint glass prism seems to have shifted the curve rather than changed its form.

In conclusion, the extreme sensibility of the photo-electric cell, even at zero potential, may be mentioned. In these later experiments, the shape and size of the CS_2 prism was such as to necessitate cutting down the beam of light through it to a few millimetres diameter. The light emerging from the collimator, when allowed to fall on a piece of white cardboard, was scarcely visible even in a dark room. And yet the photo electric currents produced by it were measured without much difficulty. This is more strikingly illustrated by reference to Fig. 2, (V.), which shows the relative energy for each wave length falling on the cell, taking into account the variable dispersion of the prism.

Laboratory Applications.—While performing some photo-electric experiments the writer was greatly impressed with the possibilities of putting this phenomena to various laboratory uses where optical measurements by eye are either extremely difficult or altogether impossible. For example, as a photometric device for monochromatic light a sensitive sodium surface excels the eye in several respects; (1) In a properly constructed cell there is absolutely no fatigue.

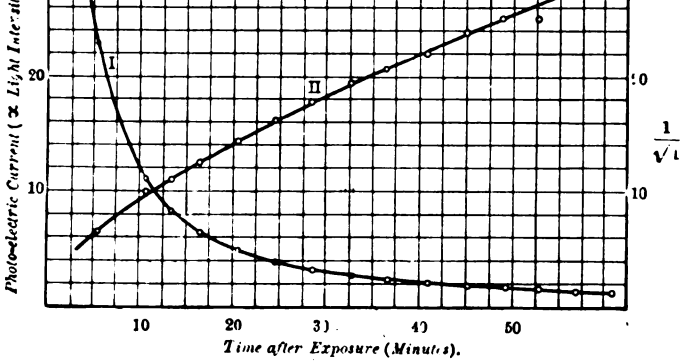

FIG. 3.—PHOSPHORESCENCE OF BALMAIN'S PAINT.

(2) The greatest sensibility is in the blue and violet region, where the eye is least sensitive. (3) The magnitude of the photo-electric current, *i.e.*, the sensibility of the device, can be increased by (*a*) increasing the area of the sodium surface, (*b*) increasing the area of the photometric field, and (*c*) decreasing the distance of the field from the sensitive surface; whereas the action of the eye depends simply on the intensity of light in the photometric field. In a photometer little gain in sensibility results from increasing the size of field, or, within limits, of moving the field nearer the eye.

A case in point is the measurement of decay of phosphorescence. A sample of Balmain's paint on a visiting card was exposed to sunlight for 30 seconds, and then placed over a window about 8 cm. in front of a sodium surface, so that 10 or 12 sq. cm. of the card were exposed. At first the rate of deflection of the electrometer was too rapid for accurate measurement. After about six minutes, however, observations were begun and the rate of charge taken about every four minutes, continuing for one hour after exposure. The results are shown in Fig. 3 (I.). in which the ordinates, while photo-electric currents, are proportional to the intensity of light emitted by the phosphorescing paint.

At the end of one hour the substance was just visible. Accurate measurements by the eye would have been practically impossible, whereas the electrometer was being deflected at a fairly measurable rate (over 0·1 mm./sec.); and this rate of deflection could have been increased many times had the exposed area of paint, and its distance from the cell been sufficiently altered.

When the data are plotted in the usual manner, with $I/\sqrt{I}$ against time the curve shown in Fig. 3 (II.) results. Except in a general way no great amount of importance should be attached to the compound linear character of this curve, as no special care was taken to eliminate or correct for the leakage currents mentioned in a previous article) through the glass walls of the cell, the object being simply to test the cell as a photometric device and not the study of phosphorescence.

Another possible application results from the fact that the total quantity of electricity discharged from the sensitive surface, and therefore the permanent deflection given to the electrometer, depends on the integral $I\,dt$, where I represents the light intensity over an interval of time dt. That is, such a combination of cell and electrometer is to light measurements what the electrolytic cell is to the measurement of quantity of electricity. In this way the study of short decay phosphorescence might be possible. The writer has also made measurements of the relative total quantity of light passing through a photographic shutter set at speeds of 0·01, 0·02 and 0·04 sec. For this purpose the closed shutter, mounted in front of the cell, was illuminated by a beam of parallel light. The "exposure" was then made and the resulting deflection of the electrometer noted. Unfortunately these data were not preserved and it must suffice to say that in the case of 0·01 sec. the deflection was 20 mm. or 30 mm.

Although possibly a little troublesome to work with, nevertheless it would seem that this phenomenon is capable of more extended laboratory use than has heretofore been made of it.

ELECTRICAL EQUIPMENT OF THE ROSE BRIDGE AND DOUGLAS BANK COLLIERIES, WIGAN.

BY W. WINSBOROUGH.

The Rose Bridge & Douglas Bank Colliery Co. first considered the electrical equipment of their collieries some years ago, and the present electrical installation was commenced early in 1903. This possesses several features of interest, as will be seen from the following brief description of the plant. Particular attention may be called to the method of preventing leakage and the protection against shock.

The power station is 60 ft. by 32 ft., and is built of pressed brick, the inside walls being of white glazed brick. The floor is covered with cork linoleum.

Generating Plant.—This consists of two 200 kw. 40 cycle three-phase 550 volt Brown-Boveri generators, direct coupled to Belliss & Morcom 250 H.P. compound engines running at 400 revs. per min., with direct coupled exciters, supplying power down the mine and on the surface for haulage, pumping and lighting.

Switchboard.—The main switchboard (Fig. 1) is of white marble, and is 15 ft. long by 6½ ft. high, all live parts at a pressure of over 230 volts being at the back of the board. There are five panels; reading from right to left these control two generators, the surface motors, transformers and shaft cables.

The two generator panels are each fitted with a voltmeter and ammeter, triple-pole switch, synchronising lamps and rheostat.

The third panel contains two ammeters, two triple-pole switches (one for a surface motor and one as spare), also an automatic voltage regulator, which keeps the pressure within 10 volts on either side, and a leakage indicator. No. 4 panel is equipped with two ammeters, two triple-pole switches (one for transformers and one as spare), also three change-over switches from transformers to direct-current generators for lighting the screens; whilst on No. 5 panel are two ammeters, two triple-pole switches, two triple-pole oil-break circuit-breakers with overload trips on two phases for the shaft cables, and a patent "Winhey" detector for the protection of the whole of the underground electrical apparatus. Fitted over the switchboard is a synchroniser clock and wattmeter.

Shaft Cables.—The cables from the switchboard to the pit shaft are run in troughing filled with bitumen, and then laid in casing down the shaft. This casing is clamped to the bearers and taken in at each pit eye to the main distribution boxes. These cables are 37/13 S.W.G. bitumen insulated, and are unarmoured, their length being 726 yds.

From the pit eye distributing boxes the motors are supplied with current through three-core steel-taped armoured bitumen cables, which are run behind the bar legs along the intake roads. This provides a splendid protection against falls of roof, &c. The length of the three-core cables is 3,144 yds., and their sizes range from 7/20 up to 37/13 S.W.G.

Underground Plant.—This comprises two 80 H.P., four 50 H.P. and four 25 H.P. motors for haulage and two 15 H.P. and two 5 H.P. motors for pumping. The motors are all of the Brown-Boveri slip-ring type, and are situated in the intake air roads, an ammeter, main and reversing oil switches and liquid starter being provided for each motor.

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The cables are run to cast-iron fuse boxes at each motor, and are then extended on through fuses to the next motor, which makes a very convenient arrangement for isolating and testing purposes.

The haulages (Fig. 2) are of the endless rope type, and the gears are provided with 4 ft. rope wheels and treble reduction gearing driven from the motor through Unica pinions. The haulage ropes are from 400 yds. to 2,340 yds. in length, and are of 1 in. steel wire, hauling from the level and up to gradients of 1 in 2½ at a speed of 1½ miles per hour.

There are 200 incandescent 16 c.p. lamps installed underground, supplied at 230 volts through 6 kw. single-phase transformers;

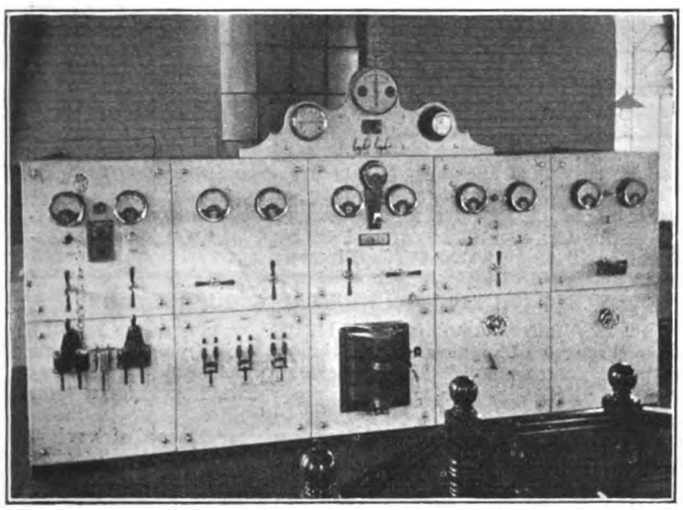

Fig. 1.—Main Switchboard.

whilst the whole of the mine signals are electrically operated, and each motor house is connected by telephone.

The patent "Winhey" detector mentioned above has been installed on the main switchboard for the past eight months, and has given every satisfaction. Although very sensitive, it has not caused the slightest delay in the working of the colliery. The object of the instrument is to cut off the current whenever a serious leakage occurs, or such leakage as would take place by a person accidentally touching a live conductor, and it thereby prevent any person receiving a severe shock, and obviates any fire risks through leakage.

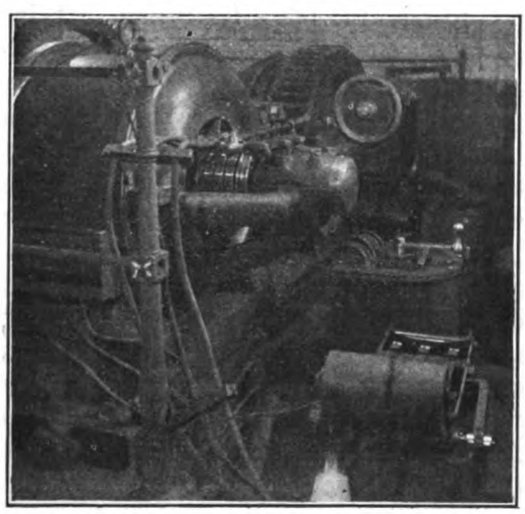

Fig. 2.—Electric Haulage.

The detector has been put through some very severe tests, and the spark obtained by putting one phase dead to earth is hardly perceivable. It has also been tested from all parts of the system with regard to the severity of a shock. In all cases the shock obtained was only very slight, owing to the quickness and sensitiveness of the instrument.

It has come into operation twice through punctures in the shaft cables caused through a blown-out steam joint. Considering that these cables are unarmoured and in wood casing, which practically insulates them from earth, it has well proved its value as a protection. This leakage detector has been a source of considerable interest to the numerous engineers who have visited this plant, and many have tested the same by making actual contact with a live conductor to prove that the detector will come into action with so small a leak as will pass through the finger tips without giving a severe shock.

Surface Plant.—The surface installation comprises one 25 H.P. motor for driving a dirt haulage and full tub creeper, one 2 H.P. motor for driving oil pumps, drilling machine and lathe for the lamp rooms, and one 1 H.P. motor driving a lamp cleaning machine.

There are 40 Crompton enclosed arc lamps for the sidings and workshops, also 480 incandescent lamps, which are supplied by three 12 kw. single-phase transformers.

REPORT ON CENTRAL STATION ADVERTISING.*

The report of the committee of the National Electric Light Association on central station advertising gives the result of a series of inquiries made of member companies, and contains a number of reproductions of newspaper advertisements. Fifty out of 80 companies report that newspapers form the very best medium of advertising for the central station, the next most popular method being direct-by-mail advertising. A very general use is being made of electric signs in advertising the office location of the company, and also the business of the lighting and power company at various favourable locations in cities where they operate. The maintenance of display rooms and display-window lighting has also become very general, but the use of billboards is very slight. The street-car card is only used by those companies spending large sums of money each year on advertising as a whole, or by companies operating traction lines in connection with their electric light and power business. The committee find that companies expending large sums of money employ almost all of the well-known advertising methods, while a limited expenditure for advertising narrows itself to the newspapers, company bulletins, direct-by-mail literature and the use of various booklets, folders, inserts, &c., furnished the operating companies by manufacturers of electrical apparatus and supplies. It is stated that the yearly amount spent by different companies shows surprising variations. The committee state that an appropriation for advertising, exclusive of soliciting, could reasonably be from 1 per cent. to 2 per cent. of the gross revenue of the larger, and perhaps from 2 per cent. to 3 per cent. of the smaller companies.

DISCUSSION.

Mr. L. E. Gibbs, of Boston, said that the small company always had an advantage in that it was closer to its consumers. Advertising helped to bring the large company nearer to its consumers. Along with it all employés must be impressed with the necessity of loyalty and of putting the best foot forward. The effect of advertising might be neutralised inside of a company's office if the enthusiasm of the advertising man was not contagious and did not permeate the entire force. In Boston a certain appropriation of kilowatt-hours every year was made for advertising the furnishing of energy to electric signs for electric contractors. The name of the central station company was not necessarily mentioned in such advertising. He next referred to the difficulties of keeping close to consumers in handling a large district with central supply, as in Boston and its suburbs. As a result of the distances between the main office and the various distributing centres, his company was about to decentralise its business organisation and to establish offices in each territory. These would be business centres for that territory, carrying a stock of supplies and dealing with the public directly.

Mr. M. E. Bearsley, of St. Louis, told of the advertising campaign which the Union Electric Light & Power Co. was engaged in. One of the features brought out was that power could be obtained by a manufacturer anywhere in the city, and that he did not have to rent an old-style building with power as in former days. The company also advertised for "kicks." While many came in response to this invitation it was believed that it was a good thing. The company advertised in a number of different daily papers.

Mr. J. C. McQuiston, publicity manager of the Westinghouse Companies, said that from figures recently compiled it appeared that about 90 per cent. of the population of the country were not using electric service. In small towns in the West as high as 60 or 70 per cent. were using the service. In some Eastern cities the percentage was as low as four. His companies were now furnishing advertising copy free of cost to central stations desiring it. This copy was prepared by specialists and was available to the central station company at a much lower price than if prepared specially by each company.

Mr. P. S. Dodd, publicity director of the National Electric Lamp Association, Cleveland, told how the lamp manufacturers had gone into the trade papers in various industrial lines to advertise their products. He also had prepared campaigns of advertising for central station companies.

Mr. C. W. Lee urged members to use the advertising matter which had been prepared by manufacturing companies and which was available at a nominal cost.

* From the "Electrical World," slightly abbreviated.

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The Oldest Electrical Journal (established as a weekly Journal, 1861-1878).
Published every Friday, Price Sixpence; Post Free, Sixpence-Halfpenny.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON
(ONLY ADDRESS.)
Tel.: Holborn **6363** (Two Lines). *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITOR. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fifty-second issue of the Supplement was published (Gratis) with the number of "THE ELECTRICIAN" for August 19.

The "INDUSTRIAL SUPPLEMENT" is a comprehensive record of developments in Electrical Plant, Machinery, Apparatus, Accessories, Sundries and Materials, and of their proved suitability for various industrial purposes.

ELECTRICITY SUPPLY AS A BUSINESS.

During a discussion at the Institution of Electrical Engineers some two or three years ago the opinion was expressed by several station engineers that the introduction of the metal filament lamp would certainly temporarily, and perhaps permanently, affect their lighting loads. Some of those taking part even went so far as to say that the only way of preventing any reduction in revenue, due to this cause, was to raise the prices for energy—not, it will be agreed, a very commercial proposition, or one which was likely to appeal with any great force to their consumers.

The prognostications of these prophets of evil have to some extent been realised; and as all disaster is popularly supposed to be directly due to our own shortcomings, an immediate examination to discover whether anything was lacking in the economic conduct of our electricity supply undertakings was not out of place.

It did not take long to discover a point of weakness. The sense of stability of our electricity undertakings up to that time was too liable to engender in the staff, after the first few years of working, an inclination towards *laisser-aller* which is met with in most Government and many municipal offices. As long as it was possible to run the station fairly economically and to increase the number of consumers by an adequate amount each year, every one was satisfied and matters went quite smoothly. But the introduction of the metal filament lamp changed all this, and we are of the opinion that this invention has been distinctly a blessing to electrical engineering generally. Perhaps supply engineers may have thought that during the past two years the benefits have been rather disguised, but they, too, are now beginning to recognise that their troubles were of the chastening variety. The metal filament lamp has, in fact,

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jerked many a supply undertaking into vigorous life, and the reduction in load has set many an engineer on a career of business-getting.

Now, this operation of business-getting can be performed in a number of ways. We are heartily in agreement, as regards principle, with the enterprise exhibited by those supply engineers who have set up show rooms and sent canvassers on travels round their area, but we have also had occasion to point out that much of this work has been undertaken without a clear idea as to the end in view, and that an inefficiency exists which an engineer should abhor, as we are told Nature abhors a vacuum. The responsibility of this publicity campaign has been placed in many cases on an engineering assistant. But it seems to have been forgotten that because a man is both a theoretical and practical expert in electrical engineering, and is well acquainted with the way in which a station should be run, it does not follow that he is also capable of persuading that shy bird—the prospective consumer—of the benefits which will result from connection to the supply mains.

A canvasser, no less than a poet, is born, not made. He must be possessed of brazen cheek and of the wisdom of the serpent, without the harmlessness of the dove. He must be able to treat his superiors, inferiors and equals in just the way in which they like to be treated, and in just that way which will eventually draw them on to the electricity network. He must be at home in other people's houses (a difficult accomplishment to many), and must be as capable of congratulating the lady of the house on the appearance of the baby, as the master of the house on his acumen in getting the better of the plumber. It will, therefore, be seen that the canvasser requires very different characteristics from those of the engineer, and that to employ one of the electrical staff on such work is a grave tactical error. No one would think of placing a whilom canvasser in charge of a generating station, though the reverse operation is apparently to many quite without its ridiculous side.

In Sunderland Mr. A. S. BLACKMAN has reached the stage of finding that canvassing cannot be efficiently performed by an engineering staff who are at the same time engaged on other duties; and he recently recommended that a canvasser be appointed to deal with this portion of the work. The reasons which have led him to this decision are not without interest. The number of units sold for lighting has, for the last two years, been decreasing, and the last of this decrease has, it is thought, not yet been reached; also the reduced cost of lighting, due to the new lamp, is not great enough to attract sufficient new consumers to maintain the former position. The new lamp, if it is to be used to the best advantage, requires the remodeling of installations to some extent, and thus "there is always a risk of losing consumers to an active opposition." This recognition of an "active opposition" is a confession of present weakness, which Mr. BLACKMAN should counteract by setting up a well-organised publicity campaign.

This, in fact, he proposes to do. Up to the present, canvassing has been conducted by the engineering staff, on commission, and in addition to their other duties. The scheme has not been a success, for as a result only 27 consumers have been added to the mains during the greater part of the year. Mr. BLACKMAN now points out the necessity for an up-to-date show-room to which prospective consumers may be invited. Further, he recommends the appointment of a canvasser, as he recognises that the work of obtaining new consumers cannot be carried out satisfactorily by the engineering staff. This is a step in the right direction. We are a little doubtful, however, whether the salary suggested—£78 and commission—is as high as it should be, and whether Mr. BLACKMAN will get a man of sufficient ability for the sum proposed to affect materially the number of new consumers. Even a canvasser is worthy of his hire, and the results obtained in such cases generally vary as the nth power of the salary given, the value of n being greater than unity, within certain limits. The question as to who should ultimately rule the electricity supply undertaking, the business manager or the engineer, is a wide subject which cannot be argued here, but it must be remembered that such undertakings are now business concerns and must, therefore, be carried on under commercial control, whether this control is subordinated to engineering requirements or not. This recognition at Sunderland of what is required is a hopeful sign, and we only trust that Mr. BLACKMAN'S example will be followed by many of his brother engineers.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Handbuch der Elektrotechnik. Vol. IX. "Elektromotoren, Umformer und Elektrische Motorantriebe." By Dr. F. Niethammer. 2nd edition. (Leipzig: S. Hirzel.) Pp. xvi. + 469. M.20.

This is a most difficult book to criticise. It is one of the most extraordinary conglomerations of electrical matter that it would be possible to imagine. Probably the best description of the book would be to call it a mixture of catalogues and text-books, but we only give this description for want of a better. The reviewer is at a loss what to do. To praise the book would be flattery, to condemn it would be unjust. But if we really must come to a decision, we might appeal to the analogy of a well-known allegory, and say that "parts of it are excellent."

The chief obstacle that prevents our making a satisfactory review of the book is that we cannot find out for whom it is written. We have tried all manner of heads, but the hat will not stay on any one of them. At times we think the book is written for the manufacturer, and go merrily on seeking what may be of interest to those engaged in this branch of electrical engineering. But, alas! we soon come to grief, for we find that in the descriptions of the machines—which occupy a considerable portion of the book—most of the examples given are reproduced from the 1900 edition; but this is 1910, and machines are being remodelled year by year. Moreover, the information given is seldom sufficient; usually it is indescribably meagre and scrappy, being apparently thrown together anyhow, whilst some of the types given refer to firms long since unheard of, being either merged into larger concerns or obscurity.

Nor even after a closer inspection are we able to modify these first impressions—in fact, there are so many examples to confirm this view that it is difficult to know which to select. Thus, Figs. 73 and 74 are plates showing a ¾ H.P. to 1 H.P. motor by Helios—which we take to be a former firm in Cologne. Of this motor, we learn that it is totally enclosed, has but one pole

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wound, and a few other mechanical details, along with the usual dimensions given in a catalogue. No mention is made of voltage, speed, weights, nor of any electrical particulars whatever. In another instance the number and size of the slots, the armature dimensions and the flux density in different parts of the circuit are given. Indeed, scarcely any two motors seem to be treated alike, and practically none are described fully.

Equally unsatisfactory is the result when an attempt is made to criticise the matter from an historical point of view. But a gleam of hope did certainly come when we tried to fit the hat on to the head of the more general engineer, who, having either no wish or chance of making investigations for himself, might appeal to such a book to find out the practical part of the technical knowledge contained in text-books and genuine trustworthy information gleaned from the multifarious matter contained in manufacturers' catalogues and advertisements. But, alas! we are again disappointed here, for the material is given in very much the same way as it would be found in its original sources. On the other hand, what a useful handbook it would have made if such an independent authority had collected and summarised such material, and, after pruning all superfluous and obsolete matter, given a good critical digest of the remainder. Such a treatise would be appreciated by everyone, because it would be useful to everyone. The manufacturer, on the one hand, would be pleased to have such a treatment, for it would show him how his apparatus and machines ought to be designed and constructed in the light of best modern practice, whilst, on the other hand, the user would have a work placed in his hands informing him what he had a right to expect and demand, at the same time giving him a clear insight into the method of working of the various machines, so that when called upon to make his selection he would have the advantage of an unbiassed judgment. In other words, such a book would serve the double purpose of keeping the designer up to his work and at the same time make the intelligent buyer and consultant largely independent of the partial advice offered by the various competitors. For example, think what aid such a work would be to the man actively engaged in the manufacture of electrical machines to be able to compare his experience with that gained by other manufacturers. Equally useful it would be to the man engaged outside manufacture, who requires to know, let us say, why and when commutating poles should be used and the advantages obtained therefrom, what reasonable speed regulation may be expected thereby, and so on. Or, again, when ought one to sacrifice price for efficiency? at what output ought an induction motor to work at its best advantage? and how ought such a machine to be rated with respect to overload capacity and power factor? It is only on some such lines as these that we think a book like the present could be properly written, and because it has fallen short of this standard we are bound to consider it in some ways a failure. Moreover, it is certain that unless a treatise on electrical engineering is written with some definite object, there is little chance of its success in the ever-increasing volume of English, German and American literature published nowadays.

Turning again to the contents of the book, it is with the first two parts that we have chiefly to find fault. Part I., dealing with electric motors, occupies some 230 pages, just one half of the book. We have already stated our main objections to the unsatisfactory method of treatment and the out-of-date material. Part II., dealing with converters, occupies some 28 pages. Really we cannot understand why converters should have a place in the title of the book, especially when 15 out of these 28 pages deal with stationary transformers. Our chief reason, therefore, for not recommending the first two parts of the book is because the subject matter is treated much better elsewhere.

The last part of the book, Part III., dealing with "Electric Motor Driving," is by far the best. This section occupies some 200 pages, and is much better arranged than either of the other sections. Though even here there are many signs of incompleteness, yet the author has, on the whole, done well in the collection, arrangement and criticism of his matter. Starting with the selection of motors and their various accessories, he passes on to the application of electric motors to all kinds of cranes, lifts, transporters, winches, haulage gears, pumps, &c. In another chapter he treats of electric driving of tools, rolling mills and the like, whilst finally he sketches out the equipment of factories and other installations where electric power is employed. In addition to the large amount of interesting matter given in this section, there is also much useful data which can be well employed in planning out projected installations. STANLEY P. SMITH.

L'Électricité dans les Mines. By E. J. BRUNSWICK. (Paris: Gauthier-Villars.) Pp. vii. + 255. 7fr.50.

Some four years ago a series of very interesting discussions on electric winding took place at the Institution of Electrical Engineers and its various local sections, and opinion was very divided as to whether electrical winding could be economically adopted in place of steam. Even now our Engish mine owners and mining engineers do not seem to be quite satisfied that the decrease in running expenses due to electric winding will compensate for the increased capital expenditure of an electric over a steam winding plant; with the result that, although electricity is largely employed in England in other branches of mining work, there are but few examples of electric winding engines in this country. On the Continent, however, electric winding has made great headway both in France and Germany, the results obtained being in the majority of cases quite satisfactory.

The book under notice is almost entirely devoted to electric winding, and should be valuable to the English mining engineer, since it will enable him to see what has actually been accomplished in this direction on the Continent. The author presented a report on the electrical equipment of mines to the Congrès International des Applications d'l'Electricité, held at Marseilles in 1908, and this book is the outcome of his work upon that report. It will be seen, then, that the author has had an excellent opportunity of becoming familiar with every aspect of the subject of the electrical equipment of mines.

The book is composed of 19 chapters, of which the first eight are devoted to a brief treatment of the various applications to which electricity has been put in mines—for lighting the mine, for driving pumps and ventilators, special motors for service at the bottom and for haulage and traction systems. The benefits to be derived from the application of electricity to all these purposes is now quite generally recognised, and already electrical power is being largely used in England for such work. The whole of these subjects are dismissed in less than 40 pages, the remainder of the book being given up to electric winding.

The advantages which electrically-driven winding gear possesses over steam winding machinery are all clearly stated; the author, too, states clearly the advantages claimed for the Koëpe pulley—so largely used on the Continent—over ordinary winding drums. English engineers, however, are in favour of winding drums. The various continuous and alternating current systems in use, and the methods of equalising the load on the central station are all discussed at some length, and an actual installation is worked out for the three most important systems at present in use. The remaining two-thirds of the book are devoted to actual detailed descriptions of the most important and typical installations at present in operation, and should prove very useful to mine managers and consulting engineers.

The book throughout is clearly and simply written; it is essentially a practical treatise, and should prove a good investment for all engineers connected with mining work, and also for students of mining engineering. A. E. C.

"The Gas, Petrol and Oil Engine."—Messrs. Longmans, Green & Co. write us that the published price of vol. I. of "The Gas, Petrol and Oil Engine," by Dugald Clerk, which was reviewed in our last issue (p. 777) is 12s. 6d. net, *not* 4s. 6d. net as erroneously stated.

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AN OVERLAP LOOP TEST.

BY DANIEL SHIRT.

The loop method of fault localisation on electric mains has found favour with many engineers; yet there are still to be found those who fail to realise the great accuracy attainable by its means and who prefer one or other of the so-called "fall of potential methods."

Apart from the errors introduced in the latter methods by variations in the resistance of the fault and possible variations in the earth potentials at the fault and the testing point, produced by stray tramway or other currents, one may easily make an error of, say, 1 per cent. in reading the instrument deflections. This last source of error does not obtain, however, in "null" methods. Then again the instrument itself may have an index error of over 1 per cent. On the other hand, the accuracy of a loop test is only limited by the permissible strength of the testing current, and the sensibility of the galvanometer employed, provided due regard be given to the elimination of contact resistances.

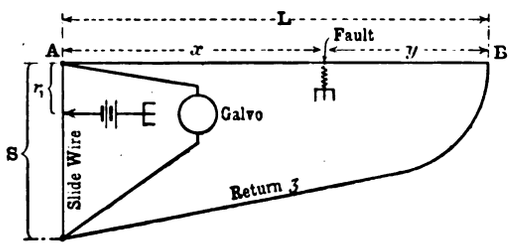

FIG. 1.

Mr. F. C. Raphael, in his excellent work "The Localisation of Faults in Electric Lighting and Power Mains," deals with the subject of loop testing in a comprehensive manner, and points out the few simple yet necessary precautions to be observed. In the present article the writer proposes to deal with a particular method of applying the Murray test, which possesses, he believes, distinct advantages.

Cases frequently occur in fault localisation by loop test where it is found necessary to employ a *return* of different section or length from that of the faulty cable. In such cases, failing exact data as to the ratio of the resistances of the two conductors, or the diameter and number of wires in each cable, one would be compelled to assume that their resistances were in inverse ratio to their *nominal* sectional areas. For example, a nominal 0·50 sq. in. cable would be assumed to be double the resistance of a nominal 1·00 sq. in. cable. The true ratio, however, between the resistances of these cables—assuming

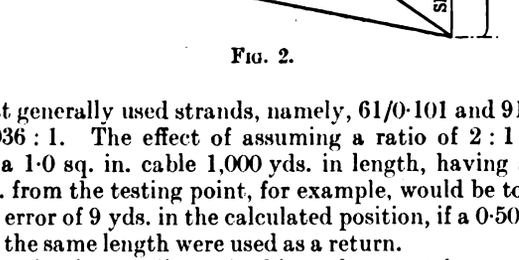

FIG. 2.

the most generally used strands, namely, 61/0·101 and 91/0·118—is 2·036 : 1. The effect of assuming a ratio of 2 : 1 in the case of a 1·0 sq. in. cable 1,000 yds. in length, having a fault 759 yds. from the testing point, for example, would be to introduce an error of 9 yds. in the calculated position, if a 0·50 sq. in. cable of the same length were used as a return.

By the simple expedient of taking a loop test from *each* end of a faulty cable, we need not know the resistance of the return, or even of the line, if it does not vary in section, provided the resistance of the loop remain constant.

Further, leakages to earth from the return itself become partially compensated for, because the calculated position of the fault will always lie between the two resultant faults due to such leakages.

Let AB (Fig. 1) represent a faulty cable of constant section and resistance L, divided by a fault into two sections x and y. Let us call the resistance of the return z. Let us also assume that a slide-wire bridge is used to carry out a Murray loop test at each end. At the end A, balance will obtain when the slide-wire is divided into two portions, such that $r_1 : S :: x : x+y+z$. Similarly, at the end B (Fig. 2), balance will obtain when $r_2 : S :: y : x+y+z$. Compounding these ratios

$$r_1 : r_1+r_2 :: x : L.$$

That is,
$$x = \frac{r_1 L}{r_1+r_2} \quad \ldots\ldots\ldots \quad (1)$$

Obviously, this equation is also true if we express x and L in units of length (yards, for instance), and r_1 r_2 in number of divisions of slide-wire from the points A and B, respectively.

It will be noticed that neither the resistance of the return nor the total length of slide-wire enters into this equation. It is, therefore, clear that when the resistance of the return is high compared with that of the faulty cable, we may, by adding a resistance in series with the slide-wire, increase the values for r_1 and r_2, which might otherwise be too small to read to the required degree of accuracy. This added resistance must not, of course, be altered throughout the tests, and should, if possible, be of the same metal as the slide-wire itself, otherwise errors may be introduced by possible differences in temperature at the testing points.

This test, with a simple correction, may often be advantageously employed in fault localisation on multicore or concentric cables, where a sound return is not available, but, in this case it is necessary to know the ratio between the resistances of the line and return conductors, where great accuracy is desired. A typical case of this kind would be where a fault had developed on one conductor of, say, a three-core cable, and that the insulation of the other conductors had fallen considerably owing to the ingress of water or the development of excessive heat at the fault.

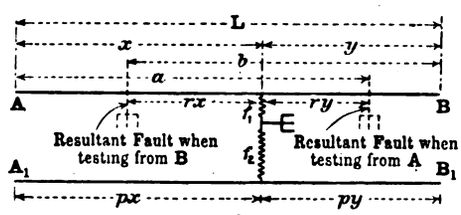

FIG. 3.

Fig. 3 illustrates diagrammatically a case of this kind, only the two conductors used for the test being shown.

Let f_1 and f_2 be the fault resistances of the conductors AB and A_1B_1 respectively, f_2 being high as compared with the resistance of the loop.

Let $x+y=L$=the resistance of AB.

Let $p(x+y)$=the resistance of A_1B_1, where p is the ratio of the resistance of A_1B_1 to that of AB.

Let a=the resistance from A to the resultant of the faults f_1f_2, as found by test from A, BB_1 being coupled together.

Let b=the resistance from B to the resultant of the faults f_1f_2, as found by test from B, AA_1 being coupled together.

Let $r = \frac{f_1}{f_1+f_2}(1+p)$.

Then, $x=a-ry$ and $y=b-rx$. From these equations we obtain

$$x = \frac{(a-br)\,L}{(a+b)\,(1-r)} \quad \ldots\ldots\ldots \quad (2)$$

As in equation (1) we may express x and L in units of length, and a and b in the number of slide-wire divisions from the points A and B to their respective points of balance.

Referring to Fig. 3, we see that the distance between the resultant faults is rL. Therefore, if by P we represent that length of slide-wire which corresponds to the conductor AB, namely, $\frac{S}{1+p}$,

$$r = \frac{a+b-P}{P} \quad \ldots\ldots\ldots \quad (3)$$

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Note that the value of x is indeterminate when $r=1$, that is, when $a=b=P$, and that the smaller r becomes, the nearer x approaches to the value $\frac{aL}{a+b}$.

Let us now consider a numerical example. A fault occurs on, say, a three-core cable 1 mile in length, having cores nominally of equal section. Selecting for our line and return the two cores having the lowest and the highest resistances to earth respectively (a few cells and a linesman's detector are convenient for this purpose), we carry out a Murray test, first at the end A and then at the end B. Let us assume that we obtain 247 and 278 divisions for our balance points respectively. We, of course, are careful to measure our slide-wire divisions from the *same* core at each end. Let us further assume that our slide-wire has 1,000 divisions (in practice one must allow for the effect of connecting leads when their resistances are not negligible quantities). Now, the number of slide-wire divisions corresponding to our line conductor is in this case $\frac{1,000}{1+1}=500$. Substituting for a, b and P in (3),

$$r=\frac{247+278-500}{500}=\frac{1}{20}.$$

Again, substituting in (2)

$$x=\frac{\left(247-\frac{278}{20}\right)1,760}{(247+278)\left(1-\frac{1}{20}\right)}=822{\cdot}6 \text{ approx.}$$

We therefore search for the fault 822·6 yds. from the end A.

As a check on the accuracy of our figures, we may calculate the result by reading the number of slide-wire divisions to the points of balance from the *other* core at each end. At the end A we have 1,000−247=753 divisions, and at the end B we have 1,000−278=722 divisions.

In this case

$$r=\frac{753+722-500}{500}=\frac{39}{20}.$$

Substituting in (2), we obtain as before

$$x=\frac{\left(753-722\times\frac{39}{20}\right)1,760}{(753+722)\left(1-\frac{39}{20}\right)}=822{\cdot}6.$$

In the example we have just considered, it will be interesting to investigate the effect of making an erroneous assumption as to the relative resistances of our line and return. Let us suppose that the return is 2 per cent. higher than the line. (This is a very much greater percentage than is likely to obtain in modern multicore cables.) Now, the number of slide-wire divisions corresponding to the line in this case is $\frac{1,000}{1+1{\cdot}02}$ =495 approx.

Consequently

$$r=\frac{247+278-495}{495}=\frac{2}{33},$$

and substituting in (2)

$$x=\frac{\left(247-278\times\frac{2}{33}\right)1,760}{(247+278)\left(1-\frac{2}{33}\right)}=821{\cdot}3 \text{ approx.}$$

From this result we may conclude that one is not likely to be misled to any great extent in multicores of nominally equal section, if they do not exceed a mile in length.

In order to apply the above formulæ when using a box of resistance coils, r_1, r_2, a and b must represent ratios obtained in the usual manner, namely, the ratio of the resistance in the arm adjacent to the core from which one wishes to obtain one's readings, to the total resistance unplugged in the box. P will then be $\frac{1}{1+p}$, *i.e.*, the ratio of the resistance of the line to that of the loop.

With regard to the relative merits of the two kinds of bridges, it would appear that the slide-wire is to be preferred to the resistance box for fault localisation on low resistance loops, because a reading to the third, or even the fourth significant figure can be readily obtained, notwithstanding that the wire may have a resistance of ½ ohm, or even less. On the other hand, with the usual types of resistance boxes, to obtain a ratio to the third significant figure, one has usually to unplug more than 100 ohms. This is a decided disadvantage in most cases. Plug contact resistances, too, often introduce serious errors. Moreover, a current which would seriously overheat the coils of a resistance box, and thus prejudice the accuracy of a test, could be passed through an ordinary slide-wire bridge with impunity.

Where two faults are known to exist, as in cases like the numerical example given above, the testing current must be reduced as much as the sensibility of the galvanometer will permit; otherwise r may vary slightly during the test. It will generally be found better to balance to "false zero" when a third core is available through which the galvanometer may be earthed at the fault itself. The testing current may then be reduced to a minimum.

Where the galvanometer "kick," due to the difference in the capacities of the line and return, is troublesome, it may be eliminated by inserting a suitable variable condenser, or a standard condenser with a variable series resistance between the line terminal of the bridge and the galvanometer earth.

ABNORMAL TRANSMISSION OF ELECTROMAGNETIC WAVES.*

BY PAUL SCHWARZHAUPT.

It is well known that wireless telegraph stations whose normal range is, say, 100 km., may, under certain conditions, be heard at a distance of 1,000 km. or more. The Table on next page gives examples in which a reciprocal intercourse was possible between the stations named.

The ships named have a range of 300 km. to 500 km.; that of Scheveningen and New Orleans is about 700 km.

From the table it appears that the phenomenon of abnormal range only occurs at night. This is probably due to the low ionisation of the atmosphere after sunset. Towards sunrise the distance that can be reached takes its normal value.

Frequently one station may be heard by another at a great distance away, but not the second by the first. On Dec. 17, 1908, evening, the ss. "König Wilhelm II." and "Cap Roca" communicated with one another over a distance of about 50 miles, south of Lisbon. At the same time the ss. "Cap Arcona," in the English Channel, heard, during several hours, the correspondence of both ships, at a distance of 2,400 km. On Oct. 17, 1908, the "Bremen" was able to receive telegrams from the Norddeich station, near Bremerhafen, at midnight, in the harbour of Port Said; the distance being about 3,100 km., one-third over sea, two-thirds over land.

On Jan. 14, 1909, in the evening, the "Bremen," when north of Haaks lightship, in the North Sea, heard distinctly not only the two stations at Marseilles but also the signals between the American warship, going from Port Said to Marseilles, and Algiers.

It is strange that such favourable results have only been obtained at quite definite places, such as the Gulf of Lyons, Port Said, the region between Cape Finistere and Lisbon; a place in the Atlantic Ocean, long. 10° 15′ W., lat. 48° 40′ N.; the neighbourhood of Scheveningen and Haaks lightship.

An interesting series of observations was made on the s.s. "Bremen," during a voyage in the Mediterranean Sea, whilst receiving from the Norddeich station over the Alps. When leaving Naples, about 540 km. south of Genoa, telegrams could be received at night, with an intensity which we will denote by unity, next day 260 km. south of Genoa, the intensity had decreased to 0·65, rising at night in the harbour of Genoa to 2·4, and falling next day at the same place to 0·085. Thus, although the intensity in the daytime decreased as the ship approached the Alps, no such effect was observed at night.

The variation in intensity for the whole journey is shown by the curves. The ordinates, which represent the intensity, are the ratios of the resistance of the telephone to that of a shunt across it;

* Abstract of an article in the "Elektrotechnischer Zeitschrift."

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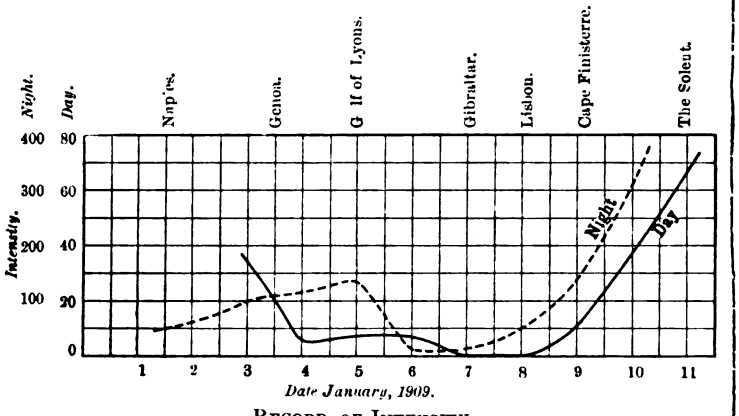
Stations.		Date.	Time.	Distance.	Positions of stations.
ss. "Cap Arcona"	Scheveningen	10/1/09	8 p.m.	1,600 km.	Scheveningen, on the coast of Holland. "Cap Arcona," 15 nautical miles south of Vigo.
ss. "Bremen"	ss. "Cap Arcona" ...	10/1/09	8:40 p.m.	1,400 km.	"Cap Arcona," 20 miles south of Vigo; "Bremen" in English Channel, north of Cherbourg.
ss. "Bremen"	Scheveningen	5/1/09	9:50 p.m.	1,280 km.	"Bremen," in Gulf of Lyons, lat. 41° 48′ N., long. 5° 6′ E.
New Orleans, Louisiana	St. Augustine	24/12/06	Evening	900 km.	New Orleans, south coast of United States; St. Augustine, East Coast.
Guantanamo, Cuba	Washington	24/12/06	Evening	2,500 km.	
ss. "Cap Frio"	ss. "Cap Vilano" ...	27/3/08	9 p.m.	1,216 km.	"Cap Frio," 26° 20′ N., 20° 34′ W. "Cap Vilano," 35° 46′ N., 14° 6′ W. Direction 34° 4′ E. of N.
ss. "Cap Verde"	ss. "Cap Arcona" ...	2/9/08	Evening	1,850 km.	"Cap Arcona," 600 miles north of Bahia; "Cap Verde," Madeira.

the latter being adjusted each time so that the signals could just be distinguished. The deep depression on the curves corresponds to the time of passing the Spanish mountains, illustrating the powerful deflecting or absorbing effect of mountains and forests. It may be noticed that the intensity at night was always sufficient to allow the telegrams to be received. At the place on the curves corresponding to the Gulf of Lyons there is a distinct maximum. Here it was found possible to signal to Scheveningen, a distance of



RECORD OF INTENSITY.

1,200 km., and it is striking that this favourable direction follows that of the Rhone Valley. It is also noteworthy that the Ushant station heard these signals of the "Bremen," this direction coinciding with that of the Garonne.

With regard to atmospheric disturbances, the following observations have been made:—

1. The disturbances always begin in the afternoon, reaching their maximum towards midnight, and disappearing almost completely by sunrise.
2. They are most frequent in tropical climates.
3. They are more violent in summer than in winter, in consequence of the more frequent thunderstorms.
4. They are particularly noticeable in the neighbourhood of high mountains, *e.g.*, the Red Sea, the coasts of Italy and Spain. In the Mediterranean Sea the disturbances in winter are relatively weak.

Frequently violent disturbances are observed when the sky is quite clear; it is assumed that these proceed from a distant thunderstorm.

Unfortunately, little has so far been published on this subject. It is desirable that reliable statistics should be collected and radio-topographical maps prepared, which would be particularly useful on ships equipped with radio-telegraphic apparatus.

CORRESPONDENCE.

FISCAL POLICY AND THE ELECTRICAL INDUSTRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice from a cutting from THE ELECTRICIAN sent on to me here that Mr. Hookham points out that no one has taken up his challenge. I did not do so in detail myself as I was just leaving for this part of the world, but if you will grant me the space when I return I shall be glad to make the attempt to show that exports do not pay for imports.—Yours, &c.,

Calgary, Alberta, Aug. 4. A. BRUCE ANDERSON.

THEORY OF THE QUADRANT ELECTROMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The method of establishing an electrometer formula adopted by Prof. Robertson, in his letter in your issue of August 19th, is the familiar and traditional one based on a consideration of changes of capacity in the system. In my article, purposely and avowedly eschewing this method, I base everything on a consideration of the electrostatic forces at work. It may be a retrograde step to call a force a force, rather than a space rate of change of energy, but it certainly seems to me that by doing so there is a distinct gain in clearness of treatment and simplicity of statement when dealing with certain classes of electrometer problems.

The final formula arrived at by Prof. Robertson looks curiously odd with V_1 absent from the denominator on the right-hand side, which would seem to suggest a mistake somewhere. In working with the method used by him, I have been in the habit of assuming that, for small deflections and with initial symmetry, $dc_1/d\theta$ and $dc_2/d\theta$ are linear functions of θ and can be represented by $a-b\theta$ and $a+b\theta$ respectively. This is equivalent to assuming that the electrostatic forces on the two sides of the needle vary linearly, and is more general than the assumption of Maxwell that the capacities on the two sides vary linearly. The formula then becomes

$$\theta=\frac{a(V_2-V_1)\left(V-\frac{V_1+V_2}{2}\right)}{k+\frac{b}{2}(V-V_1)^2+\frac{b}{2}(V-V_2)^2};$$

but this can hardly be regarded as more than a special case of the electrometer formula. In an actual electrometer, one can readily see, on general principles, that a term containing the product V_1V_2 may be required in the denominator, as in the last formula in my Paper quoted from Orlich's "Elektrometrische Untersuchungen." Clearly Prof. Robertson's original equations, when correctly worked out, lead to the formula just given, $\frac{1}{2}\left(\frac{dc_1}{d\theta}+\frac{dc_2}{d\theta}\right)$ being written for a, and $\frac{1}{2\theta}\left(\frac{dc_2}{d\theta}-\frac{dc_1}{d\theta}\right)$ for b.

My definition of the electrostatic controlling couple was made with reference to an electrometer in which the deflection θ is small, and in which the needle is subject to a mechanical controlling couple proportional to the deflection. If in such an electrometer, the total electrostatic couple can be represented by the first two terms of a series $A+B\theta+C\theta^2$ &c., then it is quite right to call the term A the deflecting couple and the term $B\theta$ the electrostatic controlling couple. Obviously A and B will in general be functions of all the potentials concerned, and the electrostatic control will, therefore, depend upon the potentials V_1, V_2 of the quadrants as well as on the potential V of the needle. But in the ordinary use of the electrometer to measure small P.D.s the needle is charged to a potential V, high relatively to V_1 and V_2, and A is proportional to $V(V_1-V_2)$, whilst B is proportional to V^2, being thus independent of the quadrant potentials. To these assumptions I see nothing either unjustifiable or unusual; but, of course, any attempt to apply the term electrostatic control,

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in the above sense, to cases not contemplated in the definition, may easily turn out to be both the one and the other.

The notion of an electrostatic control, defined substantially as I have defined it, dates back many years, as Prof. Robertson will find on consulting the literature of the subject. Strangely enough, it has not yet filtered down to the common English text book.—I am, &c.,

Manchester University, Aug. 20. ROBERT BEATTIE.

STREET LIGHTING IN WESTMINSTER.

In our "Editorial Notes" last week we drew attention to the way in which the Gas Light & Coke Company was advertising its success in retaining certain portions of the street lighting in Westminster. From the paragraphs published on the subject it appeared that electric lighting was to be quite ousted from the city, and this because of the much greater cheapness of gas. We pointed out that the case for electric lighting was most unfairly stated, and that the true reason for the wide difference in the tenders for the two illuminants was due to the fact that the gas company were quoting an unprofitable price, in the hope that advertisement would ensue. This point of view is upheld in a letter which we have received from the Charing Cross, West End & City Electricity Supply Co. giving an extended statement of figures on the subject. We are glad to see that this statement is finding its way into the daily Press, with the result, we hope, of counteracting to some extent the value of the gas company's recent and future advertisements. This letter also brings out very clearly the disabilities under which the electric light companies suffered as regards the time limit for the repayment of capital, and from which the gas companies are free. The question as to whether the electric light companies were pursuing a proper policy in dealing with the necessary capital charges as they did has already been dealt with by us,* though we agree with our correspondent that the conditions of the specifications might have been made more flexible than was actually the case. The letter is as follows :—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is being persistently reported in the public Press that the City of Westminster have displaced electricity by gas for street lighting throughout that city. This statement, however, is untrue. The facts are as follows :—

The Westminster City Council transferred the lighting of that part only of the City of Westminster which has been hitherto very efficiently and economically lit by the St. James's Electric Light Co. to the gas company. This lighting comprised the supply to 66 arc lamps. The Westminster Electric Lighting Co. under contract are still supplying, and will continue to supply until 1931, 970 arc lamps, and the Charing Cross Co., under contracts which do not expire for some years, 165 arc lamps in the City of Westminster. It will be seen therefore that about 5¾ per cent. only of the lighting previously carried out by the electricity supply companies has been entrusted to the gas company.

These figures speak for themselves, and need no further comment on this head. When, however, so much attention is being called to the difference in the price quoted by the electricity supply companies and the gas company respectively, it is only fair to the former that the conditions under which the respective prices were quoted should be understood and appreciated, and I therefore call attention to the following points :—

The electric supply companies were invited, at considerable capital cost, to enter into a contract for five years, determinable at the expiration of that period at the option of the City of Westminster without compensation of any kind. Prices were also invited alternatively for 10 and 15 years contracts.

By the terms of the specification, the electricity supply companies (the gas company's network of street lighting mains already covered the entire area) were compelled to quote for the *whole* of such specific district or districts as might be within their particular area of supply. The City of Westminster Council on their part reserved the right *to select any part or parts* of those districts for lighting by electricity to the exclusion of other parts of the district, at the contract price per lamp quoted for the whole district. It is obvious, therefore, that the electricity companies in the event of the exclusion of parts of the district, might suffer serious loss.

The concessions of the electricity supply companies expire in 21 years and all capital charges would have to be provided for within that period. The gas company is not purchasable by the local authority, and has, therefore, a practically unlimited period in which it would be possible to deal with capital charges.

The furnishing of the supply by the electric light companies would have necessitated the laying of additional cables and the construction of other works involving a very large capital expenditure. With the gas company, as to the greater portion of the work involved, mains were already laid and capital expenditure made.

The terms of the specification imposed by the Westminster Council were thus (unintentionally, no doubt) exceedingly unfair to the electric lighting companies, and, owing to existing conditions, were relatively favourable to the gas company.

In circumstances such as these, could the electric light companies do otherwise, on business lines, than safeguard their shareholders' interest by making provision for these capital charges and contingencies in the price quoted per lamp? What could have been done if the specification had been framed so as to allow the companies, as well as the City of Westminster, to select convenient portions of districts for tender, is evidenced by the fact that the St. James's Company, owing to matters which transpired at the Westminster City Council meeting of April 14 last, offered to continue their supply to the section then lighted by them at a price which compared not unfavourably with the gas company's. Their request, although supported by nearly the whole of the principal shopkeepers in the area, was refused on the ground that it had already been decided to place the contract with the gas company.

It has also been published abroad that the City of Westminster will effect very large savings by the arrangement with the gas company. This is not accurate *qua* electric lighting. The City of Westminster in this connection is saving only the small difference between the low price charged by the St. James's Co. and the cut prices offered by the gas company. If, therefore, a saving is being effected, it is probably due to the drastic revision of the gas company's own prices for the supply they themselves have hitherto given in the City of Westminster.

The question whether or no the contract will pay the gas company other than as an advertisement is, of course, one for themselves and their shareholders, but an analysis of their published accounts would appear to show that their costs are 1s. 10d. per 1,000 ft., while the contract price, which includes capital charges for street work, would appear to yield certainly not more than 10½d. per 1,000 ft. as against 2s. 8d. per 1,000 ft. charged to the general public. Would it be very unfair to deduce that considerations of advertisement and preference had an undue bearing upon the composition of the prices tendered by the gas company?

To put the matter shortly, making allowance for the considerations mentioned in the preceding paragraph, the whole of the difference between the price tendered by the gas company and the electric lighting companies respectively is due to this question of capital charges in connection with the short unexpired periods of the provisional orders, the duration of the proposed contract (five years) and the handicapping conditions imposed by the terms of the tender upon the electricity supply companies, and not in the price at which electricity could be sold under ordinary and reasonable conditions.—I am, &c.,

EDWD. WILLMOT SEALE, Secretary.
The Charing Cross, West End & City
London, W.C., August 20. Electricity Supply Co. (Ltd.)

The method of arriving at the above figures of 1s. 10d. per 1,000 cubic ft. (the cost to the gas company of the gas sold to the public at 2s. 8d. per 1,000 cubic ft.) and 10½d. per 1,000 cubic ft. (the price likely to be obtained by the company under their contract with the City of Westminster) is set out by Mr. Seale in a further communication. The substance of this is as follows :—

High Pressure Gas.—According to Mr. Bradley's report published in THE ELECTRICIAN of March 11, 1910, a 1,000 c.p. (nominal) high pressure gas lamp, giving an average candle power of 880, takes 30 cubic ft. of gas per hour; therefore a 3,000 c.p. lamp must take at least 90 cubic ft., or, say, 1,000 cubic ft. per 11 hours. As the number of lighting hours per annum are 3,940, the total consumption of gas would therefore be 354,600 cubic ft.

With gas at 10½d. per 1,000 cubic ft. the cost of 354,600 ft. is	£15	10	3
Leaving for maintenance of 3,000 c.p. lamps (3 mantles)	6	9	9
Contract price	£22	0	0

It should be noted that maintenance items are not chargeable against private consumers in the price of 2s. 8d. per 1,000 ft., so this item is therefore omitted in the comparison, and the figure of 10½d. compares with 2s. 8d. Also, when the extreme urgency of the conditions relating to maintenance of candle-power for the street lamps is borne in mind, it will be evident that the above sum allowed for maintenance will probably be exceeded.

Moreover, no allowance has been made for capital charges. In this connection, it is true that the expenditure has already been incurred in the greater part of the area, but we understand that special mains are being laid for the 3,000 c.p. lamps, so that the figure of 10½d. must include capital charges, and make the price more inadequate still.

In regard to the cost of manufacturing the gas, the following figures

* THE ELECTRICIAN, Vol. LXV., p. 92.

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are taken from the half-yearly accounts, to December 31, 1909, of the Gas Light & Coke Co. :—

		1,000 cubic ft.
Gas sold by meter		10,846,734
Gas sold, public and contracts		445,772
Gas manufactured		12,109,500
Costs.		
Total costs, including distribution		£1,424,941
Less lighting and repairs of public lamps	£19,573	
„ depreciation of works on leasehold lands	500	
„ received for residuals	367,517	
		387,590
		£1,037,351

The cost per 1,000 cubic ft. of gas manufactured is therefore 1s. 8½d., and cost per 1,000 cubic ft. of gas sold 1s. 10d.

UNDERGROUND WINDING PLANT OF THE NEW MODDERFONTEIN G.M. CO.*

BY R. H. COPELAND.

The object of these notes is simply to show difficulties contended with in installing the cable, getting the hoist into position, and to describe and show the system of control, safety devices, &c. The winding plant referred to is of a somewhat unique type, being the largest ever erected on the relay contact system. It is not submitted that this is the ideal system of hoisting, but a description of it will no doubt be of interest. The hoist was under order from the manufacturers some considerable time before a decision was arrived at by the management to instal the three-phase system for the electrifictaion of the remainder of the mine. I do not anticipate that another hoist of this particular type will be erected on these fields, owing to the cost of cable, &c., unless it is in close proximity to a local power station.

The plant was installed for the purpose of hauling in the incline shaft, which necessitated cables being laid from the power house to the collar of the shaft, a distance of 200 ft., down the No. 1 shaft vertically 280 ft., and on the incline (40 deg.) 1,220 ft., then 840 ft. through a crosscut, along a drive for 340 ft., and up a slope to the hoist chamber 220 ft., a total length of 3,100 ft. Before commencing this work, a temporary telephone system was put in, which proved an invaluable acquisition.

Two cables were laid, a positive and negative, having a total length of 6,200 ft., and a weight of 50 tons. The cable, composed of 61 wires between Nos. 8 and 9 S.W.G. of a sectional area 0·9 sq. in., insulated with impregnated paper, 0·50 in. thick, on which was laid one layer of very thin linen tape, lead covered, armoured with flat steel wires and served. The overall dimensions were 2 in. The lowering of the cable was effected by means of a disused hauling engine drum with good brakes. The cable drum was mounted on trestles and three turns taken round the engine drum. As soon as one cable drum was emptied, each successive length of cable was clamped securely with four clamps to the end of the previous cable and lowered down the shaft. Rollers were fixed every 30 ft. through the cross-cut, a very winding passage, necessitating many vertical rollers at the bends. The cable was rolled through to the mouth of the drive, after which natives were employed to carry it to the stope. 650 hardwood clamps were used in fixing the cable to the timbers, cross-arms, &c. The cable was moving the whole distance from the engine drum, down the shaft, through the cross-cut, and along the drive to the foot of the stope at the same time ; the only accumulation of cable which could be allowed was a large bend at the bottom of the shaft.

The jointing of the cable was effected with brass sleeves 6 in. long by $1\frac{5}{8}$ in. internal diameter, with two rows of set screws holding the ends of the cable firmly in the sleeve while the joint was being soldered. The joint was finally placed in the usual cast-iron junction box and filled in with bituminous compound. There were 10 junction boxes installed. The insulation of this paper cable required very careful treatment. In one instance a piece was cut off the end of the cable in a moist atmosphere underground and tested, showing 40 megohms ; the end was exposed for about an hour and then securely sealed. The following day the same length was tested, and gave 1½ megohms. A further length of 6 ft. was then cut off and tested, 40 megohms being again shown ; this illustrates the hygroscopic character of paper insulation in general, and of this cable in particular. After this, and several other similar experiences, it was found necessary to make the joints as quickly as possible.

* Abstract of a Paper read before the South African Institute of Electrical Engineers

The mechanical engineering department experienced quite an anxious time in lowering the hoist parts underground (a different route was taken from the one used for the cable). The cases, &c., were lowered down No. 2 shaft (vertical, 1,200 ft.) during week-ends ; they were stacked in every available nook along the mechanical haulage way, weeks prior to their being required for erection. The hoist chamber is situated about 200 ft. up the stope, which is about 4 ft. high and at an angle of 50 deg., and it contains the hoisting engine and motors, the contactors, controller, resistances and switchgear. All the material was taken up by a winch, the heaviest part weighing 5 tons, the longest, the shaft, being 18 ft. The total weight taken up amounted to 83 tons.

The winding drums are 8 ft. in diameter, and 5 ft. 6 in. wide, and are geared to two eight-pole compound wound motors, with auxiliary poles, coupled back to back in tandem. Each motor runs at 450 volts, and 364 revs. per min., and has a capacity of 210 B.H.P. for continuous operation, or 415 B.H.P. for three minutes. Two motors were considered preferable to one large motor, allowing the series parallel control to be used, and having the advantage of smaller armature diameters to reduce the flywheel effect. These motors are of the ventilated type, Morganite brushes being used, and up to full load the commutator is absolutely sparkless. The shunt field windings of both motors are connected in series, and in series with the brake magnet, and are constantly excited. It is a question whether the advantages derived through having shunt fields are sufficient to warrant expending 5 kw. continuously in their excitation.

The drums are fitted with hard wood brake blocks. Under normal working conditions the brakes are actuated by compressed air by means of the usual hand lever, but a drop weight serves as a safety brake, and is actuated through the depth indicating gear, or in case of the current being interrupted, by the magnetic brake. The drop weight is kept balanced by a compressed air cylinder, but it can also be released by the emergency hand lever.

The discharge resistance supplied for use in switching off the motor fields was discarded, and a bank of lamps, 16 c.p., 120 volts, four rows of 12 in series parallel, was installed, which took the back kick satisfactorily. As an extra precaution a carbon sparking gap set at $\frac{1}{32}$ in. was inserted.

On the main switch panel there is an automatic circuit-breaker, one double-pole main switch, one double-pole field switch with field discharge resistance, and volt and ampere meters. From this panel the cables are taken to the emergency apparatus panel, situated on the left-hand side of the foot-plate and easily accessible to the driver. The emergency panel consists of one circuit-breaker with no voltage release, brake magnet short-circuiting device, overwinding arrangement, and emergency press button switch. From thence the cables lead to the cast-iron instrument column (directly in front of the driver) carrying volt and ampere meters and air-pressure gauge, to guide the driver in starting up, and to indicate whether the correct air-pressure is available for the brakes. From the iron instrument column the wires go to the contactors.

The contactor cases, each weighing 600 lb., are mounted on a 3 in. angle iron frame, 24 ft. long by 10 ft. high, standing on a concrete foundation, and securely fixed by wedge bolts driven into the rock. The total weight of contactor cases is 6,000 lb. ; the weight of contactor bus-bars, 1½ in. × ¼ in. copper (five sets), is 150 lb. The contactors, 46 in number, are contained in 10 iron cases. There are three copper movable contacts on each contactor dealing with the main working current. The central contact is set slightly in advance of the outer two, which causes it to make contact first and break contact last, taking the full effect of the flash. This contact is easily changeable, although I consider a carbon break might have been used here to advantage.

The controller is of the horizontal drum type with 18 in. diameter drum and 32 finger contacts. It is actuated by the starting lever. The lever is set up for the driver in precisely the same way as in the case of a steam winding engine. In the mid position of the lever, the current is cut off and the motors electrically disconnected ; on moving the lever backwards or forwards the current is sent through the armatures and auxiliary poles of the motors for one direction or the other of rotation. There is an arrangement of dash pots on the controller which prevents the driver from throwing over the lever too quickly, allowing only a step by step action, but the lever can be brought back to the mid position instantly. The current dealt with by the controller is very small, so that sparking at controller contacts is negligible, and a blow-out quite unnecessary. The resistances are of the cast metal grid type, and are contained in four perforated metal cases. The series parallel control is used.

Should the driver at any time lose his presence of mind, the various safety devices are : (1) The electrical overwinding gear, a form of knife switch actuated by the depth indicating gear. Its action is

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to short-circuit the no voltage coil, releasing the circuit-breaker, which also short-circuits the brake magnet, cutting off the compressed air supply, and putting on both brakes. (2) The press-button switch acts in an exactly similar manner. (3) There is a small emergency lever adjoining the control lever, the throwing over of which releases the drop weight, cutting off the air and putting on the brakes; the overload caused by putting on the brake opens the circuit-breaker. (4) The depth indicating gear also cuts off the air, thus braking the engine drums; the excessive load opening the circuit-breaker as in the previous case. (5) Supposing the hoist is working with control lever in any running position, the driver, by throwing either of the brake levers violently over to the "brake full on" position, releases the drop weights putting on the brakes, at the same time the control lever is thrown to the mid position, disconnecting the motors electrically.

Owing to the dampness of the hoist chamber, the test on both armature and field windings was zero. After a few days the test of the field coils went up to 100,000 ohms, the effect of playing a blow-lamp flame on the outside of the field frame. A current at 250 volts from a lighting set was switched on the two field windings in series; this after a few days raised the field test to 300,000 ohms. The armatures were then treated inside the drums to a steady mild blow-lamp flame, until the test rose to 200,000 ohms, the two motors were then run in series, with all resistance in, as shunt machines at 500 volts continually reversing, using the small starting current to heat the windings, and occasionally putting on an artificial brake load of 300 or 400 amperes. This dried both motors satisfactorily, giving a test of 500,000 ohms, after which the compounding and auxiliary poles were connected and the motors run, gradually increasing the speed, until both motors were in parallel across the full line potential.

DISCUSSION.

The PRESIDENT (Mr. C. W. R. Campbell) mentioned, in connection with the drying out of the various parts of the windings, that drying, if alternating current was available, was generally rather simpler, owing to the relatively easy means of obtaining large currents at low voltage by transformation. A test immediately on finishing such drying out which gave a result of so many ohms resistance to earth, did not necessarily mean that the windings were completely dried out.

Mr. C. F. ANDERSON: With reference to the use of blow lamps for drying out motors, said the use of blow lamps, together with stoves, added greatly to the salvation of a three-phase 80 kw. machine after the considerable damage brought about by a flood early last year at the Transvaal Gold Mining Estates at Pilgrims Rest. One of the stations was completely washed away, leaving only the turbine and generator standing; all external parts were badly twisted and damaged, and the generator being totally submerged in water for several days. As soon as possible a temporary cover was rigged up and the generator thoroughly cleaned. The possibility of drying it out by incandescent lamps was out of the question owing to the distance from any source of power; such other methods as hot blast, &c., were also impossible, as owing to the weight of the machine it could not be dismantled, the crane having been washed away with the power house. The only hope, therefore, was the use of blow lamps, Premier stoves and fires. For the first three days Premier stoves and a wood fire were placed around the frame, and blow lamps in the spider of the rotor. Then the generator was run slowly with all the heating apparatus around the frame, and later the machine was short-circuited through fuses and the current increasing gradually to full load current. The generator ran a fortnight in this manner and was then put on load, gradually increasing this to full load. One coil gave out after it had been running a short time at full load, but no trouble had since arisen. This machine was supplied by Messrs. Siemens & Halske, and was at least 12 years old.

M.P. WIRING SYSTEM.

The tendency of late years in electric wiring has been towards simplicity, a state of things to a great extent caused by the high first cost of certain solid, though efficient systems, which have to a great extent precluded the use of electric light in small houses, cottages and other similar places. Many systems have been proposed to overcome this disadvantage of high first cost, while at the same time retaining the safety and efficiency of the older methods. Among the latest of these may be mentioned that due to Mr. S. W. Martyn, of Camden Town, known as the M.P. system, and described in the following article.

The M.P. system has been devised to provide a simple, cheap and reliable method of supply of electrical energy for lighting. Its component parts consist of two classes of flexible cables, viz., twin flat lead-covered cable and twin round cable armoured with galvanised iron wires, the simple fitting for mounting the switches, ceiling roses, junction boxes and wall plugs which is an ordinary wood block mounted on a metal plate with easily attached spring washers or clips for bonding purposes, and the equally simple arrangement for mounting the main fuses, the combined main switches and fuses and the distribution fuse boards which consists of a flat-shaped box with simple metal clips and spring washers inside for bonding the metallic armouring or sheathing of the cables. Either kind of the two standard types of cable can be used, the twin flat lead-covered cable being small, neat in appearance and easily bent into position; while the round armoured cable is mechanically and electrically well protected and easily erected for both surface and concealed wiring. This armoured cable can be sunk in plaster for house wiring, the armouring will, it is claimed, not unwind at the free ends before

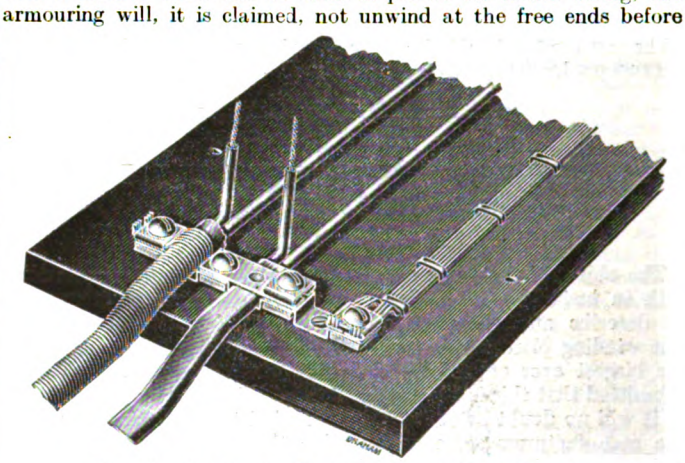

FIG. 1.—STANDARD BACK BOARD IN M.P. SYSTEM.

bonding, and it is rust-proof, owing to its being well galvanised. Cables of either type, in any required size, can be used for connecting the main fuses or combined main switches and fuses with the distribution fuse boards, and a cable of the usual 3/22 S.W.G. size has been standardised for connecting the distribution fuse boards with the standard fittings, such as the junction boxes, ceiling roses, switches or wall plugs for lighting purposes.

Fig. 1 shows a part of the back board with the two standard types of flexible cable in position. It indicates how the bonding arrangements are carried out in every case, a number of electrically connected clips being fastened together to ensure continuity. The cables are

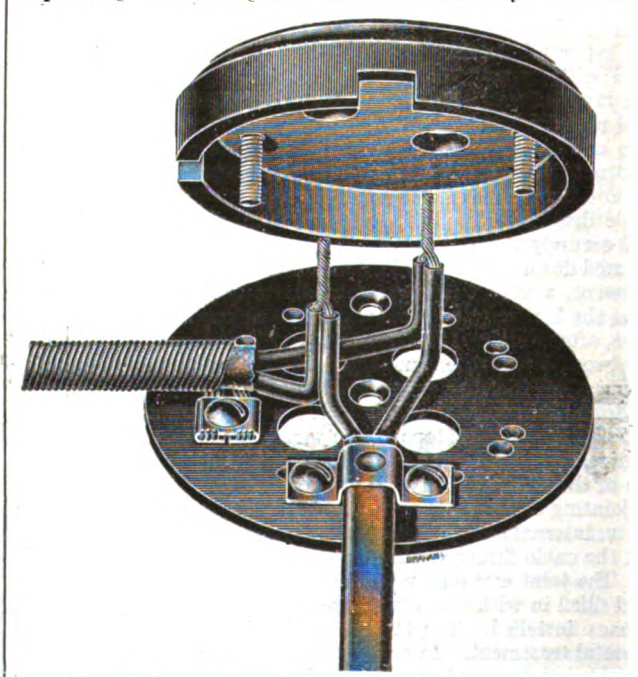

FIG. 2.—METHOD OF SIDE ENTRY TO SWITCH OR FITTING.

placed in the grooves formed by the clips being turned upside down, and in the case of the armoured round cables the ends of the galvanised iron wires are placed in simple spring washers which are held by the same bolts and nuts which hold the overlapping ends of the clips. In the case of the twin flat lead-covered cables the lead sheath is placed in the grooves of the clips and bridged over by brass plates, which are also held by the same bolts and nuts. These brass plates have holes—one in the middle of each—which allow them to be easily soldered to the lead sheath, so as to make the connections

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thoroughly sound electrically. As many clips are used as there are cables to be bonded. If the clips are not all together, as in the case of cables entering a box from the top and bottom, the two sets of bonding clips are connected by a length of wire which is held at both ends by spring washers. The waste wire from the armouring of the round cables can be used for this purpose with the greatest success, being stapled to the wood back board as shown, and by its use there is the further advantage of having the full current-carrying capacity of the armouring throughout the system for bonding purposes. If necessary, double clips can be used, and this arrangement allows a pair of cables to enter the box side by side instead of having a small space between them.

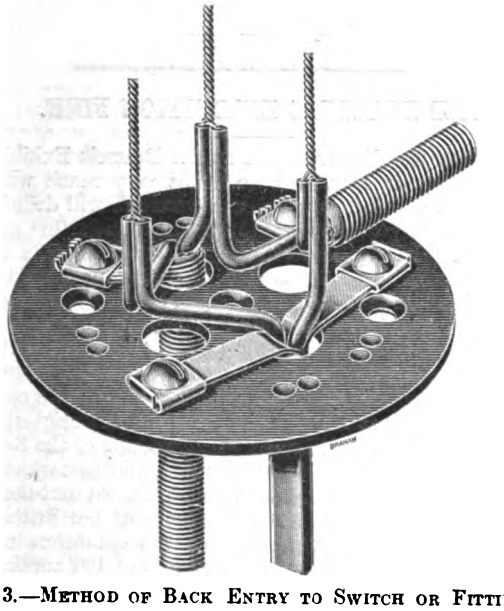

FIG. 3.—METHOD OF BACK ENTRY TO SWITCH OR FITTING.

A standard type of bonding plate is used on this system to which all the cables are connected before the wires are led to a switch or fitting. Fig. 2 shows the arrangement of this plate when the connections are from the side, and Fig. 3 when they are from the back. The back plate is of the universal kind—it provides twelve distinct paths by which a cable may enter and the necessary tapped holes for the bonding screws, eight paths from the side for surface wiring, and four paths from the back for concealed wiring. In practice this plate can accommodate eight circuits, which is an exceptional case in actual work. It has sixteen tapped holes to provide for all possibilities, four plain holes to allow the cables to come through from the back, and three countersunk holes for the wood screws which hold it in position. The wood block is of the ordinary kind, but with a large recess to make room for the bonding clips. This wood block is fixed to the back plate by two screws, as shown, which fit into any pair of opposite holes not required for bonding purposes. The twin

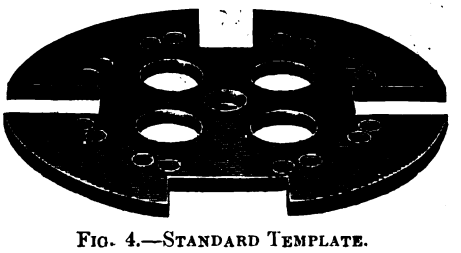

FIG. 4.—STANDARD TEMPLATE.

flat lead-covered cable is fastened to the plate by a clip and screws, and the clip is further connected electrically to the lead sheath by solder, which is put in easily through a hole in the clip, as shown. The galvanised iron wires of the armouring of the round cable have their ends placed in a simple spring washer and screwed rigidly to the plate, the live wires in all cases being brought through the block in the usual way to the fitting. In the case of the back fitting, the armouring of the cable coming in from the back is given a quarter turn so as to bring the spring washer flat against the plate for screwing purposes. The lead sheath is divided as shown, and the two portions securely clamped to the plate by a spring washer. The washers are then soldered.

The switches and ceiling rose for use with this system are of a standard pattern, all the metal parts being earthed. The introduction of the wires into these fittings is facilitated by the use of the template shown in Fig. 4. By this means the wireman can accurately and quickly mark out the position of the slots in the wood block where the cables enter. Having selected the pair of tapped holes in the back plate for holding the block (any pair not required for bonding purposes may be selected) the corresponding holes in the template are used for holding the block when being slotted out in the usual way, a round wood file being a very convenient tool for finishing off when the slot is for the round armoured cable. The three small slots in the template are used when single cables of either type enter and the wider slot when they enter in pairs. This template is in reality a back plate with the addition of four marking-out slots.

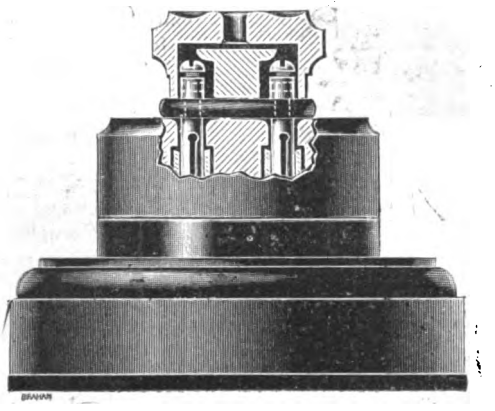

FIG. 5.—SECTION OF NEW WALL PLUG.

In this connection mention may also be made of a special safety type of wall plug designed by Mr. Martyn. The essential parts of this are shown in Fig. 5. The terminals are sunk in the socket and protected, while the cord grip arrangement enables the plug to be easily wired, at the same time relieving the terminals of all mechanical stress.

THE "BUTT" ARC LAMP.

The development of the flame arc lamp, though great, has been retarded by a number of unfortunate circumstances. It was not until this type of lamp had been on the market for some time that devices were invented for lengthening the rather short burning life, while not until just lately have attempts been made to do without the complicated mechanism of the earlier lamp.

Among the latest of these attempts, and not, we hope, one of the least successful, is exemplified in the General Electric Co.'s new "Butt" lamp. This lamp is devoid of complicated mechanism and clockwork parts, and is self-regulated though without regulation coils. It has one vertical and one converging carbon. The "Butt" lamp is recommended for burning singly on 65 volts, two in series on 110 volts or four in series on 220 volts. Ordinary round-cored carbons are used, thus overcoming the great disadvantage of employing special ribbed carbons. The maintenance costs are said to be small, while there is one pattern of lamp made which is so designed and constructed as to give equally good results irrespective of the nature of the supply and current intensity. The lamp is but little affected by voltage variations, and instruments for equalising any fluctuations are quite unnecessary.

An important feature of the "Butt" lamp is its simplicity and solidity of construction. The rods are strongly dimensioned, brass nickel-plated and highly polished in order to limit the friction of carbon guides for the feed. The clutched carbon is in a vertical position in the centre of lamp; whilst the striking (inclined) carbon is under the influence of a magnet by which it can be moved laterally in order to strike and to form the arc. As the carbons are always in the same position and do not move horizontally after the arc is struck, the arc chamber is very effectively sealed against the rod chamber, and the guide rods are, therefore, kept free from deposit. The clutched carbon which controls the feed touches the incombustible lower arm of the clutch lever in the economiser. This lever is pivoted, and presses with its small upper arm above the lamp plate against the carbon. As long as the slightest weight bears on the incombustible arm, the lever grips the carbon sideways, thus relieving the fine carbon point. By progressive consumption the carbon becomes shorter, the pressure of the point on the lower lever arm decreases, and through that also the side pressure of the upper lever arm against the carbon becomes less and less, until finally the weight of the carbon overcomes the break action so that it can slide down.

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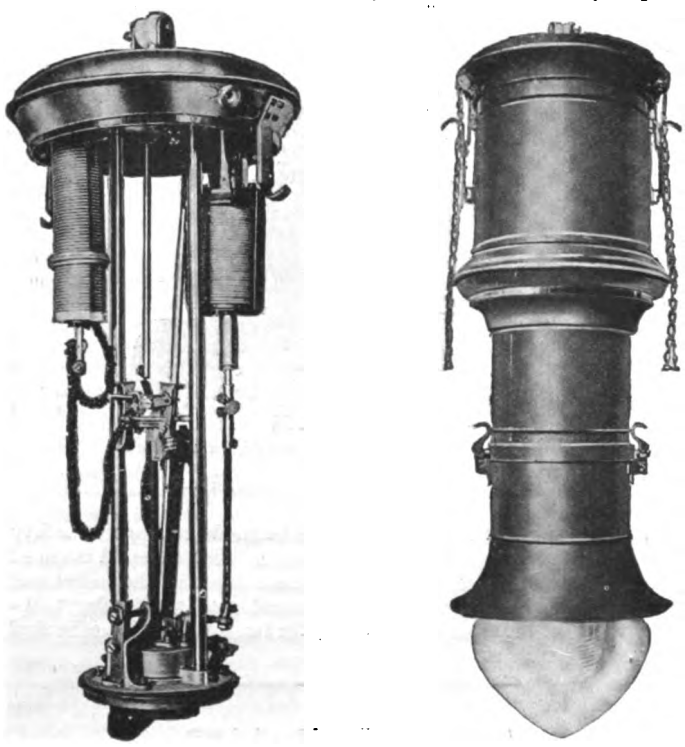
The fact that the point of carbon is relieved eliminates, it is claimed, the danger of it being broken. It forms into a longer and longer point, thus raising the arc away from the lower lever arm, so that the latter cannot be burnt. The current is interrupted by the automatic discharge of the clutched carbon when consumed down to a small stump.

All lamps are fitted with conical-shaped inside globe, the use of which prevents, it is claimed, the outside globe from becoming dirty, and thus effects a considerable saving in time and labour by dispensing with the necessity for cleaning, sometimes a very complicated operation. This inner globe in no way affects the light intensity, as there is no light absorbing deposit on same. The outside globe is closed, and the air is admitted through the openings at the upper brim, passing between the inside and outside globe and rising past the ash tray into the inner globe up to the arc, forcing the fumes and deposit which form here through the high corona, directly into the open.



Long hour "Butt" Flame Arc Lamp.

The "long hour" lamp, which is mostly used for street lighting and long distance radiation, is provided with dioptric inner globe, by means of which a great lateral reflection is produced in order to obtain homogenous widespread lighting of the ground. There is only one universal pattern of "Butt" lamp for each length of carbon. The same lamp can be used for either direct, alternating or rectified current, and has only to be fitted for the respective diameter of carbons, which, of course, varies according to the nature and intensity of current. For this it is merely necessary to alter the carbon holders and carbon guide plates—an operation taking not more than a few minutes.

Short hour "Butt" Lamp.

Numerous attempts have been made since the advent of the flame lamp to produce a satisfactory pattern giving long burning hours, and owing to the great simplicity of feeding arrangements in the "Butt" double carbon lamp, and to entire absence of complicated clock work and regulating mechanism, the existing difficulties have, it is claimed, been overcome and a really safe and practical flame lamp for long burning has been obtained. With the "Butt" double carbon lamp from 32 to 38 hours' burning are obtained without any special attention being necessary, thus providing a sure means of keeping labour expenses down to a minimum. Contrary to other similar types with clock work and other mechanical regulations, the "Butt" double carbon lamp switches the arc from the first carbon pair to the second and from the second carbon pair to the first; this change occurring absolutely automatically as soon as the respective pair of carbons has been consumed, without any interruption whatever of the light. This is an exclusive feature of the "Butt" double carbon lamp, and entirely overcomes the necessity for the hitherto complicated arrangement of using carbons of different lengths according to seasons. It will be appreciated what an enormous saving in trimming and carbon costs is effected by this arrangement. This lamp is principally recommended for the lighting of railway stations, railway lines, large open spaces, streets, exhibition grounds and halls, large workshops, &c., and can be used like all other "Butt" lamps for both direct and alternating current. Two arcs can also be run in series and burn simultaneously. The illustrations show the interior and exterior of the "long hour" lamp and the exterior of the "short hour" lamp.

THE BRUSSELS EXHIBITION FIRE.

The cause of the disastrous fire at the Brussels Exhibition is as much a mystery as ever, and we doubt very much whether the official inquiry, which is now being prosecuted, will definitely clear the matter up. The past week has witnessed no further attempt on the part of the daily papers or the gas journals to affix the blame upon the electrical installation, so we may regard the old bogey as being dispelled. A vast amount of work, however, has been carried out during the week by the British Commissioner and his staff. Arrangements have been completed for the re-opening of the British exhibit section in the Salle des Fetes, and visitors to Brussels during the remaining months of the Exhibition will be given an opportunity of seeing duplicates, at any rate, of many of the original exhibits. The Earl of Lytton presided at a special meeting of the Royal Commission for the Brussels, Rome and Turin Exhibitions which was held on Saturday last, and at which it was made known that the Treasury had made a grant towards the continuance of the British section, provided that adequate response from the exhibitors was forthcoming. Since this announcement upwards of 100 applications for space in the new section have been received and the exhibits will be sent to Brussels with every possible despatch. In this latter connection it is of interest to note that the John Cockerill line, which runs steamers between Tilbury and Ostend, has placed its freight service at the disposal of British exhibitors free of all charge. This generous action should materially assist towards the re-opening of the section.

So far as the scientific instruments are concerned, most of these were of special design and cannot be entirely replaced for some little time. The manufacturers, however, are being asked to send photos and technical descriptions, which will answer the purpose in the meantime.

In the new section the utmost precautions are being taken against fire. Messrs. Mather & Platt are supplying a Grinnell sprinkler installation, and Merryweather & Sons a modern steam fire engine. A special fire brigade will also be organised for the section. In company with the British section the Belgian exhibits are being restored.

It may be noted that of the total area of the Exhibition, viz., 250 acres, only 10 acres were affected by the fire.

Emergency Electric Lighting for Ships.—According to the "Electrical Review and Western Electrician" the steamship "Alabama" of the Goodrich line, which runs between Chicago and Muskegon, has recently installed an interesting system of emergency electric lights which are furnished with current from a storage battery. These lights have been installed to provide illumination in the corridors and on the stairways in case of an accident to the generating apparatus, while, in case of the sinking of the vessel, lights would be available to aid the passengers in making their escape even after the hull of the boat had sunk some distance into the water. In order to provide illumination as long as possible in case the boat should sink, the battery has been placed at the highest point of one of the upper decks. The storage battery in use is composed of 56 cells in glass jars, having a rated output of 4·5 amperes for eight hours. This battery will supply current for 10 hours on one charge for 25 4 c.p. 110-volt carbon lamps which are in use in this installation. The battery is charged during the day, and at night, after the generators stop running, the lights used on decks, in halls and stairways are supplied with current from the battery alone. This system, it is claimed, provides a reliable source of lighting which is always available in case of accident.

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BOARD OF TRADE RULES FOR PROVISIONAL ORDER APPLICATIONS.

The Board of Trade have issued, in pursuance of sec. 5 of the Electric Lighting Act, 1882, a revised set of rules with respect to applications for provisional electric lighting orders. The following extracts give all important changes in the rules:—

(I.) Every application must be made by memorial addressed to the Board of Trade, headed with short title, description of objects, &c., and the memorial must be lodged by December 21st.

(II.) In October or November applicants must publish notice of their intended application by advertisement, and this must contain, in addition to the particulars hitherto required as to objects, address and description of applicants, &c., the following information: 7.—(*a*) In the case of a provisional order to authorise the compulsory acquisition or the use of land for a generating station, a description of that land.* (*b*) In the case of a provisional order relating to the purchase of a generating station, mains or other works used solely for supplying electricity within the districts of two or more local authorities, but not situated within any of those districts, a description of the position of the generating station, mains or other works to be purchased. (*c*) In the case of a provisional order for the constitution of a joint committee or joint board, the basis upon which representation on, and the financial requirements of the joint committee or joint board and the contribution to the common fund by the constituent authorities are to be provided for.

(III.) Where a company or person applies for a provisional order for a district, and the local authority waives its right to receive (under sec. 4 (1) of the Electric Lighting Act, 1882) notice of intention to apply for an order, the waiver must be proved in the same manner as the consent to an application by a local authority.

(IV.) Any local authority, company or person intending to apply for a provisional order to authorise the distribution of electricity must, on or before November 1st in the year in which the application is made, give notice of their intended application to every company or person authorised under statutory powers to distribute electricity within the area to which the proposed application relates; and any local authority, company or person intending to apply for a provisional order to authorise the supply of electricity in bulk must, on or before the said date, give notice of their intended application to every local authority, company or person authorised under statutory powers to supply electricity in bulk or to distribute electricity within the area to which the proposed application relates.

(V.) In the case of a provisional order to authorise the compulsory acquisition of land for the purpose of a generating station, the applicants must on or before December 15th serve a notice on the owners, lessees and occupiers of all lands intended to be so acquired. Notice should be in the form set out in the schedule to the rules.

(VI.) On or before December 15th, in the year application is made for a provisional order to authorise the compulsory acquisition or use of land for the purpose of a generating station, applicants must serve notice upon the local authority of the district and upon all owners and lessees of land situate within 300 yards of the land proposed to be acquired or used.

(VII.) Notices must be in writing and must be served by leaving same at the offices of the local authority or company, or at the address of the person on or before the day prescribed, or by forwarding same by post in a registered letter, so that same would in ordinary course of post be delivered on or before that date.

(VIII.) An application for a provisional order to authorise the distribution or the supply in bulk of electricity (other than an application from the local authority of the district), or the breaking up of roads outside the applicant's area of supply, will not be entertained unless proof of the consent of every local authority within the districts in which the roads are situate to the grant of the order, or where such consent has been refused a request from the applicants asking the Board of Trade to dispense with the consent and giving the reasons for such request, must be deposited with the Board on or before February 22nd.

(X.) In regard to the deposits to be made at the Board of Trade on or before November 30th, the following are additional rules:—

In the case of a provisional order relating to the purchase of a generating station, mains or other works used solely for supplying electricity within the districts of two or more local authorities, but not situated within any of those districts, the applicants must deposit at the office of the Board of Trade a map (of not less than 6 in. to a mile) showing the area of supply, position of generating station, mains and other works to be purchased.

In the case of a provisional order for the constitution of a joint committee or joint board the applicants must deposit at the office of the Board a similar map showing the districts or parts of districts in respect of which the joint committee or joint board is proposed to be constituted.

In the case of a provisional order to authorise the compulsory acquisition or the use of land for the purposes of a generating station, the applicants must deposit at the office of the Board a plan of the site of the land and, in the case of compulsory acquisition, a book of reference. The plan must be on a scale of not less than ¼ in. to every 100 ft., and must have shown thereon any building, yard, courtyard, land within the curtilage of any building, and any ground cultivated as a garden. The book of reference must contain the names of the owners, lessees and occupiers of all lands and houses proposed to be taken compulsorily and must describe such lands and houses respectively. It must also contain the names of the owners or reputed owners and lessees or reputed lessees of land situate within 300 yds. of the land upon which the generating station is to be constructed.

The applicants must also on or before November 30th deposit a copy of the advertisement and of the said maps or plan and book of reference for public inspection at the office of the clerk of the peace for every county, riding or division, and at that of the local authority of every district to which the application relates. (In the case of a provisional order relating to the Administrative County of London, the deposit of the maps, plan and book of reference must be at the office of the London County Council.)

(XI.) In regard to the draft order, where the application is other than for the constitution of a joint committee or joint board, the draft must contain (amongst other things) a description of the proposed area of supply (if any), and, in the case of a provisional order authorising the supply of electricity in bulk, a description of the roads, railways and tramways along the route along which electric lines are to be laid for giving the supply, and in the case of a provisional order authorising the compulsory acquisition or use of land for a generating station a description of such land.

In the case of a provisional order to authorise a supply of electricity at any point within an area to be used for purposes incidental to the working or lighting of a railway, tramway or canal (other than haulage or traction or the lighting of vehicles or vessels) partly within and partly without that area, a description of the railway, tramway or canal, the names of the districts in which the electricity is to be used and a statement of the purposes for which the supply is to be given.

In the case of a provisional order relating to the purchase of a generating station, mains or other works used solely for supplying electricity within the districts of two or more local authorities, but not situate within any of those districts, a description of the generating station, mains or other works to be purchased, and a list of the districts to which electricity is supplied therefrom.

In the case of a provisional order for the constitution of a joint committee or joint board the draft order must also contain: (*a*) A description of the purposes for which the committee or board is to be constituted; (*b*) provisions for constituting the committee or board, for the appointment and removal of members, and for the meetings of the committee or board; (*c*) provisions (1) relating to the financial arrangements between the proposed constituent authorities, (2) for the appointment and remuneration of officers, and (3) for settling differences between the committee or board and any of the constituent authorities; (*d*) provisions as to audit of accounts; and (*e*) provisions for adapting the provisions of the Electric Lighting Acts, 1882 to 1909, or any provisional order in force in the area of supply or any part thereof to the case of the committee or board proposed to be constituted.

(XII.) With regard to the deposits which must be made with the Board of Trade when lodging the memorial, the following are additional requirements:—

In the case of a provisional order relating to the purchase of a generating station, mains or other works used solely for supplying electricity within the districts of two or more local authorities, but not situate within any of those districts, a list of the local authorities within whose districts the generating station, mains and other works are situate.

In the case of a local authority, in addition to the particulars required by the existing rules, a statement showing that a definite scheme (including an estimate of the cost) for the supply of electricity has been prepared and considered by the local authority, and a report by an electrical engineer on the proposed scheme.

In the case of a provisional order for the constitution of a joint committee or joint board there must be deposited with the memorial (in addition to such of the deposits hereinbefore specified as are applicable) the following particulars: (*g*) The rateable value of each of the districts of the proposed constituent authorities; (*h*) the amount of indebtedness and the borrowing powers of each of the proposed constituent authorities; (*i*) the amount of the rates in the pound in the district of each of the proposed constituent authorities; (*j*) a statement showing (where the proposal is not for the combination of existing undertakings actually worked) that a definite scheme (including an estimate of the cost) for the supply of electricity has been prepared and considered by the proposed constituent authorities and also a report by an electrical engineer on the proposed scheme; (*k*) a statement of the proportions in which the cost is to be defrayed by the proposed constituent authorities; and (*l*) a copy of any agreement between the proposed constituent authorities relating to the application.

In the case of an application other than by a local authority for an order to authorise the breaking up of roads, &c., outside the area of supply to enable electricity to be brought into that area from a generating station outside that area, there must also be deposited a list of the local authorities in which the roads, &c., are situate and a list of the roads, railways and tramways, and if the applicants are a company incorporated under the provisions of the Companies' Acts, a copy of the Memorandum and Articles of Association.

The fee has been fixed at £35 (instead of £50 hitherto required), and must be paid to the Accountant-General of the Board of Trade.

The rules also provide for deposits of copies of the draft order at certain offices in London and the provinces, and with the London County Council where the draft order affects the London area.

* At the time of proving the publication of the notice, the Board of Trade will require proof that at the date of the first publication of the notice no part of the land proposed to be compulsorily acquired belonged to any gas or water undertakers and was used or authorised to be used by them for the purposes of their undertaking. (*See* sec. 24, Electric Lighting Act, 1909.)

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(XX.) In any case where the Board of Trade refuse to grant a provisional order to authorise a supply of electricity in bulk, on the ground that the matter ought to be dealt with by private bill, and the applicants intend to proceed by private bill, the notice required by sec. 4, sub-sec. 2, of the Electric Lighting Act, 1909, informing all opponents of that intention, must be served by being addressed to each opponent or his parliamentary agent or solicitor within 14 days from the date of the Board's refusal to grant the provisional order.

▶ The form of notice to landowners and others is set out in a schedule to the Rules.

PACIFIC CABLE BOARD.

The report and accounts of the Pacific Cable Board for the year ended March 31, 1910, are just issued, as ordered by the House of Commons on July 29th.

Traffic receipts for the year were £115,735. 7s. 3d., less £4,269. 18s. 9d. payment to the Atlantic companies for work done in the United Kingdom in connection with the Board's traffic, leaving, therefore, £111,465. 8s. 6d., which, with interest on deposits (£40. 16s. 8d.) and refunds (£217. 13s.), brings the total to £111,723. 18s. 2d. Ordinary expenditure came to £93,767. 6s. 9d., leaving £17,956 available for reduction of the amount (£77,544) contributed annually for interest and sinking fund on the capital advanced by the National Debt Commissioners. The amount payable by the Governments associated in the Pacific Cable enterprise is thus £59,588, against £60,888 for the previous year. The Board's contribution to the redemption fund in 1909 was £1,300 more. Traffic receipts for the year show the small increase of £403. The real increase was, however, considerably larger, as, owing to accidental delay in transfers to the Board's account by the Governments of Australia and New Zealand, £2,211 which should have been credited to the revenue for 1909-10 was not brought to account until after March 31st. But for this, the revenue would have exceeded that of 1909 by £2,614, and would have been £1,534 in excess of the estimate. In the miscellaneous receipts there was a falling off of £1,773, those of 1908-9 having been swollen by the sum received for a charter of the "Iris" (£1,339).

Expenditure for the year shows a net decrease of £2,668, the principal saving (£5,343) being ship's salaries and expenses. There was a reduction of £1,000 in amount carried to renewal account, the annual charge for which reached in the year £30,000, the figure at which it will for the future stand. There was an increase of £353 on head office expenses due to ordinary increments of salaries and to the addition to the staff of a special canvasser for London and the provinces, and another for Germany; and an increase of £3,221 for cable stations (salaries and expenses).

The preliminary forecast of revenue and expenditure for the year ending March 31, 1911, prepared December 6, 1909, was: Traffic revenue £128,000; renewal fund £30,000, working expenses £84,702, excess £13,298, total £128,000. The large increase in the estimate of traffic revenue and of working expenses is due to the new arrangements for the working of the Canadian land lines between Montreal and Vancouver. The Board, after full consideration, came to the conclusion that much could be done to minimise land line troubles if it could take into its own hands the working of the lines between Montreal and Bamfield. Accordingly, after obtaining sanction of all Governments interested, it entered into an agreement with the Canadian Pacific Railway to lease for five years the exclusive use of a copper wire between Montreal and Bamfield, the company to maintain it in good condition, and the Board to provide the staff necessary to work the line and to retain for itself such portion of the tolls as have hitherto been paid over to the railway company. This arrangement will keep a clear passage for the Board's traffic, and obviate any risk of delay from congestion of ordinary traffic over the lines of the company; it will allow of the adoption of the European system of signalling, which involves much less risk of error in transmission than does the American Morse system, and will enable the Board to make and enforce regulations of its own for early notification of any breakdown in the lines, and for the prompt diversion of messages to other routes, so as to avoid any serious delay in their reaching their destination.

For 11 months of the year under review the Pacific Cable worked without interruption, and no repairs were required. But at the beginning of March last a break occurred—the first since the cable was laid in 1902—about 3 knots from Doubtless Bay station, and caused a total interruption of communication on the New Zealand–Norfolk Island section for five days. During this period, messages to and from New Zealand were sent round by Sydney, but nevertheless a certain amount of traffic was diverted to the Eastern route with consequent loss of revenue to the Board. The injury to the cable was caused by chafing on rock, and was promptly and efficiently repaired by the Board's repairing vessel.

The health of the staff has been good throughout the year, and the service rendered by them has continued on the high level of efficiency and zeal which has characterised it in previous years.

In deference to the opinion in favour of a cheapening of cable rates for Press messages the Board offered to reduce by one-half its charge on Press messages between Australasia and Vancouver, provided the Australian and New Zealand Governments would do the same, and so allow of a reduction from 1s. to 9d. per word of the total charge between the United Kingdom and Australasia. Those Governments at once gave their assent, and the new rates were brought into force as from August 1, 1909. The effect of the change has been to increase substantially the amount of Press traffic carried by the Pacific Cable.

LEGAL INTELLIGENCE.

Wentworth & Co. v. Dean's Rag Book Co.

In the City of London Court, on Tuesday, before Judge Lumley Smith, K.C., plaintiffs claimed two guineas for supplying and fixing a number of tantalum lamps as an advertising device. Plaintiffs said defendants wanted electrical apparatus fixed with tantalum lamps for the purpose of putting it in a fountain. For that purpose the lamps had to be watertight. On Dec. 9, 1909, plaintiffs fitted the apparatus and soon afterwards had a complaint because defendants broke the tip of one of the bulbs. After Christmas the water again came in and someone had unscrewed one of the lamps. All the complaints were satisfied until April when a complaint was made that the rings were not of the right size. Some clips were put on the rings to see if that would suit defendants.

Judge LUMLEY SMITH said that the lamps were very delicate and would not stand shaking.

Evidence was given that defendants had expressed their approval of the lamps.

For the defence, it was said that the lamps had never worked satisfactorily. Water got into the lamps, causing a short-circuit, and that caused the apparatus to fail. They wanted a practical article to be sent to Manchester and other parts of the country as it was to be used as an advertising device, books being put in the windows of their customers and water played on them to show that they would not be damaged by water. They had had to get the device supplied by other electricians, who had given them every satisfaction.

Judge LUMLEY SMITH said he thought the work was experimental and had never been satisfactory. Judgment for defendants, with costs.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the vacant position of assistant lecturer in the physics department of the Technical College, Sunderland. Commencing salary £150 per annum. Particulars from the assistant clerk to the Education committee (Mr. Herbert Reed), 15, John-street, Sunderland. Applications by Sept. 10. See also an advertisement.

An experienced electrical engineer is wanted for the north of England. Applicants must be conversant with latest practice in application of electric power to steel works, rolling mills, &c., and must have had experience in negotiating for and carrying out large contracts for the installation of electrical equipment. See an advertisement.

A designing engineer is required by a leading firm of turbine machinery makers. See advertisement.

A first-class fitter-erecter is required, with experience of high-speed electric machinery and of general engineering. See advertisement.

A sub-station attendant is wanted for h.t. three-phase and l.t. direct-current railway plant in London. See advertisement.

The Council of the University of Birmingham invite applications for the appointment of assistant lecturer and demonstrator in electrical engineering. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by Sept. 17.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

A professor of engineering is required for the University of Queensland (Australia). Applications in duplicate to the Agent-General, 409, Strand, London, W.C., by August 31.

An assistant professor of mechanical engineering is required for the Heriot-Watt College, Edinburgh. Salary £225 per annum. Particulars from the Principal, and applications to the Clerk, 20, York-place, Edinburgh, by Sept. 3.

Wandsworth (London) Guardians require an engineer and an assistant engineer. Salaries £2. 17s. 8d. and £2. 2s. per week respectively. Applications to the Clerk, St. John's Hill, S.W., by Oct. 31.

Mr. F. E. Saunders, tramway manager at Maidstone, has resigned, to take up an appointment with Messrs. Balfour, Beattie & Co.

EDUCATIONAL NOTICES.

King's College (University of London).—In the Faculty of Engineering complete courses of study, extending over three or four years, are arranged in civil, mechanical and electrical engineering for the engineering degrees of the University of London and for the diploma and certificate of the College. There will also be special

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courses of advanced lectures on "Internal Combustion Engines" and "The Theory and Practice of Construction." The entrance day for new students is Tuesday, Oct. 4.

University of Manchester.—A prospectus giving particulars of the lecture and laboratory courses in physics, preparing for both the ordinary and honours degrees, will be forwarded on application to the Registrar.

University of Bristol.—At this university complete courses of instruction in electrical, mechanical and civil engineering are given, and also instruction in the evening classes. The 1910-11 session in the faculties of arts, science and medicine will commence on Oct. 3, and in the faculty of engineering on Sept. 13. Particulars and prospectuses from the registrar, Mr. James Rafter.

A Merchant Venturer's research scholarship of the value of £50, tenable for one year, in the faculty of engineering of the University, which is provided and maintained in the Merchant Venturers' Technical College, has been awarded to Mr. Harold Heaton Emsley, B.Sc., Bristol (with first-class honours in mechanical engineering).

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

University of Birmingham.—The session 1910-11 commences on Monday, Oct. 3. The full courses in the engineering department extend over four years, and students who enter after matriculation and who pass successfully the examinations at the end of each year will be entitled to the degree of Bachelor of Science in the branch of engineering to which they devote themselves. The technical engineering classes include lectures on the strength of materials, theory of steam, gas and other heat engines, hydraulics, machine design, strength of structures and distribution of power, design of tools, prime motors, dynamos, &c. The courses in civil engineering cover a wide range. Lectures and demonstrations are given on all branches of electrical engineering and the electrical laboratory work comprises the testing of c.c. and a.c. machinery, instruments, meters, lamps and batteries and insulation and magnetic testing. The courses also include mathematics, physics, chemistry, geology and metallurgy. Syllabus, &c., from the Secretary.

University College of North Wales (Bangor).—In October a systematic course of instruction in electrical measurements and practical electricity for students proposing to enter the profession of electrical engineering will be commenced. The physical laboratory is well equipped for experimental and research work. The course extends over two sessions. Prospectus and further information may be obtained from the secretary and registrar, Mr. J. E. Lloyd, M.A.

Northampton Polytechnic Institute (London).—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Monday, Oct. 3.

The courses in mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include specialisation in radio-telegraphy. The entrance examination takes place on Sept. 28 and 29. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in engineering at the University of London. There are full and part time courses in all branches of technical optics. Particulars as to fees, &c., can be obtained at the Institute, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

City and Guilds of London Institute.—The entrance examinations of the City and Guilds Central Technical College, Exhibition-road, S.W., and the City and Guilds Technical College, Finsbury, E.C., are held in September, and the sessions commence in October.

Both institutions provide courses of instruction in engineering, chemistry, mechanics and mathematics, &c. Particulars of entrance examinations, scholarships and courses of study may be obtained from the respective colleges or at the head offices of the Institute, Gresham College, Basinghall-street, London, E.C. The Central Technical College is intended for higher technical instruction for day students not under 16 years of age, preparing to become civil, mechanical or electrical engineers, chemical or other manufacturers and teachers. The college is a school of the University of London, and forms the engineering section of the Imperial College of Science. The courses of the study for the associateship of the Institute cover a period of three years.

The City and Guilds Technical College at Finsbury (London, E.C.) is designed for day students preparing to enter engineering and chemical industries and for those who have already served an apprenticeship and also for evening students. The day courses in mechanical or electrical engineering cover two years and those in chemistry three years.

Glasgow and West of Scotland Technical College.—The day classes begin on Tuesday, Sept. 27, and the evening classes on Thursday, Sept. 22. The diploma of the College is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, building and textile manufactures. The courses of study for the diploma usually extend over three sessions, and holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. Preliminary examinations begin on Sept. 19. There are new and well-equipped laboratories in the departments of physics, chemistry, mechanics, motive power and electrical engineering, &c., and facilities are afforded for research. Copies of calendar (price 1s. 4d.) and prospectus (gratis) can be obtained from the Secretary.

We have received a copy of the college calendar for 1910-11 which gives full particulars of the courses of instruction in engineering, naval architecture, &c., including evening class arrangements. The electrical engineering course extends over three years and is designed to give a sound training in the theory of electricity as well as in the fundamental principles underlying the construction and use of all apparatus required in the generation, distribution and use of electric currents. The "Sir John Pender" bursary has been awarded to Frank T. Gerstenberg for the 1910-11 session. The calendar also contains sets of examination questions, particulars of scholarships and bursaries, &c. The price is 1s., post free 1s. 4d.

South-Western Polytechnic Institute (London, S.W.)—At this Institute a complete three years' course in electrical engineering is held during the day, and a four years' course in the evening. Courses of lectures and practical work are given in a number of subjects, including elementary, intermediate and advanced electrical engineering, electrical design, instruments and lamps, alternating and polyphase currents, wiring and fitting, and the calculus for engineers. Particulars from the Secretary, Manresa-road, Chelsea, S.W.

BRITISH NOTES.

Aldershot.—The Council have obtained sanction to a loan of £2,300 for extensions of their electricity supply undertaking.

£770 for defraying excess expenditure to March 31 last and for a coal shed and mechanical stoker (loan repayable in 10 years), £1,200 for prospective expenditure on mains (25 years), and £330 for services (15 years).

Barnstaple.—In order to pay off an overdraft of £1,078 on the electricity works and to provide for some extensions of mains, &c., the Council have decided to apply for sanction to a loan of £1,970.

Belfast.—The Tramways and Electricity committee has adopted a suggestion of the chairman (Sir R. Anderson) to hold an exhibition of electric motors, lamps, electric light fittings, &c., in the Ulster Hall. The city electrical engineer (Mr. T. W. Bloxam) has been instructed to report on the matter at the next meeting.

Blackrock (co. Dublin).—The Council have asked the Board of Trade not to revoke their electric lighting order for another 12 months.

Brumby and Frodingham.—A special meeting of the Council will consider a scheme for the electric lighting of the streets at a cost of £1,100.

Bury St. Edmunds.—An inquiry was held here on Wednesday into the application of the Corporation for sanction to borrow £1,463 for an additional 200 kw. generating set, a feeder main, &c.

Dartford.—The Council have applied for sanction to a loan of £10,000 for additional generating plant at the electricity works and of £1,000 for feeders and distributors.

Electric Power in Waterworks Construction.—The "Glasgow Herald" gives some interesting particulars of the scheme for augmenting the water supply of Glasgow by the addition of Loch Arklet watershed to the existing catchment basin of Loch Katrine.

The new scheme is designed to provide an additional supply of 10 million gallons per day, and an interesting feature of the undertaking is the hydro-electric power scheme of the contractors (Messrs. Brand & Co.) for the driving of all the machinery required on the work. Not a single steam crane is in use on the workings. After careful surveys it was decided to tap the Arklet Water at a point rather more than a mile inland from Loch Lomond. From this point the water is led in steel riveted flanged pipes (21 in. diameter) along the south side of the burn round the steep hillside to a point 310 ft. above the level of Loch Lomond, and immediately over the site selected for the temporary jetty. Here the head race pipe terminates, and the water is transferred to the heavy pressure pipes, 16 in. in diameter, which are laid down the side of the hill to the power house on Loch Lomond-side. The pipe has two branches as it enters the power house, to each of which is attached a pelton wheel of 135 B.H.P., and these again drive two compound-wound d.c. electric generators of 80 kw. each. Current is generated at a pressure

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of 550 volts. The effective hydraulic head is 300 ft., and either or both pelton wheels can be operated according to the power required. When working at full load about 650 cubic ft. of water per minute is used. A very efficient type of governor has been fitted to the turbines for controlling their speed. In order to provide an ample supply of water during the dry seasons the contractors have built a dam across the outlet from Loch Arklet into the burn. The electricity is conveyed by overhead cables over the hillside to the works at the dam and tunnel, where it supplies power for working all the machinery. The mechanism of the aerial ropeway is also driven by electricity. The distance from the power station at Loch Lomond to the tunnel workings is nearly six miles. The problem of transport was solved by constructing an aerial electrically-driven ropeway from Loch Lomond-side to the water-works. A pier was built on Loch Lomond-side and on it one terminal of the aerial ropeway was placed, the other terminal being situated within a short distance of the new dam. The length of the ropeway is 1½ miles, and it runs in a straight line from the jetty to the dam. At the highest point on the hill it attains an altitude of 540 ft. above the level of Loch Lomond, and from that point it descends into the Arklet Valley. The ropeway consists of two fixed burden ropes running parallel to one another and supported on steel lattice-work standards having projecting arms at the top. These arms are fitted with c.i. saddles for supporting the burden ropes. The heavier of the two ropes, which is 1¼ in. in diameter, forms the track for the loaded skips coming from the jetty, while the empty skips return on the smaller (1 in. diameter) rope. One end of each burden rope is anchored to the jetty and the other end at the unloading station at the dam is passed over a pulley and supplied with suitable tightening arrangement. To the heavier rope a weight of 26 tons is attached, and to the lighter one a weight of 16 tons. These weights are free to move up and down in a specially constructed pit. The tightening arrangement keeps the proper amount of tension on both burden ropes independent of any stretching that may be caused by the weight of the load or any expansion or contraction due to changes of temperature. Immediately underneath the burden ropes is the endless hauling rope, which conveys the load. This rope, which is of lighter section, passes round the driving drum at one end, and the tension drum at the other. The carriers of the skips are fitted with a special device, which automatically grips the moving rope as it leaves the station, and lets go on entering the station at the other end. There are 22 standards over the 1½ miles of line, of which the highest is 35 ft. The longest span between standards is 950 ft. The rope-way is driven by a 55 B.H.P. electric motor and is capable of carrying 50 tons per hour in single loads of 2 tons each. The plant was supplied by Messrs. A. Bleichert & Co. and erected by Messrs. Brand. The machinery used in the various parts of the work is all of the most up-to-date description. Rock-boring is carried out by means of small hand-hammer air drills. The drills are driven by compressed air at a pressure of 80 lb. per square inch. The compressors, which are situated at the dam and at the tunnel, are driven by 40 H.P. electric motors. There are also two electrically-driven gyratory stone crushers, which grind the rock obtained from the excavations into suitable material for concrete. By a process of screening the crushers also provide sufficient quantities of sand for the cement mortar required in the masonry work of the dam and tunnel. The concrete for the dam is mechanically prepared by a large mixer capable of turning out 30 cubic yards of concrete per hour. There are various derrick cranes on the workings at the dam, tunnel and jetty. They are all driven electrically, and vary in lifting power from 3 to 5 tons. The work is being carried out under the direction of Mr. Robert S. Grey, as agent for the contractors; while the Corporation is represented by Mr. George Smith, C.E., resident engineer.

Greenock.—The municipal electricity department commenced the supply of electrical energy to the torpedo factory on 25th ult.

A letter has been received from the Scotts Co. intimating that they will require an increased supply to the extent of 900 H.P. for driving their machinery. In view of the increase in the demand the burgh electrical engineer (Mr. J. A. Robertson) thinks it probable that a further extension of the generating plant will be required early next year.

Harrogate.—The Council have applied to the Board of Trade for an order to supply electric current to premises in the area of Knaresborough Rural Council.

Hoylake and West Kirby.—At the industrial exhibition and eisteddfod, to be held in the Hoylake Institute in November, there will be a display of electric cooking and heating appliances, &c.

Maidstone.—The tramways manager (Mr. F. Saunders) has resigned and a successor is to be advertised for at £200 per annum.

Manchester.—The L.G. Board recently sanctioned a loan of £40,000 for extensions of the electricity undertaking without holding a local inquiry.

The local Ratepayers' Association has been challenging the propriety of sanctioning a loan of such magnitude without a public inquiry, but it is pointed out that some three years ago the Board recognised the impracticability of preparing advance plans and detailed estimates for expenditure on such objects as motors and consumers' sub-stations. These things accounted for £30,000, for which the Board granted borrowing powers tentatively. These powers were recently made final on the satisfactory production of accounts of actual expenditure, plans, statements, &c., as called for by the Board.

Municipal Wiring.—Maidstone Council decided last week to support the Municipal Electrical Association in its efforts to promote a bill in Parliament giving power to local authorities who own electricity undertakings to supply, let for hire, fix, &c., fittings and wires on consumers' premises. The member for the borough has been asked to support the bill, and the Council will give financial support towards the expenses of the promotion up to £25.

Belfast Corporation have also decided to support the Bill and to make a grant (not to exceed £20) towards the expenses.

Newcastle-on-Tyne.—The Assessment committee have now agreed to reduce the assessment of the municipal tramways to the figure suggested by the Tramways committee, and the appeal to the Quarter Sessions against the assessment will be withdrawn.

The Tramways committee have under consideration the question of adopting the railless trolley system of traction in the Heaton, Gosforth and Benton districts.

P.O. and National Telephone Co.'s Staff.—On Monday, the Postmaster-General (Mr. H. Samuel) stated that there had lately appeared in some newspapers a paragraph dealing with the transfer of the business of the National Telephone Co. to the Post Office, which would take place at the end of next year—perhaps one of the most gigantic industrial undertakings that had ever been effected in this country. The paragraph stated that at that time the whole body of men and women now employed by the National Company would be temporarily unemployed, but that the Postmaster-General had undertaken to find places for about half of them with the Post Office, and that the oldest employés of the National Company would be taken on first. That paragraph was a totally incorrect assertion, which would give cause for anxiety to many thousands of homes. The whole staff of the National Company, with a few exceptions already announced and upon lines which had been well understood by the Telephone Company's staff, would be transferred to the service of the Post Office. The preliminary arrangements were already actively proceeding. No change of policy had been decided upon, and there has been no modification of the lines already announced under which the staff would be transferred to the service of the State.

Personal.—*Correction.*—With reference to a personal note on page 662 of our issue of July 29, we are informed that Mr. Arthur Greenwood, who has been appointed a director of the North-Eastern Railway Co., is not connected with Greenwood & Batley (Ltd.)

Peterborough.—An inquiry was held on Tuesday into the Council's application for sanction to borrow £2,100 for the extension of the electricity supply cables.

The chairman of the Electricity committee (Ald. Clifton) said that there were numerous applications for a supply of electricity from the district proposed to be supplied.

Porcelain Insulators.—H.M. Trade Commissioner for New Zealand (Mr. G. H. F. Rolleston) reports that a firm at Wellington wish to get into communication with British manufacturers of porcelain insulators. Communications, with catalogues and price lists, with discounts, to the Commissioner, 9, Grey-street, Wellington, N.Z.

Presentation.—The staff of York electricity works have presented Mr. W. E. Wright with a case of silver dessert spoons on the occasion of his marriage.

Railway Electrification.—It is stated that the Lancashire & Yorkshire Railway Co., encouraged by the success that has attended the electrification of their line from Aintree to Maghull, are contemplating the extension of the system to Ormskirk, and that work will be commenced shortly.

The good financial results of the electrification of the line from Liverpool to Southport has proved the efficiency of the system, and the steam service is practically superseded between all the stations from Maghull to Exchange station. The company intend, it is rumoured, to inaugurate an electric scheme which will embrace a belt route between Liverpool, Ormskirk and Southport (via Burscough Bridge), thus linking up a triangular section of the line with the electric system. To enable them to do this overhead electric cables are to be carried from the power station at Formby to a sub-station between Aughton Park Halt and Ormskirk, and for this purpose the West Lancashire Rural Council have authorised the company to cross certain roadways in their district.

School Lighting.—In the annual report of East Ham Medical Officer of Health it is stated that the gas lighting in many of the local schools is unsatisfactory. Electric lighting is recommended.

Swaythling.—The public electric lighting, due to the generosity of Lord Swaythling, was inaugurated on 15th inst.

Suicide.—An inquest was held at Crook on the 17th inst. on Arthur P. S. Adcock, 23, electrician, employed at the power station of the Newcastle-upon-Tyne Electric Supply Co. at Bankfoot, who was found dead in the sub-station there at midnight on the 15th inst. from the effects of a dose of cyanide of potassium. The jury returned a verdict of suicide by poison whilst of unsound mind.

Telephoning Telegrams.—It is reported that the recent experiment of the G.P.O. to telephone to Post Office telephone subscribers the

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telegraphic messages received for them is gradually coming into favour. The experiment was begun three months ago in four London districts, and the result has justified the addition of two more districts, and within the last few weeks several more districts have been included. It is now proposed to extend the scheme all over the metropolis and to inaugurate it, on a small scale, in some of the provincial towns.

The late Harry W. Cox.—A petition to Parliament, urging that a sufficient pension be granted to the widow of the late Mr. Cox is being prepared by a committee of Hackney (London) Council.

Torquay.—Torquay Tramways Co. recently applied to the Board of Trade to appoint an arbitrator to settle the differences which had arisen between them and the Corporation in regard to the system of electric traction on the Torbay-road tramways, as the Corporation refused to consent to the company's proposal to convert the present surface-contact system to the overhead system. The Board of Trade have now appointed Mr. Archibald Reed to conduct the arbitration, which will take place in London on Sept. 12.

West Ham.—The Corporation have received sanction for borrowing sums amounting to £118,525 for their electricity supply undertaking. In 1908 the Corporation applied for power to borrow £74,000, but consent of the L.G. Board was withheld until last week, when permission was given to borrow £67,025, as well as a loan of £51,500 applied for last month. Both the applications made to the Board were opposed by the India Rubber, Gutta Percha & Telegraph Works Co., who were successful in the recent application to the High Court for a declaration that the Corporation's borrowings without the consent of the L.G. Board were illegal.

Weymouth.—A special meeting of the Council is to consider a report on the relative merits of tramways and motor omnibuses. The Electric Light committee consider the capital cost of petrol omnibuses would be £10,000, electro omnibuses £12,000, railless trolley system £12,000, and electric tramways £27,000.

Wireless Telegraph Notes.—Mr. A. Walshaw, of Otley, Yorks, is an enthusiastic wireless telegrapher, and has erected a "station" at Otley, where he has been granted by the District Council the use of a spot called the Maypole, from which elevation he is able to communicate with Cullercoats, Cleathorpes, Liverpool and other places. Mr. Walshaw is concerning himself chiefly with meteorological matters.

An additional reason for the compulsory establishment of wireless telegraph stations on board ship is urged to be the epidemic of cholera which has broken out on the Continent. Prompt intimation of the disease, when it occurs on board ship, is regarded as an extremely important matter.

The extension of the use of wireless telegraphy for improving and increasing the number of meteorological reports over a widely extended area of the world's surface is notified by the Meteorological Office. There still remains much to be done to make wireless telegraphy the useful handmaiden to this service that it can be made, and much has already been done. The principal difficulty appears to be in collating the messages so that all those that bear upon any particular point of weather prognostication may be utilised at the right moment. It seems to be a growing opinion that weather messages, of wireless telegraph origin, may prove extremely useful in aviation as heralds of the immediately coming weather in the higher atmosphere.

A French dockyard mechanic, named Debrix, working at Cherbourg, is reported to have invented a piece of apparatus by means of which Hertzian waves can be connected with a Morse telegraph circuit, admitting of Morse and wireless working being operated simultaneously. The invention is said to be under examination by the French naval authorities, the object of its application being to dispense with high-potential stations.

In the "Canadian Electrical News" for August a brief yet interesting description is given of the wireless telegraph stations on the Pacific Coast. There are 12 of these stations, two owned by the U.S. Government (at Sitka Island and at Tatoush Island), eight owned by the Canadian Government (at Digby Island, Prince Rupert, the terminus of the Grand Trunk Railway in the Pacific; Ikeda Bay, Queen Charlotte Islands; Triangle Island; Esteven Point, on the West Coast of Vancouver Island; Point Lazo, on the east coast of Vancouver Island; Tatchu Point, on the west coast of Vancouver Island, Point Grey and English Bay, Vancouver; and Victoria City), and two owned by the United Wireless Co. (at Vancouver and at Frida Harbour). The Canadian Government stations are all equipped with Marconi apparatus, the plant of these stations being of 2 kw. capacity and of 200-mile range. The three latest stations in this group are Triangle Island, Ikeda Bay and Digby Island, and the latest station to come into operation is the last-mentioned, and this is claimed to be one of the best furnished wireless stations in the world. The island is very heavily timbered. The task of clearing was a difficult one. The masts at each station are 180 ft. high, built in three sections. The tower at Triangle Island is 620 ft. high and the 180 ft. mast makes this the highest station in the world, with the exception of the Eiffel Tower at Paris. The station stands out in the Pacific 40 miles from the nearest land, on an almost barren rock, and is what may be termed the key to the wireless stations in the Pacific. It is stated that after 9 or 10 p.m. operators in the Vancouver station of the United Wireless Co. regularly interchange messages with Los Angeles, California, 900 miles distant, and that the latter station can carry on communication over 1,300 miles.

According to the shipping journals, the Wireless Telegraphy Bill introduced by Sir Edward Sassoon, making it compulsory for all vessels of a certain class to be equipped with wireless telegraph apparatus, has been withdrawn.

The latest report is that all the Turkish warships are to be equipped with wireless apparatus, and that the Turkish Government are negotiating with the Marconi Co. to this effect.

COLONIAL AND FOREIGN NOTES.

Argentina.—The "Review of the River Plate" states that the Buenos Ayres Western Railway Co. have come to a satisfactory arrangement with the Anglo-Argentine Tramway Co. in connection with the construction of the Tube from the Once to Plaza Mayo. (The subject was referred to in our last issue.)

A company has been formed in Buenos Ayres to take over the concession granted to Mr. A. Lemousin for electricity generating works in the city of La Plata. The River Plate Electricity Co. have been supplying electricity in La Plata for many years.

Australasia.—Mr. F. A. McCarty is preparing a report for the Complex Ores Co. on the proposal to construct an electric tramway over the Huon, *Tasmania*. Mr. W. F. Marshall recently visited the district on behalf of Mr. McCarty to collect information.

Ulverstone (Tasmania) Council recently accepted tenders for electric generating plant.

Launceston Council have started the installation of an auxiliary steam plant at the power station, and Messrs. Bell & Hales have been asked to advise as to the best and most economical means of increasing the water-power.

Gawler (S. Australia) Council have appointed a committee to report upon the possibility of adopting an electric lighting scheme.

The Treasurer of *Victoria* (Mr. W. A. Watt) recently announced that the Ministry had decided to include in a bill for the amendment of the Local Government Act a clause extending the borrowing powers of Councils to enable them to purchase, equip and maintain tramways. The measure will be dealt with during the present session.

The Order in Council authorising the Melbourne Electric Supply Co. to construct electric tramways in *Geelong* (Victoria) has been passed. The lease is for 30 years, to be extended by five yearly periods at the option of the municipalities.

The formal inauguration of the *Kerumburra* (Victoria) electricity works took place on 28th ult.

Electricity in Gold Mining.—In the course of the recent inaugural address the president of the Transvaal Institute of Mechanical Engineers (Mr. J. A. Vaughan) said he believed the use of purchased electric power on the mines which had contracted with the power companies for a supply would lead to a saving of 10d. per ton crushed.

This estimate relates to operations after Oct. 1, 1912, when the price per unit is to be reduced to 0·325d. for 70 per cent. load factor or over.

The mines which are not contracting have been formed into groups with sufficiently large power requirements to justify the erection of large central power stations, expect to obtain their electric power at an equally cheap rate. Mr. Vaughan states: "knowing what I do of the actual costs at the present time at one of the largest power stations on the Rand, I consider that a saving of at least 1s. per ton crushed may be anticipated, and that in a few years' time the old figure of 2s. for power costs per ton crushed will be reduced by one-half." In July the mines within the Witwatersrand district alone crushed an aggregate of 1,814,686 tons, and on the July basis a reduction of 1s. per ton in working costs would mean an addition to the profits of over £90,700 monthly, or £1,088,400 a year. Mr. Vaughan adds: "The electrification of the mines is certain to increase the proportion of white labour to coloured labour."

Finland.—The Helsingfors local tramways had a successful year in 1909, the re-laying of the lines and doubling of the track having been completed. The number of passengers carried was 6,338,00 0, against 5,094,00 in 1908, an increase of 24 per cent. The traffic receipts for the year were £37,000.

The value of the electrical apparatus imported during 1909 into Abo from Gt. Britain was £15,459, and into Hangö £4,250.

Hungary.—The Municipal Council of Kecskemet has decided to raise a loan of £62,500 for the construction of electric tramways in the district.

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Imports of Electrical Goods into Australia.—A recent issue of the "Australian Mining Standard" contains particulars showing the relative values of the exports of electrical goods of various countries to Australia in 1909:—

Actual and Relative Values of Exports of Various Countries to Australia.

	Class A.	Class B.	Class C.	Class D.	Class E.	Class F.	Class G.	Class H.	Total.
	£	£	£	£	£	£	£	£	£
U.K. ..	73	51	36	58	89	41	49	63	60
Germany	19	14	30	6	11	43	31	7	17
U.S.A. ..	5	30	31	14	—	12	10	4	15
Others ..	3	5	2	2	—	4	10	26*	8
Tot. value,	£222,500	£235,500	£32,300	£29,500	£29,200	£26,500	£126,100	£115,900	£817,400

Class A.—Accumulators, arcs and carbons, cables, instruments, tapes. B—Dynamos and motors below 200 H.P. C—Dynamos and motors over 200 H.P. D—Fittings, as switches and fuses; arresters. E—Generators for direct coupling to turbines (steam). F—Rheostats and controllers; switchboards (except for telephones). G—Electric and gas appliances n.e.i. H—Telephone apparatus. * Swedish telephone exportations.

Russia.—In his report on the trade and commerce of the consular district of *Odessa* for the year 1909 Mr. Consul-General C. S. Smith states that Odessa is the principal port for importation, and also the most considerable manufacturing town in South Russia.

There is a scheme under consideration for the construction of a new grain harbour. The elevators and certain of the warehouses will have mechanical appliances for transporting the grain to other stores or on board ship, and electric lighting will be adopted on the quays.

The construction of the electric tramway system at Odessa has been begun and parts are ready to be opened for traffic. The concession is held by the Société Anonyme des Tramways d'Odessa.

It is reported that electrical enterprise in Russia seems unattractive to British firms. Electric tramways are a Belgian speciality; there are Belgian concessions or installations (or both) in Odessa, Kursk, Kharkov, Nikolaiev and Sevastopol. Electric generating stations seem to be mainly German, and the supply of electric lighting plant, &c., seem to be mainly German. One German firm is believed to have had a turnover in 1909 (mainly in the Donetz district) of about £300,000. It sold 20 steam turbine generators of 500 kw. to 1,200 kw.

In his report on the trade of *Kertch* Mr. Vice-Consul H. E. Dickie says that German manufacturers have been particularly successful in trading in the district; their methods are practically those he has recommended; their travellers speak Russian and are in touch with the people; they give reasonable credit and supply price lists and catalogues in German and Russian.

Mr. Vice-Consul C. Blakey states that the proposal of a Belgian company to convert the present horse trams at *Kharkoff* to electric traction was refused. The municipality is, however, building electric lines to compete with the horse tramways. Trade in electric lamps and fittings for Kharkoff as also in Donetz mining district and with sugar factories is considerable. Metal filament lamps are growing in favour.

In 1909 2,321 tons of electric motors, dynamos, &c., were imported into Russia against 1,934 tons in 1908, and 1,645 tons in 1907.

In *Nicolaiev* Mr. Vice-Consul J. P. Bagges states that it is proposed to raise a municipal loan of £1,000,000 for carrying out various undertakings, the chief of which are the buying out of the existing horse tramways and the electrification of the system, the construction of new lines, port improvements, &c.

Mr. Vice-Consul Young states that a concession for the construction of an electric tramway at *Simferopol* has been given to the Belgian company which owns electric tramways and lighting undertakings at Sevastopol.

Spain.—Owing to the availability of abundant water power, electrical energy is extensively used in the province of Granada, mainly for lighting. There are three power stations in the town of Granada, and about a dozen smaller stations in the province. Plans are being drawn up for the utilisation of other large waterfalls in the Sierra Nevada, with the object of supplying electrical energy to the neighbouring provinces.

Uruguay.—The Government have approved the proposed reduction in the price of electric current supplied to industrial establishments in Montevideo. The new rate is to be two cents gold per unit when the total consumption of any consumer exceeds 2,000 units per month.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Acton.—The Borough Accountant, in his annual report, states that there was a satisfactory decrease in the deficiency on the electricity undertaking from £4,943. 17s. 10d. in 1908-9 to £675. 1s. 2d. for 1909-10.

The reduced charges made by the Metropolitan Electric Supply Co., which came into operation on July 1, 1909, resulted in the Council obtaining 242,468 more units than in the previous year for a decreased payment of £762. 18s. 6d. The average price paid for each unit purchased from the company was 0·86d., against 1·26d. The Council were also fortunate in not having to expend any considerable amount on repairs to transformers and machinery, and the expenditure on new meters and installations, which although in the nature of capital expenditure, are paid for out of revenue, was £427. 13s. less than in 1909. The sales increased by 188,004 units of which increase 79,273 units are accounted for by the reinstatement of the electric street lighting on the main roads and 95,824 units for sewage pumping. Although the charges to ordinary consumers for lighting units were increased by 1d. per unit, the average amount realised per unit was only 3·38d. against 3·33d. The total cost to the Council of each unit sold, exclusive of loan charges, was 2·24d. against 3·51d., and the gross profit on the year's working was equal to 1·32d. per unit sold. The expenditure during the year on capital account (principally on mains and services) was £1,167. 2s. 7d. A further loan of £7,000 was raised, and after crediting repayments, the total debt at the end of the year was £66,088. 5s. 3d.

Exeter.—The accounts of the Electricity undertaking for the year ended March 31 show total income of £18,235, including £12,827 for the sale of current for private lighting and power, and £4,386 for traction.

The expenses were £8,211 and the gross profit was £10,024. Interest came to £2,822, and sinking fund £4,118, and after paying income tax (£157) the net profit (£2,927) was carried to reserve and renewals account. The gross capital expended was £108,346, an increase of £1,138. 815,044 units of current were sold for private lighting and power (607,399), and for public lighting (203,704), and by contract (3,941). There are 47 arcs and 499 incandescents for public lighting, and electric current is also supplied to three public clocks. 637,679 units of current were generated for traction, and 598,718 units were sold to the department, 38,961 units being used on the works. The total maximum supply demanded was 740 kw. for lighting and power and 400 kw. for tramways.

The traffic receipts of the tramways department were £16,929 (9·563d. per car-mile), and the working expenses £11,296, leaving a gross profit of £5,633. After paying loan charges (£2,537), income tax (£41) and contribution to sinking fund account (£1,631) the balance profit (£464) was carried to reserve. 4,097,133 passengers were carried and 424,873 car-miles run.

Ipswich.—The total income of the electric supply department for the year ended March 31 was £17,202, including £13,694 from the sale of electrical energy for private and public lighting, power, and traction and £3,043 from the installation department.

Total expenses were £10,162 and the gross profit was £7,039. Interest on loan came to £2,397, bank interest to £603 and cost of loans £40; redemption of debt charges were £2,918, second instalment of preliminary expenses was £240 and final instalment of cost of renewal of boiler settings £105, and with £166 brought forward the balance was £902. The total capital expenditure was £89,042, an increase of £2,027. 1,543,044 units of current were sold, including 456,395 units for private lighting, 322,988 for power, 757,948 for traction and 5,713 units for public lamps. The total maximum supply demanded was 944 kw.

In the report of the chief engineer and manager (Mr. F. Ayton) it is pointed out that the net profit on the year's working is £1,080. 6s. 5d., and, excluding the installation department, the revenue increased by £1,457. 10s. 7d. (11·5 per cent.) over 1908-9, while the expenditure only increased by £329. 10s. 11d., or 4·7 per cent. The units sold increased by 10·2 per cent.; the increase in lighting units was 24·9 per cent. and for power (excluding traction) 8·9 per cent. The free wiring (rental) system has been in operation for upwards of two years and during the past year had been the means of obtaining 51 out of the 128 new consumers connected. The profit on the installation department was £166. 8s. 11d.

The total revenue of the tramways department was £20,883 and the traffic receipts were £20,304. The total working expenses were £16,590, leaving a gorss profit of £4,293. Interest absorbed £3,917, redemption of debt charges were £1,908 and preliminary expenses £200, leaving a deficit of £1,732, against £2,294. The total capital expenditure is £114,431. 5,006,881 passengers were carried and 644,786 car-miles were run. The percentage of working expenses to receipts was 79·44 against 81·23.

Nelson (Lancs.)—The total income of the electricity supply department for the year ended March 31 was £9,525, including £8,810 from the sale of electricity for lighting, power and traction.

Working expenses were £5,114 and gross profit £4,411 (against £4,561 in 1909). After paying interest (£1,885) and sinking fund instalment (£2,657) there was a net deficit of £132, against a profit of £36. Total capital expended was £74,701, increase £534 during the past year: the sinking fund instalments amount to £19,326. 936,580 units of current were sold (against 889,573), including 292,128 for private lighting (against 267,464), 77,337 for power (65,188), 284,649 for tramways (303,006), 254,912 for light railways (231,926) and 27,554 by contract (21,989). The equivalent of 34,500 8 c.p. lamps is connected (against 31,578), and there are motors of 310 H.P. The maximum supply demanded was 855 kw. (745 kw.).

The total revenue of the light railways department was £7,163. Expenses were £5,994, leaving gross profit £1,169 to meet interest (£1,069) and sinking fund instalment (£872), the net deficit being £771. The capital expended is £35,730. 2,001,538 passengers were carried and 200,115 car-miles run. The traffic revenue was 8·56d. and the working expenses 7·19d. per car-mile.

Portsmouth.—The income from the sale of current for public and private lighting during the year ended March 31 was £46,145, against £47,264 in 1909. The total income was £47,194, against £48,631.

The total expenditure was £24,321, against £24,442. 2s. 10d., and the gross profit was £22,873 against £24,189. Interest required £9,984, instalments of principal repaid £10,653 and income tax £436, leaving a net profit of £1,801 (against £3,930) of which £1,500 was voted in relief of rates. The total capital expended is £334,818, an increase of £4,034. 3,521,570 units of electric current were sold, including 2,721,021 to private consumers by meter, and 3,248 by contract, and 797,301 units were supplied to the public lamps (267 large and 142 flame arcs and 472 incandescents). The total maximum supply demanded was 2,790 kw.

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TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

LITTLEBOROUGH District Council invite tenders for the supply and delivery of alternating-current (single and three-phase) electricity meters. Specifications and forms of tender from the clerk to the Council (Mr. Geo. H. Wild). Specifications may be seen (but not obtained) at the offices of the consulting engineers (Messrs. Hawtayne & Zeden), 9, Queen-street-place, London, E.C. Tenders, addressed to Mr. Wild, at the Council offices, Littleborough, by Tuesday, Sept. 13. See also an advertisement.

ALDERSHOT District Council invite tenders for supply of one chain grate mechanical stoker to be delivered and fixed at their electricity works. Further particulars and specification from the electrical engineer (Mr. F. Garside), and tenders to the Clerk to the Council (Mr. W. E. Foster), Municipal Buildings, Aldershot, by 6 p.m., Tuesday Sept. 6. See also an advertisement.

By command of the POSTMASTER-GENERAL tenders will be received until noon, Monday, Sept. 26 for supply of Swedish, Norwegian, Finland or Russian red fir telegraph poles to be delivered at one or more of the ports set out in an advertisement in another column. Forms of tender from the Controller of Stores (Mr. G. Morgan), Stores Dept., G.P.O., 17-19, Bedford-street, London, W.C.

The POSTMASTER-GENERAL also requires tenders (by noon Sept. 26) for creosoting, &c., telegraph poles. Forms of tender, &c., from the Controller of Stores, 17-19, Bedford-street, London, W.C.

The Calcutta Electric Supply Corpn. is prepared to receive tenders for supply, delivery and erection at their Cossipore station and sub-stations, CALCUTTA, of motor-generators, turbo-alternators and condensing plant. Copies of specifications, drawings and general conditions from the secretary (Mr. Francis R. Reeves), Salisbury House, London Wall, E.C., to whom tenders by 10 a.m. of Sept. 19. See also an advertisement.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone insulators to the Postmaster-General's Department in all the States of the Commonwealth of AUSTRALIA. Tender forms, &c., may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Oct. 5 for the supply of 5,000 porcelain insulators to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Oct. 4 for the supply of telephone material to the Postmaster-General's Department in VICTORIA. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited up to Sept. 27 for the supply of electric lamps to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 20 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA (Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 7 for supply of battery material and glassware to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Official Secretary in Great Britain of the Commonwealth of Australia, 72, Victoria-street, London, S.W.

Tenders will be received (up to 3 p.m. Sept. 13) by the Deputy Postmaster-General, MELBOURNE, for supply of 8,510 telephones. Local representation necessary.

The Deputy Postmaster-General, SYDNEY (N.S.W.), invites tenders (until 2:30 p.m., Oct. 5) for supply of 5,000 porcelain insulators. Local representation necessary. Specifications, &c., from 72, Victoria-street, London, S.W.

LONDON County Council invite tenders for the covering with asbestos tape of certain electric cables in manholes in the south of London. Specification, drawing, form of tender, &c., from the Clerk of the Council, Mr. G. L. Gomme, Spring Gardens, S.W. Tenders by 11 a.m. Aug. 30.

LONDON County Council also invite tenders for wiring and fitting for electric lighting of the second section of the central car repair depot, Woolwich-road. Specifications, &c., from the Clerk of the Council. Tenders by 11 a.m. Tuesday, Aug. 30.

BOURNEMOUTH Tramways committee want tenders by Aug. 31 for reconstruction of 2½ miles of tramway permanent way and supply of 450 tons of rails, with fastenings. Specifications, &c., from the General Manager.

ROCHDALE Tramways committee want tenders by 9 a.m. Aug. 31 for the construction of 1 mile of permanent way for Whitworth tramway extension. Forms of tender from Mr. J. S. D. Moffet, Tramway Offices, Mellor-street, Rochdale.

ROCHDALE Electricity committee want tenders by noon, Aug. 31 for 12 months' supply of paper insulated cables. Specification from the engineer and manager.

KIRKCALDY Corporation want tenders by Aug. 29 for the extension of the tramways to Dysart. Specification, &c., from the Burgh Surveyor.

CHELMSFORD Education committee want tenders by Aug. 31 for electric light wiring at Trinity-road school. Forms, &c., from Mr. W. H. Pertwee, London-road, Chelmsford.

POPLAR (London) Guardians want tenders by 6:30 p.m. Aug. 31 for 12 months' electrical supplies, ironmongery, packing and jointing, &c. Forms, &c., from the Clerk.

WEST HAM Guardians want tenders for 12 months' supply of electrical fittings, engineers' oil, &c. Tenders to the Chairman of the Board, at 11 a.m., Sept. 1.

The directors of the Powell Duffryn Steam Coal Co. (ABERDARE) invite tenders for stores, including electrical goods. Tenders to London office (101, Leadenhall-street, E.C.) by Sept. 12.

HACKNEY (London) Council want tenders by 7 p.m. Sept. 15 for extension of main switchboard. Specification from Town Clerk, Town Hall, Mare-street, N.E.

MANCHESTER Tramways committee invite tenders (until Sept. 6) for supply of steel girder tramway rails.

SALFORD Corporation invite tenders for supply and delivery of a vertical steam-feed pump. Tenders by noon Sept. 12.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W., and also from Messrs. R. W. Cameron & Co., 23, South William-street, New York, and Mr. H. Stephenson Smith, 244, California-street, San Francisco, Cal. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

The Ministry of Public Works, CAIRO, require tenders for electrical installations and refrigerating plant for the lunatic asylum in course of construction at Khanka. Specifications from the Chief of the Administrative Service, Ministry of Public Works, Cairo. Stamped paper for tenders is obtainable from Mr. A. L. Webb, Westminster, S.W. Tenders by noon Oct. 20. Legal domicile at Cairo is necessary in the case of this contract, and to obtain temporary domicile British

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firms must, before electing such domicile, formally advise the Consulate at Cairo of intention to do so, formally authorise the Consulate on their behalf and inform the Consulate of the address to which documents should be forwarded.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

MOSTAR (Austria-Hungary) municipality will receive tenders until Oct. 1 for the installation of electric generating plant.

Tenders are required for supply of machinery and tools intended for the workshops of the Directorate of Hydraulic Works, Buenos Ayres. Tenders to Dirección General de Contabilidad, BUENOS AIRES, by 3 p.m. Oct. 10.

Tenders are invited by the ITALIAN State Railways Administration for the following:—

One rolling machine for sheet metal, worked by an electric motor, for the workshops at Rimini, and 12 cranes for Turin workshops. Tenders by Sept. 13 to the Direzione Generale delle Ferrovie dello Stato, 16, Via Ludovisi, Rome. (Only those firms (Italian and foreign) on the list kept by the Administration are allowed to tender, and generally only when invited. Local representation is practically necessary.)

TENDERS RECEIVED AND ACCEPTED.

Rawtenstall Council have accepted the following tenders for the construction of the Whitewell tramways:—

Clough, Smith & Co., overhead equipment; W. T. Glover & Co., cables, ducts, &c.; Wm. Underwood & Bro., permanent way construction.

West Ham Education committee have accepted the tender of J. T. Halsey (lowest tender) for the electric lighting of West Silvertown schools at £287. 17s. 6d. (Eight tenders received; highest £1,500.)

The tender of the Worthington Pump Co. for a surface condensing plant and oil separator with accessories, at £400, has been recommended for acceptance by Belfast Harbour Commissioners.

Maidstone Corporation have accepted the tender of Arthur Lowcock (Ltd.) for supply and erection of a fuel economiser at the electricity works at £343. 10s.

Crewe Education committee have accepted the tender of Carrington & Button for supply of electric light fittings for their Bedford-street schools.

The Steeplejack & Engineering Co. (Nottingham) have received instructions from the City of London Electric Light Co. to carry out extensive repairs to their two large chimney shafts at Bankside.

The tenders of J. Banks for a dynamo, &c., and the National Gas Engine Co. for a gas engine for the electric lighting of the large hall at the Town Hall, Skipton.

Dartford Council have accepted the tender of the Baker Oil Separator Co. for an oil separator at £167. 15s.

Maidstone Council have placed an order with Arthur Lowcock (Ltd.) for a fuel economiser at £343. 10s.

Canterbury Guardians have accepted the tender of F. A. Parry for wiring the Woodvill Children's Homes.

The tender of Sutherland & Ashman has been accepted for the supply and erection of electric lighting plant at Ulvertone (Tasmania) at £4.487. 5s. 11d.

Sydney (N.S.W.) Council have accepted the tender of Stewarts & Lloyds for supply of steel poles for the Annandale lighting contract at £1,709. Delivery is to be made in 12 weeks.

An order has been placed by Sydney (N.S.W.) Council with W. T. Henley's Telegraph Works Co. for 15 miles 11,000-volt cable for the electric lighting of Bunnerong-road, Randwick, and Long Bay Penitentiary, and other Government buildings in Randwick municipality (N.S.W.), at £4.760. Three tenders were received. Noyes Bros. (tendered at £5,317. 8s. 3d.) and British Insulated & Helsby Cables (£6,735).

Sydney (N.S.W.) Municipal Council recently received the following tenders:—

For supply and erection of coal and ash-handling plant at new boiler house at the electricity works, Babcock & Wilcox tendered at £5,887. 5s. and Gibson, Battle & Co. £8,798.

For house service fuse boxes, Noyes Bros., Lawrence & Hanson, India Rubber, Gutta Percha & Telegraph Works Co., W. G. Watson & Co., Haes & Eggers and British Insulated & Helsby Cables tendered.

For generator cables the tender of Noyes Bros. (£1,763. 8s. 9d.) was recommended for acceptance; W. T. Henley's Telegraph Works Co. (£1,852) and British Insulated & Helsby Cables (£1,986. 1s. 3d.) also tendered.

For contract and suspension gear, W. G. Watson & Co. (£525) and Noyes Bros. (£580) tendered; and for arc lamp winches W. G. Watson & Co. (at schedule rates) and Noyes Bros. (£163. 4s.) competed.

For the supply of 250 tons bitumen the quotation of the Patent Asphaltum Co. at £1,113. 15s. was recommended for acceptance.

Staerker & Fischer have secured the contract for the sub-station equipment of the Launceston (Tasmania) electric tramways at £3.302. 17s. 6d.

The contract includes two synchronous motor-generator sets, each consisting of one 5,000-volt 50-cycle synchronous motor, three phase, running at 500 revs. per min., direct coupled to shunt-wound continuous-current dynamos, with auxiliary poles, of 100 kw. capacity (500 to 600 volts), h.t. switchboard control panels, high-tension cubicle construction and battery booster switchboard. The booster will be of the A.E.G. Pirani type, and the battery of 266 Tudor cells, having a discharge capacity of 185 amp.-hours. In addition, the firm are also supplying spares and extras at £881. 17s.

Messrs. Stewarts & Lloyds are to supply tubing and brackets for the Launceston (Tasmania) tramway sub-station at £60.

Haes & Eggers (Sydney, N.S.W.) have received an order for the supply and erection at Ultimo power house (Sydney) of two centrifugal circulating pumps, capable of pumping 9,000 gallons per minute to a head of 60 ft.

The pumps are 22 in. motor-driven centrifugal type, and the motors will be supplied by the Australian General Electric Co., and will be of 260 B.H.P. each.

Haes & Eggers have also received an order for two 60 H.P. variable-speed d.c. motors for operating air compressors. The motors will be supplied by the Lancashire Dynamo & Motor Co. and the pumps will be manufactured by Gwynnes (Ltd.).

The tender of F. A. McCarty & Co. (£60,973) has been accepted for the construction of the permanent way of the Adelaide (S. Australia) outer area tramways.

Commonwealth Tenders.—The following tenders have been accepted by the under-mentioned Government departments of States of the Commonwealth:—

Postmaster-General's Dept. (*N.S.W.*)—Western Electric Co. (Australia), 100 party line keys, at 18s. each; 100 party line relays, at 7s. 8d. each. India Rubber, Gutta Percha & Telegraph Works Co., 18 pole changers (telegraph, electromagnetic), £5. 15s. each; 12 differential galvanometers, £4. 15s. each; 12 transmitters (telegraph), £4. 5s. each.

W. Australian Railway Dept.—General Electric Engineering Co., 243 Osram lamps, £39. 9s. 9d.

Government Contracts.—During the past month the following contracts were among those given out by the Government Departments mentioned:—

War Office.—British Insulated & Helsby Cables, conductors and supports for Aldershot electricity supply; Electric Construction Co. and Siemens Bros. Dynamo Works, electric motors; G. E. Taylor & Co., wiring Ewshott Camp Institution.

India Office.—Pritchetts & Gold, accumulators, &c.; J. Stone & Co., dynamos, &c.; Lancashire Dynamo & Motor Co., electric motors; Morgan Crucible Co., plumbago.

G.P.O.—Gent & Co., house telephone apparatus; British Insulated & Helsby Cables and W. T. Henley's Telegraph Works Co., i.r. and cotton core cable; Johnson & Phillips and Callender's Cable & Construction Co., paper core cable; India Rubber, Gutta Percha & Telegraph Works Co., submarine cable; Siemens Bros. & Co., supply and laying of cable, and also dry cells; Bullers (Ltd.) and J. Bourne & Son, insulators; T. Bolton & Sons and F. Smith & Co., bronze wire; British Insulated & Helsby Cables, T. Bolton & Sons, Elliott's Metal Co., R. Johnson & Nephew, Shropshire Iron Co., F. Smith & Co. and Wilkes, Sons & Mapplebeck, copper wire.

H.M. Office of Works.—T. Clarke & Co., wiring Edinburgh Royal Scottish Academy.

Water-Tube Boiler Contracts.—Messrs. Clarke, Chapman & Co. (Ltd.), of Gateshead-on-Tyne, have recently received some large and important orders for their Woodeson patent water-tube boilers, including the following:—

Large installation of boilers for extensions to the generating station at Devonport Dockyard (a repeat order from the Government for this type of boiler during the last 12 months); two large boilers for W. Sommerville & Sons' paper works; four boilers for utilising the waste gases from coke ovens for the Nunnery Colliery Co.; four boilers for utilising waste heat from re-heating furnaces for Wm. Cooke & Sons; four large boilers for Sir B. Samuelson & Sons (Middlesbrough) to work in connection with blast furnace gases; one boiler to utilise the waste heat from re-heating furnaces for Brown, Bayley & Co.; one large boiler for Luton Corporation; and one boiler for Whitehaven Colliery (the third repeat order from this company).

The above orders, together with a large number of boilers booked during the previous few weeks for various parts of the country are keeping Messrs. Clarke, Chapman & Co.'s boiler yard well employed, and speaks well for the success of the Woodeson boiler. It is generally admitted by steam users that for economy, ease of accessibility and efficiency this is one of the most successful boilers on the market. All the above-mentioned orders are for this country; there are several large orders in hand for Continental and other foreign countries.

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BUSINESS NOTICES.

Mr. C. A. B. Pyne (late of Messrs. Balmer, Lawrie & Co., Calcutta) and Mr. E. M. Hughman (for 12 years with Messrs. Robert Hammond & Son, consulting engineers, Westminster, and late of the County of London Electric Supply Co.) have entered into partnership as electrical engineers and contractors, under the style of Pyne, Hughman & Co. Mr. Archibald Gall (late of Messrs. James Hodgkinson (Ltd.), Manchester, and formerly of Messrs. Andrew Yule & Co., Calcutta) has joined the staff as chief engineer. The headquarters of the firm are in Calcutta, and the London office at 95, Leadenhall-street, E.C.

Communications for the secretary of the Incorporated Municipal Electrical Association should be addressed to Mr. C. McArthur Butler, 28, Bedford-square, London, W.C.

Messrs. Ferranti Limited notify that their works and offices at Hollinwood will be closed for the annual district holidays from this (Friday) evening, until Monday morning, Sept. 5, a small staff being retained to deal with urgent correspondence.

In order to cope with the continued increase of business, Messrs. Babcock & Wilcox have found it necessary to extend their works at Renfrew, and they are erecting three large additional shops, each 300 ft. long by 60 ft. wide.

The shops will be fully equipped in the most modern style. Two of them are required for the manufacture of mechanical stokers and coal-handling plant, and the third is needed in connection with the manufacture of marine boilers, for which the demand is rapidly increasing, large orders being in hand for boilers for battleships and cruisers for the British, Colonial and Foreign Governments, while several important contracts have been secured recently for boilers for the mercantile marine.

Electrical Cookers.—The manufacturers of "Tricity" cookers which have been steadily perfected for use on both d.c. and a.c. circuits have appointed Messrs. Gillespie & Beales, Amberley House, Norfolk-street, Strand, W.C., as sole wholesale agents. Messrs. Gillespie & Beales are now appointing local agents. Provincial contractors should make a note of this forward move on the part of the Berry Construction Co., and should communicate with their wholesale agents, if they have not already done so.

Plant Wanted.—Mr. Thomas Johnson, Prescott-street, Wigan, requires a 300-400 kw. generating set, 500 volts.

"Osrams" for Public Lighting.—One of the finest examples of street illumination by means of metal filament lamps is that of the

OSRAMS ON O'CONNELL BRIDGE, DUBLIN.

famous O'Connell Bridge at Dublin, which serves at night the useful purpose of a directing sign to travellers requiring to go in this direction.

Anyone familiar with this part of Dublin must be greatly impressed by the radical change for the better that has taken place since the conversion of the lighting arrangements from gas to Osrams. The present result is obtained by quite a small number of lamps. In all, 39 100-volt 55-watt Osram lamps are used, these being fitted in the old lanterns originally put up by the gas company and which have since been converted for their new use. It will, of course, be appreciated that in such a position the lamps are very exposed, and naturally encounter more than an ordinary share of rough weather. We learn that they have proved fully capable of withstanding this treatment, and up to the present the Corporation consider they have behaved remarkably well. The illustration herewith, which has been reproduced from an untouched photograph, is rather of the freak order, owing to the long exposure necessary. The regular lines shown running across the centre of the picture are occasioned by the headlights of tramcars, which were continually passing up and down while the photograph was being taken. The installation is of particular interest, however, on account of its exposed position.

Patents Development.—The owners of patents No. 23,501/1899, relating to "Improvements in vacuum table lighting," and No. 12,582/1902, relating to an "Improved system of electric lighting," desire to negotiate with electrical engineers with the view of granting licences. Information from Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C.

Telegraphone Patents.—The owners of certain telegraphone patents (Poulsen's, Pedersen's and Schou's) desire to grant licences or to enter into arrangements for working same in this country. Particulars from Messrs. W. E. Heys & Son, Patent Agents, 51, Deansgate-arcade, Manchester. See also an advertisement.

"Faraday House Journal."—The August issue of this journal contains interesting technical articles, including one upon the "Commercial Production of Aluminium," and another upon "Electrically-Driven Winding Engines." The adoption of electrical winding in this country is receiving considerable attention from colliery managers at the present time. We note also that students of Faraday House appear to obtain substantial appointments when their time has expired.

Workshop Wrinkles and Recipes.—Messrs. Percival Marshall & Co. have ready No. 10 of their practical manuals with the above title. This is useful for amateur workers, and contains many of those little tips which it is impossible to carry always in one's head. It is cheap at 1s.

CATALOGUES, &c.

ELECTRIC LAMPS.—We have received from Messrs. L. E. Wilson & Co., Manchester, an illustrated catalogue showing the various types of the small electric lamps made by them. Full details of these useful apparatus are given. They are fitted with small accumulators, and are finding a wide application among householders, doctors and motorists.

BARWICK SWITCHGEAR.—We have received from Messrs. Donovan & Co. a pamphlet dealing with Barwick switchgear and fuses and electric light accessories of various kinds.

ELECTRICITY FOR ALL INDUSTRIAL USES.—The Union Electric Co. have just issued a very well illustrated pamphlet dealing with this subject. It contains illustrations of typical Union plant and also shows the shops in which these useful equipments are made. The ranges covered by the Union motors are apparently very wide and vary from such large work as bending and straightening rolls, saws, traversing tables and other similar plant to small table fans.

SWITCHGEAR.—Messrs. Cowans (Ltd.) send us a series of leaflets dealing with switchgear made by them. These illustrate and describe circuit-breakers, relays, fuses, rheostat, starting switches and transformers.

MINING PANEL.—We have received from Messrs. A. Reyrolle & Co. a pamphlet describing a type of mining panel which is now being manufactured by them. The isolated switch on this cannot be re-opened until the corresponding oil-switch has been put in the off position, while the oil switch cannot be closed while the isolating switch is in the off position. Each door is also locked so that it cannot be opened until the pressure has been cut off by the isolating switch. These panels have been designed to accommodate current and potential transformers and the fronts can be fitted with any combination of instruments required.

TELEPHONE APPARATUS AND SUPPLIES.—The Western Electric Co. have sent us a very complete catalogue dealing with this subject. It is claimed to be one of the most complete yet issued, and in it are to be found all the latest systems including those for the central battery system. Any firm doing business in telephone work should apply for a copy of this list.

BANKRUPTCIES, LIQUIDATIONS, &c.

The first meeting of creditors of Fredk. Peacock, electrician, 59, North Station-road, Colchester, will take place on Sept. 9 at the Cups Hotel, Colchester, and the public examination on the same date at the Town Hall, Colchester.

Frederick Peacock, electrician, 59, North Station-road, Colchester, has been adjudicated bankrupt.

The Telewriter Synd. (Ltd.) is being wound up voluntarily, the telewriter and other assets having been sold to the National Telewriter Co. A meeting of creditors was held on 24th inst.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

*NOTE.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

May 27, 1910.

12,868 HALL. Electric ignition apparatus.
12,889 BRUSH ELECTRICAL ENGINEERING CO. & JONES. Cooling the commutators and slip-rings of dynamo-electric machines.
12,893 HALL. Dynamos.
12,903 GUNNER. Electrical conduit fittings and the accessories for same. (Date applied for, 29.11.09. Comprised in No. 12,563, dated 27.5.09.)*
12,926 BERRY. Alternating electric current distributing systems.
12,936 WEYDE. Electric heating apparatus.

May 28, 1910.

13,015 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckert Werke G.m.b.H., Germany.) Movable coil alternating-current transformers for supplying currents of constant values.*
13,020 JOHNSON & PHILLIPS & GRAFTON. Electric lighting of tramcars and other vehicles.
13,021 JOHNSON & PHILLIPS & GRAFTON. High-frequency alternating-current generators.
13,035 GABREAU. Electric lighting of vehicles.*

May 30, 1910.

13,040 COTTON. Couplers for electrical switches.
13,095 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Circuit arrangements for telephone exchanges with automatic calling devices.*
13,123 B.T.-H. CO. (G.E. Co., U.S.) Control and protection of electric motors.
13,124 B.T.-H. CO. & EVEREST. Systems of electrical distribution.
13,125 B.T.-H. CO. & WOOTTON. Dynamo-electric machines.

May 31, 1910.

13,176 CONNER & PEEL CONNER TELEPHONE WORKS. Coating electric cables.
13,177 CONNER & PEEL CONNER TELEPHONE WORKS. Construction of telephone receivers.
13,195 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Switches.*
13,197 JESSON, BIRKETT & CO. & BIRKETT. Adjustment of electric and other lamps or fittings.
13,216 B.T.-H. CO. (G.E. Co., U.S.) Watchman's clock recorder systems.
13,224 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Starting devices for electric motors.*

June 1, 1910.

13,243 MOORES & MOORES. Insulators for telegraph, telephone and like wires.
13,257 PENSABENE. "Brush" or contact arrangement for dynamo-electric machines.
13,292 TAYLOR. Limiting the current on a short-circuit.
13,295 B.T.-H. CO. (G.E. Co., U.S.) Leading-in conductors for electric devices.
13,299 MATTHEWS. Effecting telephonic communication without connecting-wires.
13,305 JABURG, JUN. Arc lamps. (Date applied for, 2.6.09.)*†
13,311 MIDDLETON & BAKER. Electric fuses.*
13,325 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*
13,330 KETCHUM. Dynamo-electrical machines.*
13,335 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Starting devices for electric motors.*
13,336 LAKE. (Weston Electrical Instrument Co., U.S.) Synchronising alternating-current generators.*

June 2, 1910.

13,405 VINCENT. Vapour electric lamps.
13,406 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controlling the speed of electric motors.*
13,410 B.T.-H. CO. (G.E. Co., U.S.) Dynamo-electric machines.

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

18,869 BROADFOOT. Ships' telegraph apparatus.
19,434 IRVING. Electrical detectors or contact makers for use with railway switch points.
19,834 LAVY. Telegraph or telephone insulators and the like.
20,013 BRUCKERT. Magneto ignition devices for internal combustion engines.
20,105 BEAVES & CLAREMONT. Filling electric joint boxes.
20,584 B.T.-H. CO. (Nogyverath.) Dynamo-electric machines.
21,109 DAMBY. Means for securing electric incandescent lamps.
22,302 HEIMANN & SCHAFFER. Working arc lamps in series with incandescent lamps. (Date applied for, 1.10.08.)
22,866 CARBONI & TIRONI. Electric signalling for railways.
23,719 BULT. (Acme Automatic Street Indicating Co.) Electric circuit closing devices on electric railways and the like.
23,937 MONNIER. Distributing box for cables with multiple electrical conductors. (Date applied for, 19.10.08. Request under sec. 19 not granted.)
23,938 FORTESCUE. Electrical transformers. (Date applied for, 19.11.08.)

COMPANIES' MEETINGS AND REPORTS.

ABERDEEN SUBURBAN TRAMWAYS CO.—The directors' report for the half-year ended June 30 states that the profit was £1,260. A dividend of 2½ per cent. is declared for the past year.

BOLCKOW, VAUGHAN & CO. (LTD.)—In the directors' report it is stated that the total expenditure upon new bye-product ovens, exhaust steam turbines, electrical installations, new ironstone mine machinery, extensions, &c., during the past year was £173,602. 13s. 4d. A dividend bringing the amount for the year to 6 per cent. is declared.

BRITISH CONTINENTAL ELECTRICITY CO. (LTD.) (SAN REMO).—During the past year 171 new installations were connected, and the number of equivalent 8 c.p. lamps added was 1,295 (motors calculated in equivalent lamps). The output of electricity has increased, and the working expenses been reduced. The extension of the company's network to the neighbouring village of Poggio has now been carried out. After allowing for depreciation, the balance standing to credit of revenue (including sum brought forward) is £1,670. 8s., which the directors recommend shall be carried forward to meet payment of future dividends, the amount having been temporarily appropriated to capital account, pending the issue of further capital

NAIROBI ELECTRIC POWER & LIGHTING CO. (LTD.)—The accounts for the period to Dec. 31, 1908, included only the first few months of revenue earning period, and the working expenses at Nairobi were considerably in excess of receipts, making a net working loss of £1,233. 11s. 11d. The steady progress of the operations during 1909 has resulted in the receipts being slightly in excess of all working expenses there. There has been considerable further expenditure on capital account, and this is still proceeding. At June 30 last there were 228 customers (against 178 at end of 1909), and the equivalent of 4,728 8 c.p. lamps was connected (against 3,628), the connections for street lighting being 1,192 (against nil). There were also motors of 228 B.H.P. (against 178 B.H.P.

YORKSHIRE ELECTRIC POWER CO.—The directors in their report for the half-year ended June 30 state that the growth of the business is proceeding steadily and satisfactorily. The customers have increased their demands, and a number of important new customers have been connected during the half-year. The receipts from the sale of energy and for work charged to consumers, &c., for the half-year were £16,675. 10s., against £11,169. 4s. 2d. for the corresponding half-year of 1909, and £8,698. 9s. in 1908. The gross profit for the half-year is £4,950. 3s. 6d., against £2,598. 12s. 11d. in 1909 and £1,249. 16s. in 1908. After payment of mortgage interest (£799. 10s. 10d. more than the corresponding half of last year) the net revenue account shows a profit of £2,621. 17s. 8d., compared with £1,069. 17s. 11d., in 1909 and £363.6s.10d. in 1908. Further remunerative business is being pressed upon the company in districts not yet covered by their mains, but further capital is required for this. An extraordinary meeting will be held to pass a resolution sanctioning the terms of issue.

NEW COMPANIES, MORTGAGES AND CHARGES, AND RECEIVERSHIPS.

NEW COMPANIES.

CARTMAN & CO. (LTD.) (111,363).—Reg. Aug. 18, capital £5,000 in £1 shares, to take over the business of electric piano and musical instrument manfacturers and merchants carried on as the Tel Electric Co., and to adopt an agreement between C. E. Cartman and T. S. Chadwick. Private company.

TAYLOR & ROMANY (LTD.) (111,359).—Reg. Aug. 17, capital £2,000 in £1 shares, to take over the business of ironmongers and locksmiths, bellhangers, electric, hydraulic and mechanical engineers, manufacturers of and dealers in electric, magnetic, telegraphic, telephonic and other appliances, carried on as Taylor & Romany. Private company. First directors C. A. Taylor and F. O. Romany. Reg. office, 35, Little Pulteney-street, London, S.W.

MORTGAGES AND CHARGES.

JOHNSON & PHILLIPS (LTD.)—Issue on July 28 of £13,000 debentures, part of a series of which particulars have already been filed.

J. C. LYELL & CO. (LTD.)—Mortgage debenture dated Aug. 1, 1910, to secure £500, charged on company's undertaking, present and future. Holder, Mrs. H. Lyell.

VAN RADEN & CO. (LTD.)—A memorandum of satisfaction in full on Aug. 15 of mortgage dated Nov. 25, 1903, securing £1,300, has been filed.

RECEIVERSHIPS.

BRITISH TUNGSTEN LAMP CO. (LTD.)—Notice of the appointment, on Aug. 8, of H. Lonsdale, 26, North John-street, Liverpool, as receiver, under powers contained in second mortgage debentures, dated Sept. 15, 1909, has been filed.

CITY NOTES.

MEMORANDA (Aug. 25).—**Bank rate 3 per cent. (since June 9, 1910). Price of silver,** 24¼d. per oz. Consols 80⅞—81⅛ for money and for **account. Consols Pay Day, Sept. 1; Stock and Shares Continuation** Days, Aug. 29 and Sept. 13; Ticket Days, Aug. 30 and Sept. 14 Pay Days, Aug. 31 and Sept. 15; Mining Shares Carry Over Day, Aug. 26.

PRICES OF METALS (London).—*Copper*, cash, 55⅝; three months, 56⅛. *Lead*, English, 12⅞—13; foreign, 12½—12¾. *Spelter*, 22⅝—22¾. *Tin*, English, 152½—154½; foreign cash, 157¾; three months, 156⅝. *Iron*, Cleveland, cash, 49/10½, three months, 50/8.

MACKAY COMPANIES.—The regular quarterly dividend of 1 per cent. on the preferred shares and the regular quarterly dividend of 1¼ per cent. on the common shares in the Mackay companies will be paid on Oct. 1. The transfer books will not be closed.

SOUTH AMERICAN LIGHT & POWER CO. (LTD.)—The directors announce a dividend of 5 per cent. for the year ended March 31, £1,500 being placed to reserve and £558 carried forward.

STEWARTS & LLOYDS (LTD.)—An interim dividend for the half-year ended June at the rate of 10 per cent. has been declared on the preferred ordinary shares.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted quotations to £286,500 5 per cent. debentures (in lieu of scrip) and £13,500 5 per cent. debentures of the *Amazon Telegraph Co. (Ltd.)*, and a further issue of £530,000 4½ per cent. perpetual consolidated debenture stock of the *British Columbia Electric Railway Co. (Ltd.)*

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 17	1,679	— 80	11	17,237	— 354
Airdrie	„ 12	225	— 9	32	6,940	+ 61
Anglo-Argentine	„ 19	45,345	+ 4,483	33	1,455,680	+ 170,933
Ayr Corporation	„ 22	507	+ 1	14	6,106	+ 293
Barnsley	„ 12	178	— 3	32	5,489	+ 179
Barrow	„ 12	357	+ 32	32	8,606	+ 1,261
Bath Electric Trams, Ltd...	„ 17	1,010	+ 59	33	26,726	+ 1,238
Birmingham Corporation ..	„ 20	6,595	+ 343	20	136,333	+ 874
Birmingham & Midland....	„ 5	1,146	+ 63	31	26,329	+ 336
Blackburn Corporation	„ 17	1,144	+ 16	‡21	22,858	— 975
Blackpool and Fleetwood ..	„ 20	1,867	+ 2	..	..	..
Bolton Corporation.....	„ 21	2,353	+ 56	21	49,212	— 317
Bombay	July 22	2,674	+ 303	29	78,562	+ 5,786
Bournemouth Corporation..	Aug. 17	2,429	— 60	20	39,779	+ 3,812
Bradford Corporation.....	..	..	..	..	..	..
Brighton Corporation.....	„ 21	1,343	+ 62	§20	21,851	— 60
Bristol Trams & Carriage ..	„ 19	6,352	+ 365	7	45,567	+ 2,329
Burnley Corporation	„ 20	1,331	+ 23	7	9,053	— 31
Burton Corporation	„ 21	278	— 2	20	5,559	— 58
Bury Corporation	„ 21	1,148	— 21	§20	24,462	— 476
Calcutta Tramways Co.....	„ 20	R53,920	+ R3,936	7	R369,298	+ R19,669
Camborne-Redruth	„ 20	137	+ 16	33	4,037	— 113
Cardiff Corporation.....	„ 6	2,917	— 613	19	42,195	— 226
Cavehill.....	„ 12	139	— 13	32	2,975	+ ₹ 162
Central London Railway ..	„ 20	4,743	+ 270	7	37,185	+ 2,230
Chatham & Dist. Lt. Rys. ..	„ 18	972	— 61	33	27,722	+ 952
City & South London Rly...	„ 21	2,971	— 91	7	21,491	+ 7
City of Birmingham	„ 12	2,615	+ 36	32	91,373	+ 1,965
Colchester Corporation	„ 17	244	+ 7	..	..	..
Cork Electric Trams Co....	„ 18	540	— 9	43	16,078	+ 1,605
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams ..	„ 12	548	+ 108	32	13,475	+ 1,726
Dover Corporation	..	..	..	..	..	..
Dublin & Lucan Railway ..	„ 19	184	+ 17	7	1,259	+ 45
Dublin United	„ 19	6,109	— 90	7	43,154	— 61
Dudley-Stourbridge	„ 12	950	— 102	32	25,234	— 719
Dundee Corporation	„ 17	1,253	+ 33	§13	16,494	+ 281
East Ham Council	„ 20	1,103	+ 81	¶20	21,403	+ 446
Exeter Corporation.....	„ 19	381	+ 6	20	6,779	— 677
Gateshead & Dist. Trams ..	„ 12	1,007	— 42	32	31,497	— 186
Glasgow Corporation	„ 20	17,559	+ 297	12	204,158	+ 11,959
Glossop Trams.....	„ 20	129	— 9	33	3,871	— 240
Gloucester Corpn.....	„ 17	319	— 11	..	..	..
Gravesend-Northfleet.....	„ 12	226	— 30	32	6,634	+ 26
Great Northern & City Rly..	„ 20	1,240	+ 47	7	8,972	+ 254
Greenock & Port Glasgow ..	„ 12	800	+ 59	32	19,971	+ 2,680
Hartlepool Tramways	„ 12	323	— 29	32	7,844	+ 432
Hastings Elec. Trams Co. ..	„ 18	1,611	— 8	7	9,952	+ 67
Hong Kong	„ 20	$9,573	+ $108	7	$62,562	+ $4,724
Huddersfield Corpn.	„ 20	1,965	+ 222	20	36,297	+ 1,899
Hull Corporation.....	„ 20	2,753	+ 103	20	54,935	+ 3,123
Ilford District Council.....	„ 20	556	+ 53	20	11,078	+ 556
Ilkeston District Council ..	„ 17	137	— 14	20	2,602	— 156
Ipswich Corporation	„ 20	559	+ 38	20	9,247	+ 555
Isle of Thanet Co.	„ 20	2,162	+ 244	¶44	26,542	+ 1,479
Jarrow	„ 12	141	— 18	32	3,966	+ 208
Keighley Corporation.....	..	..	..	..	..	..
Kidderminster & District ..	„ 12	160	— 9	32	3,570	+ 104
Kilmarnock Corporation ..	..	..	..	..	..	..
Lanarkshire Trams Co.	„ 18	1,543	+ 18	33	45,603	— 3,683
Lancashire United	„ 17	1,504	— 43	33	43,192	— 540
*Leamington	„ 12	187	— 61	32	5,282	— 254
Leeds Corporation	„ 20	7,077	— 100	20	145,742	+ 4,596
Leicester Corporation.....	„ 20	2,366	+ 77	..	..	..
Leith Corporation	„ 20	696	+ 28	14	9,220	+ 56
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	„ 18	11,066	— 95	32	356,962	+ 13,153
Liverpool Overhead Rly. ..	„ 21	1,440	— 61	8	11,987	+ 2
Llandudno&ColwynBayRy.	„ 19	800	+ 29	§37	10,035	+ 34
*London County Council	„ 10	40,356	+ 2,857	¶19	797,811	+ 108,817
London Elec. Ry. Co.....	„ 20	10,270	— 160	7	81,565	+ 610
London United	„ 20	7,631	+ 260	33	211,663	+ 9,404
Lowestoft	„ 20	500	+ 51	47	8,644	+ 488
Maidstone Corporation	„ 20	203	— 3	20	3,719	— 222
Manchester Corporation....	„ 20	15,483	+ 620	20	315,522	+ 4,946
Mersey Railway	„ 20	1,870	+ 49	7	13,668	+ 198
Merthyr	„ 12	215	— 12	32	6,622	— 230
Metropolitan Dist. Railway..	„ 20	9,053	+ 528	7	71,399	+ 4,685
Metropolitan Elec. Trams ..	„ 12	7,834	+ 502	32	237,091	+ 41,486
Middleton	„ 12	346	+ 129	32	10,121	— 651
Nelson Corporation.....	„ 20	163	+ 15	§20	3,023	+ 93
Newcastle-on-Tyne Corp. ..	„ 20	3,870	+ 68	¶20	81,710	+ 912
Newport (Mon.)	„ 20	693	+ 17	21	14,618	+ 519
Northampton Corporation..	„ 20	535	— 12	§20	10,307	— 3
Oldham, Ashton & Hyde ..	„ 12	562	— 94	32	17,690	— 124
Oldham Corporation	„ 21	1,821	+ 32	21	39,769	— 1,069
Perth (N.B.) Corporation ..	„ 17	198	+ 17	§13	2,465	+ 168
Perth (W.A.) Elec. Trams ..	..	..	..	..	..	..
Peterborough	„ 12	137	— 16	32	3,681	— 59
Portsmouth Corporation ..	„ 20	2,963	+ 224	20	44,898	— 1,698
Potteries	„ 12	1,497	— 42	32	55,795	— 619
Preston Corporation	..	..	..	..	..	..
Rotherham Corporation....	„ 18	661	+ 53	20	12,523	+ 486
Rothesay	„ 12	632	— 14	32	6,979	+ 139
Salford Corporation	„ 22	4,526	+ 169	‡21	97,051	+ 985
Sheerness	„ 12	85	+ 8	32	1,589	— 7
Sheffield Corporation	„ 21	5,995	+ 518	¶21	127,359	+ 7,484
Singapore Trams.....	„ 20	$10,473	+ $1,507	7	$60,535	+ $5,906
South Metropolitan.....	„ 12	989	— 179	32	26,305	+ 1,100
South Staffs.....	„ 12	815	— 42	32	26,720	+ 44
Southend Corporation	„ 17	1,069	+ 105	20	13,105	+ 1,118
Southport Tramways	„ 12	446	— 56	32	9,475	+ 158
Stalyb'dge,Hyde,&c.,Jt.Bd.	„ 20	790	— 32	¶20	14,888	— 1,320
Sunderland Corporation....	„ 21	1,292	+ 94	21	24,433	— 363
Sunderland District	„ 17	512	+ 38	42	18,001	— 1,323
Swansea Trams	„ 12	1,255	+ 57	32	34,521	+ 4,004
Swindon Corporation	„ 17	170	..	20	2,853	+ 119
Taunton	„ 12	61	— 9	32	1,355	+ 118
Tynemouth and District....	„ 12	497	— 117	32	8,205	+ 404
Tyneside Trams Co.	„ 17	520	+ 44	7	3,679	+ 288
Wallasey District Council ..	„ 20	1,111	+ 119	§20	20,080	+ 7
Walsall Corporation	„ 20	592	+ 12	33	17,694	+ 750
Warrington Corporation....	..	..	..	..	..	..
West Ham Corporation	„ 11	2,443	— 6	19	47,692	+ 1,931
Weston-super-Mare	„ 12	484	— 47	32	4,580	— 47
Wolverhampton Co.	„ 12	428	— 1	32	13,528	+ 292
Wolverhampton Corpn.	„ 17	1,003	+ 125	20	20,313	+ 3,010
Worcester	„ 12	333	— 43	32	8,997	+ 147
Wrexham	„ 12	99	— 21	32	3,100	— 3
Yorkshire W.R. Trams	„ 21	1,631	+ 140	34	42,412	..
Yorkshire Woollen District.	„ 12	1,006	— 67	32	31,394	+ 2,649

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	NAME.	Price Wed., Aug. 24	Rate per cent. Yielded.	Dividend Due.	Business Week to Aug. 24. Highest.	Lowest.
		Electricity Supply.		£ s. d.			
10	6/0	†Bournemouth & Poole Elec. Sup. Ord.	8½ —9½	5 16 0	Mar, Sep	..	..
10	4/6	†Do. 4½ per Cent. Cum. Pref.	9 —9¾	4 12 6	Feb, Aug	..	..
10	6/0	†Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 13 0	Feb, Aug	10⅞	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	..	..
5	4/6	†Brompton & Kensington Elec. Sup. Ord. ..	6¾—7⅛	6 9 0	March....	..	..
5	3/6	†Do. 7 per Cent. Pref.....	6 15/16—7 1/16	4 14 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	†Charing Cross (W. End & City) El. Sup. Co.	3⅜—3⅝	6 5 6	Feb, Aug	3½	..
5	2/3	†Do. 4½ per Cent. Pref.	4⅛—4⅜	4 15 0	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deo. Stock (red.)	100½—102½	4 8 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅜—4⅛	5 9 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.....	3⅜—4⅛	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	99½	..
10	6/0	City of London Electric Lighting Ord.	11¼—11⅝	6 9 0	Feb, Aug	11½	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅝—12¼	4 18 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 —124	4 0 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99½—102½	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.....	1⅛—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2⅜—3½	7 14 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7⅜—7½	6 7 6	Feb, Aug	7 15/16	7 7/16
10	6/0	Do. 6 per Cent. Cum. Pref.	10½—11	5 9 0	Mar, Sept	10 15/16	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104 —107	4 4 0	Jan, July	106½	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	101⅛	101⅛
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4½	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	..	..
St.	4½%	†Do. 4½ 1st Deb. Stock (red)	99 —102	4 8 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.....	7 —7½	5 9 0	April, Oct	..	..
5	4/0	†Kensington & Knightsbridge Ord.....	6⅞—7⅛	5 6 9	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅞—6½	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	81 —85	5 6 0	Jan, July	..	..
3	1/2⅔	London Electric Supply Ord.	1⅝—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	5 1/16—5 1/16	5 13 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/6	†Metropolitan Electric Sup. Ord.	3⅛—3⅜	6 13 3	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	4 —4⅛	5 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95¼—97½	4 12 6	June, Dec	..	..
5	1/6	Newcastle Elec. Supply Ord.....	3⅛—4⅛	4 14 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛—4⅜	5 5 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	99 —101	4 9 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6⅜—6⅝	5 2 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7⅞—8⅛	6 2 3	Feb, Aug	7⅛	..
5	3/6	Do. 7 per Cent. Pref.....	6¾—7⅛	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1½—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2¾—2⅞	6 18 0	April	..	..
St.	5%	Do 5 % 1st Mort. Stock (red.).....	99 —102	4 13 0	..	101	..
1	0/8½	South Metrop'n Elec. Lt. & Power Ord.	1/16—1/8	..	..	..	..
St.	4½%	Do. 7 per Cent. Cum. Pref.	1/16—1 1/16	6 12 0	Feb, Aug	..	..
5	2/6	Do. 4½ 1st Deb. Stock (red.).....	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	⅛—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.....	7¾—8⅛	5 16 9	Mar, Sept	6⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5⅛	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	..	4 3 6	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.....	⅛—3/16	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	1/16—⅛	6 12 9	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.).....	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6¼—6⅜	8 18 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7¼—7⅜	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅛—1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅜—3½	..	Feb, Aug	..	..
St.	5%	Do. 5 per Cent. Perpetual Debs.....	86 —90	5 11 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	68 —73	6 3 0	May, Nov	..	..
St.	3%	†Central London Ordinary Stock	64 —66	4 11 6	Feb, Aug	64⅛	64
St.	4%	†Do. 4 per Cent. Pref. Stock	84 —86	4 14 6	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	49 —51	3 18 0	Feb.	49	..
100	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	101⅛	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	..	4 4 0	Jan, July	..	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5⅛	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord. ..	27 —28	5 6 0	Feb, Aug	29⅛	..
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —104	4 16 0	Feb, Aug	..	..
St.	5%	Do. (1901)	99 —102	4 18 0	Feb, Aug	..	..
St.	5%	Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do 4 per Cent. Perpetual Debs.....	99 —101	3 19 0	May, Nov	..	..
10	6/0	†Dublin United Trams, 6 per Cent. Pref....	12⅞—13¼	4 6 6	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8⅛	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾—1	..	Feb, Aug	..	..
10	4/0	†G. Northern, Picc. & Brompton 4% G. Pf.	8⅛—8⅝	4 15 0	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	..	4 4 0	Jan, July	..	..
5	..	Hastings & District Elec. Trams, 6% C. P.	⅞ —1½	..	Mar. Sept	..	..
St.	4%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3⅛—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1⅛—1½	4 3 9	Mar, Sept.	1⅜	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —75	5 16 0	Jan, July	73	72½
10	5/6	Lanarkshire Tramways	9⅛—9 11/16	5 19 3	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —86	5 16 0	Jan, July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	67 —71	5 12 6	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	1 —2	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.....	3/4—15/16	..	..	..	..
1	..	Do. Deferred	1/16—⅛	..	..	..	..
1	0/6	†Do. 5 per Cent. Cum. Pref.	¾—⅞	5 11 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	96 —99	4 11 0	Jan, July	98⅛	..
St.	..	Do. 5 per Cent. Db. Stk	95 —97	..	..	96⅛	96½
St.	1½%	Metropolitan Railway Consolidated.....	38 —38½	2 18 0	Feb, Aug	38⅛	38
St.	2½%	Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	65⅛	65
St.	3½%	Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	84⅛	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	92⅛	91½

* In calculating the yield allowance has been made for accrued interest, but not for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Electric Railways and Tramways—*Continued.*

Share	Last Dividend	Name	Price Wed. Aug. 24	Rate per Cent. Yielded £ s. d.	Dividend Due	Business Week to Aug. 24 Highest	Lowest
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	90 —92	3 15 6	Jan, July	90	..
St.	..	†Metropolitan District Railway Ord.	20½—21	..	Feb, Aug	20[illegible]	20½
St.	..	Do. Extension Pref. (5 per Cent.)	75 —77	..	Feb, Aug	76½	75½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 0	Feb, Aug	71½	70½
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	75½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	4 0 0	Jan, July	..	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	140 —142	4 4 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto	94 —96	4 3 6	Jan, July	..	..
1	4½d.	Potteries Electric Traction Ord.	[illegible]	..	April, Oct	..	..
1	0/6	†Do. 5 per Cent. Cum. Pref.	[illegible]	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	[illegible]	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoup5	39 —41	4 16 9	June, Dec	40½	..
..	5%	Do. 5% Prior Lien Bonds	103 —104	4 16 0	..	..	..
..	4½%	Do. 4½% Bonds with coup. 6	89 —91	5 0 0	..	90½	89½
..	4%	Do. 4 per Cent. 1st Power Ho. Dbs.	98 —100	4 0 0	..	99½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	[illegible]	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	77 —80	5 12 6	Jan, July	..	..

Electric Manufacturing, &c.

Share	Last Dividend	Name	Price Wed. Aug. 24	Rate per Cent. Yielded £ s. d.	Dividend Due	Highest	Lowest
St.	4½%	Anchor Cable Co. 4½ % Deb. Stock	100 —102	4 9 0	..	100	..
1	..	Aron Electricity Meter Ord.	[illegible]	..	..	..	..
1	1/9[illegible]	Do. 6% Cum. Pf.	[illegible]	6 16 0	April, Oct	5[illegible]	..
1	3/2½	Babcock & Wilcox Ord.	5½—5¾	4 5 6	April, Oct	..	..
1	0/7½	Do. Pref.	1[illegible]—1[illegible]	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¾—7¼	6 18 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	5½—6½	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	100 —103	4 8 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	[illegible]	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	99½—101½	5 19 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	61 —63	3 3 6	Jan, July	61	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	39 —44	10 4 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	23 —27	16 12 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9 —10	7 10 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4½—5½	4 15 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	100½—102½	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.	2[illegible]—2[illegible]	4 19 6	May, Nov	2[illegible]	2[illegible]
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	104 —107	4 4 0	Feb. Aug	..	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1[illegible]—1[illegible]	5 19 0	March ..	..	..
1	0/8½	†Consolidated Electrical Co.	[illegible]	6 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.	[illegible]	5 12 9	April, Oct	[illegible]	..
1	0/7½	Do. 6 per cent. Cum. Pref.	[illegible]	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	[illegible]	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	84 —87	5 15 0	Jan, July	..	..
1	0/7½	Davis & Timmins	[illegible]—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	1 —1½	5 7 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1½	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	[illegible]	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1½	9 3 0	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	[illegible]	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1½—2	..	May, Nov	1½	..
St.	4½%	Do 4½ per cent. 1st Mort. Deb. (red.)	75 —78	5 15 6	Jan, July	76½	75½
2	..	Electric Construction Co.	[illegible]	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1½—1½	4 13 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs	59 —61	6 5 0	Jan, July	62½	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs	82 —86	4 13 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.	12½—12¾	5 19 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 5 0	Feb, Aug	5½	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 5 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works	14½—15	6 12 0	Feb, Aug	14[illegible]	..
10	5/0	Do 5 per Cent. Cum. Pref.	10½—11	4 14 0	..	10[illegible]	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	97½	..
1	..	National Elec. Construction Co.	[illegible]	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	[illegible]	..	Nov	[illegible]	..
1	..	Do. 6 per Cent. Cum. Pref.	[illegible]	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	78 —83	5 9 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	34 —35	5 18 0	Mar, July	35	34
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 17 0	Jan, July	100	..
1	1/0	†Vickers, Sons & Maxim, Ltd., Ord	2[illegible]—2[illegible]	4 5 0	..	2½	2[illegible]
1	0/6	†Do. 5 per Cent. non-Cum. Preference	[illegible]	4 0 0	..	1½	..
St.	5%	†Do. 5 per Cent. non-Cum. Preferred	107 —110	4 12 0	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	104½	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 6	..	105	..
10	10%	J. G. White & Co. 6% Cum. Pref.	12½—13½	7 8 0	..	13½	12[illegible]
1	..	Willans & Robinson Ord.	[illegible]	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1½—1⅞	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	60 —70	5 14 0	May, Nov	..	..

Telegraphs.

Share	Last Dividend	Name	Price Wed. Aug. 24	Rate per Cent. Yielded £ s. d.	Dividend Due	Highest	Lowest
10	..	Amazon Telegraph	3½—3½	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan. July	..	..
St.	15/0	Anglo-American	64½—66½	5 9 0	F,My,Ag,N	64½	64½
St.	30/0	Do. Preferred	105 —106	5 10 6	F,My,Ag,N	107½	106½
St.	25/0	Do. Deferred	25½—26½	4 18 0	F,My,Ag,N	26	25[illegible]
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	84 —86	4 13 0	Jn,Ap,Jy,O	..	..
10	6/0	Cuba Submarine Ord.	8½—9	6 13 6	Feb, Aug	8½	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 15 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3½—3½	5 14 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7½—8½	6 1 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	99 —101	4 19 0	Jan, July	..	..
20	6/0	Direct United States Cable	14½—15½	6 2 3	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½%Rg.Db.(rd.)	99 —102	4 10 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	132 —135	5 4 0	Ja,My,Jy,O	134½	133
St.	17/6	Do. 3½ per Cent. Pref. Stock	84 —86	4 1 6	Ja,My,Jy,O	85½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	102½—104½	3 17 9	May, Nov	104	103
St.	2/6	Eastern Extension	12½—12½	5 15 0	Ja, Ap,Jy,O	12½	12½
100	4%	Do. 4 per Cent. Deb. Stock	99½—102½	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	100 —102	3 18 0	May, Nov	..	..
[illegible]	5/0	G.N (of Copenhagen), with Coupon 80	29½—30½	5 15 0	Jan, July	30[illegible]	30½
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	53	..
100	5%	Mackay Companies Common	84 —88	5 14 0	Ja,Ap,Jy,O	..	..
100	4%	Do. Preference	74 —78	5 2 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	[illegible]	..	April	[illegible]	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	96½—98½	4 2 0	June, Dec	..	..
[illegible]	[illegible]	West Coast of America	1½—1½	3 12 9	May	..	..
[illegible]	[illegible]	Do. 4 per Cent. Debs.	96½—98½	4 2 0	Jan, July	..	..
[illegible]	[illegible]	[illegible] India & Panama	[illegible]	..	May, Nov	[illegible]	..
[illegible]	[illegible]	[illegible] per Cent. 1st Pref.	8½—9	6 12 6	May, Nov	8½	..
[illegible]	[illegible]	[illegible] Pref.	8 —9	6 18 6	May, Nov	8[illegible]	..
[illegible]	[illegible]	[illegible] Cent. Debs.	100 —102	4 19 0	Jan, July	..	..
10	[illegible]	[illegible]	13½—14½	4 19 3	Mr,Ju,O,D	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 19 0	June, Dec	..	..
—	4%	Western Union [illegible]	[illegible]—106	[illegible]	..	..	..

Telephones.

Share	Last Dividend	Name	Price Wed. Aug. 24	Rate per Cent. Yielded £ s. d.	Dividend Due	Highest	Lowest
100	2$	Amer. Telephn. & Telegh. Cap. St.	137 —140	5 19 0	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 7 3	Jan. July	..	..
St.	4%	†Do. 4% Cons. Bonds 1936	103 —105	3 16 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101½—103½	4 19 0	Mar, Sept	..	..
5	5/0	Chili Telephone	9½—9½	4 4 3	August ..	9½	..
1	0/7½	Monte Video Telephone Ord.	[illegible]	6 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	[illegible]	5 12 0	May, Nov	[illegible]	..
St.	6%	†National Co. Pref. Stock	104 —105½	6 1 0	Feb, Aug	104	..
St.	6%	†Do. Def. Stock	123 —125	4 17 6	Feb, Aug	124½	123½
10	6/0	†Do. 6 per Cent. Cum. 1st Pref.	10 —10½	5 8 6	Feb, Aug	..	..
10	6/0	†Do. 6 per Cent. Cum. 2nd Pref.	10 —10½	5 8 6	Feb, Aug	..	..
5	2/6	†Do. 5 per Cent. non-Cum. 3rd Pref.	5½—5½	4 8 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	97½—99½	3 10 6	June, Dec	97½	97½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	98½—100½	3 19 6	Jan, July	..	..
..	4½%	New York Telephone Co. 30 yr. Bnds.	98½—99½	4 12 0	..	99½	98½
1	1/0	Oriental	1½—1½	4 14 6	April, Oct	1½	..
1	0/7½	Do 6 per Cent. Cum. Pref.	1½—1½	4 11 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	86½	..
St.	4½%	Telephone Co. of Egypt 4½%Db.Stk.(red.)	98 —100	4 10 0	Jan, July	99½	..
5	5/0	United River Plate Ord. ex rights	6½—7½	5 12 3	July	7[illegible]	6[illegible]
5	2/6	Do. 5 per Cent. Cum. Pref.	5[illegible]—5[illegible]	4 14 0	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.	102 —104	4 6 6	Jan, July	..	..

Financial, Investment, &c.

Share	Last Dividend	Name	Price Wed. Aug. 24	Rate per Cent. Yielded £ s. d.	Dividend Due	Highest	Lowest
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	2½—3½	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10½—10½	5 9 6	Sp,DcMrJu	10½	10½
10	3/0	Do. 6 per Cent. Pref.	13 —13½	4 9 0	Sp,DcMrJu	13[illegible]	13½
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 0	April, Oct	..	..

Colonial and Foreign Electric Railways, Tramways, &c.

Share	Last Dividend	Name	Price Wed. Aug. 24	Rate per Cent. Yielded £ s. d.	Dividend Due	Highest	Lowest
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4[illegible]—4[illegible]	5 9 6	April, Oct	4[illegible]	4½
5	2/6	Do. 5% Cum. 2nd Pref.	4½—4½	5 14 0	Jan, July	..	..
St.	4%	Do 4% Deb. Stock	90½—92	4 7 0	June, Dec	91½	90½
St.	4½%	Do. 4½% Deb. Stock	94 —97	4 13 0	..	95½	94½
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	103 —105	4 15 3	Jan, July	..	..
5	4/6	Brisbane Electric Trams. Invest. Ord	5½—6½	5 19 0	May	6	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4½—5½	4 15 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	99 —102	4 8 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	144 —148	5 10 6	Mar, Sept	146	145½
St.	£3	Do. Pref. Ord. Stock [illegible]d & bonus	124 —128	4 13 9	May, Nov	125½	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	109½—112½	4 9 6	Jan, July	112½	111½
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	102½	102½
100	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	101½	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	104½—106½	4 0 6	..	105	105
St.	5%	†Buenos Ayres Lacroze Trams 1st Mt. Db.	96½—99½	4 19 0	Mar, Sept	..	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	..	..
5	2/6	Calcutta Tramways (1 to 137,610)	4 —4½	5 0 0	Mar, Sept	4[illegible]	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4[illegible]—4[illegible]	5 2 9	Jan, July	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red)	96 —99	4 11 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	[illegible]	..	..	..	..
5	1/3	†City of Buenos Ayres Trams Co. (1904) Sh.	5[illegible]—5[illegible]	4 5 6	F,My,A,N	5[illegible]	5[illegible]
St.	4%	Do 4 per Cent. Deb. Stock	98 —101	4 0 0	June, Dec	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 —99	5 1 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	93 —101	5 4 0	Feb, Aug	99½	99½
1	..	Kalgoorlie Elec. Trams Sh.	[illegible]	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock	92 —95	5 5 0	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	†Lisbon Elec. Trams. Ord.	1½—1½	4 8 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1½—1½	4 16 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	97½—101½	4 18 6	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	95 —98	5 2 0	Jan, July	..	..
100	5%	Manaos Trams and Lt. Co. 5% Debs	86½—89	5 13 6	..	87½	87
..	5%	†Manila Elec. Ry. $1,000 Gold Bonds	96 —98	5 3 0	Feb, Aug	..	..
100	$1½	Mexico Trams Co. Com. St.	117 —119	5 17 6	..	119½	118
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	99½—100½	5 2 0	..	100½	99
St.	6%	Do. 6% 50 yr. Mort. Bds.	97½—98½	6 4 6	..	98½	98
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	100 —102	4 8 0	Feb, Aug	102½	..
St.	4½%	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	..	..
1	0/6	Perth Elec. Trams Ord.	[illegible]	5 15 5	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5½—5½	5 2 6	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	94½	92
100	$1½	Rio Janeiro Tram, Lt. & P. Co.	91½—93½	4 12 0	..	95½	98
..	5%	Do. 30 yr. Gold Bnds.	98½—99½	5 3 6	..	90½	89
100	5%	Do. 50 yr. Mt. Bnds	89½—90½	5 13 6	..	..	..
..	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	144 —145	7 1 0	..	146	145
..	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102½	102
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	101 —103	4 7 6	Feb, Aug	..	..

Colonial and Foreign Electricity Supply, &c.

Share	Last Dividend	Name	Price Wed. Aug. 24	Rate per Cent. Yielded £ s. d.	Dividend Due	Highest	Lowest
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—5½	5 2 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	10½—11	5 11 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red)	93 —95	4 15 0	Jan, July	..	..
..	5%	Do 5 per Cent. 2nd Mort. Deb. Stock	97 —99	5 1 0	..	..	..
5	4/9	Calcutta Elec. Supply Ord.	6½—6½	6 6 0	April, Oct	..	..
100	7/2½	Canadian Cen. Elec. Co. Com. St.	105 —109	6 13 0	..	122½	..
100	$3½	Do. 7% Cm. Pf. Stock	122 —125	5 12 0	..	..	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	86½	86
500	5%	Elect. Development Co. of Ontario	85 —88	5 12 6	..	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1½—1½	..	..	..	..
10s	1½d.	Kalgoorlie Elec. Power & Ltg. Ord.	[illegible]	..	..	[illegible]	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	[illegible]	8 0 0	April, Oct	..	..
..	5%	Kaministiquia Power Co.5% Gold Bnds.	100½—102½	5 0 6	..	..	..
5	..	Madras E. S. Corp. Ord.	2½—3	..	..	..	..
St.	..	Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock	90½—92½	5 9 0	..	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	81½—85½	5 15 9	..	65½	..
St.	$1	Mexican Lt. & Power Co. Com. St.	79 —81	5 3 6	..	[illegible]	79
St.	$3½	Do. 7% Cum. Pref. St.	103½—105½	6 16 6	..	105½	10[illegible]
500	5%	Do. 5% 1st Mort. Gold Bnds.	93½—94½	5 4 [illegible]	..	94	93
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	132 —138	5 5 0	F,My,A,N	..	..
St.	£9	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	..	..
St.	6%	Do. 6 per Cent. non-Cum. Pref. Stk.	105 —115	5 5 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
5	3/0	Rosario Elec. Co. Ord.	8½—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
5	3/0	Do. 2nd Pref.	8½—8½	6 14 6	..	100½	9[illegible]
100	$1	Shawinigan Water& Power Co.Ca	99 —101	4 4 0	..	..	..
..	5%	Do. 5 per Cent. Bds.	108 —110	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	101	10[illegible]
St.	4½%	Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	..	..
..	6d.	Victoria Falls Power Co. Pref.(1 to 808,000)	[illegible]	5 6 6	Jan, July	..	..
..	..	Do. (808,081 to 1,200,000)	[illegible]	..	..	..	..

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,685. [No. 21. Vol. LXV.] FRIDAY, SEPTEMBER 2, 1910. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

The British Association.

THIS year the British Association meets at Sheffield, and everything points to a successful gathering. On Wednesday evening the Rev. Prof. T. G. BONNEY delivered his presidential address before a crowded and brilliant audience, and yesterday the presidents of the various sections delivered their addresses. At the time of going to press the official number of persons attending this year's meeting was 1,400. An attractive programme of social events has been arranged, and it would appear that Sheffield is determined to maintain its ancient reputation for hospitality to strangers within its gates.

PROF. DALBY'S presidential address to Section G was of the ideal British Association type. It dealt with an extremely interesting and difficult subject in a manner capable of being understood by the veriest amateur. Statistics relating to railways always claim the attention of the intelligent public, but they are rendered positively thrilling when they are accompanied by reliable data furnished by a distinguished engineer. The burden of Prof. DALBY'S song is that electric traction is the only thing for services involving frequent starts and stops; but he goes further than this and says that the London, Brighton & South Coast Railway Co.'s so-called "experiment" contains the germs of practicable long-distance electrification. It is almost to be regretted that he did not dwell rather more fully on this part of the subject but we may hope that he will have more to say after Mr. PHILIP DAWSON has read his Paper.

Municipal Wiring Powers.

IT will be remembered that a clause conferring powers on municipal authorities to do wiring and to supply electrical fittings on hire within their areas was inserted in the Electric Lighting Bill of 1909. This clause was so amended in the House of Lords as to make it unacceptable to municipal electrical engineers, and it was, therefore, deleted from the Bill. The Incorporated Municipal Electrical Association, who discussed the subject at their annual convention in Glasgow, recently sent out a communication to the various local authorities to discover whether sufficient support would be forthcoming should a Bill be introduced to confer, among other things, powers for wiring and hiring on such local authorities as possess electricity supply undertakings. The results of this canvass will be found on another page of this issue, from which it will be seen that a large majority of those who replied are in favour of the proposal, and even go so far as to promise financial support. We may, therefore, presume that the Municipal Electrical Association will introduce a Bill in the next Parliamentary Session to obtain the powers they require, and we may certainly prophesy that their proposals will meet with opposition. It is well that this should be so. We have no objection to municipalities wiring or hiring where no contractors are available to do the work or where the contractors are supine and do not appreciate what is required of them. But we do not approve of a municipality becoming a trading concern and entering into destructive competition with those who help to provide its sinews of war. Unfortunately this course is occasionally adopted by some municipalities who already possess the powers which the proposed Bill would confer on all. In view of the necessity for those supplying electricity being

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in a position to develop their undertakings on modern business lines we think that a well-planned scheme of letting motors and heating and cooking apparatus on hire would be of great advantage to them. As, however, there appears to be a conflict of interests between the supply authorities and the contractors, we hope that the subject will be fully discussed in all its aspects and a compromise reached.

Breakdowns of Machinery.

THE annual report of Mr. M. LONGRIDGE, chief engineer to the British Engine, Boiler & Electrical Insurance Co., always provides interesting reading, on account of the valuable information and hints that it contains. The report for the year 1909, of which an abstract will be found elsewhere in this issue, is no exception to the general rule. On the present occasion less space is devoted to the customary descriptions of typical breakdowns, which latter have proved of smaller interest than usual; but this has allowed particulars of some interesting tests carried out by the engineers of the Company to be included with the report. The rate of breakdown among both steam engines and gas engines is about the average for the last few years, the figures being 1 in 10·2 and 1 in 10·4 respectively for the two types of engine. At present only comparatively few steam turbines are insured, but in a year or two, doubtless, some valuable information as to their reliability compared with reciprocating engines should be available. It is interesting to notice Mr. LONGRIDGE'S observations on the improvement in British methods of design brought about by technical education and foreign competition. In this connection the design of gas and oil engines is apparently inferior to that of steam engines, crankshafts in particular showing an increased tendency to failure, as is clearly indicated by the fact that, whereas for the six years previous to 1908 the percentage of breakdowns due to failure of crankshafts was 5·0, this figure had increased to 9·1 in 1908 and to 13·4 in the past year. The producer also seems a weak point in gas plants, the percentage of failures showing a marked increase.

TURNING now to electrical machinery, it is very gratifying to observe evidence of greater reliability, as indicated by the fact that the percentage of breakdowns of dynamos has decreased by 2·2 per cent., of motors by 6·2 per cent., and of starting switches and controllers by 7·5 per cent. It is to be noted, however, that bad workmanship or defective design accounts for a greater proportion of failures in all electrical apparatus than a year ago, whilst age and deterioration have become a much less frequent cause of trouble, probably largely owing to the inspection carried out by the Company. One of the most striking testimonies in favour of electrical machinery is the fact that only 1 per cent. of the breakdowns has been due to overloading. In view of the small indication given by electrical apparatus when subjected to an overload and the frequent placing of such apparatus under the control of unskilled workmen, such a record is certainly noteworthy.

Tramway Brakes.

THE question as to which is the most satisfactory brake for an electric tramcar has received considerable attention during the last few years both in this country and abroad; but although valuable contributions to this subject have been made, substantial difference of opinion still exists. It is interesting to note that in New Zealand this question has been deemed worthy of the attention of a Royal Commission. This Commission, which was appointed to report upon the most suitable form of brake for the Auckland (N.Z.) electric tramways and also to consider generally the question of tramway efficiency and safety, has recently sent in its report to the Government. It recommends that the Auckland Tramway Co. be requested to fit its cars with an approved type of pneumatic wheel brake and pneumatic sanding gear and to reconstruct the existing track brakes so that it may be possible to transfer 45 per cent. of the weight of a loaded car to the slipper blocks. The pneumatic brake was favoured by the Commission on account of its reliability, independence of track equipment, smoothness of working, efficiency at all attainable speeds, and ease of installation compared with that of the magnetic brake, which is stated to be unsuitable for the existing equipment of the Auckland cars. It appears, however, that the latest forms of magnetic brake have not yet been tested in the Dominion. Although adopted to no small extent abroad, the pneumatic wheel brake for tramcars has not found favour in this country; but that it is worth consideration is shown by the fact that, in their 1908 report on brakes, the Committee of the Light Railways and Tramways Association suggested that more attention might be paid to air brakes.

Brussels Exhibition Fire.

As may be seen on reference to our correspondence columns, the rumour that the Brussels fire originated from defective electrical apparatus has been officially contradicted. In support of the statement, it is pointed out that all electrical supply had been cut off for several hours from the buildings where the outbreak commenced. Clearly, this gives the *coup de grâce* to the "fusing of an electric wire" theory. Fortunately, the daily papers are becoming more cautious about alleged electrical fires, and this is only as it should be. If, however, they are really beginning to see the futility of their policy for the last few years, it now remains with them to make amends by giving as much publicity as possible to statements of fact issued by responsible persons. Meantime the Board of Trade Exhibitions Department is making most satisfactory progress with the new British section. Mr. WINTOUR, the Commissioner-General, states that applications for space in the Salle des Fêtes have been so numerous and spontaneous that personal negotiations have been unnecessary. The electrical exhibitors have responded promptly to the call for a representative display in the remodelled section, and practically all the firms formerly showing have got their new exhibits together. The firms include Messrs. Kelvin & James White, Nalder Bros. & Thompson, R. W. Paul, Cambridge Scientific Instrument Co., and Gambrell Bros., who are to be complimented on the enterprising manner in which they have reconstructed their exhibits.

Engineering Standards Committee.—We have received from this committee a copy of the revised edition of the specification for Portland cement. On account of the difference

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found in the initial setting time when the British standard and Vicat needles were used, it was considered preferable that one instrument only should be specified for determining the initial and final setting and the Vicat needle has been adopted for this purpose. A minimum lime content has been inserted, with a view to excluding cements other than Portland cements; the total loss on ignition has been specified to provide an additional criterion of the quality of the cement and to restrict the amount of water present, and provision is now made for limiting the total amount of sulphur present in the cement, whether in the form of sulphides or sulphates.

Remarkable Performance of an Induction Motor.—According to "Engineering News" the behaviour of apparatus under exceptional circumstances reveals the weak or strong points in its design and determines whether it is suitable to perform the service for which it has been installed. A 20 H.P. three-phase 220-volt standard induction motor recently demonstrated its ability to operate successfully under the trying conditions met with in mines where the air is unusually damp. The motor was only partly enclosed; this is important, for thorough ventilation of the motor is absolutely necessary in mines where high temperatures prevail. The motor in question was geared to a mine pump located at the bottom of a shaft on the mines of the Richmond Iron Works. Surface water broke into one of the upper levels and flooded the mine. The water rose so rapidly that the electric pump and motor were soon 2 ft. below the level of the water. Under such circumstances it was imperative that the pump should continue in operation. At the end of two hours, during the whole of which time the motor was submerged, it had pumped itself clear and was then stopped long enough to clean the dirt and chips from the rotor and to put oil in the bearings. It was re-started immediately. The pump has been running about 20 hours a day ever since, and the motor apparently suffered no injury from its unusual experience.

Electric Locomotives on Steep Gradients.—The "Engineering and Mining Journal" describes an installation at Holt & Gregg's lime quarry at Kennet, California, as an example of the operation of electrical apparatus under heavy conditions. This quarry is near the copper mines and smelting works of the Mammoth Copper Mining Co., and supplies the limestone flux. The quarry is 2 miles from the station where the rock is stored for the smelting company, and about 2,000 ft. above the ore bins. In order to transport the rock to this point a road was built round two mountains, necessitating many curves and heavy gradients. There are 35 curves, with radii varying from 35 ft. to 55 ft. The entire road has heavy gradients, varying from 4 to 12 per cent., the average being about 7 per cent. This road was originally laid out as a wagon road, but was afterward changed into a 30 in. gauge mule tramway, equipped with 30 lb. rails. The demand for limestone became so great that it was not possible to supply it with this equipment. An electric locomotive was purchased and a new system put into operation. The locomotive handles three-car trains, each car weighing 4,400 lb. empty. The wooden body is mounted on substantial double trucks, having a 3 ft. wheel base. A complete braking equipment was provided, consisting of both track and wheel brakes. The locomotive had a rating of 11 tons, and was equipped with two 42 H.P. 550-volt motors. On account of the heavy gradients and consequent wear of the wheels by the brakes, the locomotives were equipped with track brakes in addition to the standard wheel brakes. Three locomotives are in use and a switching system has been installed, so that two locomotives can travel back and forth, each making about 10 trips during the day. Owing to the mountainous country, it was necessary to instal the power station at the end of the line.

Cable Interruptions.

	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910
Bonny—Duala	Aug. 3, 1910
Cape St. James—Deson	Aug. 23, 1910

A.C. Motors in New Axle Mill at Gary.—The "Electrical World" states that, following the practice initiated with the design of the new 14 in. and 18 in. merchant mills of the Indiana Steel Co. at Gary, Ind., which employ alternating-current motors throughout, the axle mill now nearing completion shares with them the distinction of having no direct-current lines entering the building except a single pair of wires conveying energy for the electric lifting magnets. These are used for lifting the steel billets from cars and placing them on the platforms of the re-heating furnaces. The main rolls are driven by a 500 H.P. 6,600-volt three-phase 25-cycle induction motor, running at 260 revs. per min., which is controlled from a contactor panel employing alternating-current auxiliary circuits of 220 volts. A number of 25 H.P. and 50 H.P. motors, used to control and raise the tables, conveying rolls, transfers, cut-off saws, &c., are also supplied from the 220-volt secondaries of the mill transformers, a transmission voltage of 6,600 being employed about the plant. At the Gary axle mill the process of shaping the axles by the rolls is carried further than at any other plant, requiring less subsequent work in finishing the axles by means of the steam hammers. In the rolls each billet is reduced to practically a round section twice the length of a car axle. Heretofore it has been the practice to attempt only a rough shaping by the rolls. All the crane and hoist motors in this mill are of the alternating-current type.

The Scattering of Homogeneous β-Rays and the Number of Electrons in the Atom.—In a Paper on this subject read recently before the Royal Society, Mr. J. A. Crowther showed that the scattering of a homogeneous pencil of β-rays had been measured for various substances and for rays of different velocity. It had been shown to obey the following laws: For rays of given velocity the intensity I of the radiation contained within a given cone may be expressed by the equation $I/I_0 = 1 - e^{-kt}$, where t is the thickness of material and k a constant depending upon the angle of the cone. For rays of given velocity the most probable angle of emergency was proportional to the square root of the thickness of material traversed by the rays. For rays of different velocities the probable angle of emergence divided by the square root of the thickness traversed was inversely proportional to the product of the mass of the incident β-particle into the square of its velocity. From equations given by Sir J. J. Thomson the number of electrons contained in atoms of different elements was deduced. It was thus found: That the ratio of the number of electrons per atom to the atomic weight was constant, the ratio being very nearly 3·0 for all the elements examined; that the positive electricity within the atom was not in an electronic condition, but was distributed fairly uniformly over the space occupied by the atom. Experiments were also described on the absorption of homogeneous β-rays. It was shown that the first stage in the absorption of a pencil of homogeneous β-rays consisted in the scattering of the rays according to the laws already considered. The absorption of the completely scattered radiation was then shown to take place according to an exponential law.

New Telephone Exchange at Willesden.—A new telephone exchange will be opened on Saturday next by the Post Office in the metropolitan area at Willesden. Its present capacity is 2,700 lines, with facilities for an increase to 8,100 lines. The general equipment, which has been provided by the Peel Conner Telephone Works (Ltd.), is on exactly similar lines to that of the new Glasgow telephone exchange, which we have recently described. It is interesting to note that the exchange is the first in the London area to employ a 40-volt common battery, as distinct from the more usual 22-volt battery. Provision has been made for 208 incoming junctions, 240 outgoing junctions and 40 incoming order wires. The subscribers' board is divided into six eight-panel sections with nine-panel multiples, there being three operator's positions for each section. All the cables which enter the exchange are underground, and are brought into the building by way of the basement, where the junctions between the paper insulated and the silk and cotton cables are made in the usual way. The bulk of the equipment is on the ground floor, and includes

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the main frame, intermediate distribution frames, wire chief's desk, and relay and condenser racks. The power plant, which has been provided by the General Electric Co., is on the same floor, together with a battery of E.P.S. cells. The switch-room is on the first floor where ample provision for natural lighting is made.

Electric Shock.—At the recent meeting of the British Medical Association Dr. S. Jellinek, of Vienna, read a Paper on "Disorders and Death following Electric Shock." He said that, while in some cases fatal accidents had been brought about by shocks at 100 volts, in other cases, in which the voltage had been 1,000, and even 10,000, recovery had ensued. In order to understand a matter so seemingly inconsistent, it should be kept in mind that the danger of an electric current depended on circumstances which might be placed in the following two categories: 1. The external: (*a*) voltage, (*b*) amperage, (*c*) number of poles, (*d*) the time of contact, and (*e*) the kind of current (continuous or alternating). The continuous current appeared to be more dangerous than the alternating. 2. The individual: (*a*) the resistance of skin and body, (*b*) the way, or the path, of the current through the body and over the surface of the skin, and (*c*) the condition of mind and body. With regard to section (*a*) of the second category, the resistance of the skin played a very important rôle, and not only the resistance of entrance, but also that of exit for the current. As to section (*b*), Dr. Jellinek said that the failure of American electrocution was most probably due to causes connected with the management of the poles, which were much moistened, a great part of the current passing over the surface of the skin, and thus not coming in contact with the organs of sensibility—the brain, the heart, &c. Under section (*c*) there was, he said, an enormous difference between the touching of a current intentionally (the mind being prepared and ready for the shock) and doing it accidentally, in the latter case the shock being liable to produce an inhibition of the functions of important organs. Electricity which passed into the body had, he said, two actions—a psychological action and a material actiont on the cells of the brain through the microscopical vessels of the brain, the spinal cord, the heart, &c. The result of both these actions might be either disease or death. The clinical symptoms emanated from various organs—unconsciousness, spasm, paralysis, hæmorrhage of the kidneys, degeneration of nerves, &c. The alteration of the skin (local lesions) sometimes took the form of genuine burnings and sometimes of so-called specific electric changes, which pathologically and clinically were quite different in character from other wounds. It was important to know that genuine electric lesions were painless. With regard to the mechanism of death by electricity there was no definite scheme or model. In most cases it seemed like suspended animation. It was an interesting fact that there was between electric shock and death an interim of a few seconds in which the stricken person appeared to be in quite a normal state. By experiments on dogs in the physiological institute of Prof. von Tschermak it had been discovered that the irritability of the brain, which had subsided immediately after a shock, had a few seconds later become re-established, and everything then depended upon whether the action of the heart would be continued or not. As there were sometimes hæmorrhages in the brain, and as the pressure of the cerebro-spinal liquid was increased, it was necessary and important in cases of first aid to lay the patient with the head elevated.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Dr. W. H. Eccles contributes an article on "Recent Patents in Wireless Telegraphy."

We conclude our description of the new Post Office telephone exchange at Glasgow.

Mr. D. Owen contributes an article on "Rutherford's Work on the α-Particle."

At the meeting of the British Association at Sheffield yesterday the presidential addresses to the various sections were delivered. We give an abstract of Prof. W. E. Dalby's address to Section G (Engineering) and of Prof. E. W. Hobson's address to Section A (Mathematical and Physical Science).

Mr. M. Longridge, chief engineer of the British Engine, Boiler & Electrical Insurance Co., has issued his annual report dealing with the breakdowns of machinery. Considerable improvement is recorded in the reliability of electrical apparatus.

In our correspondence columns Mr. P. A. Mossay describes a new system of railless traction.

Sir Joseph Ward, Prime Minister of New Zealand, recently announced that it was the intention of the Government to control the whole of the powers for utilising water power throughout New Zealand.

An interesting consular report on how to develop trade with Russia is abstracted in another column.

It is evident that the recent fire at the Brussels Exhibition was not caused electrically, since the electrical supply in the buildings where the fire started had been cut off for some hours previous to the outbreak.

We analyse the accounts for the year ended March 31 last of the Bolton Corporation electricity department.

Particulars of an important Indian hydro-electric scheme are given on another page.

Brighton Council are recommended to renew the piping of the condenser circulating system at Southwick electricity works, at a cost of about £1,800. This renewal is necessitated by mussel spawn and other marine growths having got through the strainer and attached themselves to the inner surfaces of the pipes. The timber piling of the wharf is also to be replaced by reinforced concrete.

Bradford Tramways Committee have appointed a sub-committee to superintend the construction of a route on the railless trolley system.

Plymouth Tramways committee are considering a report on the advisability of equipping a route on the railless trolley system.

An abstract of the report of the New Zealand Post and Telegraph Department for 1909-10 appears in another column.

An interesting report is issued by Glasgow Electricity Department on the result of the past year's operations to May 31st. A surplus of £191 compares with a deficit last year of £3,545.

Loans for Electricity Undertakings.—Bispham Council have applied for sanction to a loan of £9,855 for electricity supply.

Companies' Meetings and Reports.—At the meeting of the Mersey Railway Co. last week the chairman announced that the electrification of their line had enabled them to increase the number of passengers carried by 120 per cent. and the receipts by 85 per cent. The line was making steady progress.

INSTITUTIONS AND SOCIETIES.

University of Sheffield.—On the occasion of the meeting of the British Association a special degree congregation of the University will be held at which the following honorary degrees will be conferred:

Doctor of Science.—Mr. W. Bateson, F.R.S., the Rev. Prof. T. G. Bonney, F.R.S., Sir W. Crookes, F.R.S., Mr. F. Darwin, F.R.S., Prof. T. W. Rhys Davids, Sir A. Geikie, P.R.S., Prof. E. W. Hobson, F.R.S., Sir O. Lodge, F.R.S., Sir N. Lockyer, F.R.S., Dr. H. A. Miers, F.R.S., Sir W. Ramsay, F.R.S., Prof. C. S. Sherrington, F.R.S., and Sir J. J. Thomson, F.R.S.

Doctor of Engineering.—Sir J. Jonas, Sir W. H. White, F.R.S.

Doctor of Metallurgy.—Mr. J. E. Stead, F.R.S.

Doctor of Laws.—The Lord Mayor of Sheffield (Lord Fitzwilliam).

Tramways and Light Railways Association.—The "Official Circular" of this Association for August contains a reproduction of the settlement arrived at with the Board of Inland Revenue in 1909 in regard to allowances for depreciation for assessment of income tax, an official list of the returns available in regard to the exercise of the powers conferred by light railway orders since the passing of the act of 1896, and a list of the results obtained in regard to bills relating to tramways promoted during the current year.

Municipal Tramways Association.—The annual conference of this Association will take place at Bradford from September 21st to 23rd.

ARRANGEMENTS FOR THE WEEK.

BRITISH ASSOCIATION.

FRIDAY, September 2nd (To-day) to WEDNESDAY, September 7th.
Meeting at Sheffield.

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BOLTON CORPORATION ELECTRICITY SUPPLY ACCOUNTS.

In analysing the accounts of the Bolton Corporation electricity department a year ago we had to record a set-back in the output of electrical energy. This decrease was due to trade depression and the use of metal filament lamps, the sales of energy for both lighting and power being smaller than in the previous year. On the present occasion, however, we are pleased to see that the steady expansion which has usually marked this undertaking has been resumed, the number of units sold during the year ended March 31, 1910, amounting to 11,993,271, compared with 10,677,764 last year and 10,791,105 in 1907-8. The most satisfactory feature of the expansion is that an increase is recorded in the sales of energy for all purposes; thus, private lighting shows an increase of 3·6 per cent., power 22 per cent. and traction 4·1 per cent.

The Bolton electricity undertaking has of recent years been noteworthy for its low costs of generation and its low charges for power supply. A large proportion, moreover, of the output of the undertaking now goes to meet the requirements of power users, 6,013,928 units, or over 50 per cent. of the total output, being sold for private motors and 4,352,208 units, or 36 per cent., to the tramway department. When it is mentioned that the average price received from power users was only 0·812d. per unit (0·85d. a year ago), whilst lighting consumers obtained their energy at an average price of 2·75d. per unit (2·81d. a year ago), it is evident that cheap power supply by no means implies penalising lighting and other consumers. It is noteworthy that, although the average price received for the total output was only 1·18d. per unit (after deducting discounts), a sum of £6,500 was handed over to the district funds in aid of the rates, after £4,664 had been set aside for renewals.

It need scarcely be remarked that such a result is only possible by careful attention to the cost of generation and distribution and to capital expenditure. As will be seen from our analysis of the accounts below, the total costs (excluding capital charges) were 0·56d. per unit, whilst capital charges amounted to 0·46d. per unit, the inclusive cost, therefore, being 1·02d., as against 1·07d. last year.

In regard to the growth of the undertaking, 185 new consumers were connected to the mains during the past 12 months, bringing the total number of consumers to 2,628. The motor load has increased during the same period by about 800 H.P., representing 99 motors installed by 25 new consumers. The total power load on March 31st last was 915 motors of 10,017 H.P. aggregate. The length of mains laid has also been increased by 9,700 yds. during the year, so that the department has been by no means inactive.

We notice that the number of units unaccounted for has considerably increased—viz., 1,288,851 units, as against 977,045 last year. This represents for the year ended March 31st last 9·04 per cent. of the total energy generated, compared with 7·85 per cent. in 1908-9 and 7·33 per cent. in 1907-8.

The plant capacity remains unchanged—viz., 7,600 kw.—the maximum load recorded during 1909-10 being 5,941 kw., compared with 4,925 kw. in the year 1908-9. The load factor continues to decrease, being now only 23·1 per cent., as against 24·75 per cent. a year ago and 27·35 per cent. in 1907-8.

We give below an analysis of the expenditure and revenue for the year ended March 31st last, together with the cost per unit sold, the latter figure for the year 1908-9 being given for the sake of comparison.

Generating Costs.		Cost per unit sold. 1909-10.	1908-9.
Fuel	£12,500	0·25d.	0·26d.
Oil, waste, stores, &c.	990	0·02d.	0·02d.
Salaries and wages at station	3,549	0·07d.	0·08d.
Repairs and maintenance	3,753	0·08d.	0·09d.
Total Generating Costs	£20,792	0·42d.	0·45d.
Distribution Costs.			
Wages	£352	0·01d.	0·03d.
Repairs and maintenance of mains, meters, motors, &c.	693	0·01d.	
Meters and motors purchased out of revenue	1,335	0·03d.	
Total Distribution Costs	£2,380	0·05d.	0·03d.
Management Costs			
Salaries	£1,292	0·03d.	0·03d.
Printing, stationery, &c.	96	0·00d.	0·00d.
Insurances	54	0·00d.	0·00d.
Miscellaneous	331	0·00d.	0·01d.
Total Management Costs	£1,773	0·03d.	0·04d.
Rents, rates and taxes	£3,140	0·06d.	0·07d.
TOTAL COSTS (ex capital charges)	£28,085	0·56d.	0·59d.
Capital Charges.			
Interest	£8,563	0·17d.	0·19d.
Sinking fund	14,584	0·29d.	0·29d.
Total Capital Charges	£23,147	0·46d.	0·48d.
TOTAL COSTS (inc. capital charges)	**£51,232**	**1·02d.**	**1·07d.**
Depreciation	4,664	0·09d.	0·13d
Special, written off mains	356	0·01d.	—
Work executed for customers and goods for sale	11,888	0·24d.	0·14d.
TOTAL EXPENDITURE	**£68,140**	**1·36d.**	**1·34d.**
Revenue.			
Sale of current	£62,730	1·25d.	1·33d.
Meter and motor rentals	1,604	0·03d.	0·03d.
Work executed for customers and goods sold	13,051	0·26d.	0·20d.
Less discounts, &c.	3,806	0·07d.	0·09d.
TOTAL REVENUE	**£73,579**	**1·47d.**	**1·47d.**
Balance	£5,439	0·11d.	0·13d.

To this balance of £5,439 is added £2,680 brought forward from April 1, 1909, making a total of £8,119, from which £1,000 is written off for the Duncan-street sub-station, £6,500 handed over to the relief of the rates, and the balance of £619 carried forward to next year's accounts.

During the 12 months the capital expenditure has been augmented by £8,110, and now amounts to £359,690. In the following table we give the total amounts expended on the various sections of the plant, together with the cost per kilowatt installed.

	Total.	Per kw. installed.
Land	£4,709	£0·6
Buildings	46,628	6·1
Machinery	148,396	19·5
Mains	109,505	14·4
Motors	13,428	1·8
Transformers	9,305	1·2
Meters	13,747	1·8
Instruments	443	0·1
Well sinking	2,124	0·3
	£348,285	£45·8

PROF. DALBY'S ADDRESS TO SECTION G OF THE BRITISH ASSOCIATION.*

The author calls attention to the large part that railways play in our national life, and figures and curves are given to show the development in capital, length of track, number of passengers carried, &c., between the years 1850 and 1909. In 1908 the total paid-up capital was 1,310 millions sterling, 38 per cent. of this being ordinary stock. Gross receipts were 120 millions of pounds and net revenue 43½ millions. At the end of 1908 there were 23,205 miles of line open, corresponding to 53,669 miles of single track, including sidings. Of this, 85 per cent. was standard 4 ft. 8½ in. gauge, 12·3 per cent. 5 ft. 3 in., and 2·2 per cent. 3 ft. gauge. The remainder was made up of small mileages of 1 ft. 11½ in., 2 ft. 3 in., 2 ft. 4 in., 2 ft. 4½ in., 2 ft., 2 ft. 9 in., 4 ft. and 4 ft. 6 in. gauges.

* Abstract of the Presidential Address delivered by Prof. W. E. Dalby, M.A., at Sheffield yesterday.

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Curves showing mileage, passengers carried and goods carried increase regularly with the increase of capital, indicating that up to the present time the possibility of remunerative return on capital invested in railway enterprise in this country is not exhausted. In 1908 the railways of the United Kingdom carried 1,278 millions of passengers, exclusive of season-ticket holders, and 491 million tons of goods. It is curious that very approximately the companies carry per annum one passenger and about 0·4 ton of goods for every pound sterling of paid-up capital.

Fig. 1 indicates the cost of working the traffic calculated in terms of the train-mile, no data being available regarding the actual work done as represented by the ton-mile or the passenger-mile. In some respects the train-mile is the fairest way of comparing costs, because when a train is running, whether it is full or empty, the same service must be performed by the majority of the departments. The curves bring out clearly that the proportion of the total expenditure per train-mile absorbed by these several services remains fairly constant over a series of years. To the right is exhibited the average for the four years 1905 to 1908. Locomotive power absorbs an amount about equal to the traffic expenses; and companies actually pay in rates and taxes a sum nearly equal to the whole amount required to maintain the rolling-stock in an efficient state. To the right is shown a scale the divisions of which represent an amount estimated in pence per train-mile corresponding to 1 per cent. of the average dividend. This shows that if the whole of the locomotive power could be obtained for nothing, the average dividend would only be increased

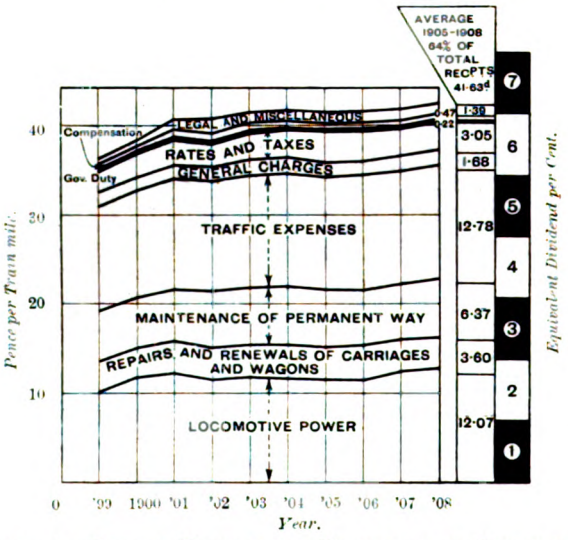

FIG. 1.—COST OF WORKING PER TRAIN-MILE OF RAILWAYS IN ENGLAND AND WALES.

by 1¾ per cent. Reckoned on the ordinary stock alone, however, the increase would be about three times this amount.

The author next compares the financial position and the cost of the working of railways in their earlier days with the state of things now. For this purpose the position of the old London & Birmingham Railway is compared with the position of the London & North Western Railway, the system into which it has grown. The years selected are 1840 and 1908. The comparison brings out some curious facts. For instance, the gross receipts of the London & North Western Railway in 1908 were 22½ times as much as those of the London & Birmingham Railway in 1840, and the track mileage open was about 22 times as great. The money earned per mile of track open is thus practically the same after a lapse of 70 years. To earn the same amount per mile of track open, however, the trains of the London & North Western Railway had in 1908 to run 68·3 times the number of train-miles that the trains of the London & Birmingham Railway ran in 1840. That is to say, in order to earn a sovereign a London & North Western train has now to run three times the distance which it was necessary for a London & Birmingham train to run to earn the same amount.

Another point to notice is that although the mileage and the receipts per mile of track open have each increased in the same proportion, yet the capital has increased at a greater rate, being on the total amount 24 times as much as in 1840, and the stock and share capital has increased 28 times. So that with the necessity of running three times the train-mileage to obtain the same return per mile of track open there is the obligation to pay interest on an ordinary stock which has been increased in a greater proportion than the mileage and in a greater proportion than the earning power of the line. Lower dividends are, therefore, inevitable. The cost of working per train-mile has decreased gradually to about half its value in 1840, but at the same time the receipts per train-mile have dwindled to one-third of the amount in 1840. These figures show that a more conservative system of financing the railways might have been adopted in the earlier days with advantage. If when the receipts per train-mile were larger, a proportion of the revenue had been used annually for the construction of new works and for the provision of new rolling-stock instead of raising fresh capital for everything in the nature of an addition to the railway, the companies would to-day have been in a position to regard with equanimity the increasing cost of working. It is too late in the day to recover such a strong financial position, but even now on many lines a larger proportion of the revenue could be sunk in the line with great ultimate advantage to the financial position.

Locomotive Problems.—During the last 20 years the demand on the locomotive has steadily increased. The demand has been met, though with increasing difficulty, owing to the constructive limitations imposed by the gauge. An accurate estimate of the rate at which work must be done to run a stated service can only be made if there are given the weight of the vehicles in the train, the weight of the engine, the kind of stock composing the train, the speed and acceleration required at each point of the journey and a section of the road; and, in addition to this, allowance must be made for weather conditions.

A general idea of the problem can, however, be obtained by omitting the consideration of acceleration, gradients and the unknown factor of weather conditions, considering only the rate at which work

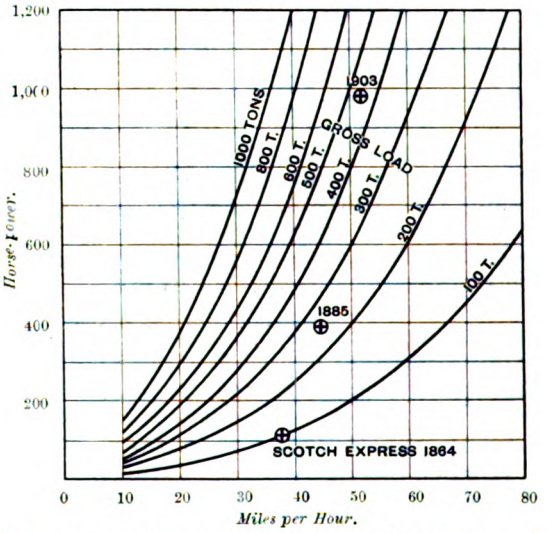

FIG. 2.—POWER REQUIRED TO MAINTAIN SPEED ON THE LEVEL.

must be done to draw a given load at a given speed on the level. Even thus simplified the problem can be solved only approximately because, although the tractive resistance of a train as a whole is a function of the speed, the tractive resistance per ton of load of the vehicles and per ton of load of the engine differ both in absolute value and in their rates of change for a stated speed, and, further, the ratio between the weight of the vehicles and the weight of the engine is a very variable quantity. For our purpose, however, it will be sufficiently accurate to assume that the resistance of the whole train, expressed in pounds per ton, is given by the formula $T = 5\frac{1}{3} + V^2/256$. It follows that the horse-power which must be developed at the driving-wheels to maintain a speed of V miles per hour on the level with a train weighing W tons is

$$HP = W\left(\frac{V}{70} + \frac{V^3}{96{,}000}\right).$$

Fig. 2 shows curves of horse-power plotted from this equation for various weights of trains. From this diagram a glimpse of the problem confronting locomotive engineers at the present day can readily be obtained. To illustrate the point, consider the case of the Scotch express on the West Coast route. Three specific examples are plotted on the diagram, showing the power requirements in 1864, 1885 and 1903 for this train. Typical trains in 1864, 1885 and 1903 weighed, including engine and tender, 100 tons, 250 tons and 450 tons respectively. The average speeds were 38, 45 and 52 miles per hour respectively. A glance at the diagram will show that the power required to work this train was about 100 H.P. in 1864, 400 H.P. in 1885 and 1,000 H.P. in 1903. Moreover, the increase in the weight of the train does not mean a proportionate increase in the paying load. Far from it. In 1903 an average of 1·4 tons of dead load had to be hauled

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by the engine per passenger, assuming the train to be full. In the days before corridor stock and dining cars were invented the dead load to be hauled was about a quarter of a ton per passenger for a full train. Notwithstanding the increase in the dead load of luxurious accommodation, the fares are now less than in former days on corresponding services. Similar developments have taken place in almost every important service, and new express services are all characterised by heavy trains and high speeds.

Characteristic Energy-curves of Steam Locomotives.—This steadily increasing demand for power necessarily directs attention to the problem, What is the maximum power which can be obtained from a locomotive within the limits of the construction-gauge obtaining on British railways? The answer to this can be found without much ambiguity from a diagram which I have devised consisting of a set of typical characteristic energy-curves to represent the transference and transformation of energy in a steam locomotive, an example of which is given in Fig. 3. While examining the records of a large number of locomotive trials, I discovered that if the indicated horse-power be plotted against the rate at which heat energy is transferred across the boiler-heating surface the points fall within a straight line region, providing that the regulator is always full open and that the power is regulated by means of the reversing-lever, that is to say, by varying the cut-off in the cylinders. It is assumed at the same time, of course, that the boiler-pressure is maintained constant.

In Fig. 3 the horizontal scale represents the number of British thermal units transferred across the boiler-heating surface per minute. This quantity is used as an independent variable. Plotted

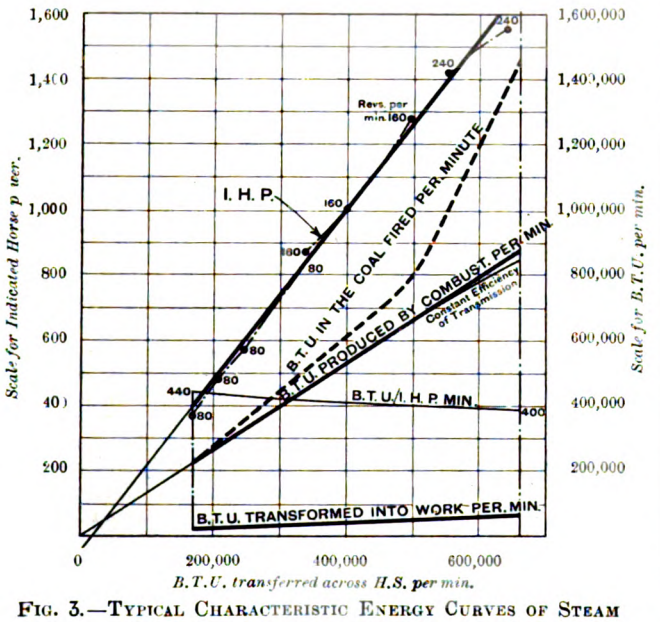

FIG. 3.—TYPICAL CHARACTERISTIC ENERGY CURVES OF STEAM LOCOMOTIVES.

vertically are corresponding horse-powers, each experiment being shown by a black dot on the diagram. The small figures against the dots denote the speed in revolutions of the crank-axle per minute. Experiments at the same speed are linked by a faint chain dotted line. A glance at the diagram will show at once how nearly all the experiments fall on a straight line, notwithstanding the wide range of speed and power.

The ordinates of the dotted curve just below the indicated-horse-power curve represent the heat energy in the coal shovelled per minute into the fire-box—that is, the rate at which energy is supplied to the locomotive. The thick line immediately beneath it represents the energy produced by combustion. The vertical distance between these two curves represents energy unproduced, but energy which might have been produced under more favourable conditions of combustion. Some of the unproduced energy passes out of the chimney-top in carbon monoxide gas, but the greater portion is found in the partially consumed particles of fuel thrown out at the chimney-top in consequence of the fierce draught which must be used to burn the coal in sufficient quantity to produce energy at the rate required. The rate of combustion is measured by the number of pounds of fuel burnt per square foot of grate per hour. In land practice with natural draft 20 lb. of coal per square foot of grate per hour is a maximum rate. In a locomotive the rate sometimes reaches 150 lb. per square foot per hour. In the diagram shown the maximum rate is about 120 lb. per square foot, and the dotted curve begins to turn upwards at about 70 lb. per square foot per hour. The vertical distance between the curves shows what has to be paid for high rates of combustion.

I found that in almost every case the curve representing the energy actually produced by combustion differed very little from a straight line, passing through the origin, showing that at all rates of working the efficiency of transmission is approximately constant. That is to say, the proportion of the heat energy actually produced by combustion in the fire-box which passes across the boiler-heating surface per minute is nearly constant and is therefore independent of the rate of working. The lowest curve on the diagram represents the rate at which heat energy is transformed into mechanical energy in the cylinders of the locomotive. It seems a small rate in proportion to the rate at which heat energy is supplied to the fire-box, but it is not really so bad as it looks, because the engine actually transformed 60 per cent. of the energy which would have been transformed by a perfect engine working on the Rankine cycle between the same limits of pressure. The engine efficiency is represented in a familiar way by a curve labelled "B.T.H. per indicated-horse-power minute." It will be seen that the change of efficiency is small, notwithstanding large changes in the indicated horse-power.

The diagram indicates that the indicated-horse-power is practically proportional to the rate at which heat is transferred across the boiler heating surface, and as this is again proportional to the extent of the heating-surface, the limit of economical power is reached when the dimensions of the boiler have reached the limits of the construction-gauge, the boiler being provided with a fire-grate of such size that, at maximum rate of working, the rate of combustion falls between 70 lb. and 100 lb. of coal per square foot of grate per hour. A boiler of large heating-surface may be made with a small grate necessitating a high rate of combustion to obtain the required rate of heat-production. Then, although a large power may be obtained, it will not be obtained economically.

Returning now to the consideration of the type of locomotive required for a local service with frequent stops, the problem is to provide an engine which will get into its stride in the least time consistent with the comfort of the passengers. The average speed of a locomotive on local service is low. The greater part of the time is occupied in reaching the journey speed, and the brake must then often be applied for a stop a few minutes after the speed has been attained. In some cases the stations are so close together that there is no period between acceleration and retardation. Without going into the details of the calculation I may say that to start from rest a train weighing, including the engine, 300 tons, and to attain a speed of 30 miles per hour in 30 seconds requires about 1,350 I.H.P. During the period of acceleration the engine must exert an average tractive pull of nearly 15 tons. Mr. James Holden, until recently locomotive engineer of the Great Eastern Railway, built an engine to produce an acceleration of 30 miles per hour in 30 seconds with a gross load of 300 tons. The engine weighed 78 tons and was supported on 10 coupled wheels each 4 ft. 6 in. diameter. There were three high-pressure cylinders, each 18½ in. diameter and 24 in. stroke. A boiler was provided with 3,000 sq. ft. of heating surface and a grate of 42 sq. ft. area. Boiler pressure, 200 lb. per square inch. This engine practically reached the limit of the construction-gauge.

An acceleration of 30 miles per hour in 30 seconds is considerably below what may be applied to a passenger without fear of complaint. But it is clear that it is just about as much as a locomotive can do with a train of reasonable weight. Even with a gross load of 300 tons nearly one-third of it is concentrated in the locomotive, leaving only 200 tons to carry paying load. The problem of quick acceleration cannot therefore be properly solved by means of a steam locomotive. But with electric traction the limitations imposed on the locomotive by the construction-gauge and by the strength of the permanent way are swept away. The equivalent of the boiler power of a dozen locomotives can be instantaneously applied to the wheels of the electric train, and every axle in the train may become a driving axle. Thus the whole weight of the stock, including the paying load, may be utilised for tractive purposes. The problem of quick acceleration is therefore completely solved by the electric motor.

Electric Railways.—December 18, 1890, is memorable in the history of railway enterprise in this country, for on that date the City & South London Railway was opened for traffic, and the trains were worked entirely by electricity, although the original intention was to use the endless cable system of haulage. Since that epoch-marking year electric traction on the railways of this country has made a gradual if somewhat slower extension than anticipated. But electrically operated trains have in one branch of railway working beaten the steam locomotive out of the field and now reign supreme—that is in cases, as indicated above, where a quick frequent serivce is required over a somewhat short length of road. The superiority of the motor over the steam locomotive, apart from questions of cleanliness, convenience and comfort, lies in the fact that more power

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can be conveyed to the train and can be utilised by the motors for the purpose of acceleration than could possibly be supplied by the largest locomotive which could be constructed within the limits of the construction gauge. There are many other considerations, but this one is fundamental and determines the issue in many cases.

The author next gives a few statistics relating to the present state of electric railways in the United Kingdom, and refers to the "Tables of Electric Lighting, Power and Traction Undertakings of the United Kingdom" published annually by THE ELECTRICIAN.

The total number of passengers carried (exclusive of season tickets) on the 138 miles of electrical track during the year 1908 was nearly 342 millions, being roughly one-third of the total number of passengers carried on all the railways of England and Wales during the same period. The average cost of working this traffic is 22·3d. per train-mile. This figure includes the service of the lifts, which is presumably returned with the traffic expenses. The cost is made up as follows for the year 1908:—

	Pence per train-mile.
Locomotive power	8·40
Repairs and renewals of carriages and wagons	1·50
Maintenance of permanent way	2·40
Traffic expenses	5·22
General charges	1·52
Rates and taxes	2·36
Government duty	0·088
Compensation	0·116
Legal and miscellaneous	0·75
Total	22·35

The corresponding total receipts were 38·65d. per train-mile. The working expenses are thus 58 per cent. of the total receipts. Comparing this with the diagram given above for the whole of the lines in England and Wales, it will be seen that the cost for locomotive power on the electric railways appears to be about two-thirds of the cost on steam lines per mile run, the cost for repairs and renewals of carriages and wagons about one-half and the cost for traffic expenses about one-half. The two kinds of working are, however, not strictly comparable, as all the conditions of traffic in the two cases are different and the length of the electric lines is relatively so small that the problems which arise out of the transmission of electric power over long distances are excluded. The traffic expenses and the cost of repairs and renewals of carriages and wagons, general charges &c., are practically inedpendent of the kind of power used for locomotive purposes, and, moreover, the difference in weight of electric trains and the steam-hauled trains is on the average so great that no comparison can be instituted without ton-mile statistics.

With two exceptions the method of working the electrified lines of this country is in the main the same. A third conductor rail is laid on insulators fixed to the ordinary track sleepers, and is maintained throughout the whole of its length at as nearly as possible a pressure of 600 volts, except in a few cases where the pressure is 500 or 550 volts.

In 1908 the Midland Railway Co. opened for traffic the single-phase electrified line connecting Lancaster, Morecambe and Heysham, the method of electrification being a departure from the general practice hitherto applied to electrified lines in this country. The traffic conditions on this line are simple. In December, 1909, the electrified portion of the London, Brighton & South Coast Railway was opened for traffic. This work marks an epoch in the history of electric traction in England. For the first time the single-phase system was applied to meet the exacting traffic conditions of a London suburban service where the main condition is that the trains should be accelerated rapidly. The system has shown that it can meet all the conditions of the service perfectly. The results of this electrification will be of unusual interest because not only has the method applied shown itself to be quite suitable for dealing with a stopping traffic where quick acceleration is the dominating condition, but it contains the germ of practicable long-distance electrification. The near future may see the extension of the system to the line between London and Brighton, giving a frequent non-stop service which would bring Brighton in point of time nearer than the suburbs on opposite sides of London are to one another.

Power Signalling.—During the last 10 years a considerable number of trial installations of power-signalling apparatus have been made by the railway companies of this country. The electric lines have generally adopted power signalling, and the District Railway has installed a complete system on all its lines and branches. The term "power signalling" is applied to any equipment in which the actual movements of the points and signals are done by power, the signalman's work being thus reduced to the movement of small light control levers or switches. Of the several systems tried and proposed three bulk largest in the equipments applied in this country—namely, the all-electric, the low-pressure pneumatic and the electro-pneumatic systems.

The "all-electric" system is represented by installations of the McKenzie-Holland and Westinghouse system on the Metropolitan and Great Western Railways, by installations of the "Crewe" system on the London & North Western Railway, and by installations of Siemens Bros. on the Great Western Railway. The general feature of the all-electric system is that the points are operated by motors sunk in a pit by the side of the rails, the signals are pulled off electrically, and all the apparatus is controlled electrically.

The low-pressure pneumatic system is represented by installations on the London & South Western Railway and the Great Central Railway. The points and signal arms are moved by air compressed to about 20 lb. per square inch, and led to cylinders connected to the points and to the signal arms. The control is also done by means of compressed air, small pipes leading from each air-cylinder to the cabin.

The electro-pneumatic system has found most favour in this country up to the present time. The equipment installed includes such notable stations as the Central at Newcastle with 494 levers, and the Glasgow Central with 374 levers, and the whole of the Metropolitan District system of underground railways. In this system an air-cylinder is connected to each set of points and to each signal-arm. Air compressed to 65 lb. per square inch is supplied to the cylinders from a main running alongside the railway kept charged by small air-compressors placed at convenient intervals. Each air cylinder is provided with a small three-way air-valve operated by an electro-magnet. The movement of each air-valve is controlled electrically from the cabin through the electromagnet associated with it.

The obvious advantage of power signalling is the large reduction of physical labour required from the signalman. His energy can be utilised in thinking about the traffic movements rather than in hauling all day at signal levers. One man at a power frame can do the work of three at the ordinary frame. The claims made for power signalling in addition to the obvious advantage of the reduction of labour, are briefly that the volume of traffic which can be dealt with is largely increased, that the area of ground required for the installation is considerably less than with the ordinary system, with its rodding, bell-crank levers, chains and pulleys, and that where the conditions are such that power signalling is justified the maintenance cost is less than with a corresponding system of normal equipment.

Automatic Signalling.—Several of the power-signalling installations are automatic in the sense that between signal cabins on stretches of line where there are no junctions or cross-over roads requiring the movement of points, the movement of the signal-arm protecting a section is determined by the passage of the train itself. The most important equipment of this kind is that installed on the group of railways forming the "Underground" system. This includes the District Railway with all its branches. On this line the particular system installed is the electro-pneumatic, modified to be automatic except at junctions. Signal cabins are placed only at junctions and at places where points require to be operated. The contrivance by means of which the train acts as its own signalman is briefly as follows. One rail of the running track is bonded, and is connected to the positive pole of a battery or generator. The opposite rail is divided into sections, each about 300 yds. long, bonded, but insulated at each end from the rails of the adjacent sections and each section is connected to a common negative main through a resistance. A relay is placed at the beginning and at the end of each section, and is connected across from the positive to the negative rail. Current flows and energises the relay, in which condition the relay completes a circuit to the electromagnet operating the admission valve of the air cylinder on the signal post, the air is admitted, and the signal arm is held off. This is the normal condition at each end of the circuit. When a train enters a section it short-circuits the relays through the wheels and axles, in consequence of which the relays, de-energised, break the circuit to the admission valve, which closes and allows the air in the cylinder to escape, and the signal arm, moved by gravity alone, assumes the "on" or danger position. At the same time the short-circuit is removed from the section behind, directly the train leaves it, the relays are at once energised, the admission valve to the air-cylinder on the protecting post of the section is opened, air enters and the signal is pulled down to the "off" position.

The speed at which traffic can be operated by this system of power signalling is remarkable. At Earl's Court junction box 40 trains an hour can be passed each way—that is 80 per hour—handled by the one signalman in the box. As the train approaches the box both its approach to the section and its destination must be notified to the signalman. When it is remembered that with ordinary signalling, to take an express train for example, a signalman hears some 24 beats on the gongs in his box, and sends signals to the front and rear box which give altogether some 24 beats on the gongs in these two boxes, 48 definite signals in all, for every express train he passes into the section which his signals protect, it will be understood that the

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system must be profoundly modified to admit such a speed of operation as 80 trains per hour per man. The modification is radical. No gong signals are used at all. There is a small cast-iron box standing opposite the signalman with 15 small windows in it, each about 1½ in. square. Normally each window frames a white background. A click in the box announces the approach of a train, and a tablet appears in one of the empty windows showing by code the destination of the train. The signalman presses a plug in the box, a click is heard, and a tablet is seen in a precisely similar apparatus in the next box. When the train passes the man presses another plug and the tablet disappears.

Four wires run between the signal boxes along the railway, and by combining the currents along the four wires in various ways 15 definite signals can be obtained, a number sufficient for the District traffic. Each of the 15 combinations is arranged to operate one particular tablet in the box. Current from these four wires is tapped off at intermediate stations, and is used to work a train indicator showing the passengers assembled on the platform the destinations of the next three trains. The whole equipment is a triumph of ingenuity and engineering skill, and it is a splendid example of the way electricity may be used to improve the railway service quite apart from its main use in connection with the actual driving of the trains.

The facts and problems I have brought before you will, I think, show the important influence that scientific discovery has had upon our railway systems. When engineers endeavour to apply the results of scientific discovery they often find themselves confronted by new problems unperceived by the scientist. Together they may find a solution and thus enlarge the boundaries of knowledge and at the same time confer a practical advantage on the community. The pure scientist, the practical engineer, act and react on one another both to the advantage of pure science and to the advantage of the national welfare. The future success of our railways depends upon the closer application of scientific principle both to the economic and engineering problems involved in their working, some decrease in unprofitable competition with one another, and a more just appreciation by the State of the part railway companies play in our national well-being.

RECENT PATENTS IN WIRELESS TELEGRAPHY.*

BY W. H. ECCLES, D.SC.

We will take first the developments in methods of generating oscillations. Of these the method in which a fairly high voltage discharge takes place between metal surfaces in rapid relative motion is prominent. It may be recalled that in one of the original forms of Marconi discharger for producing a musical note, the discharge took place across a gap when it was almost bridged by copper studs carried on a rotating disc. Now types of discharger are described in which the discharge gap is formed by electrodes that move in opposite directions. Specification 17,505 (1908) shows two discs running in separate insulated bearings with their shafts in line and with their opposed flat faces rather close together. Each disc carries two symmetrically placed pegs ; and the discharge takes place across the narrow gaps between the pegs when they pass one another. It is stated that the best material for the pegs is copper—a fact fully accounted for by the high thermometric (as distinct from calorimetric) conductivity of the metal. It is also stated that in order to get the best results in producing oscillations, the time-period of the generator circuit with its choking coils must be an integral multiple of the interval between successive discharges of the primary condenser. Specification 8,581 (1909) is different from the last only in having the discs rotating in the same direction, which, no doubt, makes a better mechanical job, but there is the disadvantage that the discs must now be geared together. On the shafts of the two discs (Fig. 1) are two equal pinions gearing with an intermediate pinion in such a way that pairs of studs pass when on the line joining the centres of the discs. The discs may be rotated by a single motor driving the pinion, but it is better to use two similar motors, one driving each disc, so that the gearing transmits only half the difference of the powers of the motors at any moment. These simple improvements over the original forms of disc discharger give two benefits, first, the number of discharges per second is doubled; second, the duration of the discharge is reduced. The first means that the musical note can be more easily maintained ; the second brings more important advantages, especially if long waves are being produced. When the spark starts across the gap between two studs approaching one another, the condenser begins an oscillatory discharge. If the period of oscillation is long, comparatively speaking, the teeth separate and the spark dies down before many oscillations take place. Meanwhile the aerial coupled to the discharge circuit has been

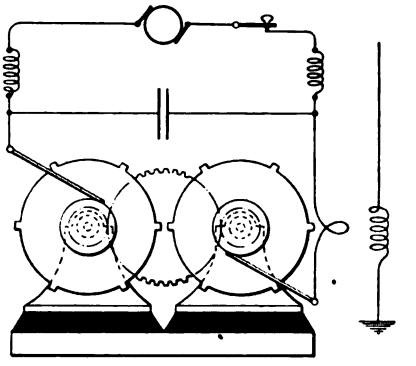

FIG. 1.—G. MARCONI, No. 8,581 (1909).

quickly urged into vibration ; and if, as is the case in the transatlantic stations, for example, the damping of the aerial by radiation (and it is to be hoped, by Joulean waste also) is small, the aerial will go on vibrating long after the the spark is finished. A rough guess at the peripheral speeds and the voltages leads one to suggest that about 25 oscillations occur before the primary is opened by the extinction of the spark—but this is a long shot. Thus this disc discharger, when used with long waves, gives the advantages of singleness of wave, very slight damping, and operation off a direct-current supply.

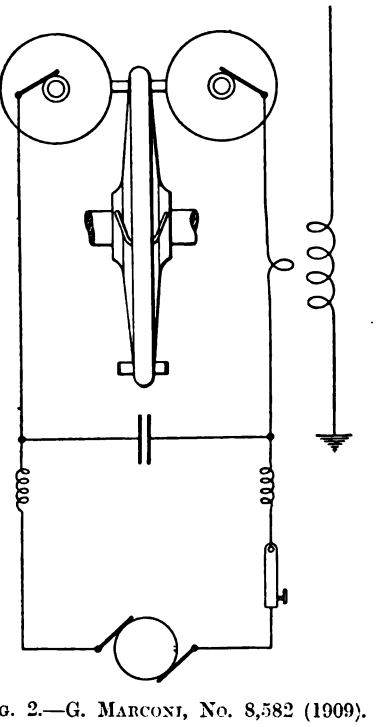

FIG. 2.—G. MARCONI, No. 8,582 (1909).

Another patent possessed by G. Marconi and Marconi's Wireless Telegraph Co. is No. 8,582 (1909) (Fig. 2). The generator is connected through inductances or resistances to a condenser, which is part of the oscillation circuit, and which is in series with the primary of the oscillation transformer. The terminals of this circuit are discs, which may be rotated to prevent burning, and the circuit is closed at regular frequent intervals by a rapidly rotating wheel that carries on its

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periphery yielding metal bridging pieces, such as studs with spring tops or studs supported on springs. It will be seen that in this mode of generating oscillations the inventor passes from the principles underlying his other generators just described, to the opposite extreme; instead of cutting short the primary vibration at the earliest possible moment, the primary vibration is encouraged by the provision of a low resistance path to persist as long as possible. The prime requirement for the success of such a method is that the process of short-circuiting the gap should take place in a time that is small compared with the period of the oscillation generated. This is not easily done, for the oscillations may start, and even finish, long before complete closure can be effected, unless the mechanical motions are exceedingly rapid or the electrical oscillations are exceedingly slow, as these things go. The specification points out that low voltages can be used; probably only very low voltages can be used, and therefore, in order to get power enough, large currents must be made and broken by the moving bridging pieces. I recall that in some old experiments of my own on generating quite feeble oscillations by a similar process, in which a toothed wheel made and broke a current under 4 volts pressure, the energy losses at the minute spark gap were enormous unless the wave length was several thousands of metres. It must be added that in this method of generating oscillations the primary circuit is kept coupled to the aerial, and therefore, in general, two waves are radiated.

Two important methods of generating oscillations are described in Nos. 17,349 (1908) and 6,424 (1909). The earlier one is that of Egbert von Lepel, the latter is the method used

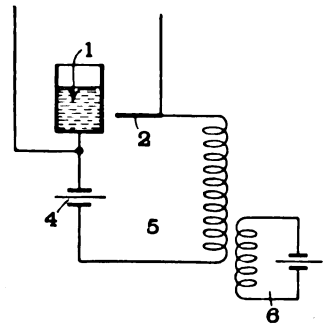

Fig. 3.—S. Eisenstein, No. 5,578 (1909).

by the Gesellschaft für Drahtlose Telegraphie. Both methods are stated to utilise that form of shock excitation first properly explained by Wien, and the plant for both methods has been fully described and discussed in former numbers of The Electrician. In both, the discharge of the primary condenser is made to take place between very close large metal surfaces, which are cooled to prevent the primary oscillation persisting long enough to affect the period or the damping of the secondary oscillation after this has once started. The Telefunken specification lays stress on the use of alternating current of rather high frequency with a number of gaps in series, and proceeds to elaborate the constructional details worked out for cooling the metal plates and providing for the easy and accurate assembling of these plates. It is stated that with a single pair of plates the range of transmission is only 50 km. to 100 km., and that therefore a number of gaps is essential. But surely this figure depends on the electrical dimensions of the primary circuit. The reason assigned for using alternating instead of direct current is that with the latter a definite place is soon selected for jumping the gap, with the result that the surface is soon spoiled and the whole arrangement put out of action. It may be mentioned that the use of an alternating current of musical frequency is not, as such, protected in this patent.

Another method that must be included in the shock excitation class is laid down by S. Eisenstein in 5,578 (1909) and 17,217 (1909). The spark is made to occur at a gap possessing strong rectifying properties. In Fig. 3 the gap is shown between the electrodes 1, 2. When the spark occurs the condenser 4 discharges suddenly, and, since the gap permits of current in only one direction, without vibration. The sudden discharge starts circuit 6 into vibration, and as the gap in circuit 5 is now open the former circuit vibrates in its own period. The present invention is merely concerned with the details of the valve or rectifier. The valve action is produced by keeping one electrode hot and the other cold. When a heavy feeding current is being used this current itself keeps the electrode 2 sufficiently hot, but otherwise special means such as a spirit lamp or an auxiliary electric arc is required. The advantage claimed is, besides singleness of wave, a very low rate of damping. This will enable sharp tuning to be obtained; and the inventor thinks that the efficiency will be good, especially if high-tension continuous current be used. In the above the vibration of the gap-circuit is supposed to be checked at the close of the first half period of that vibration. In a further specification, 17,217 (1909), by the same inventor, a method is suggested in which the process is checked after one complete oscillation. This is managed, according to the inventor, as follows:—The pointed or hot electrode of the rectifying valve is connected with the negative pole, and the cooled electrode of large area with the positive pole. The tension of the feeding current is selected in such a manner that it is at the limit of the penetrating force of the valve, so that, in the first place, the current passes from the large to the pointed electrode. Then "a fresh current in the opposite direction takes place, but a further passage of current, and consequently a continuation of the oscillation process, is prevented because in the meantime the energy of the oscillation has diminished so that the passage of current in the direction of the first half period is impossible."

A quite different purpose is held in view by M. Monasch, whose primary object is to provide a means of producing

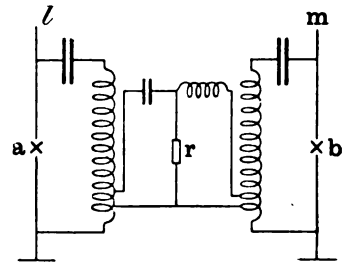

Fig. 4.—M. Monasch, No. 9,427 (1909).

phase-displaced oscillations, that is, of producing in two or more circuits vibrations possessing predetermined phase differences. The invention consists in bringing two or more sources of undamped, or but slightly damped, vibrations into connection with one another in such a manner as to establish a continuous mutual control that will maintain the desired phase-differences. Three ways of doing this are spoken of. Firstly, one or more of the sources of oscillations can be made predominant so that each of these compels one or more other sources to oscillate in definite phase relation to it. Secondly, every one of the sources may be made to participate in the control actively in such a manner that each of the mutually influencing sources vibrate in the desired phase. Thirdly, these two modes of operation may be combined with one another. In Fig. 4 is shown diagrammatically a means of persuading two sources, here supposed to be vibratory arcs, so to influence one another that their phase difference is anything desired. Here *a*, *b* represent Poulsen arcs, *l*, *m*, aerial conductors, and *r* an adjustable resistance. The intermediate circuit containing *r* establishes the connection between the sources *a*, *b*. It is not explained within what limits phase displacements are obtainable, nor is it stated which mode of vibration set up in any particular circumstances is the important one—though in a group of circuits coupled as here shown there are four possible free periods of vibration.

Finally, among methods of generating, that of E. Huth, 15,891 (1909), may be mentioned. In this an arc shunted in the usual manner is formed between two diverging electrodes simila- to the horns of a lightning arrester. The arc, it is

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claimed, is thus intermittently elongated and broken by the rush of heated air; but the advantages of this are not very apparent.

Turning to methods of producing signals, and kindred matters, we find in R. A. Fessenden's specification, 14,826 (1909) a noteworthy mode of operation described. It is based on the principle that the frequency of a high-frequency current through any circuit in series with a high-frequency alternator undergoes transient alteration when inductance is introduced into or removed from the circuit. The effect of introducing or removing an inductance is shown in Fig. 5. The frequency change endures, of course, only when the phase displacement produced by an inductance is in the act of being created or destroyed. Success in the application of this principle must depend largely on the possibility of introducing and removing the inductance without undue arcing. However this may be, the present inventor proposes to cause the

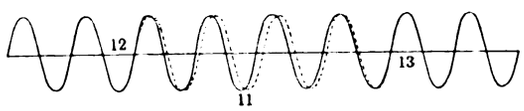

Fig. 5.—R. A. Fessenden, No. 14,826 (1909).

sending key of a telegraph station to alter in the above manner the frequency of the otherwise uniform stream of radiation from the aerial. The actual method of carrying out signalling is indicated in Fig. 6. Here 14 represents the armature of a high-frequency alternator possessing two windings, one extending from the point 15 to the point 16, and the other from the point 16 to the point 17. "The part extending from 16 to 17 is wound at a quarter phase difference from the part extending from 15 to 16 and the two parts are in series; 18 indicates resistances so adjusted as to maintain the intensity of the impulses constant when the coils 16 to 17 are inserted or cut out. 24 is a double-throw switch, 25 and 26 are commutators, either of which can be used as desired by throwing the double-throw switch 24. The commutators are preferably attached to the shaft of the armature 14. When the tele-

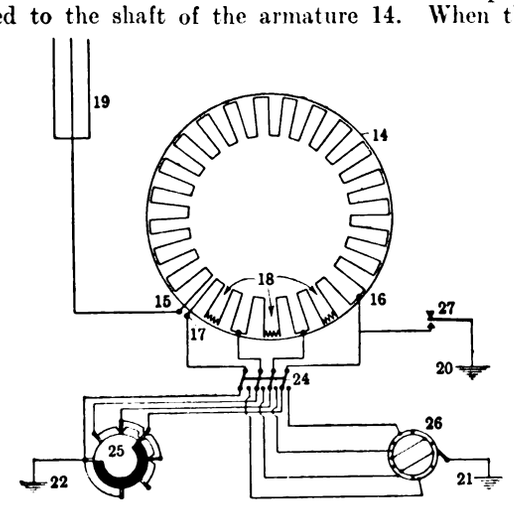

Fig. 6.—R. A. Fessenden, No. 14,826 (1909).

graph key 27 is up and switch 24 thrown to the left, commutator 25 is continually short-circuiting and opening the coils 16 to 17, and thus producing a fluctuating frequency which is higher than the normal frequency during one portion of the revolution and lower during the other. When the key 27 is depressed the section 16 to 17 is cut out, a steady frequency is generated and thus telegraphic signs transmitted." It is stated that this mode of sending does not disturb in any way the operation of neighbouring stations. This statement can be admitted if it be understood to mean that the neighbouring stations work with wave-lengths differing considerably from that of the station using the new device. No. 25,305 (1908) is another patent by R. A. Fessenden dealing with the broad question of telegraphic transmission. The objects of the invention are announced as the securing of secrecy, the attainment of high speeds of transmission, and duplex working. The essence of this very comprehensive invention is the proposal that instead of sending dots and dashes dots only are used, and the dashes and dots of the Morse code are discriminated by the employment of proper time intervals. Of course, the novelty of the invention does not lie in this proposition, but in the means designed for carrying it out. These means include devices for synchronising running machinery at the sending and receiving stations, which are worked out along obvious lines, but are much too complicated to describe here.

In specification No. 2,169 (1909), A. W. Sharman describes apparatus for transmitting signals by a method which is a development of that kind of wireless telegraph in which large currents are fed into two reasonably separated earth-plates at the sending station and small currents are picked up by two similar earth-plates at the receiving station. Instead of using

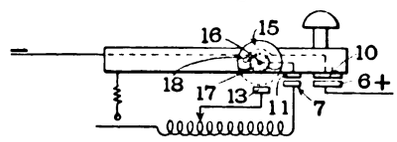

Fig. 7.—A. F. H. S. Simpson, No. 27,746 (1908).

continuous currents, the inventor proposes to use electrica impulses or shocks. The chief practical details described in the present invention may be summed up by saying that the shocks are produced by a sort of inductorium with only one winding—an auto-transformer, in short. By making tappings in this winding the primary and secondary portions may be given different proportions. Signals are made by making and breaking the primary current, and the consequent secondary impulses are delivered to the earth-plates. As for receiving, the principal thing required is a sensitive current detector. It is stated that the primary portion of the auto-transformer is best made larger than the secondary when working at sea, while the reverse is the case on land—a fact that may be explained by the lower resistance of the sea water circuit. In No. 27,746 (1908) A. F. H. Simpson developes an interesting proposal for combating wireless eavesdroppers. The inventor arranges his Morse key to change automatically the wave-length of the radiation, at more or less regular intervals, by its mere manipulation. A simple way of accomplishing this is to mount a ratchet wheel and pawl on the Morse key so that manipulation of the key lever causes the ratchet wheel to

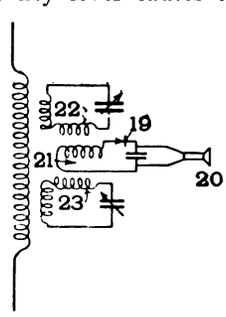

Fig. 8.—A. F. H. S. Simpson, No. 27,746 (1908).

rotate and connect up the different circuits in turn. Fig. 7 shows an arrangement for a two-wave station. 15 is a portion of a circular disc carrying the ratchet wheel 16 which is actuated by a pawl 18. As the wheel 16 rotates the contact 15–13 adds inductance to or subtracts it from the vibratory circuit. An eavesdropper with apparatus tuned sharply to one of the two wave-lengths of the sender would miss the dots and dashes sent on the other wave-length. The proper receiving station must be fitted in such a way that it receives both waves indifferently. Fig. 8 is a suggestion for the receiving circuits. Here the resonant circuits 22 and 23 are tuned to the two waves, and 21 is the detector circuit. A weak point of this particular design is that the aerial is out of tune with one or both of the resonant circuits, but this difficulty could be easily overcome.

(To be concluded.)

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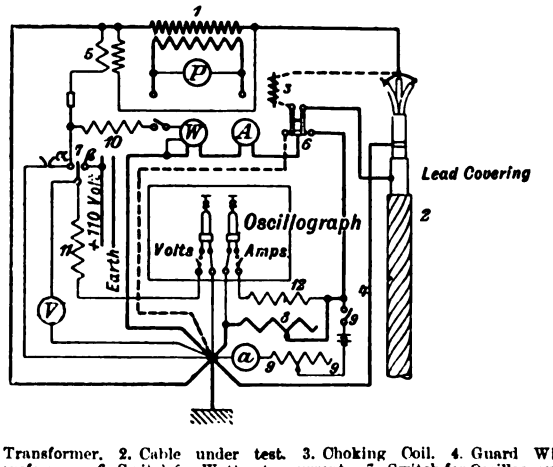
THE DIELECTRIC PROPERTIES OF MODERN HIGH-TENSION CABLES.*

BY M. HÖCHSTÄDTER.

Summary.—The author describes experiments made on paper cables at high pressures with a view to determining the dielectric losses in the insulation. The pressures were gradually increased until the insulation broke down; and from the oscillographic records, the author describes a method which he has devised for drawing the so-called hysteresis curve, corresponding to that for the magnetisation of iron. He also shows that there is apparently no "viscosity" traceable in paper cables, and that the breakdown takes place suddenly. He concludes with some remarks on the design of insulated transmission cables, and the effect of the choice of the value for the frequency.

Lately, and more especially in the last two years, great advances have been made in the manufacture of high-tension cables, particularly in the direction of higher breakdown voltage, greater uniformity in construction and increased mechanical strength. At the Siemens-Schuckert works the breakdown voltage over a short length of cable is at least ten times the working voltage. Polyphase cables for 10,000 volts are made to withstand 130,000 volts between the conductors, and for lower pressures the factor of safety is still higher. This paper is not concerned with details of manufacture, but is an enquiry into the problem, posed by the makers, as to the economies in thickness of insulating material which might be possible with higher voltages, seeing that the thickness of insulation is already reaching an impracticable limit. The



1. Main Transformer. 2. Cable under test. 3. Choking Coil. 4. Guard Wire. 5. Voltage Transformer. 6. Switch for Wattmeter current. 7. Switch for Oscillographs. 8. Shunt resistance for Oscillograph. 9. Calibrating circuit. 10, 11 and 12, Series resistances.

FIG. 1.—DIAGRAM OF CONNECTIONS BETWEEN INSTRUMENTS AND CABLE.

work of investigation, which occupied the second half of the year 1909 and some of the first months of 1910, deals exclusively with paper cables up to pressures of 60,000 volts.

The insulation resistance and its variations have often been examined. The losses in the dielectric, on the other hand, have received insufficient attention. Most of the work has been of the nature of a few physical experiments, carried out at low voltages. Very short lengths of cable have generally been used, and this tends to make the losses at the ends an undue proportion of the whole, which are only partly to be avoided by very awkward manipulative methods even for low voltages. A cable several hundred yards long is the least that is practically possible for our present purposes. Apt and Mauritius in 1904, and Humann in 1906, did some work on the subject of dielectric losses. The latter showed clearly the difficulties which attend measurements with a power factor of 0·03 and less. Humann, however, showed that the losses of a cable carrying no load were (within the limits he examined) proportional to the square of the effective volts and to the frequency. This shows clearly that the loss is not due to leakage, but to something dependent on the frequency, which is of the nature of dielectric hysteresis. For our present purpose it will be necessary to find the connection between the dielectric losses and the voltage for different dimensions of cables, having regard also to the effect of frequency and temperature.

The determination of the capacity is not always easy. Its value, as determined ballistically, is often very different from that given by alternate-current measurements. Something, doubtless, depends on the shape of the current wave and voltage wave; but it is not at all certain this explains everything. The breakdown voltage is a matter of the first importance, and in order to investigate it properly a method similar to that employed in testing the mechanical strength of a substance must be devised. Is there anything in a cable corresponding to the elastic limit, and do the properties of the dielectric undergo a change after passing a certain point before a breakdown occurs? This can only be determined by testing the value of capacity and hysteresis throughout the whole range. This would throw light on the disputed point as to whether a cable is injured by the nature and duration of the factory tests, and whether, for some reason or another, long lengths of cable are more liable to breakdown than short test pieces.

Fig. 1 shows the connections adopted generally when it was possible to earth one pole. [A slightly different arrangement was used when this was not possible, for which the original paper should be consulted, as also for a description of the instruments employed.] The ends of the cable had to be very carefully prepared, and this was so far successful that in a perfectly dark room at 50,000 and 60,000 volts it was only possible to notice the very faintest glimmer. Even with a long-continued pressure of 50,000 volts between the conductors of a polyphase cable and the lead covering the ends did not become hot. A protecting wire was used to prevent the end discharges from affecting the indications of the wattmeter; it carries the discharges directly to the corresponding pole, and these thus are shunted past the wattmeter. The most serious difficulties arose from the effect of the low power factor on the accuracy of the readings of the wattmeter, and this necessitated a great deal of preliminary work, which is fully described in the original paper, but for which it is impossible to find space here.

In order to study the laws relating to dielectric losses, it is proposed in the first instance to confine our attention to a certain cable which was very thoroughly tested. This was a three-core cable, each conductor having a section of 25 sq. mm., and being suitable for a working pressure of 5,000 volts. Its total length was 880 metres, and the thickness of the insulation

Table I.—*Showing Measurements on a Three-core Cable* 670 *metres long, and the Dielectric Losses between the Three Conductors and the Lead Covering. Sectional area of each Conductor,* 25 *sq. mm.; thickness of the insulation,* 3·5 *mm.; working pressure of the Cable from* 3,000 *to* 5,000 *volts.*

Frequency.	Amplitude factor from oscillogram.	Effective amperes.	Effective volts.	Maximum volts.	Capacity in mfds. per kilometre, calc. from formula.	Capacity calculated from oscillogram.	Capacity determined ballistically.	Dielectric loss per kilometre.	Power factor.
50	1·411	0·72	8,210	11,600	0·417	0·394		220	0·025
50	1·410	0·88	9,880	13,930	0·424	—		356	0·0275
50	1·40$_8$	1·23	13,900	19,570	0·422	0·403		740	0·0289
50	1·39$_8$	1·60	17,700	24,760	0·432	0·396 0·400		1,236	0·0292
60	1 336	0·62	6,050	8,100	0·407	—		87	0·0155
60	1·338	0·85	8,260	11,060	0·408	—		242	0·023
60	1·345	1·08	10,430	14,030	0·412	—		433	0 0258
60	1·335	1·21	11,730	15,650	0·409	—		563	0·0265
60	1·345	1·47	14,160	19,040	0·413	—	0·384	837	0·0268
30	1·517	0·34	6,260	9,500	0·430	—		76	0·0239
30	1·514	0·44	8,130	12,300	0·429	—		154	0·0288
30	1·508	0·59	10,500	15,850	0·445	—		278	0·030
30	1·518	0·68	11,950	18,120	0·450	—		371	0·0305
30	1·505	0·78	14,100	21,200	0·438	—		517	0·0315
40	1·320	0·42	5,950	7,850	0·419	—		55	0·0148
40	1·315	0·56	7,910	10,400	0·420	—		139	0·0210
40	1·324	0·72	10,070	13,320	0·425	—		270	0·0250
40	1,331	0·85	11,800	15,610	0·427	—		384	0·0257
40	1·325	1·03	14,570	19,300	0·420	—		622	0·0278

* Abstract of articles in the "Elektrotechnische Zeitschrift."

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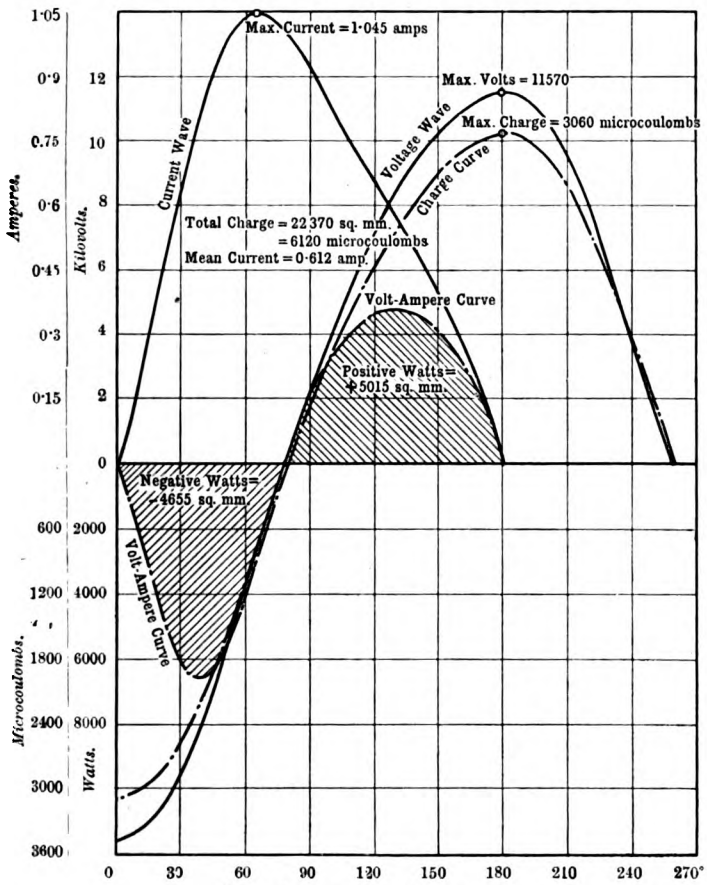
was 3·5 mm. Curves were first constructed showing the connection between the dielectric losses and the maximum of the voltage curve, taking account also of the effect of the frequency, which was varied from 30 to 60. These show that, although the amplitude factor varied from 1·33 to 1·41, the shape of the voltage curve does not affect the result, provided that account is only taken of its maximum value. The dielectric loss is exactly proportional to the frequency, and the readings were continued up to 20,000 volts on a length of 670 metres of cable. The figures obtained under test are given in Table I., which shows the values of the dielectric losses and of the capacity, as deduced from the oscillograms. A series of curves follows, by means of which it is shown how to draw the dielectric hysteresis loop from the oscillograms, which are first very carefully magnified by hand on accurately squared paper. Figs. 2 and 3 are typical of these curves. The resulting dielectric hysteresis curve is clearly analogous to that found



Dielectric loss = 5015 − 4655 sq. mm.
= 360 sq. mm.

i.e., dielectric loss per Km. = 199 watts: capacity calculated from maximum values of charge and volts per Kilometre $= \frac{3060}{11570 \times 0{\cdot}67}$
= 0·394 microfarad
Frequency = 50. Length of cable = 670 m.

FIG. 2.—CALCULATION OF OSCILLOGRAM.

in testing the magnetic properties of iron, with the understanding that amperes and volts are interchanged and magnetic induction is replaced by the electric charge on the cable. We see from the oscillogram that the maximum value of the voltage occurs simultaneously with the zero value of the current, and this occurred in all the paper cables under test, even at the highest voltages, at all frequencies and temperatures. In not one single oscillogram out of 100 was there the slightest trace of any deviation from this, not even in the case of very sharply pointed voltage curves. On the other hand, the maximum value of the current does not occur simultaneously with the zero value of the voltage. The values corresponding to the products of the instantaneous values of current and voltage are then plotted, the dielectric loss being obviously determined as being the algebraic sum of the positive and negative areas enclosed by the curve and the axis of co-ordinates. From these the dielectric loss could be finally estimated with the planimeter with an error of not more than 10 per cent., if extreme care were taken; but it was usually possible to get a more exact value from the hysteresis loop. In order to determine this loop, it is necessary to know the exact amount of the charge on the cable from instant to instant; but the oscillogram for the current values only allows a determination of the total charge by measuring the area enclosed between the current curve and the axis. By doing this in sections it is possible to determine the charge which flows in during the successive intervals, and in this way a curve connecting the voltage with the charge can be constructed. Seeing that the maximum of the voltage curve always coincides in point of time with the zero of current, and also with the moment of maximum charge, it is evident that there is nothing of the nature of "viscosity," and the hysteresis curve ends in sharp points. The similarity of this curve to that for the magnetic hysteresis of iron is very marked, except for the fact that in this case the lines forming the curve are more or less straight. The lower line is, indeed, almost exactly straight, whereas the upper, showing the descending charge, is very slightly curved. The characteristic of the sharp tip is present in both curves. It is possible to speak of a "coercive force" and a "residual charge" exactly in the same way as in the case of the magnetism of iron, for a charge still remains on the cable when the voltage has reached its zero value. The capacity of the cable corresponds precisely to the permeability of the iron, and is the

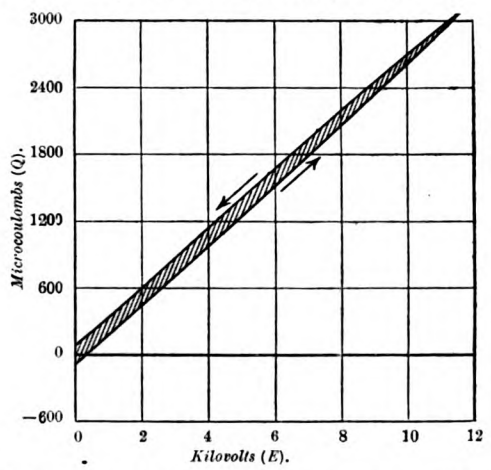


FIG. 3.—DIELECTRIC HYSTERESIS CURVE FOR A MAXIMUM APPLIED VOLTAGE OF 11,570, DRAWN FROM THE CURVES FOR CHARGE AND VOLTS SHOWN IN FIG. 2.

ratio of the charge to the voltage. Taking instantaneous values in the neighbourhood of the axis of x, it passes through the values of zero and infinity in rapid succession. The "true capacity" is best taken as being the ratio of charge to voltage when both have their maximum values. From these facts we may conclude that the dielectric loss in a cable is of the nature of hysteresis, and is a kind of internal friction which opposes electrification.

It has already been pointed out that the "true" capacity of a cable, as estimated by alternate-current measurements, is best calculated from the curve showing the hysteresis loop, and can be taken as being the ratio of the charge to the voltage when both have their maximum value. From a large number of oscillograms the "true" capacity of the given cable was found in this way, and in all cases the value was found to be the same. This leads us to think that the method gives the true value, seeing that the maxima of the two quantities are coincident in point of time, and, in the absence of any sign of "viscosity," are obviously physically correlated. This value of the capacity is neither affected by the shape of the wave form nor by the voltage nor by the frequency. Another method of estimating the capacity is by means of the formula connecting it with the effective values of voltage and current, and depending obviously on the shapes of the waves. But this gave values which differed in extreme cases by as much as 50 per cent. It can also be determined ballistically by direct current in the

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usual way, and this leads to the interesting fact that the value found in this way agrees almost exactly with the so-called "true" capacity, the greatest difference that was noted amounting to about 3 per cent., which is within the limits of errors of observation. The numerical results of several tests are given, showing that the "true" capacity of the cable at normal temperature and at voltages up to six times that of the working voltage is constant, and the same as that determined by statical methods.

The next point for investigation was the effect of temperature, and for this purpose the cable was gradually heated by the passage of a suitable current up to 60°C. The testing pressure was 14,000 effective volts, with a maximum of 19,500 volts. The results are shown in Fig. 4. At 60°C. the asphalt covering was becoming soft, and the same applied to the impregnating substance of the cable. It was found that the dielectric loss fell steadily up to 40 deg., at which point there seemed to be a minimum. At 60 deg. it seemed to be rising again. Humann seems to have found very similar results. The insulation resistance decreased in the well-known fashion according to an exponential curve, as shown by the straight-line curve, giving the logarithm of the megohms. It will be noticed that the ballistic method seems to show a great increase in the value of the capacity with a rise of temperature; but this is an illusion, and depends on the fact that the insulation resistance falls, and this, of course, affects the galvanometer

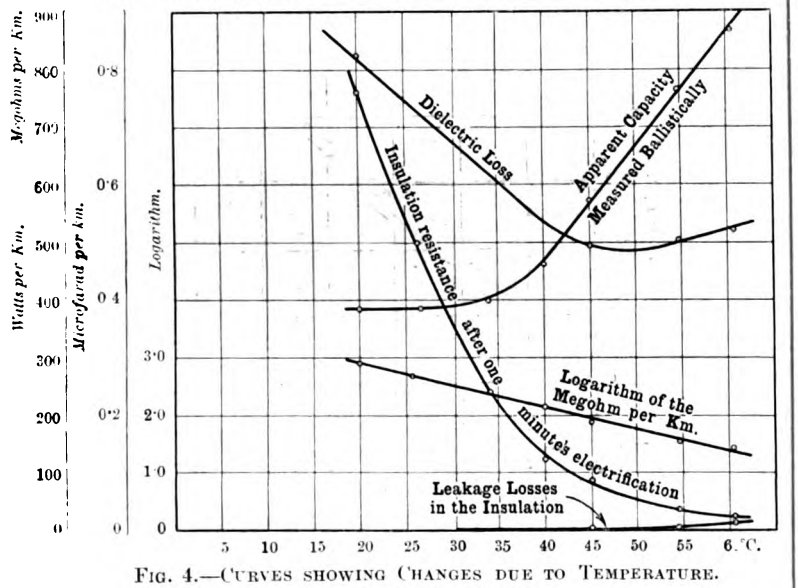

FIG. 4.—CURVES SHOWING CHANGES DUE TO TEMPERATURE.
Length of Cable = 670 metres.

reading. Measured by alternate-current methods, as described earlier in this paper, the capacity was found to be absolutely constant during the test extending over six hours, during which the temperature was gradually raised to 60°C. This shows that no internal change takes place within the cable even under these trying conditions, which are, of course, below the region of the breakdown voltage; and after the cable had cooled and resumed its normal condition it was found that it had sustained no damage whatever, and that the insulation resistance had its normal value.

The point in the neighbourhood of the breakdown voltage was next examined, and measurements were made at voltages between 15,000 and 50,000. In the first instance, curves were constructed up to a point near that of breakdown, and subsequently the cable was submitted to long-continued pressures a good deal below this point. A length of 200 metres of the cable was taken, and the pressure was between the three conductors and the lead covering, as shown in Fig. 1. At 45,000 volts there were slight but unmistakable signs of a probable breakdown, and, though a momentary pressure of 49,600 volts (effective) was applied, no oscillographic records were taken at this point. The readings, however, were perfectly steady up to this point, and showed that the true capacity remained perfectly constant, and the dielectric losses increased according to a steady curve, which showed no trace of any unusua change, even in the neighbourhood of the breakdown point. The cable was then tested for three hours at 25,000 effective volts, and then on the next day for three hours at 34,100 effective volts. Beyond such small changes as were traceable to a slight increase of temperature, no changes whatever were found to have taken place in any of the properties of the cable. Finally, the cable broke down after being submitted to an effective pressure of 45,500 volts for three minutes, and the readings, taken an instant before the cable broke down, showed that it had up to that stage experienced no change whatever. A large number of test pieces of the same cable were then taken, and the voltage was gradually raised in each case till the breakdown took place. These tests tended to show that there was no noticeable difference between the longer and shorter lengths, and that for all practical purposes it might be said that the breakdown voltage did not depend on the length of the cable, and that in all cases the breakdown took place suddenly and without any marked premonitory symptoms. The insulation was of such a character that a pressure of about 20,000 effective volts was required to break down an average thickness of 1 mm. of the insulation.

Curves are then given showing the dielectric losses in cables of different types and lengths, the thickness of the insulation, and also its weight per metre run, being stated. These curves naturally vary considerably; one general conclusion, however, seems to be that the dielectric loss in three-core cables at high voltages depends rather on the intensity of the applied voltage than on the type of cable. For instance, at pressures above 30,000 maximum volts, there was found to be very little difference between a cable which had a thickness of 3·5 mm. of insulation and others which had 12 mm. or 13 mm. of thickness, the weights per foot-run in the latter cases being 9 or 10 times that in the former. With single-core cables the same is true to some extent, but the losses are naturally less than in a three-core cable with the same thickness of insulation. The so-called "specific dielectric loss" is calculated in watts per kilogramme of insulating material per metre-run, the abscissæ of the curve being volts per millimetre thickness of the insulation. In the case of the cables with thicker insulations, it was found that the "specific" losses increase very quickly with a rise of voltage. A careful individual examination of various types of cables is next made, and results, including curves for some of these, are given, the pressures applied in some cases rising to nearly 100,000 maximum volts.

The author concludes with the comparison, for three-phase transmission, of one three-core cable with three single-core cables, the total weights of insulation applied to the cable or cables being in the two cases approximately the same. Up to 30,000 effective volts there seemed very little difference between the two; at 50,000 volts and a frequency of 50, the dielectric loss per kilometre was 4·5 kw. for the three-core cable, as compared with 2 kw. for the three separate cables. At 60,000 effective volts, the corresponding figures were 7·5 kw. and 3 kw. respectively. The question is—how far these figures should affect the design of a transmission scheme. It may be assumed for our present purpose that insulated cables are considered advisable owing to some local necessity, and that overhead cables have been thought unsuitable. The capacity of a system of insulated cables is 15 or 20 times that of overhead cables; in the latter case, the figure may be taken at about 0·01 mfd. per kilometre. This, however, is only one reason out of many for choosing a low frequency. The examination of a particular case will help to explain matters. The three-core cable may be supposed to transmit a full load of 15,000 kw. over a distance of 50 km., the power factor being 0·85, the pressure 50,000 volts and the sectional area of each conductor being 100 sq. mm. Let us take two cases in which the frequency is (1) 50 and (2) 15. Each phase carries 203 amperes, and the losses in ohmic resistance are 21·7 kw. per kilometre. Therefore, over 50 km., 1,085 kw. are lost from this cause. The dielectric loss for a frequency of 50 is, according to our tests, 225 kw. for 50 km., and for a frequency of 15 it is 68 kw. The resulting total efficiency at full load is 92 per

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cent. for a frequency of 50, and 92·7 per cent. for a frequency of 15. In this case there seems, therefore, no great difference between the two. But at no load things are different. With a capacity of 0·2 mfd. per kilometre (as found earlier in this article), the charging current is 95 amperes for a frequency of 50 and 28·5 amperes for a frequency of 15; and the ohmic losses due to currents of these magnitudes are, relatively speaking, serious. Taking the total yearly results, and supposing the average load to be 40 per cent. of the full load, the losses are as follows: For a frequency of 50 the ohmic losses are 3 per cent. and the dielectric losses 4 per cent. of the total output, the resulting overall efficiency being 93 per cent.; with a frequency of 15 the ohmic losses are, as before, 3 per cent., and the dielectric losses 1 per cent. of the total output, the efficiency being therefore 96 per cent. When translated into pounds, shillings and pence the advantage resulting from the lower frequency appears very great. [The above case is fully worked out in the original paper, though it is treated very briefly here; account is taken of the reaction of the charging current on the ohmic losses, having regard to the difference of phase between it and the working current.]

We thus see that at 50,000 volts the dielectric losses are of the same order of magnitude as the ohmic losses, and that if a sufficiently low frequency is chosen it is quite reasonably possible to use insulated cables somewhat of the type described for transmission purposes. Insulated cables with conductors of small sectional areas, intended for carrying comparatively small loads, are unsuitable, partly on account of the charging current and partly owing to dielectric losses. In the case examined above the cable should not be more than about 100 km. long. In concluding the comparison of the three single cables with one three-core cable, the case may be thus stated: A given weight of insulation is more effectively applied to a three-core cable, but the dielectric losses are in this case nearly twice as great as in the other. The capacity of the single-cable system is 0·162 mfd. per kilometre, as compared with 0·2 mfd. per kilometre, and these figures have a corresponding effect on the overall efficiency. The cost of three single cables, including armouring and laying, is obviously greater than that of the three-core cable; but the single-cable system has an undoubted and probably deciding advantage in the ease with which joints can be made.

It remains to be said that during the time the present paper was in the press the author's attention was drawn to the work of H. F. Haworth, who investigated the dielectric properties of porcelain plates. It is not possible here to discuss his results, which seem to differ from those here set forth. In any case, it is very probable that the nature of dielectric losses cannot be stated in general terms, but that much depends on the particular substance under consideration. Some substances may show signs of viscosity and polarisation, while others do not do so. The author does not claim that his results apply generally, but only to the materials used by the Siemens-Schuckert works for the insulation of their cables. If other substances behave in a different way, this shows that the insulating medium selected for the Siemens-Schuckert cables has been the result of a very happy choice, since its properties are similar to those of an ideal dielectric.

NEW POST OFFICE TELEPHONE EXCHANGE AT GLASGOW.

(*Concluded from page 811.*)

In connection with the junction working, some interesting departures from present practice have been introduced. The incoming order wires terminate upon break jacks which are provided so that a faulty order wire may be quickly substituted by a good incoming junction. It is only necessary for the operator to insert the plug of the incoming junction selected for the purpose into the break jack associated with the faulty order wire. All incoming order wires are connected to the main springs of a position throwing key, the object of this key being to transfer groups of incoming wires to the next succeeding position during slack periods. In order to facilitate testing the common connection which normally joins all the position plug tips together, and to the 58-ohm winding, is also transferred by the action of the position throwing key. The operation of the junction supervisory relay when a B. operator responds to a ringing junction call is assisted by a 1,400-ohm retardation coil placed across the common leads of the speaking keys. A signal is also given to the distant A. operator, and the machine ringing key is released at an intermediate point if the operator, when using the junction to connect a third exchange, had inadvertently depressed this key.

As regards the incoming junction from common battery exchanges, it has been customary to provide for four party lines with selective ringing by placing the five ringing keys in the speaking circuit. In the present case, however, the ringing keys are quite independent of the speaking circuit. The connections for the busy-back jack are similar to those employed in the Department's existing busy-back circuit. The machine ringing arrangements are of a special character, and an illustration of a machine ringing and speaking key is given in Fig. 14. A locking plate is provided, which is common to all the five buttons, and a relay circuit is closed when any button is pressed down as far as it will go. When the button is released it travels upwards to a half-way position in which it engages the clutch of the locking plate. The button remains in this position even when the ringing circuit is automatically disconnected from the junction circuit, until some time later another button is depressed, when the locking plate is forced outwards from the shoulder of the plunger. The half-way position is an advantage because the B. operator, if asked to ring a subscriber a second time, can distinguish the button previously depressed. Each ringing button for the party line service has control of six key springs, which when the button is depressed select the type of ringing current required for the subscriber's circuit. Osram

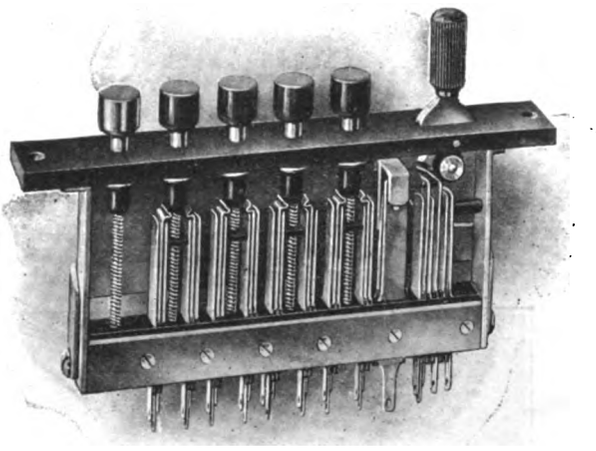

FIG. 14.—SPEAKING AND RINGING KEYS.

resistance lamps are inserted for protective purposes between the positive and negative pulsation brushes of the generator and the machine ringing key. Party line ringing, as well as ringing for ordinary lines, is intercepted by interrupters which give one second ringing period and two seconds interval. These interrupters are inserted between the generators and the resistance lamps.

The "three-lamp set" commonly used for testing in C.B. exchanges was modified for the present exchange. 36-volt lamps are used for the tip, ring and sleeve circuits. The treatment of a typical fault may be referred to in some detail, namely, "tip" conductor of subscriber's line circuit to earth. In this case the earth will reduce the sensitiveness of the line and supervisory relays, also it will unbalance the transmission circuit. The tip lamp of the set will glow intensely when the peg of the tester is inserted into the jack of the faulty line. Depression of the S key of the tester in the majority of cases will not cause the tip lamp of the set to darken. In the minority of cases the fault will be between the cut-off relay springs of the line relay coil. Under these conditions the sensitiveness of the line relay is reduced but not that of the supervisory relay; the insertion of the peg causes the tip lamp to glow brightly as before, but the depression of the key causes the darkening of the tip lamp. The latter fault though unusual is very serious, and to locate it the resistance in series with the sleeve key of the tester is of such value that the depression of the key will not actuate either cut-off relay when two are in multiple, but one relay only by itself.

The switchroom desk equipment has been made very complete. The information desk is in two sections of two positions each, and extensions can be readily made. The information operators attend

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to the following circuits: incoming line circuits from switchboard, monitoring circuits, official circuits, service observation circuits and intercepting circuits.

which was published in the Post Office Engineers' "Journal," of January last. We are indebted to his excellent article for the diagrams and data embodied above.

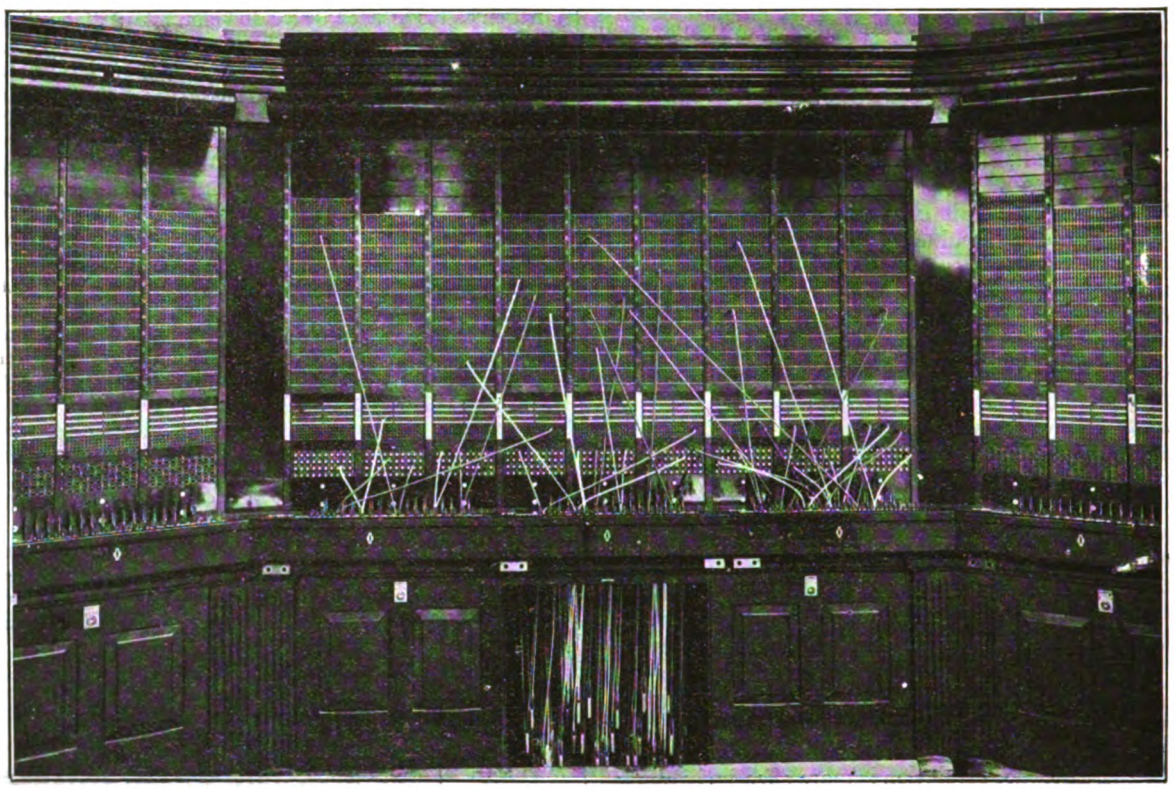

FIG. 15.—SECTION OF SUBSCRIBERS' SWITCHBOARD. Front View.

In the equipment of the exchange no less than 15,000 signal lamps were installed, together with 30,000 relays and 500,000 spring jacks. The wiring of the exchange has utilised 5,000 miles of wire, and three million soldered connections were made. The quality of the work

As already mentioned, the whole contract for manufacture and installation of the plant was entrusted to the Peel-Connor Telephone Works (Ltd.), of Salford. This company has taken over the Peel works telephone business of the General Electric Co., and has London

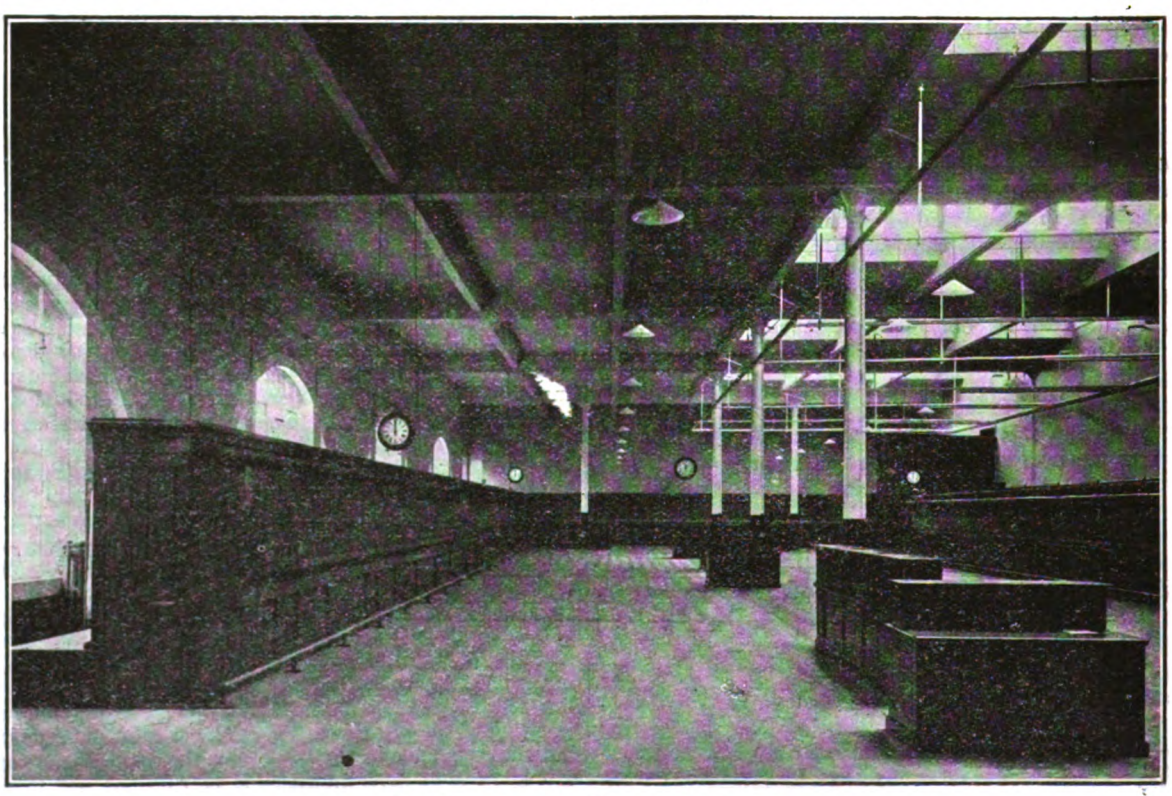

FIG. 16.—GENERAL VIEW OF SWITCHROOM.

put into the installation may be gathered from the fact that the exchange faults, on testing out, were less than 10.

We must refer our readers for fuller information to a detailed description of the equipment of this exchange by Mr. J. W. Turner,

offices at Midland Bank Chambers, Queen Victoria-street. Our thanks are due to the secretary and London manager of the company, Mr. P. P. Kipping, for the supply of much of the information and illustrations on which the foregoing articles are based.

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ELECTRICAL RECORDING THERMOMETERS FOR CLINICAL WORK.*

BY H. L. CALLENDAR, LL.D., F.R.S.

Summary.—The conditions of sensitiveness in measuring a resistance by the Wheatstone bridge method are first discussed; after which the author proceeds to describe the construction of electrical resistance thermometers and recorders for clinical work.

The scientific interest and importance of a method of continuously recording the temperature of the body, whether in health or disease, is now being generally recognised. My attention was first directed to the subject by Prof. J. G. Adami, F.R.S., of McGill College, Montreal, at whose suggestion I constructed some electrical resistance thermometers specially adapted for recording the temperature of different parts of the surface of the body. Unfortunately, I had to leave Montreal early in 1898, before the apparatus had taken its final shape. I returned to the subject in November, 1908, when I undertook to make some thermometers for Dr. A. Gamgee, F.R.S., and to collaborate with him in evolving a practical method suitable for general use in clinical work. He had become convinced that the thermoelectric method was unsuitable for general use, on account of the delicacy of the apparatus, and the necessity for employing an elaborate thermostat. A serious difficulty in practice was the necessity of keeping one of the junctions of the couple at a constant temperature in the neighbourhood of 37°C. for long periods. In the application of the resistance method no thermostat was required, and it was easy to obtain a tenfold larger deflection with the same galvanometer. The objections that have commonly been urged against electrical resistance thermometers for this kind of work are (1) that resistance thermometers are more difficult to construct and to insulate satisfactorily than thermocouples, and (2) that their indications are liable to be disturbed by the heating effect of the current employed. These objections undoubtedly exist, and have

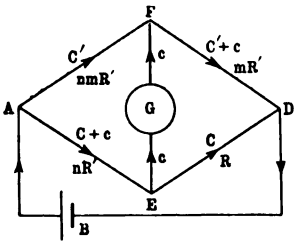

FIG. 1.—DIAGRAM OF WHEATSTONE BRIDGE.

frequently proved fatal to the employment of resistance thermometers, but they have arisen chiefly from faulty application or construction, and not from defects inherent in the method. Objection (1) is readily surmounted by proper methods of construction, and objection (2) by a proper consideration of the conditions of sensitiveness.

Conditions of Sensitiveness.—The conditions of sensitiveness in measuring a resistance by the Wheatstone bridge method have been discussed by Maxwell and Heaviside, whose results have generally been quoted and applied to the problem under consideration. They start with the assumption that the battery power available is limited by the internal resistance of the cells, and give rules for obtaining the maximum current through the galvanometer with this implied limitation. The limitation of battery power was no doubt an important consideration in many kinds of telegraph testing 30 years ago, but it is rarely applicable in modern laboratory practice, and never in dealing with electrical resistance thermometers. In the majority of resistance measurements and more particularly in electrical thermometry, the limiting condition is imposed by the heating effect of the current on the resistance to be measured, and the resistances, &c., should be chosen and arranged to give the greatest sensitiveness for a given limiting value of the current through the resistance to be measured. The resistance of the battery circuit is quite immaterial, provided that the battery can be arranged to give the required limiting current. The problem has been discussed from this point of view by Guye and by Schuster, and in several of my own Papers, but it will facilitate discussion to reproduce here the investigation itself in a simplified form.

Let Fig. 1 represent the arrangement of resistances in a Wheatstone bridge, in which C is the current through the resistance to be measured R, and c is the current through the galvanometer of resistance G, when the bridge is not balanced. The resistance in series with R is nR' traversed by a current $C+c$; the resistance in parallel with R on the same side of the galvanometer circuit is mR' traversed by a current $C'+c$. The resistance in the opposite arm of the bridge to R is nmR', traversed by a current C'. The currents are assumed to flow in the directions indicated by the arrows, and it is evident that they satisfy the condition of continuity. The numbers n and m, representing the ratios of the arms of the bridge, may have any positive values. The bridge is balanced when $R=R'$, in which case $c=0$, and $C'=C/m$. Since the difference of potential between the ends of the galvanometer circuit is Gc, we have by Ohm's law,

$$RC-mR'(C'+c)=Gc=nmR'C'-nR'(C+c).$$

Eliminating C', we obtain for the ratio c/C,

$$c/C=(R-R')/(G(1+n)/n+(1+m)R'). \quad . \quad . \quad . \quad . \quad . \quad (1)$$

It is obvious that this ratio, which may be regarded as a measure of the sensitiveness of the arrangement, is quite independent of the resistance or E.M.F. in the battery circuit. It is also at once evident that, for a given defect of balance, as measured by $R-R'$, the value of the ratio c/C will be a maximum when n is as large as possible, and m as small as possible, the limiting value of the ratio c/C in this case being, when

$$n=\infty, \text{ and } m=0, \; c/C=(R-R')/(G+R').$$

This point has been emphasised by both Guye and Schuster, and comes out clearly in Heaviside's investigation. The advantage which can be gained by making n large and m small is not very great, because when $n=m=1$, $c/C=(R-R')/2(G+R')$, or the sensitiveness is still half as great as in the limiting case. For practical purposes it is more important to observe that if n is small or m large, the sensitiveness may be indefinitely reduced. This arrangement should always be avoided if possible, as shown by the following example.

Maxwell has given a rule which is very often quoted and applied ("Electricity and Magnetism," Vol. I., section 348): "Of the two resistances, that of the battery and that of the galvanometer, connect the greater resistance so as to join the two greatest to the two least of the four other resistances."

This rule is seldom applicable to accurate resistance measurements, and when applied in platinum thermometry has often led to disastrous results. A simple numerical example will make this clearer. Suppose that it is required to measure the resistance of a platinum thermometer, R = 10 ohms, with a Post Office box having ratio arms 10 and 1,000 ohms. Suppose that the galvanometer has a resistance G = 10 ohms, and that the battery is a 2 volt cell of negligible resistance. According to Maxwell's rule we should connect the galvanometer so as to join the two resistances of 1,000 ohms to the two resistances of 10 ohms, in which case we should have $n=1$, and $m=100$ in Fig. 1. Suppose that the balance is slightly disturbed by a change $dR=R-R'$. Substituting in equation (1) we obtain:

Case (A), Maxwell's rule, $n=1$, $m=100$, $c/C=dR/1{,}030$, $C=0{\cdot}1$ amp.

If, however, we interchange the connections of the battery and galvanometer, which is simply equivalent to interchanging the values of n and m in the equation, we obtain for the anti-Maxwell arrangement:

Case (B), anti-Maxwell, $n=100$, $m=1$, $c/C=dR/30$, $C=0{\cdot}002$ amp.

The actual value of the current through the galvanometer in case (A) is greater than in case (B) in the proportion of 3 to 2. Maxwell's rule is so far justified. But the current through the resistance to be measured is 50 times greater in (A) than in (B), and the heating effect of the current is 2,500 times greater. With an ordinary platinum thermometer arrangement (A) might give an elevation of temperature of about 5°C., which would be fatal for any purpose of measurement. Whereas arrangement (B), with nearly the same sensitiveness, would give an elevation of 0·002°C. only, which is sufficiently small for the most accurate work. The essential point is to observe that the ratio c/C of the galvanometer current to that through the thermometer, which is the true measure of sensitiveness in this case, is 34 times greater in (B) than in (A). (B) is therefore by far the better arrangement in the case where the heating effect of the current on the resistance to be measured is the primary consideration.

The rule to replace Maxwell's in this case, if there is any choice as to the arrangement of the battery and galvanometer connections, is: "Connect the battery so as to make the resistance in series with the thermometer greater than the resistance in parallel." This will make n greater than m in Fig. 1, and it is evident that the ratio c/C will be diminished or the sensitiveness reduced, if n and m are interchanged.

In the practical use of platinum thermometers, we have the further restriction that n must be equal to unity, because it is necessary to compensate the changes of resistance of the leads by

* Abstract of Prof. Callendar's Presidential Address to the Physical Society.

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the equal changes of resistance of a pair of compensating leads on the opposite side of the galvanometer contact on the bridge-wire. The loss of sensitiveness, as compared with the case of n very large, does not amount to more than 20 or 30 per cent., and is of no consequence as compared with the trouble and uncertainty involved in measuring the resistance of the leads separately at each observation. Moreover, if n is made large, the heating effect of the current C on the resistance nR' may become serious. As a matter of fact this is a common and very insidious source of error in the use of a P.O. box with $n=100$, especially if the coils are of german silver or platinoid. With maganin resistances the effect is much less marked.

It is still possible to gain some advantage in point of sensitiveness by making m smaller than unity, provided that it is not made so small that the heating effect of the current C/m on the resistance mR' becomes appreciable. For the most accurate work I have generally employed thermometers having a resistance about 25·6 ohms at 0°C., with a fundamental interval of 10 ohms, and have made the ratio coils about 6·4 ohms, giving $m=1/4$, which gives an advantage of about 20 per cent. in point of sensitiveness as compared with $m=1$. A more important consideration in this case is that the same box can be used with thermometers of lower resistance, *e.g.*, $R_0=2·56$ ohms, F.I.=1 ohm, without serious loss of sensitiveness.

Resistance of Galvanometer.—It is generally possible to vary the resistance of a galvanometer through a wide range, by altering the connections of the coils or by substituting one coil for another, without altering the mass of the coils. In this case the sensitiveness will vary approximately as the square root of the resistance G. We see from equation (1) that the deflection of the galvanometer, which is proportional to $c\sqrt{G}$, will be a maximum when $G=n(1+m)\,R'I(1+n)$. This result agrees with that given by Maxwell, and shows that in the majority of cases which occur in practice, G should be of the same order of magnitude as R, being restricted to the limits 2R and R/2, if n is never less than 1, or m greater than 1. If we are restricted, as in platinum thermometry, to the case $n=1$, we should take $G=(1+m)R'/2$. The best resistance for the galvanometer is restricted to the same limits, 2R and R/2, provided that m does not exceed 3.

For example, in the case of the box already quoted, with ratio coils 6·4 ohms, when used with a thermometer $R_0=25·6$ ohms, the best resistance for the galvanometer was 16 ohms. When the same box was used with a thermometer 10 times smaller, $R_0=2·56$ ohms, the best resistance for the galvanometer would be 4·5 ohms. This could be secured approximately by putting the two coils of the 16 ohm galvanometer in parallel, but the advantage gained thereby would be only 10 per cent. If, on the other hand, the ratio coils had been made equal to 25·6 ohms each, according to the rule given by Maxwell and generally followed, there would have been a loss of sensitiveness of 20 per cent. with the 25·6 ohm thermometers, and 50 per cent. with the 2·56 ohm thermometers, which could not so well be neglected.

Resistance of the Thermometer.—For a platinum thermometer of resistance R_0 at 0°C., the change of resistance per 1°C. is approximately 0·004 R_0, which must be substituted in equation (1) for the value of dR or $R-R'$, in order to find the deflection of the galvanometer per degree change of temperature. Making this substitution, and remembering that $n=1$, we find that, when the resistance of the thermometer is changed, the deflection per degree, which is proportional to $c\sqrt{G}$, varies as $RC\sqrt{C}/(2G+(1+m)R)$.

The rise of temperature produced in the thermometer by the measuring current C is directly proportional to C^2R and inversely proportional to the rate of dissipation of heat per degree rise of temperature of the thermometer above its surroundings. The rate of dissipation of heat depends on the form and surface of the thermometer, and on the conditions of exposure. For similar thermometers of different resistances, but of the same size, under similar conditions of exposure, we must have C^2R the same in order to secure the same degree of accuracy as limited by the heating effect of the current. The permissible current C will therefore vary inversely as the square root of the resistance of the thermometer. Making this substitution, we have

$$c\sqrt{G} \text{ varies as } \sqrt{G}R/(2G+(1+m)R).$$

We see from this result that, if it is possible to choose the best resistance for the galvanometer, namely $(1+m)R/2$, and if m is the same for all, the sensitiveness and accuracy of the thermometer, so far as the heating effect of the current is concerned, will be independent of its resistance. In accurate laboratory work, where a delicate galvanometer is available, the heating effect of the current is so small as to be relatively unimportant, and the resistance of the thermometer is chosen chiefly with a view to minimise errors due to defects of insulation or imperfect contacts, or small differences in the resistance of the thermometer and compensator leads. On the other hand, for practical applications, or for ink recording, it is necessary to employ a fairly robust and portable galvanometer of the suspended or pivoted coil type; the current employed must be considerably increased if a large scale record is required, and it may be important to choose the resistance of the thermometer to suit the galvanometer or vice versa, in order to minimise the heating effect of the current.

The symmetry of the above expression in respect of G and R shows that the condition governing the choice of the resistance of the thermometer, if the galvanometer is given and m is constant, is the same as that already given for the galvanometer in terms of R, namely, $R=2G/(1+m)$.

If, however, the value of $mR=S$ is constant, being fixed by the resistance of the ratio coils, each equal to S, of the bridge employed, the maximum sensitiveness is obtained when $R=2G+S$. The latter condition gives the limit beyond which no advantage can be gained by increasing R and diminishing m, even if the heating effect of the current on S can be entirely neglected. If the heating effect of the current in the thermometer is kept constant, as already assumed, the heating effect in S increases in proportion to R/S. On the same assumption the total current to be supplied by the battery (which is a consideration in records of long duration) is a minimum when R=S, but is only increased in the ratio 5/4 when R=4S. The maximum sensitiveness is obtained when S=0 and R=2G, but the sensitiveness will be reduced by little more than 10 per cent. if we make S=G/2, keeping R=2G. It would be reduced a further 20 per cent. if we made R=G=S, according to Maxwell's investigation.*

In employing the deflection method described below, the advantage of making R larger and S smaller than G is really greater than would appear at first sight, because, if the sensitiveness is reduced 20 per cent. for the same heating effect of the current, it means in practice that the current must be increased 20 per cent. to give the required deflection, or that the heating effect of the current must be increased more than 40 per cent. The most important error to avoid is to make R small compared with G or S. The sensitiveness may in this way be very greatly reduced, and the heating effect of the current increased five or 10 times. Thus, a pyrometer of low resistance designed for work at high temperatures (where the resistance is high and an open scale is not required) would not be a suitable instrument to employ for recording small variations of temperature on an open scale at low temperatures, unless G and S were made inconveniently small, and the pyrometer itself specially wound with extra thick wire to give a large cooling surface.

Construction of Thermometers.—The author proceeds to describe the construction of thermometers:—(1) For insertion in the mouth; (2) for the rectum; (3) for the surface of the skin or for the axilla (armpit).

A great improvement on the ordinary type of platinum thermometer in point of quickness of action and diminuation of the heating effect of the current, is readily effected by winding the wire on a *flat* plate of mica in place of a cross, and melting the lower part of the containing tube (which is preferably of lead glass) down on to the wire so as to form a flat bulb, as illustrated in Fig. 2. If the glass is thin, the sensitiveness may be increased nearly five times, as compared with a thermometer of the ordinary type, and the heating effect of the current reduced in nearly the same proportion. When inserted in a water bath at 37°C. this thermometer takes less than a minute in arriving within a hundredth of a degree of the final temperature; but when inserted cold in the mouth, it may take 4 or 5 minutes to get within a tenth of a degree, because the tissues of the mouth take time to recover from the cooling effect of inserting the thermometer. Where quickness of action is an essential condition, as in some kinds of calorimetric work, the flat-bulb thermometer is a great improvement on the ordinary type with a round tube, but it shares with the mercury thermometer the disadvantage that, if broken or damaged, it cannot easily be repaired.

It is essential that thermometers of this type should be provided with compensated leads, otherwise there will be a variable immersion error, and an apparent lag due to slow conduction of heat along the leads. It is also most important for accurate work to avoid screw terminals in the head of the thermometer, and to provide each instrument with flexible leads two or three metres long, permanently soldered to the thermometer and compensator leads, and securely attached to the head of the thermometer, as indicated in Fig. 2.

The smallest size of quartz-glass resistance thermometer constructed by Heræus has a bulb 25 mm. long and 3 mm. in diameter,

* Maxwell, "Electricity and Magnetism," Vol. I., section 349. This is the right arrangement if all the four arms of the bridge are similar, and equally affected by the current.

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and is therefore very similar in dimensions to an ordinary clinical thermometer. The bulb contains a coil of fine platinum wire wound on a rod of quartz-glass, and protected by a very thin tube of quartz-glass fused over it. The bulb is fused on to a larger quartz tube, containing the two leading wires, which are of gold. The resistance of the coil is 25 ohms nearly at 0°C., but, as there are no compensating leads, the resistance cannot be measured very accurately. This type of thermometer is very suitable for insertion in the mouth but is unsuitable for records of long duration owing to its shape and the risk of breakage. It does not appear to be quite so sensitive as a mercury thermometer of similar dimensions, partly owing to the low conductivity of the central rod of quartz-glass, and partly to the fact that the leads are not compensated.

The author specially designed a flat platinum tube thermometer for calorimetric work, where quickness of action and small mass are important. It is similar to the flat glass bulb thermometer, except that the containing tube is of platinum about 0·05 mm. thick, which permits the thermal capacity of the bulb to be greatly reduced. The coil is wound on a flat plate of very thin mica, and insulated

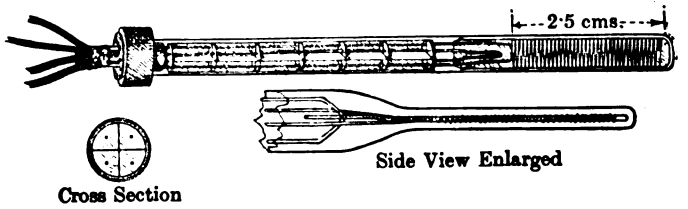

Fig. 2.—Flat Glass Bulb Thermometer.

from the flattened platinum tube by thin strips of mica on either side. Owing to its size and shape, it was not very suitable for insertion in the mouth.

A comparison of the records of the platinum tube thermometer (Pt) and the Heræus quartz tube thermometer (He) when placed in the mouth under similar conditions is shown in Fig. 3, which illustrates the importance of extreme quickness and small thermal capacity in such tests. It might appear at first sight as though the slow and long continued rise indicated by both thermometers in different degrees, was due to the heating effect of the measuring current, which might easily produce a result of this nature if the current were excessive or the mass considerable. But the current employed in taking these records scarcely exceeded one hundredth of an ampere, and the heating effect of the current was measured in both cases and found to be very small. Records proving that the apparent lag of the thermometer is really due to the slowness of recovery of the temperature of the mouth itself after being cooled in any manner are given by the author.

For records of long duration, the best results are undoubtedly to be obtained by insertion in the rectum. The thermometer bulb should be of small dimensions and the leading wires should be

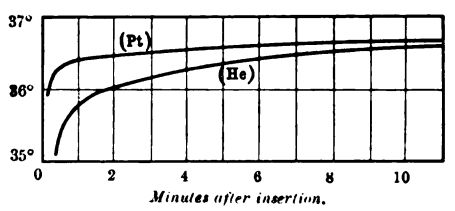

Fig. 3.—Comparison of Quartz and Platinum Tube Thermometers in mouth after closure for 10 minutes.

enclosed in a flexible but inextensible tube of small diameter, such that it can be attached to the bulb in a perfectly secure and water-tight manner. Such a thermometer may be made in a variety of ways. The following is a description of a method of construction which I have found very satisfactory. The fine wire forming the bulb is wound on a thin celluloid tubes, 5 mm. in diameter, and is protected by another thin celluloid tube which closely fits the first. One end of the protecting tube is closed by a small celluloid stopper, the other is cemented with celluloid cement to the cut end of a Porges catheter 5 mm. in external diameter, and 32 cm. long, through which the flexible thermometer and compensator leads are passed. Records obtained with this thermometer are given by the author.

A tube form of thermometer is not very suitable for surface use, since the contact between the thermometer and the skin is necessarily imperfect. It is desirable to give the thermometer as large a surface as possible, in order to diminish the heating effect of the current and to make the bulb flexible and thin. The first thermometer of this type which I constructed for Prof. Adami in 1897 was made by sticking a thin bolometer grid of platinum foil on to a thin sheet of celluloid photographic film. The substitution of fine wire for the foil greatly facilitated the construction and adjustment, and was found to make little, if any, difference to the sensitiveness. In any case it is most important that the thermometer should be fairly robust, as it has to undergo somewhat rough usage. In my experience nothing answers so well as celluloid film for the insulating material, the thermometer can preferably be inserted in a thin flat celluloid sheath. A surface thermometer of this type is extremely sensitive, and shows no appreciable lag when placed in a water bath; but when placed on the surface of the skin, it may take 15 minutes or more to reach a steady temperature.

Recording Instruments.—Two principal types of recording instruments are available, corresponding respectively to the deflection method and the balance method of measuring variations of electrical resistance. In the deflection method, the greater part of the resistance to be measured is balanced on a Wheatstone bridge by a balancing coil, and the small variations are observed by the deflection of the galvanometer. In the balance method, the galvanometer contact is moved along a bridge-wire until balance is obtained. This method is not so quick for small variations, but is generally most suitable for work with resistance thermometers, and has the advantage that the scale is uniform and independent of the E.M.F. of the battery. In clinical thermometry, the range of temperature to be covered is so small that the deflection method is generally applicable and the scale practically uniform. The scale is readily adjusted to read in degrees of temperature by means of a suitable rheostat in the battery circuit. If storage cells of sufficient capacity are employed there is little risk of error from variation of the E.M.F. of the battery. Thus, for clinical thermometry, there is little to choose between the balance and deflection methods, if the instruments employed in either case are equally sensitive.

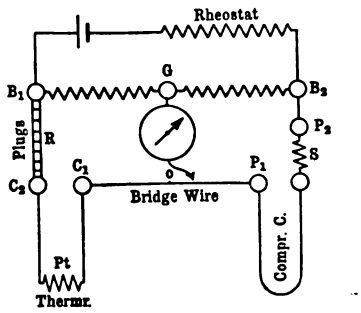

Fig. 4.—Diagram of Connections for Thread Recorder.

A practically continuous record may be obtained by the deflection method if the thread recorder of the Cambridge Scientific Instrument Co. is used. The standard type of thread recorder is a fairly robust instrument, having a resistance of about 10-12 ohms, and a scale of 80 mm. to 1 millivolt. With a copper constantan thermocouple this instrument gives a scale of about 3 mm. to 1°C., which is rather too small for clinical records. With a resistance thermometer, it is easy to get a scale of 50 mm. to 1°C. if desired, but a scale of 10 mm. to 20 mm. is usually sufficient. In using the thread recorder with a resistance thermometer, some form of platinum thermometer bridge with a slide-wire is required, and a rheostat or resistance box capable of fine adjustment between 30 and 50 ohms. This rheostat is connected in series with a 2 volt storage cell to the battery terminals, B, and serves to adjust the scale of the record. The thread recorder is connected to the terminals marked G on the bridge, one of which is connected between the equal ratio coils of 10 ohms each, and the other to the sliding contact on the bridge-wire, as shown in Fig. 4.

The two thermometer leads are *not* connected to the terminals marked P on the bridge (which is the usual arrangement when the balance method is used), but to the terminals marked C_1 C_2 (for compensator) so as to be in series with the adjustable plug resistances denoted by R in the annexed diagram of connections. The compensator leads are connected in series with the balancing coil denoted by S in Fig. 4, to the terminals marked P, P. With this arrangement the resistance S+C is nearly constant, so that if the galvanometer deflection is adjusted to be correct when the thermometer is at 0°C. or 20°C., or any convenient temperature, the scale will be very nearly correct when the thermometer is at any other temperature, the plugs R being suitably adjusted.

After describing the method of testing for defects and the calibration of the scale of the galvanometer, the author considers the balance method with the slide-wire recorder. This is the type of

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recorder generally employed with resistance thermometers, especially where a large range of temperature is to be covered. It is equally applicable for clinical work, or for small ranges of temperature, provided that a suitable thermometer is employed, and that the current is properly adjusted to avoid excessive heating of the thermometer. It gives a strictly continuous ink record, with a pen attached to the sliding contact on the bridge-wire, which is automatically maintained at the balance point by means of a pair of motor clocks actuated by the deflection of the galvanometer. The galvanometer coil carries a light arm terminating in a contact fork consisting of two short platinum wires close together. A wheel with a platinum edge rotates between these two wires, one or other of which makes contact with the wheel (according to the direction of deflection of the galvanometer), and completes a relay circuit actuating one or other of the motor clocks. This form of relay is incredibly delicate, and has since been adopted by Brown for the purpose of submarine telegraphy. The scale of the instrument is independent of the E.M.F. of the battery, being determined by the resistance of the bridge-wire in relation to that of the thermometer. A recorder of this type is more expensive than the thread recorder, but is complete in itself, with the exception of the battery, and does not require either an auxiliary resistance box or a rheostat for adjusting the scale. It is a great advantage in practice that the scale never requires adjustment, but is always correct to about 1 in 1,000, provided that the bridge-wire is correct and uniform. For ordinary work thermometers are generally provided with an "ice-bobbin" or balancing coil, equal in resistance to the thermometer at 0°C. Some observers have experienced trouble with this type of recorder owing to the heating effect of the measuring current. Such troubles have arisen chiefly from the employment of unsuitable thermometers with excessive currents. With a 26 ohm thermometer the instrument can be adjusted to work perfectly on a scale of 4 cm. to 1°C. with a current of one hundredth of an ampere through the thermometer. The record can be read easily to less than a hundredth of a degree, or 1 in 30,000; and the heating effect of the current, with a celluloid thermometer of the surface type described, is only two or three thousandths of a degree, or practically inappreciable on the most open scale of the record.

The testing and adjustment of the slide-wire recorder are next dealt with by the author, who finally gives some interesting records which show that accurate clinical records of temperature on a fairly open scale under practical conditions may readily be obtained by the aid of electrical resistance thermometers, with either of the recording instruments above described.

POWER FOR ELECTROLYTIC COPPER REFINING.*

BY W. L. SPALDING.

Power is an important item in the cost of electrolytically refining copper. Per ton of product, it is less than in many electrochemical industries, since with soluble anodes the voltage factor of the power is used mostly in overcoming the ohmic resistance of an electrolytic and metallic circuit, and meets no opposing E.M.F. from decomposition of the electrolyte. Nevertheless, this item is in round numbers 40 per cent. of the cost of converting anode to cathode copper, or 20 per cent. of the cost, including furnace treatment. The relative amount, though not the actual, is increased by the extensive use of labour-saving machinery and mechanical handling of material. This use has been so far perfected that further reduction of costs must most easily be obtained through lower power charges.

In securing cheap power there are several considerations which greatly aid the refiner. First, the unchanging resistance and the continuity of the process allow a constant load day and night, and the steadiness and magnitude of the power used ensures the economy either of its generation at the plant or of its purchase from a power company. Secondly, waste-heat boilers on the reverberatory and cupola furnaces furnish considerable power at little expense, since the item of fuel is entirely eliminated from its cost, and were there a sufficient amount of it the refiner would not need to seek further. Its one disadvantage is its irregularity; for several hours during the day the furnaces are being dipped, charged or repaired, and furnish little steam, while for a couple of hours in the morning during poling they give a large quantity. The amount of this power available for electrolytic work depends, therefore, upon the material treated at the refinery, one commencing with pig copper or anodes receiving relatively a much smaller amount than one smelting ores or concentrates.

The purchase of electric power from a power company is very desirable electrically, and under some conditions is the most economical. If alternating-current power is received, the units for supplying the tank house circuits are synchronous motor-generator sets, which give a high efficiency of conversion, a 100 per cent. power factor, great facility of operation and regulation, and practically uninterrupted service. A refinery thus equipped should be the most favoured customer of the power company, as, with proper regulation, the load curve is absolutely flat, and no interest charge on machinery held in reserve can equitably constitute a portion of the rates. Moreover, the refinery may be used for filling up the valleys in the company's load curve, and the refiner may be able to contract for additional power at such times as the company directs for a figure lower than for his steady 24-hour load. It is true that the current-density will increase at these times, but as the deposition of copper can proceed satisfactorily under a wide range of current-density, this fluctuation is not open to the same objections as in processes that require a fixed minimum voltage or a constant supply of heat. A calculation of the saving from this cheaper power should involve the consideration that the cost of power per ton of copper is nearly proportional to the current-density, and too great an increase in the density will overbalance the lower rate. On the other hand, steps may be taken materially to lessen this increase. The tanks with insoluble anodes used for depositing excess copper from the electrolyte may be placed in circuit only at these times; each takes about eight times the energy of the ordinary tank, due to electrolytic decomposition, so that if their number is 2 per cent. of the total, their resistance is 14 per cent. of the total. A certain number of other tanks are also regularly short-circuited during the day for cleaning. Also it must be borne in mind that the current-density is proportional to the square root of the power, and hence its variation is less than that of the power.

In Buffalo, the cost of Niagara Falls power in lots of 500 H.P. or over is £5. 10s. per horse-power-year, which, converted to continuous current at 87 per cent. efficiency, equals £6. 3s., a surprisingly large sum for a region situated near a source of vast water-power. Unfortunately for the consumer, there is but one company owning a franchise in the city, and it has been able to keep the field free from rivals, and itself from adverse legislation. The price of power is, therefore, determined not by competition with other power companies, nor by cost of production, but by competition with steam power.

The refiner who wishes to use both waste heat and electric power for electrolysis is confronted by the interesting problem of combining the two so as to secure minimum cost per ton of output. The most satisfying way seems to be to supply a tank house circuit with two generators in parallel, one driven by a motor running on a constant amount of the purchased power, the other driven by a steam engine whose load varies with the steam. This arrangement permits the load to be divided in any ratio between the two generators by hand or automatic regulation of the shunt field rheostats, or the engine may be shut down on Sundays and during the dipping of the furnace charges when the supply of steam is not more than sufficient for driving air compressors or pumps and heating or evaporating the electrolyte. When the two loads are very different the equilibrium is delicate, but not disturbed. A series arrangement of the generators with half the circuit interposed between them would divide the voltage between the tank house terminals and decrease the current loss through earths, but excessive sparking due to the commutation of heavy current in a weak field would not allow the engine-driven generator to carry as small a load at periods of low steam. It is not economical to use the waste heat power on an independent circuit, as part of the time it would receive little or no current; the output of copper with a given power is proportional to the square root of the number of tanks and the electric power could be used to greater advantage if spread out over this circuit.

To determine the number of kilowatts to be bought for each month, a calculation of the amount necessary for the desired production should be made, the probable power from steam deducted, and the remainder maintained as a constant load on the motor. When the power paid for is the maximum two-minute peak occurring in the month, and these peaks are recorded by a graphic wattmeter, close regulation is essential. This can be obtained by hand regulation aided by a bell alarm, or, better still, by an apparatus that automatically changes the resistance of the shunt-field circuit of the generator when the wattmeter on the motor circuit records more or less than the desired quantity. With this attachment, the maximum two-minute variation from the average will be less than 5 kw. This combination of power necessarily gives a current-density greater at night than at day, but the fluctuation is not objectionable, and can be decreased as already mentioned. Further uniformity can be secured by using the peak of the steam for storing up heat in the electrolyte at night, and by rearranging the schedule of the furnaces so that their periods of dipping do not coincide.

The practicability of the use of electric power for refining copper has a direct bearing on a problem that is receiving considerable

* Abstract of a Paper read before the American Electrochemical Society.

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attention in the industrial world—the problem of meeting, on the one hand, the demands of the electrochemical manufacturer for cheap power and, on the other, the desire of producers of electrical power to obtain customers who maintain a constant load, or who, better yet, can use large amounts of it at times when the rest of the producer's load is light. The magnitude of the scale on which electrolytic copper refining is now conducted makes the availability of cheap power an important consideration in the location of the refinery; and at the same time such a plant is an ideal customer for the power company. The existence of these common interests makes certain a mutual profit from their mutual recognition.

THE HIGH-TENSION NETWORK OF A GENERAL POWER SYSTEM.*

BY P. M. DOWNING.

Summary.—The author describes the experience of the Pacific Gas and Electric Co. with their extra high-tension transmission lines at from 20,000 to 100,000 volts pressure. The method of operation, transformers, switches, insulators, &c., are discussed.

This Paper is restricted to conditions as they have developed and as they exist in California at the present time, and to the experiences in connection with the different transmission systems, which together form probably the greatest mileage of high-tension network to be found anywhere in the world.

The system of the Pacific Gas & Electric Co. as it stands to-day represents the consolidation of a number of smaller companies, each with a system peculiar to itself. As a result, almost every type of apparatus is represented. This Company controls and operates 11 different hydro-electric generating stations, having an aggregate capacity of 64,270 kw. at generator pressures of from 500 to 5,500 volts. Ten of these stations have a common frequency of 60 cycles and run in parallel on a 60,000-volt network, which is also supplied with additional power from four independent companies. The Great Western Power Co. delivers 60,000 volts by stepping down from its main line voltage of 100,000; the Sierra & San Francisco Power Co., the Northern California Power Co. and the Snow Mountain Power Co. deliver current at 60,000 volts direct. At times the load carried by these four companies amounts to an aggregate of 41,500 kw. In addition there are steam and gas engine plants in reserve at three stations to a capacity of 21,500 kw.

The entire length of lines represented by the different systems which are tied together, exclusive of those of 11,000 volts and under, amounts to 1,920 miles. The voltages of the different lines making up the network are as follows: 150 miles of 100,000-volt line, 1,390 miles of 60,000-volt line and 380 miles of 20,000-volt line. Lines of 11,000 volts and under are not included in the above, as they are considered merely as distributing lines.

The paralleling of stations in this manner, regardless of the length of line between them, or the loads carried, has not developed any difficulties, but on the contrary it has been found that it could be done much more readily than where the generators are paralleled in the same station; nor is it customary to do this paralleling at generating stations alone, or on the low-voltage side of sub-stations. As a matter of fact, it is done almost entirely on the 60,000-volt side, using transformers of relatively small capacity connected from line to earth for synchronising purposes.

Operation.—The governing and the division of load between the different stations furnishing power to a system of this kind is not as great a problem as it would at first appear. Each station, excepting one, takes its alloted portion of load and makes no attempt whatever to govern, unless the frequency varies beyond certain predetermined limits, the speed control being left entirely to a single station. All important power houses are equipped with governors, which, except in the case of the governing station, are set so that they will be sluggish in their action, and will not operate except on wide variations of speed. Those in the governing station should obviously be adjusted to regulate as closely as possible. The governing is not limited to any one particular station, but it can be done at any station having sufficient capacity to handle the fluctuations of load.

In order to operate with a large number of stations running together we found it necessary to have a chief operator, or what we have seen fit to call a "load dispatcher," who, so far as the details of operation are concerned, is in absolute charge of the entire system. In his office there is a board showing diagrammatically every generating station transmission line and sub-station on the system, together with dummy switches representing every air and oil switch, and the exact position of these switches, that is, whether open or closed. In addition to the record as shown by the board, a very complete log is kept of every detail in connection with troubles of any kind, loads carried by the different stations, and any other matters pertaining to operation.

Telephone circuits are run on all transmission lines, but these are not depended upon for anything more than local use, such as for linemen reporting on and off the line, &c. They do not give satisfactory service when used over long distances, and they become inoperative when there is trouble on the line and when they are most needed. For communicating between important stations we have circuits leased from the telephone company, which run on its regular toll line leads, and being over entirely different routes are not affected to any extent by transmission troubles.

As stated above, the different stations are, for the greater part of the time, operated in parallel. There are two distinct advantages in operating in this manner: (1) The regulation of voltage is much more readily accomplished. (2) The capacities of the different stations can be utilised to their fullest extent. On the other hand, there is a distinct disadvantage, as trouble on any part of the system will, to a certain extent, affect the entire system.

The inductive drop on the long lines forming a network of this kind is obviously high, especially where the induction motor load is heavy and the power factor correspondingly low. The wattless current, therefore, becomes quite a problem, and has to be taken care of either by distributing it among the different power houses, or by taking it entirely on a single station, which can be handled very readily by proper adjustment of generator fields.

From an operating standpoint, and in order better to guarantee continuity of service to the more important districts, a reserve steam plant is very essential, and in this respect the modern steam turbine serves the purpose admirably. By reason of the fact that it operates equally well at all loads it can be connected in parallel with the transmission line, and under normal conditions will carry a good portion of the wattless current. At the same time it acts as a stand-by, and in case of line trouble it can pick up the load on very short notice.

Troubles on the long lines forming networks such as this do not always seriously affect the entire system, but show only as momentary drops in voltage. The station generators are connected directly to the line without circuit-breaking devices of any kind, and power is never cut off the lines unless it is impossible to keep it on. Immediately on the slightest indication of line trouble the system is separated, leaving different sections or districts supplied from different sources. If the trouble is far enough removed from the generating station it will not be very severe on account of the inductive and ohmic drop of the intervening lines, and generally the operators will have time to separate the sections without more than a temporary drop in voltage. If, however, the trouble is near a power-house, that particular station will be thrown out of synchronism with the system, and even the machines in that station may be thrown out of synchronism with each other.

The greater number of the lines feeding into the system are supplied from transformers delta-connected on the low-tension side and star-connected on the high-tension side with the neutral earthed. This arrangement has proved very satisfactory, and while it might be said that there is a disadvantage in using such a connection on account of the earthing of one wire throwing a short-circuit on the system, yet there is a question as to whether or not this is a real disadvantage. Where lines are run along public highways and through more or less thickly settled districts it seems almost necessary that there should be some very positive indication to show when a wire goes down.

Some objection has at different times been raised by the telegraph and telephone companies to an earthed neutral system, on account of the inductive influences due to curent through the ground, at times when the load is unbalanced. Experience, however, has shown that this is not the real cause of the trouble, but that the troubles these companies have are the result of what might be called static unbalance, or high-frequency disturbances due to arcing earths, or other causes which occur to a greater extent in an unearthed system than in one where the neutral is earthed, and therefore at zero potential. This statement is borne out by experiments.

Our usual practice is, where one of three transformers in a bank at the generating end is out of service, to carry load up to the capacity of the other two, or should occasion demand, to over-load the two, making them carry the normal load of the three. This same condition obtains in the case of step-down transformers. When the load to be supplied is small, and where the expense of installing three, or even two transformers to give a three-phase distribution would not be justified, it is customary to instal a single transformer, connecting it from the line wire to earth. Installations of this kind ordinarily give no trouble whatever, but work as satisfactorily as though a bank of three were installed. Careful attention must

*Abstract of a Paper read before the American Institute of Electrical Engineers.

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always be given to the earth connection. These are made by connecting to the water mains, and also to earth plates buried to a depth depending on the character of the soil.

Occasionally it has been found where only a single transformer is used, that a severe static stress occurs on the low-tension side, which is severe enough to puncture the insulation of the lower voltage transformers supplied from the main transformer. These instances, however, have been comparatively few, and while it is something which might be expected from a connection of this kind, it very seldom occurs, and it has never been serious enough to make it necessary to abandon the practice.

The connection on the low-tension side of the step-down transformers is either delta or Y, depending entirely on the particular voltage condition to be met. Where the Y connection is used the neutral is earthed in the same manner as on the high-tension side, and to the same wire. So far as the actual operation of the system is concerned, there is no preference as to the connection on the low side, but for economic reasons the greater number of low-tension distributing systems are supplied from the Y-connected transformer. We have never yet had any troubles which we could trace back and find to be the result of the manner in which transformers were connected.

Transformers.—The capacities of transformers used range from 100 kw. to 1,500 kw. Most of them, except some of the smaller sizes, are shell type, oil-insulated and water-cooled. The most satisfactory case for oil-cooled transformers is one of boiler iron mounted on a cast-iron base and having a cast-iron top. The merits of the different insulating materials used in transformers for high-voltage work, the kind of oil to be used and the methods of cooling the oil have been much discussed. During the past few years the tendency of the transformer manufacturers has been toward the use of a press board or horn fibre for the insulating barriers between the coils, this material being used to replace the micanite used in the earlier transformers. This gives a transformer of lower first cost, but one correspondingly less staunch and reliable. The micanite insulation has two distinct advantages; first, it will not absorb moisture as readily as the pressboard or horn fibre; and second, being non-inflammable, it will localise trouble, and a burn-out in one coil, unless it be exceptionally bad, will not damage adjacent coils. Until a few years ago all of the transformers on the system had micanite insulation. They would be received from the factory, and without attempting to dry them out they would be filled with oil and put into service. The oil was generally shipped in iron drums containing from 50 to 100 gallons, and when received, it would be put into the transformer without treatment of any kind, and even without being tested to see that it had the proper dielectric strength. The pressboard has superseded the micanite, and the methods of handling transformers have entirely changed. We now find it necessary to dry them out thoroughly even after they have been standing without oil for not more than 10 days or two weeks. The oil also is being handled much more carefully than formerly, and separate samples taken from the different tanks in which it is shipped must be tested. If the dielectric strength is found to fall below a certain standard, it is safe to assume that the low insulating qualities are due to moisture, which can be readily removed by heating to a temperature slightly above 212° F.

The pressboard or horn fibre will not only absorb moisture from the atmosphere, but it will, when in direct contact with water, absorb sufficient of it to allow the layers of fibre making up the sheet to separate, thus rendering it worthless. This objection to its use might on first thought seem hardly worth considering, but in practice it is an important one. In handling transformers out of doors during stormy weather, or in the event of a damaged water coil allowing water to get into the winding, the pressboard would be damaged to such an extent that the transformer would have to be torn down and the barriers replaced.

As to the relative fire risks of air and oil-cooled transformers, I think it is now generally conceded that the oil type with a properly designed case is the safer of the two. The greatest danger from an oil-insulated transformer is from fire external to the transformer itself, which might damage the case and allow the oil to escape.

From the point of view of operation, particularly in connection with long high-voltage lines, I am inclined to question the advisability of attempting to sacrifice the reliability of the transformer in order to cut down the first cost. In the absence of any approved device or apparatus that can be relied upon to take care of high-voltage line disturbances, the transformer must bear this burden to a very great extent, and the breaking down of a transformer with the resulting interruption to service will in a very short time more than offset any saving in first cost. For this same reason the three-phase transformer is at a disadvantage, as trouble on one phase would entirely interrupt service unless a spare were installed.

For cooling the oil we employ the usual method of circulating water through copper coils immersed in oil. Different metals have been used in these coils, but on account of there being less liability of copper being acted upon by acids in the cooling water, and also because of the fact that it will not corrode, it has been found most satisfactory. In localities where there is any great amount of mineral in the water, a cooling coil will in time become filled to such an extent that it will not carry a sufficient amount of water to cool the transformer. This deposit closely resembles boiler scale, and in some instances it can be removed by taking the coil out of the case and hammering it on the outside to loosen the scale, after which it can be blown out by either steam or compressed air. In cases where it cannot be removed in this way we have used dilute muriatic acid as a last resort, but as this acts upon the metal of the coil, as well as upon the scale, it cannot be considered entirely satisfactory.

Periodic pressure tests are made on all cooling coils without removing them from the transformers, and very often without taking voltage off the transformer. This we do by disconnecting both ends of the coil and allowing the water in the lower turns either to drain off, or, if both ends of the coil come up over the case, a small rubber hose is inserted on the riser side of the coil and the water syphoned out.

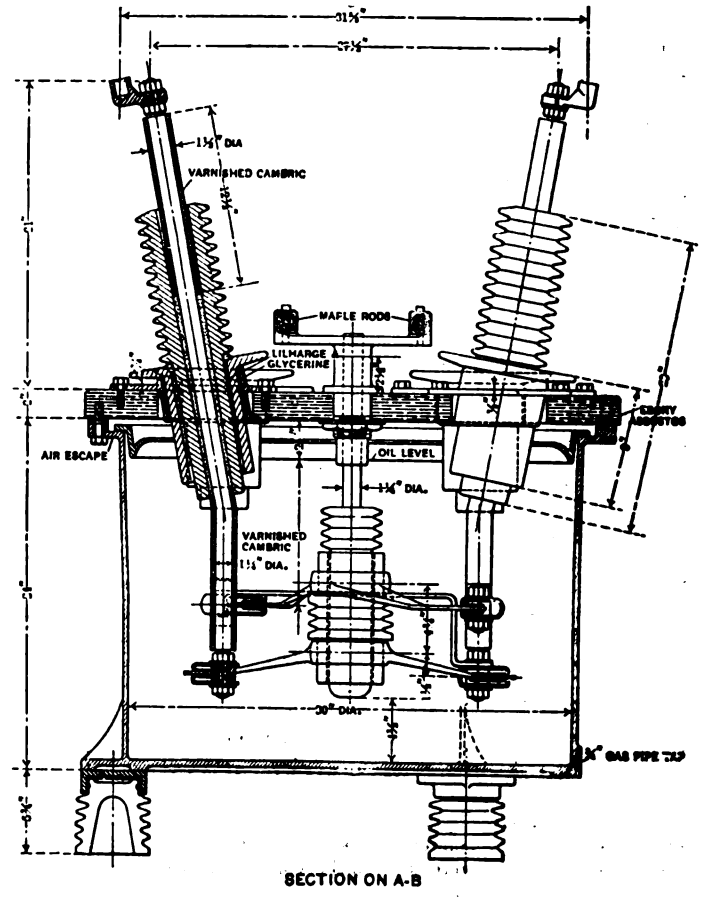

FIG. 1.—SECTIONAL ELEVATION OF HIGH-TENSION SWITCH.

To know that the coil is thoroughly dry, and that in the event of its breaking down under pressure no water will get into the transformer winding, a light blast of air is passed through the coil, which, with the heat from the oil on the outside of the coil, will in a very short time remove any moisture which might remain. One end of the coil is then plugged and air pressure applied by means of an ordinary automobile tyre pump. A small pressure gauge connected to the coil shows the pressure on the coil, and also whether or not there are any leaks which would allow the pressure to drop. Generally where there is no back pressure on the coils, 15 lb. to 25 lb. will be as high a test as is necessary.

Switches.—Outside of the lightning arrester or line discharger for taking care of high voltages, high-tension switches were probably slower to develop than any other piece of apparatus used in connection with long transmission lines. The system of the Pacific Gas & Electric Co. was one of the first to use oil switches for voltages in excess of 40,000. As early as 1900 we built and put into operation switches which were of practically the same type that we are now using. While the switch was in the experimental stages the framework supporting the tanks was of wood, and the tanks themselves were the ordinary fibre or paper mâche tubs such as are used for

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laundry purposes. Switches of this kind served their purpose well, and are even now in use after years of service, but where they are called upon to break heavy loads, such as come on at times of short-circuit, they are apt to throw the oil out of the container when operated.

To overcome this trouble we designed a four-break switch along practically the same lines, but with a considerably greater depth of oil over the contacts. Four-break switches similar to that shown in Figs. 1 and 2 have been in service in some of our largest power-houses for several years, and they have never failed to open the line under all conditions of short-circuit. The particular features which recommend this switch are: (1) The absence of any insulating material that might become saturated with oil and catch fire either from leakage or from an arc. (2) The insulation of the switch from the ground, thereby affording the greatest protection against break-downs due to surges or other high-voltage disturbances when the switch is open. (3) A constant depth of oil over the contacts at all positions of the blades. (4) The comparatively small amount of space taken up by the switch.

We have never attempted to operate any of these high-tension switches either automatically or by any electric or pneumatic means, preferring rather to keep to the more positive hand-lever control. This control has generally proved quite satisfactory, but we have just installed some reverse current relays to be used in connection with the automatic operation of switches on lines which are connected together at both ends. We have yet to learn to just what extent these can be successfully employed, on account of the inherent weakness of alternating-current reverse-current relays, whose operation is dependent on both current and voltage, and the fact that in cases of severe trouble the voltage may drop so low that the relay will be inoperative.

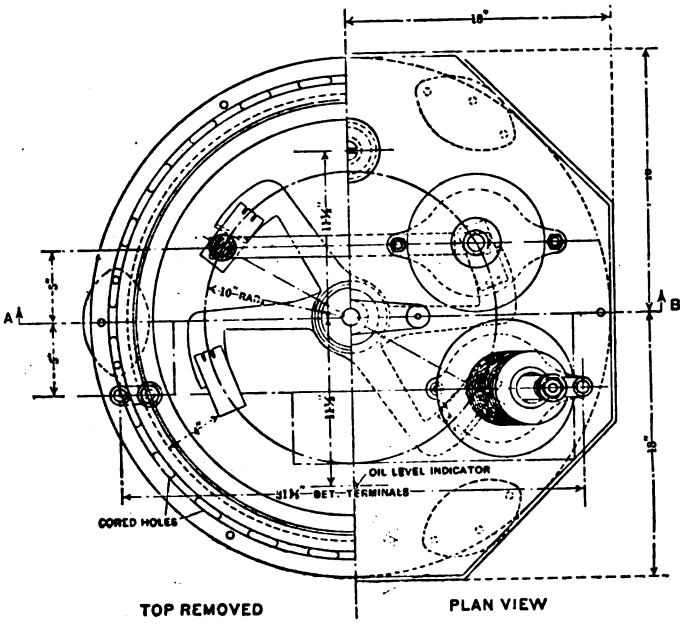

FIG. 2.—PLAN OF HIGH-TENSION SWITCH.

Lightning Arresters.—Except in the higher mountain districts, the Pacific coast is comparatively free from lightning, and we make no attempt whatever to protect against lightning disturbances. We use only the horn-gap type arresters with the air-gap set so that they will arc across on voltages approximately 25 per cent. above normal. The particular design of arrester used consists of two gaps in series with the earth side connected directly to earth without resistance. These are used more on account of their being voltage limiting devices than on account of their being a protection against high voltages. We do not instal them at every station, but only at the power-houses and more important stations where heavy switching is done.

Insulators.—The limiting voltage of a transmission system is at present governed by the insulators. The climatic conditions of the greater part of the Pacific coast are peculiar in that there are two seasons, one wet and one dry; and it may seem strange to say that the insulator trouble during the dry season, or just when the first rains start, is as much as or more than during the winter storms. The trouble is due to leakage over the surface of the insulator on account of the dirt and the salt which is deposited by the ocean fogs. As soon as the heavy rains come this accumulation of dirt, &c., is washed off, and the number of insulator troubles is materially reduced. The suspension insulator has a decided advantage in the fog district (where cleaning of pin insulators is necessary twice each year), in that a much greater part of the surface of the insulator is exposed to the rain and dirt is washed off during stormy weather. However, with the higher voltages at which this type of insulator is designed to be operated, there is every reason to think that similar troubles will be experienced, and doubtless the same homely means will sooner or later be resorted to in order to overcome it.

RESULTS OBTAINED AT THE BOULOGNE RADIO-TELEGRAPH STATION.

In a Paper read before the Société Internationale des Electriciens, A. Tosi gives a description of the new wireless telegraph station at Boulogne, together with some results of experiments which have been made there. The general appearance of the station and its aerial system can be gathered from the photograph already given in THE ELECTRICIAN of December 24, 1909 (p. 421). As regards the construction of the aerial, it suffices to say that in the present case, although for the Bellini-Tosi directive aerials pairs of inclined antennæ are used, the angle made with the vertical being about 32 deg., the distance between the tops of the aerials is now largely increased, being some 81 metres, as compared with 3 metres at the Dieppe experimental station. A further point is that the conductors joining the lower ends of the aerials are raised higher (4 metres) above the ground. The whole design thus approximates more nearly to what theoretical considerations indicate as being desirable. The station is fitted for working with the fixed wave-length of 300 metres for both the directive and the ordinary systems. A somewhat unusual method of working on the harmonic is employed, the natural wave-length of the directive aerial system being artificially increased so that it is three times as great as the wave-length used for signalling. For receiving, the ordinary system is used as a finder, or, in other words, for picking up signals, and the change over to the directive system is then made—by turning a switch handle—the security against interruption from ordinary or atmospheric causes being made greater with the directive method.

The results obtained as regards communication are stated to be excellent, messages having been regularly exchanged at night between Boulogne and Algiers, a distance of 1,500 km., using only ½ kw. of primary energy at Boulogne. It has been found that in all cases the signals received on the directive system—which is not earthed—are considerably stronger than those of the ordinary system. Some quantitative experiments made with a Duddell thermo-galvanometer at a distance of 3 km. from the station showed that, using the directive aerial, the deflection obtained is practically six times (113 : 19) as great as with the ordinary vertical antenna (earthed).

The concluding portion of the Paper makes mention of the use of the radiogoniometer on board ship for position finding. The author calls the radiogoniometer when used for this purpose a "wireless azimuthal compass," since it serves the same purpose as the standard compass.

In the course of a voyage to New York and back on the "Louisiane," of the Compagnie Générale Transatlantique, which was fitted with a temporary compass installation, it was proved that the useful range of the wireless compass was at least equal to that of the standard compass—namely, about 40 km. The bearings of several wireless telegraph stations as determined with the wireless and the standard compass were always identical. The important point was also established that the elevated metal parts of the vessel have no influence whatever on the bearing as determined with the wireless compass. The use of such a compass in time of fog is obvious, and is still further increased if a land station fitted with the directive method is available within range.

BOOKS RECEIVED.

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"Science Abstracts." Vol. XIII. Part VIII. Section A—Physics; Section B—Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

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The "INDUSTRIAL SUPPLEMENT" is a comprehensive record of developments in Electrical Plant, Machinery, Apparatus, Accessories, Sundries and Materials, and of their proved suitability for various industrial purposes.

DIELECTRIC LOSSES IN CABLES.

Cable makers have often been reproved in the past for the air of mystery which is said to surround their proceedings. Not that it is alleged that other manufacturers are any less secretive, but it has become a standing joke to affect an air of amused surprise when a cable maker takes part in any discussion at the Institution of Electrical Engineers. Why this should be so we do not pretend to know; we merely record the fact. If there are any mysteries connected with the art of cable making, there is no reason why anyone should be called on to disclose them. Probably the whole thing is a matter of accumulating experience, and no one can blame the man who refuses to give away his most valuable asset.

Still, the progress that has been made of late years in the matter of making cables has been very great. When one considers the raw material out of which the insulating medium is evolved, and the way in which these substances are liable to vary commercially, and the extraordinary difficulty of carrying out the process on a large scale, so as to get a product that shall be sufficiently uniform to stand the test of time and galvanometers, we can only feel satisfied that a good deal has been already learnt. It has almost certainly been learnt in some form or another by experience alone, in which the element of time has played a very important part; workshop test-rooms have probably taught something, but laboratory tests little or nothing.

However, there are certain important aspects of the problem on which light can only be thrown by galvanometers and oscillographs, and specially among these are matters that are referred to under the head of dielectric losses, though they have not so far produced results that are

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capable of affecting the routine of the workshop to any large extent. It is not so many years since the question of dielectric losses was first mooted, only to be met with the derisive suggestion that the whole thing was a mare's nest. If we look back to the year 1901, when Mr. W. M. MORDEY read his Paper on the subject, it is easy to see what was then the state of knowledge on the subject. A very stormy discussion hinged on that Paper, but it led many to look a little deeper into the problem. Anyone who has had to do with the testing of cables knows that it is often accompanied with many perplexing incidents which need care for interpretation. After-thoughts and side-lights help one forward; but that man would be either very bold or very young who thinks that anything short of very prolonged work is sufficient to draw the veil from the many mysteries connected with the functions performed by the insulating cover of a high-tension cable. Without in any way depreciating the work which has been done in this country, it is only fair to say that a great deal of light has been thrown on the subject of dielectric hysteresis by the work which has been undertaken from time to time in the test rooms of the German makers. APT and MAURITIUS, on behalf of the Allgemeine Elektrizitäts Gesellschaft, in 1904 published valuable results; HUMANN in 1906, on behalf of Felten & Guilleaume, did the same; and Herr HÖCHSTÄDTER, working on behalf of the Siemens-Schuckert works in Berlin, in an investigation extending over more than six months, has now published his results, of which we give an abstract in our present issue. We think that this abstract will be read with great interest by those who have in any way studied the problem, and, if they do so, we think they are likely to agree with us in saying that it is no longer possible to reproach the manufacturer with any backwardness in the search for knowledge, or any disposition to hide from others, within certain limits, such things as he has found out.

When studying such a question as dielectric hysteresis great difficulty is experienced in the measurements owing to the low power factor. But they are not insuperable, as Herr HÖCHSTÄDTER and others have shown. His work is both interesting and important, owing to the fact that he has extended his researches to very high voltages, and has devised a very ingenious and successful method by which he has traced out the hysteresis loop, similar in all respects to the analogous case presented by the problems connected with the magnetisation of iron. He has applied voltages up to 60,000 and even more, and has continued up to the point at which the cable eventually breaks down under the electric stress. Some of his conclusions seem to differ from those of previous investigators. For instance, he asserts that the breakdown takes place suddenly; not, perhaps, so suddenly as to give no sign of impending dissolution, but so suddenly that if stopped just short of the point at which it is clearly seen that the cable is about to break down, it will after a short interval resume its normal state without trace of any internal change. Its insulation resistance and its capacity will then be found to be the same as before the test began. This is certainly a fact which has been alleged by some to be the case, whereas it has been disputed by others with good show of reason. Moreover, he states that he finds no trace of anything of the nature of a so-called viscosity or polarisation, and this, too, is to some extent contrary to the observations of some who have preceded him. HAWORTH, for instance, has stated that this is not the case with porcelain plates treated as a dielectric medium. It seems quite likely that no general statement can be made on this point, or perhaps on any other point, which applies generally to all types of insulating medium; and something may depend on the peculiarities of the particular substance under examination. Still, dielectric losses seem to be due to a kind of internal friction opposing electrification, whereas they were sometimes thought to be of the type of leakage losses, and to be traceable to the ohmic resistance of the insulation. But there is now a large accumulation of evidence to the effect that this is no true explanation of a loss which varies with the frequency.

Herr HÖCHSTÄDTER'S Paper indeed bristles with suggestive points, and not least of all should be mentioned that which is concerned with the choice of the most suitable frequency for a long transmission line if it should be proposed to use insulated cables. For many reasons it has of late years been found to be necessary or advisable to lower the frequency, and, if any further arguments are necessary, they may perhaps be found in the considerations that are bound up with the losses that are likely to take place in the transmission line in this case. The capacity of such a system of cables is very much greater than that of one making use of bare overhead wires, and the ohmic losses, due to the charging current, which are specially serious at times of light load, may become a factor of sufficient importance to merit attention. Further, there are matters connected with the measurement of the capacity of cables, and the discordant results which depend on the different methods of alternate-current measurement. It is now stated that the capacity, as measured ballistically, is exactly the same as that given by alternate-current methods if proper means are employed in the latter case, whereas the well-known formula, depending on effective volts and amperes, has long been known to give very variable results. This being so, it may help to explain some outstanding points, and to harmonise the disputes which have raged between earlier workers in the field.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Indiarubber and Gutta Percha. Translated from the French of T. Seeligmann, G. L. Torrilhon and H. Falconnet by JOHN GEDDES MCINTOSH. Second English Edition. (London: Scott, Greenwood & Son.) Pp. xvi. + 408. 12s. 6d. net.

The first edition was reviewed in our issue of August 28, 1903 (Vol. LI., p. 780), and this second edition does not seem to have benefited much by revision; on the contrary, the change from the direct to the oblique mode of quotation, where long extracts from the works of various authors or from patent specifications occur, has been so faultily effected that it is often difficult to decide on whom the responsibility for conclusions or remarks rests; while the bibliography has been omitted.

The English is very much of "the French as she is translated" order, and while the chemistry still remains in parts

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"apalling" (the epithet of your former reviewer, than whom no one more capable to determine), the description of the mechanical plant is often bewildering even to the initiated, and must be incomprehensible to the ordinary reader; and the electrical portion displays throughout a lamentable want of acquaintance with the subject. The only method of testing dielectric resistance given is that with the electrometer by loss of charge, and this to be effected by Jenkin's "inferred zero" method of using the instrument, not, however, thus termed, and the description of which is unintelligible; and we would ask what are "Logarithms of the Resistance" tabulated in this fashion "1,973,959"?

The botanical and arboricultural sections are outside our domain.

The contents may be described as a compilation from a very large number of sources, existing mostly at the time when the manufacture of I.R. and G.P. was conducted on tentative and more or less experimental lines, long since abandoned. A small amount of more modern material has been drawn upon, as, for instance, Wright's Paper read before the Society of Arts (wrongly termed "Cantor Lecture") and Obach's Cantor Lecture, as well as Pontio's method of chemical analysis, which latter is based on the determination of certain constituents merely by differences, and can, therefore, hardly be considered as more trustworthy than that of Henriques, which is also described.

Unless, however, the reader have considerable acquaintance with the subject, and so knows how to refuse the evil and choose the good, we fear that he is here presented with a broken reed on which to lean if hoping for reliable information.

We had marked a few mysterious paragraphs for quotation, but we shall confine ourselves to one which stands without beginning of explanation, or end of comment, alone in all its simplicity (italics are in the original): "*Relative resistance* (after a minute of electrisation) *at different temperatures of ordinary gutta percha as cores in which the thickness of the gutta percha does not exceed* 2·79 *millimetres* ($\frac{1}{9}$ in.) (Willoughby Smith)."

The opinion of the vulcanisation of G.P. is thus expressed: "It will be well to pass the unfortunate experiments silently," and we propose thus to treat the further quotations from this "Complete Treatise," for such is the claim on the title page, but, alas! how little confirmed by the text! F. J.

Stromverteilung, Zählertarife und Zählerkontrolle b.i städtischen Elektrizitäts-werken und Ueberlandzentralen. Edited by CARL SCHMIDT. (Berlin: Julius Springer.) Pp. 99. M.2·60.

A great deal has already been published on distributing networks and methods of charging. Nevertheless, a book such as the present volume, which treats of the subject on lines representing the outcome of several years' practical experience, and from the point of view of the altered conditions due to recent progress and the extension of the system of distribution over wider and more scattered areas, forms a welcome addition to the literature of this branch of electrical engineering. Moreover, as the author himself points out in his preface, the results which are embodied in the book are in direct opposition to more generally accepted views. Within the small compass of the work it is not pretended that the whole question has been exhaustively dealt with.

The book is divided into two main portions, dealing respectively with current distribution and supply to consumers, and the main divisions are preceded by an introduction of a general character. The correct dimensioning of the feeders is briefly discussed, and then a number of numerical calculations are given for determining the voltage drop in lighting and power distributing mains, as well as in trolley wires and return rails for a tramway system, and the results are plotted graphically. Certain typical cases are then more closely investigated, with special reference to the voltage differences which occur in the most unfavourable case of a 5 H.P. motor being suddenly switched on in side streets, a corresponding higher consumption in the main streets and an overload of 50 per cent. in an individul route. The positions of feeder and transformer sub-stations are also dealt with, and the question of how to connect large consumers to the supply on the most advantageous lines is also carefully considered. These investigations are ably carried out, and are rendered clear by the aid of curves. Three-wire direct-current systems, alternating-current and three-phase networks are treated in this way. The first portion of the book concludes with examples on tramway feeders and return cables, and current distribution in bulk supply.

The second portion of the volume is on supply to consumers, tariffs and meter control. In a short review it is impossible to give an adequate idea of the contents. This part is divided into five sub-sections—generating and distributing costs, tariffs with capital charges and duration rebates, calculation of the receipts and expenditure in supplying current to small consumers, tariffs for small consumers, and tariffs for large consumers. In each case fully worked-out examples are given. The book is certainly one which deserves close study on the part of those engaged and interested in methods of electricity supply. H. G. S.

Das Elektrische Bogenlicht. By E. RASCH. (Brunswick: F. Vieweg & Sohn.) Pp. xxi. + 176. M6.

This is an extremely interesting book, giving in a concise form practically all that modern physics has to say about the electric arc. This information is carefully classified, so that the inventor or manufacturer can readily utilise it in any work on which he may be engaged. Each theory or physical fact is fully set forth, together with tables of constants or curves embodying recent experimental results where such are available, references being given in most cases to original Papers. The following examples may be given of its contents: Taking first the general theory, there is a clear statement of Schwedoff's ballistic theory of spark discharge, according to which a free ion moves in the electric field in a similar manner to that in which a lead ball falls under the action of gravity in a resistant medium. The curve given by this theory connecting sparking distance and P.D. shows the inflection near the origin obtained experimentally by Baille and Earhart. This theory is clearly explained without any skipping of the steps of the demonstration, and is accompanied by a table and curve giving a comparison of the results obtained by calculation with those obtained experimentally by four independent observers. Everything that is likely to be useful is discussed, *e.g.*, thermal conductivity and specific heat of mixtures of electrode materials, theories of light, &c.

As regards empirical matters, formulæ are given for the variation in the diameter of carbons with current for direct and alternating currents in open and enclosed arcs, including the diameter of the cores of cored carbons. Flame arcs, mercury vapour arcs and salted carbons are also discussed. The book is one of the well-known series "Elektrotechnik in Einzel-Darstellungen," edited by Dr. Benischke, of which the volume on "Illumination and the Emission of Light," by P. Högner, was noticed a short time ago in these columns. It should not be overlooked by any engineer interested in arc lamps who has a knowledge of German. It may be added that the style is clear and should not offer difficulty to those whose knowledge of that language is comparatively small.

The Aeroplane Portfolio. (London: Percival Marshall & Co.) 1s. net.

This portfolio contains nine scale drawings of the Farman, Voisin, Santos Dumont, Wright, Curtiss, Cody, Blériot, Antoinette and Rep aeroplanes, along with a pamphlet giving a short description of each, drawing attention to the chief characteristic points. The drawings are well done, and as the scale is generally in the neighbourhood of 4 ft. to the inch, a good deal of detail is shown. In each case the lift in pounds per square foot per horse-power is stated, but we should like to know on what the value of the horse-power is based. Unfortunately, its determination is generally very vague. It would add to the interest of the pamphlet if the author would in future include the weight of each aeroplane, the weight of the engine and the pounds per horse-power of engine. The portfolio will no doubt be welcomed by those interested in aviation, and we hope the author will keep it up to date, for progress is rapid in this new branch of engineering.

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RECENT PHYSICAL RESEARCH.

III.—RUTHERFORD'S WORK ON THE α-PARTICLE.

BY DAVID OWEN, B.A., B.SC.

In the era of electrical research which one may conveniently date as beginning with the discovery of X-rays, one investigation has been by common consent singled out as a supreme intellectual and experimental achievement—namely, Sir J. J. Thomson's "counting" experiment, culminating in the estimate of the value of the charge of the electron, or negative unit of electricity. This result was announced in 1903. A second outstanding piece of work is that selected for the subject of this article, and embodied in two memoirs presented to the Royal Society in 1908. The first is entitled "An Electrical Method of Counting the Number of α-Particles from Radioactive Substances"; the second, "The Charge and Nature of the α-Particle." We may now accept the α-particles emitted by radioactive bodies, amongst which radium itself occupies the place of first importance, as consisting of rapidly moving particles of *helium* carrying a charge of positive electricity. If we denote this charge by the symbol E, using e to denote the numerical value of the unit negative electric charge, then, according to the above work of Prof. Ernest Rutherford, we have $E=2e$. The particles emitted by different radioactive bodies differ only in the speed of ejection. In their passage through matter they smash up or ionise the molecules in their path. In doing so they lose kinetic energy, and at a certain minimum velocity their ionising action ceases. The distance traversed, or the "range" of action, increases with the velocity (about one-tenth the speed of light) of initial projection. For example, in air at normal pressure the range of α-particles from radium emanation is 4·3 cm., whilst for those from radium C the range is 7 cm.

The determination of E involved two operations. Firstly, the actual counting of the number of particles emitted in a given time by a particular sample of radioactive matter; and, secondly, the direct determination of the charge carried by the same particles in the same time. The unique feature of Rutherford's work is the experimental method selected for the counting experiment, a method which was carried in his hands to a triumphantly successful conclusion.

It is well known that a screen of zinc sulphide when subjected to bombardment by a sample of radium shows scintillating points. This brilliant effect is plainly seen in the scintilloscope, and is now delightfully familiar. It was early observed that these scintillations were due to α-radiation, and not to β or γ-rays; and it was suggested that possibly there was one scintillation for every α-particle striking the zinc blende target. Rutherford's results establish this as a fact. In the scintillating point we have the visible effect of a single atom of matter, the helium atom, impressed with the enormously high velocity of its projection from a radioactive body.

The identification of the α-particle with the helium atom (with positive charge) has been carried by Rutherford to a remarkably direct test. The Papers already quoted, in conjunction with earlier work, lead to the result that the α-particle has a mass 3·84 times that of a hydrogen atom. The atomic weight of helium is known to be 3·96. The agreement of these numbers might be considered sufficiently within the probable limits of experimental error to warrant the deduction that the α-particle is identical with the helium atom. The direct experimental proof by Prof. Rutherford is in itself a further notable achievement. It will be found described in the "Philosophical Magazine" for February, 1909.

We will now proceed to consider the essential details of the crucial experiments referred to.

1. *Measurement of E.*—The determination of E consists in the measurement of the ratio

$$\frac{\text{total charge carried by a stream of α-particles}}{\text{number of particles in the stream}}.$$

Let us take first the method of determination of the denominator—that is, the "counting" experiment. The detectibility of the α-particle lies in the very great ionising power it possesses. It is estimated that in its passage through a gas, 46,000 ions are produced. Imagine these ions to be produced in the gas between a pair of parallel metal plates maintained at a steady difference of potential. The ions of one sign would be swept by the field into the plate of opposite sign. Thus, if one plate is insulated its charge would be instantly altered by 46,000 e for each α-particle shot between the plates, where e denotes the ionic charge. This amount lies just on the verge of detection by a sensitive Dolezalek electrometer. To enhance the effect a magnifying device was employed. Townsend has shown that the production of a spark by an electric field is due to the rapid generation of fresh ions which is caused by the collision with neutral molecules of the ions already present in the gas, and which, moving along the lines of the field, acquire the requisite amount of kinetic energy. For P.D.s much below the sparking P.D. only the negative ions are effective; but very near to the sparking P.D. the positive ions come into play, and likewise generate fresh ions. If, then, an α-particle be fired into the gas exposed to an electric field somewhat below the sparking value, each of the ions formed may in its turn generate fresh ions, multiplying in that proportion therefore the charge swept into each plate bounding the field. Such was the plan adopted by Rutherford. Each ion generated by the α-particle generated several thousands in its passage through the field.

Fig. 1 shows the apparatus employed. The radioactive preparation is placed in a very thin layer about 1 sq. cm. in area at D, centrally on the end of a hollow iron tube, P, which can slide along the interior of a glass tube, KL, 2·5 cm. in diameter and some 4 metres in length, one end of which is fitted with a diaphragm containing at its centre C a

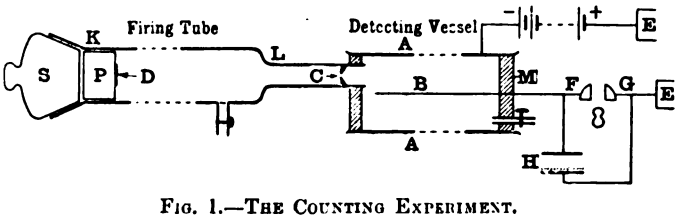

FIG. 1.—THE COUNTING EXPERIMENT.

hole of known size, about 1·5 mm. diameter, whilst the other end is closed by a ground glass stopper S. This tube we may call the *firing tube*. Connected to this tube, to the right of C, is a brass cylinder AA, closed by the ebonite stopper M, through which tightly passes a central wire B. The aperture at C is closed by a thin mica plate, which completely prevents the passage of gas between the chambers AA and KL. We may call AA the *detecting vessel*. The outer brass tube AA is connected to the negative pole of a secondary battery, the positive of which is earthed. The inner wire B is connected to one pair (represented by F) of the quadrants of a Dolezalek electrometer, the other pair being earthed.

Consider now the action in the detecting vessel and its connections. The contained gas is at a pressure of a few centimetres of mercury. Let the two pairs of quadrants of the electrometer be metallically connected. The electrometer needle will be at its zero position. Now remove the connection between F and G. The side F is insulated. Since between A and B is the electrical field produced by the battery, there will, even though the field is small, be a slight current through the gas from A to B. When the battery E.M.F. approaches the sparking P.D., this current will be much greater as already indicated. Thus the quadrants F will be charged up, and the needle will steadily move away from zero. By now placing in parallel with the quadrants a radioactive leak, consisting of a layer of a radioactive substance spread over the lower of a pair of plates, H, the upper one of which is insulated and in connection with F, this charge will produce a current in the ionised gas between the plates of H, tending to reduce F and G to the same potential. The needle will thus after a time acquire a position of equilibrium, at a deflection whose value can be conveniently controlled by the adjustment of H. If now an

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α-particle pass through the mica window covering C into the detection vessel, the sudden increase of current from A to B will cause a ballistic throw of the electrometer needle, which will afterwards speedily resume its former position.

Consider, in the next place, the action in the firing chamber. A certain number of particles per second are flying off from the preparation at D. The average fraction that passes through the aperture at C may be calculated in terms of the distance between D and C, and the area of C. The actual number entering the detection vessel may be varied by altering the activity of the preparation at D, and by adjusting the distance between D and C, a magnet being used to draw the iron cylinder P along the firing chamber. Rutherford arranged that the number of particles entering the detection vessel should be on the average about three or four per minute, at which rate the superposition of the effects of two successive particles is avoided, and the ballistic throws can be counted with certainty. By this means, then, the number of particles leaving a radioactive preparation in one second could be accurately determined. The preliminary tests to determine the best conditions for accuracy, such, for instance, as the best dimensions of the chambers to employ, are here passed over. In order to avoid stoppage of α-particles between D and C the firing chamber was exhausted to a charcoal vacuum. The stopping power of the thin mica film across C was found and allowed for. The actual preparation employed at D was radium C, the α-particles of which escape with the same velocity. The amount of RaC is estimated by comparison with a standard sample of radium in radioactive equilibrium, whence the result can be finally expressed in terms of the number of α-particles emitted in one second by 1 gramme of radium in radioactive equilibrium. The number expelled from the RaC in 1 gramme of radium was found to be $3{\cdot}4 \times 10^{10}$ per second. There are three other α-ray products which each emit the same number of α-particles. The total number of α-particles expelled per second from 1 gramme of radium in radio-active equilibrium is therefore $13{\cdot}6 \times 10^{10}$.

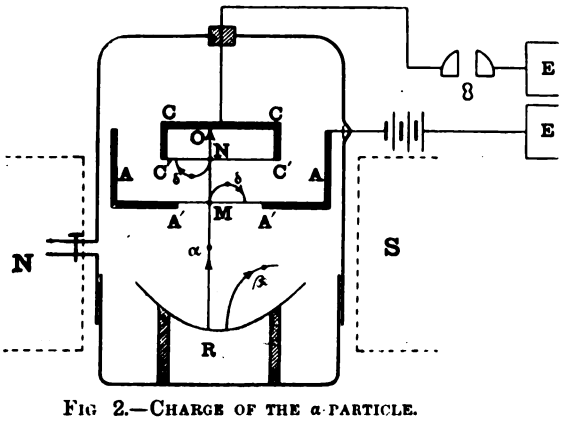

FIG 2.—CHARGE OF THE α PARTICLE.

There remains now the determination of the denominator, or the total charge of positive electricity carried by the stream of α-particles from the same RaC preparation; or, as in fact was the case, from a preparation of RaC whose strength is obtained by comparison with the standard sample of radium in precisely the same manner as in the counting experiment. The method of trapping the α-particles and of measuring their aggregate charge is one that had already been adopted with success by many workers, in the case of β- and cathode- as well as α-particles. A very brief outline only of this measurement will here be given. The cup R (*see* Fig. 2) is coated internally with a thin layer of the radioactive preparation. The thick metal box CC facing R is connected with one pair of quadrants of an electrometer, the other pair being earthed. R and CC are enclosed in a vessel in which a charcoal vacuum is produced. α- and β-particles leave R, and the latter are turned aside by the magnetic field between the poles N and S of a magnet. A calculable proportion of the α-particles leaving R will strike CC and be absorbed completely, giving up their charges. The attached pair of quadrants thus becomes charged positively, and the needle has a steadily increasing deflection from zero. The charge received is the product of the electrostatic capacity of CC (with its attached pair of quadrants), and the potential to which it has been raised. The measurement would be extremely simple if the vacuum were perfect. The α-particles, however, ionise the residual gas, thereby making it a conductor. The charge of CC would, therefore, leak away. To eliminate this effect a second metal plate, AA, is placed below CC, the central portion A′A′ being composed of a very thin sheet of aluminium. CC is likewise closed by a thin aluminium sheet C′C′. To AA one pole of a battery of a few cells is attached, the other pole being to earth. α-particles starting from R now reach CC after passing through the two thin plates A′A′ and C′C′, whose stopping power is comparatively small and calculable. If now, by means of the battery, CCC′C′ be given a potential which is negative with respect to AA, positive ions are carried into CCC′C′, whose positive charge, therefore, accumulates more rapidly than before. If, however, the poles of the battery be reversed the negative ions are swept into CCC′C′, which then gains positive electricity less rapidly than in absence of the battery. The mean rate of increase of the potential of CC measures the rate of reception of the charges of the α-particles alone. There is another disturbing element to be eliminated. When α-particles strike a metal, slow-moving β-rays, or δ-rays, as they are termed, are generated. Those forming at M have to be prevented from striking C′C′, whilst those generated at N have to be prevented from permanently leaving C′C′. The same magnet NS effects both these requirements. The diagram shows the slowly moving rays being bent into small circular orbits exactly as desired. (In Fig. 2, for diagrammatic simplicity, the orbits of the β and δ-rays are shown in the plane of the paper. Their planes are, of course, in reality perpendicular to the magnetic field.) The charge nE carried by n particles is thus measured. The counting experiment has supplied the value of n. The resulting value of the charge of the α-particle as given by Rutherford is

$$E = 9{\cdot}3 \times 10^{-10} \text{ E.S. units.}$$

The accuracy obtained appears to be high, of the order of 1 or 2 per cent. It is important to note that it is independent of the assumed radium content of the standard sample in terms of which the strength of the RaC preparation was determined.

2. *Mass of the α-Particle.*—It had for a few years been suspected that the α-particle is a positively charged atom of helium. Helium is invariably found in radioactive minerals, and in these alone. It has furthermore been directly proved, first in 1903, by Ramsay and Soddy, by aid of the spectroscope, that the radium emanation gives rise, in course of its transformation, to helium. Again, since the counting experiment gives the number of α-particles leaving a known quantity of radium in 1 second ($13{\cdot}6 \times 10^{10}$ per gramme per second for radium in radioactive equilibrium), knowing also the number of molecules per cubic centimetre of any gas at standard temperature and pressure ($2{\cdot}72 \times 10^{19}$), the rate of evolution of helium from radium may be theoretically calculated if we assume each α-particle to be a (charged) helium atom. The calculated quantity is 158 cubic mm. per year, or 0·43 cubic mm. per day. The actual amount has been determined directly by Sir James Dewar, the pressure of helium generated in a known space in a given time by a known quantity of radium being measured by the McLeod gauge. In experiments extending over 1,000 hours the rate of evolution of helium worked out at 0·48 cubic mm. per day. The agreement is very remarkable.

However, the above evidence does not necessarily prove that the helium actually consists of these aggregates of α-particles which have parted with their charge. As already stated, this point appears to have been satisfactorily set at rest by Rutherford's Paper of 1909.

The experiment is a very simple one. Radium emanation is enclosed in a very thin-walled glass tube, A (*see* Fig. 3), quite impervious to the emanation or to ordinary helium, but not to the rapidly moving α-particles. The surrounding vacuous space B may thus be examined spectroscopically for helium, utilising the capillary portion V of this space. The success of

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the experiment was complete. The equilibrium quantity of emanation from 140 mg. of radium was compressed by a mercury column into the tube A, which had been drawn with walls only $\frac{1}{100}$ mm. thick, equivalent in stopping power to 2 cm. of air. B was initially exhausted to a charcoal vacuum. By raising the mercury column in B any gas present could be compressed into V, and the induction coil discharge made to pass. At first no trace of the helium line was to be seen; nor yet after 24 hours. In 48 hours the yellow helium line was visible; after four days the yellow and green lines of helium were bright, and after six days all the stronger lines of the helium spectrum were observed. Blank experiments were made to show that no helium was present in the glass or other parts of the apparatus. Helium gas was introduced into A, but no diffusion into B could be detected.

3. *The Natural Unit of Electricity.*—The question of the exact value to be assigned to the electronic charge cannot yet be regarded as settled. The value which has thus far been commonly accepted is that given by Sir J. J. Thomson—namely, $3{\cdot}4\times10^{-10}$ E.S. units. H. A. Wilson arrived at the value $3{\cdot}1\times10^{-10}$, whilst Millikan, also utilising the formation of drops by the condensation of aqueous vapour on negative ions, gave the number $4{\cdot}06\times10^{-10}$. Townsend, by a distinct method, concluded that the simple ionic charge is about $3{\cdot}0\times10^{-10}$. Boltwood's determination of the transformation constant of radium, combined with Rutherford's counting experiment, leads to $e=4{\cdot}1\times10^{-10}$. Perrin's estimate, from observations on Brownian particles, of the number of atoms in 1 gramme of hydrogen, leads to the value $4{\cdot}1\times10^{-10}$. Regener made observations on the α-particles emitted by polonium, counting with extreme care the number of scintillations produced on a zinc sulphide screen. This number was assumed to be equal to the number of α-particles emitted by the polonium. Combining this with a determination of the total charge carried by these particles, the value $9{\cdot}58\times10^{-10}$ was arrived at for E. By assuming $E=2e$, Regener finds for e the value $4{\cdot}79\times10^{-10}$. It should be added here that Rutherford has determined the number of scintillations produced by a radioactive sample, and at the same time the number of α-particles as obtained by the method of his "counting" experiment; and has discovered practically perfect agreement. For instance, in one experiment 294 scintillations were counted, this number proving to be 99 per cent. of the number given by the counting experiment. In a second, involving 150 scintillations, the ratio was 96 per cent. This experimentally observed agreement adds weight to the value obtained by Regener for e. Rutherford's experiments give E as $9{\cdot}30\times10^{-10}$, and this number is evidently one to which much consideration should be accorded in a revision of the value to be assigned to e. He accepts the view that the charge e carried by the hydrogen atom in the electrolysis of water is the fundamental unit of electricity, and that, therefore, E must be some multiple of e, either two or three. From considerations based on Boltwood's experiments, referred to above, he fixes upon the multiple two. Thus, for e he assigns the value $4{\cdot}65\times10^{-10}$. Finally, there is Planck's estimate of e based on thermodynamical considerations applied to radiation data, which lead to the number $4{\cdot}69\times10^{-10}$. It will be seen that the later values are distinctly higher than those first found. More work perhaps requires to be done before a revised value can be confidently chosen.

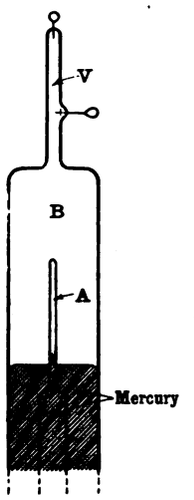

FIG. 3.—PROOF THAT THE α-PARTICLE IS AN ATOM OF HELIUM.

Telephones in Mines.—According to "Telephony," the Ohio General Assembly propose to enact a law compelling colliery owners to equip their mines with complete telephone systems. This has already been carried out in the state of Illinois and has proved of great service.

CORRESPONDENCE.

RAILLESS TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: So much interest is now being taken in England in the trackless trolley system, as shown by the articles lately published in your paper on the subject, that I am taking this opportunity to call your attention and also that of your readers to the Köhler Namag system. Although this system is the latest in the field (the patents being hardly a year old) it has made rapid progress in Germany. There is at present one line in operation and two others in course of erection which will be opened in a few weeks.

The new system differs in every main feature from the existing ones, as shown in the description given below. The overhead equipment consists of two hard drawn copper wires suspended one above the other in a vertical plane. The Köhler current-collecting device is a combination of the trolley wheel and the bow. The trolley wheels, two in number, run on the upper negative wire and the two bows are pressed against the lower part of the underlying positive wire by means of a spiral spring (Fig. 1).

The current is led to the vehicle by means of a flexible line which winds itself automatically on a drum mounted on the car, enabling this latter to behave on the road with the ease and freedom of a self-propelled vehicle. The current-collecting

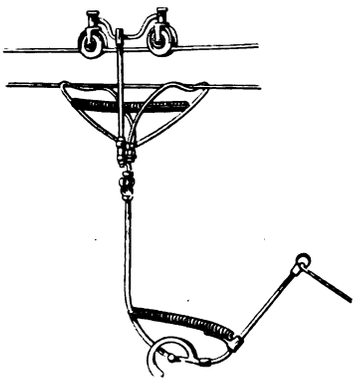

FIG. 1.

device is further fitted with an elastic articulation which guards the overhead system from the shocks which are caused by the sudden starting or stopping of the car.

The exceedingly small weight of the apparatus, combined with its ability to negotiate sharp curves, to adapt itself to the slightest movement of the car, and to operate in spite of differences in the sag of the two wires, all lead to light and cheap overhead work. It has the further advantage that it can be used without alteration for ordinary rail traction should increased traffic render this necessary.

The cars are built by the Norddeutsche Automobile & Motoren Aktien Gesellschaft, of Bremen, which is well known on the Continent as one of the first makers of electric vehicles. It is interesting to note that they are similar in construction to the petrol cars of the same firm. The only change is that, in place of the engine and change-speed gear, an electric motor is rigidly mounted on the pressed steel chassis, and drives, through cardan and differential gearing, the rear wheels. There are two mechanical brakes and one electrical. The first mentioned are operated by foot pedals; one of them, the service brake, acts on the driven wheels, the other, the emergency brake, is mounted on the motor shaft.

According to prevailing conditions the motor is either an 8 H.P. or 14 H.P. moderate-speed continuous-current series motor, fitted with commutating poles. The main field is wound in two sections, thus permitting series parallel speed control (Fig. 2). The advantages of this construction are numerous. In the first instance, a moderate-speed motor realises the conditions of high efficiency, large starting torque

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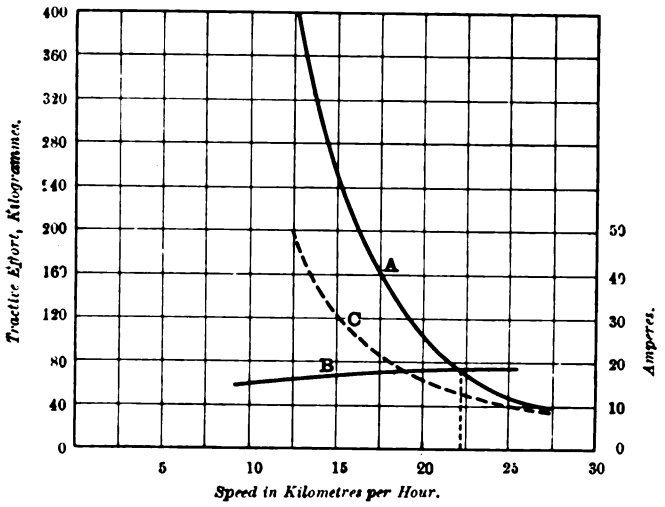
and overload capacity required in traction work. Its position just under the car flooring makes it easily accessible from all parts. Being rigidly fixed in the centre of the chassis, it springs with this latter and approaches the conditions met with in stationary work.

The controller is of the normal type for traction purposes, but is fitted with a special tripping device which breaks the current



A. Speed and tractive effort curve. B. Tractive resistance of 5-ton car (on level). C. Ampere speed curve.

FIG. 2.—CURVES FOR 8 H.P. 480 VOLT TRACTION MOTOR.

by operating one or other of the mechanical brake pedals. To establish the circuit again, the driver must first bring the controller to the neutral position.

The cars have seating accommodation for 20 people, and have also a back platform capable of holding four people. When fully loaded each weighs about 5 tons. The speed on the level under such conditions is about 23 km. per hour. Each car in addition can haul a trailer capable of accommodating 20 people (Fig. 3).

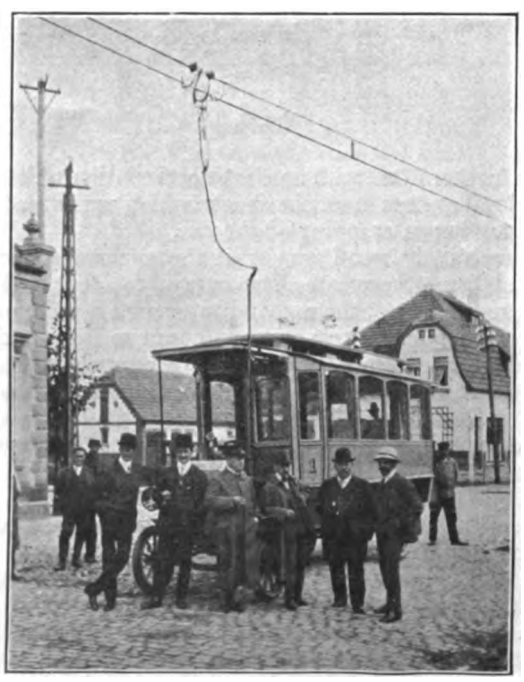


FIG. 3.

For freight transport the same company is building a heavy car with trailer capable of carrying 12 tons of goods at a speed of 10 km. per hour on level road. The construction is similar to the above; in this case, however, there is a double transmission, the motor driving through differential back gear on the rear wheels by means of chains and sprocket wheels.—I am, &c.,

Verviers, Aug. 24. P. A. MOSSAY.

THEORY OF THE QUADRANT ELECTROMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Mr. Beattie's reply in your current issue to my former letter, allow me again to emphasise my points, as these seem to have been obscured. They are:—

1. Electrometer formulæ in which absolute potential appears as a factor, instead of the differences of these potentials, are irrational, because the phenomena depend on these differences only.

2. The electrostatic forces cannot, in general, be split into two portions of which one is independent of the position and the other proportional to the displacement. This may, of course, be true in some particular case, but the law connecting the force and displacement varies with the shape of the vanes and the quadrants, and also with their relative position at zero.

Like Mr. Beattie, I also deal with the forces acting, or the torques caused by these forces. Beyond the above two points, I think the only difference between us is that he uses a "k," whereas I, following the usual custom, express the k in terms of a well-known physical quantity.

A numerical factor of $\frac{1}{2}$ has inadvertently been omitted from the right-hand portion of the expression given in my letter for the total torque and of the denominator of the final equation. The absence of V_1 in this denominator is not an error. If $-dC_2/d\theta$ had been taken as a factor for the numerator, we should have had V_1 instead of V_2 below. By combining the two expressions the formula Mr. Beattie now gives can be easily obtained, which is rather more symmetrical than the one I gave, but at the same time more difficult to evaluate. It is also rational. When comparing Mr. Beattie's last formula with the one I gave, it should be noted that his convention as to the sign of $dC_2/d\theta$ is the opposite to mine.—I am, &c.,

DAVID ROBERTSON.

Merchant Venturers' Technical College, Bristol, Aug. 30.

BRUSSELS EXHIBITION FIRE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With regard to the erroneous statements published in certain quarters, that the recent fire was due to electrical causes, and in view of the possible prejudicial influence this might have on electrical interests, your readers will be interested to know that I have the assurance of the engineer and director of the electrical department of the city of Brussels that the fire was not caused electrically.

Further, I am assured that the electrical supply in the buildings where the trouble started had been cut off some hours prior to the fire commencing.

My committee trust you will find space in your next issue for this letter.—I am, &c.,

H. B. RENWICK,

Chairman of the Electric Supply Publicity Committee.

London, Aug. 30.

INSPECTION AND INSURANCE OF ELECTRICAL AND OTHER MACHINERY.

The annual report of Mr. M. Longridge, chief engineer to the British Engine, Boiler & Electrical Insurance Co., always contains much of interest to electrical enigneers. In the report for the year 1909 it is mentioned that the breakdowns during the period under consideration were of less interest than usual, so that the descriptions of these occurrences have been curtailed, and the space thus made available has been filled by extracts from reports of trials made by the Company's engineers.

Dealing first with the breakdowns of machinery, we notice that these are considered under the usual headings, viz., (1) inspection and insurance of steam, gas, and oil engines; (2) inspection and insurance of electrical machinery; (3) insurance and inspection of boilers; (4) boiler explosions, collapses and sundry mishaps

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In regard to the inspection and insurance of engines, the rate of increase of this branch of the Company's business was only about one-half the normal rate of a little over 6 per cent., the decrease being attributed to the state of trade generally. It is instructive to notice that the proportion of steam engines to gas engines insured has decreased from 27:20 to 26:20. The rate of breakdowns during 1909 was, among steam engines and turbines, 1 in 10·2 of the machines insured, and among gas and oil engines, 1 in 10·4, slightly lower in both cases than the figures of 1 in 9·4 and 1 in 9·1 respectively recorded in 1908, but slightly higher than those of 1907. The number of steam turbines insured is not yet sufficient to afford reliable information as to the ratio of breakdowns between this type of plant and steam engines. In steam engines, valves and valve gear continue to be the main cause of breakdown, the proportion of such failures being 34·1 per cent. of the total, compared with 34·8 per cent. in 1908 and 21·4 per cent. the average for 25 years previous to 1908. A considerable increase is shown in the number of breakdowns attributed to the failure of air-pump buckets and valves, the percentage of the total breakdowns being 10·7, as against 6·2 per cent. a year ago and 7·2 per cent. the average of the previous 25 years. In the case of gas and oil engines, valves and valve gear accounted for 29·6 per cent. of the total number of failures, compared with 31·3 per cent. in 1908, whilst gas producer plants seem to be increasingly unreliable, the percentage of failures of this part accounting for 11·4 per cent. of the total number of failures, the figure last year being only 3·0 per cent., and 0·5 per cent. for the previous 25 years. It is instructive to notice the causes of the breakdowns as set out in the following table :—

—	Steam engines.	Gas and oil engines.
	Per cent.	Per cent.
Accidents and causes unascertained	27	34
Old defects or deterioration by wear and tear	41	19
Weakness, bad design, workmanship, or material.	18	23
Negligence of owners or attendants.....	14	24
	100	100

In regard to these percentages Mr. Longridge remarks : The number of breakdowns of steam engines attributed to old defects and wear and tear is unusually high, and, as the number assigned to accidents and causes unascertained is little below the normal, it follows that the numbers due to weakness, bad design and negligence must be unusually low. A few years ago the writer (Mr. Longridge) remarked on the evidence of improved design and workmanship furnished by the analyses of breakdowns of insured engines. The analysis for 1909 supports the view that technical education and foreign competition are influencing British methods of design. The decline in the number of casualties resulting from neglect is also satisfactory. In regard to gas engines, the large percentage of breakdowns from unknown causes is unsatisfactory, but difficult to alter, because so many of the gas engines insured are small, and on the occurrence of a breakdown are either repaired or dismantled for repair before the inspector can examine them. The cases of weakness and bad design are also rather numerous. The weakest parts are undoubtedly the crank-shafts ; as many as 13 per cent. of the breakdowns for the year were breakages of shafts. Has not the time come to build these parts instead of forging them in a single piece ? That about one-fourth of the breakdowns resulted from neglect, arises from the practice of leaving small gas engines without skilled attendants, or without attendance altogether. Typical examples of steam and gas engine failures are given in the report.

Turning to the second part of the report, dealing with the electrical branch of the Company's business, the rate of increase in new business in this section has been affected by the state of trade. It is very satisfactory, however, to learn that the rate of increase in the number of breakdowns is much less than in previous years ; in fact, fewer breakdowns of dynamos were recorded than in 1908. The cost of repairing the damage done was also less, except in the case of starting switches and controllers. The rates of breakdown among the various classes of machines were as follows : Dynamos—continuous current 1 in 17·2, alternating current 1 in 17·5 (1 in 13·7 and 1 in 5·7 respectively in the previous year) ; motors—continuous current 1 in 8·2, alternating current 1 in 9·5 (1 in 9·2 and 1 in 11·3 respectively in the previous year) ; starters and controllers—1 in 25 (1 in 24 in the previous year). The proportion in which the various parts of the machines caused or initiated the breakdowns are tabulated below, with the figures for 1908 and the averages for the preceding seven years :—

Parts believed to have failed first.	Dynamos.			Motors.		
	1901–7	1908.	1909.	1901–7	1908.	1909.
Armatures & rotors, per cent.	57·3	30	40	51·4	36	37
Commutators and „ slip rings.	20·0	40	29	22·0	26	27
Magnet coils and „ stators.	8·6	11	12	13·6	16	20
Brush gear and „ terminals	...	...	3	...	5	4
Shafts, spiders, cores, „ binders, pulleys, and gear wheels.	14·1	11	12	13	9	7
Frames, pole pieces, „ bearings, &c.	...	8	4	...	8	5
	100·0	100	100	100·0	100	100

STARTING SWITCHES AND CONTROLLERS.

—	1905-7.	1908.	1909.
Resistance coils .....per cent.	52·0	52	52
Contacts and switch arms ..... „	11·0	10	9
Automatic apparatus ..... „	14·4	13	21
Frames, slabs, carriers for coils, springs, &c. „	22·6	25	18
	100·0	100	100

As a large majority (85 per cent.) of the machines insured are motors, it may be interesting to tabulate the figures for the last two years for continuous and alternating current motors separately as under :—

Part which is believed to have failed first.	D.C. motor.		A.C. motor.	
	1908.	1909.	1908.	1909.
Armatures or rotors.....per cent.	38	39	21	23
Commutators or slip rings ..... „	29	31	2	6
Magnet or stator coils..... „	11	15	53	49
Brush gear and terminals ..... „	6	3	...	8
Shafts, spiders, cores, binders, „ pulleys, gear wheels, &c.	9	7	6	6
Frames, pole pieces, bearings, &c. „	7	5	18	8
	100	100	100	100

The causes of the above breakdowns are believed to be as follows :—

—	Dynamos.		Motors.		Starters.	
	1908.	1909.	1908.	1909.	1908.	1909.
Accidental .....per cent.	6	5	4	2	8	5
Dirt and neglect... „	23	20	30	26	17	19
Age and deterioration „	25	16	20	14	25	17
Bad work or design „	20	23	11	14	9	14
Overloading ..... „	...	1	1	1	2	2
Unascertained .... „	26	35	34	43	39	43
	100	100	100	100	100	100

The following typical examples of breakdowns selected from the report will probably prove of interest :—

1. Four-pole series-wound 16½ H.P. motor, 2 years old, receiving current at 440 volts from the two outer wires of a three-wire continuous-current system, with the middle wire earthed. The motor was attached to a 4 ton stationary jib crane. One of the Company's inspectors was sent for to find out why the craneman got a shock, as he averred he did, when he put his foot on the brake. The inspector found that when the man, standing with one foot on the ground, put his other foot on the

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brake, he at the same time pressed with his knee one of the cables from the controller to the motor against the edge of an iron bracket which carried the supply cables. The rough edge of the bracket had gradually worn away the insulation which had previously guarded the copper conductor from the iron. Consequently, when the man pressed the cable against the bracket, the bracket, the crane, and the man's body formed a 220 volt circuit between the outer and the earthed middle wire of the supply. The moral is that all the ironwork of the crane should have been efficiently earthed.

2. Three-phase alternating-current motor, 4 years old, with wound rotor fitted with slip rings, giving 350 H.P. at a speed of 195 revs. per min., with current at 500 volts. The motor was coupled by spur gearing to the crank shaft of an old hauling engine, from which the connecting rod had been uncoupled. Its speed was regulated by a controller of the barrel type, immersed in oil, which cut in or out resistances in the rotor circuit. The motor and controller were placed in the engine-room below ground, close to the down-cast shaft, and separated from the up-cast by wooden doors. The room had a wood floor, and was surrounded by virgin coal. Owing to some defect, possibly a short-circuit between contacts of different phase within the controller, the oil in the box and the resistance cables leading from it were set on fire. The heat was sufficient to vaporise the oil, which burnt furiously and set fire to the doors dividing the up-cast from the down-cast shaft, thus short-circuiting the ventilation of the pit. The sand provided for the extinction of fires, in accordance with special rules issued in 1905 for the installation and use of electricity under the Coal Mines Regulation Act of 1887, was useless, as it would not smother a vertical or suspended cable, but the fire was put out before the coal became ignited. Whether one of the chemical extinguishers would be effective in such a case remains to be proved, but at first sight it would seem more promising than sand.

3. Three-phase alternating-current 12-pole induction motor, built in 1907, to give 350 B.H.P. at 500 revs. per min., with current at 11,000 volts per phase, frequency, 50 per second. The stator winding consisted of 5,760 No. 13 S.W.G. double cotton-covered and braided copper wire conductors, distributed in 144 tubes of insulating material carried in as many partly-closed slots, so that each slot held a tube containing 40 conductors. The stator was probably wound by the "pin" method; that is, each tube was filled with 40 steel wires, which were drawn out one by one to allow of the winding being threaded through the space left by the withdrawal. The winding was divided into 18 coils, six coils per phase, star-connected, so that the voltage between each terminal and the neutral point was 6,360, and between each coil 1,060, under normal working conditions. The rotor was of the wound type, with three slip rings and brush gear for connection to a variable liquid resistance for starting. There was no starting apparatus in the stator circuit beyond a three-pole oil-immersed switch, without any impedance, inductive or otherwise, between the supply and the motor terminals. The motor was coupled to and drove a continuous-current dynamo, giving 478 amperes at 500 volts. It was first insured in July, 1907. The stator windings repeatedly broke down, first one and then another of the coils nearest the terminals giving way by short-circuiting on themselves. One of these failures occurred inside one of the insulating tubes above mentioned, the rest outside. It was at first thought that the breakdowns were due to concentration of potential across the coils at starting, and then that the failures were due to "surging" or resonance effect from disturbances in the supply cables, but the Company could find no evidence to support the theory. An examination of a damaged coil in July, 1909, however, gave a clue. The cotton covering was bleached, stained green, and absolutely rotten. A test with litmus paper showed it to be acid, and analysis proved the acid to be nitric acid. The Company, therefore, came to the conclusion that the cause of the repeated breakdowns was the destruction of the insulation by nitric acid formed by decomposition of the air by brush discharge from the high-tension conductors, the result of the electrostatic action being the production of a compound, N_2O_5, which, in combination with the moisture in the air, is changed into nitric acid according to the formula $N_2O_5 + H_2O = 2\,HNO_3$. The reasons why the coils nearest the terminals were specially affected are: (1) The difference of potential is highest at these parts of the windings, and the brush discharge and formation of nitric acid greatest; (2) concentration of potential, which in this case no doubt broke down the rotten insulation, is bound to occur more or less across the terminal coils at starting.

Unless brush discharge can be sufficiently reduced, as has been claimed, by restricting the conductors in each slot of the stator to a single row, laid one on top of each other, the only way of preventing damage seems to be to insulate the conductors completely from air and moisture. This may be done by using formed coils thoroughly impregnated and made up solid with waterproof materials before being placed in the slots. Unfortunately this method involves open slots in the stator core, which are detrimental to induction motors, especially small ones, both as regards efficiency and power factor on the one hand, and weight and cost on the other. It has not been found practicable thoroughly to impregnate windings after being placed in position. Adequate protection can, however, be obtained for conductors wound by the "pin" method by placing them in waterproof tubes projecting beyond the ends of the slots in the stator core, and binding the projecting portions and the end windings emerging from them with a thick covering of tape saturated in some adhesive and waterproof material, to seal them completely from air and moisture. Had this been done in the present case the motor would no doubt have run satisfactorily on the 11,000 volt supply, but the makers preferred to alter and rewind the machine for 440 volts, and to supply a step-down transformer, rather than risk further trouble from the higher voltage, and to this the owner of the motor agreed.

Mr. Longridge concludes this section of the report by reminding all who have to clean or inspect high-tension machinery that when insulated and endowed with large electrostatic capacity it will conserve a charge for a considerable time after current has been switched off. No one should therefore, Mr. Longridge remarks, attempt to handle any part until he has satisfied himself that it has been completely disconnected from the source of supply for a sufficient time, say, 10 minutes, and the part before being handled should be always touched lightly and quickly with the finger.

The increase of 4¾ per cent. in the number of boilers under inspection is considered very satisfactory, having regard to the rate at which small steam engines are being supplanted by gas engines and electric motors.

After referring to the Board of Trade reports on boiler explosions and mishaps of various kinds, the testing of the discharge of a turbo blower is described.

An extract from the report of the test of a 500 kw. exhaust steam turbo-generator is also given: The machine was put down to generate three-phase current at 550 volts, with the exhaust steam from a pair of winding engines, supplemented when necessary by steam from the boilers, reduced in pressure by a reducing valve. The turbine was of the impulse type, and ran at 1,500 revs. per min. During the trial the exhaust from the engines was not used, but steam was supplied at an average pressure of 129 lb. by two Lancashire boilers. The exhaust from the turbine was led into a barometric condenser. Near the turbine the steam passed through a reducing valve said to be set at 1 lb. above atmosphere, and in passing through the throttle valve the pressure was further reduced to 10·5 lb. absolute or about 4·25 lb. below atmosphere.

Assuming the specific heat of superheated steam to be 0·5, the superheat due to the fall of pressure from 129 lb. gauge pressure or 144 lb. absolute pressure to 10·5 lb. absolute pressure, would be $(1{,}222 - 1{,}173) \div 0{\cdot}5 = 98°$ F. The actual superheat shown by a thermometer in a mercury cup between the throttle valve and the turbine was 78 deg., the missing 20 deg. of superheat being only sufficient to evaporate 1 per cent. of the feed water, even if no heat were lost by radiation. It is, therefore, clear that practically the whole of the steam condensed in the steam range was drawn off by the drains and steam traps.

The steam consumption per kilowatt-hour worked out, over a 7 hours' test, at 40 lb. It would, of course, have been higher if the turbine had been driven by the exhaust steam from the engines, as this steam would not have been superheated.

Mr. Longridge's report concludes with an abstract from some tests on a horizontal compound tandem engine.

PROF. HOBSON'S ADDRESS TO SECTION A OF THE BRITISH ASSOCIATION.*

Reference is first made to the death of Sir William Huggins, one of the most illustrious of the British workers in science during the nineteenth century.

The names of the great departments of science, mathematics, physics, astronomy, meteorology, which are associated with Section A, are a sufficient indication of the vast range of investigation which comes under the purview of our section. An opinion has been strongly expressed in some quarters that the time has come for the erection of a separate section for astronomy and meteorology, in order that fuller opportunities may be afforded than hitherto for the discussion of matters of special interest to those devoted to these departments of science. I do not share this view. I believe that, whilst the customary division into sub-sections gives reasonable facilities for the treatment of questions interesting solely to specialists in the various branches, a policy of disruption would be injurious to the wider interests of science. It appears to me unwise, in view of the general objects of the British Association, to give too much prominence in the meetings to the more technical aspects of the various departments of science. Ample opportunities for the full discussion of all the detailed problems, the solution of which forms a great and necessary

* Abstract of the presidential address delivered by Prof. E. W. Hobson, Sc.D., F.R.S., at Sheffield yesterday.

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part of the work of those who are advancing science in its various branches, are afforded by the special societies which make those branches their exclusive concern. The British Association will, in my view, be performing its functions most efficiently if it gives much prominence to those aspects of each branch of science which are of interest to a public at least in some degree larger than the circle of specialists concerned with the particular branch. To afford an opportunity to workers in any one department of obtaining some knowledge of what is going on in other departments, to stimulate by means of personal intercourse with workers on other lines the sense of solidarity of men of science, to do something to counteract that tendency to narrowness of view which is a danger arising from increasing specialisation, are functions, the due performance of which may do much to further that supreme object, the advancement of science, for which the British Association exists.

I propose to address to you a few remarks, necessarily fragmentary and incomplete, upon the scope and tendencies of modern mathematics; and not to transgress against the canon I have laid down, I shall endeavour to make my treatment of the subject as little technical as possible. Probably no other department of knowledge plays a larger part outside its own narrower domain than mathematics, some of its more elementary conceptions and methods having become part of the common heritage of our civilisation, interwoven in the every-day life of the people.

The concepts of the pure mathematician, no less than those of the physicist, had their origin in physical experience analysed and clarified by the reflective activities of the human mind; but the two sets of concepts stand on different planes in regard to the degree of abstraction which is necessary in their formation. Those of the mathematician are more remote from actual unanalysed precepts than are those of the physicist, having undergone in their formation a more complete idealisation and removal of elements inessential in regard to the purposes for which they are constructed. This difference in the planes of thought frequently gives rise to a certain misunderstanding between the mathematician and the physicist, due in the case of either to an inadequate appreciation of the point of view of the other. On the one hand it is frequently and truly said of particular mathematicians that they are lacking in the physical instinct; and on the other hand a certain lack of sympathy is frequently manifested on the part of physicists for the aims and ideals of the mathematician. The habits of mind and the ideals of the mathematician and of the physicist cannot be of an identical character. The concepts of the mathematician necessarily lack, in their pure form, just that element of concreteness which is an essential condition of the success of the physicist, but which to the mathematician would often only obscure those aspects of things which it is his province to study. The abstract mathematical standard of exactitude is one of which the physicist can make no direct use. The calculations in mathematics are directed towards ideal precision, those in physics consist of approximations within assigned limits of error.

There exists a widespread impression amongst physicists, engineers and other men of science that the effect of recent developments of pure mathematics, by making it more abstract than formerly, has been to remove it further from the order of ideas of those who are primarily concerned with the physical world. The difficulty of obtaining an adequate notion of the general scope and aims of mathematics, or even of special branches of it, is perhaps greater than in the case of any other science. Many persons, even such as have made a serious and prolonged study of the subject, feel the difficulty of seeing the wood for trees. The severe demands made upon students by the labour of acquiring a difficult technique largely accounts for this; but teachers might do much to facilitate the attainment of a wider outlook by directing the attention of their students to the more general and less technical aspects of the various parts of the subject, and especially by the introduction into the courses of instruction of more of the historical element than has hitherto been usual. All attempts to characterise the domain of mathematics by means of a formal definition which shall not only be complete, but which shall also rigidly mark off that domain from the adjacent provinces of formal logic on the one side and of physical science on the other side, are almost certain to meet with but doubtful success. Such definitions, many of which have been advanced, are apt to err by excess or defect, and often contain distinct traces of the personal predilections of those who formulate them. Perhaps the least inadequate description of the general scope of modern pure mathematics—I will not call it a definition—would be to say that it deals with *form*, in a very general sense of the term; this would include algebraic form, geometrical form, functional relationship, the relations of order in any ordered set of entities such as numbers, and the analysis of the peculiarities of form of groups of operations.

The belief is very general amongst instructed persons that the truths of mathematics have absolute certainty, or at least that there appertains to them the highest degree of certainty of which the human mind is capable. It is thought that a valid mathematical theorem is necessarily of such a character as to compel belief in any mind capable of following the steps of the demonstration. Any considerations tending to weaken this belief would be disconcerting and would cause some degree of astonishment. At the risk of this, I must here mention two facts which are of considerable importance as regards an estimation of the precise character of mathematical knowledge. In the first place, it is a fact that frequently, and at various times, differences of opinion have existed among mathematicians, giving rise to controversies as to the validity of whole lines of reasoning, and affecting the results of such reasoning; a considerable amount of difference of opinion of this character exists among mathematicians at the present time. In the second place, the accepted standard of rigour—that is, the standard of what is deemed necessary to constitute a valid demonstration—has undergone change in the course of time. Much of the reasoning which was formerly regarded as satisfactory and irrefutable is now regarded as insufficient to establish the results which it was employed to demonstrate. It has even been shown that results which were once supposed to have been fully established by demonstrations are, in point of fact, affected with error.

The author next explains in general terms how these phenomena are possible. A set of data ideally perfect in respect of precision and permanence is unattainable—or at least has not yet been attained; and the adjustment of frontiers is one of the most frequent causes of strife. As a matter of fact, variations of opinion have at various times arisen within the ranks of the mathematicians as to the nature, scope and proper formulation of the principles which form the foundations of the science, and the views of mathematicians in this regard have always necessarily been largely affected by the conscious or unconscious attitude of particular minds towards questions of general philosophy. It is in this region, he thought, that the source is to be found of those remarkable differences of opinion amongst mathematicians which have come into prominence at various times, and have given rise to much controversy as to fundamentals.

Both in geometry and in analysis our standard of what constitutes a rigorous demonstration has in the course of the nineteenth century undergone an almost revolutionary change. That oldest text-book of science in the world, "Euclid's Elements of Geometry," has been popularly held for centuries to be the very model of deductive logical demonstration. Criticism has, however, largely invalidated this view. It appears that, at a large number of points, assumptions not included in the preliminary axioms and postulates are made use of. The fact that these assumptions usually escape notice is due to their nature and origin. Derived as they are from our spatial intuition, their very self-evidence has allowed them to be ignored, although their truth is not more obvious empirically than that of other assumptions derived from the same source which are included in the axioms and postulates explicitly stated as part of the foundation of Euclid's treatment of the subject. The method of superimposition, employed by Euclid with obvious reluctance, but forming an essential part of his treatment of geometry, is, when regarded from his point of view, open to most serious objections as regards its logical coherence. Physicists and others often maintain that the modern extreme precision amounts to an unnecessary and pedantic purism, because in all practical applications of mathematics only such functions are of importance as exclude the remoter possibilities contemplated by theorists. Such objections leave the true mathematician unmoved; to him it is an intolerable defect that, in an order of ideas in which absolute exactitude is the guiding ideal, statements should be made, and processes employed, both of which are subject to unexpressed qualifications, as conditions of their truth or validity. The pure mathematician has developed a specialised conscience, extremely sensitive as regards sins against logical precision. The physicist, with his conscience hardened in this respect by the rough-and-tumble work of investigating the physical world, is apt to regard the more tender organ of the mathematician with that feeling of impatience, not unmingled with contempt, which the man of the world manifests for what he considers to be over-scrupulosity and unpracticality.

It is true that we cannot conceive how such a science as mathematics could have come into existence apart from physical experience. But it is also true that physical precepts, as given directly in unanalysed experience, are wholly unfitted to form the basis of an exact science. Moreover, physical intuition fails altogether to afford any trustworthy guidance in connection with the concept of the infinite, which is in some form indispensable in the formation of a coherent system of mathematical analysis. The hasty and uncritical extension to the region of the infinite, of results which are true and often obvious in the region of the finite, has been a fruitful source of error in the past, and remains as a pitfall for the unwary student in the present.

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The school of thought which has most emphasised the purely logical aspect of mathematics is that which is represented in this country by Mr. Bertrand Russell and Dr. Whitehead, and which has distinguished adherents both in Europe and in America. The ideal of this school is a presentation of the whole of mathematics as a deductive scheme in which are employed a certain limited number of indefinables and unprovable axioms, by means of a procedure in which all possibility of the illicit intrusion of extraneous elements into the deduction is excluded by the employment of a symbolism in which each symbol expresses a certain logical relation.

The actual evolution of mathematical theories proceeds by a process of induction strictly analogous to the method of induction employed in building up the physical sciences; observation, comparison, classification, trial and generalisation are essential in both cases. Not only are special results, obtained independently of one another, frequently seen to be really included in some generalisation, but branches of the subject which have been developed quite independently of one another are sometimes found to have connections which enable them to be synthesised in one single body of doctrine. The essential nature of mathematical thought manifests itself in the discernment of fundamental identity in the mathematical aspects of what are superficially very different domains. The mathematical physicist is familiar with the fact that a single mathematical theory is often capable of interpretation in relation to a variety of physical phenomena. In some instances a mathematical formulation, as in some fashion representing observed facts, has survived the physical theory it was originally devised to represent. In the case of electromagnetic and optical theory, there appears to be reason for trusting the equations, even when the proper physical interpretation of some of the vectors appearing in them is a matter of uncertainty and gives rise to much difference of opinion; another instance of the fundamental nature of mathematical form.

One of the most general mathematical conceptions is that of functional relationship, or "functionality." Starting originally from simple cases such as a function represented by a power of a variable, this conception has, under the pressure of the needs of expanding mathematical theories, gradually attained the completeness of generality which it possesses at the present time. The opinion appears to be gaining ground that this very general conception of functionality, born on mathematical ground, is destined to supersede the narrower notion of causation, traditional in connection with the natural sciences.

In conclusion, I propose to say a few words about some matters connected with the teaching of the more elementary parts of mathematics. Of late years a new spirit has come over the mathematical teaching in many of our institutions, due in no small measure to the reforming zeal of Prof. J. Perry. The changes that have been made followed a recognition of the fact that the abstract mode of treatment of the subject that had been traditional was not only wholly unsuitable as a training for physicists and engineers, but was also to a large extent a failure in relation to general education, because it neglected to bring out clearly the bearing of the subject on the concrete side of things. With the general principle that a much less abstract mode of treatment than was formerly customary is desirable for a variety of reasons, I am in complete accord. It is a sound educational principle that instruction should begin with the concrete side, and should only gradually introduce the more general and abstract aspects of the subject; an abstract treatment on a purely logical basis being reserved only for that highest and latest stage which will be reached only by a small minority of students. At the same time I think there are some serious dangers connected with the movement towards making the teaching of mathematics more practical than formerly, and I do not think that, in making the recent changes in the modes of teaching, these dangers have always been successfully avoided.

Geometry and mechanics are both subjects with two sides: on the one side, the observational, they are physical sciences; on the other side, the abstract and deductive, they are branches of pure mathematics. The older traditional treatment of these subjects has been of a mixed character, in which deduction and induction occurred side by side throughout, but far too much stress was laid upon the deductive side, especially in the earlier stages of instruction. It is the proportion of the two elements in the mixture that has been altered by the changed methods of instruction of the newer school of teachers. In the earliest teaching of the subjects they should, I believe, be treated wholly as observational studies. At a later stage a mixed treatment must be employed, observation and deduction going hand in hand, more stress being, however, laid on the observational side than was formerly customary. This mixed treatment leaves much opening for variety of method; its character must depend to a large extent on the age and general mental development of the pupils; it should allow free scope for the individual methods of various teachers as suggested to those teachers by experience. Attempts to fix too rigidly any particular order of treatment of these subjects are much to be deprecated, and, unfortunately, such attempts are now being made. Of the many evils which our examination system has inflicted upon us, the central one has consisted in forcing our school and university teaching into moulds determined not by the true interests of education, but by the mechanical exigencies of the examination syllabus. The examiner has thus exercised a potent influence in discouraging initiative and individuality of method on the part of the teacher; he has robbed the teacher of that freedom which is essential for any high degree of efficiency.

The great and increasing importance of a knowledge of the differential and integral calculus for students of engineering and other branches of physical science has led to the publication during the last few years of a considerable number of text-books on this subject intended for the use of such students. Some of these text-books are excellent, and their authors, by a skilful insistence on the principles of the subject, have done their utmost to guard against the very real dangers which attend attempts to adapt such a subject to the practical needs of engineers and others. It is quite true that a great mass of detail which has gradually come to form part—often much too large a part—of the material of the student of mathematics, may with great advantage be ignored by those whose main study is to be engineering science or physics. Yet it cannot be too strongly insisted on that a firm grasp of the principles, as distinct from the mere processes of calculation, is essential if mathematics is to be a tool really useful to the engineer and the physicist. There is a danger, which experience has shown to be only too real, that such students may learn to regard mathematics as consisting merely of formulæ and of rules which provide the means of performing the numerical computations necessary for solving certain categories of problems which occur in the practical sciences. Apart from the deplorable effect, on the educational side, of degrading mathematics to this level, the practical effect of reducing it to a number of rule-of-thumb processes can only be to make those who learn it in so unintelligent a manner incapable of applying mathematical methods to any practical problem in which the data differ even slightly from those in the model problems which they have studied. Only a firm grasp of the principles will give the necessary freedom in handling the methods of mathematics required for the various practical problems in the solution of which they are essential.

INTERNATIONAL TELEGRAPHIC COMPETITION IN 1911.

In our issue of July 1st we stated that the Italian Minister of Posts and Telegraphs had issued invitations to the Government Telegraph Administrations and the telegraph companies adhering to the International Telegraph Convention, the Imperial Chinese Telegraph Department, and the other principal private telegraph companies to participate in a competition in the transmission and reception of messages with Morse, Hughes and Baudot apparatus at the Turin International Exhibition next year. The following is an abstract of the regulations, which have already been approved by the Telegraph Administrations of Austria, Spain, France and Turkey:—

The tests will commence on August 22nd, and will be open to male or female members of the staffs of telegraph administrations and army or navy telegraphists. Applications to be sent by June 15th next to the Secretariat General, Bureau du Concours International de Telegraphie, Rome. The tests will include 20 minutes' transmission and 30 minutes' reception of messages by the Morse apparatus, the receiving being done with either the sounder or the writing instrument; and one hour of transimisson by Hughes apparatus, mechanical or electrical, and with either E or W key; and one hour of transmission by Baudot quadruple apparatus. The text will be in languages suitable to the operators, will be printed on sheets containing 50 words each, and will consist of words, groups of letters and figures. The text will be different for each system, but the same for competitors in the same system. A special test for reception by sounder and the writing of the text by a writing machine (the writing machine being provided by the competitor) will also be held, if not less than 10 competitors belonging to three different administrations apply by June 15, 1911. The transmission will be effected in accordance with the International Telegraph Regulations. There will be a championship cup, which will remain the property of the successful competitor, and which will be competed for by competitors who gain a prize in each of the three systems (Morse, Hughes and Baudot). There will also be an international representation prize cup to be competed for by groups of three competitors who all represent one State and have between them won prizes in all the three sections. There will also be individual prizes, 10 for the Morse, eight for the Hughes and eight for the Baudot tests.

Foreign competitors must present themselves at the Direction Supérieure des Postes et des Télégraphes de Turin two days before the tests commence.

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THE ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

The third general engineering and machinery exhibition, which is being held this year under the more imposing title of the Naval, Mercantile Marine and General Engineering and Machinery Exhibition, was opened at Olympia yesterday by the Marquis of Graham. This exhibition has been organised by Mr. F. W. Bridges, assisted by a strong advisory committee under the presidency of Sir David Gill, K.C.B., F.R.S. As seems to be usual on these occasions, very few purely electrical firms are exhibiting, but the opportunity has nevertheless been taken to employ electricity for the general lighting of the building and for the driving of most of the machinery on the stands. We shall hope in due course to give a detailed account of some of the more interesting exhibits, and this week shall, therefore, confine ourselves to merely describing some of the things which ought to be seen by visitors to Olympia.

We may first mention that Messrs. Babcock & Wilcox on their stand have a number of interesting models. These models include one of a sea-going torpedo boat destroyer, which has been fitted with White-Foster water-tube boilers, for which Messrs. Babcock & Wilcox are the sole licensees. A model of a marine type water-tube boiler, as installed in various navies and in the mercantile marine, is also to be seen. Messrs. Babcock & Wilcox have supplied nearly 2,000,000 H.P. of these boilers. A standard land type of water-tube boiler, which is suitable for use in all industries, and of which 7,000,000 H.P. have been supplied, is also to be found on this stand. This boiler is fitted with one of Babcock & Wilcox patent steam superheaters. Other models are those of a patent chain grate stoker, a Lassen & Hjort water purifier, a collection of wrought steel steam piping with wrought steel flanges, and samples of headers used in the construction of Babcock boilers with pieces of tubes expanded therein. There is also a collection of turbine tube cleaners for removing scale from the inside of boiler economisers and other tubes.

An interesting series of ship models is to be found on the stand of Messrs. Cammell, Laird & Co., of Birkenhead. These include the "Leviathan," one of the largest dredgers in the world, models of the two latest additions to the fleet of the London & South Western Railway Co., and other similar passenger steamers which have been supplied to the Great Western Railway Co.

Messrs. Pickerings (Ltd.), of Stockton-on-Tees, are showing several designs of lifting and hauling appliances, amongst which is their electric friction hoist. This is driven by a motor through cut spur wheel and raw hide pinions, the special feature being the arrangement of eccentric for throwing the friction surfaces together. They are also exhibiting one of their self-sustaining dinner lifts, and a travelling trolley with two hooks, also of the sustaining type. It may be mentioned that this firm make a special feature of push button electric lifts for all kinds of services.

Messrs. Geo. Kent (Ltd.) are showing a number of apparatus illustrative of their specialities. Among these may be mentioned the Venturi station meter for gas works and the Venturi air meter for use where compressed air is employed. We understand that this type of meter is being used in connection with the supply from the Victoria Falls and Transvaal power scheme to the mines. A number of Kent's well-known Venturi water meters are also being shown. This firm is also exhibiting for the first time their "Uniform" hot water heater. This is guaranteed to be suitable for any temperature of water, and is, it is claimed, a perfectly satisfactory, reliable instrument at low pressures.

The Worthington Pump Co. are showing a large number of their well-known pumps. Among the working exhibits is a 1,600 sq. ft. Worthington condenser, which operates in connection with electrically-driven Worthington centrifugal circulating and hot well pumps with Worthington rotary air-pump. There is also a 4 in. three-stage centrifugal boiler feed pump driven by a 50 H.P. turbine. On this stand are also to be found a number of Worthington low-lift centrifugal pumps with couplings, marine low-lift centrifugal pumps with belt drive, and a 3 in. steam-driven centrifugal marine pump. A centrifugal house tank pump of the single-stage type and motor driven may also be seen.

Messrs. J. Marse & Co. are showing a Piat hydro-electric riveting machine of a portable type. This machine will close 340 $\frac{1}{8}$ in. diameter rivets per hour, the capacity of the motor being $2\frac{1}{2}$ H.P. The total weight of the machine is 14 cwt. It is claimed for this arrangement that it is easy to transport, no large plant is required, and it is always ready for use, while, unlike purely hydraulic apparatus, it can be worked, however low the temperature.

The Lea Recorder Co. are showing a new instrument for integrating as well as indicating and recording the flow of water over V notches and weirs. Mr. Lea's apparatus has been described from time to time in The Electrician, but our readers will doubtless take the opportunity of inspecting the latest patents shown at Olympia.

The Adams, Watkin Co. are showing the Adams-Watkins switch in a specially arranged exhibit which has been fitted up to demonstrate the facilities afforded by the switch for reducing the candle-power of electric lamps. Instruments are fitted up which show how the current in the circuit is cut down when the light is lowered. This switch has recently been described in detail in The Electrician.

Messrs. Stockall, Marples & Co. are exhibiting time recorders, electric clocks and watchmen's tell-tales.

Messrs. Clarke, Chapman & Co. have taken stand No. 166. The firm are showing a number of photographs of their various productions, including all classes of ship's deck machinery, windlasses, winches, capstans, &c., driven both by steam and electricity; electric machinery of all descriptions, including hauling gears, search-light projectors, &c.; water-tube boilers (Woodeson's patents), direct-acting steam feed pumps and various models, including one of the Clarke-Chapman water-tube boiler (Woodseon's patent).

We may also mention the exhibits of the Standard Engineering Co., who are showing a variable-speed single-phase motor, as well as the Stanlock multiple unit system, which is used in connection with the heating and ventilating of engineering workshops.

Other exhibitors are Messrs. Kelvin & James White and the Witton-Kramer Tool & Hoist Co. We shall hope to describe these exhibits in greater detail in another issue, but the names of these firms are sufficient indication of the apparatus they are showing.

LEGAL INTELLIGENCE.

British Westinghouse Electric & Mfg. Co. v. Redings Arc Lamp Co.

This action came before the Vacation Court on Wednesday upon a motion for an interlocutory injunction to restrain an alleged infringement of patent. Counsel stated that an injunction had been granted ex parte over that day and defendant now agreed to treat the motion as the trial of the action, submit to a perpetual injunction, an inquiry as to damages and delivery up of the infringing articles and to pay costs. Order accordingly.

Mining Regulations.

At Linlithgow on Tuesday Sheriff MacLeod gave judgment in a case of much interest to mine owners and managers. John Leckie, mine manager, Blackridge, was recently charged with having, on March 4 last, in No. 3 Blackrigg Colliery, Torphchen (occupied by the United Collieries, Ltd.), failed to see that a competent person was on duty at the colliery when the electrical apparatus or machinery installed there for driving pumps was in use.

The prosecution arose out of a fatal accident to a pump attendant in the pit by his coming in contact with a faulty joint of an electric cable. The Home Office desired a decision as to what was a competent person within the meaning of their special rules for the working of electrical plant in mines.

His Lordship said the question was whether what Mr. Leckie did was sufficient. He did not know what Mr. Leckie did. Therefore, he could not say whether it was sufficient or not, and he found the charge not proven. He had taken the liberty of making a suggestion to the Home Office. It seemed to him that H.M. Inspector of Mines ought always to find out on going to a mine what the manager had done, and he had suggested a very simple expedient by means of which the inspector should always be able to find out what he had done.

The Home Office will appeal from the decision.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the vacant position of assistant lecturer in the physics department of the Technical College, Sunderland. Commencing salary £150 per annum. Particulars from the assistant clerk to the Education committee (Mr. Herbert Reed), 15, John-street, Sunderland. Applications by Sept. 10. See also an advertisement.

First-class managers, experienced in the design, costing, testing and laying of all classes of insulated cables are required for new cable factories (two on the Continent and one in the East); those with knowledge of French and German preferred. Applications to the Eastern Trading Co., 4, Coleman-street, London, E.C. See an advertisement.

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A first-class foreman is wanted for the rubber department of an Italian cable manufacturer. See advertisement.

An outdoor representative is required for a London Electric Supply Co. See advertisement.

The Council of the University of Birmingham invite applications for the appointment of assistant lecturer and demonstrator in electrical engineering. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by Sept. 17.

Applications will be received until Sept. 10 for appointment to the Henry Overton Wills Chair of Physics at Bristol University. Salary £600 per annum. Particulars from the Registrar.

An assistant designer is wanted for a.-c. motors, familiar with calculation, construction and testing of all sizes from ¼ B.H.P. to 50 B.H.P.

Mr. Hy. Wren, M.A., Ph.D., D.Sc., has been appointed professor of pure and applied chemistry at the Municipal Technical Institute, Belfast.

Mr. Howard, of Taunton, has been appointed borough electrical engineer by Taunton Corporation.

EDUCATIONAL NOTICES.

King's College (University of London).—In the Faculty of Engineering complete courses of study, extending over three or four years, are arranged in civil, mechanical and electrical engineering for the engineering degrees of the University of London and for the diploma and certificate of the College. There will also be special courses of advanced lectures on "Internal Combustion Engines" and "The Theory and Practice of Construction." The entrance day for new students is Tuesday, Oct. 4.

University of London, Goldsmiths' College.—The new session commences on Monday, Sept. 26, and the enrolment of students commences on 19th inst. Complete courses of instruction are provided in mechanical, electrical and constructional engineering, telephony, fitting and machine pattern making and smithing, land surveying, &c. Students are prepared for the London University degree of B.Sc. in engineering, for the examinations of the Institution of Civil Engineers, Board of Education and City and Guilds of London Institute and for the National and Whitworth scholarships. There are reduced fees to course students if paid by Sept. 23. Particulars of fees, &c., from the Warden, Goldsmiths' College, New Cross, S.E.

University of Bristol.—At this university complete courses of instruction in electrical, mechanical and civil engineering are given, and also instruction in the evening classes. The 1910-11 session in the faculties of arts, science and medicine will commence on Oct. 3, and in the faculty of engineering on Sept. 13. Particulars and prospectuses from the registrar, Mr. James Rafter.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

University College of North Wales (Bangor).—In October a systematic course of instruction in electrical measurements and practical electricity for students proposing to enter the profession of electrical engineering will be commenced. The physical laboratory is well equipped for experimental and research work. The course extends over two sessions. Prospectus and further information may be obtained from the secretary and registrar, Mr. J. E. Lloyd, M.A.

Northampton Polytechnic Institute (London).—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Monday, Oct. 3.

The courses in mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include specialisation in radio-telegraphy. The entrance examination takes place on Sept. 28 and 29. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in engineering at the University of London. There are full and part time courses in all branches of technical optics. Particulars as to fees, &c., can be obtained at the Institute, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Glasgow and West of Scotland Technical College.—The day classes begin on Tuesday, Sept. 27, and the evening classes on Thursday, Sept. 22. The diploma of the College is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics, building and textile manufactures. The courses of study for the diploma usually extend over three sessions, and holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session upon prescribed University classes. Preliminary examinations begin on Sept. 19. There are new and well-equipped laboratories in the departments of physics, chemistry, mechanics, motive power and electrical engineering, &c., and facilities are afforded for research. Copies of calendar (price 1s. 4d.) and prospectus (gratis) can be obtained from the Secretary.

South-Western Polytechnic Institute (London, S.W.).—At this Institute a complete three years' course in electrical engineering is held during the day, and a four years' course in the evening. Courses of lectures and practical work are given in a number of subjects, including elementary, intermediate and advanced electrical engineering, electrical design, instruments and lamps, alternating and polyphase currents, wiring and fitting, and the calculus for engineers. Particulars from the Secretary, Manresa-road, Chelsea, S.W.

BRITISH NOTES.

Bispham.—The Council have decided to apply for sanction to a loan of £9,855 for electricity supply and dust destructor works. The consulting engineer is Mr. J. W. Speight, and it is estimated that the cost of site for a generating station (which has been conditionally purchased) will be £2,105, while the generating plant, mains, &c., will cost £7,200.

Bradford.—At a meeting of the Tramways committee on Monday a sub-committee was formed to carry into effect the provisions of this year's Corporation Act, authorising the construction of railless tramways, and it is anticipated that a line will be in operation in the near future.

Braunton.—The Parish Council have received a favourable report from Mr. Jenkins on the electricity supply scheme proposed by Messrs. Crompton & Co., and it is probable that a contract will be entered into for public lighting in the event of the scheme being carried out. The majority of the inhabitants favour electric lighting, and an effort will now be made to form a local company.

Brighton.—Yesterday (Thursday) the Council had under consideration a report from the engineer and manager of the electricity department (Mr. John Christie) in regard to the condition of the pipes of the condenser circulating system at the Southwick electricity works.

In his report Mr. Christie states that at the last meeting of the Lighting committee he verbally reported that they were experiencing trouble due to mussel spawn and other marine growths having got through the strainer and attached to the inner surfaces of the pipes of their condenser circulating system. These growths had increased in size and multiplied in a most alarming manner. Further investigation showed that the trouble was more serious than at first anticipated. There was a 5 ft. suction pipe from the harbour, which, some 10 ft. inside the face of the quay, branched off into two 30 in. pipes. A diver went up the 5 ft. pipe as far as the branch, and reported that beyond it there were clusters of large mussels and other marine growth, some 7 in. thick, all round the inner surface of the pipes. That reduced the effective bore of the 30 in. pipe to 16 in., greatly restricting the flow of water to the condensers, and putting an overload on the pumps and motors which they were never designed to carry, in order to circulate sufficient volume of cold sea water to effectively condense the steam and maintain the high vacuum, so necessary for the efficient operation of the turbines.

Mr. A. Wright had unfortunately been detained in South Africa by illness, and he had been unable to discuss the matter with him. He had, however, gone fully into the matter with his deputy, and he had consulted several expert marine biologists, and a few station engineers who had to work their plant under somewhat similar conditions. They all agreed that there was no cure for the trouble except scraping the growth off the pipes by some mechanical means and removing the debris. It was quite impossible to do that in their case, and the only alternative was to provide a new system of pipes laid above the floor, with suitable manholes to give access to them for the periodical scraping and removal of any growth that might accumulate. Their new turbine, which they were arranging to erect in a few months time, was originally intended to be coupled up to the existing circulating system. In view, however, of the unfortunate development, it would be best to connect it up to an entirely new system of piping. With that end in view he had had a new scheme of pipe arrangement got out, embodying a pipe line for the new turbine and four new pipe lines which could be worked in in the same way to each of the existing turbines in turn, each set being distinct from the others and entirely disconnected from one common pipe system as at present. He had discussed the question with Messrs. Richardsons, Westgarth & Co. (the makers of the turbine) and they approved the new arrangement. They quoted £870 for supplying the necessary pipes, valves, &c., to connect up the condenser of the new set with the harbour. That would work in with the complete scheme, and they would have to carry out the excavation for and laying of these pipes themselves by direct labour, and he asked the Lighting committee to approve of the work being put in hand at once, and for authority to invite prices from some of the leading pipe makers for the remainder of the pipes necessary to run a new system to each of the first four turbines. The cost will be approximately £1,800, exclusive of the cost of excavation and erection. The cost of the piping

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for the new turbine should (Mr. Christie considers) form a capital charge, but the cost of supplying similar arrangements for the first four turbines would have to be met out of reserve. As the summer is now gone, and the mussel growth will not seriously increase before next spring, and with the temperature of the sea water gradually falling, and consequently the amount of water necessary for cooling the steam getting proportionately less, Mr. Christie hopes that, with the fifth turbine coupled up to a new system of pipes, as suggested, they will be able to get through this winter's load without mishap.

The Lighting committee reported that they considered that the only means of dealing with the matter was to carry out the suggestions set out in Mr. Christie's report, and they recommended that tenders for carrying out the necessary work be called for.

Chelmsford.—The Guardians propose to provide electric power plant for the workhouse laundry at a cost of £560.

Church Lighting.—The Causewayend U.F. Church, Aberdeen, has recently been re-decorated and fitted for electric lighting. The wiring work was carried out by Mr. J. Jackson and the fittings and pendants were supplied by Messrs. Benson & Co. The entrance hall is lighted by two 50 c.p. osram lamps, two side entrances and staircases have each a single pendant with 50 c.p. lamps. Along each aisle are four solid bowl pendants, each with three 50 c.p. lamps on two switches. The back gallery is lighted by a similar bowl pendant, and arranged under the galleries are 13 single 50 c.p. pendants.

Cobham.—The Woking Electric Light Co. propose to commence laying cables in this district in about five weeks. The Parish Council are to invite tenders from the electric light and gas companies for street lighting. At present oil lamps are used.

Electric Pumping in Emergency Work.—Recently a serious fire occurred at the Stoney Heap pit of the Consett Iron Co., owing to the ignition of some oil or waste used in connection with an oil engine driving a pump. After the fire was extinguished there was danger of the workings being flooded out unless within a week a replace pump equipment was in commission. The Cleveland & Durham County Electric Power Co. came to the rescue by running a cable from their main transmission system, about ½ mile away, to the pit head, where a step-down transformer was installed, from which about 350 yds. of 440-volt cable was run to a 60 H.P. motor, which, together with the necessary pump, had been hurriedly secured. The work was completed in good time to allow of pumping operations being resumed before the water had encroached dangerously. This instance affords an excellent example of the advantage of the existence of a network of electric power mains throughout the colliery districts of Durham.

Exhibition Award.—We are pleased to announce that the Japan-British Exhibition authorities have awarded the Grand Prize (the highest possible award) to Mr. Louis Brennan for his gyroscopic mono-rail invention.

Grassington.—A meeting of ratepayers called by the Parish Council was held on Tuesday, when it was decided to approve the electric lighting scheme put forward by Grassington Electric Supply Co. At present £30 per annum is paid for lighting, but the company will give a much better light for £20 per annum.

Greystones (co. Wicklow).—At a recent meeting of Rathdown (No. 2) Rural Council a discussion took place on the proposal to adopt public electric lighting.

The L.G. Board had written stating that they were not aware of any authority empowering the Council to borrow if they did not themselves intend to apply to the Board of Trade for a provisional order, or licence, authorising them to supply electricity.

It was also stated that counsel's opinion was that the Greystones Electric Light Co. could not enter into a contract for public lighting without first obtaining a provisional order. Until this was done the Council had no power to come to an agreement with the company.

Mr. Hewson said he knew, as a matter of fact, that other urban districts had done their lighting without a provisional order being obtained. It was done at Ballinrobe and other places. It was the policy of the L.G. Board to play into the hands of the Board of Trade, and to put the ratepayers to expense. They should imitate the West of Ireland, and carry out their lighting without bothering themselves about the Board of Trade. Mr. Hewson undertook to make inquiries, and report to the next meeting.

[We believe that in rural districts powers for public lighting (by electricity or gas) are obtainable for any parish or part of a parish in a district under the Lighting and Watching Act, 1833, and provided the act is adopted in the regular way for the district (or any parish in it) the Council can then enter into a contract with a company for the supply of electricity and the erection and maintenance of the lamps. It is not necessary that the Council should borrow for this purpose. In fact, it is not a charge which should fall upon capital.—ED.]

Halifax.—A sub-committee of the electricity committee recommend the purchase and erection of additional generating plant at the electricity works at a cost of £10,000.

The additional plant is required in order to meet the increased demand for electrical energy, especially for power. In the proposed Parliamentary bill further borrowing powers will be sought.

Haslingden.—The Board of Trade has sanctioned the arrangement whereby Accrington Corporation is to supply electricity to Haslingden, and the question of the revocation of the Haslingden electric lighting order has been deferred for a year from Sept. 30.

Inquest.—An inquest was held at Pencoed on Tuesday into the death of a collier named Jones, who was killed at South Rhondda Colliery on 19th ult.

EDWARD JORDAN said he and deceased were working on the night shift putting up iron girders. Deceased picked up a few yards of old loose signal wire which was lying on the side of the roadway to hand to witness. He had no sooner done so than he shouted and fell down, apparently dead. Witness tried to take the wire from him, but was rendered unconscious for a few seconds by a shock.

JOHN MATTHEWS said he heard a scream and saw a flash of light. On running to the spot he saw deceased lying on the ground with the wire in his hand. The wire extended across the roadway to the electric cable. He caught hold of the cable, using india-rubber gloves, and cut it. He unsuccessfully tried artificial respiration. He examined the cable and found that the signal wire, which Jones had picked up, was hitched into the cable near the joint, and some of the insulating tape around the joint had got loose. Witness believed the tape had been pulled loose by the piece of wire catching into it—that a sharp end of the wire had cut through the tape to the core of the cable.

WILLIAM DAVID, mechanic, said the electrical apparatus was under his supervision.

Mr. R. NELSON (H.M. electrical inspector of mines): Were you present on Monday when I opened four joints in the cable and found no empire tape?—Yes; we had an electrician. We thought he was not using sufficient empire tape. I spoke to him about it, but he said he was using it.

Is that electrician with you still?—No, he has left. We disagreed about something else, and he went.

Mr. W. WILLIAMS, manager, said he had notices posted up in the colliery about the electrical installation. At the spot where the accident occurred the cable was carrying continuous current at 300 to 400 volts.

Mr. R. NELSON said he examined the cable generally. He concluded from the evidence that the shock was conveyed in some way from the piece of disused signal wire. Whenever repairs were being carried on, or girders erected, electrical cables should certainly be protected. Disused wires should always be removed, and not be left on the roadway where there were electrical cables.

A verdict of accidental death was returned., and the jury added a rider that death was due to electric shock, but that there was not sufficient evidence to show whether the cable was defective at the point where the accident occurred. They were of opinion that the recommendations of Mr. Nelson should be strictly carried out at all collieries.

Llanelly.—The Llanelly & District Electric Lighting & Traction Co., which recently made an issue of capital, has acquired a site for a generating station. A contract has been made with Messrs. Balfour, Beatty & Co. for the erection and equipment of the station, which will have an initial capacity of 1,000 kw. A portion of the tramway system has been re-constructed for electric traction, and the remainder will be re-constructed next year. The Council have entered into a 10 years' contract with the company for street lighting, which will be effected by 40 arc lamps and over 500 incandescents.

Municipal Wiring.—We have received from the hon. secretary of the Incorporated Municipal Electrical Association (Mr. H. Faraday Proctor), of Bristol a list of the municipal electricity undertakers which have replied to his circular letter of July 9, in connection with the promotion of a bill for further powers, including authority for municipal electricity departments to wire consumers' premises, let motors on hire, &c.

The following 36 towns will give financial support: Barnes, Barrow, Bolton, Blackpool, Bradford, Cardiff, Coventry, Devonport, Dewsbury, Eastbourne, Eccles, Govan, Gillingham, Hastings, Ilkeston, Ilford, Londonderry, Lincoln, Maidstone, Middlesbrough, Peterborough, Portsmouth, Rochdale, Sheffield, St. Marylebone, St. Helens, Taunton, Walsall, West Ham, Wimbledon, Wigan, Edinburgh, Glasgow, Bristol, Doncaster.

The following 12 towns have decided to give the bill their moral support: Birkenhead, Bury, Broughty Ferry, Colne, Canterbury, Dartford, Exeter, Fulham, Falkirk, Hackney, Loughborough, Southend-on-Sea, West Bromwich, Warrington and Halifax.

Brighton, Carlisle, Darlington, Keighley and Swindon are in favour of the proposal, but the following will take no action: Aberdeen, Epsom, Farnworth, Grimsby, Hammersmith, Ipswich, Liverpool, Salford, Southwark, Tunbridge Wells, Batley and Sutton Coldfield. Derby Electricity committee will consider the matter again. Hull has replied "Yes" as regards stand-by by unauthorised undertakers, but not wiring; and Mansfield already possess the powers.

Newcastle-on-Tyne.—Deputations from the Newburn and Blaydon Councils have waited upon the sub-committee of the Tramways committee dealing with the extension of the municipal tramways by railless trolley routes or otherwise, in order to urge the necessity of improved transit facilities in Newburn and Blaydon respectively. The sub-committee is favourable to the principle of extension, but a further meeting will be held between the parties.

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Nottingham.—The Corporation have commenced the construction of the Carlton-road tramway route. The line, about a mile in length, will be double throughout, and the estimated cost is £13,000.

Obituary.—We regret to record the death of Col. Sir Charles Euan-Smith, K.C.B., C.S.I., which occurred in London on Tuesday. Deceased, who was 68 years of age, was associated with several electric tramway and lighting undertakings, and was chairman of the Cape & Lisbon Electric Tramways Companies, a director of the Chilian Electric Tramway & Light, Marconi's Wireless Telegraph and the Marconi International Marine Intercommunication Companies.

We also regret to record the death of Mr. William Anderson, manager, and since 1896 managing director of the Dublin United Tramways. Mr. Anderson was also a director of the Cork Electric Tramways & Lighting Co.

The death is also announced of Herr Isidor Loewe, of Berlin. Deceased was associated with Ludwig Loewe & Co. and other German companies. In 1892 he founded the Union Electrical Co. (Berlin) in connection with the Thomson-Houston Electrical Co. of Boston for the construction of electric railways on the Thomson-Houston system. Herr Loewe was also connected with the management of a number of important financial and industrial enterprises.

The death took place in London on Aug. 24 of Arthur Willoughby Foord, Director of Indian Government Telegraphs. Deceased was 50 years of age.

Overcrowding on Tramcars.—At a recent meeting of the Plymouth Tramways committee a letter was received from the Board of Trade asking for an explanation of overcrowding of tramcars on recent occasions.

The tramcars are allowed to carry seven excess passengers on Saturdays from noon, on Sundays and holidays, and on other days when the weather is inclement.

The committee received a report from the tramways manager (Mr. Everson), in which it was stated that the utmost pains had been taken to find out where and when 10 and 15 passengers were seen standing in a tramcar at any one time, and he had been unable to find a single occasion, except occasionally when three or four people were on top of a car when a downpour of rain came on. These people rushed from the top and took shelter from the heavy rain on the platform and inside the car.

After reading the reports on the matter, the committee decided to reply that strict instructions had been issued to the inspectors and conductors and that those instructions had been strictly adhered to, except very occasionally.

A report has been received from the borough surveyor (Mr. Jas. Paton), the electrical engineer (Mr. E. G. Okell), and the tramways manager (Mr. Everson) on the relative cost of establishing a service of cars on the railless trolley and the ordinary tramway systems to Laira, and also on the cost of extending the tramways to the borough boundary at Hartley. The committee are to inspect the routes on the 13th inst., and will then consider the reports.

Presentation.—Chatham Dockyard electrical engineers' staff have presented a travelling bag, a case of pipes and a safety razor to Mr. W. J. Rhodes, who has been appointed inspector of electrical fitters at the Cape of Good Hope Dockyard.

Railway Employees' Wages and Hours of Labour.—The Railway Department of the Board of Trade have issued as a blue book a statement of settlements regarding questions as to rates of wages and hours of labour of railway employés that have been effected under the conciliation scheme of November, 1907, and of settlements on certain railways which remained outside the scheme.

Particulars are voluntarily supplied of settlements arrived at upon four railways not under the general scheme, viz., the City & South London, Underground Electric Railways of London, Metropolitan District and North-Eastern Railways. As to the methods of arriving at decisions under the conciliation scheme for the different railways, the return shows that settlements were made by sectional conciliation boards in 23 instances, while the conciliation boards effected settlements in three or four cases. Intervention by the central conciliation board proves to have been fairly common, while many settlements were effected "through usual channels," and a few by arbitration.

Ramsbottom.—The official inauguration of electricity supply for private lighting and power took place on Saturday last.

Seaforth (Ont.).—The ratepayers recently voted in favour of the acceptance of the offer of the Hydro-Electric Commission to supply electricity in bulk, and £5,000 has been voted for the equipment of a transformer sub-station and the laying of a distribution network.

Sewage Pumping.—An L.G. Board inquiry has been held into an application of Doncaster Rural Council for sanction to a scheme of main sewerage and sewage disposal for Adwick-le-Street and property near the station.

It is proposed to convey the sewage of a portion of the district to an underground pumping station where storage tanks will be provided, and the sewage pumped to the Woodlands sewage disposal works automatically by electric motors driving centrifugal pumps. The other portions will gravitate to the works. The population to be dealt with at the works will be about 12,000. The scheme has been designed by Messrs. D. Balfour & Son, of London and Newcastle-on-Tyne.

Strike.—On Aug. 25 a strike of pattern makers commenced at Preston, in consequence of their demand for an increase of their wages by 2s. per week not having been conceded. It is stated that the men's demand for an advance in wages was due to an abnormal demand for labour caused by the engagement by Messrs. Dick, Kerr & Co. of between 60 and 70 men to make steam turbine patterns.

Todmorden.—An unopposed inquiry was held into the Council's application for sanction to borrow £300 for the electric lighting of the town hall.

Village Lighting.—At Askrigg electricity has been adopted for street lighting, and the Wesleyan Church, the Queen's Arms Hotel and a number of private houses have been wired. Water power is used in generating current.

A Wireless News Service.—It is announced that the Marconi Wireless Telegraph Co. are about to establish a news service which promises to be of considerable interest. The results of recent arrangements for establishing communication between ships at sea and the authorities on shore have pointed to the feasibility of establishing a central office for the regular collection of news items from ships at sea and at the same time, of course, conveying news from shore to ship. The fact that a large and increasing number of the principal steamships are now equipped with Marconi apparatus gives the proposal a promising appearance. The new service will be established within the next few weeks.

Wireless Telegraphy in the Pacific.—In our last issue, under the heading of Wireless Telegraph Notes, we gave a long extract from a recent article in the "Canadian Electrical News." We have received the following communication on the subject of this note:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of Aug. 26, under "Wireless Telegraph Notes," you quote from an article in the "Canadian Electrical News" for August, which is full of discrepancies. For instance, the Canadian Government stations are not all equipped with Marconi apparatus. The original apparatus at Point Grey, Victoria, Cape Lazo, Pachena and Estevan was supplied by the International Telegraph Construction Co., of New Jersey, and consisted of the Shoemaker system. Each set was of 1 kw. capacity, and was covered by a guarantee, power being derived from a 3 H.P. Fairbanks-Morse gasoline engine. The masts, except at Point Grey, were 180 ft. high; at the latter place a standing Douglas fir, 300 ft. high, was used (after being stripped of its limbs, and an occupied bald eagle's nest, 7 ft. 6 in. in diameter).

On the appointment of a new superintendent, an ex-Marconi man—Marconi sets having double the power (2 kw.) were added to the Shoemaker sets at Cape Lazo, Victoria and Pachena. Supplement No. 10, dated July 15, 1910, of the Berne List of Radiotelegraph stations, shows Shoemaker sets to be in use at Victoria, Pachena and Estevan.

The article further states that "the tower at Triangle Island is 620 ft. high, and the 180 ft. mast makes this the highest station in the world." This is liable to lead to a misconception, because 620 ft. is undoubtedly a rough (and outside) estimate of the height of the top of the mast above sea level as the island is some 300 ft. high, and the cost of a 620 ft. tower would be altogether inconsistent with the vote for these stations.

I would add that the 1 kw. Shoemaker sets, at Pachena and Estevan, had a nightly range of communication extending from Sitka, Alaska to San Diego, Southern California, and could hear Honolulu.

The writer had local charge of the construction of five of the stations referred to.

A. H. MORSE,
Installer, United Wireless Telegraph Co. of New York.

[We cannot truthfully express regret for having quoted from our esteemed Canadian contemporary in view of the fact that it has given Mr. Morse an opportunity of correcting us by means of this very interesting letter. In the early days of the telegraph incidents of the kind set out in Mr. Morse's letter were frequent, and it is quite a reminder of old times to read of the expedients adopted by the installers of wireless telegraphy to overcome natural difficulties.—ED. *E.*]

A Reuter's message states that wireless communication was successfully established on Saturday last at Sheeps Head Bay aviation track, New York, from a moving aeroplane at a height of 500 ft.

In his report on the trade of Iquitos (Peru) for 1909, Consul Cazes says the wireless telegraphy system is still rendering good service, but communication with Lima and Europe is often interrupted beyond Puerto Bermudez, whence messages go by overhead cable.

The public journals relate that preparations are reaching completion for the crossing of the Atlantic Ocean by airship, driven by an American aviator, Mr. Wellman. This mighty effort is to be made towards the end of the current month of September, and it is arranged that the airship is to be provided with a Marconi wireless telegraph installation and night signalling apparatus to enable the six persons who are to be accommodated on board to communicate with creatures on terra firma. The reported success of the experiment at the aviation grounds at Sheeps Head Bay, New York, have satisfied the parties concerned of the practicability of the proposal.

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"Robertson and Osram" Sports.—The fifth annual sports of the Robertson and Osram social and athletic club were held on Saturday last. 28 events were all keenly contested, and some fine sport, as well as amusement, was provided, the competition for supremacy between the employés at Robertson's Lamp Works, the Osram Lamp Works and the General Electric Co. being very keen, the number of handsome and useful prizes offered helping in this direction. Much credit is due to the committee and other officials for the excellence of the arrangements and management generally. After the competitions, Mrs. C. Wilson, wife of the genial president of the club, presented the prizes, after which dancing on the lawn was indulged in.

COLONIAL AND FOREIGN NOTES.

Argentina.—The "Review of the River Plate" states that Government has approved the statutes of the Compañia Hidro-Electrica de Tucuman.

About a year ago Santa Fé Municipality called for tenders for the electrification of its tramways. Several proposals were received, but all were rejected. Fresh tenders have just been received, and it is stated that none of them are as advantageous to the Corporation as those presented previously.

Australasia.—The "Australian Mining Standard" states that a deputation from Canterbury (N.Z.) recently waited upon the Prime Minister (Sir Joseph Ward) to urge that the Government should at once proceed with the Lake Coleridge hydro-electric power scheme for Christchurch, or that the Corporation should be allowed to do so.

Sir Joseph Ward, in reply, said the Government had rightly changed its policy in the bill that would be considered this session regarding water power, because they found that in some places large sums were being made out of options before any work was done. If that were permitted it would mean imposing upon the people very high charges for power. The Government could provide water power at a cheaper rate than any corporation, and they would not allow a superior body to have an opportunity of making an over-riding profit out of the business. Legislation on the subject would be put through this session. They would not, of course, spend the whole of the £500,000 in Canterbury. They had come to the conclusion that it was in the best interests of the State that the Government should control the whole of the powers for utilising water power from end to end of New Zealand.

Wellington (N.Z.) city electrical enigneer (Mr. Stuart Richardson) reports that the Parsons 1,500 kw. turbo-generator at the Mercer-street station has been running continuously and has given complete satisfaction since the beginning of this year. Mr. Richardson estimates that the machine will effect a saving of nearly £3,000 per annum in generating expenses. The coal consumption has been reduced by 1,600 tons in the half-year (equal 25 per cent.).

In the Tasmanian Legislative Assembly recently Mr. N. K. Ewing gave notice of a motion to advance to the municipalities of Huan, Lovett, Esperance and Kingborough moneys for the construction of an electric tramway from Hobart to Huonville, with branch into Kingston and connecting Huonville with Lovett and Geeveston, and for a line from Huonville up to the Huon river to tap the available Crown lands, and that the committee have power to enter into a contract to take electrical energy from the Complex Ores (Ltd.), or any other company acquiring their rights. The Complex Ores company are already negotiating with the municipalities for electric lighting.

Mr. A. H. Wood, electrical engineer, of Melbourne, has been engaged to report to the Yea & Mansfield (Victoria) Dairy Co. on a proposal to instal suction gas plant for operating electrical plant for lighting the company's works.

The Electric Supply Co. at Hamilton (Victoria) are duplicating their plant by putting down a 100 H.P. engine gas producer plant and dynamo.

Toora (Victoria) ratepayers are discussing a proposal to adopt electric lighting. Mr. A. H. Wood advises that the water power of the Agnes and Franklin rivers (both within three miles) could be utilised for generating current.

The Derwent Mfg. Co. is being formed to establish a hydro-electric plant on the Derwent river, near Hobart, Tasmania. Mr. H. J. Spencer (formerly electrical engineer to the Hobart Gas Co.) is connected with the scheme.

Chili.—The "Review of the River Plate" says the special committee appointed by the Chilian Government to report on the proposed electrification of several of the State lines and which will shortly have finished its work, are in favour of electrification.

Customs Decisions.—Electric tramrail filing machines driven by mechanical power can be imported into the Netherlands duty free.

Under the French Customs tariff porcelain insulators mounted on an iron or steel stand are dutiable under 347 *bis* and 558 *bis* if the parts are separable (*i.e.*, each part is dutiable separately), but if the parts are inseparable the whole pays duty at the highest rate applicable to any part.

By coils of insulated metallic wire, under the heading of "electric and electro-technical apparatus" in the French tariff, is to be understood all coils of wire having an insulation, such as wire surrounded by a covering of textile threads, by a sheath of ribbon, trimming or tissue, by an insulating coating with a base of indiarubber of gutta or any other material, except uncovered (bare) metallic wires set in a bobbin of porcelain, glass or pottery.

Electricity in Mining.—At the recent meeting of the Tasmanian Copper Co. it was announced that the electric power plant on order is on its way from England, and that the foundations, &c., for the first unit are ready.

Hydro-Electric Works in India.—"The Times" announces that an Indian company is in course of formation for the utilisation of water power (at Lanauli, in the Western Ghats) for generating electrical energy which would be transmitted to mills and factories at Bombay. The company is to have a capital of 170 lakhs of rupees (£1,133,220), 70 per cent. of which has been already subscribed. The scheme is to furnish 30,000 H.P., with a reserve of 10,000 H.P., and possibilities of expansion to 50,000 H.P. It is stated that this will be the biggest industrial enterprise inaugurated in India, except the Tata Ironworks.

Italy.—Application for a concession for the construction of an electric tramway from Bergamo to Albino has been provisionally approved by the Superior Council of Public Works.

Japan.—The report of Mr. E. F. Crowe, commercial attaché to H.M. Embassy (*Tok'o*), states that imports to Japan in 1909 included machinery to the value only of £2,072,500, compared with £3,498,600 in 1908 (a decrease of 40 per cent.).

This total included dynamos and motors £184,400 (£209,200) and other electrical machinery £121,800 (£170,600). Imports of telephones were £12,200 (£11,500), steam engines £72,000 (£180,300), gas, oil and hot air engines £39,100 (£98,700) and steam turbines £23,700 (£76,500). Exports of machinery were valued at £183,600 (£234,500). The total imports for the year included £8,802,416 (£11,004,630) from the United Kingdom and £16,275,603 (£16,849,278) from the British Empire, the largest increase being India £6,651,453 (£5,035,612), compared with the United States £5,516,907 (£7,925,398), Germany £4,105,540 (£4,724,266) and France £567,449 (£535,574). Imports included insulated electric wire £191,500 (compared with £190,600 and £251,400 in 1908 and 1907), electric cars £115,200 (£47,200 and £57,000).

One of the features of the year has been the activity with regard to water power schemes. There are already in many parts of the country small plants in operation supplying current to electric light and tramway companies. Of large hydro-electric undertakings, however, the only one which appears to be meeting with success is that of the Uji river, which is intended to supply Osaka. The other great consumer of power in Japan is the capital, Tokio, where there are five or more water power schemes under consideration. Two of these enterprises have been jointly undertaken by British and Japanese capitalists, but difficulties have arisen and it does not appear that either scheme is making progress.

Another noticeable feature of the year, especially of its closing months, has been the boom in electric tramway and gas undertakings, more particularly for the district round Osaka and Kobe and the south of Japan.

In November, 1909, the revised laws with regard to patents, trade marks, designs and utility models came into force. Already some satisfactory decisions have been given in trade marks cases which it would only have been possible to obtain with great difficulty under the old law.

Imports at *Yokohama* included submarine and underground cables £7,230 (compared with £22,518 and £99,180 in 1908 and 1907), other electric wires £90,421 (£108,681 and £64,800), electric machinery £126,045 (£181,551 and £134,370), steam turbines (German in 1909; British and U.S.A. in 1907-8) £6,464 (£22,571 and £21,690), steam engines (chiefly British) £16,090 (£59,608 and £52,100), steam boilers (chiefly British) £9,152 (£34,052 and £48,980), gas and petroleum engines (chiefly British) £20,564 (£49,818 and £33,160). Exports of machinery were valued at £98,560, against £124,072 and £141,350.

New Zealand Telegraphs.—The annual report of the N.Z. Post and Telegraph Department for 1909-10 states that the working expenditure of the telegraph department was £411,296. 17s. 2d. (against £394,649. 19s. 6d. in previous year), which exceeded the revenue by £16,786. 12s. 4d.

The bureau (telephone) messages have so greatly interfered with the ordinary telegraphic work that telegrams have barely held their own. Telegrams transmitted were 7,846,890 (increase 421,197, or 5·67 per cent.) and bureau (telephone) communications were 1,757,869 (against 1,423,093). On March 31 last there were 10,901 miles of telegraph line and 34,788 miles of telegraph wire. Submarine cables within the Dominion were 368 knots. There were 291 telegraph and 1580 telephone offices open. New Zealand's proportion of the deficit of £60,887. 9s. 10d. on the 1908-9 (seventh) year's working of the Pacific cable was £6,765. 5s. 6d. The estimated deficit for 1909-10 was £59,683, of which New Zealand's proportion is stated at £6,631.

Seventeen new telephone exchanges were opened during the year, the number of subscribers increased by 2,104, and the total number of connections by 2,848. There are now 153 exchanges. The total number of connections is 29,681, compared with 26,833 in 1909. On March 31, 1910, there were 1,270 miles of telephone line and 35,233 miles of wire. New switchboards were installed at Te Aroha, Paeroa, Te Kuiti, Greytown, Kimbolton, Manaia, Opunake, Pahiatua, Waipawa, Waitara, Woodville, Picton and Kumara, and two sections were added to the Auckland exchange switchboard, increasing the capacity to 3,599. The central battery equipment which was brought into operation at Invercargill and Timaru in June, 1909, has given entire satisfaction to subscribers, besides greatly facilitating switching operations. At Hastings the conversion to metallic circuit and the installation of the central battery system are well forward. The conversion of exchange subscriber's circuits from earth working to metallic was completed at Auckland, Wellington

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Wanganui and Christchurch. Preliminary steps have been taken to establish the metallic circuit system at New Plymouth, Feilding, Hawera, Palmerston North, Napier, Gisborne and Masterton. In August, 1909, the work of laying conduits to provide for placing the telephone cables in Auckland City underground was commenced. Over five miles of lead cable, representing 1,615 miles 74 chains of twin wire, have been drawn into the underground ducts in Wellington City. Arrangements are being made to immediately erect two copper wires between Wellington and Auckland for telegraph purposes by a new route on the main trunk railway line, which is much shorter than the existing routes. These wires will also be used during certain hours for telephonic purposes between the two cities. Between Auckland and Whangarei (126 miles) a telephone circuit was superimposed on two telegraph wires with most satisfactory results. The two wires (Morse and telephone) between Nelson and Motueka have been utilised to form a trunk metallic circuit with the Morse superimposed over it. A similar circuit has been arranged between Nelson and Wakefield. Additional telephone circuits have been superimposed over existing metallic circuits between Ashurst and Palmerston North, Masterton and Greytown and Masterton and Eketahuna; and Morse circuits have been superimposed over metallic circuits between New Plymouth and Waitara, Manaia and Opunake and Wellington and Levin.

Norway.—It is intended to start electric smelting at Odda, in Hardanger, and an experimental electric steel furnace constructed by Eng. Ab. Hiorth at Jösingfjord has produced a few tons of steel. The electrical works were busy during 1909, and there has been a large export of telephones.

Among the new industrial projects in the Bergen district electric iron and steel smelting must be placed foremost. Two processes have been tried in Western Norway—viz., the Heroult method (tried at some smelting works at Trondhjem) and the Grönvall process, and a company is being formed for the erection of electric iron and steel smelting works near Odda, in Hardanger, the necessary electric power to be supplied by the Tysse Falls Co.

Work has been proceeding apace with the Bergen municipal hydro-electric works at Samnanger for supplying power for lighting and industrial purposes in the city, which is at present dependent on steam-driven plant. The work includes the blasting of a water tunnel over 2 miles long, and which, it is estimated, will take 2½ years to complete. The power station will contain machinery of 35,000 H.P. Current will be generated at 7,500 volts, then stepped up to 40,000 volts for transmission to Bergen. The six cables are to be about 22 miles long, and the works are to be completed by the first half of 1912, at an estimated cost of about £200,000.

A report is current that the erection of zinc smelting works is contemplated at or near Odda and also in Romsdalen.

Russian Trading Methods.—In a recent report on the trade of Kharkoff for 1909 Mr. Vice-Consul C. Blakey deals somewhat fully with Russian trade methods.

Mr. Blakey states that the usual advice of trade journals to British exporters to adapt themselves to local conditions by giving metric measures, prices in roubles, Russian, German or French correspondence and catalogues is of first importance in the smaller trades, and even the experienced commercial traveller is not in every case the all-powerful trade factor, and he can often be replaced by local commission agents. I do not mean (says Mr. Blakey) that commercial travellers are of little importance. Thus, for instance, machine tools are frequently sold by travellers, and I should say that in 1909 in the Alexandrovsk manufacturing district alone the increased demand for agricultural machinery will have brought orders to the amount of about £10,000 to the travelling representative of a Berlin tool merchant. In this case personal acquaintance and the patriotic views of the German manufacturers will have assisted to get the orders placed in Germany.

But the trade in which the United Kingdom should be particularly interested, and of which the British manufacturer might gain a larger share, the engineering business, is held by the Germans on a much sounder method, by thorough commercial and technical knowledge, by strenuous energy and financing. In face of a heavy tariff, and against the competition of excellently equipped Russian engineering works, they continue to supply machinery which, though of high quality, is probably neither cheaper nor better than the British. In electrical engineering, cranes, lifts, transporters, machine tools, pumps, steam, gas and oil motors, flour milling machinery, they have a well-established reputation. Some of the firms have their own branches in Russia with commercial and technical staff; they build factories in Russia or have understandings with some Russian works for the supply of certain parts of the machinery or of the contracts that cannot be profitably imported; they have experienced agents with their own assistant engineer and a staff of experts ready to submit plans and estimates, and, where necessary, to take over the erection; they will keep ready in Russia a stock of machines, such as pumps or dynamos, and get orders, say, for emergency work in mines, because they can supply more promptly than the Russian manufacturer. Other machines, such as oil or gas engines, they can generally supply promptly from Germany, and finally they are ready to give credit and guarantees. It wants a large trade to justify such expenses, and any attempt on these lines by a single firm, whose goods are not known here, is sure to be a failure. But what is beyond the power of a single firm may be within the reach of a combination. Comparatively few of the large engineering works have engineers that understand English. German is more frequently needed. Where, however, any special machinery is offered, which is likely to find a more general sale, and, therefore, requires advertising, the advertisement should be in Russian, as it will probably be read by foremen. A good translation and clear type is wanted.

Dimensions of machinery are best given in metric measure, though English inch measure is still frequently used in Russia, and is generally understood. Many factories still work to the English inch, but in the technical high schools metric standards are used. The Russian official measure of length is the arshine (28 English inches) or the sazen (7 English feet) used in the wood trade in building, &c. The Russian poud is the commercial standard of weight, and even to the modern Russian engineer comes more natural than the kilogramme.

In attempting to trade with Russia two difficulties must be faced; the first difficulty is that railways and Government works, the institutions that use the bulk of all engineers' products, are forced by law to purchase exclusively Russian-made goods—from a file to a main engine. Exceptions are only made when unavoidable, but rarely on account of price or of quality. The second difficulty is that trade must be done in face of an apparently prohibitive tariff. Notwithstnding this protective tariff, Russian works manufacturing machine tools and engines are not prospering. Many have closed down, others work with a chronic deficit in this department. The reason is partly to be found in the inexperience of the designing engineers, partly because the necessary high standard of workmanship is so far unattainable, but more particularly because of the limited and irregular demand, which prevents repeat orders or the introduction of more modern designs except by changing costly models before they are depreciated by use. Machine tools that require a high grade of workmanship, or of which the weight is small as compared with the workman's wage put into it, or machines which are being constantly improved, or for which repeat orders are not to be expected, are unlikely to be made in Russia. But all these machines should be made as light as is possible consistently with their efficiency, and in every case the quotation should be made without such of the more massive parts that can be easily made after its arrival in Russia. Thus, engines are purchased without flywheels, oil engines without bed or silencer, lifts without counterweights. For these parts drawings and, if necessary, templates or gauges are supplied by the manufacturers.

Every quotation should contain (besides an advertising description) price and terms of payment, also net and gross weights and shipping dimensions, to enable the prospective purchaser to calculate the cost. This is very frequently omitted, and causes avoidable correspondence and delay. Prices are generally given f.o.b. British port (preferably Hull), since it is only from there that there is a regular steamship service to Baltic and Black Sea ports. In dealing with firms that are not used to custom-house business, it will be better to give the price free on rail at the Russian port and also to arrange with the custom-house and shipping agent. German firms frequently quote free (duty paid) delivered to customers' inland station.

In the matter of credit, easy terms of payment very distinctly assist trade in Russia. Ready money is not plentiful, and a sale can often be made on credit, where the demand for net cash would put the order out of question. This does not refer quite so strictly to large machinery for engineering works (though even here it is frequently necessary) as it does to dealings with agents and more particularly with those referred to above. In every case a strict inquiry into the character and financial standing of the purchaser is necessary. If this is done, and the sale department is in the hands of a man experienced in Russia, I believe the money is as safe in Russia as anywhere. I know importers that do a very large credit trade in Russia and whose bad debts for any one year do not amount to 1 per cent. of the turnover.

Small machine tools that find a regular sale amongst the smaller factories, on estates, &c., are best handled through the medium of wholesale importers and shops that specialise in the sale of technical articles. Such importers are found in commercial centres, particularly in Moscow.

Far better than an importing agent or a casual traveller would be the opening of a sales office, say, as a limited company, in one of the centres, best in Moscow, that would combine the interests of a group of British manufacturers, be financed and controlled by these and managed by a man of trust and experience. The financial arrangement, distribution of expenses and profits could be managed, if only a number of manufacturers were convinced that the trade can be done. The group would have to cover such specialities as high-speed steam, turbine, gas and oil engines, a list of specialities in modern machine tools, also flour milling and foundry machinery, pumps, emery grinders, &c. It should not be necessary to have a stock of machines or exhibition stores in Russia. Such a sales office could be relied upon to do a trade and to look after the interests of the manufacturers far more satisfactorily than an agent. A number of foreign manufacturers have branches in Russia, but they are from that class of manufacturers whose trade demands the assistance of experienced engineers, such as the equipment of flour mills, electrical and heating engineering, transporters or aerial railways and such. They will supply plans and estimates and superintend the erection. In some cases, as for instance in electrical engineering or light railways, such branches will work in conjunction with a Russian factory, which supplies those parts of the contract which cannot be imported.

ELECTRICITY SUPPLY TABLES AND DATA.

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ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Bexhill.—For the year ended March 31 the income of the electricity department was £10,244, including £6,789 from the sale of current by meter (an increase of £354) and £2,948 from public lighting.

The total expenditure was £5.158 (increase £44) and gross profit was £5,086 (increase £445). Interest (£1,837), instalments of principal (£2,390) and depreciation (£236) came to £4,462, leaving net profit £624 (against £536 in 1908-9), out of which £220 was expended on meters and £435 on public lighting. The units sold were 562,150 (against 558,137), including 393,178 to private consumers, 1,056 by private contract and 167,916 for public lighting. There are 53 arcs and 368 incandescent pillars for street lighting, and the total maximum supply demanded was 474 kw. The total capital expended is £68,625, an increase of £1,459. The working cost was 2·2d. (against 2·19d.) per unit and the total cost 4·1d. (against 3·86d.), and the equivalent of 43,350 8 c.p. is connected (against 40,101).

Cleckheaton.—The total income of the electricity department for the year ended March 31 was £4,532 (against £4,557 in 1908-9).

Total expenditure was £2,789, including £2,082 cost of generation, and gross profit was £1,743. Interest on loans absorbed £776 and sinking fund £981, leaving a deficit of £14, against a profit of £51 in previous year. The total capital expenditure is £28,353, an increase of £1,888. The works cost per unit sold was 0·74d. (0·74d.), and the total cost (including capital charges) was 1·62d. (against 1·51d.). The equivalent of 17,479 8 c.p. lamps is connected (against 11,492 8 c.p.), and there are 88 motors (of 380 H.P.) against 52 motors (of 190 H.P.). The total maximum load was 500 kw. (209 kw. lighting and 309 kw. power), the same as in 1909. The number of units sold was 668,812 (against 716,443), including 52,723 for private lighting (against 49,709), 225,270 for power (against 290,483), 381,383 for traction (against 372,323), and 9,436 for street lighting (against 3,928).

In the report accompanying the accounts it is stated that £164. 12s. was charged to the department for the use of refuse for raising steam, compared with £253. 14s. 9d. last year, which was for two years' supply. The increase in the lighting and power consumers was well over the average, but the majority of the new consumers were connected during the last quarter of the year.

Doncaster.—The revenue of the electricity department for the year ended March 31 was £10,435, including £9,885 from the sale of current by meter for lighting and power and for traction.

Working expenses were £5,491 and gross profit £4,945. Interest on loans came to £1,515 and sinking fund instalments to £1,940, and after providing for amount added to sinking fund to make good deficiency in interest (£299) the balance (£1,223) was placed to renewal fund. The capital expended is £64,501, an increase of £1,615 over 1909.

Traffic receipts of the tramways department for the past year were £14,962, and the total revenue £15,172. The total working expenses were £11,186, leaving £3,986 to meet interest (£2,666), sinking fund instalments (£1,240), amount added to sinking fund (£265) and bank interest (£81), showing a deficit of £135. The capital expended is £91,395, an increase of £4,753. 3,411,522 passengers were carried, and 488,261 car-miles run; the percentage of working expenses to receipts was 73·7; the total number of units used was 602,045 or 1·22 per car-mile.

Glasgow.—The 18th annual report and balance-sheet of the municipal electricity undertaking for the year ended May 31 last) were recently presented to and adopted by the Corporation.

Gross revenue amounted to £245,960 (including £234,369 from sale of electric current by meter and £11,591 from public lighting). Working expenditure was £105,438, leaving £140,522. Out of this sum interest (£57,381) and sinking fund (£39,475) were paid. From the balance (£43,666), depreciation (at the rate of 4 per cent. upon the gross capital expended) absorbed £43,475, leaving a surplus of £191 on the year's working, against a deficit of £3,545 in 1908-9. The capital expended during the year was £96,707 and the total capital expenditure (less depreciation) stands at £1,853,434.

The committee recommend that the present rates of charging for current be continued, though a scheme is under consideration whereby domestic consumers may get a supply of energy from the lighting circuits for cooking, heating and other domestic purposes at a lower rate than the charge for lighting, the cost of separate wiring being avoided.

During the past year, 34,742,853 units of electrical energy were sold to private consumers (compared with 32,736,058 in 1908-9), including 15,087,680 units for lighting and 19,655,173 for power and heating. The number of consumers was 19,489, against 18,158, an increase of 1,331 or 7·33 per cent. The total number of motors was 4,851 (of 32,918 H.P.), against 4,292 (of 29,505 H.P.). There are 837 arc lamps and 24 incandescents for street lighting. The equivalent of 1,759,120 8 c.p. lamps is connected, against 1,637,187. The average number of units consumed by private consumers was 20·63 per lamp, against 21·17. The maximum load was 21,719 kw., compared with 21,585 kw. The extension to the boiler house at Port Dundas station has been completed, and a 1,000 kw. motor-generator has been erected at the Springburn sub-station. Six miles of feeders and 5 miles of distributors have been laid on the north side and four miles each of feeders and distributors on the south side of the river during the past year. The total statutory expenditure per unit sold was 1·33d. per unit (against 1·36d.) and the total cost (including depreciation was 1·61d. (against 1·73d.)

Portsmouth.—The accounts of the electricity department for the past year were submitted to the Council last week.

Coun. FOSTER said it was proposed to allocate £1,500 out of the profits in relief of rates. He explained that during the year £900 had been spent out of revenue upon works which should be charged to capital account. The old machinery was being kept as a reserve in case of breakdown. The reduction of revenue was due to a reduction in the charge for public lighting, and to the extended use of metal filament lamps. The average income per unit sold was 3·14d., compared with 3·26d.

Coun. MACTAVISH attacked the proposal to allocate a sum for the relief of rates. The sum, with the tramway grant, represented a 1½d. rate. He thought the committee should bring the light to the reach of the small householder.

Coun. STOBIE asked the Town Clerk if the surplus could not be distributed amongst the consumers. He did not see why those who had not contributed to the surplus should benefit by it.

The TOWN CLERK replied that the application of the money received was prescribed by Act of Parliament, and could not be dealt with in the manner suggested.

Ultimately, the accounts were passed.

Redditch.—The accounts of the electricity department for the year ended March 31 show capital expenditure £41,642 (increase £1,597), and £8,824 has been repaid out of £40,366 borrowed.

Revenue was £5,825 (increase £383), working and general expenditure £4,710 and gross profit £1,115 (against £215 in previous year). Interest and instalment of loans and balance brought forward (£451) required £3,133, and to meet this £1,750 has been taken from general district rate and £268 carried forward. Works costs were 1·20d. per unit (compared with 1·44d.), and total costs, exclusive of capital charges, 1·36d. (1·60d.). Consumers connected are 682 (increase 119), with 41,215 equivalent 8 c.p. lamps (increase 3,863). Units sold and used at works were 770,702 (increase 39,881).

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

ALDERSHOT District Council invite tenders for supply of one chain grate mechanical stoker to be delivered and fixed at their electricity works. Further particulars and specification from the electrical engineer (Mr. F. Garside), and tenders to the Clerk to the Council (Mr. W. E. Foster), Municipal Buildings, Aldershot, by 6 p.m., Tuesday, Sept. 6. See also an advertisement.

Tenders are invited up to Oct. 5 for the supply of 5,000 porcelain insulators to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W. See advertisement.

Tenders are invited for supply of telegraph and telephone cable (schedule No. 284) and insulators (schedules Nos. 373 and 374) to the Postmaster-General's Department, VICTORIA. Tender forms at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to noon Oct. 17 for the supply of telegraph and telephone instruments and material (as per schedules 1 to 9) to the Postmaster-General's Department in TASMANIA. Tender forms and specifications at the office of the High Commissioner, 72, Victoria-street, London, S.W. See advertisement.

LITTLEBOROUGH District Council invite tenders for the supply and delivery of alternating-current (single and three-phase) electricity

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meters. Specifications and forms of tender from the clerk to the Council (Mr. Geo. H. Wild). Specifications may be seen (but not obtained) at the offices of the consulting engineers (Messrs. Hawtayne & Zeden), 9, Queen-street-place, London, E.C. Tenders, addressed to Mr. Wild, Council offices, Littleborough, by Tuesday, Sept. 13.

By command of the POSTMASTER-GENERAL tenders will be received until noon, Monday, Sept. 26 for supply of Swedish, Norwegian, Finland or Russian red fir telegraph poles to be delivered at certain ports in the United Kingdom. Forms of tender from the Controller of Stores (Mr. G. Morgan), Stores Dept., G.P.O., 17-19, Bedford-street, London, W.C.

The POSTMASTER-GENERAL also requires tenders (by noon Sept. 26) for creosoting, &c., telegraph poles. Forms of tender, &c., from the Controller of Stores, 17-19, Bedford-street, London, W.C.

MANCHESTER Electricity committee require tenders by noon Sept. 8 for the supply of 1 sq. in. single conductor paper-insulated cable. Specifications, &c., from Mr. F. E. Hughes, Town Hall, Manchester.

The directors of the Powell Duffryn Steam Coal Co. (ABERDARE) invite tenders for stores, including electrical goods. Tenders to London office (101, Leadenhall-street, E.C.) by Sept. 12.

HACKNEY (London) Council want tenders by 7 p.m. Sept. 15 for extension of main switchboard. Specification from Town Clerk, Town Hall, Mare-street, N.E.

PONTYPRIDD Council want tenders by Sept. 5 for supply of l.t. rubber-insulated cables with lead or fireproof covering. Specification from the generating station, Treforest.

MOUNTAIN ASH Council want tenders by 10 a.m. Sept. 12 for 12 months' supply of electrical stores. Forms of tender, &c., from the Electrical Engineer.

SALFORD Corporation invite tenders for supply and delivery of a vertical steam-feed pump. Tenders by noon Sept. 12.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone insulators to the Postmaster-General's Department in all the States of the Commonwealth of AUSTRALIA. Tender forms at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 27 for the supply of electric lamps to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 20 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA (Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 7 for supply of battery material and glassware to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders will be received (up to 3 p.m. Sept. 13) by the Deputy Postmaster-General, MELBOURNE, for supply of 8,510 telephones. Local representation necessary.

The Deputy Postmaster-General, SYDNEY (N.S.W.), invites tenders (until 2:30 p.m., Oct. 5) for supply of 5,000 porcelain insulators. Local representation necessary. Specifications, &c., from 72, Victoria-street, London, S.W.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W., and also from Messrs. R. W. Cameron & Co., 23, South William-street, New York, and Mr. H. Stephenson Smith, 244, California-street, San Francisco, Cal. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

The Calcutta Electric Supply Corpn. is prepared to receive tenders for supply, delivery and erection at their Cossipore station and sub-stations, CALCUTTA, of motor-generators, turbo-alternators and condensing plant. Copies of specifications, drawings and general conditions from the secretary (Mr. Francis R. Reeves), Salisbury House, London Wall, E.C., to whom tenders by 10 a.m. of Sept. 19.

The Ministry of Public Works, CAIRO, require tenders for electrical installations and refrigerating plant for the lunatic asylum in course of construction at Khanka. Specifications from the Chief of the Administrative Service, Ministry of Public Works, Cairo. Stamped paper for tenders is obtainable from Mr. A. L. Webb, Westminster, S.W. Tenders by noon Oct. 20. Legal domicile at Cairo is necessary in the case of this contract, and to obtain temporary domicile British firms must, before electing such domicile, formally advise the Consulate at Cairo of intention to do so, formally authorise the Consulate on their behalf and inform the Consulate of the address to which documents should be forwarded.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

MOSTAR (Austria-Hungary) municipality will receive tenders until Oct. 1 for the installation of electric generating plant.

Tenders are required for supply of machinery and tools intended for the workshops of the Directorate of Hydraulic Works, Buenos Aires. Tenders to Dirección General de Contabilidad, BUENOS AIRES, by 3 p.m. Oct. 10.

Tenders will be received at the Junta Económica (Dirección del Material), Valparaiso, until 2:30 p.m. Sept. 30 for supply of three dynamos and searchlights and machines and tools for the naval station at TALCAHUANO (Chili). Particulars from the Junta Económica.

TENDERS RECEIVED AND ACCEPTED.

Morecambe Council received 16 tenders for supply of feeder pillars, and that of Boydell & Son was accepted. For the supply of arc lamp carbons 14 tenders were submitted, and the contract was let to G. Hill & Co.

Walthamstow Council have accepted the following tenders:—Hurst, Nelson & Co., six car bodies (with spring fenders), £1,860, and trucks £426; Brush Co., electrical equipments, £1,684; Bartlett & Sons, weighbridge, at £112.

Brighton Corporation have accepted the tender of Richardsons, Westgarth & Co. to supply pipes, valves, &c., to connect up the condenser of the new turbine (now being supplied by them) with Shoreham Harbour, for £870.

Bolton Electricity committee have accepted the tender of Newton, Chambers & Co. for a feed water tank.

The tender of J. T. Foggo has been accepted for wiring the new schools at Batley Carr, Dewsbury, at £100.

Dundee Corporation have accepted the tender of J. C. Keay for fitting up 500 electric stairlights at £323.

Pooley & Austin's tender has been accepted by Battersea (London) Council for a new feeder switchboard.

Ulverstone (Tasmania) Council have accepted the tender of Sullivan & Ashman (at £4,417) for supply and erection of a Babcock & Wilcox boiler, 80 H.P. Allen high-speed engine and 50 kw. generator, with booster and balancer (made by General Electric Co., Sweden), switchboard and battery of Tudor cells.

Commonwealth Tenders.—The Postmaster-General's Department, Melbourne, have accepted the tender of Siemens Bros. Dynamo Works for 1,640 tubular iron poles, as follows:—

600 poles, with two side plates, length 24 ft. (at £2. 6s. each), 432 ditto, length 26 ft. (£2. 19s. 3d. each), 280 ditto, length 28 ft. (£4. 18s.), 150 poles, with steady plate and bog plate, length 24 ft. (£2. 10s.), 108 ditto, length 26 ft. (£3. 4s. 9d.), and 70 ditto, length 28 ft. (£5. 3s. 8d.).

The Victorian Railways Department have placed an order with the Railway Signal Co. for 40 electric staff instruments at £1,526.

Turbo-Pump and Turbine Contracts.—Messrs. Jens Orten-Boving & Co. have recently received orders for "Victoria" turbo-pumps of the automatic balancing type, including

One pump to deliver 390 gallons per minute against 228 ft. head for the Delta (B.C.) municipality, one pump to deliver 600 gallons per minute against 60 ft. for Messrs. Takata & Co., Japan; one pump to deliver 125 gallons per minute against 196·5 ft. head for New Zealand Government railways; and two pumps each to deliver 250 gallons per minute against 184 ft. head for the Hydro-Electric Commission, Preston, Canada.

Water turbine plant orders include one unit of 250 H.P. at 28 ft. for Soma Denki, and one turbine of 165 H.P. at 165 ft. for the Motomiya Light Co., Japan (through Messrs. Dick, Kerr & Co.); one of 28 H.P. for Messrs. J. Hardie, Glasgow; one Böving patent oil pressure governor for the Hachinoche Hydro-Electric Co., Japan; one turbine of 165 H.P. at 165 ft. for the Motomiya Light Co., Japan (through Messrs. Dick, Kerr & Co.); one turbine of 135 H.P. at 61 ft. head for South Falls, Canada; two turbines of 565 H.P. at 27 ft. head, complete with Böving patent governors, for Farnham, Quebec.

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BUSINESS NOTICES.

The Calcutta branch of Messrs. Crompton & Co. has been removed from 99, Clive-street to 13/1, Clive-row.

The works of the British Electric Calibrated Fuse Co. have been removed to Luton, Beds. Telegrams, Fuses, Luton; telephone, 278.

As the lease of their Chelsea works has expired, the Cowper-Coles Galvanizing Synd. have secured larger works at Stratford, known as the Magnet Galvanizing Works, Bow Bridge, E.

The Smoke Consumption Synd. (Ltd.), which controls the Cowper-Coles patents for the consumption of smoke, has erected a plant at Willesden for the manufacture of its "Caloriser" bricks. The syndicate is applying the caloriser bricks to water-tube as well as to Lancashire and Cornish boilers.

Messrs. Thos. E. Noakes and Thos. W. Dickson have acquired the goodwill of Thomas Noakes & Sons (Ltd.), including all the designs, drawings and patterns of up-to-date boiler and engine fittings and other specialities, and they will continue the business in future as Thomas Noakes & Sons. The new offices and warehouse are at 16, Whitechapel-road, E.

Plant for Sale.—Northampton Electric Light & Power Co., Northampton, advertise for sale two exhaust steam feed water heaters and two battery charging boosters.

Patents Development.—The owners of patents No. 23,501/1899, relating to "Improvements in vacuum table lighting," and No. 12,582/1902, relating to an "Improved system of electric lighting," desire to negotiate with electrical engineers with the view of granting licences. Information from Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C.

The proprietor of patent No. 19,979/1904, for "Improvements in magnetic wheels or electromagnetic motors" desires to enter into arrangements by way of licence or otherwise for exploiting and working same in this country. Apply to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, London, W.C.

"The Journal."—Part 203 of the "Journal" of the Institution of Electrical Engineers is now ready, price 5s. Particulars of contents are given in an advertisement.

Textile Institute Journal.—We have received a copy of the first number of the "Journal of the Textile Institute," which gives particulars of the movement for the formation of the Institute and of its inauguration in Manchester in April last. The number also gives a list of the officers, committees, foundation members, &c.

"Osrams" in a Synagogue.—The following is from a recent issue of the "Jewish World," and shows how far reaching is the popularity of the metal filament lamp. The Jewish fraternity are more than ordinarily conservative in regard to the introduction of modern ideas into their places of worship, but at Bradford the tempting claims of "Osrams" have broken down all barriers to the march of progress. This is, the General Electric Co. inform us, the first instance in this country of a synagogue being illuminated by metal filament lamps.

An installation of electric light has recently been added to the Bradford Synagogue, consisting of three six-light electroliers, carrying 50 c.p. "Osrams" in the body of the synagogue and two seven-light "Osram" candle lamps on the Menoroth, on the two sides for the holy arc, besides lamps in the organ loft and the two schoolrooms. They were lighted for the first time on Shevuoth, and proved a great success. The whole of the expense was defrayed by Mrs. Von Halle, in memory of her husband, who died last winter.

"Sistoflex" Pressspahn.—Messrs. Spicer Bros., 19, New Bridge-street, London, E.C., will forward a sample of their registered "Sistoflex" Pressspahn to anyone sending their trade card. Upon the face of this sample are printed particulars of the sizes and thicknesses in which the material is supplied for electrical insulation. The firm holds possibly the largest stock of Pressspahn in London. The sample which is being sent out is fitted with a hanger to be hung up for easy reference. Particulars are also given of other insulating materials, such as varnished cloth, paper, tapes, vulcanised fibre, defiance insulation (Leatheroid), pure manilla and red rope papers which this firm supply in high class qualities and at low prices.

The British Association.—The Great Central Railway runs a series of fast trains every day to Sheffield, some of these being non-stop until reaching that station. The fact that the British Association is this year meeting at Sheffield will give this information additional interest to many of our readers. The best trains from Marylebone are 8:45 and 10:0 a.m. and 12:15, 3:15 and 6:20 p.m., and returning to Marylebone from Sheffield 8:50 and 11:21 a.m., 3:27 and 6:21 p.m. (These have restaurant cars.)

Encyclopædia Britannica.—The University of Cambridge has acquired the copyright of the Encyclopædia Britannica, and is about to publish, at the University Press, an entirely new (eleventh) edition. A pamphlet issued by the syndics of the Cambridge University Press explains the circumstances which have led to this new departure in widening the educational labours of the University. The new edition has been constructed and will be published as a whole. There will be an India paper as well as an ordinary paper impression.

CATALOGUES, &c.

G.E.C. Apparatus.—From the General Electric Co. have come a number of pamphlets dealing with their specialities. These include the new Butt arc lamp described in last week's Electrician, the "Salford" type ironclad switchgear, Witton switches of various kinds, and oscillating fans suitable for running on either direct or alternating current.

Adnil Motors.—The Adnil Electric Co. have sent us a list in which are given particulars of motors from 3 to 68 h.p. and dynamos from 2·5 to 48 kw. Much useful descriptive and technical information regarding these machines is given in the pages of this catalogue. Particulars are also to be found regarding motor generators, flexible couplings and other similar accessories.

Thermometers.—Engineering Supplies (Ltd.) have ready a pamphlet illustrating and describing various types of industrial thermometers.

Electric Driving of Rolling Mills.—We have received from the Allgemeine Elektricitäts-Gesellschaft (Berlin) a list in which details of various rolling mills equipped by the company with the electric drive are given. Besides some impressive figures, illustrations showing the type of plant employed are also furnished.

BANKRUPTCIES, LIQUIDATIONS, &c.

The trustee (Mr. F. C. Brogden, 10, Bank-street, Lincoln) in the bankruptcy of Saml. Emerson Smith, electrical engineer, formerly trading at 271, High-street, Lincoln, has been released.

The trustee (Mr. E. Barlow, 1, Berridge-street, Leicester) in the bankruptcy of Wm. C. Ellis, electrician, Applegate-street, Leicester, has been released.

A first and final dividend of 3s. will be payable on Sept. 6 at 12, Cherry-street, Birmingham, to creditors of Herbt. J. Burdett, electrical engineer and contractor, 16, Regent-street, Rugby, and 32, Earl-street, Coventry.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

*Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

June 3. 1910.

13,453 Rankin. Electric controlling and regulating apparatus.
13,476 McGeoch & McGeoch & Co. Electric switches.
13,481 Hirst & Coates. Insulating device for electric lamp-holders. (Addition to No. 17,101/09.)
13,489 Rimington. Carbon holders for arc lamps.*
13,502 Akt.-Ges. Brown, Boveri et Cie. Driving dynamo-electric machinery. (Date applied for, 22/6/09.)*†
13,518 B.T.-H. Co. (G.E. Co., U.S.) Arc light electrodes.
13,519 B.T.-H. Co. (G.E. Co., U.S.) Fittings for electric lamps.
13,520 B.T.-H. Co. (G.E. Co., U.S.) Controlling devices for electric circuits.*
13,521 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems.*

June 4, 1910.

13,525 Parsons & Ball. Electromagnets and armatures.
13,528 Moul. Arc lamps.
13,535 Ridings. Arc lamps.
13,572 Curtis, Mackley & Adams Mfg. Co. Starting switches for electric motors.

June 6, 1910.

13,643 Stewart. Combined braking and starting apparatus for electrically-propelled vehicles.
13,646 Suchostawer. Electric traction on the induction system.
13,655 Beard, Townsend & Wray. Electric fittings, wirings and the like.
13,662 Boult. (Walter A. Crowdus, U.S.) Electromagnetic devices.*
13,669 Cowper-Coles. Electro-deposition of iron.
13,672 Siemens Bros. & Co. & Dieselhorst. Electrical conductors.*
13,676 Creasey. Insulating electric cables and apparatus therefor.
13,694 B.T.-H. Co. (G.E. Co., U.S.) Electrical transformers. (Addition to No. 13,278/04.)
13,704 Hamilton & Ferranti. Electrical time switches.
13,709 Routin. Regulating dynamos.*

June 7, 1910.

13,739 Herold. Primary batteries. (Date applied for, 8/7/09.)*†
13,765 Siemens & Halske Akt.-Ges. Operating appliance for photographing and examining by means of Röntgen rays. (Date applied for, 19/6/09.)*†
13,823 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current motor-control systems.
13,828 Lange. Portable electric lamps. (Date applied for, 28/2/10.)*†

June 8, 1910.

13,843 Dean. Protected or armoured electric switch fuses.
13,889 Taylor. Methods of limiting the flow of current on a short-circuit.
13,946 B.T.-H. Co. (G.E. Co., U.S.) Insulating material.
13,947 Todd. Track brakes for tramway cars or like vehicles.

June 9, 1910.

13,961 & 13,962 Electric Construction Co. & Pensabene. Resistances in connection with controlling induction motors.
13,985 Siemens & Halske Akt.-Ges. Receiving and registering appliances for electric signals. (Date applied for, 26/8/09.)*†

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14,009 WALL. Calling apparatus for telephones and the like.
14,024 ALLGEMEINE ELEKTRICITATS-GES. Alternating-current dynamo-electric machines of the commutator type. (Addition to No. 23,289/02. Date applied for, 19/6/09.)*†

June 10, 1910.

14,042 KIRBY & LOXLEY & Co. Electrical ceiling roses, junction boxes, fuses and the like.
14,045 STANILAND. Terminals or connectors for wires, cables or the like.
14,092 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckert Werke G.m.b.H., Germany.) Electrical condensers.*
14,097 WILSON. Lamp-locking device for electric lamp-holders.
14,116 WOLFRAM LAMPEN AKT.-GES. Process of decarbonising filaments for use in metallic filament glow lamps. (Date applied for, 26/6/09.)*†
14,125 ALLGEMEINE ELEKTRICITATS GES. Dynamo-electric machines. (Date applied for, 10/6/09.)*†
14,126 HOLDEN. Electric clocks. (Addition to No. 14,873/09.)

June 11, 1910.

14,141 BROWN. Operating mechanism of arc lamps.
14,153 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckert Werke G.m.b.H., Germany.) Preventing remanent magnetism in dynamo-electric machines.
14,193 FAYE-HANSEN. Protective apparatus for alternating-current distribution systems and apparatus.
14,196 SIEMENS BROS. & Co. (Siemens & Halske Akt.-Ges., Germany.) Circuits for automatic telephone exchanges.*

June 13, 1910.

14,213 RICHARDSON. Controller for use with electric motor for blowing organs.
14,263 BEARD, TOWNSEND & WRAY. Locking devices for electric lamps.
14,296 MAYES. Electrical fuse carriers.
14,300 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.

June 14, 1910.

14,315 ALLISON. (La Verne W. Noyes, U.S.) Magneto generators.*
14,324 LECOCHE & CATTANEO. Electrical generating plants.
14,336 JONES. Electric resistances.
14,345 SIEMENS SCHUCKERTWERKE G.M.B.H. Controlling the speed of electric motors. (Date applied for, 14/6/09.)*†
14,349 HIRST & MAURICE. Electrically-illuminated letters, signs, and the like devices.
14,352 SIEMENS BROS. DYNAMO WORKS & LEDEBR. Searchlights.*
14,353 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Braking action in polyphase commutator electric motors.*
14,354 SIEMENS SCHUCKERTWERKE G.M.B.H. Searchlights. (Date applied for, 28/10/09.)*†
14,355 SIEMENS BROS. & Co. (Siemens & Halske Akt.-Ges., Germany.) Signalling apparatus operated from a distance. (Addition to No. 14,240/09.)*
14,380 PRICE. Prevention of sparking in the control of electric circuits.
14,382 CASTLE, RIDDIFORD, BIDWILL & MCDERMOTT. Electric alarm systems.*
14,391 AKT.-GES. BROWN BOVERI ET CIE. Alternating-current commutator machinery. (Date applied for, 17/6/09.)*†
14,394 ALMERS & WAITE. Telephones.

June 15, 1910.

14,429 HALLIWELL & JEREMIAH. Locking electric incandescent lamps to their holders.
14,466 EVANS. Electrical incandescent lamp-holders.
14,476 REVROLLE & CO. & SCHUIL. Lightning arresters.
14,496 PINDTERSHOFEN. Electric cables. (Addition to No. 6,757/08.)*
14,499 PRICE. Electrical machines.
14,505 STEWART & WESTMINSTER TOOL & ELECTRIC CO. Electric drills.
14,512 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric distribution systems.

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

24,784 MASCHINENFABRIK OERLIKON. Electro-hydraulic press. (Date applied for, 19/11/08.)
24,838 MILTON. Magneto generators.
25,156 EVERED & EVERED & Co. Electrical switches.
26,251 HARDEN. Electric furnaces.
26,374 SCHMELZER. Transmission of power.
26,929 KORBER. Electric resistances. (Date applied for, 20/11/08.)
27,026 BOULT. (Felten & Guilleaume-Lahmeyerwerke Akt.-Ges.) Electrically controlling machine tools.
27,101 GODDARD, GROVER & THRALL. Telegraph transmitters.
29,087 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckert Werke Ges.) Electric cartridge fuses.

1910 SPECIFICATIONS

1,301 SIEMENS BROS. & Co. & DIESELHORST. Electric conductors.
2,057 AITKEN & BRITISH INSULATED & HELSBY CABLES. Telephone switching apparatus
3,914 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke Ges.) Regulating the position of the brushes on the commutator of a dynamo-electric machine.
3,927 LUNDBERG, LUNDBERG & LUNDBERG. Electric switches.
4,446 GOTTSCHALK. Telephone transmitters.
5,282 RENDLE & CHURCHILL. Holding submarine cables.
6,875 SIEMENS & HALSKE AKT.-GES. Semi-automatic telephone exchanges. (Date applied for, 18/3/09.)
9,832 WILSON & WILSON. Electric condensers. (Date applied for, 9/6/09.)

COMPANIES' MEETINGS AND REPORTS.

COMPANIA MARCONI DE TELEGRAFIA SIN HILOS DEL RIO DE LA PLATA (BUENOS AIRES).—The directors' report states that the expenditure for the past year was $24,640.15 gold and income $11,998.28, a loss of $12,641.87, which, with balance of $52,526.44 from previous year, makes a total of $65,168.31. The station at Punta del Este is working regularly, but in view of the increased shipping trade, it has been decided to instal new and more powerful apparatus there, with which it will be practicable to communicate with all vessels three or four days before arrival at and after departure from Buenos Aires. The station at Bernal has not yet been opened for public service, due to the delay by the Government in granting the necessary authorisation. The company has continued the preparations for direct communication with Europe, and, it is stated, only awaits reports from Mr. Marconi before commencing work on same.

MERSEY RAILWAY CO.—At the meeting on Friday Mr. James Falconer, M.P., said their receipts had increased during the half-year by £1,425 and expenditure had diminished by £1,274. Taking the working for the whole year ended June 30, receipts had amounted to £109,016, compared with £105,121. Working expenses amounted to £68,986, against £72,169, or a net gain for the year of £8,778 on the working of the railway. During the last half-year of steam working the number of passengers carried was 3,357,000; during the half-year with which they were now dealing they had increased to 7,395,000, an advance of 4,000,000 passengers. Passenger traffic had increased by 120 per cent. and receipts 85 per cent. The reason for the increase had been made apparent half-year after half-year, ever since, in fact, they had adopted electric traction, and no one could place a limit to the possibilities of their line if facilities continued to be afforded to the people to get to and from Liverpool to different parts of the Worral Peninsula. The train service of the Mersey Railway was unsurpassed in any other part of the country, and American people had told him that they had nothing to equal it in the United States.

UNION OTTOMANE (SOCIETE POUR ENTREPRISES ELECTRIQUES EN L'ORIENT).—This combination of German, Swiss and French capitalists has issued its report for the year ended June, which states that the past year was one of preparation. The principal business was the re-organisation of the Constantinople tramways, in which the company has acquired £153,000 in ordinary and £21,000 in preference shares. The tramway concession was prolonged (in 1906) to 1993, and the Union Ottomane hopes definitely to receive the order for the conversion of the lines to electric traction. The company also took part, in conjunction with the leading German and French electrical firms, in the competition for the establishment of electricity supply in Constantinople, and a decision is expected to be arrived at by the Ministry of Public Works by the middle of December at latest.

VERA CRUZ ELECTRIC LIGHT, POWER & TRACTION (LTD.)—At the meeting on Wednesday the chairman (Mr. V. W. Yorke) said that their anticipations had been realised. There had been a considerable increase in business, and a satisfactory saving had been effected in the costs of operation by the good results obtained from the oil engine plant. The net profits showed an increase of nearly 100 per cent. over those for 1908. There was an improvement in all three departments (power, lighting and tramways), and during the first six months of the present year they had still further increases in gross and net profits. The outlook for the future was very hopeful. They had just completed the installation of the additional arc lamps for public lighting, and the business in sight would enable the company to show a satisfactory increase in the profits for the current year.

NEW COMPANIES, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

CHILIAN CONSTRUCTION CO. (LTD.) (111,448.)—Reg. Aug. 25, capital £500,000 in £1 shares, to carry on the business of financiers, constructors of roads, railways, tramways, docks, &c., and any electric light, hydraulic and other public works. Private company. First directors, J. S. P. Samborne (chairman), C. Grenfell, J. E. P. Coyne and P. Burton.

T. & J. JACKSON (LTD.) (111,461.)—Reg. Aug. 25, capital £11,000 in £1 shares (5,000 preference, 5,000 ordinary and 1,000 deferred), to take over the business of electricians, electrical and mechanical engineers, machinists, dynamo and motor manufacturers, &c., carried on as T. & J. Jackson & Co. Private company. First managing directors, T. Jackson and J. Jackson. Reg. office, 14, Park-road, Regent's Park, London, N.W.

MORTGAGES AND CHARGES.

ELECTRICAL APPARATUS CO. (LTD.)—A memorandum of satisfaction in full on Aug. 19 of debentures dated Oct. 27, 1909, securing £500 has been filed.

COMPANIES INCORPORATED OUTSIDE THE U.K.

HOBART ELECTRIC MFG. CO.—Particulars filed Aug. 15. Capital stock $200,000 in shares of $100. Reg. at Troy (Ohio, U.S.A.) in August, 1897. British address: 1-3, Holborn-circus, E.C. Messrs. McIntyre & Capel Peters, solicitors, are authorised to accept service at 401, Birkbeck Bank Chambers, Holborn, W.C.

CITY NOTES.

MEMORANDA (Sept. 1).—**Bank rate 3 per cent. (since June 9, 1910). Price of silver,** 24⅛d. per oz. Consols 80⅞—81⅛ for money; 81⅛—81⅜ for account. **Consols Pay Day, Oct. 5; Stock and Shares Continuation Days, Sept. 13 and 27; Ticket Days, Sept. 14 and 28; Pay Days, Sept. 15 and 29; Mining Shares Carry Over Day, Sept. 12.**

PRICES OF METALS (London).—*Copper*, cash, 55¾; three months, 56⅜. *Lead*, English, 12¾—13; foreign, 12½—12¾. *Spelter*, 22⅜—22½. *Tin*, English, 157—158; foreign cash, 163; three months, 159. *Iron*, Cleveland, cash, 49/4½, three months, 50/3.

ASCOT DISTRICT GAS & ELECTRICITY CO.—The directors have declared an interim dividend at the rate of 5 per cent., less tax, for the past half-year.

BLACKPOOL & FLEETWOOD TRAMROAD CO.—A dividend of 4 per cent. has been declared.

BRITISH INSULATED & HELSBY CABLES (LTD.)—An interim dividend at the rate of 8 per cent. per annum has been declared on the ordinary shares for the half-year to June 30.

OXFORD ELECTRIC CO. (LTD.)—The directors announce an interim dividend at the rate of 6 per cent., less tax, on the ordinary shares for the past half-year, payable Sept. 14.

UNITED ELECTRIC CAR CO. (LTD.)—The directors have declared a dividend of 2½ per cent. for the year ended June 30.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 24	1,592	+ 23	12	18,829	— 331
Airdrie	„ 19	222	— 3	33	7,162	+ 58
Anglo-Argentine	„ 26	43,987	+ 6,465	34	1,499 667	+ 177,398
Ayr Corporation	„ 27	408	— 7	15	6,514	+ 285
Barnsley	„ 19	210	..	33	5,699	+ 179
Barrow	„ 19	317	+ 46	33	8,924	+ 1,307
Bath Electric Trams, Ltd..	„ 24	954	+ 85	34	27,681	+ 1,323
Birmingham Corporation ..	„ 27	6,768	+ 535	21	143.101	+ 1,408
Birmingham & Midland....	„ 12	883	+ 22	32	28,087	+ 376
Blackburn Corporation	„ 24	1,002	— 7	‡21	23,860	— 976
Blackpool and Fleetwood ..	„ 27	1,643	+ 82	..	..	..
Bolton Corporation.....	„ 28	2,396	+ 73	22	51,608	— 245
Bombay	July 29	2,519	+ 187	30	81,081	+ 5,973
Bournemouth Corporation..	Aug. 24	2,412	+ 201	21	42,191	+ 4,013
Bradford Corporation.....	„ 27	5,088	+ 326	22	111.103	+ 3,621
Brighton Corporation.....	„ 28	1,255	— 37	‡21	23,107	— 98
Bristol Trams & Carriage ..	„ 26	6,163	+ 421	8	51,730	+ 2,750
Burnley Corporation	„ 27	1,260	— 10	8	10,313	— 41
Burton Corporation	„ 28	323	+ 42	21	5.883	— 16
Bury Corporation	„ 28	1,180	+ 31	‡21	25,642	— 442
Calcutta Tramways Co....	„ 27	₹51,904	+ ₹3,384	8	₹421,202	+ ₹23 053
Camborne-Redruth	„ 27	127	— 9	34	4,164	— 122
Cardiff Corporation.....	„ 13	2,446	— 99	20	44,642	— 325
Cavehill.....	„ 19	117	— 18	33	3,091	+ 144
Central London Railway ..	„ 27	4,744	+ 195	8	41,929	+ 2,425
Chatham & Dist. Lt. Rys. ..	„ 25	1,028	+ 99	34	28,750	+ 1.050
City & South London Rly...	„ 28	3,079	+ 189	8	24,570	+ 195
City of Birmingham	„ 19	2,808	+ 69	33	94,184	+ 2,034
Colchester Corporation	„ 24	244	+ 9	..	..	..
Cork Electric Trams Co.....	„ 25	520	+ 16	44	16,599	+ 1,621
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams ..	„ 19	468	+ 84	33	13,942	+ 1,810
Dover Corporation	„ 30	417	+ 116	20	4.792	+ 173
Dublin & Lucan Railway ..	„ 26	183	+ 2	8	1.442	+ 47
Dublin United	„ 26	6,985	+ 137	8	50,140	+ 322
Dudley-Stourbridge	„ 19	926	— 42	33	26,160	— 761
Dundee Corporation	„ 24	1,247	+ 29	¶14	17,741	+ 310
East Ham Council	„ 27	1,062	+ 74	¶21	21,944	+ 520
Exeter Corporation.....	„ 26	379	+ 4	21	7,158	— 673
Gateshead & Dist. Trams ..	„ 19	1,034	— 5	33	32,531	— 190
Glasgow Corporation	„ 27	16,967	+ 125	13	221,126	+ 11,219
Glossop Trams.....	„ 27	129	— 3	34	4,000	— 243
Gloucester Corpn.....	„ 24	317	+ 24	..	..	..
Gravesend-Northfleet.....	„ 19	235	— 14	33	6.870	+ 11
Great Northern & City Rly..	„ 27	1,297	+ 71	8	10.269	+ 325
Greenock & Port Glasgow ..	„ 19	796	+ 112	33	20.767	+ 2,792
Hartlepool Tramways	„ 19	367	+ 72	33	8.211	+ 504
Hastings Elec. Trams Co. ..	„ 25	1,598	+ 153	8	11.550	+ 221
Hong Kong	„ 27	$8,916	+ $610	8	$71,478	+ $5 334
Huddersfield Corpn.	„ 27	1,7.5	+ 26	22	37,989	+ 949
Hull Corporation.....	„ 27	2,772	+ 203	21	57,708	+ 3,324
Ilford District Council.....	„ 27	533	+ 48	21	11,611	+ 623
Ilkeston District Council ..	„ 24	139	— 8	21	2.741	— 164
Ipswich Corporation	„ 27	513	+ 29	21	9,789	+ 584
Isle of Thanet Co.	„ 27	1,931	+ 232	¶45	28,473	+ 1.711
Jarrow	„ 19	154	+ 23	33	4.121	+ 230
Keighley Corporation.....	„ 25	182	+ 15	21	3.846	+ 136
Kidderminster & District ..	„ 19	140	— 9	33	3.710	+ 95
Kilmarnock Corporation ..	„ 27	150	+ 5	15	2,394	+ 56
Lanarkshire Trams Co.	„ 25	1,396	— 45	34	46 999	— 3,633
Lancashire United	„ 24	1,308	— 5	34	44,516	— 572
*Leamington	„ 19	245	+ 35	33	5.527	— 219
Leeds Corporation	„ 27	7,071	+ 223	21	152,813	+ 4,876
Leicester Corporation.....	„ 27	2,356	+ 201	..	..	..
Leith Corporation	..	..	..	..	..	..
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	„ 20	11,502	+ 491	33	368,465	+ 13,645
Liverpool Overhead Rly. ..	„ 28	1,430	+ 7	9	13,417	+ 9
Llandudno&ColwynBayRy.	„ 26	734	+ 5	§39	10,769	+ 39
*London County Council	„ 17	41.373	+ 4,097	¶20	839,184	+ 112.914
London Elec. Ry. Co.....	„ 27	10,435	— 65	8	92.000	+ 545
London United	„ 27	6,944	+ 62	34	218,607	+ 9,466
Lowestoft	..	..	..	..	..	..
Maidstone Corporation	..	..	..	..	..	..
Manchester Corporation....	„ 27	15,098	+ 305	21	330,624	+ 5,524
Mersey Railway	„ 27	1,890	+ 38	8	15.558	+ 236
Merthyr	„ 19	210	+ 1	33	6,832	— 228
Metropolitan Dist. Railway.	„ 27	9,124	+ 505	8	80.523	+ 5.190
Metropolitan Elec. Trams ..	„ 19	8,059	+ 1,153	33	245.159	+ 42,639
Middleton	„ 19	321	— 63	33	10.512	— 714
Nelson Corporation.....	„ 27	143	— 3	§21	3,166	+ 90
Newcastle-on-Tyne Corp. ..	„ 27	3,703	— 26	¶21	85,413	+ 887
Newport (Mon.)	„ 27	706	+ 24	22	15.324	+ 543
Northampton Corporation..	„ 27	529	+ 40	§21	10.836	+ 37
Oldham, Ashton & Hyde ..	„ 19	613	+ 28	33	18.303	— 95
Oldham Corporation	„ 28	1,985	+ 1	22	41.754	— 1,069
Perth (N.B.) Corporation ..	„ 24	196	+ 16	§14	2,662	+ 184
Perth (W.A.) Elec. Trams ..	..	..	..	..	..	..
Peterborough	„ 19	141	— 14	33	3,822	— 73
Portsmouth Corporation ..	„ 27	2,702	— 6	21	47.601	— 1,703
Potteries	„ 19	1,670	..	33	57,465	— 619
Preston Corporation	„ 24	724	— 14	21	15,616	— 338
Rotherham Corporation....	„ 25	649	+ 55	21	13.173	+ 541
Rothesay	„ 19	589	— 62	33	7.568	+ 70
Salford Corporation	„ 29	4,477	+ 14	†22	101,528	+ 1,025
Sheerness	„ 19	73	— 3	33	1,662	— 10
Sheffield Corporation	„ 28	5,838	+ 251	¶22	133,198	+ 7,735
Singapore Trams.....	„ 27	$9,915	+ $1,116	8	$70,450	+ $7,022
South Metropolitan.....	„ 19	1,147	+ 124	33	27,452	+ 1,224
South Staffs.....	„ 19	862	+ 10	33	27,582	+ 54
Southend Corporation	„ 24	1,048	+ 243	21	14.153	+ 1.351
Southport Tramways	„ 19	389	+ 27	33	9,863	+ 184
Stalyb'dge,Hyde,&c., Jt.Bd.	..	..	..	..	..	..
Sunderland Corporation....	„ 28	1,191	+ 64	22	25.624	— 299
Sunderland District	„ 24	449	— 39	43	18.451	— 1,362
Swansea Trams	„ 19	1,192	+ 76	33	36.713	+ 4,080
Swindon Corporation	„ 24	154	+ 11	21	3.003	+ 131
Taunton	„ 19	49	— 13	33	1.405	+ 106
Tynemouth and District....	„ 19	515	+ 54	33	8,720	+ 458
Tyneside Trams Co.	„ 24	464	+ 32	8	4 143	+ 320
Walsall Corporation	„ 27	1,323	+ 56	§21	21.103	+ 63
Warrington Corporation....	„ 25	541	+ 34	34	18.235	+ 784
West Ham Corporation	„ 18	385	+ 8	21	8.264	+ 162
Weston-super-Mare	„ 19	2,489	+ 97	20	50.182	+ 1.985
Wolverhampton Co.	„ 19	449	— 16	33	5,029	— 64
Wolverhampton Corpn.	„ 19	443	— 13	33	14,071	+ 279
*Worcester	„ 24	916	+ 154	21	21,229	+ 3,164
Wrexham	„ 19	354	+ 20	33	9.351	+ 159
Yorkshire W.R. Trams	„ 19	105	— 8	33	3.204	— 11
Yorkshire Woollen District.	„ 28	1,191	— 69	35	43,603	..
	„ 19	1,078	+ 57	33	32.473	+ 2,706

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shrs	Last Dividend	NAME.	Price Wed., Aug. 31	Rate per cent. Yielded.	Dividend Due.	Business Week to Aug. 31. Highest.	Lowest.
		Electricity Supply.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	8¼—9¼	5 16 0	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.....	9 —9½	4 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 13 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord. ..	6¼—7¼	6 9 0	March....	7¼	..
5	3/6	Do. 7 per Cent. Pref.....	6¼—7¼	4 14 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¼—3¾	6 5 6	Feb, Aug	3¼	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 15 0	Feb., Aug	4¼	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 0	..	102	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¼—4¼	5 9 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.....	3¼—4¼	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	City of London Electric Lighting Ord.	11¼—11¾	6 9 0	Feb, Aug	11¾	11¼
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼—12¼	4 18 0	Jan, July	11¼	11¼
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 —124	4 0 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99¼—102¼	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.....	1¼—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾—3¼	7 14 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7¼—7¾	6 7 6	Feb, Aug	7¼	7⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾—11	5 9 0	Mar, Sept	11	10¾
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104 —107	4 4 0	Jan, July	105	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	101½	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4¾	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	99 —102	4 8 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.....	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.....	6¾—7¼	5 6 9	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5¾—6¼	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	8¼ —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1¼—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	4¼—5⅛	5 15 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/0	Metropolitan Electric Sup. Ord.	3¼—3¾	6 13 3	April, Oct	3¼	3⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.....	4 —4¼	5 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95½—97½	4 12 6	June, Dec	..	..
5	1/6	Newcastle Elec. Supply Ord.....	3¾—4¼	4 11 0	Feb, Aug	4¼	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¼—4½	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	100 —102	4 8 0	Jan, July	100½	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6¼—6½	5 2 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7¼—8½	6 2 3	Feb, Aug	7½	..
5	3/6	Do. 7 per Cent. Pref.....	6¼—7½	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1¼—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2¾—3	6 4 6	April	..	..
St.	5%	Do 5 % 1st Mort. Stock (red.).....	99 —102	4 19 0	..	102	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅞—1	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	⅞—1 1/16	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.).....	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	¾—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.....	8 —8½	5 17 9	Mar, Sep	7⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5¼	4 2 0	Jan, July	..	..
		Electric Railways and Tramways.					
St.	4%	Baker St. & Waterloo 4% Perp. Deb. Stock	..	4 3 6	Jan, July	..	..
1	..	Bath Elec. Trams Pref. Ord.....	⅞—1	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	6 12 9	Jan, July	¾	..
St.	4½%	Do. 4½ 1st Mort. Deb. (red.).....	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6¼—6½	8 18 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7¼—7½	5 3 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¾—1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2¾—3¼	..	Feb, Aug	2¾	..
St.	5%	Do. 5 per Cent. Perpetual Debs	87 —91	5 10 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	68 —73	6 3 0	May, Nov	69	..
St.	3%	Central London Ordinary Stock	64 —66	4 11 6	Feb, Aug	65¼	64¼
St.	4%	Do. 4 per Cent. Pref. Stock	84 —86	4 14 6	Feb, Aug	85¼	..
St.	2%	Do. Deferred Stock	47 —49	4 2 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Deb Stk	..	4 4 0	Jan, July	..	..
5	2%	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5¼	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	97 —101	3 19 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord. ..	27½—28½	5 5 0	Feb, Aug	27⅝	27½
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —104	4 16 0	Feb, Aug	..	..
St.	5%	Do. (1901)	99 —102	4 18 0	Feb, Aug	..	..
St.	5%	Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.....	99 —101	3 19 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref....	12¾—13¼	4 6 6	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾—1	..	Feb, Aug	..	..
10	4/0	G. Northern, Picc. & Brompton 4% G. Pf.	8¼—8¾	4 15 0	Feb. Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	..	4 4 0	Jan, July	..	..
5	..	Hastings & District Elec. Trams, 6% C. P.	¾ —1¼	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3¼—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1⅛—1⅜	3 12 9	Mar, Sept.	1⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —75	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—9⅜	5 19 3	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2¼	..	Jan, July	2⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	67 —71	5 12 6	Jan, July	6¾	..
St.	..	Mersey Con. Ord. Stock	2¼—3½	..	Feb, Aug	3	..
1	1/0	Metropolitan Elec. Tramways Ord.....	⅞—1	..	..	⅞	..
1	..	Do. Deferred	⅞—1	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	¾—1	5 11 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	96 —99	4 11 0	Jan, July	98¼	..
St.	..	Do. 5 per Cent. Db. Stk	96 —98	5 2 0	..	97	96¾
St.	1½%	Metropolitan Railway Consolidated.....	38 —38½	2 18 0	Feb, Aug	38¼	37½
St.	2½%	Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	66	65¾
St.	3½%	Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	87½	87
St.	3½%	Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	92½	91½

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	NAME.	Price Wed. Aug. 31	Rate per cent. Yielded.	Dividend Due.	Business Week to Aug. 31 High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock	90 —92	3 15 6	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.	20⅞—21⅛	..	Feb, Aug	21⅜	20⅛
St.	3%	Do. Extension Pref. (5 per Cent.)	78 —80	..	Feb, Aug	75⅛	76½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 0	Feb, Aug	..	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	74½	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	4 0 0	Jan, July	..	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock	140 —142	4 4 6	Jan, July	140⅜	..
St.	4%	Do. 4 per Cent. Ditto	95 —97	4 2 6	Jan, July	96	95
1	4½d.	Potteries Electric Traction Ord.	⅛—⅜	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅜	6 14 0	Feb, Aug	⅜	..
St.	4½%	Do. 4½ per Cent, Deb. Stock	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—⅜	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	66 —70	5 14 6	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. with coup 5	39 —41	4 16 0	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds	103 —104	4 16 0	..	103⅛	..
..	4½%	Do. 4½% Bonds with coup. 6	90 —92	4 18 0	..	91⅛	90½
..	4%	Do. 4 per Cent. 1st Power Ho. Dbs.	98 —100	4 0 0	..	99⅛	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	⅛—⅜	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛—2⅛	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Anchor Cable Co. 4½ % Deb. Stock	100 —102	4 9 0	..	..	..
1	..	Aron Electricity Meter Ord.	⅛—⅜	..	..	⅜	..
1	1/9½	Do. 6% Cum. Pf.	3⅞—4	6 16 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.	5⅛—5⅝	4 3 0	April, Oct	5⅝	..
1	0/7½	Do Pref.	1⅞—1⅞	3 16 3	..	1⅝	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7⅛	6 18 0	July, Feb	7⅛	..
5	3/0	Do. 6 per Cent. Pref.	5⅞—6⅛	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	..	..
St.	4½%	†British Thoms'n-Houst'n 4½% 1st Mt. Db.	99 —101	4 9 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.	⅞—1	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)	99½—101½	5 19 0	..	62	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	61 —63	3 3 6	Jan, July	..	..
St.	4½%	†Brush E. Eng. Co. 4½% Perp. 1st Deb. Stock	37 —42	10 14 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	22 —26	17 6 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9 —10	7 10 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4½—5½	4 15 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	100½—102½	4 7 6	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.	2⅛—2⅛	4 19 6	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	104 —107	4 4 0	Feb, Aug	..	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	5 19 0	March ..	..	..
1	0/8½	Consolidated Electrical Co.	⅛—⅜	6 0 0	August ..	..	..
1	0/6	Consolidated Signal Co.	⅛—⅜	5 12 9	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	⅛—⅜	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	⅛—⅜	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)	83 —85	5 18 6	Jan, July	..	..
1	0/7½	Davis & Timmins	⅛—⅜	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.	1 —1⅛	5 7 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	⅛—1⅛	5 6 6	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅞—⅞	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.	⅞—1	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛—2	..	May, Nov	1⅜	..
St.	4½%	Do 4½ per cent. 1st Mort. Deb. (red.)	75 —78	5 15 6	Jan, July	76	..
2	..	Electric Construction Co.	⅛—⅜	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1⅛—1⅛	4 13 6	July	1⅛	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	59 —61	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	7⅛—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.	82 —86	4 13 0	Mar, Sept	..	..
5	5/0	†Henley's Telegraph Works Ord.	12 —12½	5 17 6	Feb, Aug	12⅛	12⅛
5	2/3	†Do. 4½ per Cent. Pref.	4½—5⅛	4 8 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 3 6	Mar, Sept	108	..
10	5/0	India Rubber, Gut. Per., &c., Works	14½—15	6 12 0	Feb, Aug	..	..
10	5/0	Do 5 per Cent. Cum. Pref.	10½—11	4 14 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April, Oct	..	..
1	..	National Elec. Construction Co.	⅛—⅜	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov	⅜	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—⅜	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5⅛	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	34 —36	5 18 0	Mar, July	35⅛	34⅛
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100 —102	3 17 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅛	4 5 0	..	2⅛	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference	1⅛—1⅛	4 1 6	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	107 —110	4 12 0	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	103⅛	102⅛
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	105⅛	104
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip.	105 —107	4 13 6	..	105⅛	105⅛
10	10%	J. G. White & Co. 6% Cum. Pref.	12½—13⅛	7 8 0	..	13⅛	..
1	..	Willans & Robinson Ord.	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅛—3⅜	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan, July	..	..
St.	15/0	Anglo-American	67⅛—69⅛	5 6 0	F, My, Ag, N	..	5
St.	30/0	Do. Preferred	110 —112	5 7 0	F, My, Ag, N	111	106⅛
St.	25/0	Do. Deferred	27⅛ —28	4 9 0	F, My, Ag, N	28⅛	26⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	84 —86	4 13 0	Jn, Ap, Jy, O	85⅜	84⅛
10	6/0	Cuba Submarine Ord.	8⅛—9	6 13 6	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.	16½—17⅛	5 15 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3⅛—3⅜	5 12 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	7⅛—8⅛	5 19 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	6/0	Direct United States Cable	15⅛—16⅛	5 11 6	Ja, Ap, Jy, O	16	15⅛
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 —101	4 9 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	132 —135	5 4 0	Ja, My, Jy, O	134⅛	132⅛
St.	17/6	Do. 3½ per Cent. Pref. Stock	84 —86	4 1 6	Ja, My, Jy, O	84⅛	84⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	102½—104½	3 17 9	May, Nov	103⅛	..
St.	2/6	Eastern Extension	12⅛—12⅞	5 15 0	Ja, Ap, Jy, O	12⅛	12⅛
100	4%	Do. 4 per Cent. Deb. Stock	99½—102½	3 17 6	Feb, Aug	..	..
25	4%	Eastern and S. Af., 4% Mauritius Sub. Debs	100 —102	3 18 0	May, Nov	100⅛	..
10	5/0	G. N (of Copenhagen), with Coupon 80	29⅛—30⅛	5 15 0	Jan, July	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	Mackay Companies Common	86 —90	5 11 0	Ja, Ap, Jy, O	..	..
100	4%	Do Preference	74 —73	5 2 6	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅞—1	..	April	⅞	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	96½—98⅛	4 2 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	96½—98⅛	4 2 0	Jan, July	..	..
10	..	West India & Panama	⅞—1	..	May, Nov	..	..
10	6/0	Do. 6 per Cent. 1st Pref.	8⅛—9	6 12 6	May, Nov	..	..
10	9/0	Do. 6% 2nd Pref.	8 —9	6 13 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	103 —102	4 19 0	Jan, July	..	..
10	3/0	Western Telegraph	14 —14⅛	4 16 9	Mr, Jn, O, D	14⅛	14⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 12 0	June, Dec	101	..
—	4%	Western Union Telegraph. $1,000 4% Bds	103 —106	3 15 3	—	..	..
..	4½%	Do. $1,000 4½% Fdg. & Rl. Est. Gd. Bnds	99 —102	..	..	..	..
		Telephones.					
100	2$	Amer. Telephn. & Tslegh. Cap. St.	138 —141	5 18 6	..	..	..
St.	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 7 3	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	102 —104	3 16 6	..	..	..
St.	5%	†Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —102	4 18 0	Mar, Sept	..	..
5	5/0	Chili Telephone	9½—9⅝	4 4 3	August ..	..	..
1	0/7½	Monte Video Telephone Ord.	⅜—⅝	6 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅜—⅝	5 12 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	104 —105½	6 1 0	Feb, Aug	105	104
St.	6%	Do. Def. Stock	123 —125	4 17 6	Feb, Aug	124	123½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	10 —10⅜	5 8 6	Feb, Aug	10⅛	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —10⅜	5 8 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.	5⅛—5⅜	4 8 0	Feb, Aug	97⅛	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)	97⅛—99⅛	3 10 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	98½—100⅛	3 19 6	Jan, July	99⅛	98⅜
..	4½%	New York Telephone Co. 30 yr. Bnds.	98½—99½	4 12 0	..	99⅛	98⅜
1	1/0	Oriental	1⅛—1⅜	4 14 6	April, Oct	1⅜	..
1	0/7½	Do 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	86 —88	4 11 0	Jan, July	87	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	98 —100	4 10 0	Jan, July	..	..
5	5/0	United River Plate Ord. ex rights	6⅛—7⅛	5 11 0	July	7⅛	7⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅛	4 14 0	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.	102 —104	4 6 6	Jan, July	103⅛	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	2⅛—3⅛	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10⅛—11	5 7 6	Sp, Dc, Mr, Ju	10⅛	10⅛
10	3/0	Do. 6 per Cent. Pref.	13 —13⅛	4 9 0	Sp, Dc, Mr, Ju	13⅛	13⅛
10	6%	Submarine Cables Trust (Cert.)	130 —133	4 10 6	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
		Anglo-Argentine 5% Cum. 1st Pref.	4⅞—4⅛	5 9 6	April, Oct	4⅛	4⅛
		Do. 5% Cum. 2nd Pref.	4⅛—4⅜	5 14 0	Jan, July	4⅛	..
		Do 4% Deb. Stock	91 —92⅛	4 6 6	June, Dec	92⅛	91⅛
		Do. 4½% Deb. Stock	94 —97	4 13 0	..	95⅛	95
St.	4½%	Auckland Elec. Trams. 5% Deb. (red.)	103 —105	4 15 3	Jan, July	..	..
		Brisbane Electric Trams. Invest. Ord	5⅜—6⅛	5 19 0	May	..	..
		Do. 5 per Cent. Cum. Pref.	4⅛—5⅛	4 15 0	May, Nov	..	..
		Do. 4½ per Cent. Db. Prov. Certs.	99 —102	4 8 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	143 —147	5 9 0	Mar, Sept	146⅛	..
St.	£3	Do. Pref. Ord. Stock and & bonus	124 —128	4 13 9	May, Nov	126⅛	126
St.	5%	Do. 5% Cum. Perp. Pref. Stock	111 —114	4 7 6	Jan, July	113⅛	111⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	102⅛	..
40	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
St.	4½%	Do. 4½% Perp. Con. Deb. St.	104½—106½	4 0 6	..	106⅛	105⅛
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	96½—99½	4 19 0	Mar, Sept	..	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	95 —98	6 2 0	Feb, Aug	98	..
		Calcutta Tramways (1 to 137,610)	4½—4⅞	4 14 9	Mar, Sept	4⅞	4⅞
		Do. 5 per Cent. Cum. Pref.	4⅛—4⅜	5 2 9	Jan, July	..	..
		Do. 4½% 1st Deb. Stock (red)	96 —99	4 11 0	Jan, July	..	..
		Cape Electric Tram Shares	⅛—⅜	..	..	..	..
		City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 5 6	F, My, A, N	..	..
		Do 4 per Cent. Deb. Stock	98 —101	4 0 0	June, Dec	..	..
		Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 —99	5 1 0	May, Nov	..	..
St.	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
		Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	93 —101	5 4 0	Feb, Aug	99⅛	99
		Kalgoorlie Elec. Trams Sh.	⅛—⅜	..	..	..	..
		Do. 5 per Cent. "A" Deb. Stock	92 —95	5 5 0	Jan, July	95	94⅛
		Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	72	..
		Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 8 0	July	..	..
		Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 16 0	Jan, July	..	..
		Do. 5 per Cent. Reg. Mort. Debs.	97⅛—101⅛	4 18 6	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	..	..
		Manaos Trams and Lt. Co. 5% Debs	86½—89	5 13 6	..	87⅛	..
		Manila Elec. Ry. $1,000 Gold Bonds	96 —98	5 3 0	Feb, Aug	..	..
		Mexico Trams Co. Com. St.	122 —124	5 5 0	..	122⅛	120⅛
		Do. Gen. Con. 1st Mort. 5% Gold Bds.	99½—100⅛	5 1 0	..	100⅛	99⅛
		Do. 6% 50 yr. Mort. Bds.	98⅛—99⅛	6 0 3	..	99⅛	98⅛
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	100 —102	4 8 0	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	103	..
		Perth Elec. Trams Ord.	⅞—1⅛	5 15 5	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	99 —102	4 18 0	Jan, July	..	..
		Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 3 9	..	..	..
		Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	..	..
		Rio Janeiro Tram, Lt. & P. Co.	94½—95⅛	4 5 3	..	95⅛	93
		Do. 30 yr. Gold Bnds.	98½—99½	5 3 6	..	99	98⅛
		Do. 50 yr. Mt. Bnds	90½—91⅛	5 9 6	..	91	9.⅛
		Sao Paulo Tramway, Light & Power Co. $100 Stock	148 —150	6 13 4	..	150	145
		Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	..	..
		†Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 9 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	†Adelaide Elec. S'ply Co. 6% Cu. Pr.	5⅛—5⅜	5 5 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	10⅜—11⅛	5 6 6	..	11	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red)	93⅛—95⅛	4 14 0	Jan, July	..	..
	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock	97 —99	5 1 0	..	98⅛	93
		Calcutta Elec. Supply Ord.	6⅛—6⅜	6 6 0	April, Oct	..	..
		Canadian Gen. Elec. Co. Com. St.	105 —110	6 7 0	..	108	..
		Do. 7% Cm. Pf. Stock	120 —123	5 14 0	..	123	121
		Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
		Elect. Development Co. of Ontario	85 —88	5 12 6	..	86⅛	..
		Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	87 —90	5 9 0	Jan, July	..	..
		Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
		Kalgoorlie Elec. Power & Ltg. Ord.	⅞—1	..	..	..	..
		Do. 6 per Cent. Cum. Pref.	⅛—⅜	..	..	..	..
		Kaministiquia Power Co. 5% Gold Bnds.	100⅛—102⅛	5 0 6	..	..	..
		Madras E. S. Corp. Ord.	2⅛—3	..	..	..	..
		Melbourne E. S. Co. 6% Cum. Pref.	33 —38	..	..	..	..
		Do. 5% 1st Mortg. Deb. Stock	90½—94⅛	5 9 0	..	91⅛	93⅛
		Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	81⅛—85⅛	5 15 9	..	85⅛	85⅛
		Mexican Lt. & Power Co. Com. St.	79 —81	5 3 6	..	80	79
		Do. 7% Cum. Pref. St.	104 —106	6 12 0	..	105⅛	104⅛
		Do. 5% 1st Mort. Gold Bnds.	93 —94	5 6 7	..	96⅛	93⅛
		Montreal Lt. Ht. & Power Co. Cap. St.	132 —138	5 5 0	F, My, A, N	..	..
		River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	..	..
		Do. 6 per Cent. non-Cum. Pref. Stk.	105 —115	5 5 0	May	..	..
		Do. 5 per Cent. Deb. Stock	100⅛—102⅛	4 17 6	Jan, July	..	..
		Rosario Ele. Co. Ord.	8⅛—9	..	..	..	..
		Do. 6% Pref. (1-20,000)	6 —6⅛	4 12 0	April, Oct	..	..
		Do 2nd Pref.	8⅛—8⅜	6 14 6	..	..	..
		Shawinigan Water & Power Co. Cs	99 —101	4 4 0	..	100⅛	99⅛
		Do. 5 per Cent. Bds.	108 —110	4 10 0	Jan, July	109⅛	..
		Do. 4½ Per Con. Mt. Db. St.	101 —103	4 7 6	..	..	..
		Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	..	..
		Victoria Falls Power Co. Pref. (1 to 808,000)	⅛—⅜	5 6 6	Jan, July	..	..
		Do. (803,061 to 1,700,000)	⅛—⅜	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote the

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,686. [No. 22. Vol. LXV.] FRIDAY, SEPTEMBER 9, 1910. PRICE SIXPENCE (by post. 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Tariffs in Electricity Supply.

FEW Papers of practical interest to electrical engineers were presented to Section G of the British Association this year, and it is curious that the Paper of probably greatest importance to them—that by Mr. E. W. COWAN, on "The Price of Electricity"—was read before the section dealing with Economic Science and Statistics. Mr. COWAN apparently hoped to find here a more sympathetic audience than that provided by his fellow engineers, so that the support which his views received from such eminent engineers as Mr. S. L. PEARCE and Mr. W. B. WOODHOUSE should prove particularly gratifying to him. Mr. PEARCE, however, drew attention to the difficulty of converting principles into practical tariffs, which latter have always been the *bête noire* of supply engineers. The broad-minded policy advocated by Mr. PEARCE, of arriving at a fair price for power supply to large consumers by basing such charges on the present cost of installing additional plant, is one which we have from time to time defended; and although some classes of consumer, such as tramway undertakings and lighting consumers, frequently feel themselves unduly penalised, there is little doubt that the above policy is commercially sound. Commercial methods are being more and more introduced, although somewhat slowly, into electricity supply, so that a fixed relation between the price charged per unit and the calculated average cost of production will probably soon be considered of secondary importance. Nevertheless, the problem is not quite as simple as Mr. COWAN would have us believe. Electric energy generated for a particular purpose may sometimes be regarded as a by-product of the whole supply, just as hides may be regarded as a by-product of beef. But there is an important difference in the two cases. The animal kingdom unfortunately does not permit us to grow hides without beef, or beef without hides, whereas it is possible to generate energy for light without at the same time producing energy for power, and *vice versâ*. Consequently, the price of energy for power does not necessarily fall when the demand for light increases, whereas hides might become a drug on the market if people insisted on eating enough beef. Nevertheless it is a good thing to have these economic points discussed and we are glad that Mr. COWAN has read his Paper, which we hope will be studied carefully by all station engineers. It is a bad thing to have very set ideas on most subjects, and more flexibility in ideas on tariffs may lead to such a large expansion in electricity supply as would rejoice the heart of many an engineer.

Coasting on Electric Railways.

ANOTHER Paper in which considerable interest was taken by electrical engineers was that read before Section G by Mr. PHILIP DAWSON, on "The Electrification of the London, Brighton & South Coast Railway between Victoria and London Bridge." The main features of this line are well known to readers of THE ELECTRICIAN, but there was one point mentioned by the author to which reference may here be made, namely, the system of calling the attention of motormen to the most economical places at which to cut off current for coasting or for stopping at stations. For this purpose a St. Andrew's Cross has been painted on the ironwork at such points along the track. That considerable economy is possible where this method is adopted can be gathered from the fact that a saving of from 5 to

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10 per cent. in the energy consumption has thereby been effected on the South London line. Although motormen may be instructed to handle their controllers effectively so as to economise in current consumption, the best results can obviously only be obtained by making such operation as automatic as possible, as in the above case, so that individual judgment is obviated. This is particularly important where frequent stops are necessary. That so large a saving is possible by such a simple expedient emphasises the importance of attention to detail.

Hysteresis Effect in Weston Cells.

In the report of the Electrical Standards Committee of the British Association, reference is made to hysteresis effects which occur in a small percentage of Weston normal cells. The report further points out that cells which exhibit marked hysteresis effects invariably change with time at a comparatively rapid rate. The cause of the hysteresis seems to be different from that observed, many years ago, in the case of the tube form of Clark cell, for in the latter case the irregularities appeared to be chiefly due to a difference of concentrations of the zinc sulphate solution at the anode and cathode. Inasmuch, however, as the Rayleigh H form of vessel is used for the Weston cell, a difference of concentration in the cadmium sulphate solution at anode and cathode is most improbable. We are informed that if a Weston cell, in which the hysteresis effect occurs, is raised in temperature, the decrease in E.M.F. is, in general, very nearly normal; but when, afterwards, the temperature is lowered, the increase in E.M.F. is abnormal. Although the changes have not yet been explained, users of cells will be interested to know that all cells sent for test at the National Physical Laboratory are examined for this hysteresis effect, and no certificate is granted if the effect exceeds a certain limit. For the purpose of the test the cells are kept at a constant temperature for a few days and their E.M.F. measured; afterwards, the temperature is increased 10°C. and the cells maintained at this temperature for 24 hours. The cells then cool in a normal manner to the initial temperature and after two days the E.M.F. is again measured. If this disagrees with the E.M.F. first observed by 0·0001 volt or more, the cell is regarded as abnormal and no certificate is granted. Fortunately, comparatively few cells fail in this test—in many cases there is absolute agreement between the initial and final values of the E.M.F. The whole matter is being investigated and the solution of it promises to clear up the sole remaining cause of disturbance in a few Weston cells.

Glow Lamp Tests.

In comparing the results obtained by laboratory measurements in different countries, a doubt has sometimes been felt whether the results were really comparable owing to possible differences in the standards employed. Any such doubts are now disappearing rapidly owing to more general agreement and to comparisons between the various national laboratories. One of the most recent steps of this kind relates to the testing of glow lamps, and is described in another column by Messrs. C. C. Paterson and E. H. Rayner. The object in view was to see if lamp tests carried out in England and in America in accordance with the specification of the Electrical Standards Committee would give the same results. For this purpose a dozen carbon lamps were prepared on each side of the Atlantic; half the English lamps were sent to America and half the American lamps were sent to England. The two batches of mixed lamps were then run for life tests at the National Physical Laboratory and at the Electrical Testing Laboratories of New York. One of the English lamps seems to have undergone a change between the time when it was tested at Teddington and its arrival at New York. But if this lamp is discarded and a correction is introduced for the slight difference in pressure at which the lamps were tested in the two countries, it is found that the difference in the average life obtained at the two laboratories does not exceed 2 per cent. This result is certainly gratifying, and may be said to be remarkably good for such a small number of lamps, even though "selected."

Accidents in Mines.

Some acute differences of opinion have been expressed by mining engineers from time to time, usually on the score of danger, on the subject of the application of electricity in the underground operations of coal mining. Certainly if such carelessness as was reported last week at the inquest held at Pencoed on a workman killed at South Rhondda Colliery were generally practised in coal mines, the views of those who hold that the installation of electric cables and apparatus in coal mines is likely to be dangerous would be justified. But it is difficult to understand how, in view of the regulations which obtain in connection with mining operations, or with most ordinary precautions such an accident could have happened in any mine. To leave disused wire lying about so that it may come in contact with live conductors is to invite disaster, and it is clear that a greater appreciation of the danger likely to result from such carelessness must be brought directly home to the men before a mine can be considered safe. Surely, however, this is no argument against the employment of electrical methods in a coal mine. Whatever system of working were adopted, loose wire would prove a danger in differing degree. That such danger is increased where electric cables are installed seems too obvious to need pointing out. If similar occurrences to that at South Rhondda Colliery become at all prevalent, the hands of the clock will certainly be put back in regard to the application of electricity in mining work. It therefore behoves all mining electrical engineers to take instant steps towards educating the men under them to a better appreciation of what may happen if electrical apparatus be not used in a proper way.

Isolation of Radium.—According to the Paris correspondent of "The Times," Mme. Curie and M. Debierne have just presented a joint memoir to the Académie des Sciences announcing that they have succeeded in isolating pure radium. The metallic radium which they have obtained is of a brilliant white colour, which blackens when exposed to the air. It burns paper, rapidly decomposes water, and adheres to iron.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Assab—Perim	July 8, 1909	—
Malta—Tripoli	April 20, 1910	—
Reunion—Mauritius	May 20, 1910	—
Latakia—Palura	May 26, 1910	—
Obock—Djibouti	June 24, 1910	—
Bonny—Duala	Aug. 3, 1910	Sept. 3, 1910
Cape St. James—Doson	Aug. 23, 1910	Sept. 5, 1910

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Electric Power in Stone Quarries.—According to the "Canadian Electrical News" the Point Anne Quarries Co. is considering the advisability of replacing its present steam-driven plant by electric motors. A certain number of motors have been used hitherto, but these will be considerably increased in number, and all the power required will be taken from the high-tension mains of the Seymour Power and Electric Co.

Brussels Exhibition Fire.—It is hoped that the King of the Belgians will open the reconstructed British Section of the Exhibition on September 15. The preliminary work in connection with the equipment of the new section has progressed so satisfactorily that there is little doubt everything will be completed by the above date. The Exhibitions Branch of the Board of Trade hope that the Brussels fire will not affect the chances of a representative exhibit at the Rome and Turin Exhibitions next year.

International Conference of Government Telegraph and Telephone Engineers.—The second conference of the International Association of Government Telegraph and Telephone Engineers commenced at the Sorbonne, Paris, on Monday, representatives from 22 Government Departments being present. M. Millerand, French Minister of Public Works, delivered the inaugural address, which dealt chiefly with the subjects of the standardisation of telephonic circuits and the development of automatic telephonic communication.

Cyrus Field.—We consider the family of the late Mr. Cyrus Field, a name famous in telegraph circles, have a legitimate complaint to make against the officials of the British Criminal Investigation Department, who selected for the man Crippen, charged with the murder and mutilation of his wife in London, the name of Cyrus Field during his journey across the Atlantic. The name is an uncommon one, and its adoption in this objectionable way must have caused a deep feeling of annoyance amongst the late Mr. Field's family and his numerous friends on both sides of the Atlantic.

German Central Station Statistics.—In a recent number of the "Elektrotechnische Zeitschrift" Mr. G. Dettmar gives some details regarding electric power stations in Germany, the figures referring to the period ended April 1, 1910. The total number of stations on that date was 2,358, and these supplied energy to 6,470 cities and towns. Their aggregate capacity was 1,373,000 kw. Of these stations 767 used steam, 214 hydraulic power, and 350 internal combustion engines, while 51 were transformer or converter stations. Fifty-two stations supplied single-phase current, 241 three-phase, and 1,736 continuous-current, while the remainder used some combination of these three systems.

Street Lighting in Westminster.—A controversy on this subject has recently been taking place in the columns of our contemporary the "Westminster Mail." In reply to a letter by Mr. E. Wilmot Seale, secretary of the Charing Cross, West End & City Electricity Supply Co., (which also appeared in our issue of August 26th), Mr. F. W. Goodenough, of the Gas Light & Coke Co., writes that it has been officially stated that the electric lighting in the St. George's district is costing £10,000 a year more than would efficient gas lighting, while he complains of the righteous attitude taken up by electrical engineers towards the gas prices. "When," he writes, "the St. James' Company reduced their price five years ago from £30 to £17 per lamp per annum to keep out gas, I do not remember much being said about 'considerations of advertisement and preference having an undue bearing on the composition of the prices tendered.'" In reply to this Mr. S. T. Dobson, chief engineer of the St. James' & Pall Mall Electric Light Co., writes :—

In correction of the statement in Mr. Goodenough's letter I would say that the St. James' Company was able to reduce the price five years ago from £30 to £17 per lamp per annum for the reason that during the nine years of the previous contract the sum of £5,000, representing the original capital expenditure, had been written off, and that the cost of electric supply in the district had been generally reduced. But the contract at £17 per lamp per annum was run at a fair profit, and on this account the Company has been in a position to supply the 16 flame lamps in Regent-street which have given such great satisfaction for the past 12 months at the same price of £17 per lamp per annum, and to replace the other 50 electric lamps on the circuit with similar lamps at the same price. This offer is clearly set out in a letter of the company to the City Council, dated April 21, 1910, and if it could have been accepted, the 66 electric lamps of the Regent-street type would have cost a total sum of £1,122 per annum, as compared with the total sum of £1,127 per annum which is to be expended on the corresponding gas lamps. But this special offer was barred out by the form of tender, and the subsequent proceedings, and there is no more to be said on that.

Current Topics.

Subjects of current interest dealt with in this issue include the following :—

Messrs. C. C. Paterson and E. H. Rayner contribute an article on "Comparative Life Tests on Glow Lamps." The tests have been carried out at the National Physical Laboratory and the New York Electrical Testing Laboratories.

We give an account of the proceedings at the meeting of the British Association at Sheffield, where, among others, Papers were read by Mr. Philip Dawson on "The Electrification of the London, Brighton & South Coast Railway between Victoria and London Bridge"; by Mr. E. W. Cowan on "The Price of Electricity"; by Prof. S. P. Thompson, F.R.S., on "The Laws of Electromechanics"; and by Prof. E. Wilson and Mr. W. H. Wilson on "A New Method for Producing High-tension Discharges." Among the reports presented were those of the Electrical Standards Committee and the Committee on Electro-Analysis.

Dr. W. H. Eccles contributes an article on "Recent Patents in Wireless Telegraphy."

We analyse the accounts for the year ended May 31st last of the Glasgow Corporation electricity department.

Bootle Council have applied for sanction to a loan of £8,500 for extensions of their electricity undertaking.

The Allgemeine Elektricitäts Gesellschaft, Berlin, have purchased the dynamo factory of the Felten & Guilleaume-Lahmeyerwerke at Frankfort.

On another page we give an abstract of the new Transvaal Power Act.

Coventry City Council have appointed a special committee to consider the advisability of purchasing the local tramways.

The accounts of Bradford tramways department show a nett profit of £32,365 for 1909-1910.

The power house of the Northern Light, Power & Coal Co. was completed on August 24th, and electrical energy is being transmitted to Dawson City (British Columbia), a distance of 44 miles.

An interesting report of the City Electrical Engineer on the past year's work of the Aberdeen electricity department is abstracted in another column.

Municipal Electricity Supply Extensions.—Halifax Corporation decided on Wednesday to put down additional generating plant at a cost of over £10,000.

INSTITUTIONS AND SOCIETIES.

The Institution of Gas Engineers.—The visit of the German Association of Gas and Water Engineers to Great Britain, which was postponed on account of the death of King Edward, has now been arranged to take place during the week commencing October 2nd next. The visitors are to be the guests of the Institution of Gas Engineers, the Gas Light & Coke Co., the South Metropolitan Gas Co., the Croydon Gas Co., and the Corporations of Edinburgh and Glasgow respectively. The engineer of the gas department of the latter city, Mr. Alex. Wilson, is now the President of the Institution of Gas Engineers.

The Association of Mining Electrical Engineers.—A meeting of this Association, which will be held with a view to extending the membership in Scotland, will take place at the Grosvenor Restaurant, Glasgow, on Saturday, September 17th, at 6 p.m. The Association of Mining Electrical Engineers has been founded to consider means for minimising the risks attending the application of electricity to the industry of mining; to promote the adoption of improved methods and devices tending to increase safety; to promote the general advancement of electrical science in its application to the industry of mining; to facilitate the exchange of information and ideas on this subject among the members of the Institution and otherwise; and generally to extend the experience, increase the efficiency and elevate the status of those engaged in such applications. In view of probable legislation in the future, it is felt to be of great importance that the collective opinion of mining electrical engineers should be expressed upon any suggested regulations or rules, and that the Association should be afforded an opportunity of submitting evidence. The secretary is Mr. C. Saunders, of London-road, Derby.

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GLASGOW CORPORATION ELECTRICITY SUPPLY ACCOUNTS.

In analysing the accounts of the Glasgow Corporation electricity supply department for the year ended May 31, 1909, we had to record a deficit of £3,545, due to unusual conditions. On the present occasion, however, in considering the accounts for the 12 months ended May 31, 1910, it is satisfactory to notice that a surplus is again shown by the undertaking. Although the output of units has not increased to the same extent that it did a few years ago, the sales of energy for the past year are greater by over two million units than in 1908-9. Of the total quantity sold, viz., 36,479,243 units, 15,087,680 units were used for private lighting, 19,655,173 units for power and heating, and 1,556,661 units for public lighting, whilst the remaining 179,729 units were sold by contract. The consumption of electrical energy by private consumers shows an increase of 6·13 per cent. compared with the previous year's figures. It will probably prove of interest to give the following details of the sales of energy with the price obtained. The large number of units sold at ½d. and ¾d. per unit is noticeable

Lighting.			
Shops, warehouses, offices, &c.	915	units @	8d.
" " "	7,885,833	" "	3½d.
" " "	3,613,578	" "	½d.
Domestic consumers, churches, schools	1,804,107	" "	3d.
Special lighting	1,711,764	" "	1½d.
" "	71,483	" "	1d.
	15,087,680		
Power and Heating.			
Power and heating	5,175,341	" "	1½d.
" "	9,011,794	" "	¾d.
Power	1,172,238	" "	1d.
"	4,295,800	" "	½d.
	19,655,173		

The following analysis of private consumers' demands should also prove instructive. The figures given in brackets are the corresponding number of consumers a year ago, whilst the increase or decrease in the output for each class of consumer, compared with the previous year's sales, is also tabulated.

	Max. Demand	No.		Consumpt. Units.	Comparison with 1908-9.	
Consumers under 1 hr.		3,537	(3,461)	790,305	Dec.	37,914
" " 2 "		2,919	(2,789)	2,474,197	Dec.	157,496
" " 3 "		1,545	(1,506)	2,181,078	Dec.	448,637
" " 4 "		695	(665)	1,459,549	Dec.	94,327
" " 5 "		305	(264)	1,020,080	Inc.	116,188
" over 5 "		375	(268)	2,606,315	Inc.	473,103
Theatres, halls and schools		289	(231)	1,158,633	Inc.	3,952
Special		102	(59)	1,711,764	Inc.	239,062
Domestic consumers and churches.		6,417	(5,928)	1,685,759	Inc.	10,737
Power		2,630	(2,504)	19,438,936	Inc.	1,826,453
Heating		340	(265)	216,237	Inc.	75,674
		19,154	(17,940)	34,742,853	Inc.	2,006,795

One of the most interesting points brought out by the above tabulation is the decrease in consumption by "short hour" and what may be called "medium hour" consumers; and this in spite of a considerable increase in the number of consumers. Perhaps the most gratifying feature is the increase in the sales of energy for heating, the increase of 75,674 units representing 54 per cent. of the previous year's output. In this connection it is interesting to notice that the Electricity Committee are at present considering a scheme whereby domestic consumers may obtain a supply of electrical energy from their lighting circuits for cooking, heating and other purposes at a lower rate than the charge for lighting, the cost of separate wiring being avoided.

Considerable expansion is also shown in power supply, the number of units sold having increased by 1,826,453, whilst 126 new power consumers were connected. In this connection it may be mentioned that the total number of motors supplied from the Corporation mains on May 31st last was 4,851, with a total horse-power of 32,918, compared with 4,292 motors and 29,505 H.P. at May 31, 1909. In seven instances transforming plant has been placed on consumers' premises. The total capacity of such private sub-stations is now 4,000 H.P.

In addition to the large expansion in power supply, the other main increase in the above table is about 600,000 units in the consumption by long-hour consumers. The number of units used by private consumers per lamp installed averaged 20·63, compared with 21·17 last year, but this figure is not very reliable as consumers frequently make alterations in lamps without notice. The figures are based on the number of 8 c.p. lamps or the equivalent in other devices, the total connections at May 31, 1910, being equivalent to 1,759,120 lamps, an increase of 121,933 during the 12 months. The number of public arc lamps in use at May 31st last was 837, the same as last year, but 24 incandescent lamps have been added during the year. The mains department have laid during the twelve months 10 miles of feeder cables and 9 miles of distributors.

Turning now to the distribution of the energy, 43,245,524 units were generated; of this total, 2,368,359 units were used on the works; 36,479,243 units were sold, and the remainder, viz. 4,397,922 units, or 10·17 per cent. of the total, were expended in distribution or unaccounted for. As will be seen from our analysis of the expenditure below, small economies have been introduced in the cost of generation and distribution, and the total costs also stand at a lower level than in any previous year. The bulk of the output is now generated at Port Dundas station, 28,458,213 units being supplied from that works, 14,235,302 units from Pollokshaws-road station, and 552,009 from Kelvinside station. It is interesting to notice that the coal bunkers at Port Dundas have been extended so as to have a capacity of 7,000 tons, sufficient to keep the works going for a considerable period in the event of a strike or adverse weather conditions on the canal preventing delivery.

The following is an analysis of the expenditure during the past financial year, together with the cost of working per unit sold, both for last year and for 1908-9 :—

		Cost per unit sold. 1909-10.	1908-9.
Generating Costs.			
Fuel	£31,437	0·207d.	0·251d.
Oil, waste, water, &c.	2,635	0·017d.	0·019d.
Salaries and wages at station	14,747	0·097d.	0·098d.
Repairs and maintenance	8,547	0·056d.	0·045d.
Total Generating Costs	£57,366	0·377d.	0·413d.
Distribution Costs.			
Wages	£3,140	0·021d.	0·021d.
Repairs & maintenance of cables, &c.	5,036	0·033d.	0·037d.
Repairs & maintenance of meters, &c.	3,106	0·020d.	0·019d.
Total Distribution Costs	£11,282	0·074d.	0·077d.
Management Costs.			
Salaries	£6,266	0·041d.	0·042d.
Stationery, printing, &c.	1,192	0·008d.	0·007d.
General establishment charges	4,475	0·030d.	0·023d.
Total Management Costs	£11,933	0·079d.	0·072d.
Rents, rates and taxes	£21,161	0·139d.	0·144d.
Attending and repairing public and private lamps.	3,696	0·024d.	0·024d.
TOTAL COSTS (*ex.* capital charges)	**£105,438**	**0·693d.**	**0·730d.**
Capital Charges.			
Interest	£57,381	0·378d.	0·381d.
Sinking fund	39,475	0·260d.	0·253d.
Total Capital Charges	£96,856	0·638d.	0·634d.
TOTAL COSTS (*inc.* capital charges)	**£202,294**	**1·331d.**	**1·364d.**
Depreciation	£43,475	0·286d.	0·371d.
TOTAL RECEIPTS from all sources	**£245,960**	**1·618d.**	**1·711d.**
Balance (surplus)	£191	0·001d.	0·024d. (deficit)

The surplus of £191 has been transferred to the Reserve Fund, which amounts to £20,131. In regard to this surplus of £191, it must be noticed that the sum set aside for depreciation, £43,475, is almost £10,000 less than the amount provided in the previous year. The total of £43,475 is obtained by allowing 1 per cent. on the cost of land and buildings, 3½ per cent. on machinery, instruments, &c., 5 per cent. on accumulators, 2 per cent. on mains and cables and 4 per cent. on meters.

During the past year the capital expenditure amounted to £96,707, bringing the total capital expenditure (less depreciation written off) to £1,853,434.

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UNIVERSITY OF CALIFORNIA

DIRECT-CURRENT TURBO-GENERATORS.*

BY W. L. WATERS.

Summary.—The author outlines the present position of the direct-current turbo-generator, discussing the limits as regards speed and output. The type of brush to employ and the question of vibration are also considered.

While large power stations are gradually abandoning the use of direct-current generating apparatus, and generating instead alternating current for distribution to sub-stations, yet the number of small power stations and isolated plants generating direct current is increasing yearly. The advantages of the steam turbine set for such plants are smaller floor space and lower maintenance, due to absence of reciprocating parts. The difficulty in building a small steam turbine set is to design a direct-current generator which will operate satisfactorily at the high speed required for the economical operation of the turbine.

Direct-current turbo-generators have been built in Europe for the past 15 years, but their design and operation have not until recently been sufficiently satisfactory to recommend them for use under American conditions. The early direct-current turbo-generators were built with smooth-core armature and copper brushes, so that the operation was poor. Recently, however, several European manufacturers have been turning out direct-current turbo-generators in sizes up to 1,250 kw. and 4,000 amperes, which have proved much more satisfactory. All these machines operated with metal brushes and naturally suffered from the handicap of excessive maintenance cost. The result of this has been that European manufacturers are now adapting their machines, where possible, to operate with carbon brushes. American manufacturers realised early that the direct-current turbo-generator would never be a satisfactory commercial machine until it could be built with carbon brushes. But it is only within the last five years that the skill of designers and manufacturers has been equal to constructing direct-current generators to operate satisfactorily with carbon brushes at speeds materially higher than those of standard belt-driven generators. By careful design with auxiliary commutating poles and by accurate shop work it has been possible to build motor-generators for double the speed which was formerly considered possible, while the development of direct-current generators for coupling to steam turbines has proceeded under the same conditions. It can now be stated confidently that a direct-current turbo-generator has been developed suitable for satisfactory operation with carbon brushes under American conditions. They are now built in sizes from 10 kw. to 300 kw. at 125 volts and from 50 kw. to 500 kw. at 250 volts. Although 600-volt generators do not seem to be in great demand for this type of unit, yet a number have been in satisfactory operation for some time, notably a 1,000 kw. unit (consisting of two 500 kw. generators coupled to one steam turbine) operating at 1,500 revs. per min., which was installed by the North Shore Railway Co., California, in 1907.

Standard speeds which have been found most suitable for these generators vary from 6,000 revs. per min. for a 10 kw. 125-volt machine to 1,500 revs. per min. for a 500 kw. 250-volt type. All of these machines can be satisfactorily built to operate with commutating poles when carefully designed. Most engineers, however, seem to think that a commutating pole is a universal remedy for all commutating troubles. Experience with direct-current turbo-generators and other high-speed machines has shown that this is very far from being true. The commutating pole must be proportioned as carefully as the other parts of a machine, and it was the neglect of this fact which caused the failure and abandonment of this device when it was first used many years ago. The two factors which limit the design of direct-current turbo-generators are the commutation and the collection of large currents at high speeds. The commutating difficulties can be satisfactorily met in the generators given in the above list if a properly designed interpole construction is used. For generators of more special or more extreme ratings a complete system of distributed compensating winding in the pole faces should be used.

The limiting speed for which it is possible to build large direct-current turbo-generators is decided by study of the maximum commutator peripheral speed which can be employed with the particular grade of brushes adopted. The following equation limits the design of the commutator :—

Commutator peripheral speed = circumferential distance between brushes on the commutator × the number of poles × revolutions per minute.

*Abstract from "Engineering News" of a Paper read before the National Electric Light Association.

The minimum distance between brush-arms on the commutator which can be conservatively allowed for any given voltage, is definitely fixed by the conditions of mechanical clearance necessary for accessibility and to prevent flashing, and also by the space required for the necessary number of commutator segments per pole. The number of poles is decided by the current the machine is to commutate. The maximum commutator peripheral speed is decided by the type and quality of carbon brushes which are adopted, while the revolutions per minute should be fixed by the question of maximum economy for the steam turbine. Thus we have the above equation stating a rigid relation between a number of factors, each one of which is subject to restriction.

Flexible metal brushes will operate whether the commutator runs true or not; and, having low contact resistance, they are suitable for collection of large currents. This explains why they were adopted so universally on the early European machines. If the brushes are not carefully trimmed frequently, the trailing edge of a copper gauze or wire brush becomes ragged, and when the brush is in such condition a short-circuit or sudden violent change in load is liable to make the machine flash over. A new type of copper-leaf graphite brush has been used recently in Europe with better results, but the operation cannot be considered satisfactory, and the cost is high. Carbon-trailing tips have been used with metal brushes, but this means a complicated and sensitive brush gear, which is practically as difficult to manufacture and keep in operative condition as a brush gear using all-carbon brushes. The life of metal brush gear of all types is extremely short, so that the cost of renewals and the continual trimming which is necessary become prohibitive.

It is now apparent that the only satisfactory solution of the commutator problem on a direct-current turbo-generator, for American conditions, is the use of carbon or graphite brushes. It is an open question whether it is better to design these machines to operate with ordinary good quality graphite carbon brushes or with some special high-grade brush which must be obtained, for example, from Europe. With carbon brushes a commutator is required which runs absolutely true under all conditions and at all times. Commutators to carry a large current at high speed are always relatively small in diameter and long. The diameter is fixed by the revolutions per minute and the maximum peripheral speed, which can be satisfactorily operated with the particular grade of carbon used and with the degree of accuracy obtainable in commutator manufacture. The peripheral speed usually adopted at the present time in America is from 4,500 to 6,000 ft. per minute, although peripheral speeds 40 per cent. higher than this have been used by European manufacturers with a special grade of brush. With the diameter fixed, the length of the commutator is decided by the questions of temperature rise and correct spacing of the requisite number of brushes. When the length of the commutator would be greater than about 30 in. it usually becomes advisable to build two commutators of half the length instead of one full length. A difficulty which is experienced with any long commutator, or with two commutators in tandem, is the lack of uniformity in the distribution of current between the different brushes on each brush arm. It can be avoided only by careful selection of a suitable type of brush holder carefully fitted with good quality brushes and a suitable arrangement of generator leads.

The standard type adopted for direct-current turbo-generators is a cylindrical commutator of the shrink-ring type. Radial commutators have been used to a certain extent in Europe with good results, but the inaccessibility of the brushes has prevented their extensive adoption. The only advantage claimed for them is a reduction in over-all length and less trouble due to vibration of the armature caused by lack of balance. This reduction in vibration is due to the fact that the operating surface of the commutator is at right angles to the shaft, and consequently in the same plane as any vibration, instead of being at right angles to such a plane, as is the case with a cylindrical commutator.

The V-ring type of commutator is unsuitable for long-speed commutators of small diameter, as with this construction it is difficult to keep the mechanical stresses within reasonable limits. The advantage of the shrink-ring construction is that the stresses can be directly calculated and arrangements made to take care of them. The shrink rings are of high-grade steel and are of sufficiently heavy section so that the stresses due to centrifugal action are moderate. They will retain their circular form and prevent any local distortion of the commutator.

The standard cylindrical shrink-ring type of commutator is, in small sizes, built directly on the shaft, while in large sizes it is built on a bushing. The success or failure of a commutator depends upon extremely accurate shop work and a design such that the deflections and stresses due to centrifugal action and temperature variation are moderate. The micanite or mica used in the construction, instead of

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being a heterogeneous combination of mica and shellac, must be built up of carefully gauged and selected mica segments of uniform thickness regularly arranged and cemented together with the minimum amount of shellac. This micanite has to be carefully treated so that it takes its final dimensions before being placed in the commutator. Every element in the commutator, that is, the copper, micanite, bushing and shrink rings, must be carefully gauged. After the commutator is assembled it must also be carefully seasoned, so that there remains no possibility of distortion or of change in the relative position of segments after the machine is placed in operation.

The mechanical construction of the armature is also of great importance, since it is essential that the balance of the armature should not change after the machine is put in operation. This necessitates that the punchings do not get loose or move on the shaft and that the armature winding does not move under the action of centrifugal forces. The punchings are usually either pressed on the shaft one at a time or built up on a mandrel bored out and shrunk on the shaft, no intermediate spider being used on account of the small diameter. Opinion varies as to whether the armature coils are better held in position by wedges or by wire bands, but the most satisfactory arrangement seems to be the use of bands on the small and wedges on the large armature. The end connections on the armature are probably better held in position by steel wire bands. Bronze shrink rings have been used for this purpose, but there is danger that they may get loose and change the balance of the armature, as it is very difficult to fix them securely. The question of insulation of the armature winding is extremely important. The insulation on the armature coils must be carefully baked and pressed, so that there will be practically no shrinkage and consequent movement of the coils. The armature winding is exposed to carbon and copper dust from the commutator, and the collection of dirt on such a high-speed armature is also very much greater than on the corresponding low-speed. On account of this it is necessary to be extremely careful in insulating all bare metal on the armature, so that there will be no danger of " flashing over " across dirty surfaces to the earthed parts.

The question of vibration is one of the most serious difficulties to be considered. It is difficult to determine the critical speed of a direct-current turbo-generator armature; but it is extremely important that this speed of the generator when coupled to the steam turbine shall not be close to the normal running speed. This usually means that the armature must be designed with the maximum possible diameter of shaft, and it is generally necessary to sacrifice the advantage of low commutator peripheral speed to enable a sufficiently stiff shaft to be used. The question of permanency of balance is equally important, and this requires that there be no relative movement of the component parts of the armature, and also that the shaft neither springs nor deflects under the influence of the temperature variations obtained. Direct-current turbo-generators as built a few years ago would operate perfectly on test when first built, but, after running six months, mechanical vibration and deterioration of the commutator were likely to be so great that they could no longer be considered commercial.

One of the most satisfactory constructions for small units is a two-bearing set, the turbine wheel being overhung and the two bearings self-aligning. This construction obviates any trouble due to lack of alignment. With larger units, however, it is no longer suitable on account of the axial space required by the turbine, and a three or four-bearing set with a coupling becomes necessary. Such sets again require careful alignment and careful fitting of the coupling, otherwise there will be trouble with vibration. Oil-ring lubrication is effective in the smaller sizes, but forced-flow lubrication is usually required above 100 kw. if the temperature of the bearing is to be kept within reasonable limits and if the operation is to be reliable.

Foreign practice is usually to enclose completely all the armature, except the commutator, and to supply cooling air from a special duct. Here we do not consider this advisable because of difficulty of access. The usual practice on small machines is to employ a semi-enclosed construction with natural cooling. On large machines, however, as the noise is appreciably more than in corresponding low-speed machines, it may ultimately be found advisable to adopt a more enclosed construction.

At the present time the direct-current turbo-generator can hardly be considered commercial above 500 kw. at 250 volts, and the probability is that in larger sizes it will be necessary to use an alternating-current turbo-generator and rotary converter as a substitute. This substitute may, however, be only temporary in the 750 kw. and possibly the 1,000 kw. sizes. Considerably larger sizes are at present in use in Europe, but it should be remembered that operating conditions there are by no means as severe as here, so that machines which would operate satisfactorily there might fail here.

PRINCIPAL MIERS' ADDRESS TO SECTION L OF THE BRITISH ASSOCIATION.*

I propose first to consider some general relations between teachers and their pupils, and then explain what, in my opinion, should be the change in the method of teaching, or at any rate in the attitude of teacher to pupil, which should take place when the scene changes from school to university.

First as to general relations between teachers and their pupils. Among all the changes and varieties of system and curriculum there is one factor which remains permanent and which is universally confessed to be of paramount importance—the individuality of the teacher and his personal influence upon the pupil. Personal influence is, of course, not only a matter of intellectual attainments; it appears to me, however, that at the present time so much is made of the duty of schools to aim at the formation of character that there is an unfortunate tendency to regard this duty as something distinct from the other functions of a master, and as independent of intellectual qualifications. Among the first qualities now demanded of a master in a public school for boys are manliness, athletic skill and a hearty and healthy personality, and these are often regarded as compensating for some lack of intellectual equipment. I suspect that there is a similar tendency in schools for girls. And yet I think it will be found that the only permanent personal influence is really wielded by teachers who exercise it through intellectual channels, and that those who acquire intellectual authority will generally succeed in training the characters as well as the minds of their pupils. On the other hand, the master who is not up to the proper intellectual standard will soon be found out by his cleverer pupils, and will lose influence, whatever may be the charm of his character. The formation of character so far as it can be distinguished from intellectual training, is largely worked out by the boys themselves in any public school in which healthy tradition and a sound moral atmosphere are maintained, although it is true that these traditions depend upon the character and personality of the teachers.

How is the proper personal and sympathetic relation to be established between teacher and pupil so that the individuality of the one may call out the character and the effort of the other? Those who enquire of their earliest school reminiscences will probably recollect that the teachers who obtained a real hold upon them did so by virtue of the power which they possessed of arousing their intellectual interest. In the young child I believe that this interest will be found to be mainly that of novelty. With an older student it is not enough that the impression or the idea should be new; if it is to arouse interest it must also direct his mind to a purpose. This distinction may guide us in differentiating university methods from school methods of education. Many of our failures are due to one or both of two prevalent mistakes. The first, the mistake of teaching children by methods that are too advanced; the second, that of teaching university students by methods that are better adapted for school children. It is with the latter that I wish to deal in this address; but we may in passing remind ourselves that when young men and young women are sent straight from the university to teach children with nothing but their university experience to guide them, it is not surprising that they often proceed at first on wrong lines, and as though they were dealing with university students.

Granting, then, that there should be a radical difference between the ways of school and university teaching, and that there is at present an unfortunate overlapping between the two, let me next consider how the distinction between the intellectual interest of a child and the intellectual interest of a man may guide us in adjusting our methods of teaching when students pass from school to the university. A tenable, perhaps even a prevalent, view concerning a liberal school education is that its chief purpose is not so much to impart knowledge as to train the mind. In any event, if the scheme of intellectual training be adequately fulfilled, the period of mental discipline should come to an end with the close of school life, and the mind should then be able to enter upon new studies and to assimilate fresh knowledge without a prolonged continuation of preparatory courses. Indeed, the professed object of entrance examinations to the university is to exclude those whose minds are not prepared to benefit by a course of university study. An entrance examination, then, should not be merely a test of whether a boy or girl has learnt sufficient of certain subjects to continue those subjects in particular at the university; and yet it has, unfortunately, come to be regarded more and more as performing this function, instead of being regarded as a test whether the student is generally fit to enter upon any university course. The result is that an entrance examination tends to become

* Abstract of the presidential address delivered last week at Sheffield by Principal Miers, D.Sc., F.R.S., to the Educational Science Section.

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a test of knowledge rather than a test of general intelligence; merely one in an organised series of examinations which endeavour to ascertain the advancing proficiency in a limited number of subjects, and therefore tend really to encourage specialisation. Specialisation is not to be prevented by insisting on a considerable number of subjects, but rather by teaching even one subject in a wide spirit. Another result is that the entrance examination belongs properly neither to the school course nor to the university course; if it is taken at the age of 16, the remainder of the school career tends to be devoted to university work, which should not really be done at school; if it is taken after leaving school this means that work is being done at, or in connection with, the university which ought to be done at school. It is certainly true that for various reasons a vast deal of education is now being carried on at the universities which should belong to school life, and, moreover, is being carried on by methods which are identical with those pursued at school. It is equally true that, owing to the early age at which matriculation examinations or their equivalents may be taken, many schools are now asking that at the age of 18 or 19 a school examination may be held which shall be an equivalent, not for matriculation, but for the first degree examination at the university. This would really imply that schools should be recognised as doing university work for two years of their pupils' careers—surely a most illogical procedure, and one which supports my contention that there is now very serious overlapping, for it assumes that the work for the first degree examination can be carried on either at the school or the university, and therefore that there is no difference in the methods of the two. An increasing number of candidates actually present themselves from secondary schools for the external intermediate examination of the University of London; in 1904 there were about 150, in 1909 there were nearly 500 such candidates.

The whole matter is inextricably involved with the question of university entrance examinations. It must suffice here to say that I have been led to the conclusion that matriculation examinations should be designed to suit the capacity of average pupils not less than 17 years of age, if they are to test the intelligence of those who are ready to enter upon a university course.

Starting with the principle that the period of mental discipline is closed at the end of the school career, and that those who pass to the university come with fair mental training and sufficient intelligence, what should be the relation of university teaching to that which the student has received at school? Under present conditions the schools which aim at sending students to the universities endeavour to give a general education which will fit their pupils to enter either upon a university course or upon whatever profession or occupation they may select on leaving school. They do not confine the teaching of any pupil to preparation for a special profession or occupation, and they do not generally encourage special preparation for the university. Now contrast what happens to the pupils leaving such a school to enter a profession or business with what happens to those who proceed to the university. The former pass into an entirely different atmosphere; they are no longer occupied with exercises and preparatory courses which serve a disciplinary purpose; they are brought face to face with the realities of their business or profession, and, though they have to gain their experience by beginning at the lower or more elementary stages, they do actually and at once take part in it. The university student, on the other hand, too often continues what he did at school; he may attend lectures instead of the school class, but neither the method nor the material need differ much from what he has already done. Should not the break with school be as complete for him as for his school-fellow who goes into business? Should he not be brought face to face with the actualities of learning? After his years of preparation and mental drill at school, should he not, under the direction of his university teachers, appreciate the purpose of his work and share the responsibility of it?

Take science, for instance, as an illustration. In science there should be all the difference between the school exercises, on the one hand, which teach the pupil the methods of experiment, illustrate the principles laid down in his text books, and exercise his mind in scientific reasoning; and, on the other hand, the university training, which sets him on a course involving the methods of the classical researches of great investigators and a study of the original Papers in which they are contained, illuminated by the views of his own teacher. He also should awaken to the necessity of modern languages. A boy who, on leaving school, passes not to the scientific laboratories of a university, but to a scientific assistantship in a business or Government department, will very soon find it necessary to go to the original sources and acquire a working knowledge of foreign languages. It is regrettable that under existing conditions a scientific student sometimes passes through his university without acquiring even this necessary equipment. I believe this to be largely due to the fact that he is compelled to spend so much of his time in preparatory work of a school character during the early stages of his university career.

The spirit of inquiry which drives the literary student to find for himself the meaning of an author by study and by comparison of the views of others is really the same spirit of inquiry which drives the scientific student to interpret an experiment, or the mathematical student to solve a problem. Only by kindling the spirit of inquiry can teaching of a real university character be carried on. Give it what name you will, and exercise it in whatever manner you desire, there is no subject of study to which it cannot be applied, and there are no intelligent minds in which it cannot be excited.

The first question which a university teacher should ask himself is, "Am I rousing a spirit of inquiry in my pupils?" And if this cannot be answered in the affirmative it is a confession that the university ideal is not being realised. Some assert that this principle should also guide school education, and that it should be the first aim of the school teacher to stimulate the spirit of inquiry. My own view is that with young children this should be less necessary; they all possess it, and are by nature inquisitive. It should rather be the object of the teacher not to spoil the spirit of inquiry by allowing it to run riot, nor to stifle it by making the work uninteresting; if the lesson interests them, their inquisitive minds will be quick enough to assimilate the teaching.

I have often thought it an interesting parallel that among original investigators and researchers there are two quite distinct types of mind, which have achieved equally valuable results. There is the researcher who pursues an investigation with a constant purpose, and to whom the purpose is the inspiration. But there is also the investigator who has preserved his youthful enthusiasm for novelty and has in some respects the mind of a child; passionately inquisitive, he will always seek to do something new, and very often, like a child, he will tire of a line of research in which he has made a discovery, and take up with equal enthusiasm a totally different problem in the hope of achieving new conquests. The latter is, perhaps, the most fertile type of original investigator, but it is not the type that produces the best teacher, except for very exceptional and original-minded students; and such teachers do not often found a school of learning and research endowed with much stability. For ordinary students the investigator who pursues his researches as far as possible to their conclusion is the safer guide.

It will now be clear that the principle which I am advocating is a very simple one—namely, that the business of direct mental training should be finished at school, and that at the university the trained mind should be given material upon which to do responsible work in the spirit of inquiry. Preparatory exercises belong to school life and should be abandoned at the university. All this seems so obvious that it might appear to be hardly worth saying, were it not that the methods which actually prevail are so far removed from this ideal. When, for example, a boy who has not learnt Greek or chemistry at school comes to the university and proposes to take up one of these subjects he is generally put through a course of exercises which differ in no essential respect from those which are set before a boy of 12. In other words, our university method for the trained mind does not really differ from our school method, which is supposed to be adapted to the mind in course of training.

It may be asked, In what manner is this change to be introduced, and how is it possible under present conditions, where so many students are all pursuing ordinary degree courses and have no time or opportunity for special work, to provide teachers who can educate them in this spirit, if it is also their duty to get pass students through their examinations? The answer, I think, is that in a university the professors and higher teachers should be, without exception, men who, whatever may be their teaching duties, are also actively engaged in investigation. Their assistants should be teachers who, even if the whole or part of their time is occupied in routine teaching, have yet had some experience in, and possess real sympathy with, modern advanced work under such professors. This is only to be secured by insisting that teachers in a university should all have had some experience of original work. Under the present system at most universities, unless the student has been fortunate enough to come in contact with a teacher imbued with the spirit of research who is carrying on his own investigations, it rarely happens that he has the time or the means which would enable him to obtain any insight into the meaning of investigation before he leaves to take up teaching work. The need of post-graduate scholarships for this purpose is very widely felt, and is now frequently expressed. To insist upon such qualifications for all university students is, of course, under present conditions, impossible; but there should be no insuperable difficulty in insisting upon them for those who are to be allowed to enter a university as teachers.

Researchers are born, not made, and it is not by any means desirable that all university students should be cast adrift to make

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new researches and seek discoveries even under the direction of experienced teachers and investigators. This must depend to some extent upon the character of the pupil as well as of the teacher. The mere publication of Papers may mean nothing, and much that is dignified with the name of research is of no account. To turn a lad on to research, unless it be in the right spirit, may be only to set him a new exercise instead of an old one; to leave him to prosecute an investigation for himself may be to condemn him to disappointment and failure. On the other hand, to carry on any piece of work, whether it be new or old, in the zealous spirit of inquiry, with faith in a purpose, is to ensure the intellectual interest of the student; and I cannot see why this spirit should not animate all university education, whether it be accompanied by original research or not. The essential condition is that the chief university teachers should themselves create an atmosphere of investigation. So deep-seated is the belief that nothing must be undertaken without a preparatory course of training that even the best and most brilliant students are frequently discouraged from undertaking a new study until they have been subjected to the mental discipline of an elementary course in it.

The distinction that I have in my mind between university and school teaching may be expressed in this way. At school no subject should be taught to a class as though it were intended to be their life work. To take an example: It too often happens at present, owing really to excessive zeal on the part of school teachers, that mathematics is taught as though each member of the class were destined to become a mathematician; consequently only the few scholars with a real aptitude for mathematics become interested, and the remainder are left behind. On the other hand, at the university each subject should be studied as though it really were the life work both of teacher and student. Thus, to take the same subject as an illustration, the mathematical student will attend the full courses of his professors and will follow them with the interest of a mathematician; whereas for the scientific student it will only be in those branches of mathematics which concern him that the interest of his special science will put him on terms of equality with the mathematical student.

I have endeavoured to confine myself to the subject of university education, and not to say much, except by way of contrast, concerning school teaching. I must, however, return to it for a moment to emphasise the danger of that specialisation which, since it takes place at school and not at the university, is bound to be narrow, and which is often encouraged in pupils of special aptitude preparing for university scholarships. That a boy or girl should for a year or even two years before leaving school be practically confined to one subject, and should before entering the university be examined in that alone, appears to me to be contrary to all the best traditions of school teaching, and to the often expressed desire of the universities to ensure a good general education in those whom they admit.

What should be the exact nature of the teaching before and after the age of 16 or 17 for the mass of ordinary boys I would prefer to leave to the decision of those who are best able to judge. I think it highly probable that there should be a considerable alteration of curriculum at the critical age. But, if a break and change of subject are required at this age, I believe that a yet more complete change is required at the later stage when the boy goes to the university, and that school methods should then be entirely replaced by university methods—not because there is then a natural change in the mental powers of the student, but because it is the obvious stage at which to make the change if we are to abandon preparatory training at all. Should it be proposed that the change ought to be made at 16, and that after that age something of the nature of university methods should be gradually introduced, my fear is that this would only lead to the perpetuation of school methods at the university.

An interesting question which deserves to be very seriously considered is the question, What sort of school education affords the best preparatory training for the university? I have often heard it asserted that, if a boy is capable of taking up at the university a course which is entirely different from his school course, he will generally be found to have come from the classical side, and not from the modern side. An ordinary modern-side boy is rarely able to pursue profitably a literary career at the university, whereas it often happens that ordinary classical-side boys make excellent scientific students after they have left school. I am bound to say that this, is, on the whole, my own experience. It suggests that a literary education at school is at present a better intellectual training for general university work than a scientific education.

There are no doubt many causes which may contribute to this. In some schools the brighter boys are still retained on the classical side, while those who are more slow are left to find their way to other subjects; and some whose real tastes have been suppressed by the uniformity of the school curriculum turn with relief to new studies at the university and pursue them with zeal. But the facts do also, I think, point to some defect in the present teaching of school science whereby a certain narrowness and rigidity of mind are rendered possible. This may be partly due to the lack of human interest in the teaching of elementary science; the story of discovery has a personal side which is too much neglected, though it is more attractive to the beginner and might with advantage be used to give some insight into the working of the human mind and character. Moreover, it would form an introduction to the philosophy of science, which is at present so strangely ignored by most teachers.

But another noteworthy defect is the absence of that mental exercise which is provided by the thoughtful use and analysis of language. I believe that the practice of expressing thoughts in carefully chosen words, which forms so large a part of a good literary education, constitutes a mental training which can scarcely be surpassed, and it is unfortunately true that in the non-literary subjects too little attention is paid to this practice. In school work and examinations a pupil who appears to understand a problem is often allowed full credit, although his spoken or written answer may be far from clear. This is a great mistake. A statement which is not intelligibly expressed indicates some confusion of thought; and, if scientific teaching is to maintain its proper position as a mental training, far more attention must be paid to the cultivation of a lucid style in writing and speaking.

Although it is true that the intelligent reading and study of the great masters should assist in the acquisition of a good style, it is equally true that, if they come to be regarded as a school task, they are not viewed with affection, especially in these days of crowded curricula, when there is little leisure for the enjoyment of a book that requires deliberate reading. The art of expressing one's ideas in simple, straightforward language is to be acquired not so much by study as by practice. Much would be gained if boys and girls were constantly required to express their own meaning in writing. The set essay and the précis play a useful part, but do not do all that is needed. Translation does not give quite the necessary exercise. What is required is constant, with certain periods of conscious, practice, and that is only to be obtained by making every piece of school work in which the English language is used an exercise in lucid expression. Very few paragraphs in anything written by the ordinary schoolboy—or, for the matter of that, by the ordinary educated Englishman—are wholly intelligible, and teachers cannot devote too much pains to criticising all written work from this point of view. If we first learnt by practice to express our meaning clearly we should be more likely to acquire the graces of an elegant style later. I must add that I believe the training in the manipulation of words would be improved if all children were required to practise the writing of English verse—not in efforts to write poetry, but narrative verse used to express simple ideas in plain language.

The tutorial classes for working people which have now been undertaken by several universities, and which already number about 1,200 students, offer an opportunity of dealing with a body of intelligent and enthusiastic students who have not received the conventional training for a university course. Here, if anywhere, the difference between school methods of teaching and university methods ought to be apparent; and I feel sure that, if university teachers attempt conventional methods with these students they will be condemned to failure. It is certain that these classes will increase enormously and rapidly, and I have great hope that they will for this reason influence the methods of university teaching in a very healthy manner.

The acquisition of knowledge and the training of the mind are two inseparable aims of education, and yet it often appears difficult to provide adequately for the one without neglecting the other. I think, however, the fundamental question is to a large extent one of responsibility. Left to himself, a boy or a man will acquire a knowledge of the things which interest him, and will obtain a training from experience such as no school or college can give. If the teacher bears the responsibility during the period of school training, should not the student have a large share of responsibility in the quest of knowledge at the university? Now, it is of the essence of responsibility that there should be something sudden and unexpected about it. If, before putting a young man into a position of trust, you lead him through a kindergarten preparation for it, in which he plays with the semblance before being admitted to the reality, if you teach him first all the rules and regulations which should prevent him from making a mistake, you will effectually smother his independence and stifle his initiative. But plunge him into a new experience, and make him feel the responsibility of his position, and you will give him the impulse to learn his new duties and the opportunity to show his real powers. It is because I feel that this sudden entrance into an environment of new responsibility is so necessary that I would regard with suspicion any attempt to provide a gradual transition between school and university methods. In matters of discipline and self-control it is possible and advisable to place responsibility upon school children; in intellectual matters it is not advisable, except for the

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few who are matured beyond their years. It is, therefore, all the more necessary that this should be done at the moment when they enter the university.

The spirit of independent inquiry which should dominate all university teaching and learning is not to be measured by the number of memoirs published, but it is to be tested by the extent to which university students are engaged upon work for which they feel a responsibility. Visit the universities at the present moment, and, in spite of all the admirable investigation which is being carried on, you will find the majority of students engaged in exercises in which they feel no responsibility whatever. In my opinion this indicates that for them the spirit of true university education has never been awakened. It is, after all, very largely a question of attitude of mind. Any subject of study, whether it be a scientific experiment or an historical event, or the significance of a text, is a matter of interpretation, and to approach it in the university spirit is to approach it with the question, "Is this the right interpretation?" Upon that question can be hung a whole philosophy of the subject, and from it can proceed a whole series of investigations; it embodies the true spirit of research and it opens the door to true learning.

In discussing university education I have not, of course, forgotten that many persons have taught themselves up to a university standard entirely without the aid of professors; indeed, the University of London long ago provided an avenue to a university degree which has been successfully followed by many such persons with the best possible results. But I have endeavoured to remind you that at the university, as at school, for most students the personal influence of the teacher is the important thing; that at the university, as at school, success in teaching depends mainly on the extent to which the interest of the student is aroused; and that at the university this is only to be done by providing him with a purpose and a responsibility in his work in order that he may understand to what conclusions it is leading him. Until this is done we shall still have university students complaining that they do not see the object of what they are learning or understand what it all means. In the hope that the attention of university teachers may be turned more fully to this aspect of their work I have ventured to make it the subject of my address.

COMPARATIVE LIFE TESTS ON GLOW LAMPS.*

BY C. C. PATERSON AND E. H. RAYNER.

Summary.—Comparative life tests of lamps were carried out by the authors at the National Physical Laboratory in conjunction with the New York Electrical Testing Laboratories to see how close an agreement would be obtained by different laboratories. The tests were made on 12 British and 12 American lamps, half of each being tested at each laboratory. The tests indicate that such measurements can be carried out on the basis of the Engineering Standards Committee's specification within an accuracy of ±5 per cent. for carbon lamps.

Object of Tests.—The tests described below were undertaken in order to determine the agreement which it is possible to obtain when life tests are carried out on glow lamps by different laboratories. The useful life of the carbon filament glow lamp is so sensitive to variations in the test conditions, and so many different measurements have to be made in the determination of useful life, that some scepticism is often felt in the accuracy which is possible with this class of work.

Conditions of Test.—The useful life of a lamp is taken to be the number of hours that a lamp will run before the candle-power falls below 80 per cent. of its initial value, the voltage at which it is run being that at which it consumes initially a definite number of watts per candle.* Each lamp, therefore, must be run on the racks at a voltage which, initially, for that lamp, corresponds with the standard value of watts per candle for which it is desired to determine the useful life. Now, the watts per candle of a carbon lamp are inversely proportional to about the cube of the volts, and the useful life of a lamp is inversely proportional to about the sixth power of the watts per candle and to the 20th power of the volts. It will thus be seen that to obtain an accuracy of about 2 per cent. in the useful life requires an accuracy of 0·3 per cent. in the initial determination of candle-power and watts and of 0·1 per cent. in the setting and maintenance of the average voltage on the test racks. Further, the average voltage on life test must be maintained free from fluctuations within very narrow limits (+or−½ per cent.), and the periodical measurements of candle-power must be made to the highest possible accuracy, since the termination of the test depends solely on this. The only indeterminate factor in these measurements is the difference which exists between individual lamps of a batch, and this makes it desirable to take the average of a number of lamps in order, as far as possible, to eliminate this element of uncertainty.

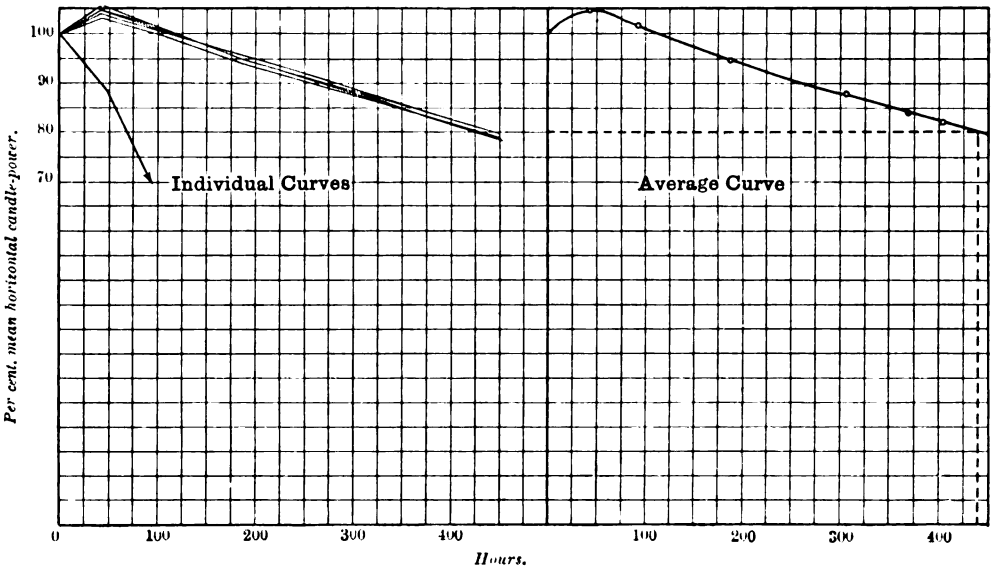

FIG. 1.—LIFE TESTS OF A BATCH OF SIX AMERICAN LAMPS RUN AT 3·1 WATTS PER CANDLE AT THE NATIONAL PHYSICAL LABORATORY.

Candle-power dropped to 80 per cent. after 440 hours. No. of filaments which broke on test—1. (Not included in average.)

The Electrical Testing Laboratories of New York have had a very long experience in the testing of large quantities of lamps for useful life, and it was agreed between this laboratory and the National Physical Laboratory to make a comparative test with a view to finding the order of agreement obtainable under the ordinary laboratory conditions of running life tests. For the purposes of the investigation it was agreed that the New York Laboratory on the one hand should prepare 12 American lamps for running at 3·1 watts per candle and that the National Physical Laboratory on the other should prepare 12 British lamps to run under the same conditions.

At the time of the test the candle-power unit in the United States had not been adjusted in conformity with the international agreement subsequently entered into by the National Laboratories of Great Britain, France and the United States, and there was also a small known difference in the standards of voltage in the two countries. Allowance was made for both of these factors in the determination of the correct voltage for each lamp which was required to give the desired watts per candle. Six of the British lamps were retained for running at the National Physical Laboratory and the other six were sent to New York to be run at the voltage assigned to them in London. Similarly six of the American lamps were

* Joint tests made by the authors at the National Physical Laboratory in conjunction with Dr. Clayton H. Sharp and Mr. Preston S. Millar, of the Electrical Testing Laboratories of New York.

* *See* E.S.C. Specification No. 33 for carbon filament glow lamps

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sent over to be run here and six were retained for running in New York.

Initial Tests.—The six lamps sent to London had assigned to them the voltages which gave the values of watts per candle scheduled in Column 1 of the table below. Column II. gives the National Physical Laboratory values for watts per candle of the same lamps. Column III. gives the National Physical Laboratory values for six of the British lamps sent to America, and Column IV. the American values for the same lamps. These figures have been corrected (as stated) for the ascertained difference of candle-power between the two laboratories.

Table I.—*Watts per Candle.*

American Lamps.		*British Lamps.*	
Values assigned at		Values assigned at	
New York.	*London.*	*London.*	*New York.*
3·09	3·10$_3$	3·10$_3$	3·09
3·09	3·07$_3$	3·10$_3$	3·18
3·10	3·07$_3$	3·10$_3$	3·12
3·11	5·10$_3$	3·10$_3$	3·09
3·11	3·10$_3$	3·10$_3$	3·12
3·11	3·09$_3$	3·10$_3$	3·12
3·10$_1$	3·09$_1$	3·10$_3$	3·12

An inspection of these tables shows an average difference in one comparison (Columns I. and II.) of 0·3 per cent., and in the other (Columns III. and IV.) of 0·5 per cent. between the average values of watts per candle assigned by the two laboratories to the two batches of lamps. This discrepancy represents a difference of between 1 per cent. and 2 per cent. in useful life. The greater difference between columns III. and IV. is accounted for by the second lamp, which evidently underwent a change between the time it was tested in London and the measurements in New York. If it had not been for this, the mean difference would have been 0·2 per cent., representing less than 1 per cent. in useful life. The foregoing tests show the accuracy obtainable in assigning the correct voltage at which lamps are to be run on life test at a given watts per candle.

Life Test.—The life test on each lamp was run at the voltage which had been assigned to it by the laboratory where it was prepared. It is, therefore, among other things, a test of the degree to which the voltage measuring and regulating devices, &c., installed for life tests in the two laboratories, give the same results.*

Table II.—*Watts per candle.*

Lamps run at New York.		*Lamps run at London.*	
American.	*British.*	*American.*	*British.*
3·09	3·10$_3$	3·10	3·10$_3$

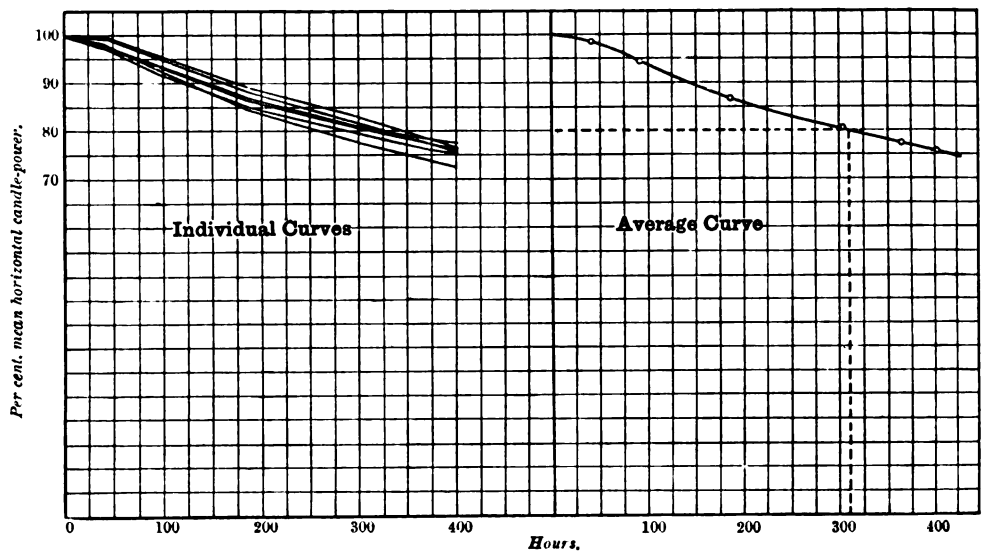

Fig. 3.—Life Tests of a batch of Six British Lamps run at 3·1 watts per candle at the National Physical Laboratory.

Candle-power dropped to 80 per cent. after 310 hours.

The above table gives the average initial watts per candle assigned to the four batches of lamps by the two laboratories respectively.

It will be noted that the batch of American lamps which was run in London has 0·3 per cent. lower efficiency than the corresponding batch run in New York. It is therefore to be expected that it will have a useful life which from this cause is 2 per cent. longer. The life curves of these lamps are shown in Figs. 1 to 4. Figs. 1 and 2 are those for the two batches of American lamps and Figs. 3 and 4 show graphically the results found for the two batches of British lamps.

If the testing arrangements and also the corresponding lamps in the two laboratories were identical these pairs of diagrams should show similar results.

Correcting the result of Fig. 2 to allow for the fact that these lamps started at 3·09 watts per candle instead of at 3·10 we have the following values for the useful life determined at London and New York, as computed from the curves of average candle-power.†

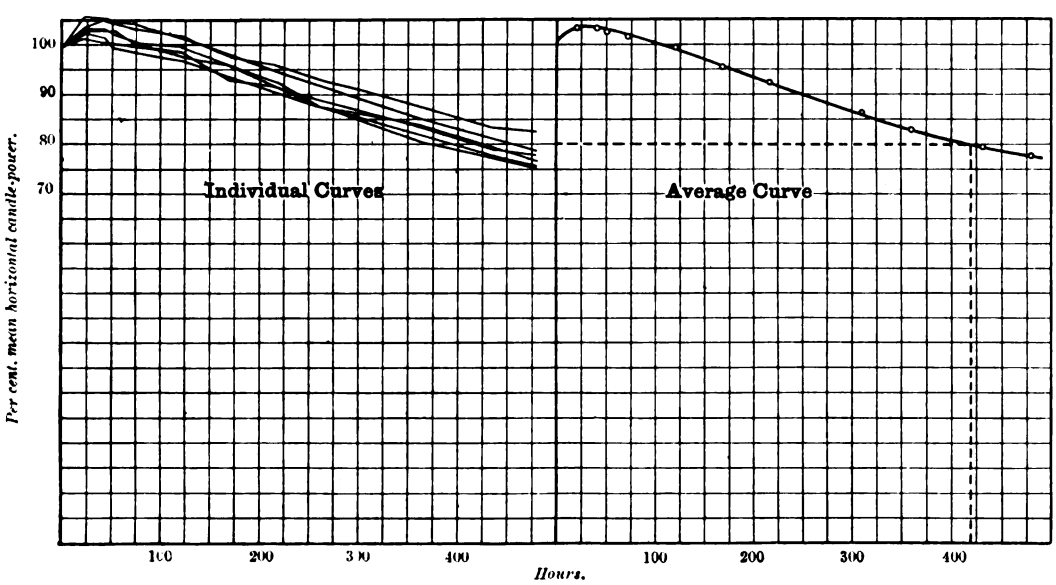

Fig. 2.—Life Tests of a batch of Six American Lamps run at 3·09 watts per candle at the Electrical Testing Laboratories, New York.

Candle-power dropped to 80 per cent. after 420 hours.

* The tests were made with alternating current and a full description of the methods and apparatus at the N.P.L. is given in the "Illuminating Engineer," October, 1908.

† Slightly different values of useful life are obtained, according to whether the computation is made from the curve of average candle-power during life (as in this Paper) or from the mean of the useful lives of the individual lamps in question, which is the usual method at the New York Laboratory. The difference between the two methods is very small and quite negligible in cases where the individual life curves keep well together as in Fig. 1.

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Table III.—*Useful Life.*

	National Physical Laboratory. Value.	New York Laboratory. Value.	Difference per cent.
American lamps	435 hours	..... 428	−1·7
British lamps	310 „	..... 330	+6·5
British lamps	310 „	..... 316	+2·0

(with one omitted from average)

The 6·5 per cent. difference is accounted for in the last column by the same lamp (given in column IV. of Table I.), which started at 3·18 watts per candle instead of at 3·10. It is seen clearly (left-hand diagram of Fig. 4) how this lamp increases the average useful life of the batch. If it had not been for this lamp the average useful life would have been 316 instead of 330 hours, thus bringing the agreement between the two laboratories for the British lamps to 2 per cent. instead of 6 per cent.

Conclusions.—In order to obtain quite definite results, free from accidental variations of this nature, it would be necessary to experiment with a much larger number of lamps. Differences between individual lamps of a batch are assumed not to exist, but the assumption is not quite justified where so few lamps are tested.

So far as the tests go, however, they indicate that measurements of the useful life of carbon filament glow lamps can be carried out on the basis of the Engineering Standards Committee's specification to give results which are quite definite and within an accuracy of less than ±5 per cent. when the test reveals that no lamp differs abnormally from the mean. It may be added that, from an experimental point of view, tests on metallic filament lamps should yield a higher accuracy. The tests described here do not form any comparison between British and American lamps as such. The British lamps were all run for about 100 hours before being "prepared" for life test. Hence the unusual form of the early part of the life curves in Figs. 3 and 4 and the apparently shorter life shown by these two figures compared with those representing the American lamps.

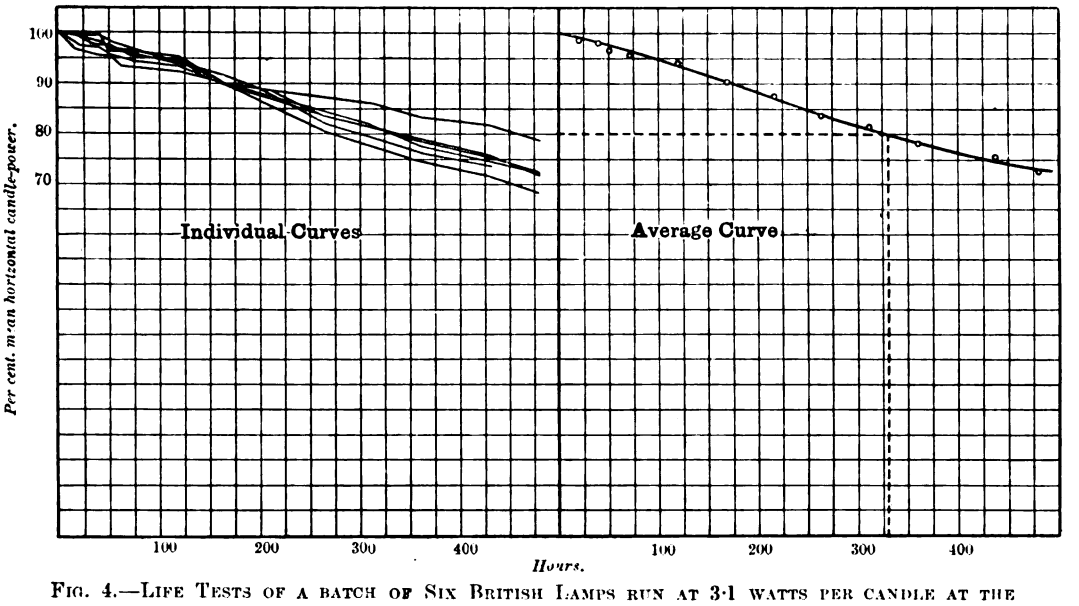

FIG. 4.—LIFE TESTS OF A BATCH OF SIX BRITISH LAMPS RUN AT 3·1 WATTS PER CANDLE AT THE ELECTRICAL TESTING LABORATORIES, NEW YORK.

Candle-power dropped to 80 per cent. after 330 hours.

Paris Floods.—The report of the Commission appointed to investigate the causes of the disastrous floods in Paris at the beginning of this year will shortly be issued. According to "The Times Engineering Supplement" the Commission consider that the generating stations, of which the majority are situated on the banks of the Seine, should be obliged to ensure a sufficient supply of coal and water for their plant; and those stations that are not out of reach of floods should arrange with the others more favourably situated for a supply of current in case of emergency.

THE PRICE OF ELECTRICITY.*

BY EDW. W. COWAN.

Summary.—The author criticises the principles on which the charges for electrical energy are usually based, this basis being an equal rate of profit from every class of consumer. Although this principle is safe, the author argues that best economic results cannot be obtained because the factor of demand is entirely ignored. The demand for electricity is of a "composite" kind, energy being required for light, power and heat. Classified tariffs should be adopted so as to secure the greatest economic advantage. The author supports his views by reference to the adjustment of prices in railway freight charges and other lines of business.

General Principles.—It is, I presume, an obvious truth that the closest and widest possible correspondence between the incidence of supply and the incidence of demand secures the greatest economic advantage to the community; but it is not perhaps so obvious that the closest coincidence of supply and demand is consistent with wide variations in the incidence of the forces which govern supply and demand and their resultant effects. Utility is not necessarily a measure of the effective demand of which it is the cause, and supply may be forthcoming independently of any direct influence of utility, operating through demand.

The forces at work behind the scenes may often operate more effectively for the attainment of the desired end when they are not coincident in respect to time nor correspondent in respect to degree.

This apparent irregularity of operation is illustrated in the case of the market for wheat and straw. The production of straw is independent of the demand for it (excepting through the indirect influence of an increased demand for straw lowering the price of wheat and thereby increasing the supply of wheat and consequently the supply of straw which is definitely related to it).

If the two commodities are treated as one, their joint price will be determined by the resultant effect of the combined supply and the combined demand, but the relation between the prices of the two parts of the supply, that is of the wheat and the straw, is determined quite independently of the relative cost of producing them. The sum of their prices must, of course, at least equal the expenses of production, that is to say the forces which govern the joint supply will exercise direct influence. In regard, however, to the separate prices of the two parts, in respect to their relation to each other, it appears to be practically correct to assume that they are determined entirely by demand† if the best results are to be obtained.

In Fig. 1 the play of these forces is statically indicated in the case of a demand which is in part met by a by-product supply.

It will be noted that at quantity of supply O.M. there is a critical change in the character of the supply curve due to the change from by-product supply to supply produced under normal conditions.

If the conception of joint production be accepted as valid, it explains many discrepancies in the relative prices of joint products in respect to the expenses of their production. Such cases are the prices of soap and its by-product, glycerine (£50 per ton, whereas the cost as a by-product is about £1), the different rates for transport of iron and brass, the Post Office rates for circulars and letters (although the former cost more to carry). The price of a by-product

* Paper (somewhat abbreviated) read before Section F (Economic Science and Statistics) of the British Association at Sheffield.

† It is not overlooked that, strictly speaking, demand alone cannot determine price, but as the influence of supply is practically rigid in the case of a by-product, such supply is not a function of price. The one necessary result is that the whole of the by-product supply offered should be sold at the highest obtainable price and in order to achieve this result, regard to the demand factor only is required in fixing its price. It is the forces behind demand and supply which we have to consider, and as price cannot affect the amount of supply offered, it should be fixed with reference to demand only.

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is what it will fetch. In such cases the relative cost of production may be ignored in fixing the price. The business should be treated as a whole and not as an assembly of distinct businesses standing alone.

Accepting such a view, we may postulate the following:—

1. When the cost of production of one unit of supply in a business is affected by the cost of production of the other units, no single unit can be said to have a separate cost of production.

2. If, under such conditions, an attempt is made to fix the price of each unit of supply upon the basis of its separate cost of production, loss will result.

3. The loss is due to the relatively faulty correspondence between the incidence of supply and of demand which arises when price is not adjusted, as nearly as supply conditions will allow, to the intensity of demand.

Further, there appears to be no reason, in theory, why any supply should not be treated as a joint supply by dividing it into two or more parts and selling these parts at different prices. But there cannot be two prices in the same market at the same time, and in practice therefore the benefit of this system of price gradation can only be partially realised by selling the same product at different prices at (1) different times, or (2) in different places, or (3) in different forms. The operation of such a system is essentially beneficial because there results a more extended and efficient distribution of wealth than is possible with a fixed price.

The Supply of Electricity.—We have in electricity a commodity which can be put to divers uses. Electricity is in demand for light, heat, power and electrolytic uses primarily. The demand is really

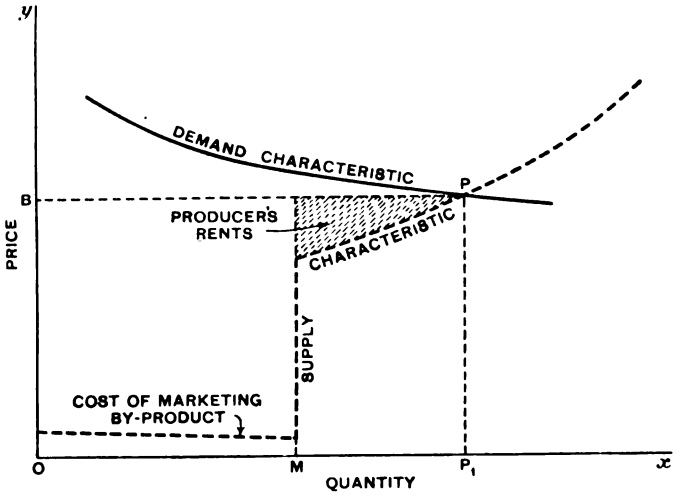

FIG. 1.

for light or heat or power, &c., and the fact that electricity is common to the supply of these commodities is only an incidental fact of no essential economic import.

Clearly the influence of demand upon price will differ considerably in respect to these different commodities. The demand for electricity for light will depend largely upon the alternative forms of light supply and their prices and partly upon its specific utility for that purpose; so with heat and so with power. The demand for these commodities is not a demand for electricity, excepting in an indirect sense.

Regarded in this light, the demand for electricity is a "composite" demand, just as the supply of wheat and straw, of beef and hides, of gas and coke, &c., are "joint" supplies. Further, so far as the different classes of demand for electricity vary in their incidence in respect to time, the supply of electricity may be considered as being "joint" in its character, as the demand for it is composite in its character. Thus, if the demand for power were a day demand and that for light a night demand, the same plant could supply both, and the supply would be correctly classed as a "joint" supply. It will be seen later that electricity supply is partially of a "joint" character. But there is this difference, that the supply of electricity being common to all its uses, one commodity only is sold in the market. We may compare the case to that of selling cattle to two customers, one buying for the sake of the hides and one for the sake of the beef. These two customers could not be charged different prices, because they buy one commodity, viz., the cattle, in one market. Now electricity could not be sold at different prices if it were sold over the counter by the yard or the pound. A point of rather nice distinction arises therefore—is it practicable to sell electricity at different prices for different uses and, if so, is it fair to make any such discrimination? If my argument is correct it will be admitted that there may be an advantage in doing so, an advantage to the producers and an advantage to the consumers, by rendering the supply more flexible, and thereby enabling it to adapt itself more fully to the character of demand. There are two questions at issue: (1) Is there a theoretical advantage in differentially charging consumers upon this basis? and (2) if so, is it practicable and just to apply the system to the sale of electricity?

The answer of electrical engineers to these questions is emphatic; they deny that any advantage can be gained by the system and hold that it is inequitable and inexpedient to employ it.

As evidence of the views held by leading electrical engineers, I give quotations below from various sources.

A definite policy in regard to the question began to take shape in 1892 when Dr. John Hopkinson delivered his Presidential Address before the Junior Engineering Society upon the subject of the cost of electrical supply. In this address it is pointed out that the charge for a service rendered should bear some relation to the cost of rendering it, and a method of charging for electricity supply is suggested which will more nearly secure the observance of that relation than attempting to charge by a uniform rate per unit. Dr. Hopkinson was dealing with the supply of a single commodity, viz., electricity for lighting purposes, and under such circumstances the principles he advocated were both sound and practical.

This was followed in 1896 and 1901 by Papers by Mr. A. Wright in which the principle was laid down that municipalities cannot be justified in selling electricity to one class of their ratepayers at a lower percentage of profit than to another class. He asserts very definitely that unless the price to any consumer covers his proportionate share of the standing charges and of the production charges a real loss must be incurred. This is a view which I find myself unable to accept.

Mr. C. H. Wordingham, in his book on "Central Station Practice," states that it is illogical to make the rate of charge depend upon the class of supply. In 1907 Mr. J. F. C. Snell read a Paper before the Institution of Electrical Engineers, in which he emphatically contended that the only rational basis of charging was one which was strictly the cost basis. Mr. J. H. Rider supported this view. Having regard to commercial stability, in his opinion the only true basis on which to charge is the load-factor basis tempered by diversity factor.

This latter statement cannot be disputed, and if stability is the chief end in view and not the rendering of the largest possible service to the community, the system of charging strictly according to cost would be an unassailable system. But, as in most undertakings, the attempt to reduce business to a process of mechanically grinding out equal percentages of profit upon all operations renders the obtaining of the maximum aggregate profit to producers and consumers impossible. Some stability must be sacrificed in order to reach the higher planes of successful undertaking. There is admittedly a risk in endeavouring to forecast the course of demand and in establishing vested interests adapted to that estimate, but there is in such an operation a large aggregate gain even though that gain is accompanied by occasional losses. A business is not and cannot be made wholly a machine, it is more akin to an organism, and as such must develop powers of adaptation to varying conditions which are beyond the range of the function of mere mechanism.

In 1908 Messrs. Handcock and Dykes read a Paper before the Institution of Electrical Engineers in which they contended that differentiating in the charges to consumers according to the class of their demand was illogical and illegal. On the other hand, Mr. S. L. Pearce goes so far as to favour the idea that new power consumers should benefit to some extent from the smaller capital charges of new plant necessary for their supply.

The quotations I have given make quite clear the attitude of the industry towards this question. It is a quite logical attitude, and if we accept the premises upon which it is founded, viz., that the supply of electricity is the supply of one commodity and can only legitimately be considered in that light, no criticism can be made which is not applicable to the supply of any other commodity at a price having a fixed relation to cost. It is impossible to escape from the conclusion, however, that electrical engineers have accepted the popular belief that the selling of all commodities at prices strictly based upon cost is not only commercially expedient but is morally right. They always speak of lower charges in relation to cost of some consumers as involving injustice because, according to their conception of the operation, the lower charges to some must be balanced by correspondingly higher charges to others. To quote a common expression, "some consumers are penalised in order that others may be subsidised."

There does not appear to me to be any validity in this view regarded as a principle which should govern electricity supply

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tariffs. With a scientifically adjusted scale of charges, having due regard to the market price of each class of commodity supplied, whether light, power, heat, &c., it is possible in many cases, not only to confer benefits upon the power and heat users, but to supply the light user at a lower price than would be possible if the principle of a uniform rate of profit from each class of consumer were adopted. The percentage contribution towards the standing charges of the business by the power and heat users may not be so large as the contribution of the light consumers, but it is a contribution, and as such provides a fund which is applicable to the reduction of prices to the light consumer, who may thus obtain his supply at a rate lower than would be possible if power and heat consumers were refused supply at prices which they could afford to pay, that is to say, prices which competed with the market price of power or of heat obtained by alternative methods.

The criticism of this Paper is directed against the acceptance of the principle that commercial expediency and moral justice are attained by fixing price upon the basis of equal profit from all classes of consumer. But I desire to emphasise that it is not intended to make out a case against the practice of the industry. This would require an elaborate investigation, in view of the many factors which influence the establishment of a practical system of charging. It is not that I hold that the practice of the electrical industry in this respect is right, but it seems to me to be worth while to attend to the question of sound principle in the first instance, leaving the application of it to actual tariffs to form the subject matter of another investigation.

If we recognise that the cost of each unit of electricity supply is affected by the total number of units supplied, we must admit that no separate unit can be said to have a separate calculable cost. Once this organic relation of the parts of a whole business is accepted, a system of attempting to price every part of a supply according to the cost of producing it, is seen to be scientifically faulty, though the exigencies of other conditions may compel us temporarily to ignore the truth of that fact. The rigid line of a fixed price for a given objective service has many uses and conveniencies from the book-keeping point of view, and is attractive on account of the security which follows its adoption. But the possible aggregate dividend is less under a fixed price than under a graded. If we regard the function of price as being a purely distributive one, it is not difficult to realise that a more efficient distribution will be effected if price can take upon itself a flexibility which reflects the variations in the intensity of demand. Demand must continue to vary in character and in degree as between its parts, and a rigid adherence to a system of pricing which only regards demand in the lump may involve the sacrifice of wealth which might be realised by the attainment of a closer adjustment of demand's detailed incidence in relation to supply. If we ignore the character of demand we can only succeed in satisfying a smaller measure of it. Demand should be the predominating influence, as it is the cause of value, supply is the servant of demand, and producers must seek to adapt supply to demand and not try and force demand to adapt itself to supply.

We have only to investigate the effect of treating the extreme cases of joint supply, such as wheat and straw, or beef and hides, mutton and wool, &c., &c., as if they were single supplies, and the great economic loss which must accompany such a practice will become at once apparent. The aggregate supply must be less and both producers and consumers must suffer loss.

Apart from the economy of production upon a relatively large scale there is a specific economy in combining separate businesses into one business, such as the supply of electricity for light and for power, &c. The differences in the character of the demands allowing of a common use of some of the employed capital and other elements which form a part of the expenses of production. This diversity of incidence of the respective maximum demands may be a source of considerable economy in the utilisation of capital which would otherwise be inert during a greater part of the 24 hours.

These two economies appertaining to combination, provide a fund which may be applied to the increase of profit or to the reduction of price, or to both.

In the case of a municipality where increase of profit is not desired the undertakers have to decide how to apply the gain, and they, quite logically, apply the gain due to production upon a large scale equally as between all classes of consumers, and the gain due to diversity of maximum load, they aim at applying to the reduction of price to those consumers whose maximum load diverges in respect to time from the aggregate maximum load demanded from supply works. As the incidence of the maximum loads of consumers in relation to the maximum load of the supply works is difficult to ascertain, a rough approximation is often made by reducing the price to the class of consumers, say, power users, whose mean maximum demand is estimated to diverge from the maximum of the whole demand. It is sound policy to do this because relatively profitable customers are encouraged, and to encourage such customers is legitimate and right from every point of view.

But it surely cannot be held that the divergent consumer has any sort of moral title to this benefit? A part of all supplies, whether of grain, coal or manufacturers, costs less to produce than other parts and for similar reasons. The purchaser does not claim discriminative treatment on such grounds, he does not consider that he has any moral right to benefit according to the relative cost of the part of supply he buys compared with the cost of the parts bought by other consumers. So with electricity supply. That A should have any moral claim to a reduction in price because his maximum demand does not coincide with B's plus C's is a quite untenable conclusion, unless, of course, he undertakes that his maximum demand shall in this respect diverge from theirs. He must do something to give him any moral basis to a claim. If the maximum load of one class of consumer exceeds that of another class there is no principle of equity which requires that the benefit of the divergence of their maximum demands should be given to the class with the lower maximum demand. A day demand may exceed that of a night demand and yet the day demand be credited with the advantage of by-product use of the plant, and not the smaller night load, without any infringement of equitable principle.

I have dealt with this point at some length because I am anxious to establish the principle that the undertaker, though he is administering a monopolistic business, is, from the point of view of equity, free to apply the gains due to combination as may be best for the business as a whole.

(To be concluded.)

RECENT PATENTS IN WIRELESS TELEGRAPHY.*

BY W. H. ECCLES, D.SC.

(Concluded from page 849.)

An ingenious combination of wireless telegraphy and the method of the submarine bell appears in No. 10,083 (1909). It is due to J. Schiessler, and its purpose is to obtain a measurement of the distance of a ship or other station emitting both kinds of signals simultaneously. The principle employed is the simple one of measuring at the receiving station the time interval between the arrival of the Hertzian wave and of the sound wave. The suggested receiving apparatus comprises five circuits—a circuit containing a submerged microphone, a telephone relay circuit, the circuit of an electrical chronometer, a circuit comprising an electromagnet that sets a tuning fork in vibration, and the telephone circuit of a wireless receiving installation. This recital gives a sufficient insight into the mode of operation of the apparatus, and conveys an adequate notion of the complexity of the scheme. If the difficulties inherent in respect of time-lags in the wireless apparatus can be overcome, and if the other parts of the apparatus can be so developed as to be installed and worked at even a shore station, the thing would be a great boon to navigators.

Here we may mention R. A. Fessenden's description, in No. 17,450 (1909), of a form of sending or receiving antennæ which consists of two capacity areas, one of which must be insulated. Fig. 9 is the diagram accompanying the specification; its complexity and novelty are only apparent. The inner web of wires is shown in two portions or may be connected by switch 11, but is always insulated, is tuned by the lengthening coil 12 and is charged by the high-frequency dynamo 5 through the sending key 25. The outer web of wires may be insulated, and then constitutes a balancing capacity, or may be earthed by switch 10, when it is given the name "wave-chute"; it is connected by coils 21 and leads 8 to the other terminal of the oscillation generator 5. Switch 26 substitutes receiver 27 for the dynamo, when receiving. The numerous leads 8 are, of course, very necessary when so extended a web of wires is used as in this balancing capacity. The wire networks may be supported on poles only 20 ft. high, and this reduction of the height of the aerial is put forward as the advantage of the proposal. The whole matter is summed up in claim 1 of the specification, where the emphasis

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falls on the sentence: "an antennæ . . . elevated to a height above the ground considerably less than its largest horizontal dimensions and a wave-chute consisting of a plurality of conductors of very low resistance . . . beneath the horizontal capacity."

Another patent relating to antennæ is that of C. Bordeloni, No. 24,187 (1909). A new disposition is given to the aerial conductor at a receiving station with the object of attaining accurate syntony with even strongly damped waves, as well as freedom from atmospheric disturbances. This is stated to be achieved by causing the whole length of the aerial to act upon the secondary circuit. It is the part of the aerial outside the instrument room, as well as the aerial lengthening coils inside, which is made to act upon the secondary. This is accomplished by extending the secondary by wires running outside the station alongside the aerial. In both of the sketches appearing in the specification (not reproduced here) the aerial is a loop aerial, and there are two secondary extensions. The extensions are each a number of vertical straight wires, and are each coupled to one side of the looped aerial; and both are, besides, coupled with the aerial inductance coils. The whole arrangement may thus be regarded as a closed or nearly closed circuit aerial with a single open secondary circuit folded along it and

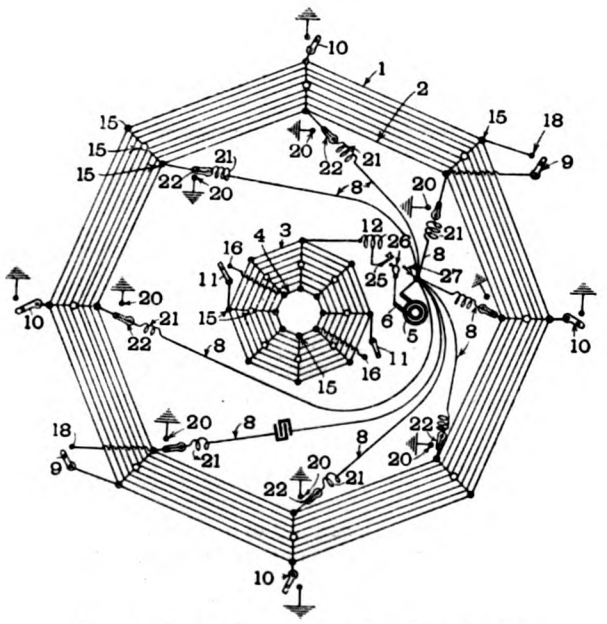

Fig. 9.—R. A. Fessenden, No. 17,450 (1909).

coupled to it as stated. The advantages of this are discussed by the patentee, but closer reasoning, not to mention practical demonstration, is needed.

Patent No. 13,865 (1908), taken out by R. A. Fessenden, is an application for protection of plant for producing and receiving singing signals of rather high acoustic frequency, on the ground of having discovered that high-pitched signals are more easily distinguished from atmospheric disturbances than those of low pitch are. A frequency of 900 per second is suggested as being good, and is said to give the operator much greater ease in reading through atmospherics than does a frequency of 250 per second. A method of carrying out telegraphy with such a frequency is described and consists of obvious means of running and regulating an alternator of 900 cycles, of producing electric waves, and of receiving the signals.

Marconi's Wireless Telegraph Co. and H. J. Round, in No. 11,544 (1909), set forth a means of determining the azimuth of a sending station and of sending waves mainly in a specified variable direction. Put concisely, the method, as adapted for receiving, consists in comparing the loudness of the signals received by two directive aerials; the receiving apparatus being switched from one aerial to the other rapidly for this purpose. Within certain angular limits the method will probably prove to be the most accurate yet proposed. Its application to reception seems more immediately useful than its application to transmission, and, therefore we need speak here of reception only. In Fig. 10, let OD^1 and OD^2 represent in plan the directions in which two fixed directive aerials would radiate and absorb most powerfully. The polar diagrams of two such aerials equally energised are shown by the curves C_1 and C_2. A radius vector drawn in any direction in these curves may be taken to represent the capability of the aerials for absorbing energy from that direction. Plainly there is at least one direction from which waves might come and produce signals of equal intensity in both aerials, namely, the direction OB′. The form of the absorption curves at this point shows that if the distant sending station moves even slightly off the line OB′ the strengths of the signals become very different on the two aerials. The specification goes on to describe how the direction of equal intensity can be changed from the line of bisection of the angle between the aerials. Suppose, for example, the signals of aerial OD^2, and that alone, are weakened from OC^2 to OC^3 by aid of a device inside the receiving station; then the direction of equality of signals will lie along the new direction OB^2. A sending station along the direction OB^2 may thus have its bearings determined, though with less accuracy than would be the case with a station along the direction OB′. *Mutatis mutandis*, what has been said of reception applies to transmission also. Means of carrying out the weakening of the signals on either aerial are suggested in Figs. 11 and 12. Here a^1 and a^2 are two directive aerials placed at an angle, s a switch, r a sending or receiving apparatus, E the earth connection, o, i^1, i^2, j^1 j^2, inductance coils, and d a rheostat. The switch s is made to move quickly to and fro, so that signals are got alternately from the two aerials and comparison easily made as to loudness. In Fig. 10 alteration of the intensity is effected by moving coil i so as to alter the coupling with i^1 and i^2. It may be remarked that if the circuit ri is intended to be a tuned circuit, this mode of working is utterly bad; the alteration of the coupling must produce mistuning and consequent con-

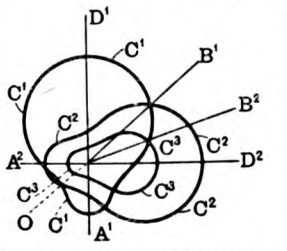

Fig. 10.—Marconi's W. T. Co. and H. J. Round, No. 11,544 (1909).

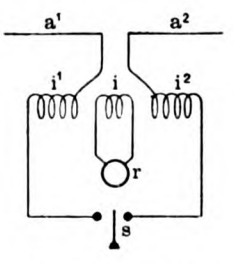

Fig. 11.—Marconi's W. T. Co. and H. J. Round, No. 11,544 (1909).

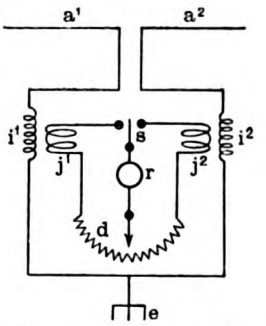

Fig. 12.—Marconi's W. T. Co. and H. J. Round, No. 11,544 (1909).

fusion. In Fig. 12 the coupling to either aerial is kept fixed in amount, and either aerial is lowered in efficiency by varying the rheostat. Taken as a whole, the invention is an important one because it overcomes a difficulty that blocks the progress of all previous methods—the difficulty, that is, of determining exactly the direction of maximum loudness on a blunt-nosed polar curve. If the present method can be improved so as to leave no room for ambiguity between fore and aft and beam bearings (as no doubt it can) it should be of immediate and immense value to the mariner.

There is very little to chronicle in respect of receiving apparatus and detectors. G. Marconi and Marconi's Wireless Telegraph Co. describe an adaptation of Dr. Fleming's valve to an old suggestion for arranging a pair of detectors to enhance the selectiveness of a receiver. Each valve is placed in a vibrative circuit, one circuit being in perfect tune with the

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signals to be read, the other being slightly out of tune. The supposition is that if the valves be arranged to oppose one another in the telephone circuit, undesired signals, if of wavelength reasonably distinct from those of the two circuits, will annul themselves by affecting both circuits almost equally. The signals to be read affect one circuit and its detector much more than the other, of course. So far as the cutting out of signals is concerned, the whole device seems to be a roundabout way of doing what can be done just as well by using a very loose coupling and very sharp tuning; but for cutting out atmospheric disturbances the method is very valuable so long as the two detectors remain equal in every respect. In No. 6,008 (1909) R. A. Fessenden proposes to construct a recording detector of oscillations by aid of the frictional method of measuring changes of magnetic induction. The frictional method of estimating the variable magnetic flux across the surface of contact of two pieces of iron consists of measuring the varying tangential effort necessary to make one body slide over the other, and was applied by W. H. F. Murdoch several years ago to making commercial tests of iron under ordinary ranges of change of B and H. The proposal in the present patent is to detect in this way the extremely minute changes produced in the magnetic flux by the weak electrical vibrations received on an air-wire. Finally, in No. 10,772 (1909), G. W. Pickard, dealing with contact detectors, emphasises strongly the necessity of provision of very accurate mechanical adjustment of the sensitive parts. The specification claims the use of an iron-pyrites and brass contact, together with a frame comprising a slow screw motion for the making and keeping of a contact of definite pressure at an invariable point of the crystal. Iron-pyrites is stated to be very sensitive and yet capable of taking heavy electrical discharges without injury.

In wireless telephony there is no striking progress to discuss, but there are a few specifications of minor importance published. In No. 7,906 (1909) W. Burstyn revives with a slight modification the old proposal to conduct wireless telephony by causing the speech sounds to vary the capacity of a condenser associated with the aerial radiator. The variation is to be accomplished, as usual, by making the condenser a part of an electrostatic telephone whose moving plate has its motion dictated by the voice. The novelty of the patent appears in employing an ordinary current-carrying microphone, which is itself actuated by the voice, to produce "electrostatically" the motions of the diaphragm of the electrostatic telephone. In No. 16,183 (1908) J. Schiessler describes a telephonic relay based on the well-known principle of bringing a fluctuating microphone-current into such relation with an unstable resistance (*e.g.*, a vibrative arc) that great fluctuations shall be produced in the currents through the resistance. Finally, in specification No. 2,330 (1909) F. J. Chambers describes a method of applying a manometric flame to the problem of varying in accordance with speech sounds the electrical magnitudes in a vibrative circuit. The flame, which is here regarded as an electrical conductor, is projected horizontally between a pair of converging electrodes so as to complete the circuit to a greater or less extent according as the flame is longer or shorter —the changes of length of the flame being dictated, of course, on the ordinary manometric principle, by the sound-vibrations.

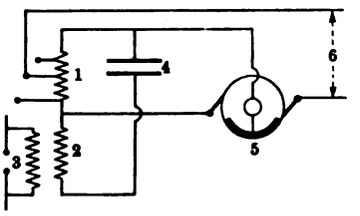
A NEW METHOD FOR PRODUCING HIGH-TENSION DISCHARGES.*

BY PROF. ERNEST WILSON AND W. H. WILSON.

It is hardly necessary to mention the importance of high-tension electric discharge apparatus at the present time, and therefore improvement in the direction of increased reliability and portability, decreased cost, and increased efficiency is highly desirable. Now that lighting systems—alternating or direct current—are generally available the advantage to the medical man will be great if by the insertion of a wall plug he can readily secure very sharp fluorescent screen effects. In radio-telegraphy the importance of improvement in the directions named cannot be over-estimated. The extended use of the apparatus on board ship makes it very desirable that it should be reliable, and in the field for military purposes great lightness and portability are desired. Other directions in which cheap portable sets will make for progress are in connection with the forcing of the growth of plants, and fog dispersion.

Referring to the diagram of connections, energy is (according to this method) stored in a magnetic field by an inductance, 1. It is then permitted to surge into a condenser 4, which forms with the inductance 1 a low-frequency oscillatory circuit. When the energy is accumulated in the condenser 4, the latter is mechanically bridged across the primary winding 2 of an induction coil with which it forms a high-frequency oscillatory circuit. The energy is then transmitted by the secondary winding 3 of the induction coil to the work circuit, and can be of an oscillatory or uni-directional character, according to the purpose in view. The above cycle of events is controlled by a contact maker, 5, which is driven by a small motor arranged with commutator and slip-rings so that the apparatus can be worked when the supply mains 6 are either direct or alternating current. Tapping points on the inductance 1 allow of a suitable range of voltages being used.

Going a little further into detail one may say that at "make" the system is switched on to the supply mains, the current rises in the winding of the inductance 1, and builds up the magnetic field. When sufficient energy has been stored the system is severed from the mains, and this may be referred to as the epoch of "break." As only the current in the condenser 4 passes through the primary winding 2 the inverse E.M.F. induced in the secondary winding 3 is so small as to be negligible, but if desired it can be entirely eliminated by a modification in the connections. At the epoch of "break" the energy stored in the condenser 4 is added to that in the inductance 1, and then the total energy in the inductance 1 begins to surge into the condenser. At the precise epoch when the condenser has received the whole of the energy in virtue of its reverse charge, the contact maker 5 short-circuits the inductance 1. The condenser then discharges with great rapidity through the



primary winding 2, and the energy then oscillates between the condenser and primary winding in well-known manner. As is also well known, the E.M.F. induced in the secondary winding 3 may be of an oscillatory or uni-directional character according to the nature of the work circuit.

Briefly the following are some of the advantages gained:

1. For X-ray work the inverse E.M.F. is eliminated, thereby leading to increased life of the tube and to a more sharply defined radiograph.

2. Only a small magnetising current is required, as the inductance 1 has nearly a closed magnetic circuit. This gives rise to very small C^2R loss and consequently higher efficiency.

3. On account of the long periodic time of the system, the voltage across the contact of the interrupter 5 at "break" does not rise to a high value, or rises so slowly that the contacts are well separated before it is developed. No oil or coal gas is required.

4. The method lends itself to few secondary turns and this keeps down the time constant. It also makes the coil lighter, cheaper, and more compact.

5. The method lends itself to low secondary resistance—a point of great importance in wireless telegraphy.

6. The iron in the spark coil can be kept small in amount, and special attention can be paid to its lamination and insulation, as it may have to be operated at frequencies of some thousand per second.

7. The elimination of sparking increases efficiency, and on board ship, where coal gas is not conveniently obtained, this is an advantage.

8. The apparatus is light, portable, reliable and cheap.

9. The apparatus can be worked from direct-current or alternating-current systems at usual voltages, or from a portable battery of a few storage cells.

10. The oscillating current at "break" does not pass through the battery and hence does not assist in its discharge.

11. The iron in the magnetic circuit of the external inductance 1 has only to operate at low frequency, and hence it has not to be finely laminated.

* Paper read before the British Association at Sheffield.

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TRANSMISSION INSULATORS.*

BY A. S. WATTS.

Summary.—The author describes the development of the high-tension insulator in America and in Europe, and compares the designs which have been evolved in the two continents. Finally, he suggests a light type of insulator which he considers is particularly suitable for pressures of from 60,000 to 100,000 volts. It is formed from a porcelain tube with undercut corrugations.

That a thoroughly practical and successful transmission insulator is not as yet on the market is yearly, almost monthly, evidenced by the attempts on the part of engineers to produce a new and superior insulator design or combination. All such designs are of interest to the insulator-producing and using world, since it can only hope thus ultimately to reach perfection. If the development of high-tension insulators, however, is to continue, as in the past, in the hands of the electrical transmission engineer it seems highly important that he possess some reliable comparable data upon the relative values of the various insulators now in use, in order, not only to be able to select from those now available, but also to place an intelligent value upon any new design presented for his approval. At the present time such data is so meagre that it is practically worthless. American engineers may justly feel proud of the progress made in the U.S.A. in the development of insulators for high pressures, compared with the progress made in Europe in this line.

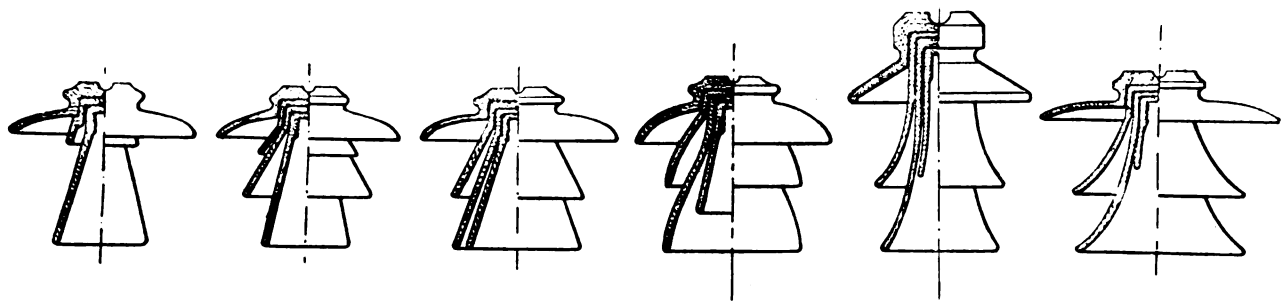
American Insulators.—The author first considers the development of insulators in the United States. In order to facilitate comparison, the illustrations of insulators are reproduced to the same scale. Scarcely 10 years ago the first genuine high-tension insulator was produced. Its construction was similar to the type shown in Fig. 1. This insulator consisted of a porcelain head and intermediate shell manufactured separately and fused together during the burning process by means of a layer of glaze. With these was used a glass centre which was attached to the other parts by means of Portland cement. This insulator was a great advance over the simple bell insulator, which had been used up to this time and which was still in service in Europe. The next step in insulator development was the lengthening of the intermediate shell and the introduction of a narrow flange on the under side of the top shell in order to lengthen the bearing surface between the top and second shells, which were now united by Portland cement, as the glaze joint proved unreliable when subjected to great strains or sudden changes of temperature. The centre was also now made of porcelain, thus eliminating the use of the glass, which caused trouble on account of its brittleness. The next step was the extending of the head portion sufficiently to permit of the introduction of a fourth shell. This type is illustrated in Fig. 2.

Up to this time the development of the insulator consisted merely in the expansion of the original type, thus furnishing greater striking and leakage distances. Insulators like that shown in Fig. 2 proved very successful from the point of manufacture and also for employment on transmission lines up to 60,000 volts, provided the operating conditions were good. If the conditions were severe or an addition of 6,000 volts was considered, the mere increase of dimensions failed to give satisfactory results.

A series of insulators varying considerably in form and possessing properties peculiar to themselves resulted. In this class are the insulators illustrated in Figs. 3, 4, 5 and 6. The insulator shown in Fig. 3 was designed with the idea that, by having two large shells close together, one would obtain two surfaces to which the rain could not gain access. The result, however, was that insects and dust collected in this protected place where the wind could not dislodge them, and this proved a conductor equal to the film of moisture accumulating during a storm. The proper cleaning of such an insulator also proved very difficult because of the narrow opening. Difficulties in manufacture were also experienced. Fig. 4 represents an insulator of almost the same dimensions as that in Fig. 3, but much superior both as regards operating efficiency and success of manufacture. This type has the peculiarity of having only convex surfaces exposed to the weather. This insulator was never put into service in the United States, although many thousands were made and sent to Japan, where they proved very successful. Fig. 5 represents an elongated specimen of the type shown in Fig. 2, and had previously been extensively employed for 45,000-volt lines. This insulator was manufactured and employed only as a three-part insulator, the pin being cemented directly to the longest shell, which served also as centre. Its failure when employed for high voltages lay in the fact that when put to the strain which its size seemed to warrant, it proved unequally balanced, causing the centre to puncture during the stress of storm service. This difficulty was overcome by expanding the various dimensions sufficiently to permit of the introduction of a fourth shell, as here shown, thus placing two thicknesses of porcelain between the steel supporting pin and the first exposed surface. However, when thus redesigned, this type proved so heavy and so expensive to produce that it was never put into use.

In Fig. 6 is shown the Fig. 2 type expanded instead of elongated. This type proved very successful for voltages up to 75,000, but, like Fig. 5, the cost of production and the expense of installing such heavy insulators is in most cases not justified by the additional efficiency obtained. In the manufacture of such an enormous extending head as this insulator possesses much difficulty was naturally experienced on account of warping during the firing process.

In the United States, as in Europe, the underhanging insulator came as a result of the discovery that for proposed 100,000-volt lines no pin-type insulator could be successfully employed. In the design of an underhung insulator it is generally agreed that it must be so constructed that in case the insulator is destroyed the line will not drop. Of the insulators so constructed, the best known types are the Hewlett insulator (Fig. 7) and the Duncan insulator (Fig. 8). In the type illustrated in Fig. 7 the supporting cable passes into the porcelain, below and through the loop which supports the next lower insulator or the transmission line. Thus there are two intersecting loops which certainly furnish absolute security against the dropping of the line. On the other hand, there is an opening in the top of the insulator into which water may enter and render the insulator liable to burst by frost unless the curved hole is so bored that it tapers from each opening to the middle. Of the type illustrated in Fig. 8 the author's personal observation in connection with the manufacture of many thousands has convinced him that with the porcelain under compression, as it is here, it is impossible to pull the bolt out of the cap with any amount of load which could be introduced by means of snow or ice added to the cable. In fact, the cable would itself part long before the strain on the insulator became enough to cause rupture. The Swedish engineer, Olav Ingeborg, who is transmitting 200 H.P. at 500,000 volts for use in his research laboratories, has recently equipped his line with this type of insulator exclusively, after testing practically all types.



FIGS. 1 TO 6.—CHRONOLOGICAL DEVELOPMENT OF AMERICAN HIGH-TENSION INSULATORS.

European Insulators.—The development of transmission insulators in Europe has been along very different lines, although the original type employed was very like that first used for lower voltages in the United States. While in Europe much larger single pieces of porcelain are produced than in the United States, the demand for transmission insulators for voltages above 50,000 has been comparatively small, only three lines operating at pressures higher than 50,000 volts. Regarding insulator development in Europe, the Hermsdorf Porzellanfabrik patented in 1897 the "delta glocke" insulator (Fig. 9). This type of insulator has been produced in all sizes up to about 12 in. diameter, and throughout Europe is

* Abstract from the "Electrical World."

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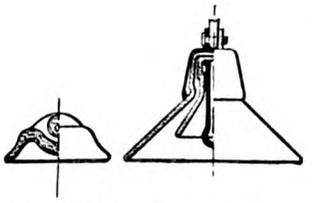
undoubtedly the most extensively employed type for moderate voltages. It has the peculiarity of having only one thickness of porcelain between the line and the pin. In the manufacture of insulators in the United States this has been considered unreliable. Furthermore, with American materials, the production of large single piece insulators has not been successful. In Germany such insulators are produced by two different methods. One is to form a mass of body large enough to permit the bells to be turned out of the mass on a lathe while still in the half-plastic condition; the other is to make the bells separately and attach them while still plastic to the body portion of the insulator. This latter process is employed for the larger insulators, and one rarely finds a German insulator that has punctured through the joint. Such joints have been attempted a number of times on insulators in the United States, but always without success. The author is convinced that the European clays lend themselves much more readily to this process than do American clays.

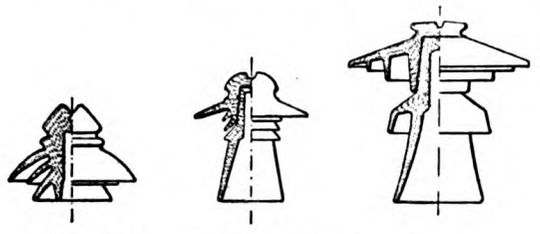
Another insulator used extensively in Europe is illustrated in Fig. 10. This type, known as the "rillen" insulator, depends upon



FIGS. 7 AND 8.—UNDERHANGING INSULATORS.

the principle of having a number of "rillen" or grooves cut into the body shell at a point well up on the body shell so that they are protected from most direct rain by the overhanging head of the insulator. The value of a number of these insignificant grooves is remarkable. The Ph. Rosenthal Co., who produced this insulator, have developed it for higher voltages into the insulator shown in Fig. 11. This insulator is said to be serviceable for voltages up to and including 66,000 volts. In its manufacture the projecting flanges are all made separately and joined in the green condition to the body portion of the insulator. The production of this type of insulator was attempted in the United States some years ago, but was abandoned on account of the difficulties of manufacture. Another insulator design, the uniqueness of which makes it worthy of attention, is shown in Fig. 12. This insulator would naturally fall in the same class as Figs. 5 and 6, since its enormous size would make its production and installation exceedingly expensive, if not prohibitive.

In Germany the Hermsdorf Porzellanfabrik have placed on the market a large variety of underhung insulators. Those most highly recommended are of the types shown in Figs. 13, 14 and 15. Figs. 13 and 14 may be properly classed with the American type shown in



FIGS. 9, 10 AND 11.—GERMAN INSULATORS.

Fig. 7. Fig. 13, however, has a straight hole for the upper loop which overcomes the danger of water collecting in this exposed opening. It also has the advantage of an extending shell which, of course, materially increases its efficiency. Fig. 14 is practically the same as Fig. 7 in principle, but has incorporated as nearly as possible the type of the old "delta glocke" in an underhung insulator. The European underhung insulator which most nearly resembles Fig. 8 is shown in Fig. 15. This insulator is notable on account of having a thin enamelled sheet-steel umbrella in place of the first porcelain shell. While the value of the insulator when dry is thus slightly reduced, its value under rain is increased, since with enamelled steel a flatter, wider umbrella can be made than with an equal weight of porcelain.

Comparison of European and American Insulators.—Any attempt to compare, from the data available, the relative efficiency of European and American insulators would be probably very misleading, except in cases where the tests were made at the same time and place and with the same testing equipment. Friese, in writing of high-voltage insulators, figured the efficiency on the basis of the formula: $A \times B =$ insulating value, where $A = \frac{\text{insulating value under rain}}{\text{insulating value in dry condition}}$ and $B = \frac{\text{insulating value under rain.}}{\text{weight of the insulator.}}$

As an example he compared a Hermsdorf "delta glocke" insulator and an American insulator tested under the same conditions and having practically the same value for A. The result was as follows:—

	Under rain.	Dry.	W'ght.	A	B	Insulating value.	Area of top shell.	H'ght.
	Volts.	Volts.	Grms.				sq.cm.	cm.
German "delta-glocke"	49,000	93,000	2,125	0·53	23·0	12	240	19·5
American insulator	49,000	92,000	2,910	0·53	16·8	9	325	23·0

Thus, a "delta glocke" insulator of approximately 7 in. diameter by $7\frac{3}{4}$ in. high and weighing 4·7 lb. was shown to have an insulating value equal to that possessed by an American insulator of 8 in. diameter by 9 in. high and weighing 6·4 lb. These figures prove beyond dispute the high efficiency of the "delta glocke" type of insulator. European engineers, however, have followed the American example in the design of insulators for higher voltages and have increased the size with more than a proportionate increase in weight.

On both sides of the ocean this has resulted in the discovery that size alone does not produce efficiency in an insulator, but that the volume of porcelain contained therein and the amount of surface as

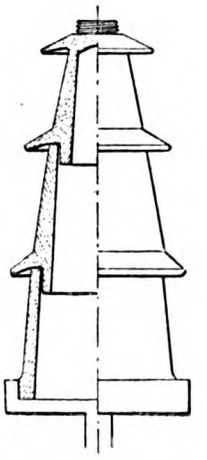
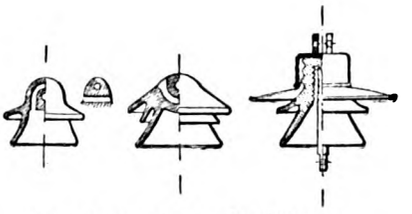


FIG. 12—KUHLMANN INSULATOR.



FIGS 13, 14 AND 15.—SUSPENSION INSULATORS.

compared with the weight of the mass bear a definite relation to the efficiency of the insulator produced. That the insulating efficiency of a porcelain mass does not increase in direct ratio with its thickness has been known for several years. Researches which the writer is pursuing upon the insulating value of porcelains from European materials, are not as yet in shape for publication, but herewith are given, in Fig. 16, the most recently published curve showing puncture voltages of various thicknesses of German porcelains. On the same diagram is shown a curve of puncture voltages for various thicknesses of American porcelains. While the two curves were not made under the same test conditions, and, therefore, the actual values therein contained cannot be compared, yet it is interesting to note the fact that the curves run practically parallel, which indicates that the influence of thickness upon insulating value is the same for European as for American porcelains. The idea prevails in the United States that German products are prepared to stand a higher test than American insulators. Based upon the relation of test voltage to working voltage, however, the German insulator is not ordinarily as severely tested as the American insulator. In fact, the Verband Deutscher Elektrotechniker specifies a much more moderate test. These lower test voltages and the above data offered by Friese regarding the "delta glocke" insulator are probably responsible for the impression that the German insulator is uniformly lighter for a given working voltage than the American insulator. When the weight, however, is compared with the test voltage instead of working voltage, it is found that the insulators of both lands fall within the same area. Thus it is seen that engineers, both in Europe and America, have reached the same point and can go no farther.

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In the study of insulators it may be said that all transmission insulators may be divided into two classes: (*a*) Those constructed with the idea that they shall possess enough dry surface at all times to provide the necessary insulation; (*b*) those constructed upon the principle that porcelain surfaces, even when damp, possess a certain insulating value, and if enough distance is provided the required insulation is secured. The fault with class (*a*) is that it is practically impossible to prevent some rain from spattering from the exposed surfaces on to the protected surfaces of the overhanging shell. This small amount of water is volatilised by surface leakage and forms steam, which rises, and hence remains under the overhanging shells of the insulator. If the rain is of any great duration, this accumulation of steam and vapour reduces the insulating value of the so-called dry surfaces to that of exposed surfaces of porcelain. If the insulator is selected with a sufficient factor of safety the sum of the insulating values of these wet surfaces, plus the insulating value of the inside surface of the centre, which generally remains dry, since no spattering can reach it, furnish sufficient insulation to prevent interference with service. All the types illustrated belong to this

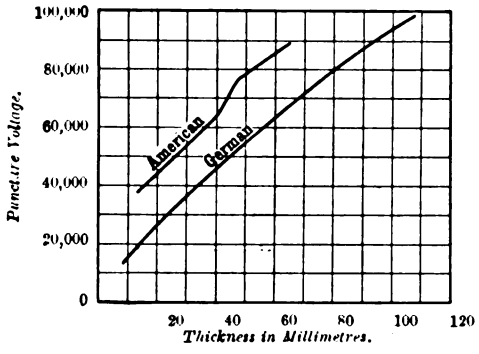

Fig. 16.—Dielectric Strength of Porcelain.

class, with the exception of Fig. 12, which plainly belong to class (*b*). The fault with class (*b*) is that it requires so long a surface that the weight, if designed as here shown, is almost prohibitive, and yet the principle of class (*b*) provides the only certain means of insulation.

The principles of these two classes may be combined to produce a reasonably light, efficient insulator, and the writer believes that the solution of the insulator problem for voltages between 60,000 and 100,000 volts is along the following line: It is known that a plain glazed porcelain tube (class *b*) 1 ft. long and 3 in. in diameter, when exposed to a rain of 1 in. in five minutes' precipitation, possesses an insulating value of about 30,000 volts. If this tube is corrugated uniformly over its entire length, it is found that its value under the same test is increased to about 50,000 volts. However, if the tube has undercut corrugations, the surface distance between ends is not only materially increased, but there is some protected surface to aid in insulation. These undercut surfaces not only have the advantage of being small and thus not permitting of any considerable vapour accumulation, but the fact that they are shallow enables the wind to free them of the vapour as fast as it accumulates. This may explain the remarkable value of the "rillen" in the Rosenthal insulator, Fig. 10. Be the explanation of the phenomena what it may, it has been proved beyond dispute that such a corrugated tube, 12 in. long and 3 in. in diameter, under rain test as above, possesses a value of about 100,000 volts. Moreover, a tube being of uniform surface design, the value may be increased by merely increasing the length of the tube.

The writer suggests the insulator shown in Fig. 17. The advantages of such an insulator are many. It is not so heavy as the ordinary 60,000-volt insulator. It can be handled with much less danger of breakage in construction and when in place is practically safe against destruction by miscreants. In case of lightning it has no extending shells to be broken by the shock. The temporary short circuit passes along its face rather than follows the small corrugations, with the result that it passes such a shock uninjured, whereas with the ordinary shell insulator destruction is certain. In the case of rain its exposed surface is small as compared with most 60,000-volt insulators, hence if it is necessary to keep the protected surfaces absolutely dry by surface leakage, the loss will be comparatively small. The only drawback to such an insulator is the difficulty of manufacture. However, such tubes are made with comparatively little loss in Europe, hence it may be assumed that a little experience would enable the American manufacturer to produce them with equal success.

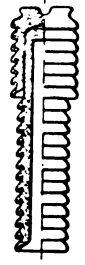

Fig. 17. Suggested Type.

In closing, the writer calls attention to what in his opinion is the greatest hindrance to progress in insulator development and which has caused more false impressions and trouble than all other causes combined. Reference is made to the absolute absence of anything like a uniform test for transmission insulators. Voltage and precipitation are spoken of as though they were standard factors not capable of influence by any varying condition. A given voltage may refer to a test with an equipment of 10 kw. rating or a 1,000 kw. equipment. A given precipitation may refer to a fine driving mist or it may refer to a gentle downpour. And so with all the other data that are recorded on insulator tests. It would be far better to have all tests with moderate equipment of a given type under standard specifications, and thus have all data comparable, than to have the present system.

REPORT OF THE BRITISH ASSOCIATION COMMITTEE ON PRACTICAL STANDARDS FOR ELECTRICAL MEASUREMENTS.*

The report of the International Conference on Electrical Units and Standards held in London in October, 1908, was printed as an appendix to last year's report. In January, 1910, the Board of Trade took action in accordance with the recommendations of the report, and an Order in Council relating to electrical units, dated January 10th, which contains definitions of the English standards of resistance, current and E.M.F. in conformity with the definitions adopted by the Congress, has been issued. This is printed as an appendix.

In accordance with a scheme approved by the International Scientific Committee appointed by Lord Rayleigh at the London Conference, international co-operative work on electric standards has this year been carried out at the Bureau of Standards, Washington. It was arranged that representatives of the Bureau of Standards, the Laboratoire Central d'Electricité, Paris, the Physikalisch-Technische Reichsanstalt, Berlin, and of the National Physical Laboratory should take part in the work. The representatives of the Bureau of Standards were Prof. E. B. Rosa and Dr. F. A. Wolff, and the European delegates were Prof. W. Jaeger, Prof. F. Laporte and Mr. F. E. Smith. Prof. S. W. Stratton kindly offered the facilities of the Bureau of Standards for the investigation, and, in his capacity as treasurer of the International Committee, was able to secure the funds to defray expenses. Towards this object the governing bodies of the American Institute of Electrical Engineers, the National Electric Light Association, the Association of Edison Illuminating Companies and the Illuminating Engineering Society most generously subscribed £100 each. Some smaller contributions were also received.

The primary object of the meeting was to determine the E.M.F. of the Weston normal cell in terms of the international units of resistance and current. At the same time it was necessary to clear up certain outstanding problems on the standard cell and the silver voltameter. Previous to the meeting a great deal of experimental work had been done at each of the four institutions, and the results obtained were compared before deciding on a programme of experimental work.

The European delegates took with them from their own laboratories a considerable quantity of apparatus and chemicals, together with standards of E.M.F., resistance and mass. The results of the meeting are very valuable, and a full report is in process of preparation.

Another careful research on the silver voltameter has been made during the year by Prof. F. Laporte at the Laboratoire Central d'Electricité. Prof. Laporte shows that the result obtained in 1908 by Profs. Janet, de la Gorce and himself is subject to an appreciable error, owing to the use of silver nitrate, now known to be impure. With carefully prepared nitrate, and using the Rayleigh form of voltameter, he obtains 1·11829 milligram per coulomb for the electrochemical equivalent of silver, the current being measured in terms of the Weston cell as 1·01830 volts at 17°C. and the international ohm as realised at the National Physical Laboratory. The unit of current was, therefore, the same as that used by Smith, Mather and Lowry in 1908, and the value for the electro-chemical equivalent found by Prof. Laporte is in very close agreement with the value 1·11827 obtained by the British investigators.

* Report presented to Section A at Sheffield. The Committee consists of Lord Rayleigh (chairman), Dr. R. T. Glazebrook (secretary), Profs. J. Perry, W. G. Adams, and G. Carey Foster, Sir Oliver Lodge, Dr. A. Muirhead, Sir W. H. Preece, Profs. A. Schuster, J. A. Fleming and Sir J. J. Thomson, Dr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Dr. G. Johnstone Stoney, Prof. S. P. Thompson, Mr. J. Rennie, Principal E. H. Griffiths, Sir Arthur Rücker, Prof. H. L. Callendar, and Messrs. G. Matthey, T. Mather and F. E. Smith.

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The General Committee at Winnipeg accepted the recommendation of the Council and the Committee of Section A in favour of the republication of all the Reports of the Electrical Standards Committee. Suitable arrangements for the work have, therefore, been made, and the material is now with the printer, but in consequence of the absence of Mr. F. E. Smith in America, and the work of preparation required for this, progress has necessarily been slow.

With regard to progress in electrical standardising work at the National Physical Laboratory, the Lorenz apparatus is practically complete, and some preliminary electrical measurements will, it is hoped, be made in October of the present year. The Ayrton-Jones current balance continues to work most satisfactorily; small and gradual changes in E.M.F. of Weston cells, amounting to less than three parts in 100,000 have been detected by its aid.

The results of the investigation on cadmium amalgams at the National Physical Laboratory were incorporated in a Paper read before the Physical Society last February. It may be useful to give here the limits of temperature between which various amalgams may be most usefully employed in the Weston normal cell :—

Percentage of cadmium in the amalgam.	Lower limit. Deg C.	Upper limit. Deg. C.
6	Below 0	about 27·7
7	,,	,, 34·6
8	,,	,, 41·0
9	,,	,, 46·0
10	,,	,, 51·0
11	about 0	,, 56·0
12	,, 8·7	,, 60·0
12½	,, 12·1	above 60·0
13	,, 16·1	,, 60·0
14	,, 24·0	,, 60·0
15	,, 32·5	,, 60·0

The degree of reproducibility which is now obtainable with the Weston cell far surpasses what it was five years ago. At the National Physical Laboratory 67 cells were tested in 1909, and of these 60 agreed with the Laboratory standards within one part in 10,000. What is not understood at present is the occurrence of strange hysteresis effects in a few cells. The E.M.F. of such cells may be normal at first, but changes comparatively rapidly with time. Indeed, a large hysteresis effect in a cell appears to be an indication that the E.M.F. will not remain constant with time, whereas its absence is in general an indication of constancy.

In view of the fact that the republication of the Reports is not yet completed, the Committee recommended that they be reappointed, that Lord Rayleigh be chairman, and Dr. R. T. Glazebrook, secretary. The Order in Council relating to Electrical Standards is contained in an appendix to the report.

COOKING AND HEATING BY ELECTRICITY.*

BY P. A. BATES.

The result of recent activity among the manufacturers of heating and cooking apparatus is that to-day we have an assortment of electrically operated devices, available at reasonable prices, which are thoroughly reliable and suitable for the purposes for which they are designed. In fact, being free from many of the disadvantages of older types, in which fuel is burned directly, their superiority for domestic use is marked. One of the very important advantages of this method of cooking and heating is its freedom from fire risk.

The cost of cooking by electricity depends, of course, upon the cost of the electric current available. Many, however, are satisfied to dismiss the question of cooking by electricity with the thought or statement that it would be impossible for electricity, produced by the roundabout means of the steam boiler, steam engine, dynamo and transmission wires to compete upon a cost basis with the direct use of coal for cooking purposes. Those who argue upon this basis lose sight of the advance which has been made by gas, also a product of coal, in this field, where it very frequently is able to show a decided saving as compared with the direct use of coal for the same purposes. The reason for this is, of course, the possibility of confining the heat of the gas flame and applying it only where needed. This is also true where electricity is used, only to an even greater degree.

The case with which the electric current may be switched on or off makes this source of heat even more convenient than gas, and the ability to confine and apply the heat where wanted is much greater with the former than with the latter. In fact, it has been found that with the ordinary gas range 15 per cent. of the heat produced is usefully applied, while with the various high-grade electrical cooking devices now obtainable 70 per cent. or more of the heat produced is utilised.

In order that electricity should compete successfully upon the basis of cost alone with gas or coal for cooking and heating purposes, the rates ordinarily prevailing throughout the United States must be reduced; and electric lighting companies generally are only just beginning to realise the possibilities in this line and to make systematic efforts to obtain this class of business.

Even at somewhat greater cost of operation, electric cooking, in common with other electrical devices, has many advantages. The rapidity with which food may be cooked by the use of electricity, the uniformity of temperature obtained, which makes cooking by the clock a possibility, the great comfort and convenience, the cleanliness and freedom from smoke and smell, make it ideal for all places where these advantages are of importance. As might be expected, the results obtained with this method are beyond all comparison with those from any of the older methods.

Unfortunately, this ideal method of cooking has not been taken hold of by the manufacturers with sufficient enterprise and business judgment, the result being that there are few noteworthy installations, and of these the number that have been tested with a view to obtaining exact and useful information as to actual performance is astonishingly small. A most interesting installation of this kind which has come under my direction, is that installed in one of the prominent club houses in New York city about three years ago. It represents a type well suited to the requirements of any club house, large residence or hotel, where it is desired to secure the best of service obtainable. The author then gives a menu, with the time required for the preparation of each item, to illustrate the service of which these devices are capable.

There are two important reasons for the superiority of the actual cooking accomplished by the electric method. One is inherent to all electrical heating and cooking devices—namely, the entire absence of all flame, gas, smoke or dirt; the other is a result of the design of this particular type of apparatus. Each broiler unit is equipped with heating coils on both vertical sides, and the spider containing the steak, chop, chicken, toast or other article to be cooked is inserted in a vertical position between the two sources of intense heat. The current, therefore, passing through the coils produces heat simultaneously on both sides. This has the double effect of halving the time necessary to do the cooking, and, in the case of meat, the outer tissues are at once seared, thus tending to prevent the escape of the natural juices which otherwise often drip into the fire and are lost. A chop or steak, for instance, cooked in an electric broiler will be juicy, but evenly done throughout, and absolutely free from all gas or odour. Compare this result with a similar cut cooked over a fire, overdone on the surface, underdone in the centre, charred in spots by the fire or burning grease as it often is, with most of the juice of the meat lost and a decided taste and odour of the fire.

The time required for the preparation of articles of food in an electric grill is important as a determining factor in the cost of the cooking process. This is particularly true in the case of a club or other restaurant, because of its bearing upon the quality of the service rendered, and the fact that the cooking can be accomplished in half the time means that a smaller grill may be installed. The menu mentioned above illustrates these points, and it is evident that the cost of cooking is but a small part of the price charged for the service or even of the market value of the unprepared food. At a rate for electric current of 1½d. or less the cost of the current required for cooking becomes almost negligible. Contrary to what might be expected, the repairs on these electric cooking devices are surprisingly small.

In the line of heating, the field for the use of electricity is more limited, being confined to special applications. General heating by electricity, except under very special conditions, is, and probably always will be, too expensive for serious consideration. There are, however, many applications where the advantages of electrical heating are sufficient to outweigh its greater cost. To meet these conditions, a number of electric heating devices have been developed and placed upon the market. Perhaps the most useful of these for home use is the electric radiator, the advantages of which over a portable oil stove, that has a very bad effect on the air of a room, need scarcely be mentioned.

*Abstract of an article in the "Electrical Review and Western Electrician."

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Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON
(ONLY ADDRESS.)
Tel.: Holborn **6363** (Two Lines). *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fifty-second issue of the Supplement was published (Gratis) with the number of "THE ELECTRICIAN" for August 19.

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THE BRITISH ASSOCIATION.

Quite apart from the calendar, signs are not wanting that the Long Vacation is drawing towards a close, and that the holiday season has practically come to an end. The most significant of these indications is the meeting of the British Association, held this year at Sheffield. For the teacher this great gathering serves a double purpose; it provides a pleasant termination to a few weeks of idleness, and it also serves as a gentle reminder of the labours in store. Quite apart from this, however, it brings technical men into intimate contact with workers in pure science, to the infinite advantage of both; and, in addition, it provides the public with an admirable opportunity of getting an insight into scientific matters at first hand, instead of having to rely on the sensational information disseminated by the daily papers. There is, of course, always the danger that statements made at British Association meetings may be misinterpreted by the uninitiated, and it is even possible that speakers may, in their endeavour to get down to the level of the layman, give utterance to remarks which are hardly warranted by facts. This is a matter that requires very careful watching, for however "popular" the British Association may become, it would be a fatal mistake to allow sensationalism to bring its veracity into dispute.

The primary object of the British Association is, as its title implies, the furtherance of scientific work—"the advancement of science"—and there can be no doubt that it has been the means of providing a large number of scientific men with the facilities for conducting important researches. The annual meeting is, after all, but a portion of its work, and an enormous amount of patient investigation goes on during the 12 months while the whole organisation is lying dormant—at all events, so far as the public are

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concerned. It would, therefore, seem that, since the lay members and associates bear a considerable share of the piper's payment, they should have a certain voice in the calling of the tune. At present they are, of course, regaled with popular lectures, receptions, garden parties and other functions of a more or less tedious nature, and in this way undoubtedly become pleasurably excited and fatigued for the modest sum of one guinea. The expense of these festivities is largely borne by the city or town, and certain of its private residents, acting as hosts for the time being. The bulk of the numerous guineas is, therefore, available for general expenses and for subsidising research. This is all very nice, and generally goes off very well; but perhaps one may be permitted to question whether it is quite the thing that the founders of the British Association had in view. It may be asked whether the unscientific members are not to be taken more seriously, and given a more active part in the "advancement of science." The numbers of those attending this year's meeting were less than they were two years ago at Dublin, and it is becoming more and more evident as years go by that the Papers and discussions are becoming more and more difficult of comprehension by the uninitiated.

Of course, there are still many people who are only too willing to sit, and perchance to sleep, in a stuffy room for three or four hours drinking in the words of wisdom that fall from the lips of the mighty, and then to go away without an intelligent comprehension of a single sentence. It is these people, more numerous than is generally thought, but undoubtedly becoming less year by year, who are intensely loyal to the Association, but receive very little in return for their loyalty. Unquestionably the problem is a difficult one, and the solution may lie in the direction of ignoring this class and frankly admitting that the day of the semi-popular Paper and discussion is over. We cannot help thinking that, in some respects, this would be an unfortunate step. There is much to be said for Sir GEORGE REID'S plea for the great men to *know* what they are talking about, so that they can explain it in plain English to others. Apparently in no section is this more desirable than in Section A (Mathematics and Physics), where physical science seems to be becoming increasingly mysterious. Indeed, it would seem that no two physicists can agree on any one subject except the excellence of an author's Paper, and it is refreshing to find that there is unanimity on at least one topic of discussion. Speculation is rife as to what one authority could do with a substance if another one could produce it for him. Every year the debates partake more of the nature of gladiatorial combats, and every year witnesses the announcement of some extraordinary feat which is received with fierce criticism and thereafter sinks into well-deserved oblivion. So the great British Association goes on. The popularity of sections waxes and wanes, that of Section G not being very great at the present moment in spite of the able presidency of Prof. DALBY. All interest seems to centre on those whom a distinguished scientist has described as the para-physicists, who employ their time in estimating the density of the ether and in counting electrons. What it will all lead to nobody knows, but there is just a suspicion of its being slightly overdone at the British Association.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Wireless Telephones and How They Work. By J. ERSKINE-MURRAY. (London: Crosby, Lockwood & Son.) Pp. 60. 1s. 6d. net.

This little book of 60 pages is intended to be understood by the bookstall public. It opens with an interesting exposition of the most elementary facts of acoustics, of the microphone and of the telephone receiver. Here all the science is expressed in the simplest language, with, however, greater loss of precision than is excusable. The author's difficulties in this respect become more pronounced when he explains the production and propagation of electric waves, and they continue right through the brief discussion of wireless telephone apparatus and the explanation of resonance. In this latter matter the author strives after simplicity by making a fallacious application of the principle of the superposition of small motions, an application that will startle those who understand the principle in the orthodox way. The author is happier when discoursing patriotically on the value of wireless communication between the parts of the Empire.

W. H. E.

Die Elektrochemischen Patentschriften der Vereinegten Staaten von Amerika. By Dr. P. FERCHLAND. Vol. I. "Elektrothermische Verfahren und Apparate: Entladungen durch Gase." Vol. XXXIII. of "Monographien über angewandte Elektrochemie." (Halle a. S.: Wilhelm Knapp.) Pp. vi. +204. M12.

Dr. Ferchland has already written for this series some monographs upon the electrochemical patents of Germany and England, and we are now indebted to him for the present one under review. In some respects the methods of the American Patent Office vary considerably from those adopted by the British and German offices, but of recent years the tendency has been for the American methods to approach the German, and, of course, since the new Patent Act, our own methods are also much more akin to the German than heretofore. The Americans are very particular that the patent shall only be given to the first and actual discoverer of a process; therefore, if anyone else takes out a patent the original discoverer can upset the patent by proving that he was the actual discoverer, even though he may not have published the fact. Greater latitude is also given for working the process before the actual patent is published; this, of course, is a very great help. Considering that 900,000 patents have been taken out in America against 200,000 in Germany, the work of Dr. Ferchland must have been extremely difficult and arduous. It is really not possible in reviewing such a book to discuss the individual patents included in its pages, except to state that any particular patent we have searched for we have been able to find. The description of each individual patent is necessarily short, but the author has succeeded in being concise, and the illustrations very much help the text. We consider the book a very useful monograph.

Nightshade. By PAUL GWYNNE. (London: Constable & Co.) Pp. x. +431. 6s.

Having received a copy of this book for review, we naturally expected to find some scientific basis for the story. This basis, however, is very slender. An old "scientist" has devised a remarkable lamp which enables the blind more or less to see when under its influence. Hence it is termed "Nightshade," from analogy to nightshade, or belladonna, which has the property of dilating the pupil of the eye. It is the special radiation of this lamp which is effective. Whether the blind are thus enabled to see by ultra-violet light, or what the type of radiation is, we are not told, but apparently the blind musician on whom the experiment is tried sees visions of the past and other things invisible to ordinary mortals. We need scarcely say that a love story, of a rather tragic kind, is wrapped up with the fate of the musician, and those of our readers who are fond of the weirdly impossible will find this book as good a companion on a holiday as most of the recent novels to be found at the sea-side

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THE BRITISH ASSOCIATION AT SHEFFIELD.

(FROM OUR SPECIAL CORRESPONDENT.)

Wednesday, August 31st.

In spite of all the attractions offered by Sheffield, no meeting of the British Association has been held here since 1879. This is, of course, a long period in the life of any scientific institution, and it has also been full of changes for the City of Sheffield itself, enormous developments having taken place within the last 15 years. Not the least pleasant feature of the meeting is the accessibility of the place from almost all parts of England, and perhaps one may pay a tribute to the Great Central Railway for that magnificent train which performs a non-stop run from London in just under three hours. In spite of the exceedingly heavy traffic, this train ran into Sheffield this evening just two minutes before time. Unfortunately, however, passengers who travelled by it, or by any train arriving after 6 p.m., were not in time to get into the Reception Room. Perhaps, in future years, arrangements might be made to keep the latter open a little later on the first day, as many people arrived only to find it impossible to get a ticket for the Presidential Address in the evening.

The President this year, Dr. T. G. Bonney, F.R.S., is a distinguished geologist and thus his address almost necessarily contained nothing of special interest to readers of THE ELECTRICIAN. He succeeds Sir J. J. Thomson who is present at the meeting.

Thursday, September 1st.

Section committees commenced work as early as 9:15 this morning, and everybody has been hard at it ever since. In Section A (Mathematical and Physical Science) Prof. E. W. Hobson delivered an admirable Presidential Address dealing largely with the teaching of mathematics. While admitting that the mathematical knowledge required by a student of physics or engineering is different from, and not so thorough as, that of the pure mathematician, yet he pointed out the danger of a too narrow acquaintance with the subject. An abstract of the address has already appeared in these columns, and it is only necessary here to call attention to Prof. Hobson's warning that it is not sufficient for a student to learn off a few formulæ, but that the principles also must be learnt. The science of mathematics is too delicate a tool for rule of thumb use. Presumably, Prof. Hobson would be quite willing to admit that certain eminent engineers and physicists are by no means brilliant mathematicians, but such an admission does not have the slightest effect on his argument.

On the conclusion of the Presidential Address, Prof. Sir J. J. Thomson read a Paper on "Positive Electricity." Following the Papers came the reports of committees. One report related to experiments for improving the construction of practical standards for electrical measurements. In the course of this report it appears that the Ayrton-Jones current balance installed some time ago at the National Physical Laboratory is working most satisfactorily. Small and gradual changes in the E.M.F. of Weston cells, amounting to less than three parts in a hundred thousand have been detected by its aid. The Weston cell can now be reproduced with great exactness, but the occurrence of strange hysteresis effects in a few cells is not at all understood.

In the report of the committee on Magnetic Observations at Falmouth Observatory it is stated that the responsibility for the magnetic and meteorological work of Kew and Eskdalemuir now rests with the Meteorological Office, and it is suggested that Dr. Shaw be added to the committee, and be asked to act as Secretary.

It is not often that Section F. (Economic Science and Statistics) is invaded by the electrical engineer, but this year the very first Paper on the list was on "The Price of Electricity," by Mr. E. W. Cowan, of which a lengthy abstract will be found elsewhere.

A lively discussion followed the reading of this Paper, the first speaker being Mr. S. L. Pearce, chief engineer to the Manchester Corporation Electricity Supply Department. On the whole he expressed agreement with the author, but he emphasised the difficulty of converting principles into a practical tariff system. There was no doubt that flexibility was greatly to be desired provided it was not of such a nature as to give undue preference to any consumers. He did not believe in the popular contention that the selling price should be proportional to the cost of production; indeed, he agreed with Mr. Cowan that energy could be sold at a profit when apparently it was being sold for less than it cost to produce. As an example of this he called attention to the fact that less than 10 years ago the capital cost of new plant was about £8 per kilowatt; to-day it was about £3. It was obvious that it would pay well to put in modern plant for new consumers and supply them at a rate based on this plant costing £3 per kilowatt, even though this price happened to be less than the average cost of production with the whole of the plant. In short, he contended that a remission of capital charges should be made to large consumers. He considered that the "equal profit" basis was fallacious, as the same profits could not be made on different units under the flat-rate system.

Mr. S. J. Watson called attention to the danger of regarding any branch of supply as a by-product. By offering it at an extremely low price, which might pay very well in the by-product stage, the demand for it might be cultivated to such an extent that it might become the main branch of the business and result in a loss.

Mr. A. J. Cridge, of Sheffield, thought that it was very unsound to base any tariff on the number of lamps or kilowatts of plant installed, as such a course tended to keep down the size of the installation.

Prof. Ashley expressed surprise that the principles of Mr. Cowan's Paper could ever be doubted by electricians. Personally, he considered that electricity supply was completely on all fours with the railway services, and the problem of a tariff should be worked out on similar lines.

Mr. W. B. Woodhouse, chief engineer to the Yorkshire Electric Power Co., said that Mr. Cowan's Paper dealt with a subject of very considerable importance, and in general he found himself in agreement with the author's argument against the insistence on a basis of equal profits from all consumers. If the expediency and justice of such a difference of basis were admitted it seemed to him that it must be considered whether there were limitations to this difference, and if so, what they were. The question raised by Mr. Cowan was whether the production of electricity to meet the composite demand for light, heat and power was a joint supply, of which a part or parts might be regarded as a by-product. If this were answered in the affirmative then each market might be considered separately without detriment to the others, provided that the price of the commodity for any particular use or demand did not fall below the cost of producing the extra amount of electricity to meet that demand. This was the equitable minimum price, because any price below this would reduce the total profit and thereby affect the other markets. The superior limit of price, was "what it will fetch," and the satisfaction of the demand at prices between these limits must prove profitable. Regarding the matter as one of ordinary trading the market price, or "what it will fetch," was the fair price for the commodity as a whole, and on the face of it the fair price for each class of supply. This latter deduction, however, was open to question if the various classes were not definite and separate. Mr. Cowan had considered four kinds of use, viz., light, heat, power and electrolytic purposes, but these classes might with equal reason be again subdivided, and it might be argued as a logical outcome that the price of electricity for power should depend on the trade or purpose for which the power was used.

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Or, again, that where two processes, such as thermal and mechanical, were in use to produce similar articles, the supplier of electricity would be justified in charging different prices. The supply of electricity, although primarily a trading concern, and therefore subject to the ordinary motives of such concerns, was a public service, and because it enjoyed certain privileges also carried certain obligations. The endeavour to earn the maximum profit consistent with security had to be tempered by a sense of equity. The privileges granted must not be abused, and security from paralysing State restrictions, such as the American undertakings had been subjected to lately, was best obtained by so adjusting prices that the profit from any one class of consumer was not unreasonable. This he (Mr. Woodhouse) thought was largely the reason why suppliers of electricity had paid more attention to the relationship between price and cost than supply and demand. There was a further reason, in many cases, viz., that the margin between cost and market price had been so small as to keep the supplier more concerned with the lower limit of price than the higher. In view of the many new uses to which electricity was being put he thought Mr. Cowan's Paper a most opportune one, and the adoption of the principle he had so clearly argued should assist such development.

Prof. Dalby's Presidential Address to Section G has appeared in abstract in THE ELECTRICIAN, and it is therefore unnecessary to deal with it here. The attendance was disappointing, especially in view of the importance of the engineering industry in Sheffield. In proposing a vote of thanks, Mr. Charles Hawksley said that Prof. Dalby was peculiarly fitted to deal with problems affecting railways. He was an example of the professor who was not a mere theorist. The scientific professor was very useful, but when they had the scientific professor combined with the man of practical knowledge, then they had the professor of the ideal type. Prof. Ripper, in seconding the proposal, echoed the remarks of Mr. Hawksley. Subsequently, Prof. Ripper described a method of testing lathe tool steel, and gave a demonstration in his laboratory.

In the afternoon, visits were paid to several of the large works of engineering interest in the locality, and in the evening the Lord Mayor and Lady Mayoress held a reception in the Town Hall.

Friday, September 2nd.

Section A opened this morning, in conjunction with Section B, to hear a report on Gaseous Combustion by Dr. Wm. A. Bone, F.R.S. This proved to be a most useful and instructive piece of work, the author describing the researches of Dixon and his colleagues, and exhibiting some beautiful photographs showing the progress of an explosion in glass tubes. In the course of the discussion Sir J. J. Thomson suggested that the velocity of the explosion might depend on the propagation of ions in advance of the explosion wave in such a way as to ionise the gases and thus prepare the way, as it were, for the subsequent combustion. He merely put this forward as a possible explanation of the great rapidity of movement of the explosion. It could easily be tried by causing the explosion to take place within a magnetic field. If ions were propagated they would be turned aside and hence the rate of propagation of the explosion wave would be altered. Subsequently Prof. Dixon said he had tried this experiment but could detect no change. Sir Oliver Lodge agreed with Sir J. J. Thomson, and further remarked on the enormous influence which surfaces had on combustion. The temperature of the surface was of great importance, and complete combustion could never take place if the combustibles were in contact with a cool surface such as that of water. Referring to the relation between the velocity of propagation of an explosion and that of sound, he said that nothing could travel through a given gas with a greater velocity than that of sound in the same gas. At the same time, although the velocity of sound under ordinary conditions was only 1,100 ft. per second, yet it was common knowledge that the initial velocity of many projectiles was double this. To reconcile these two statements it was only necessary to remember that the projectile compressed the air immediately in front of it thus raising the temperature, and thereby raising the velocity of sound in that air to a value either equal to or in excess of that of the projectile. Hence the possibility of great speeds of projectiles.

Prof. Dixon, in discussing the effect of the presence of moisture in explosive mixtures, maintained that although moisture was necessary to start the action it was not necessary for the continuance. This statement at once brought Prof. Armstrong to his feet and led him to remark that Prof. Dixon had approached very near to a point which he had advocated for many years, viz., that no interaction of any kind could take place between two molecules neither of which was an electrolyte. Hence the necessity for water being present, and it must not be pure water—that would not do—it must be dirty water, that was, water containing something capable of turning the non-conducting pure water into a conductor. Sir J. J. Thomson then asked Prof. Armstrong if he would explain what he meant by the expression "electrolyte," and the reply was that it was a substance which would convey a current and be decomposed in the process. Sir J. J. Thomson: "Well, anything can do that." Prof. Armstrong: "Can pure water carry a current?" Sir J. J. Thomson: "Yes." Prof. Armstrong thought that this would never be proved because nobody could procure pure water. He believed that it would be found that a gas pure and simple was not capable of carrying a current, and in reply to this Sir J. J. Thomson said he was prepared to get a current through it if Prof. Armstrong would provide the pure gas. At this point, a highly diverting discussion came to an end.

The next Paper on the list was on "The Molecular Weight of Radium Emanation," by Sir Wm. Ramsay and Dr. R. W. Gray. The results of their experiments gave 221 as the molecular weight of the emanation, which figure agrees pretty closely with that of 222·5 obtained on the basis of the disintegration theory. The experiments, of which there were five in number, were conducted with a view to obtaining the weight of a known small volume of the emanation, the amount used being of the order of a tenth of a cubic millimetre. The principal point of the work was an exceedingly delicate balance capable of weighing to the $\frac{1}{5000000}$ of a milligram. This balance was made of quartz fibre, and its beam was about 6 cm. in length. Its weight was approximately half a gramme. It was supported by a single knife edge 0·5 mm. in length, and enclosed in an air tight metal lined case. The emanation was enclosed in a tiny glass tube which rested in one pan of the balance. The case was partially exhausted until equilibrium was obtained, and the pressure was read off. Next, the emanation was liberated by breaking the tube and the fragments replaced in the pan. Again the case was exhausted and filled alternately several times so as to wash out the tube thoroughly. Finally it was exhausted until the balance was again in equilibrium. This pressure was read off and by calculation it was possible to determine the weight of the emanation. The mean of the five experiments gave a molecular weight of 221. In chemical behaviour, the emanation was absolutely inert, and all its properties proved that it belonged to the inactive series of gases, while its atomic weight of 222·5 which the experiments confirmed, showed that it fell into the argon series in the periodic table, and filled the second vacant space below xenon. The authors, for these reasons proposed that, for the future, the radium emanation should be known by the name Niton, and that its chemical symbol should be Nt. This proposal at once evoked a small storm of protest, Sir J. J. Thomson leading the way, and suggesting that the matter should be referred to the forthcoming congress on radiology at Brussels. Other speakers objected to the name on account of its hybrid origin.

Dr. J. A. Crowther read a Paper on "The Number of Electrons in the Atom."

Section G devoted the morning to a discussion on the report of the committee appointed to investigate Gaseous Explosions.

Monday, September 5th.

No sectional meetings were held on Saturday, and many visitors seized the opportunity of going into the country for

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the week-end. Yesterday morning a special service was held in the Parish Church, the sermon being preached by the Archbishop of York, and in the afternoon Sir Oliver Lodge delivered an excellent address in the Victoria Hall.

This morning opened well in Section G with a Paper by Mr. Philip Dawson, on "The Electrification of the London, Brighton & South Coast Railway between Victoria and London Bridge." The author showed a large number of slides illustrating the work, and gave a considerable amount of information which has already appeared in THE ELECTRICIAN. He said experience had shown that the acceleration obtained was quite as good as anything obtained by continuous current working, in spite of claims which had been put forward to the effect that the continuous motor would give superior results in this respect. Moreover, the extra weight involved by the transformers, &c., was only 10 per cent. Coming to the question of energy consumption, this was found to be about 70 to 80 watt-hours per ton-mile for the single-phase system, and 90 to 100 for continuous current. These figures referred to energy consumption at the generating station; on the trains themselves the figures were practically identical for both systems. The difference at the station arose out of the different transmission efficiencies. The power factor for the whole system was about 80 per cent. Turning to the motors, Mr. Dawson said that up to the present they had been a complete success. The commutators presented a black shiny appearance, very similar to that of a continuous-current machine, and although the sparking was more obvious than with direct current machines, yet it did not appear to do as much harm. This was demonstrated by the fact that the commutators would run for 50,000 miles before the necessity arose of turning them down. From the commencement they had not experienced the slightest trouble with the overhead work, and after eight months they could detect no appreciable wear of the conductor. Each bow strip required renewal after running for 15,000 miles. One of the most serious problems that they had to deal with was the lowering of the bow from 21 ft. in the yards to 13 ft. under bridges. This was a very difficult matter, but they had overcome it successfully, although in some instances the bow was only an inch and a half from the under surface of the bridge. Owing to the fact that porcelain was a strong, reliable substance under compression, but weak and unreliable under tension or flexion, he had adopted the former method throughout. He believed that the system described was the only one where the catenary suspensions were doubly insulated. A feature of interest was the oft-recurring St. Andrew's Cross painted on the iron work at intervals along the permanent way. These crosses marked positions where it was most economical for the motormen to switch off the current, and their adoption had resulted in a saving of from 5 per cent. to 10 per cent. in cost of energy. From diagrams which Mr. Dawson exhibited it appeared that the acceleration obtained was equal to over 1 mile per hour per second. Towards the end of his remarks he gave a brief description of an interesting petrol-electric inspection vehicle for use on the line. This little coach is equipped with a petrol engine and a small dynamo, and can be run to any part of the system with great rapidity. It is entirely independent of the overhead wires, and can therefore be employed when the current is switched off. The dynamo provides illumination and enables inspections and work to be carried out with the greatest ease.

In opening the discussion, Prof. Silvanus P. Thompson said he cordially agreed with Mr. Dawson that no one system, whether alternating or continuous current, could be set up as being suitable for all cases, but he thought that the author had shown how eminently suitable the single-phase system was for the specific purpose to which it had been applied in this particular instance. The problem with respect to short distances had already been solved, and he thought that for long distances single-phase working was greatly superior. Within the last few weeks he had seen drawings for a single-phase locomotive of no less than 2,000 H.P.

Other speakers in the discussion included Sir William White and Mr. Charles Hawksley.

The next Paper was by Mr. H. E. Wimperis "On the Use of an Accelerometer in the Measurement of Road Resistance and Horse-power." By the use of this instrument road resistances can be read off at sight, air resistances can be determined, the brake-horse-power exerted by an engine when running on the road can be found and other similar measurements can be made. An abstract of this Paper will appear in our next issue.

In the discussion, Prof. Dalby said that for years he and a number of his friends had been working at some instrument which would be capable of doing the things performed by that of Mr. Wimperis, and they had now given up all further work, as they were convinced that the problem was solved. Prof. Perry also warmly congratulated the author and remarked that the instrument described had undoubtedly a great future. Mr. Worby Beaumont also contributed to the discussion and gave demonstrations of the instrument on his car.

Prof. E. G. Coker then read a Paper on "The Cyclical Changes of Temperature in a Gas-engine Cylinder near the Walls." The following is a brief abstract.

Experiments described in October, 1908, showed that the temperature at the inner surface of a small gas-engine is about 240°C., and the cyclical variation usually less than 10°C. The steady conditions of low temperature at the wall-surface are maintained by the jacket-water, although the explosion of the gaseous mixture produces very great changes of temperature close to the walls. This variation has not hitherto been measured for a complete cycle owing to the difficulties which occur in measuring the highest temperature of the explosion. In order to obtain the cyclical variation near the walls, a couple was made of an alloy of 10 per cent. iridium and platinum, with a pure platinum wire, and this was secured in a metal plug so that it projected $\frac{1}{4}$ in. into the cylinder. On light loads and weak mixtures the couple remained unbroken, but near full load the platinum wire melted. Couples made from 10 per cent. alloys of iridium and rhodium with platinum were afterwards used, having an E.M.F. above 500°C. given by $E = -174 + 7{\cdot}6075\,T - 0{\cdot}00167T^2$, where T is the temperature Centigrade. The junctions were rolled down to five or six ten-thousandths of an inch thickness and inserted at a depth of $\frac{1}{2}$ in. from the cylinder wall. These couples were able to withstand the highest temperatures near the walls, and they were not melted except during abnormal explosions. Measurements of the cyclical variations showed a variation of E.M.F. lying between 1·56 and 7·83 millivolts with an average cold junction temperature of 30°C. The temperature variation corresponding to these values ranges between 250°C. and 1,700°C. In estimating the highest temperature reached, the upper limit of temperature is indicated by the partial melting of one of the wires when the engine ran above its full normal load, and the lower limit is indicated by the melting of platinum wire. The melting-point of platinum is $1{,}710 \pm 5$°C., and, in the absence of definite values of the melting-points of the alloys used, it is assumed that both are below the melting-point of iridium for which Violle's value is 1,950°C. The probable causes of error in the measurements were discussed, and the conclusion was reached that the temperature at the place of measurement had a maximum value between 1,850° and 1,900°C.

In the course of a demonstration of vacuum-tight seals between iron and glass, in Section A, Dr. Henry J. S. Sand showed some cathode-ray tubes in which a vacuum-tight seal between iron and glass had been obtained as follows: An iron wire was sealed into a glass tube, and while the glass was hot a small piece of heated steel tube surrounding the wire was pushed a few millimetres into the glass. After cooling, the tube was soldered to the wire. The vacuum-tight seal was produced between the inner surface of the elastic steel tube, which on cooling was put under tension, and the glass which came under compression. Seals with wires of 1 mm. diameter had been produced in this way.

Tuesday, September 6th.

Section A commenced this morning with a discussion on Atmospheric Electricity, opened by Dr. Charles Chree. As a preliminary, Dr. Chree set forth several headings which he thought were suitable for discussion, but confined himself to only two or three of these. He was more particularly concerned with the measurement of potential gradient, which was nearly always positive, the only exception occurring in bad weather, when it became negative. Relative measurement of potential gradient was a comparatively easy matter, but

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absolute measurement was a much more serious problem. The variations of potential during any one day were very irregular, but if a number of days were considered together then a smooth curve was obtained. Each daily curve could be split up into a variation extending over 24 hours, two over 12 hours, and if necessary others over 12, 8, 6 or any sub-multiple of 24 hours. It was found that the 24-hour curve varied most in mid-winter, while the 12-hour curve had maximum variation in mid-summer. Moreover, the 24-hour curve varied in phase to the extent of eight or nine hours, according to the time of year. Potential measurements taken on the earth were very unreliable, because of the effect of surrounding objects; also measurements taken by the aid of kites or balloons were unsatisfactory because it was impossible to ensure that even two consecutive readings should be taken at exactly the same spot, and again the results were affected by the proximity of the kite or balloon. The latter objection applied equally when the measurements were made on a mountain, but the mountain did at least stand still. It was found that the phase angle depended very much on the altitude. For instance, the mid-winter phase as obtained at the top of the Eiffel Tower was the same as the mid-summer phase obtained on the ground below. There was no well-marked 11-year period in atmospheric electrical conditions as was the case with terrestrial magnetism. In fine weather the potential gradient was probably about 200 volts per metre, but in bad weather it was much higher, readings as high as 1,000 volts per metre having been obtained in the presence of fog. At Potsdam the records showed 2,000 volts per metre, and it was quite possible that with improved apparatus they might be able to obtain results very greatly in excess of the existing ones. He suggested that the potential gradient might have a very important bearing on the growth of vegetation. For example, a tree was electrically connected with earth and its leaves would therefore be at zero potential, but if it were only 10 metres high the potential in the immediate neighbourhood of the leaves would be something like 2,000 volts under ordinary conditions. In connection with thunderstorms, he had never understood why it was that some trees were struck so much more frequently than others; the oak seemed particularly unfortunate, while the beech was hardly ever struck. If people must get under trees during a storm then they should select beech in preference to oak, and then not stand under an isolated tree, but go right into the middle of a wood. If he were caught by a storm while playing golf he would lie down in a bunker! In experiments on atmospheric electricity the gradual loss of charge from an insulated body was a source of great trouble, the rate of loss being much higher with a negative charge than with a positive. At Kew it was very high. From determinations with Wilson's apparatus for measuring "earth-air" currents it was ascertained that the average current in fine weather was about 2×10^{-12} amp. per square centimetre, and was always in the same direction, except in bad weather. As to whether it was a flow of positive electricity from the air to earth, or a flow of negative electricity from earth to air was a matter of opinion, but he inclined to the latter view. The question arose as to where all the electricity came from, and various unsatisfactory theories had been propounded. It was suggested by some people that the electricity went up at places of fine weather and came down at the same time at places of bad weather. This, however, could not account for the phenomenon, because it was known that the rain brought down much more positive than negative electricity. He put forward the suggestion that the radio-activity of the earth might account for it, for it had been shown that air drawn from the earth was highly radio-active. Hence, air might be forced into the earth under the influence of a high barometer and drawn out again when the barometer fell. This view was supported by the fact that the variations of the electrical conditions of the atmosphere corresponded to a certain degree with the variation of the barometer. As an illustration of the enormous penetrative power of atmospheric electricity, he quoted the case of a charged electroscope enclosed within an insulating vessel whose walls were sufficiently thick to prevent the passage of X-rays. In spite of this, the charge was gradually dissipated. He concluded by remarking that extremely practical results of investigation on atmospheric electricity might be expected in the near future.

In the course of his remarks, Sir Oliver Lodge said it must be borne in mind that the 24-hour curve might well be affected by the particles which the earth would pick up between the hours of 6 a.m. and 6 p.m. He had always wondered whether the change in the atmospheric electrification was the cause or the effect of bad weather. In other words, did the change in the potential bring about rain or did the rain bring about the potential change? If he were a capitalist he would try the experiment of controlling, or at all events modifying, the weather by varying the atmospheric electrification artificially. Of course, it would have to be done on a large scale and would involve large expenditure, but if successful would be well worth the money. On the whole there was too much drought on the earth, and it would be a great achievement to induce rain to fall where wanted. Referring to the effects of electricity on vegetation, he thought there could be no doubt that under certain conditions it had a stimulating effect. Explorers stated that plants grew with great rapidity in the Arctic regions, although they received so little sunshine, and he thought this was due to some electrical cause.

There was every reason to think that, for some forms of vegetation, electrical stimuli had the same effect as sunshine, and induced more vigorous growth. Moreover, experience showed that positive electricity, which alone produced this effect, should not be supplied in bright, dry weather, but only when it was dull and rainy. He personally knew of a farmer who increased his crops by 30 per cent. by the use of positive electricity, but on one occasion the crop was less than normal. It was discovered on investigation that for that particular year negative electricity had been supplied. The fact was that the apparatus was very simple and had been worked by a farm hand who, however, had managed to get things muddled up. Another farmer of his acquaintance had tried the treatment on a crop of beans, but the result was disappointing and he could not be induced to repeat the experiment. The fact was, he (Sir Oliver) thought that electricity appeared to damage leguminous crops. He thought that the points and edges of leaves facilitated the discharge of electricity from plants. This it was known, took place freely under the influence of ultra-violet light.

The next speaker was Dr. W. N. Shaw, who expressed disagreement with Sir Oliver Lodge regarding the control of the weather. He would like to know whether Sir Oliver realised the amount of energy represented by an inch of rainfall. In order to produce or abstract this energy something colossal would be needed. He suggested laboratory experiments first. He knew that some time ago Sir Oliver Lodge had conducted experiments in which clouds were represented by tea trays, but the fact was that there was nothing resembling a tea tray moving about in the atmosphere. Could not some closer approximation be obtained?

The next Paper of electrical interest was on "Photoelectric Fatigue," by Dr. H. Stanley Allen, and this was followed by one on "The Recoil of Radium B from Radium A," by Messrs. W. Makower, S. Russ and E. J. Evans.

In Section B (Chemistry) a report on "Electro-Analysis" was presented. This will be found in another column.

The Papers read before Section G were exceedingly good. That by Prof. S. P. Thompson on the "Laws of Electro-Mechanics" we hope to give in abstract next week. Dr. Thompson has collected together the expressions employed so frequently in electro-magnetic calculations and set them forth in his inimitable style. His exposition of the work was extremely clear, and he was particularly careful to point out that the symbol S does not always stand for number of turns, but may, in certain more complicated cases, include linkages, which, in simple cases are, of course, numerically equal to turns.

Mr. Frederic Bacon's Paper on "The Testing of Heat-Insulating Materials" was excellent; an abstract of it will appear in our next issue.

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In another column there appears the Paper read by Prof. E. Wilson and Mr. W. H. Wilson on "A New Method of Producing High-Tension Electrical Discharges," and it is necessary to refer only very briefly to it here. The fundamental is, of course, a spark coil, but it is by no means an ordinary spark coil. For instance, a 10 in. coil looks like an ordinary 3 in. coil and weighs only 10 lb. The primary of the coil is connected in series with an inductance and in parallel with them is a condenser. Attached to a small motor is a mercury contact maker with three contacts. The action is as follows: the mercury break is in such a position that the primary coil and the inductance are connected across the mains, as is also the condenser. This enables a magnetic field to be built up in the two coils and for the condenser to be charged. On the break being slightly rotated the supply is cut off, and the inductance discharges, as it were, into the condenser, raising its charge to a still higher potential. At the very instant that this discharge is completed the connections are changed, so that the inductance is cut out and the condenser connected directly to the primary of the coil, when a high frequency oscillatory discharge follows. Among the advantages claimed for this apparatus are: (1) It will work equally well on high or low tension circuits, whether alternating or continuous current. (2) It is extremely portable, weighing less than one-fourth of the ordinary coil and break. (3) The inverse E.M.F. is entirely eliminated, thus making it very suitable for X-ray work. (4) The efficiency is very high on account of small C^2R losses. (5) The resistance of the secondary is low (for a 10 in. coil about 3,000 ohms only), thus making it very suitable for wireless telegraphy. A feature of interest is the core, which is made of very fine insulated soft iron wire; this is absolutely necessary, owing to the high frequency of the discharge around the primary coil. The secondary coil is composed of fine aluminium strip, each section being one strip in width. The core of the inductance is not laminated as it is impossible for serious hysteresis losses to occur there owing to the slow rate of charge and discharge.

The Association will meet next year at Portsmouth under the presidency of Sir William Ramsay, K.C.B., F.R.S. The meeting in 1912 is to be held at Dundee, while an invitation to visit Australia has been accepted for 1914.

CORRESPONDENCE.

THEORY OF THE QUADRANT ELECTROMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The point raised by Prof. Robertson, and reiterated in his letter of September 2nd, with regard to absolute potentials occurring in electrometer formulæ, is one that will certainly demand attention when once an example of a formula containing absolute potentials is found. The veriest schoolboy knows that in electrostatic problems the potentials are represented as differences relatively to that of some one body taken as a standard of reference, and that all the actions depend on these differences. In the electrometer it may or may not be more convenient or more rational to take the needle as the standard instead of the case; but, in any event, the symbols employed represent P.D.s, not absolute potentials.

As to the second point on which he insists—namely, the impossibility of resolving the total electrostatic couple into deflecting and controlling components—I have only to explain that the type of electrometer which I had in mind when writing my Paper was the ordinary reflecting instrument working over a restricted range about a fixed zero. In such an instrument, charged to fixed potentials, the total electrostatic couple on the needle, when plotted against the displacement θ, gives a curve the part of which lying within the working range may usually be taken as a straight line, and may therefore be represented by $A+B\theta$. There is sufficient experimental evidence to render unnecessary any argument (if argument be needed) as to the correctness of this. The quantities A and B which determine the deflecting and controlling components of the electrostatic couple will, of course, depend on the potentials, the shape of the needle, &c.; but this in no way alters the fact that, for a given electrometer system under given potentials, and working about a fixed zero, the total electrostatic couple can be resolved into components in the manner described, provided always the deflections are not too large. Some misconception as to the restrictions which I impose probably accounts for any misunderstanding that may have arisen.

So far as mere algebra is concerned, I have no quarrel to pick with Prof. Robertson's formula; but it is essentially wrong in form, because V_1 is missing from that part of the denominator which does not contain k, that is, from the part which represents what I call the electrostatic control. This, on the face of it, by considering the pure physics of the problem alone, is incorrect. Prof. Robertson will see that this is so by introducing into his final formula the instrumental conditions, say, for example, the conditions for symmetry, the simplest assumptions as to which are that $dc_1/d\theta = a - b\theta$ and $dc_2/d\theta = a + b\theta$ numerically. He will then find that he has terms containing θ in the numerator, necessitating the re-casting of his formula, which ultimately takes the form given in my last letter.

It would be quite easy to frame any number of formulæ like that of Prof. Robertson containing any function of V_1 and V_2 juggled artificially into the denominator, all equally correct algebraically and all equally wrong physically. Any one of these might be set forth to masquerade as an electrometer formula with no real credentials whatever to substantiate its claims, and might easily lead the unwary to believe that the electrostatic control could be the most weird function of V_1 and V_2, or no function at all, for the matter of that. Any collection of algebraic symbols evolved to represent a physical relationship must always be submitted to the test of physical rationality, or common sense. Thus, the denominator of a correct electrometer formula must contain neither more nor less than what refers to the control, and the electrostatic part of the control must be a function of V, V_1 and V_2. Submitted to this test, both the formulæ of Prof. Robertson—the one containing $dc_2/d\theta$ in the numerator and V_1 only in the denominator, the other containing $dc_1/d\theta$ in the numerator and V_2 only in the denominator—while algebraically rational, are seen to be physically irrational. The formula obtained by combining them—that is, the formula suggested by me containing $(dc_1/d\theta + dc_2/d\theta)$ in the numerator and terms containing $(V-V_1)$ and $(V-V_2)$ in the denominator—is the correct one, being physically as well as algebraically rational.

What has just been said applies more particularly to a symmetrical electrometer, my remarks being perforce confined to this case because Prof. Robertson's manipulation of his formula, so as to get the factor $(V_2-V_1)(V-\frac{1}{2}\overline{V_1+V_2})$ into the numerator, shows that he has this special case in mind. If he has not, then he has no right to drag this factor into the problem because no such factor occurs in the final formula for an unsymmetrical electrometer. Efforts of this kind to twist, by algebraic artifices, an equation prematurely into some preconceived form, essentially foreign, very probably, to its true and ultimate character, are strongly to be deprecated; they are necessarily based on pure guesswork and are therefore pretty well bound to lead to results that are physically incongruous, if not actually erroneous. The only safeguard against hasty generalisation of this nature is to incorporate the instrumental conditions, when the desired formula will emerge at once in its proper form without the necessity of an appeal to the arts of algebraic subterfuge. Till these conditions are introduced the formula is, strictly speaking, not an electrometer formula at all, and any attempt to predict its final form, or to determine what particular functions of the variables enter into the numerator and denominator, must be very largely a matter of speculation. The necessary instrumental conditions here alluded to can be expressed approximately in Prof. Robertson's notation by putting $dc_1/d\theta = a_1 + b_1\theta$ and $dc_2/d\theta = a_2 + b_2\theta$; or, what is equivalent but preferable, by writing the total electrostatic couple in the form $A+B\theta$. Unless these precise conditions can be assumed, the resulting

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electrometer formula is much too complicated to be of any practical value. The possibility of framing a practically useful electrometer formula thus involves the possibility of representing the total electrostatic couple over the working range by an expression $A+B\theta$; in other words, it involves the possibility of regarding the electrostatic couple as resolvable into a fixed component and a component proportional to the deflection. If Prof. Robertson admits the feasibility of the one he must needs concede the possibility of the other.

Prof. Robertson says that the only difference between us is that I use a K while he expresses what K denotes in terms of a well-known physical quantity. The difference between us is that I do not introduce an entirely unnecessary quantity—namely, the capacity. My Paper was written to illustrate this particular point, and in it I nowhere even mention capacity. By the use of the electrostatic forces, expressed as such and not in terms of an extraneous quantity, I am able to account for the characteristic properties of the electrometer, as usually employed, in a way so simple as to verge on the obvious. The method even lends itself to a purely verbal explanation, without the aid of a single algebraic symbol, a claim which could scarcely be put forward for methods involving capacity. The introduction of capacity means obscuring the mental picture, and thus leads to confusion of thought, as witness the history of the electrometer theory. The correct explanation of the peculiarity in the electrometer characteristics has taken so long to arrive at, and has involved so many mathematical disquisitions, mainly because Maxwell in the first instance adopted the capacity method, and in dealing with a symmetrical electrometer said: I can assume as a first approximation that the capacities on the two sides of the needle can be represented by $a-b\theta$ and $a+b\theta$ respectively. If he had said: The electrostatic forces on the two sides of the needle vary linearly and can be represented by $a-b\vartheta$ and $a+b\theta$, the well-known characteristics would have been revealed at once, and much experimental work, together with reams of algebraical scribbling, rendered unnecessary.—I am, &c.,

Manchester University, Sept. 3. ROBERT BEATTIE.

RESTRICTED HOUR SUPPLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At Burton-upon-Trent we have been specially pushing the sale of power on the Restricted Hour System, as you are aware, and you have from time to time kindly emphasised this matter in your columns. I think the following figures, which are extracted from an article I have contributed recently to the "Electrical Review," will be of interest to your readers in this connection.

Figures showing Effect of Restricted Hour System.

	Previous to introduction of Restricted Hour System.			After introduction of Restricted Hour System.			
Year ended March 31st....	1903-4.	1904-5.	1905-6.	1906-7*	1907-8.	1908-9.	1909-10
Lighting units sold	278,289	292,602	313,254	311,899	336,805	318,319	301,964
Motor ditto	36,904	74,806	103,100	260,601	412,384	548,549	560,604
Total of above ...	315,193	367,408	416,354	572,500	749,189	866,868	862,568
Motors connected during year, kw.	11·5	44·0	62·5	169	190	62·0	102·8
Lighting connected during year, kw.	48·0	100·0	86·0	41	47	68·0	30·6
Total motors and lighting connected during year, kw.	59·5	144·0	148·5	210	237	130	133·4
Max. load, kw....	370	427	492	511	515	504	500
Load factor for lighting and motor supply...	9·73%	9·84%	9·67%	12·7%	16·6%	19·6%	19·7%

From the above it will be seen that for the 3½ years the restricted hour system of power supply has been in operation the total additional power and lighting connections amount to 710·4 kw., or an increase of 60 per cent., while the maximum load on the station has remained practically constant. This has had the effect of raising the load factor from 9·67 per cent. for the year ended March, 1906, to 19·6 per cent. in the year ended March, 1909, or an improvement of over 100 per cent. in three years.—I am, &c.,

Electricity and Tramways Department, P. J. PRINGLE.
Burton-upon-Trent, Sept. 3.

* Restricted hour system commenced at the end of October, 1906.

REPORT OF THE BRITISH ASSOCIATION COMMITTEE ON ELECTRO-ANALYSIS.*

The work on electro-analysis has been further elaborated during the year by the publication of Papers on the "Electro-deposition of Metals," by Dr. F. Mollwo Perkin and W. E. Hughes,† and by Dr. H. J. S. Sand on "Apparatus for the Rapid Electro-analytical Separation of Metals,"‡ and "The Electro-determination of Lead as Peroxide."§

Perkin and Hughes have devised and experimented with new cathodes for the rapid deposition of metals. One simple, smooth cathode is in the form of an elongated thimble, and with this, when rapidly rotated, very smooth and even deposits can be obtained; the total active electrode surface is about 16.3 sq. cm. Extended work has shown, however, that a platinum gauze cathode surrounding a spiral anode, which is rapidly rotated, gives the most satisfactory results. For separation of metals by means of graded potentials a funnel-shaped vessel with a tap for running off the electrolyte is used. This vessel has a side tube fused into it at about the centre to take the capillary of the auxiliary electrode. This form of apparatus gave very good results, and is very simple in working.

The experiments referred to a year ago by Dr. Sand with an anode made partly of glass and a cathode of metals, other than platinum, have been completed by him, and will be published shortly. Satisfactory results for copper were obtained with a cathode of silver, and for zinc with a cathode of nickel. In the former case the electrolyte deposit may be removed from the electrode by a solution of hydrogen peroxide in diluted sulphuric acid.

Experiments on the separation of the four metals—copper, antimony, tin and lead—have been continued. In connection with this work it has been shown that chlorides exert a retarding influence on the deposition of copper. This is due to the formation of derivatives of cuprous chloride during electrolysis from which copper is only deposited at a high potential. The conditions for the separation of copper from antimony have been fully elaborated, and mixtures of the three metals—copper, antimony and tin—corresponding to industrial alloys have been successfully analysed. When lead is present in small quantity this may be deposited with the tin; the greater part of the tin may afterwards be removed by making the electrode the anode in a solution containing sodium polysulphides. The lead may then be separated from the small quantity of remaining tin by means of nitric acid, and can afterwards be deposited electrolytically.‖

* This report was presented at Sheffield. The Committee consists of Prof. F. S. Kipping (Chairman), Dr. F. M. Perkin (Secretary), Dr. G. T. Beilby, Dr. T. M. Lowry, Prof. W. J. Pope and Dr. H. J. S. Sand.

† "Trans." Faraday Society, 1910, VI.

‡ *Ibid.*, 1909, Vol. CLIX.

§ *Ibid.*, 1910, Vol. CCVII.

‖ Preliminary note in "Proc." Chem. Soc., 1909, XXV., 228.

GALVANOMETER FOR ALTERNATE-CURRENT CIRCUITS.¶

BY W. E. SUMPNER, D.SC., AND W. C. S. PHILLIPS, B.SC.

Summary.—The authors describe a galvanometer for alternating-current circuits and resembling a moving coil galvanometer in almost every respect except that its field is due to a laminated electromagnet excited by an alternating voltage. A specially shaped stamping is placed between the poles. The use of the instrument as a voltmeter and for comparing inductances and capacities is explained.

The steady E.M.F.s and highly sensitive galvanometers available for use with direct-current tests render such tests excellent whether deflectional or balance methods are in question. Tests involving change of current, such as induction measurements, are not so satis-

¶ Abstract of a Paper read before the Physical Society. A brief account of the discussion that followed the reading of this Paper and a view of the instrument described appeared in THE ELECTRICIAN, June 24, 1910, p. 433

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factory. In ballistic tests the best galvanometers are in many cases not sensitive enough, and though balance methods are available they are usually not so simple in working as those in which steady currents are employed. Alternate-current tests are still less satisfactory. It is impossible to generate an E.M.F. whose constancy is comparable with that of a battery or accumulator. Special difficulties arise owing to effects of frequency, wave-form and phase. Balance methods can be devised, but they are rarely of much use, owing to the above difficulties and to the absence of sensitive instruments. A distinct advance has been made during the last few years by the construction of improved forms of vibration galvanometer. But this instrument overcomes only some of the difficulties. It is a sensitive indicator rather than a measuring instrument. It must be adjusted to resonance for the best effects, and its sensitiveness is necessarily affected by slight changes in current frequency.

The sensitiveness of ballistic galvanometer tests can be greatly increased by the use of mechanical commutators such as the secohmmeter of Ayrton and Perry, or subsequent modifications of this by Fleming and Lyle. But such methods only make use of a crude form of alternate current, and it appears that the simplest and most effective cumulative method for testing effects due to changes of current must in the end prove to be one involving the use of alternate currents generated in the ordinary way. The construction of the indicating instrument constitutes the real obstacle. The reflecting instrument for alternate-current circuits described in this Paper is the result of an attempt to overcome this difficulty. The instrument is like a moving coil galvanometer in almost every respect, except that its field is due to an electromagnet excited by an alternating voltage. The theory of non-reflecting instruments of the same type has already been fully explained,* but it may be convenient to refer briefly to it.

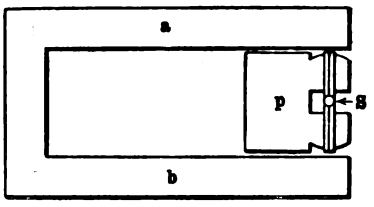
If an alternating voltage, V, be applied to an electromagnet whose winding consists of m turns, the core flux N will be such that $V = rA + m\dot{N}$, where r is the resistance of the coil and A the current traversing it. If the coil and electromagnet be so designed that for currents of the frequencies used the resistance is negligible in comparison with the impedance, we can neglect the term rA. It follows that the rate of change of N will be at each instant a measure of V, and this will be true whatever the permeability or hysteresis of the core. We thus have a magnet whose strength is accurately determined by the applied voltage whatever the physical properties of the core. Such an electromagnet can easily be made very strong. Moreover, the shorter the air-gap between the poles is made, the denser is the magnetic flux due to a given current and the greater is the ratio of impedance to resistance for a given winding. Thus the stronger the electromagnet is made by improving its magnetic circuit, the more accurate it becomes, provided this electromagnet is excited by the voltage of the circuit.

The instrument described has a laminated electromagnet formed of stampings shaped as shown herewith. These stampings are of two kinds—a rectangular portion with two straight limbs, *a b*, forming the core of the electromagnet, and a specially shaped stamping, *p*, between the poles. The stamping *p* is separated from the magnet limbs on each side by an air-gap. Each gap consists of two portions, a narrow part about 1 mm. across bounded by the straight edges of *p*, and a wider portion in which one of the vertical sides of the moving coil can turn round the curved edges of *p*. The moving coil, of 50 turns, is similar in shape, suspension and mode of control to that of an ordinary permanent magnet instrument. It has a central spindle indicated at *s* and working in a recess suitably stamped in *p*. The pile of stampings is about 4 cm. deep and 9 cm. long, the limbs being 1 cm. wide. Each of the limbs *a b* is wound with a coil of 2,000 turns of fine wire, and also with a coil of 100 turns of thicker wire. The two fine-wire coils are put in series and connected to three terminals; the two thicker coils are also put in series and joined up to two additional terminals. Thus the instrument can be excited by a winding consisting of either 200, 2,000 or 4,000 turns, according to the voltage used. The iron is not too strongly magnetised if the winding used contains 20 turns per volt on 50-cycle circuits. Thus 200 volts may be applied to the 4,000-turn coil, or 10 volts to the 200-turn coil. But the instrument is so sensitive that such excitation will only be needed for exceptional tests. The moving coil may be used with a condenser or other apparatus, either on some special circuit or in conjunction with one or other of the field coil windings. The instrument has been constructed by Robt. W. Paul, to whom several of the working details are due. The following are some of the uses of the apparatus:—

Use as a Voltmeter.—If a voltage, V, be applied to a field coil of m turns and if another voltage V_1 be applied through a condenser of K mfd. to the moving coil, it can be shown that the torque acting on the moving coil is a measure of $\frac{1}{m}KV\bar{V}_1$, or of the mean product of the two voltages. If the condenser voltage is obtained from one of the field coils of n turns the torque is measured by $Kn(V/m)^2$. There is really another factor the value of which would not be quite constant if the induction density in the gap varied with the position of the moving coil. But in the present instrument this factor is essentially constant owing partly to the shape of gap adopted and partly to the fact that for a reflecting instrument the movement of the coil is very slight. Numerous tests have shown that for any given choice of coils and condenser, the scale deflection is strictly proportional to the square of the applied voltage quite up to the limits of the scale used (300 mm. each side of zero for a scale distance of 1 metre). The numbers denoted by m and n may each be chosen either 200, 2,000 or 4,000, while the capacity K may be given widely different values. It is thus clear that the instrument can be used as a voltmeter for a large number of ranges.

The deflection is independent of frequency and wave-form if the field winding to which the voltage is applied has a resistance negligible in comparison with its impedance. This will always be the case if the frequencies used are high. But if the frequency is low and the mass of copper used in the magnetising coil is small, the resistance of this coil will become comparable with its impedance, and the deflection will then be dependent on frequency.

Use with Null Methods.—In ordinary bridge methods (of which the author illustrates six) for comparing inductances and capacities a ballistic galvanometer is used as an indicator, and to test the balance the current A through the arms of the bridge is made or broken by a key. All these methods may be used with the present instrument for steady inductive balances on alternate-current circuits, and the same formulæ apply to the zero deflection condition, provided (ii.) the alternate voltage V applied to the field-coil of the instrument also causes the current A through the bridge conductors; (ii.) the alternate current A is made essentially cophasal with V by



the use of suitable non-inductive resistances; (iii.) the moving coil of the instrument is placed directly across the bridge (using a reversing key when desirable). It results from the special properties of the instrument that the flux in the gap of the electromagnet is in quadrature with the applied voltage (and thus in quadrature with A). The inductances or capacities produce voltages or currents also in quadrature with A, and thus in phase with the flux, so that their phase is such that they produce the maximum torque of the moving system.

These methods have all been thoroughly tested on alternate-current circuits with the present instrument, and with most satisfactory results. The balance can be adjusted with ease to 1 part in 10,000, when the voltages set up on the coils or condensers are merely of the order of 1 volt, and thus suitable for use with the resistance boxes ordinarily found in laboratories. Certain special points, however, call for notice. When a balance of great precision is needed, the minute E.M.F. (e) induced in the moving coil by the alternating field of the magnet tends to cause a small deflection disturbing the balance. When the moving coil circuit is essentially non-inductive the current due to e will be in phase with e, and in quadrature with the flux, and in such cases the corresponding deflection will in general be negligible. For inductive circuits, however, a small deflection due to e will occur. But in all cases any effect due to e can be accurately eliminated by using a false zero method—that is, by adjusting the balance till the reading on the scale is unaltered by switching the bridge current on or off. In most cases it will be found sufficiently accurate to take the mean of the two conditions of balance obtained by using a reversing key with the moving coil. The false zero method is simpler and is mathematically accurate, though in practice, as with all false zero methods, there is a liability to a small error due to the variations of the false zero deflection in sympathy with fluctuations in the main current or voltage.

Examples of the bridge methods are given by the authors to illustrate the conditions of working.

Other Uses of the Instrument.—The voltmeter tests described show that the instrument can be used to measure very small capacities,

* "Proc. Roy. Soc.," Vol. LXXX. (1908), "Alternate-current Measurement."

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especially in cases where it is possible to apply high voltages to the condenser. It will be apparent from the expression $\frac{1}{m} K\bar{V}\bar{V}_1$ that if the voltage V_1 applied to the condenser is in phase with the voltage V applied to the field, and a known multiple of it, the sensitiveness can be indefinitely increased by making V_1 large.

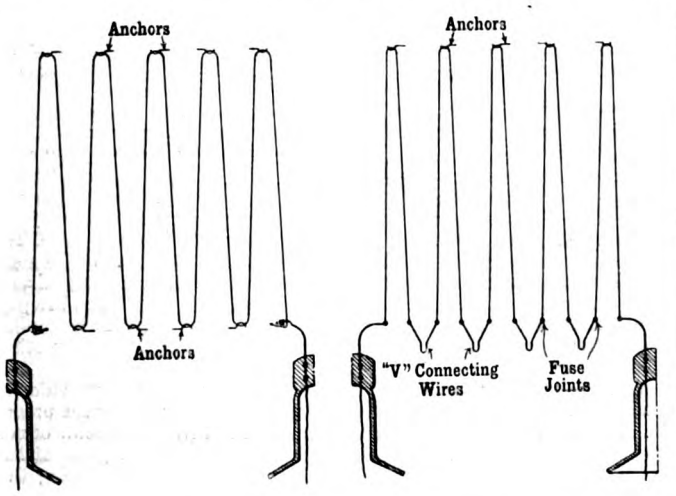
The instrument has not yet been tested with alternate currents of higher frequencies than 100 cycles per second, but there appears no reason to suppose there will be any difficulty in the way of its use for high frequency work.

Added July, 1910.—Mr. A. Campbell has drawn our attention to a Paper, previously unknown to us, in which Stroud and Oates ("Phil. Mag.," 1903) describe an instrument resembling in some respects the galvanometer here referred to. The Paper gives data of the electromagnet showing that it contained a greater volume of iron than that of the instrument here described. But no details are given of the air-gap between the poles, and it does not appear that any attempt was made to produce a magnetic field whose phase is essentially in quadrature with that of the applied voltage. The characteristics of the present instrument are the result of such a relationship. In the Stroud galvanometer the field in the gap is probably stronger and less uniform than that of the instrument here described, since the disturbing influence of this field on the moving systems seems much more serious.

A NEW FORM OF TUNGSTEN LAMP.*

BY C. F. SCOTT.

The author describes a tungsten lamp called the "wire type," which has been developed by the engineers of the Westinghouse Lamp Co. The accompanying illustrations compare the wire type



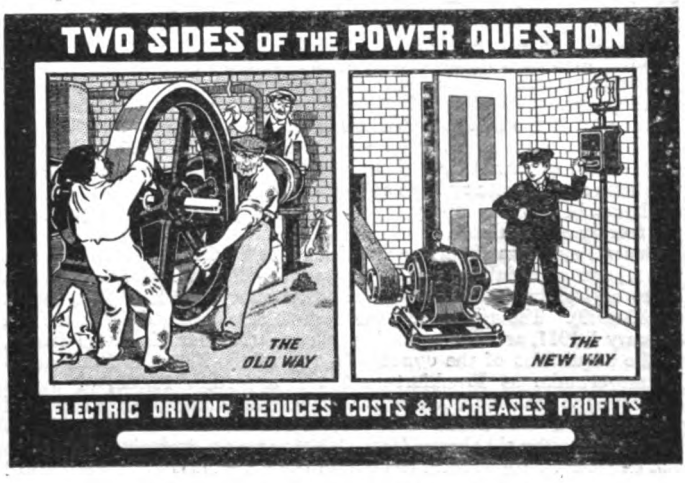
with the usual type of tungsten lamp. The main elements of the former are a single long filament, intermediate hook supports which hold the filament loosely and a terminal which is described as mechanically and electrically adequate. The common tungsten lamp consists of a number of filaments in series, the individual filaments having their ends fused together to stiff supporting wires. The new lamp adopts what is described as the ideal way of overcoming the disadvantages of this method, namely, by employing a single filament and so mounting it that the filament is not rigidly fastened to supports. The single filament is wound back and forth around hook supports at numerous points, and a few turns near each end wound in the form of a spiral spring around the respective leading-in wires, and the ends fused. The several turns of the filament around the leading-in wires act as a sort of a spring, so that a slight bending of the filament, resulting from a blow or vibration, does not act directly upon the fused joint, as would be the case if the straight part of the filament came directly from the fused joint as in ordinary construction. Furthermore, carelessness in the act of fusing is stated to be of minor consequence in the wire type of lamp, whereas it might seriously lessen the strength of the filament in the common forms of lamp.

A tungsten lamp, using, say, five filaments, is analogous to five independent lamps in series, and its life will be fixed by that of the weakest filament. On the other hand, a process in which a yard or more of filament is made in one piece is not liable to the conditions which are possible and probable when a lamp contains several filaments which have been made at different times and under the necessarily different conditions incident to commercial manufacture. It is stated that the mechanical excellence of the new lamp is attested by the result of comparative experiments with such lamps and lamps of the ordinary type. Among these was a test consisting in dropping a weight on a board held on supports about 4 ft. apart, to which lamp sockets were attached. It was found that with the wire type the weight had to fall from four times the height to cause the same destruction as in the case of the fused type of lamp. The mechanical tests in the aggregate showed that the wire type of lamp is much less liable to injury than the fused type where subjected to blows which are of a kind similar to those that may be expected in service. It is stated that the wire type tungsten filament is made in long lengths, the present equipment making several miles a day.

* Abstract from "The Electrical World" of a Paper read before the National Electric Light Association.

ELECTRICITY SUPPLY PUBLICITY.

The efforts of the Committee of Electric Supply Publicity to popularise the use of electrical methods have largely consisted of a number of well-designed posters and postals, the latter taking the



TWO EXAMPLES OF SUPPLY PUBLICITY POSTERS.

form of postcards, booklets, leaflets, &c. We have, from time to time, illustrated some of the best of these designs, and the accompanying illustrations show two of the latest examples which this class of publicity has provided. It will be noted that Sarah Anne, as might be expected, offers no objection to the easier times which electric heating gives her in the round of her daily work. If the

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electric radiator is brought into the domestic circle many of the discomforts and much of the work which coal fires entail will be avoided, and now is the time to push this side of the electricity question. The smaller illustration is a modification of an earlier poster issued by the Committee, and provides the user of small power units an object lesson. The aspect here shown of electricity supply cannot be driven home too severely. The industrial who uses the small steam, gas or petrol engine when electric current is available at a reasonable rate has only himself to thank for the trouble he finds for himself; those who know most about the subject will appreciate the pictorial way of putting it.

The present opportunity may be taken for pointing out that the Publicity Committee has recently extended its scope of usefulness to cover the provinces and a portion of the title ("London and District") is now omitted. The option of purchasing the literature issued by the Committee has also been extended to the Colonies.

GERMAN ELECTRICAL MANUFACTURERS COMBINATION.

It is officially announced that the Allgemeine Elektricitäts Gesellschaft have acquired the dynamo works (at Frankfort) of the Felten & Guilleaume-Lahmeyerwerke A.-G.

In this connection it is stated that, owing to the reduction of the dividend for 1909 of the Felten & Guilleaume Lahmeyerwerke, which was due to the slackness affecting the dynamo factory at Frankfort, negotiations were opened for the disposal of the Frankfort factory. These negotiations have now resulted in an understanding with the A.E.G., in virtue of which the Felten & Guilleaume Co. disposes of the dynamo factory to the A.E.G. in return for an issue of A.E.G. shares. The factory is to be transferred to the A.E.G. in the form of a company with a share capital of 10,000,000 marks (£500,000) and reserves of 3,000,000 marks (£150,000). The new company takes over the buildings and plant of the dynamo factory, together with inventory and stores, but not the debit and credit accounts.

The official narrative continues as follows: "The factory thus falls into the hands of an undertaking that possesses the strength and resources necessary for its profitable development. At the same time the A.E.G., in consequence of the relation established through the transfer of its shares, will be able to enter the Frankfort factory on its balance-sheet at a low book value, while the Felten & Guilleaume Co. will reap the advantage that it will for the future be able to invest with profit in its main works the considerable amount of capital that it has hitherto expended on its Frankfort factory. Its former position is considerably improved, as it can now, instead of incurring losses on its dynamo factory, effecting profits by means of the capital which is now released. The A.E.G. has (it is stated) only consented to take over the dynamo factory under the provision that a sufficient amount of shares of the Felten & Guilleaume Co. is made over to it on favourable terms. Certain far-seeing large shareholders of the Felten & Guilleaume Co. transfer 16,000,000 marks (£800,000) of shares to the A.E.G., and the latter (jointly with the Electro Bank of Zürich allied with it) acquires 32,000,000 marks (£1,600,000) of shares of the total 55,000,000 marks (£2,750,000) of shares of the Felten & Guilleaume Co. and therewith the controlling influence over this highly reputable company, from whose signature the name of Lahmeyer will henceforth be withdrawn. The advantages derived by the A.E.G. are increased by the fact that by taking over the Frankfort dynamo factory it disposes of certain competition, and acquires with the dynamo factory both material values and goodwill on favourable terms. While the A.E.G. thus considerably strengthens its position, the combination will pave the way to renewed successful efforts on the part of the Felten & Guilleaume Co. by releasing it from the care of the Frankfort works. The transactions require 20,000,000 marks (£1,000,000) of new A.E.G. shares, and at the same time shareholders will have a preference right to subscribe for 10,000,000 marks (£500,000) of shares, in order to supply funds for the working and development of the factory at Frankfort.

General meetings of both companies are called for October 13th, when the following resolutions will be proposed:—"The A.E.G. shall raise its share capital by 30,000,000 marks (£1,500,000) to 130,000,000 marks (£6,500,000). The new shares, which shall have dividend rights as from January 1, 1911, are to be applied as follows: One-third, in round figures, to the acquisition of the dynamo factory of the Felten & Guilleaume-Lahmeyerwerke at Frankfort-on-Main; a further 10,000,000 marks (£500,000) to the acquisition of 16,000,000 marks (£800,000) of shares of the Felten & Guilleaume Co.; 10,000,000 marks (£200,000) will be made over to the old shareholders at 210 per cent., inclusive of all costs and expenses. The general meeting of the Felten & Guilleaume Co. will pass resolutions to convert the Frankfort factory into an independent company, with 10,000,000 marks (£500,000) capital and 3,000,000 marks (£150,000) reserves, the transfer of these shares to the A.E.G. and the change in the name of the Mülheim undertaking into the old name of the Felten & Guilleaume Carlswerk A.G.

In order to bind the A.E.G. and the Felten & Guilleaume Companies more closely together, certain directors of the Felten & Guilleaume Co. will be proposed as a supervisory committee (Aufsichtsrät) for the A.E.G., and certain others will be proposed as a supervisory committee for the Felten & Guilleaume Co.

TRANSVAAL ELECTRIC POWER ACT, 1910.

We give below a full abstract of this act, which received assent on April 28, 1910, and constitutes an Advisory Board of not more than five persons (styled the Power Undertaking Board).

By the provisions of the act, the Government mining inspector is to be one of the members and also chairman of the Board, and all the members shall be officers in the railway or public service. No person, except the Council of a municipality, shall (save as hereinafter provided) engage in an undertaking to supply to any other persons power exceeding 20,000,000 units in one year unless the undertaking be licensed, but undertakings existing prior to the commencement of the act may be continued for one year, and no longer, unless licensed under the act. Applications for licences must be sent with plans to the Minister of Mines or other Minister to whom the administration of the act is assigned. Applications from companies must be accompanied by the memorandum and articles of association and particulars of capital, and must state situation and extent of land for sites of generating and distributing stations, names of owners and occupiers of such land, proposed sources of water for the undertaking, area of supply, route of transmission lines, powers required for breaking up roads, &c., proposed schedule of prices to consumers and minimum to be supplied to any consumer, estimated cost of generation, contracts entered into, &c., &c. The Board will fix a date to hear applications and objections, and when an applicant wishes to supply power in the area of a licensee he must give notice to such licensee 21 days before the hearing. Applicants must give notice to the town clerk if it is proposed to construct a transmission line through a municipality or to supply power within a municipality. A licensee may not supply power within a municipality without the consent of the Council thereof, except for mining purposes or to the railway administration or any Government department; but the consent of the Council must not be unreasonably withheld (in the opinion of the Board), and the Governor may in such a case authorise supply without the consent of the Council.

Licences will not be transferable without the consent of the Minister, and the licensee shall not carry on any other business or undertaking, nor in the generation of electric energy use coal from any mine in which he is interested directly or indirectly. The grant of a licence shall not be deemed to confer any monopoly. The Governor may fix a limit to the amount of power to be generated. Seven days' notice must be given to an authority having control of roads, sewers, &c., of intention to break up such roads, sewers, &c., and the licensee must pay to the authority reasonable costs of superintendence of such works. No rights over land which is not proclaimed land or land held under mining title shall be acquired without the consent of the registered owner. Power must be supplied to every person applying for same in the area of supply. In cases of delay or refusal to supply, the Minister may decide whether the licensee shall supply, and may prescribe the charges and conditions, having due regard to the provisions of the following sections of the act. A supply not exceeding 300 kw. shall be given within 6 months of the Minister's decision, 600 kw. 9 months, 1,000 kw. 12 months, 2,000 kw. 15 months, 3,000 kw. 18 months, and exceeding 3,000 kw. within such period as the Minister may determine. No person shall be entitled to a supply for premises having separate supply, unless he has agreed to pay such minimum annual sum as will give a reasonable return on the capital expenditure incurred to meet his possible demand and to cover other standing charges.

A licence may contain a schedule of standard prices and provide for periodic revision of such schedule, and for the sharing of surplus profits as follows: At the end of seven years, and thereafter at intervals of not less than three years, the Minister shall revise the schedule, and at the revision not more than one-half of the reduction effected during the interval in the cost of supplying power shall be applied to a reduction of prices, and provision may be made in a licence for an automatic adjustment of prices at any time consequent upon an alteration of railway rates or other circumstances. The licensee shall pay to his consumers 25 per cent. of the surplus profits, ascertained by deducting from gross revenue the working expenditure, head office and administration expenses, maintenance and such other charges and such interest on share capital and debentures as the licence may provide for. The allowance to be made in respect of any consideration passing to a vendor, promoter or founder shall not exceed 20 per cent. of the share and debenture capital. A licensee may vary his charges either above or below the standard price, with due regard to the amount of power consumed, uniformity or regularity of demand, time during which power is required, expenditure in furnishing the supply, &c. Disputes in regard to price shall be referred to the Minister. No arrangement whereby any charge to a consumer shall be reduced below the standard price shall be valid unless the proposal be submitted to and approved by the Minister, and no advantages, rebates, preferences or privileges shall be granted to any consumer except as provided by the act, or as the Minister may permit.

A licence may be revoked and the Governor may expropriate an undertaking for breach of conditions of licence, and continuance of such breach after a month's notice from the Minister, or if a licensee fails to satisfy the Minister within a period stated in the licence of ability to discharge the obligations imposed, or if the licensee fails to deposit the security required by the licence. The Governor may expropriate an undertaking after 37 years upon two years' notice and upon payment to the licensee of the existing value of lands, buildings, works, machinery, materials and plant, and no addition shall be made for goodwill or for prospective profits. The Governor may also purchase an undertaking on similar terms in the event of a licence being revoked. Any dispute as to the purchase price shall be determined by arbitration.

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Persons stealing electric current shall be liable to penalties prescribed for theft, and persons unlawfully injuring or interfering with apparatus with intent to cut off the supply of current shall be liable to a fine not exceeding £1,000 or to imprisonment not exceeding 10 years. In proceedings arising out of damage or injury by means of electricity the burden of proving that all due diligence was used by him shall lie upon the defendant.

Meters, fittings, &c., shall not be liable to distress for rent, &c., provided they bear marks indicating the licensee as the actual owner. If any person carry on an undertaking without a licence, or in contravention of the act or the regulations or the terms of any licence, or if any licensee fail to carry out the decision of the Minister, he shall be liable to a penalty of £50 for every day such undertaking be so carried on or such failure continue. Any person desiring to supply to any other person power not exceeding 20,000,000 volts per annum may obtain permission from the Governor. The Governor may from time to time make, alter and rescind regulations consistent with the provisions of the act. Nothing in the act shall affect the provisions of the Irrigation Act, 1908, or the Precious Metals and Base Metals Act, 1908, relative to obtaining and use of water to develop power, or the law for the time being relating to the construction, maintenance and working of telegraphs or telephones by the Post Office or Railway Administration, and save as is otherwise specially provided in this act nothing contained in the act shall be deemed to abrogate or alter any powers, rights, privileges or duties conferred upon any municipal council under any general or special law regulating the powers, rights, duties and privileges of that Council, or to prevent such a Council from carrying on without a licence an undertaking to supply power.

LEGAL INTELLIGENCE.

Feld Bros. & Co. v. Pinkerton.

In the City of London Court last week, before Judge Lumley Smith, K.C., plaintiffs sought to recover £37. 6s. for Osram and other metal filament lamps supplied.

DEFENDANT complained that the Feld lamps supplied to him went black and were returned by his customers. He said that all electric lamps went black after being burned for 1,200 hours.

Mr. FICHTERMANN (of plaintiffs' firm) said defendants had kept the lamps complained of for five months, and that was wholly unreasonable.

Mr. GIBBONS (for plaintiffs) pointed out that defendant knew the nature of the goods he was buying.

DEFENDANT said that was true, but the lamps ought to have been examined in plaintiffs' factory before they were sent out, and plaintiffs must take the risk if some of the lamps arrived at his (defendant's) place damaged. He had to send them out to his customer unexamined to save handling them. He took his customer's word if they were returned broken. More lamps were broken from rough handling than from wear. He was now demanding deductions for discounts which had not been allowed.

Mr. GIBBONS said that was because defendant was not entitled to them. Defendant said there was a 20 per cent. discount on some of the lamps and 7½ per cent. trade discount on others.

Mr. GIBBONS said that the trade discount was only allowable if defendant paid in seven days, which he did not.

Judge LUMLEY SMITH found for plaintiffs for £30 and costs, plaintiffs to fetch and take back the broken lamps.

Tramway Fare Collection.

At Manchester City police court on Friday last week two tramcar passengers were charged with attempting to avoid payment of their fares. In the first case a workman (Stanhope) was said by a ticket inspector to have boarded a car going from Guide Bridge to town near Chancery-lane, and heard the guard (who was on top) ask if all passengers had tickets. Later the conductor found defendant had no ticket, and when asked where he got on he replied Chancery-lane. A woman passenger said he was on when she sat down at Bersamy-street, and eventually defendant admitted that he got on near the Halfway House, so that 1½d. was due from him.

Defendant pleaded that he had not been asked for his fare. The Clerk made the comment that he had not been asked to get on to the car, and he ought not to expect to be asked for the fare. He was fined 5s. and costs, with extra costs for two witnesses.

In the second case, that of a youth (age 15), the charge was dismissed with a caution.

T. Fairlie & Co. v. West of Scotland Billiards Co.

On Tuesday Sheriff-substitute Smith Clark issued his decision in this action brought by plaintiffs for payment of £91. 14s. 11d. for putting in new and the rearrangement of existing electrical fittings in defendants' premises. Defendants, while admitting that plaintiffs were instructed to do certain work for them, took objection to certain items which they said had not been incurred on their instructions; that no credit was allowed for goods returned, and that plaintiffs had contracted to supply certain items at prices less than those charged. Defendants tendered payment of £60. 19s. 11d. The Sheriff held that these objections to the account had no solid foundation. He found that the prices charged were reasonable and proper, and held defendants liable to pay the account, less £4. 1s. 6d. for returns, and he gave decree for the balance outstanding (£26. 13s. 6d.) with expenses.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An assistant engineer is required by an English company operating in South America; must have had experience in station running and three-phase h.-t. working. Commencing salary £250 per annum. See an advertisement.

A telegraph and electrical instrument inspector is required for the Baro Kano Railway (Northern Nigeria) for two tours of 12 months' residential service, with possible extension. Salary £250 a year, rising to £300 by annual increments of £10. Applications to the Crown Agents for the Colonies, Whitehall-gardens, S.W., up to the 17th inst. Further particulars are given in an advertisement.

Wireless telegraph operators are required for the Canadian Navy; must be experienced men of good character. Particulars from the Captain, H.M.C.S. "Niobe," Devonport. See advertisement.

An outdoor representative is required for a London Electric Supply Co. See advertisement.

There is a vacancy for an improver (without salary) at the Watford electricity works; also for a premium pupil. Applications to the Chief Electrical Engineer. See advertisement.

Applications are invited for the vacant position of assistant lecturer in the physics department of the Technical College, Sunderland. Commencing salary £150 per annum. Particulars from the assistant clerk to the Education committee (Mr. Herbert Reed), 15, John-street, Sunderland. Applications by Sept. 10.

The Council of the University of Birmingham invite applications for the appointment of assistant lecturer and demonstrator in electrical engineering. Stipend £150 per annum. Applications to the secretary, Mr. Geo. H. Morley, by Sept. 17.

An instructor in electrical and mechanical engineering is required at the Limerick municipal technical schools. Initial salary £130 to £150, according to qualifications. Applications to the Principal, 69, George-street, Limerick.

As announced in our last issue, Mr. A. J. Howard, chief assistant at Taunton, has been appointed borough electrical engineer, in succession to Mr. Thornhill, at a salary of £200. The four candidates selected for interview by the Electricity committee were Mr. A. J. Howard (Taunton), Mr. A. W. Clay (deputy electrical engineer, Accrington), Mr. W. J. U. Sowter (engineer and manager, Bray), and Mr. W. F. Stamp (deputy electrical engineer, Devonport). The final ballot was between Mr. Howard and Mr. Sowter, and the former succeeded by a majority of two votes.

Salford Electricity committee have promoted Mr. E. H. L. Dickson, mains superintendent, to the position of deputy borough electrical engineer, at his present salary of £270 per annum, rising by biennial increases of £25 to £325.

Mr. Lambert, manager of Messrs. Stevens (Ltd.), of Maidstone, has been appointed manager of the Maidstone tramways in succession to Mr. F. Saunders.

Capt. Gerald Thorp, R.E., has been appointed an instructor in the (Army) Schools of Electric Lighting, vice Capt. A. C. J. Stevens, R.E., whose appointment has expired.

On the recommendation of the Gas committee, Leicester Corporation have appointed Mr. Hubert Pooley, manager of the gas and electricity works at Stafford, to the position of manager of the Leicester gas and electric lighting undertakings, in succession to the late Mr. Alfred Colson, at a salary of £800 a year, rising by annual increments of £100 to £1,000.

EDUCATIONAL NOTICES.

University of London, Goldsmiths' College.—The new session commences on Monday, Sept. 26, and the enrolment of students commences on 19th inst. Complete courses of instruction are provided in mechanical, electrical and constructional engineering, telephony, fitting and machine pattern making and smithing, land surveying, &c. Students are prepared for the London University degree of B.Sc. in engineering, for the examinations of the Institution of Civil Engineers, Board of Education and City and Guilds of London Institute and for the National and Whitworth scholarships. There are reduced fees to course students if paid by Sept. 23. Particulars of fees, &c., from the Warden, Goldsmiths' College, New Cross, S.E.

University of Edinburgh.—The next session opens on Oct. 4, and the preliminary or entrance examination is held in September. In the engineering department of the University complete courses of instruction are provided in civil, mechanical and electrical engineering, qualifying for the degree of B.Sc. in Engineering, and extending over a period of three years. Particulars of entrance examination

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scholarships, fees, &c., can be obtained from the Matriculation Office of the University.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

University of Liverpool.—We have received a copy of a pamphlet which gives particulars of the courses of instruction provided in the Faculty of Engineering of this university. The session 1910-11 will commence on Oct. 4.

The courses of study in the faculty leading to the ordinary degree of Bachelor of Engineering extend over at least three years, and they are so arranged as to afford a general scientific training for those who intend to become engineers, naval architects, surveyors, &c. There is a course of not less than two years, leading to a certificate in engineering, for those who do not proceed to a University degree. A fourth year of study is arranged for honours students. Arrangements are made for students to spend the summer vacation in works or to take a voyage as junior engineers in steamships. Special facilities are granted to graduates of other universities who wish to pursue some special branch of engineering or to carry out research work.

University College of North Wales (Bangor).—In October a systematic course of instruction in electrical measurements and practical electricity for students proposing to enter the profession of electrical engineering will be commenced. The physical laboratory is well equipped for experimental and research work. The course extends over two sessions. Prospectus and further information may be obtained from the secretary and registrar, Mr. J. E. Lloyd, M.A.

Merchant Venturers' Technical College.—The faculty of Engineering of the University of Bristol is provided and maintained at the Merchant Venturers' Technical College. There are complete courses of instruction in civil, mechanical, electrical, mining and motor car engineering. Calendar (6d.) or prospectus (1d.) may be obtained from the Registrar.

Northampton Polytechnic Institute (London).—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Monday, Oct. 3.

The courses in mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include specialisation in radio-telegraphy. The entrance examination takes place on Sept. 28 and 29. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in engineering at the University of London. There are full and part time courses in all branches of technical optics. Particulars as to fees, &c., can be obtained at the Institute, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Sir John Cass Technical Institute.—At this institute there are evening classes in chemistry, metallurgy, physics and mathematics, and the courses are designed to meet the requirements of those engaged in chemical, metallurgical and electrical industries, and in trades associated therewith. Facilities are given for special and advanced practical work in well equipped laboratories both in the afternoon and evening. The instruction in general physics and mathematics will prepare for the final B.Sc. examination of London University, and there are special courses on general physics and electricity and magnetism for the honours B.Sc. on induction in gases and radioactivity and on the differential and integral calculus for science students. The new session begins on Monday, 26th inst. Particulars of the courses can be obtained at the offices of the Institute, Jewry-street, Aldgate, London, E.C., or by letter of the Principal.

Battersea Polytechnic (London, S.W.).—The day courses at this Polytechnic prepare for the B.Sc. degree (in engineering) of the University of London, and for the Polytechnic diploma in mechanical, electrical, civil and constructional engineering. The day courses commence on 22nd inst. and the evening courses in the same subjects on 26th inst. Prospectuses from the Secretary.

BRITISH NOTES.

Accrington.—In order to be able to meet the increased demand for electric current entailed by the supply to Haslingden and Church the Council have purchased some plant recently in use at the Millbank station of the Westminster Electric Supply Corpn., London. The total cost of the extensions (plant, buildings and mains) for giving a bulk supply to Haslingden will be £9,687, and new cables to Church will cost about £1,000. Sanction to a loan of £16,359 has been applied for. Oswaldtwistle Council has also asked for terms for supplying electricity for power and lighting.

Aldeburgh.—Messrs. Christy Bros. & Co. have intimated that they will apply for a provisional order.

Application for Restoration of Lapsed Patent.—The Aktiebolaget L. M. Eriesson & Co. have applied for the restoration of the patent granted to Kjöbenhavna Telefon-Aktieselskab for "Improved apparatus for the automatic distribution of the operating service in telephone exchanges," numbered 14,851/1906, which expired on June 30, 1909, owing to non-payment of renewal fee. Notices of opposition must be sent to the Patent Office, London, by Oct. 31.

Barrow-in-Furness.—The Council have decided to consider the question of exercising their option of purchasing the local tramways from the British Electric Traction Co.

Application is to be made for sanction to borrow £5,000 for mains, services, &c.

Bath.—The Board of Trade have intimated to the Rural Council that their electric lighting order will be revoked as a portion of the area has been included in the order granted to the Corporation.

Bexley Heath.—Notice of three resolutions relative to the position of the electrical engineer and tramways manager had been given for the last meeting of the Council.

Coun. FRANKLIN, who moved "That the electrical engineer and tramways manager be given three months' notice to terminate his appointment," said he believed there was not a member of the Council who did not really feel that a change in the management of the tramway system was desired. He had nothing whatever to say against the manager as a man, but he was bound to remark that somehow or other he had not done sufficient to make the concern pay. He believed that if they had a fresh man who was capable he would, after 12 months' trial, make it pay.

Mr. SMITH moved, as an amendment, "That having regard to the last report from the Electric Light and Traction committee as to the deficit on the tramway undertaking, the Council give instructions for the immediate preparation of the financial statement of the working, &c., for the year ended March 31, 1910, and to fix at an early date when the same shall be considered by the Council with a view to affording an explanation to ratepayers generally, and particularly those in parts of the district who bear their portion of the burdens of deficit but do not partake in any advantages."

Mr. BAKER BEALL, who seconded, said that they should not blame their manager. The real fact was that the whole of the loss was due to the Council itself, and to its abominable business in managing.

The amendment was carried, the other two motions being ruled out of order.

Blackburn.—The Council decided last week that all tramcar drivers must be examined by the medical officer of health at least twice a year.

Bognor.—The Chichester Electric Light & Power Co. have notified the Council of their intention to apply for a provisional order, and the clerk has been instructed to ask five consulting firms to state their fees for reporting on an electricity scheme.

Bootle.—The Council have decided to apply for sanction to a loan of £8,500 for extensions of the electric supply cables and feeders and for meters, services, &c.

Brighton.—At the meeting last week the Council adopted the report and recommendations of the Lighting committee in regard to the renewal of the condensing pipes, &c., at the Southwick power station owing to the obstruction of the old pipes by mussels and other marine growths.

Cleckheaton.—An unopposed inquiry was held on Tuesday into the Council's application for sanction to borrow £2,210 for extensions of the electric cables and services.

Coventry.—The Corporation, who will have the option of acquiring the local tramways in February next, have appointed a special committee to consider and report upon the advisability of exercising the option.

Darlington.—The Electricity & Tramways committee have reduced the rent of meters by 50 per cent.

Electric Sewage Pumping.—An L.G. Board inquiry has been held into an application of Doncaster Council for sanction to a loan for works of sewerage and sewage disposal for Owston and Skellow, where a large colliery is being constructed.

The scheme, which has been prepared by Messrs. D. Balfour & Son, consists in the laying of several miles of main sewers of c.-i. and stoneware pipes surrounded by concrete, which will be conveyed to an underground pumping station where the sewage will be automatically pumped by electric motors driving centrifugal pumps to the site of the purification works.

Electricity in Collieries.—At the recent meeting of Bolckow, Vaughan & Co., the chairman said that during the past year they had spent nearly £31,000 out of profits on extensions, plant, &c., consisting principally of expenditure at their collieries and of electrical installations, haulage, &c., rendered necessary by the Miners Eight Hours Act.

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The Gwaun Cae Curwen Colliery Co. (Rotherham) recently made a fresh issue of capital, of which £70,000 will be required to sink and equip a new pit and to put down an electric power and lighting installation.

In order to give a supply of electrical energy for power and lighting to the Glebe pit of the Washington Colliery Co. a sub-station is being erected by the Country of Durham Electrical Power Distribution Co., in which there will be two 300 H.P. oil-cooled transformers.

Exhibition.—It is stated that the High Commissioners for South Africa, Canada and Australia have promised assistance for the British Imperial Exhibition which it is proposed to hold in London in 1914 or 1915.

Felling.—The Council have agreed to consider proposals for extending the tramways from Felling, through Hebburn to Jarrow.

Firing Explosives in Mines.—The Home Secretary made an order on Aug. 12 last under sec. 6 of the Coal Mines Regulation Act, 1896, repealing so much of the Explosives in Coal Mines Order of Feb. 21, 1910, as allows a charge to be fired by a permitted igniter fuze.

Greenock.—The Electricity committee recommend that the price charged for public arc lighting be reduced from £18 to £15 per lamp per annum.

Halifax.—On Wednesday the Corporation adopted a recommendation of the Tramways and Electricity committee that tenders be invited for the supply of additional generating plant at an estimated cost of £10,185.

Ald. COLLINSON moved that the minute be referred back. When the electricity charges were last fixed it was stated that the supply was greater than the demand, and that the committee wanted large customers for electricity at a very reduced price in order to get a day load. The cost of generating electricity (excluding charges for management, rates and general purposes) was 1·26d. per unit, but some large customers were being supplied at 0·83d. per unit. He contended that every unit s old for power under 1·26d. entailed an actual loss to the Corporation, and he asked that the committee should revise their charges.

Mr. A. FAWCETT said the committee would have to do something very shortly or some Saturday night they would be having a portion of the town in darkness or the trams stopped. They were buying a rotary converter for £800 in order to get through this winter. During the last two years the current supplied from the works had increased by 1,000,000 units. They could sell electricity at less than 0·83d. per unit.

Mr. C. F. SPENCER, chairman of the committee, admitted that he was not convinced the charges were on a proper basis. Before the committee came to any decision to accept tenders they would present a full report to the Council. There was a question of spending £50,000 on the electricity works. They wanted manufacturers in the town and to assist them with cheap electric power.

The amendment was lost, and the minutes were afterwards adopted.

Holmfirth.—The Council recently wrote to the Newmill and Meltham Councils suggesting that they should make a joint request to the Yorkshire Electric Power Co. to extend their mains and give a supply of electricity in the three districts.

Newmill Council have written that as many members of their Council as could make it convenient would attend the proposed meeting of representatives of the districts; but Meltham Council replied that the matter had been carefully considered by them, and they had decided not to join in the application for a supply of electricity so far as Meltham was concerned. The gas works were owned by the Council and a considerable amount of money had been spent on their extension and particularly on extension of mains for street lighting. An additional expenditure on electricity supply would, therefore, not be warranted at present.

The clerk was instructed to write to the Yorkshire Co. and get their terms for supply, &c., and the matter is to be brought up again at the next meeting.

Hove.—The local omnibus company recently requested the Council to sanction the use of the railless trolley system of traction on one or two suggested routes. The Watch committee recommend the Council not to accede to the request.

International Rubber Exhibition.—We have received a pamphlet giving some particulars of the Second International Rubber and Allied Trades Exhibition, which will be held at the Royal Agricultural Hall, London, N., between June 24 and July 11, 1911. Further particulars may be obtained from the organising manager, Mr. A. Staines Manders, 75, Chancery-lane, London, W.C.

Keighley.—The Council have revised their scale of charges for direct current supplied for power and lighting as follows:—

For a half-yearly consumption of 650 units per E.H.P. 1½d. per unit, for 800 units per E.H.P. 1d. per unit, over 800 units upon terms to be agreed between the consumer and the committee. For lighting, when the consumption exceeds 1,000 units per half-year, 3½d. per unit; exceeding 2,000 units per half-year, 3d. per unit; for supply to arc lamps, 3d. per unit; heating and cooking, 1½d. per unit. The charges for power are ¼d. less per unit, and for lighting 1d. per unit less. The charges for arc lamps and for heating and cooking are new.

The charge for electricity on the three-phase e.h.t. system will be based upon a £3 per kw. maximum demand, plus ¼d. per unit. The consumer must provide a transformer on his premises, except upon special terms to be agreed with the committee; the Corporation will run the cable into the building and deliver h.t. current at the meter on consumer's premises.

Life of Tantalum Lamps.—A correspondent in Doncaster has sent to a contractor the following striking testimony to the economy and long life of tantalum lamps:—

Three years ago you put in my electric light installation in Avenue-road with Tantalum lamps. There are 10 lights in constant use. Up to now we have only required two new lamps, and the lights are as good as ever.

Malvern.—The Council have received from the Light Railway Commissioners the draft of the light railway order for the construction of the proposed funicular railway on the hills.

The company are to purchase electrical energy from the Council if it can be supplied at a reasonable price, and the Council wish to reduce the period allowed for the construction of the line from four to two years.

On the past year's working of the electricity undertaking there was a net profit of £3. 1s. 4d., compared with a loss of £653 in the previous year.

Manchester.—At the meeting of the Corporation on Wednesday a discussion took place as to the terms and conditions upon which gas would be supplied for cooking by the gas department where electricity was supplied from the Corporation's electricity department for lighting.

The Gas committee desire that, in addition to the cooker, one light shall be placed in the kitchens of houses supplied, and at a previous meeting of the Council they had been requested to reconsider the matter.

Ald. GIBSON (chairman of the Gas committee) now said that the committee adhered to their former conclusion.

Ald. WALKER asked that the matter should be again sent back and referred to the standing joint committee for consideration.

Ald. GIBSON, after a conversation with the chairman of the Electricity committee (Mr. Howarth), agreed to take the question back again, so that he could consult that chairman.

Ald. HOLT said that the question was a serious one. There was contention between two committees as to who were going to supply light. The sooner the two committees were joined together in one Light and Power committee the better it would be for the city. At present they were both contending for business, and they had no right to allow competition between the two departments.

Municipal Wiring.—In addition to the list of towns favourable to the promotion of a bill by the Incorporated Municipal Electrical Association for the amendment of the Electric Lighting Act, 1909, to enable municipal electricity undertakers to wire premises, let motors and fittings on hire, &c., we are informed that Wolverhampton and Greenock Corporations have decided to give financial support and Bray Council to give moral support to the bill.

National Electrical Manufacturers' Association.—The next committee meeting will be held at Balfour House, Finsbury-pavement, on 13th inst., at 2:30 p.m.

Oldham.—Sanction to a loan of £12,544, to meet cost (already incurred) of extending the tramway feeder cables, has been applied for by the Council.

Porlock.—Last week a public meeting (presided over by Sir F. Carruthers Gould) was held to consider an electric lighting scheme for Porlock and Doverhay. Mr. C. H. Steele (Messrs. J. & W. Purves) attended and supplied technical details. The meeting appeared to be in favour of the scheme.

Portrush.—The Council are to have an interview with Mr. H. V. Pegg (of Messrs. Miller, Wilson & Pegg) as to an electricity scheme for the district.

Presentations.—Burslem electricity staff has presented a travelling case to Mr. A. Bremner, the late electrical engineer and manager.

Castleford tramway staff and employés have presented a timepiece to chief inspector W. Wilde, who has been appointed traffic superintendent of the Wakefield & District Light Railways Co.

On Friday last Mr. J. W. Fraser was the recipient of a writing case subscribed for by the employés of the L.C.C. tramways power house (Greenwich) on his leaving the department to take up a Government appointment.

Railway Returns.—The returns of the capital, traffic receipts, &c., of the railway companies of the United Kingdom for 1909 have been issued as a Blue Book.

The total paid-up capital of the companies was £1,314,000,000, an increase of £3,250,000 compared with 1908, £16,500,000 in 1908 and £7,750 000 in 1907. The average rate of dividend on the ordinary capital was 3·15 per cent., against 2·99 per cent., and on the preference capital 3·46 against 3·42 per cent. There was a decrease of about £500,000 in passenger traffics and a decrease of 8,269,000 in the third-class passengers carried.

The number of passengers conveyed by the "tube" railways of the

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Metropolis exceeded 168,000,000 in 1909, compared with 161,000,000 in 1908. In spite of this increase, the gross receipts of the "tube" railways from ordinary passengers decreased by £6,000, or 0·5 per cent.

The total working expenditure of the whole of the companies fell from £76,408,000 in 1908 to £75,038,000 in 1909, and the proportion of working expenses to gross receipts fell from 63·7 to 62·4 per cent. In 1900 the rates and taxes amounted to £3,757,000, and in 1909 to £5,010,000, which was an increase of £126,000 on the figures for 1908. The total length of the running track of the railways of the United Kingdom was 39,622 miles, and of sidings 14,350 miles. At the end of 1908 the length of running track was 39,316 miles, sidings 14,353 miles.

At the end of 1909 the length of line (in equivalent of single track) worked solely by electricity was 204½ miles, and 229¾ miles were being worked partly by electricity. The corresponding lengths of line at the end of 1908 were 204½ and 200¼ miles respectively. The total quantity of electrical energy used in 1909 was 253,294,628 units, compared with 249,287,308 in 1908.

Rochdale.—On the recommendation of the electrical engineer (Mr. C. C. Aitchison), the Gas and Electricity committee recommend the Council to adopt a revised scale of charging for the supply of energy for power. The scale will only apply to consumers having over 15 H.P. installed, and will come into force on Oct. 1.

Over 250 and not exceeding 300 units per quarter per b.h.p. installed, 1d. per unit, between 300 and 350 units 0·9d., 350 and 400 0·8d., 400 and 450 0·7d., over 450 units 0·6d. An alternative system will be available of 25s. per quarter per e.h.p. of maximum demand and a flat rate of ¼d. per unit, which will apply to consumers having a total of over 20 H.P. installed.

In future no motors are to be let out on hire without an agreement by the consumers hiring them to pay the ordinary rental for a period of not less than three years in addition to the existing regulations.

Stalybridge.—An inquiry was held last week into the application of the Stalybridge, Hyde, Mossley and Dukinfield Joint Tramways and Electricity Board for sanction to a loan of £22,268 for extensions of the electricity undertaking.

Stevenage.—The L.G. Board have requested the Council to inform them within two months what steps have been taken to carry out their obligations under their provisional electric lighting order, 1902.

The late H. W. Cox.—The total amount received up to Sept. 1 by Ald. Sir W. Treloar on behalf of the widow and children of the late Mr. Harry W. Cox was £3,405. 10s. 9d. It is intended to close the fund at the end of September. The money has been invested in the names of Sir W. P. Treloar, Sir W. H. Dunn, M.P., and Dr. Alexander. Donations can be forwarded to 69, Ludgate-hill, London, E.C.

Torquay.—The L.G. Board have intimated to the Council that they will sanction a loan of £4,500 to defray the cost of mains laid during the three years ending Dec. 31, 1912, provided the Council pass a supplemental resolution authorising the increase of the loan.

It was decided at the enquiry to charge to revenue account the excess expenditure of £486 incurred up to Dec. 31 last in connection with the undertaking, and that all expenditure after that date in respect of sub-stations, transformers, services and meters would also be defrayed out of that account. The practice of the Council to pool into one common fund all the loans raised for the undertaking was stated to be irregular. In future the expenditure under each sanction granted by the Board should be kept strictly separate, and the moneys borrowed under each sanction should be applied only to the specific purpose for which the loan was authorised.

On Tuesday the Council decided to ask the L.G. Board to increase the amount of the loan to £4,500.

In connection with the arbitration proceedings as to the system of traction to be adopted in place of the Dolter surface-contact system, the Council have decided to be legally represented and to call Mr. Mordey and other witnesses in support of their case.

Warrington.—The L.G. Board have sanctioned the borrowing of £6,257 for additional generating plant at the electricity works.

West Ham.—In reference to the recent loans for electricity supply extensions sanctioned by the L.G. Board, we are informed that the amount of the last application to the Board was £55,000, but at the local inquiry £2,000 in respect of certain sub-station equipment was withdrawn by the Corporation as the inspector (Mr. H. R. Hooper) stated that it would be in order if that expenditure was defrayed from a previous application for transformers which was not expended. The amount applied for has, therefore, been sanctioned in full.

The inquiry into the last application took place on July 27, and the loan was sanctioned on Aug. 16—surely a record.

Wigan.—The water department is considering a report of the borough electrical engineer (Mr. J. Slevin) recommending the installing of two electrically-driven centrifugal pumps at the pumping station.

Application is to be made to the Board of Trade to sanction the borrowing of £2,700 for extensions of present tramway loops and

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construction of additional loops, and £4,200 for six new single truck double-deck cars.

A discussion took place at Wednesday's meeting of the Council on the recent report of Mr. C. W. Mallins on the present position of the tramways.

The chairman of the Tramways committee (Ald. ASHTON) drew attention to resolutions which had been passed, on the recommendation of Mr. Mallins, for extensions of present loops and the provision of additional loops; and he moved that those resolutions should be referred back, in order that they might have a report from their own traffic manager. Before going to further expense they should pay attention to Mr. Mallins's recommendations as to improving the local service with the aid of the existing rolling stock.

Mr. M'QUAID said they were trifling with the tramways, which were going from bad to worse.

Mr. BRADSHAW urged the appointment of a general manager of the whole undertaking.

The resolution was carried, on the understanding that the committee formulated its recommendations on the whole of Mr. Mallin's report, and submit those recommendations to a special Council meeting.

Wireless Telegraph Notes.—In some important experiments in aeronautics which are being carried out by the British War Office the wireless control of airships and the establishment of communication between these vessels and terra firma are being attempted.

It is announced that arrangements have been made by the Government of Panama with an important commercial undertaking (the United Fruit Co.) for the establishment of a wireless telegraph station at Colon, where commercial messages will be received for Botas del Toro and Port Linion (Costa Rica), two districts where the fruit company carry on extensive operations. It is further reported that the Director of Posts and Telegraphs (Mr. E. Lefevre) has under consideration a project for establishing wireless stations to link up Panama with the coasts of Ecuador, Peru and Chili.

Important experiments are being carried out at Torbay in the use of wireless telegraphy in connection with submarine vessels. It is stated that the vessels have received messages successfully, but that no message from the submarines has been successfully received from the land station at Babbicombe Bay.

It is announced that the British Government authorities have made arrangements to establish at Gibraltar, Malta, Aden and Perim Island powerful installations of wireless telegraphy, and that there is a possibility that Cyprus, Alexandria and other places may be similarly connected up by wireless.

Another life-saving feat has been placed to the credit of wireless telegraphy. A British steamer, the "West Point," took fire in mid-Atlantic, and, but for wireless telegraphy, the safety of the entire crew would have been seriously endangered. Two vessels (the "Dovonian" and the "Mauretania") were successful in picking up two boatloads of the crew of the "West Point." The "Devonian" first picked up one of the boats, and, by means of wireless, put the "Mauretania" in possession of the facts and enabled her to pick up the second boat.

Some changes have been made in the arrangements for the establishment of wireless telegraph stations in the Pacific. It will be remembered that tenders were invited recently for the erection and equipment of stations at Sydney and Fremantle. It was arranged that the former station should be erected in the vicinity of what is known as Sydney Heads. The Commonwealth authorities have since decided that a more advantageous position would be at Pennant Hills, further inland, and about 13 miles from Sydney, on the railway towards Newcastle. The change has involved an additional expenditure of £2,000 on the station, the contractors (the Australian Wireless, Ltd.) stating that the station will be more expensive to erect, because of the land intervening between the sea requiring more power than would be the case at the Heads, and because greater expense has to be incurred in earthing and protecting the terminal wires. Near the coast, it is urged, better earthing can be effected than inland, and a coastal station can radiate a greater amount of energy than one inland with the same power. These reasons for the extra expenditure are admitted to be sound, but the Federal Government considers that the company has amply secured itself against loss by the change.

Wireless Telephony Notes.—Mr. W. Woodcock, of Clitheroe, Lancs., is reported to have been successful in conducting a number of experiments in wireless telephony.

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It is reported that Mr. John Burns, of Portobello, Edinburgh, has been successful in devising a means of transmitting the voice a distance of over 1 mile, and that some patents which he has taken out are being acquired by a local syndicate with a view to erecting a station at Burntisland, 10 miles from Portobello, to enable the continuance of the experiments which have been going on for some time at Portobello.

Workhouse Lighting.—Poplar (London) Guardians have received a communication from the L.G. Board as to their proposal to engage Messrs. Jackson, Pixley & Co. to make certain inquiries with a view to ascertaining the relative cost of electric current generated on the workhouse premises or obtained from the mains of Poplar Borough Council.

The L.G. Board suggest that the Guardians should first instruct their engineer to prepare a report showing the average cost of generating current during the last three years, and the capital charges, and showing what saving would be effected by obtaining a supply from the mains of the Council, and that a copy of the report should be forwarded to the Board, with the observations of the Guardians thereon. The letter has been referred to the Workhouse committee.

Electrical Engineers (London Division).—The Bohemian concert of this corps, which was postponed on account of the death of King Edward, will be held in the Pillar Hall, Victoria Station (S.E. & C.R.) on Saturday, Oct. 15., at 7:30. Tickets and all information may be obtained from the secretary, C.S.-M. A. E. Dixon, at the Headquarters of the Corps, Regency-street, S.W.

COLONIAL AND FOREIGN NOTES.

As the Cordoba Electric Light Co. have built a new steam-driven station in the city, the steam-power station built by the Government some time ago is no longer required, and will shortly be put up for sale.

Australasia.—The "Australian Mining Standard" says Newcastle (N.S.W.) Council has appointed a committee to inquire into the working of the electricity department, and an expert is to be engaged to advise at a fee of 25 guineas.

At a recent public meeting at *Toora* (Victoria) it was decided to form a company to provide electricity supply. Mr. Jas. Allan, who presided, said he and Mr. A. H. Wood (electrical engineer, of Melbourne) were prepared to take up half the initial capital (£500). The initial plant would be about 75 H.P. and water power would be used in generating current.

A deputation appointed by *Yarrawonga* (Victoria) Shire Council to inspect various provincial electricity works have reported in favour of electricity supply, and the Council have therefore decided to establish an electricity generating station.

The electrical generating plant at *Korumburra* (Victoria) was recently started. The plant comprises a Gardner four-cylinder vertical engine (supplied with gas by a Grice's suction gas plant) and a 56 kw. Mawdsley generator. By using a 500 ampere-hour battery it is expected that a sufficient supply of energy can be maintained day and night. Capital expenditure is £2,500.

Melbourne Council have arranged to take into their electricity supply department each year two students from the Working Men's College, at salaries of £1 per week. The appointments are for one year, the object of the experiment being to provide suitable candidates from whom the committee can select men for subsequent vacancies in the service.

Charlton (Victoria) Shire Council have accepted the offer of the local electric lighting company to provide 32 lamps of a total candle-power of 1,440 and supply current to same and also to provide and maintain two kerosene lamps in outlying parts for £100 a year.

Australian Wiring Rules.—The Fire Underwriters' Association of Victoria, who have adopted (with a few modifications to meet local circumstances) the wiring rules of the Institution of Electrical Engineers, have now added the following to rule 62:—

Where switch and distribution boards are placed on or within 6 in. of a wooden wall or 18 in. of a wooden ceiling, a thickness of some hard insulating fire-resisting material, such as a composition of asbestos or other mineral ingredient, is to be placed between such switch and distribution board and such wall or ceiling, and extending at least 6 in. beyond the board all around. Wires, &c., going through this material should fit as tightly as possible the holes through which they pass.

Austria-Hungary.—Smichow communal authorities are about to construct an electric tramway to Neu-Smichow and Malvazmka-Friedhof at a cost of about 1 million kronen (£42,000).

Chili.—A report by Consul-General A. Finn states that imports into Chili in 1908 included electrical machinery 7,448 tons (compared with 3,432 in 1907 and 2,014 in 1906), including 1,059 (against 1,422 and 546) from the United Kingdom, 5,582 (1,512 and 951) from Germany, 406 (454 and 494) from the U.S.A. and 401 (44 and 22) from other countries; scientific instruments, total 61 tons (against 63 in 1907), United Kingdom 14 tons (against 18), Germany 35 (26), France 7 (4), and U.S.A. (14).

Vice-Consul Steel says the electric tramways, which are a new feature in the town of Talcahuano, have done much to distribute the growing population.

Customs Duties.—According to recent decisions the following duties are leviable under the Australian import tariff:—

Printed paper cartons enclosing zinc boxes used in the manufacture of dry cells (British or foreign) 6d. per lb., or 35 per cent. ad val., whichever is higher; zinc boxes, general tariff 17½ (British goods 10) per cent.; portable electric cranes (motor, controller, crane and truck) 25 (British 20) per cent.; motor tramcars 30 (British 20) per cent.

The following (British or foreign) are duty free: Fuse boxes (one fuse in a box) and educational apparatus for teaching engineering, mechanics, metallurgy, mineralogy, physics, &c., in schools, colleges or universities.

Dawson City (British Columbia).—It is announced that the power house of the Northern Light, Power & Coal Co. was completed on Aug. 24, and electric current was transmitted over 44 miles to Dawson City, where there are already a number of power and lighting consumers of the company.

South Africa.—The "British and South African Export Gazette" reports that an extension of the *Pretoria* electricity works is in hand.

The Council are endeavouring to promote the use of electricity for cooking, heating, &c., and an opportunity now offers to British makers of electric cookers and heaters.

The Pretoria municipal tramcars will be running by October. The cars are single deckers, supplied by Dick, Kerr & Co., but the rails are of American manufacture.

The concession for the erection of an electricity generating station at *Tweefontein* has been obtained by Mr. Howard Pim, on behalf of the Transvaal Hydraulic Power Synd., and a company is to be formed with a capital of £926,000. It is understood that electro-chemical works will be started in connection with the power station.

Benoni Municipality have placed an order in England for electrical material.

The *Transvaal* Gold Mining Estates (Ltd.) are about to purchase a large power plant, and electrical plant was recently imported for *Utrecht* colliery.

The introduction of Osram lamps has (it is stated) saved *Bulawayo* Corporation over £2,000 per annum in public lighting.

The proposal of *Potchefstroom* Municipality to adopt an electricity scheme (to cost £20,000) is to form the subject of a Government inquiry.

It is proposed to spend £150,000 on the improvement of *Capetown* docks, including a sum for an electric travelling crane.

An order for a battery and Entz booster for the *Delagoa Bay* Port and Railway Council has been placed with the Chloride Electrical Storage Co.

Dick, Kerr & Co. have secured orders for spares for tramcars and water vans for *Johannesburg* Council.

Spain.—The Cia del Tranvia de Bilbao recently obtained a concession for the construction and working of an electric tramway in Bilbao.

Uruguay.—The "Review of the River Plate" says the report of the Government electric power undertaking at Montevideo for 1907-8 and 1908-9 has been published.

For 1907-8 the profit was $142,536.47, for 1903-9 $166,915.71, and for the first eight months of 1909-10, $122,921.24, representing a profit of 18 per cent., 19 per cent. and 9 per cent. respectively on the capital. The profits have been reduced by loss on the municipal service and by reductions in tariff, which within two years was reduced from $0.15 to $0.10 for Government supplies, and on July 1, 1909, the average price paid by private individuals was reduced from $0.21 to $0.12. As regards lighting on Feb. 28 last the number of lamps for private use were: Incandescents 126,734, arcs 324, other 711, the number of customers being 8,166; for public lighting there were 4,324 incandescents and 753 arcs. On June 30, 1909, there were 151 electric motors in use, total 821 H.P., and on Feb. 28 of this year the number had increased to 471 motors and 2,110 H.P.

The electric tramways in Montevideo during the half-year ended June last carried 30,183,060 passengers, compared with 26,622,750 in the first half of 1909. The car-miles run were 6,730,854, against 6,221,078.

Uruguay.—Señor A. Rossi has obtained a concession to construct telephone lines from Villa del Carmelo to Colonia Arrué, to Ombúes de Lavalle and to Paseo de Camacho (44 miles in all).

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Aberdeen.—The accounts of the electricity department for the year ended July 31 have been issued.

The total revenue was £45,219, decrease £572 compared with 1909. Revenue from sale of current by meter was £31,765, public lighting £2,326, traction (less £1,267 difference between amount charged and actual cost) £8,716, and current supplied to the Suburban Tramways Co. £1,070, hire of motors £1,633. Expenditure amounted to £19,849, increase £227, leaving a balance of £25,370. The principal items of expenditure were: Fuel £7,053, oil, waste, &c., £314, wages £2,003, repairs of buildings £394, repairs of plant £898, total £10,663 for cost of generation; distribution cost £711; rents, feu-duties and taxes £5,225, management £1,665, motor repairs £412, depreciation of motors £487, bad debts, &c., £380, and special services £302. Interest absorbed £9,426, sinking fund £14,553, one-fifth of cost of Aberdeen Corporation Electricity Act (third instalment) £477, and surplus carried to reserve £967. The amount of reserve is now £13,832. Total capital expended is £368,618, amount borrowed on mortgage £226,999, and mortgages redeemed by sinking fund £58,841. During the year 6,416,276 units of energy were generated, compared with 6,070,192 units last year. The total quantity sold was

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5,436,065 units (against 5,170,121), including 3,141,749 to consumers by meter, 291,435 for public lighting, 1,856,089 for Corporation traction and 146,792 for suburban traction. The total number of public arc lamps was 204, same as last year.

In the report of the city electrical engineer (Mr. J. Alex. Bell) it is stated that some of the features of the year were the satisfactory start and the boom given to electric heating by the hiring out of apparatus and the amended price for supply of this nature; all supply for outlying districts had been given from Ferryhill generating station, the reduction in price per unit charged for Corporation tramway supply, and the continued drop in the cost of production. The flat rate for lighting and the graduated scale for power had so far proved satisfactory. It was probable that their reduced output for lighting during the first six months of the year was to a small extent due to the caution exercised by consumers until their first half-year's accounts under the new charges were obtained. The additions made to heating apparatus was in itself a justification of the policy of hiring out, commenced August, 1909. The total heating apparatus coupled at the end of 1908-9 equalled 5,633 33-watt lamps; by the end of 1909-10 the figure had risen to 11,358 33-watt lamps. In one year, therefore, they had doubled the total heating connections. It was interesting to note that, of these additions, the apparatus sold by contractors equalled their best year—thus showing that entirely new ground had been broken by the department in the hiring out system, with advantage, not only to the electricity department, but to the electrical contractors, who obtained all the wiring for the work. The effect of the installation of the metal filament lamp was still apparent on the output; but there were compensations, as they could now obtain a class of consumer impossible in the days of carbon filament lamps. In the Deeside districts, for instance, the smallest cottages were now regularly wired for electric light. The Aberdeen architects were, to a large extent, still installing gas for lighting in small houses within the city, and he was inclined to think they neglected the fact that a thoroughly sound and satisfactory installation of electricity was as cheap to install—and, nowadays, practically as cheap light for light—as gas, irrespective of the many incidental advantages which electricity could claim. 181 new consumers were added during the year. Motors (representing 387 H.P.) had been coupled up since last report. The alterations of copper strip culverts were nearing completion. At Cults sub-station a three-phase motor was fitted to one of the dynamos originally steam-driven. The output for private lighting consumers was 99,225 and for power and heating consumers 258,040 units in excess of previous year. That satisfactory increase in power would continue as trade got better. Heating units had increased from 18,541 to 41,614. The smaller heating and cooking apparatus was in many cases used direct off lighting circuits. The Deeside district again showed a most satisfactory increase, the units having increased 30 per cent. during the year. Supply had been available for a complete year to the Woodside and Bucksburn districts, and the output sold amounted to 45,047 units. The Corporation tramways consumption showed a decrease of 90,442 units. The works costs for the year and total costs had reached the lowest level yet attained. The increased price of coal was responsible for a slight rise in works costs, but that had been more than made up by reductions in other directions. The new scale of charges has given satisfaction, and with one exception (heating) should remain the same for another 12 months. Mr. Bell recommends that the charge for electricity for heating be reduced from 1½d. to 1d. per unit. He has no doubt that the reduced charge will result in a largely increased output in that direction.

On the recommendation of Mr. Bell the Electricity committee have decided to grant a bonus of £25 for six months to employés in the engine room and boiler house as an additional inducement to practice economy.

The committee have decided to extend the mains to the Aberdeen and North of Scotland College of Agriculture provided the college authorities guarantee a minimum consumption equivalent to £50 per annum for five years from the date of commencement of supply, and the cost of all service cables required beyond the lodge gates of Craibstone House must be borne by the college.

Barnsley.—The capital borrowed for the electricity department is £75,499 and amount repaid £5,351. Capital expenditure is £77,441, increase £1,271 during the year ended March last.

The income during the year was £12,705, total expenditure £5,687, and gross profit £7,018. Interest, sinking fund and instalments of loans required £5,219, leaving £1,800 net profit. Units generated were 1,794,588, and 281,592 were supplied to public lamps, 296,876 sold by contract and 913,477 by meter. The total maximum demand was 822 kw.

Bradford.—The statement of accounts of the tramways department for the year ended March 31 shows total income £259,696, including £245,682 traffic revenue and £8,169 for carriage of parcels.

Working expenses of the tramways department were £161,951 and of the parcels department £6,330. The cost of the motor garage and Bowling-hill departments increased the expenses to £170,689, leaving gross profit £88,997. Interest on capital absorbed £22,407, income tax £2,250 and rent of leased lines £4,137. The repayment of mortgage loans and contribution to sinking fund came to £30,454; £20,000 was devoted to relief of city rate, and the balance (£12,365) was placed to reserve or renewals fund. The gross capital expenditure is £930,114 (an increase of £6,599), but nearly £300,000 has been repaid. Passengers carried were 50,518,813 (increase 2,858,802 over 1909) and the car-miles run 5,436,529 (increase 60,301). The average fare paid per passenger was 1·167d. (against 1·165d.). There was an increase of £503 in the total expenses; but power expenses were 2·073d. per car-mile (against 2·115d.), and repairs and maintenance 1·432d. (against 1·393d.). There was a net profit of £1,741 on the parcels department, against £1,028 in 1908-9.

Govan.—The annual report of the burgh electrical engineer (Mr. Theo. C. Parsons) together with the accounts of the electricity department for the year ended May 15 have been issued.

The total income (£18,590) included £14,636 from sale of current by meter and £3,305 from public lighting. Total expenditure was £9,656 and gross profit £8,935. Interest absorbed £3,830, sinking fund £3,246, and after providing for depreciation on motors let on hire (£186), arc lamps let on hire (£27. 10s.), and paying £12. 5s. loss on motor sold, £1,601 was placed to renewals reserve. 3,159,311 units were generated (against 2,877,979 in 1908-9) and 2,624,684 units were sold (2,164,136 to private consumers and 460,548 for public lighting), against 2,356,367. There are 215 10-ampere arc lamps for street lighting, the maximum supply demanded was 1,736 kw., and the load factor was 17·2 per cent. (against 18·1 per cent.) The total working costs were 0·813d. per unit and the total costs (including interest and sinking fund) 1·461d.

In Mr. Parsons' report it is stated that capital expended during the year on motor hiring, &c., was £240, bringing the net total outstanding to £3,886. The total of the motor depreciation fund is £862 or 22·2 per cent. There are 68 motors (745 H.P.) on hire, and there were 62 arc lamps on hire at May 15, a decrease of 17. Metal filament lamps are superseding small arc lamps, and no fresh capital was expended during the year on arc lamps, which stands at £279. The arc lamp rents (£46) average 16·3 per cent. on the capital. In the past year, after paying all charges, including repairs, maintenance, depreciation, interest and sinking fund, there was a credit balance of £59 on the motor department and a debit balance of £20 on the arc lamp department. All stair lighting has been changed from 8 and 5 c.p. carbon filament to 30 c.p. metal filament lamps, the price charged being the same as formerly for a 5 c.p. lamp. The increase in the units sold for lighting was 6·9 per cent. and for power 17·2 per cent. There were 67 additional customers, an increase of 6·8 per cent. The total capital expenditure to date is £132,466, but deducting the motor and arc lamp capital, the total is £127,467.

Melbourne (Australia).—For the year ended Feb. 28 the City Council's electricity undertaking showed gross revenue £113,578 (increase £10,943) and working expenses £54,662, leaving gross profit £58,916.

Interest required £42,187, and after providing for depreciation, renewals, &c., the balance was £16,728. Capital expenditure during the year was £19,043. The increase in consumers was 359, compared with 351 in previous year. The Electric Supply committee have brought forward a reduced scale of flat rates for lighting, varying from 3d. to 4½d. per unit, according to the quantity consumed. Motors connected increased from 1,218 to 1,441 (4,684 H.P.).

Shoreditch (London).—The accounts of the electricity undertaking for the year ended March 31 show an increase of income (compared with 1909) of £1,598, while expenditure showed a reduction of £1,031. 19s. 3d.

The gross profit was £23,876 against £21,335, and after paying capital charges the surplus is £6,431 which is disposed of by wiping off the debit balance brought forward, and by transferring £1,486 to change of pressure account, and placing £4,000 to reserve, leaving £616 to be carried forward. The total costs per unit sold show a reduction of 0·28d. The present form of consumers' agreements, enabling the Council to require consumers to take a two years' supply, is to be amended by the substitution of the following words for the existing clause:

"The consumer shall continue to receive and pay for a supply of electric energy for a period of at least two years, and the minimum payment per annum shall not be less than 20 per cent. on the outlay incurred by the Council in providing any electric lines and apparatus required for the purpose of such supply, unless a responsible tenant of such premises succeeds the applicant in agreeing in writing to take a supply of electric energy on similar terms from the Council."

Southend-on-Sea.—The total net income of the electricity department for the year ended March 31 was £26,104.

The gross revenue from the sales of electricity to private consumers for light and power was £17,663, and from the Corporation departments for light, power and traction £7,956. The total working expenses were £10,077, leaving a gross profit of £16,027. Interest (including income tax) absorbed £4,422 and instalments of loan repaid £10,132, and after providing for other small items (including £285 balance of cost of superseded plant written off) there was a net balance of £3,022 carried forward, against £2,036 in 1909. The total net capital expended is £129,645, an increase of £4,859.

The total receipts of the light railways department for the past year were £26,739, including £26,340 traffic revenue. The working expenses came to £18,734, leaving a gross profit of £8,004. Interest on loans absorbed £3,066 and instalments of loans £1,384, and £107 was transferred in respect of superseded work; £1,000 was applied in relief of rates and the net profit (£2,947. 12s. 3½d.) was carried forward. 5,802,132 passengers were carried and 527,393 car-miles run, the average receipts per car-mile being 12·16d. The total capital expended is £107,964, an increase of £2,826.

Wellington (N.Z.).—The accounts of the tramways and electric lighting departments of the Corporation for the year ended March 31 have been issued.

The total income of the tramways department was £139,460, including £130,711 traffic receipts and £8,416 from the sale of electrical energy. Working expenses were £92,947 and gross profit was £46,514. Interest on loans (for tramways, power supply and public lighting) absorbed £21,134, sinking fund £5,054 and depreciation £14,202, leaving net profit

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£6,124. The total capital expenditure is £595,782, an increase of £19,408 during the year. 21,932,507 passengers were carried, and 2,203,666 car-miles run. 4,371,921 units of current were consumed for traction and car lighting, or 1·98 per car-mile.

The income of the electricity department was £44,814. Working expenses were £25,934 and gross profit was £18,880. Interest on capital came to £7,161, sinking fund to £3,130 and depreciation to £6,361, leaving a net surplus of £2,228. Capital expenditure is £217,961, an increase of £21,470. Units sold amounted to 2,018,526 (1,320,183 for private and 336,067 for street lighting and 362,276 for power and heating), against 2,004,304 in 1908-9, the increase being due to an advance of over 200,000 units used for street lighting. The equivalent of 170,627 8 c.p. lamps (against 159,865 8 c.p.) is connected, including 1,187 H.P. (1,169 H.P.) of motors. There are 4,501 consumers (4,136), including 4,147 for lighting (3,821), 241 for power (244) and 113 for heating (71). The average working expenses per unit sold were 3·08d. (2·99d.), and the total expenses 5·06d. (4·79d.).

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

The Electricity and Tramways committee of the County Borough of NEWPORT (Mon.) invite tenders for material required for the extension of the works in hand, including rubber cables of various sizes, single-phase l.t. and h.t. paper lead-covered cable and e.h.t. cable, welded steel, or solid drawn steam pipes, valves and cast-steel tees, rolled steel girders, c.i. and w.i. switch gallery railing, two c.i. stanchions, motor starters and other switchboard apparatus (l.t.) and c.i. flanged water pipes. Particulars from the borough electrical and tramways engineer (Mr. H. Collings Bishop). Tenders must be delivered to the Town Clerk, Town Hall, Newport, Mon., by first post Tuesday Sept. 20. See an advertisement.

Tenders are invited for supply of telegraph and telephone cable (schedule No. 284) and insulators (schedules Nos. 373 and 374) to the Postmaster-General's Department, VICTORIA. Tender forms at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to noon Oct. 17 for the supply of telegraph and telephone instruments and material (as per schedules 1 to 9) to the Postmaster-General's Department in TASMANIA. Tender forms and specifications at the office of the High Commissioner, 72, Victoria-street, London, S.W. See advertisement.

LITTLEBOROUGH District Council invite tenders for the supply and delivery of alternating-current (single and three-phase) electricity meters. Specifications and forms of tender from the clerk to the Council (Mr. Geo. H. Wild), Council offices, Littleborough, to whom tenders by Tuesday, Sept. 13.

By command of the POSTMASTER-GENERAL tenders will be received until noon, Monday, Sept. 26 for supply of Swedish, Norwegian, Finland or Russian red fir telegraph poles to be delivered at certain ports in the United Kingdom. Forms of tender from the Controller of Stores (Mr. G. Morgan), Stores Dept., G.P.O., 17-19, Bedford-street, London, W.C.

The POSTMASTER-GENERAL also requires tenders (by noon Sept. 26) for creosoting, &c., telegraph poles. Forms of tender, &c., from the Controller of Stores, 17-19, Bedford-street, London, W.C.

The directors of the Powell Duffryn Steam Coal Co. (ABERDARE) invite tenders for stores, including electrical goods. Tenders to London office (101, Leadenhall-street, E.C.) by Sept. 12.

HACKNEY (London) Council want tenders by 7 p.m. Sept. 15 for extension of main switchboard. Specification from Town Clerk, Town Hall, Mare-street, N.E.

MANCHESTER Waterworks committee invite tenders for an electric derrick crane. Tenders to Town Hall, Manchester, by 12th inst.

Tenders are invited by WALTHAMSTOW Council for supply and erection of a storage battery. Tenders to Clerk by noon Sept. 9.

The Deputy Postmaster-General, MELBOURNE, will receive tenders until 3 p.m. Oct. 18 for supply of 23 miles of telephone cable (specification 284) and 500 composition insulators (specification 374) and until 3 p.m. Oct. 25 for 10,000 Cordeau insulators (schedule 373). Specifications, &c., from 72, Victoria-street, London, S.W. Local representation is necessary.

Tenders are invited up to Oct. 5 for the supply of 5,000 porcelain insulators to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone insulators to the Postmaster-General's Department in all the States of the Commonwealth of AUSTRALIA. Tender forms at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 27 for the supply of electric lamps to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 20 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA (Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders will be received (up to 3 p.m. Sept. 13) by the Deputy Postmaster-General, MELBOURNE, for supply of 8,510 telephones. Local representation necessary.

The Deputy Postmaster-General, SYDNEY (N.S.W.), invites tenders (until 2:30 p.m., Oct. 5) for supply of 5,000 porcelain insulators. Local representation necessary. Specifications, &c., from 72, Victoria-street, London, S.W.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W., and also from Messrs. R. W. Cameron & Co., 23, South William-street, New York, and Mr. H. Stephenson Smith, 244, California-street, San Francisco, Cal. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

The Calcutta Electric Supply Corpn. is prepared to receive tenders for supply, delivery and erection at their Cossipore station and sub-stations, CALCUTTA, of motor-generators, turbo-alternators and condensing plant. Copies of specifications, drawings and general conditions from the secretary (Mr. Francis R. Reeves), Salisbury House, London Wall, E.C., to whom tenders by 10 a.m. of Sept. 19.

The Ministry of Public Works, CAIRO, require tenders for electrical installations and refrigerating plant for the lunatic asylum in course of construction at Khanka. Specifications from the Chief of the Administrative Service, Ministry of Public Works, Cairo. Stamped paper for tenders is obtainable from Mr. A. L. Webb, Westminster, S.W. Tenders by noon Oct. 20. Legal domicile at Cairo is necessary in the case of this contract, and to obtain temporary domicile British firms must, before electing such domicile, formally advise the Consulate at Cairo of intention to do so, formally authorise the Consulate on their behalf and inform the Consulate of the address to which documents should be forwarded.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

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Tenders will be received by Tacuarembó (Uruguay) Municipality until 2 p.m. Sept. 30 for the equipment of electricity works and the supply of electric light at San Fructuoso.

Nijmegen (Holland) communal authorities want tenders by Sept. 16 for supply of tramcars. Particulars from the Gemeentebestuur, Nijmegen.

Tenders are wanted by noon Oct. 31 for supply and erection of machinery, &c., for electricity supply and water supply systems for the town of Beni-Souef (Egypt). Particulars may be obtained from Mr. A. L. Webb, C.M.G., Queen Anne's-chambers, London, S.W. Local representation is necessary.

TENDERS RECEIVED AND ACCEPTED.

Shoreditch Lighting committee obtained quotations from five firms for supplying a storage battery of 66 cells with a capacity of 750 amperes for two hours and a battery switchboard panel (with instruments, switches, &c.), and they have provisionally accepted the lowest tender, that of the Electrical Power Storage Co., at £660 and £25 for cable and connections.

Dewsbury Council have accepted the tender of Cowans (Ltd.) for switchboard controlling panel and that of the Liverpool Electric Cable Co. for cable for coupling up the turbo-generator set to the switchboard.

Keighley Council have accepted the tender of Babcock & Wilcox for supply and erection of a water-tube boiler with superheaters, stokers and pipe work at £1,458.

Zacariás Marioni y Hermano have secured the contract for an electric installation for the Buenos Ayres Custom House at 249,462 pesos (about £22,000).

Salford Council have accepted the tender of Walter Scott (Ltd.) for the supply and delivery of 500 tons of steel tramway rails at £6. 16s. 6d. per ton.

South Dublin Guardians have accepted the tender of the A.E.G. Electrical Co. (Manchester branch) for an electric lighting installation at the Workhouse at £2,537. 4s. and £250 for maintenance for five years.

Shoreditch Lighting committee have accepted the tender of Siemens Bros. & Co. for lead-covered paper-insulated cables for the next five months' requirements at following prices: 7/16, £58 per mile; 7/14, £73 per mile; 19/14, £147 per mile. (These prices were the lowest of five quotations.)

Bournemouth Council have accepted the tender of Wm Griffiths & Co. for the supply of Belgian tramway rails at £2,904.

Country House Lighting.—For putting in an electric light installation at King's Newton Hall (near Melbourne), which is being re-built for Mr. Cecil Paget, the tender of the Melbourne & District Electric Light & Power Co. has been accepted.

South African Contracts.—An order for electrical equipment for the new air compressor station of the new Modderfontein Gold Mining Co. has been placed with the British Westinghouse Co., and includes a number of 1,000 h.p. direct-coupled three-phase induction motors.

Messrs. Siemens Bros. & Co. have secured an order for 2,277 a.c. meters and the A.E.G. Electrical Co. an order for 88 d.c. electricity meters for Johannesburg Corporation.

The A.E.G. (Berlin) have secured a contract for the supply and erection of generators and compressors for the new power station at Rosherville (Transvaal).

Storage Battery Contracts.—The D.P. Battery Co., of Bakewell, have concluded contracts for the supply of their batteries to the Councils of St. Annes-on-Sea and Naas (Kildare), the Chorlton Board of Guardians and for a number of private installations. The maintenance of these batteries for terms of years has been undertaken by the company.

The company have also secured orders for three batteries for South Africa for mining and other purposes. Specimen cells of their manufacture are being exhibited at the Buenos Aires exhibition by their agents (Messrs. Milne, Makein y Cia) of that city. The company are open to appoint additional agencies in foreign countries where they are not already represented.

Large Nuremberg Gas Engines for the Far East.—Messrs. Mitsu & Co., owners of some of the most important mines in Japan, including many large coal fields, having recognised the necessity of producing power at the cheapest rate, decided some time back to modernise the power station at their Miike mines. They have, therefore, installed two large Nuremberg gas engines of 3,200 b.h.p. each, for generating electricity.

The order for these huge engines, which are to run on coke-oven gas, has been placed with the Maschinenfabrik Augsburg-Nürnberg A.G., of Nuremberg, Bavaria (whose London office is at Caxton House, Westminster). This well-known firm (known in engineering circles as the "M.A.N.") haue a high reputation as makers of the "Nuremberg" gas engine, which has been supplied in all parts of the globe. The same firm have also installed some large gas engines in this country, among which may be mentioned those supplied to the Bargoed colliery (Wales), aggregating 6,000 b.h.p., and the gas engine plant of several thousand brake-horse-power at present being put in at the Normanby Park steel works, near Scunthorpe.

The Lilleshall Co., the M.A.N.'s licensees for the manufacture and sale of gas engines in this country, are also busy with the Nuremberg gas engine, having supplied high power engines to the Barrow Hæmatite Co. (Barrow-in-Furness). The Lilleshall Co. have recently secured orders from the United Alkali Co. (Widnes) and from Messrs. Albright & Wilson (Oldbury) for large gas-engine plants.

Sale by Auction.—Messrs. Fuller, Horsey, Sons & Cassell will sell by auction on Thursday, Sept. 22, at 11 a.m., on the premises, Montmore-street, London Fields, N.E., the goodwill of the business of the Foxcroft & Duncan Engineering Co. (Ltd.), including the patterns, drawings, &c., and also, in lots in detail, the engineers' machine tools and stock, including lathes, milling and drilling machines, motors, dynamos, &c., and the stock of arc lamp and other electrical fittings. Catalogues of the receiver, Mr. C. P. Oswald (Messrs. Bolton, Pitt & Breden), 140, Leadenhall-street, E.C., Messrs. Thorp & Saunders, 79, Salisbury House, London-wall, E.C., and of the auctioneers, 11, Billiter-square, E.C. See advertisement.

Plant for Sale.—Northampton Electric Light & Power Co., Northampton, advertise for sale two exhaust steam feed water heaters and two battery charging boosters.

Patents Development.—The owners of patents No. 23,501/1899, relating to "Improvements in vacuum table lighting," and No. 12,582/1902, relating to an "Improved system of electric lighting," desire to negotiate with electrical engineers with the view of granting licences. Information from Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C.

The proprietor of letters patent No. 28,542/1907, relating to "Electrical induction furnaces," desires to enter into arrangements for exploiting same. Communications to Messrs. J. E. Evans-Jackson & Co., 19 and 20, Holborn Viaduct, London, E.C.

The proprietors of patents No. 17,533/1908, for "Improvements in electrical accumulators" and No. 19,979/1904, for "Improvements in magnetic wheels or electromagnetic motors," desire to make arrangements for exploiting the same in this country. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

"A.E.G. Zeitung."—The September number of this journal contains as a frontispiece an illustration of the single-phase locomotive being used on the Lotschberg Railway. Dr. Stern begins a serial on the subject of the "Distribution of Electrical Energy to a Distance." Other articles deal with "The Use of the Electric Motor in Gas Works," "The Instrument Showrooms of the A.E.G." and "Wind Driven Electricity Works."

CATALOGUES, &c.

G.E.C. Apparatus.—We have received from the General Electric Co. a number of catalogues dealing respectively with electric bells and accessories, electric heating and cooking apparatus and measuring instruments. The catalogues describe in an exhaustive way apparatus made by this Company under these heads, and the lists should be in the hands of every one having anything to do with this class of work.

Electric Bells and Accessories.—Messrs. Gent & Co., of Leicester, send us their latest catalogue which deals with such subjects as electric bells, indicators, pushes, contacts, wires, batteries and other similar apparatus. The catalogue is well illustrated and each type of apparatus is accompanied by sufficient description to make its method of working and purpose clear.

Western Interphone and Private Line Telephones.—The Western Electric Co. have issued a booklet dealing with private telephone lines, such as may be used on inter-communication systems or for domestic work generally. It is of book size and is primarily intended for the use of contractors and practical electricians. It can, if necessary, be provided with the name and address of the contractor printed upon it.

Cleat Ceiling Rose.—Messrs. Loxley & Co. have issued a pamphlet giving details of their "V.B." cleat ceiling rose, for which a number of advantages are claimed.

Burglar Alarm.—The Adnil Electrical Co. have ready a description of their "Blut" patent burglar alarm which is worked electrically and is claimed to overcome all the disadvantages inherent in this type of apparatus.

Iron and Steel Pipes.—Messrs. J. Spencer, of Wednesbury, forward a price list of the tubes, pipes, &c., made by them. These

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vary from quite small sizes up to tube poles suitable for tramway and arc lamp work.

WATER-TUBE BOILERS.—Messrs. Clarke, Chapman & Co. are issuing a pamphlet which sets out the various points and advantages of the Woodeson patent water-tube boiler, which is made by them.

ELECTRICAL INSULATING MATERIALS.—Messrs. Meirowsky & Co. send a pamphlet dealing with various electrical insulating materials, including megohmite of various kinds, mica cloth and mica rubber and paper. This is made up into tubes, tape and insulating fittings generally.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during August, 1910, and (*b*) during the current year from Jan. 1 to Aug. 31, with the increases or decreases compared with the corresponding periods of 1909:—

Electrical machinery (*a*) £60,354 (increase £12,451), (*b*) £383,498 (increase £45,688); telegraph and telephone cables (*a*) £12,159 (increase £704), (*b*) £91,856 (increase £7,590); telegraph and telephone apparatus (*a*) £18,157 (increase £2,589), (*b*) £117,763 (decrease £2,846); other electrical wires and cables, rubber insulated (*a*) £17,683 (increase £8,242), (*b*) £138,078 (increase £75,889), with other insulations (*a*) £1,978 (decrease £1,614), (*b*) £19,338 (decrease £38,878); carbons (*a*) £12,212 (increase £3,745), (*b*) £90,428 (increase £5,128); glow lamps (*a*) £53,735 (increase £34,263), (*b*) £374,462 (increase £106,853); arc lamps and electric searchlights (*a*) £256 (increase £20), (*b*) £2,281 (decrease £6,845); parts of arc lamps and searchlights (other than carbons) (*a*) £8,208 (increase £2,832), (*b*) £48,400 (increase £9,685); primary and secondary batteries (*a*) £3,695 (increase £1,488), (*b*) £27,634 (decrease £1,659). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £135,528 (increase £52,768), (*b*) £976,619 (increase £155,294).

Exports.—The exports of electrical machinery, material, &c., (*a*) during August, 1910, and (*b*) during the current year from Jan. 1 to Aug. 31, and the increases and decreases compared with the corresponding periods of 1909, are as follows:—

Electrical machinery (*a*) £135,082 (decrease £9,182), (*b*) £1,026,757 (increase £52,269); telegraph and telephone cables (*a*) £437,723 (increase £395,590), (*b*) £1,467,816 (increase £990,810); telegraph and telephone apparatus (*a*) £32,430 (increase £20,693), (*b*) £132,564 (decrease £52,617); other electrical wires and cables, rubber insulated (*a*) £60,286 (increase £33,919), (*b*) £288,609 (increase £112,817), with other insulations (*a*) £40,053 (increase £18,171), (*b*) £209,999 (increase £12,794); carbons (*a*) £1,846 (increase £983), (*b*) £11,707 (increase £5,656); glow lamps (*a*) £9,641 (increase £2,473), (*b*) £82,006 (increase £33,872); arc lamps and searchlights (*a*) £3,156 (increase £1,620), (*b*) £14,178 (increase £731); parts of arc lamps and searchlights (other than carbons) (*a*) £1,709 (increase £800), (*b*) £9,741 (decrease £121); primary and secondary batteries (*a*) £10,627 (increase £6,504), (*b*) £80,663 (increase £10,486). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £640,347 (decrease £481,159), (*b*) £2,603,036 (increase £1,169,412).

BANKRUPTCIES, LIQUIDATIONS, &c.

At the London Bankruptcy Court last week the adjourned meeting of creditors of J. T. Murray (77, Gunterstone-road, W. Kensington, London) took place. Liabilities £3,212, assets £73.

Debtor has been engaged in the negotiations in connection with the Scutari Tramways concession. The receiving order was made in May, 1908, but proceedings have been adjourned from time to time to enable the scheme to be carried through. The meeting was again adjourned to March 1, 1911.

A third and final dividend (4s.) is payable at 2, Clement's Inn, London, W.C., in the liquidation of Joseph Richmond & Co. (Ltd.), 30, Kirby-street, London, E.C.

The Clarence Engineering Co. (Ltd.) is being wound up voluntarily. Claims to the liquidator, Mr. J. R. Woodley, 39-41, Wood-street, Cheapside, London, E.C.

The liquidator (Mr. W. Allnatt, 5, Lime-street, London, E.C.) of the Empire Electric Light & Power Co. (Ltd.) has been released.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

June 16, 1910.

14,534 MATHIESON. Contact device.
14,575 BOSCH. Constructing magneto-electric ignition machines for internal-combustion engines. (Date applied for, 19/7/09.)*†
14,583 MORRIS, ELLIS & MURPHY. Obtaining rapidly varying electric currents.

June 17, 1910.

14,625 ELECTRIC & ORDNANCE ACCESSORIES CO. & COLLINS. Slow-motion devices for use in connection with electric controllers, starting switches and the like.
14,626 TAYLOR. Electric filament lamps.
14,658 SOLDATENKOW. Electromagnetic device.
14,659 SOLDATENKOW. Printing telegraphs.
14,672 BAKER. Electrical transmission of photographs, drawings and the like.
14,680 PARSONS & LAW. Dynamo-electric machinery.*

June 18, 1910.

14,743 B.T.-H. Co. (G.E. Co., U.S.) Alloys for use as electric resistance conductors.
14,744 MACFARLANE. Electric transformers or converters.

June 20, 1910

14,773 TAYLOR. Limiting the flow of current on a short-circuit.
14,775 SOMERS & CROWLEY. Secondary electric batteries.
14,851 ADAMS MFG. Co. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*
14,857 PODSZUS. Vapour electric apparatus. (Date applied for, 7/10/08, comprised in No. 22,827, dated 6/10/09.)*
14,859 PRESSER. Electric welding process. (Date applied for, 20/9/09.)*†
14,862 & 14,863 ALLGEMEINE ELEKTRICITATS GES. Dynamo-electric machines. (Addition to No. 13,864/04. Date applied for, 21/6/09.)*†

June 21, 1910.

14,889 RICHMOND. Depolariser for galvanic batteries.
14,912 WILKINSON. Electric heating apparatus.
14,916 CONNER & PEEL CONNER TELEPHONE WORKS. Telephone systems.
14,918 WILSON & WILSON. Electric oscillating systems.
14,946 & 14,956 ADAMS MFG. Co. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*

June 22, 1910.

15,004 THOMSON. Small or pocket electric lamps.
15,018 SIEMENS BROS. DYNAMO WORKS & NEBEL. Arc lamps for use with searchlight projectors.*
15,027 MCLEAN. Supporting electric lamps and the like.
15,031 PRESSER. Regulation of the welding heat in electric welding. (Addition to No. 14,859/10.)*
15,032 PRESSER. Connection for electric welding by continuous current and the use of condensers. (Addition to No. 14,859/10.)*
15,033 PRESSER. Polarisation of fluid condensers in an electric welding apparatus. (Addition to No. 14,859/10.)*
15,037 SWEETSER & ELECTRIC SIGN & GENERAL ADVERTISING Co. Electric switch apparatus.*

June 23, 1910.

15,086 RIDINGS. Arc lamps.
15,123 POTTS. Automatic telegraphic transmitters. (Date applied for, 29/6/09. Comprised in application No. 15,167, dated 29/6/09.)*
15,134 RØDRUP. Magneto-ignition devices for internal-combustion engines.
15,139 HERING. Electric furnaces. (Date applied for, 6/7/09.)*†
15,143 KLOSTERMANN. Arc lamps. (Date applied for, 26/6/09.)*†
15,150 ENGEL. Electrical contact device. (Addition to No. 6,765/08. Date applied for, 23/6/09.)*†
15,164 THOMSON. Resisters of electric furnaces. (Date applied for, 1/9/09.)*†
15,165 THOMSON. Revoluble or oscillatory electric furnaces. (Date applied for, 1/9/09.)*†
15,166 FITZGERALD. Electric furnaces. (Date applied for, 1/9/09.)*†
15,167, 15,168 & 15,169 THOMSON. Electric furnaces.
15,170 NORTH. Alternating-current electric meters.
15,180 KRUGER. Bending filaments for electric incandescence lamps.*

June 25, 1910.

15,306 ORLING & ORLING'S TELEGRAPH INSTRUMENTS SYND. Electric transmitters.
15,318 HÖFERMANN. Disinfecting device for telephone apparatus. (Date applied for, 27/1/10.)*†
15,325 B.T.-H. Co. & PARK. Electric traction systems.

June 27, 1910.

15,343 SMITH & LARSEN. Electric controllers. (Date applied for, 30/9/09.)*†
15,365 GARFORTH & BOUSFIELD. Electric switches.
15,388 THOMAS. Control of series-wound dynamo-electric machines.
15,414 CHRISTIAN. Trolley poles in overhead electric traction systems.*
15,415 AKT.-GES BROWN, BOVERI, ET CIE. Voltage regulation of dynamo-electric altenating current machinery. (Date applied for, 10/7/09.)*†
15,417 KOHLER. Alternating current solenoids. (Date applied for, 17/9/09. Comprised in Application No. 21,249, dated 17/9/09.)*
15,422 MONEY. Electro-magnetic apparatus for the transmission of power.
15,423 NEWTON. Constant voltage generators.
15,424 HARRISON. Electric incandescent lamps.
15,425 PRITCHETT. Accumulator boxes.*
15,426 ALLGEMEINE ELEKTRICITATS-GES. Control of dynamo-electric machines. (Date applied for, 28/6/09)*†

June 28, 1910.

15,448 O'HARA. Sanitary telephone mouthpieces.*
15,482 WINTERHALDER. Cut-out switches.*
15,497 GALLETTI. Production of continuous wave trains by means of primary spark circuits. (Date applied for, 29/6/09.)*†
15,548 THOMPSON. Controller regulators for electric motors.*
15,564 MOORE. Electrical switches oerated by a vehicle passing along a railway.

June 29, 1910.

15,574 BISHOP. Locking nuts on insulator attachments of telegraph poles and for other like uses.
15,587 HOLBECH. Dynamo-electric machinery.
15,618 ANDERSON, RUSSELL & RAY. Systems for the distribution of electric energy. (Addition to No. 21,219/09.)*
15,619 LAMBOT. Automatic electric recording devices.*
15,621 SKAUPY. Manufacture of electric metal filament lamps. (Date applied for, 6/12/09.)*†
15,625 MIDGLEY & VANDERVELL. Dynamo-electric machinery. (Addition to No. 16,447/09.)
15,664 SEFTON-JONES. (Paul Prevot, France.) Electrolytic copper process.

June 30, 1910.

15,684 DEAN. Armoured or protected electric switches and fuses.
15,692 LENZ. Apparatus in wireless telegraphy, for detecting the direction of transmitting station from receiving station.
15,710 QUINT. Enclosed electric lamps of the inverted type.
15,731 CHAMPION. Electric-junction boxes and similar or other chambers.
15,734 MONTAGNA. Telegraphic and telephonic transmission of pictures. (Date applied for, 6/11/09.)*†
15,744 SOCIETE DES ETABLISSEMENTS GAUMONT. Energy relays. (Date applied for, 30/5/10.)*†
15,753 ALLGEMEINE ELEKTRICITATS-GES. Dynamo-electric machines. (Date applied for, 1/7/09.)*†

July 1, 1910.

15,770 CARTER. Dynamo-electric machines.
15,789 PECHIN. Cup insulator with centrifugal contacts for arc lamps.*
15,792 BOWYER & ANCHOR CABLE Co. Providing electric conductors with an identifying covering.
15,807 JANDUS ARC LAMP AND ELECTRIC Co. & JONES. Arc lamps.
15,836 MAHONEY. Braking systems for electric motor-driven vehicles. (Date applied for, 29/7/09.)*†
15,837 ROSENTHAL. Transmitter for submarine telegraphy and telephony. (Date applied for, 8/7/09.)*†

July 2, 1910.

15,862 HOPE. Fusible cut-outs for controlling electric circuits.
15,865 SOCIETE ANONYME FORGES DE BELLECOURT. Bogies for the rolling-stock of railways and tramways. (Date applied for, 11/4/10.)*†
15,873 BULLIMORE & COSSOR. High-tension electrical condenser.
15,879 SCHROTER. Manufacture of electric metal filament lamps. (Date applied for 21/1/10.)*†

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SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

2,014 WHITING. Crossings for tramway rails and the like. (Post-dated 26/8/09.)
5,777 BELL & PLETTS. Electrically heating air and other media.
9,242 HENWOOD. Optical electromagnetic speed-indicators.
11,956 WALKER. Dynamo-electric machines.
13,509 WILSON & WILSON. Spark coils. (Cognate application, 28,699/09.)
13,530 DONOVAN. Electric starting and regulating switches.
13,842 RIDINGS. Arc lamps.
13,961 B.T.-H. Co. (G.E. Co., U.S.) Electric heating devices.
14,352 GEORGI & REYROLLE & Co. Protective arrangements for electrical current distribution systems.
14,763 LAMKIN & NUNWICK. Holders for incandescence electric lamps
14,873 HOLDEN. Electric clocks.
14,980 FASSLER. Rectification of alternating electric currents and devices for use therein.
15,273 LEIGH. Suspension cables or supports.
15,287 JOHNSON & PHILLIPS & BROCKIE. Magazine electric arc lamps.
15,441 VERITY'S & PIPKIN. Construction of quick make and break electrical switch.
16,558 LAKE. ("Polyfrequenz" Elektricitäts-Ges.) Producing electrical oscillations.
16,607 CHETWYND, KELVIN & JAMES WHITE (LTD.) & CLARK. Portable magnetic compasses. (Addition to No. 21,634/08.)
16,649 WEST. Quick make and break electric switches.
17,564 B.T.-H. Co. (G.E. Co., U.S.) Rotary electric converters.
17,863 MAGGIORA & SINCLAIR. Electric motors.
19,465 DE STEFANO. Electro-magnetic device. (Date applied for, 26/8/09.)
21,021 HIGHFIELD. Installation of electrical conductors.
21,480 B.T.-H. Co. (G.E. Co., U.S.) Electrolytic condensers.
21,526 WATKINS. Insulator for supporting the current rails of electric railways and tramways.
21,564 ROYCE. Electric heaters.
21,649 BURNET & TUDOR ACCUMULATOR Co. Jointing of rails for tramways and the like.
22,029 DENEREAZ. Socket and plug for electric lamps and other apparatus utilising electric current.
22,458 KRAUSE. Metal filament lamps having filament carriers arranged elastically. (Date applied for, 10/6/09.)
23,429 MUIRHEAD & MUIRHEAD & Co. Electric telegraphy.
24,134 MANDERS. Production of continuously maintained and sustained oscillations of electricity.
26,444 MITCHELL & DUDGEON. Means for supporting overhead electric wires and cables.
26,570 DENNY. Electric tumbler switches.
26,705 KÖRTING & MATHIESEN AKT.-GES. Arc lamps. (Date applied for, 23/11/09.)
29,026 VAN RADEN. Electrical ignition apparatus for internal-combustion engines.
29,481 FESSENDEN. Wireless electric signalling. (Date applied for, 11/2/09.)
29,801 BROS. Automatic telephone exchanges.
30,093 HIBBERD. Coin-freed mechanism for electricity meters. (Date applied for, 23/6/09.)

1910 SPECIFICATIONS.

350 KRAUSE. Metal filament lamps having filament carriers arranged elastically. (Date applied for, 7/7/09, originally included in No. 22,458/09.)
722 FARRELL. Electric motor power transmission.
1,428 SIEMENS BROS. & Co. (Siemens & Halske Akt.-Ges.) Damped electrical relays.
1,482 JACKSON & SCHEIBE. Control apparatus for vapour electric rectifiers. (Date applied for, 21/1/09.)
2,377 WILLIAMS & TORTORICE. Railway rail joints
2,904 HEUTERMANN. Cross tie or sleeper for railway rails.
3,579 DUTTON & MCKENZIE & HOLLAND (LTD.) Signalling and interlocking for railways and tramways. (Addition to No. 784/09.)
5,917 SIEMENS & HALSKE AKT.-GES. Rectifier for high-tension alternating currents. (Date applied for, 28/5/09.)
6,125 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke Ges.) Regulation of electric frequency converters.
6,168 MORRIS & BASTERT. Overhead runways.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

GEORGE HILL & CO. (LTD.) (111,525.)—Reg. Aug. 30, capital £4,000 in £1 shares, to take over the business carried on by George Hill & Co., Manchester, and to carry on the business of electricians, engineers, manufacturers, &c. Private company. First directors, A. R. Walmsley, A. K. Walmsley and R. Barron. Reg. office, 12, Cornbrook Park-road, Manchester.

SWANN GARLAND (LTD.) (111,606.)—Reg. Sept. 3, capital £5,000 in £1 shares, to carry on the business of manufacturers of and dealers in art metal work, electric light fittings, stove grates, fenders, &c. Private company. First directors, T. Swann Garland (permanent managing director, subject to holding 500 shares) and M. D. Cooke.

UNITED LIGHTING & MAINTENANCE CO. (LTD.) (111,517.)—Reg. Aug. 29, capital £2,000 in £1 shares, to take over the business of electricians, &c., carried on by S. Mundler as the National Lighting Co. Private company. First directors, M. Kaiser, S. Mundler and J. W. May. Reg. office, 35, Cock-lane, London, E.C.

WILLIAM H. SAYER & CO. (LTD.) (111,590.)—Reg. Sept. 2, capital £500 in 10s. shares, to take over the business of an electrical and mechanical London and export merchant carried on as W. H. Sayer & Co. Private company. W. H. Sayer is first director. Reg. office, 10, New-street, Bishopsgate, London, E.C.

W. V. WAITE & CO. (LTD.) (111,537.)—Reg. Aug. 30, capital £1,000 in £1 shares, to carry on the business of electrical, mechanical, hydraulic, civil, railway, consulting and general engineers, agents, &c. Private company. First directors, W. Waite, C. P. Waite and W. V. Waite (managing director).

STATUTORY RETURNS.

CHILI TELEPHONE CO. (LTD.)—According to return dated July 28 capital is £250,000 in £5 shares. 44,000 shares taken up. £220,000 paid. Mortgages and charges, nil.

CHILIAN ELECTRIC TRAMWAY & LIGHT CO. (LTD.)—In return dated July 21 capital is £1,150,000 in 500,000 ordinary and 650,000 preference shares of £1 each. All shares taken up. £650,000 paid on the preference. £500,000 considered as paid on the ordinary. Mortgages and charges, £433,400.

ELECTRIC CONSTRUCTION CO. (LTD.)—Return dated July 28 gives capital as £400,000 in 150,000 preference and 50,000 ordinary shares of £2 each. 112,100 ordinary and 31,390 preference shares taken up. £2 per share called up on 2,100 ordinary and 18,245 preference. £40,690 paid. £246,290 considered as paid on 110,000 ordinary and 13,145 preference. Mortgages and charges, £210,000.

MADRAS ELECTRIC SUPPLY CORPN. (LTD.)—Return to Aug. 3 gives capital as £400,000 in £5 shares. 60,000 shares taken up. £300,000 paid. Mortgages and charges, nil.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—The capital in return dated Aug. 2 is £1,000,000 in 150,000 ordinary, 40,000 preference and 10,000 unissued shares of £5 each. 150,000 ordinary and 40,000 preference shares taken up. £5 per share called up on 134,000 ordinary and 40,000 preference. £870,000 paid. £80,000 considered as paid on 16,000 ordinary shares. Mortgages and charges, £300,000.

MORTGAGES AND CHARGES.

F. BURKS & CO. (LTD.)—Issue on July 8 of £480 debentures, part of a series of which particulars have already been filed.

WILLIAM COATES & SON (LTD.)—Deposit of deeds on Aug. 19 securing all monies due to and to accrue from the company to holders, charged on premises in Castle-street, Belfast.

IMPERIAL LAMP WORKS (BRIMSDOWN) (LTD.)—Issue on Aug. 18 of £25,000 debentures, part of a series of which particulars have already been filed.

VAN RADEN & CO. (LTD.)—Mortgage, dated Aug. 15, to secure £1,850, charged on freehold factory, land and premises at Coventry. Holder, C. W. Hill.

CITY NOTES.

MEMORANDA (Sept. 8).—**Bank rate 3 per cent. (since June 9, 1910) Price of silver,** 24⅛d. per oz. Consols 80⅜—80⅝ for money; 80½—80¾ for account. **Consols Pay Day, Oct. 5; Stock and Shares Continuation Days,** Sept. 13 and 27; **Ticket Days,** Sept. 14 and 28; **Pay Days,** Sept. 15 and 29; **Mining Shares Carry Over Day,** Sept. 12.

PRICES OF METALS (London).—*Copper*, cash, 55⅜; three months, 56¾. *Lead*, English, 12¼—13; foreign, 12½—12⅝. *Spelter*, 22⅛—22⅜ *Tin*, English, 156½—157½; foreign cash, 166; three months, 157⅜. *Iron*, Cleveland, cash, 49/6, three months, 50/3.

AMALGAMATION OF CANADIAN ELECTRICAL COMPANIES.—It is announced that the Montreal Street Railway Co. and the Canadian Power Co. have been amalgamated. The new company will have a capital of $60,000,000.

CANADIAN GENERAL ELECTRIC CO.—A dividend of 1¾ per cent. has been declared on the common stock for the quarter ending 30th inst.

DAVIS & TIMMINS (LTD.)—An interim dividend of 6 per cent. on the ordinary shares, for the half-year ended June 30 has been declared.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Sept. 9 a special settling day in scrip, fully and partly paid, for £300,000 6 per cent. Government guaranteed loan of the *Electric Light & Power Co. of Cochabamba*. The committee have been asked to grant quotations to a further issue of £50,000 4½ per cent. first mortgage prior lien gold bonds of £100 each of the *Montreal Water & Power Co.*, £250,000 5 per cent. first mortgage debentures (in lieu of the scrip) of *Vera Cruz Electric Light, Power & Traction (Ltd.)*, and a further issue of £200,000 4½ per cent. perpetual consolidated debenture stock of the *Winnipeg Electric Railway Co.*

YORKSHIRE ELECTRIC POWER CO.—At the meeting on Tuesday the chairman (Mr. A. G. Lupton) said that it was interesting to compare the past half-year with the corresponding half-year of 1903. In the two years the total receipts for the six months had increased from £8,698 to £16,675, and the gross profit had grown from £1,249 to £4,950. It was to the increasing ratio of profit to revenue that they looked to put the company on a dividend basis. Supply had been given for several months to a large colliery in Castleford for hauling, pumping, ventilating, lighting, &c. Negotiations were proceeding with colliery proprietors both in that and other portions of the company's area, and they anticipated a largely increased demand for these purposes in the near future. Castleford was also providing a number of other customers anxious for their supply. An overhead line was being carried to the western portion of their area from Brighouse to Sowerby Bridge, where the Distribution Company was being pressed for a supply, and where some important contracts had already been made, including a considerable supply to a large cotton mill now being built there. A further extension was also being proceeded with in the vicinity of Barnsley, where a large colliery would shortly be taking energy. During the half-year further connections had been made to the mains laid or erected before the present year. In the case of a large mill in the Dewsbury district, owing to the total collapse of one of the main mill engines the company had been called upon for an emergency supply. The damage was so considerable that many months would have elapsed before the engine could have been repaired or renewed, but a partial supply was given within a few hours, and some hundreds of horse-power of motors were connected, and the whole mill running as before in less than a fortnight, greatly to the relief of both employers and workpeople.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 31	1,681	+ 70	13	20,510	— 262
Airdrie	„ 26	212	— 35	34	7,375	+ 23
Anglo-Argentine	Sept. 2	44,075	+ 8,885	35	1,543,742	+ 181,283
Ayr Corporation	„ 3	302	— 11	16	6,817	+ 274
Barnsley	Aug. 26	207	+ 2	34	5,905	+ 181
Barrow	„ 26	305	+ 40	34	9,228	+ 1,346
Bath Electric Trams, Ltd...	„ 31	1,046	+ 105	35	28,728	+ 1,429
Birmingham Corporation ...	Sept. 3	6,565	+ 251	22	149,667	+ 1,659
Birmingham & Midland....	Aug. 19	878	+ 18	33	28,088	+ 375
Blackburn Corporation	„ 31	933	— 78	‡22	24,843	— 1,041
Blackpool and Fleetwood ..	Sept. 3	1,421	— 24	..	..	..
Bolton Corporation.....	„ 4	2,475	+ 100	23	54,084	— 144
Bombay	Aug. 5	2,522	+ 166	31	83,603	+ 6,139
Bournemouth Corporation..	„ 31	2,262	— 21	22	44,453	+ 3,991
Bradford Corporation.....	..	..	..	..	..	..
Brighton Corporation.....	Sept. 4	1,273	+ 55	§22	24,379	— 43
Bristol Trams & Carriage ..	„ 2	6,314	+ 344	9	58,044	+ 3,094
Burnley Corporation	„ 3	1,198	— 54	9	11,511	— 95
Burton Corporation	„ 4	269	+ 4	22	6,151	— 12
Bury Corporation	„ 4	1,223	+ 38	§22	26,865	— 404
Calcutta Tramways Co.....	„ 3	₹58,510	+₹12,076	9	₹479,712	+₹35,129
Camborne-Redruth	..	..	..	..	..	..
Cardiff Corporation.....	..	..	..	..	..	..
Cavehill.....	Aug. 26	95	— 10	34	3,186	+ 134
Central London Railway ..	Sept. 3	4,931	+ 236	9	46,860	+ 2,661
Chatham & Dist. Lt. Rys. ..	„ 1	976	— 24	35	29,727	+ 1,027
City & South London Rly...	„ 4	2,982	+ 9	9	27,552	+ 204
City of Birmingham	Aug. 26	2,872	+ 209	34	97,056	+ 2,245
Colchester Corporation	„ 31	228	+ 3	..	..	..
Cork Electric Trams Co.....	Sept. 1	519	+ 13	45	17,118	+ 1,636
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams ..	Aug. 26	462	+ 78	34	14,404	+ 1,888
Dover Corporation	Sept. 3	289	+ 21	22	5,383	+ 122
Dublin & Lucan Railway ..	„ 2	189	+ 23	9	1,631	+ 70
Dublin United	„ 2	6,432	+ 609	9	56,571	+ 731
Dudley-Stourbridge	Aug. 26	1,008	+ 115	34	27,169	— 646
Dundee Corporation	„ 31	1,341	— 27	§15	19,083	+ 283
East Ham Council	Sept. 3	1,054	+ 76	¶22	23,518	+ 578
Exeter Corporation.....	„ 2	354	— 16	22	7,512	— 689
Gateshead & Dist. Trams ..	Aug. 26	989	— 5	34	33,520	— 196
Glasgow Corporation	Sept. 3	17,914	+ 893	14	239,040	+ 12,149
Glossop Trams.....	„ 3	109	— 10	35	4,109	— 253
Gloucester Corpn.....	Aug. 31	295	— 15	..	..	..
Gravesend-Northfleet.....	„ 26	233	— 16	34	7,102	— 5
Great Northern & City Rly..	Sept. 3	1,328	+ 74	9	11,597	+ 399
Greenock & Port Glasgow ..	Aug. 26	720	+ 53	34	21,487	+ 2,844
Hartlepool Tramways	„ 26	301	+ 25	34	8,512	+ 529
Hastings Elec. Trams Co. ..	Sept. 1	1,458	— 126	9	13,018	+ 94
Hong Kong	„ 3	$7,723	—$1,436	9	$79,211	+$3 898
Huddersfield Corpn.	„ 3	1,713	+ 77	23	39,702	+ 2,024
Hull Corporation.....	„ 3	2,800	+ 115	22	60,508	+ 3,439
Ilford District Council.....	..	..	..	..	..	..
Ilkeston District Council ..	Aug. 31	141	— 21	22	2,883	— 185
Ipswich Corporation	Sept. 3	504	+ 20	22	10,293	+ 594
Isle of Thanet Co.	„ 3	1,705	+ 139	¶46	30,178	+ 1,850
Jarrow	Aug. 26	142	+ 8	34	4,263	+ 238
Keighley Corporation.....	Sept. 1	182	+ 3	22	4,028	+ 139
Kidderminster & District ..	Aug. 26	142	+ 12	34	3,852	+ 107
Kilmarnock Corporation ..	Sept. 3	152	+ 14	16	2,546	+ 70
Lanarkshire Trams Co.	„ 1	1,448	+ 15	35	48,447	+ 3,653
Lancashire United	Aug. 31	1,242	— 77	35	45,775	— 671
*Leamington	„ 26	215	+ 8	34	5,744	— 211
Leeds Corporation	Sept. 3	7,043	+ 204	22	159,856	+ 5,021
Leicester Corporation.....	„ 3	2,322	+ 125	..	..	..
Leith Corporation	„ 3	638	+ 4	16	10,440	+ 14
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	Aug. 27	11,001	+ 183	34	379,466	+ 13,827
Liverpool Overhead Rly. ..	Sept. 4	1,428	+ 49	10	14,845	+ 58
Llandudno&ColwynBayRy.	„ 2	663	+ 9	§39	11,432	+ 48
*London County Council	Aug. 24	41,915	+ 5,556	¶21	881,100	+ 118,470
London Elec. Ry. Co.....	Sept. 3	10,730	— 160	9	102,730	+ 385
London United	„ 3	6,794	— 8	35	225,406	+ 9,463
Lowestoft	..	..	..	..	..	..
Maidstone Corporation	„ 3	193	— 16	22	4,103	— 252
Manchester Corporation....	„ 3	15,333	+ 465	22	345,957	+ 5,866
Mersey Railway	„ 3	1,922	+ 18	9	17,480	+ 254
Merthyr	Aug. 26	223	— 13	34	7,055	— 241
Metropolitan Dist. Railway..	Sept. 3	9,457	+ 403	9	89,980	+ 5,593
Metropolitan Elec. Trams ..	Aug. 26	7,884	+ 1,311	34	253,033	+ 43,950
Middleton	„ 26	390	+ 32	34	10,901	— 682
Nelson Corporation.....	Sept. 3	150	+ 13	§22	3,316	+ 103
Newcastle-on-Tyne Corp. ..	„ 3	3,851	+ 188	¶22	89,264	+ 1,074
Newport (Mon.)	„ 3	721	+ 72	23	16,045	+ 615
Northampton Corporation..	„ 2	502	+ 9	§22	11,338	+ 46
Oldham, Ashton & Hyde ..	Aug. 26	617	— 10	34	18,920	— 106
Oldham Corporation	Sept. 4	1,770	+ 51	23	43,524	— 1,017
Perth (N.B.) Corporation ..	Aug. 31	183	+ 15	§15	2,845	+ 199
Perth (W.A.) Elec. Trams ..	..	..	..	..	..	..
Peterborough	„ 26	131	+ 1	34	3,956	— 86
Portsmouth Corporation ..	Sept. 3	2,533	+ 6	22	50,133	+ 1,697
Potteries	Aug. 26	1,763	— 17	34	59,228	— 636
Preston Corporation	..	..	..	..	..	..
Rotherham Corporation....	Sept. 1	645	+ 55	22	13,818	+ 596
Rothesay	Aug. 26	500	— 21	34	8,068	+ 49
Salford Corporation	Sept. 5	4,902	+ 323	†23	106,465	+ 1,462
Sheerness	Aug. 26	72	— 1	34	1,734	— 12
Sheffield Corporation	Sept. 4	6,038	+ 436	¶23	139,235	+ 8,171
Singapore Trams.....	„ 3	$10,270	+ $421	9	$80,720	+ $7,443
South Metropolitan.....	Aug. 26	897	— 17	34	28,349	+ 1,207
South Staffs.....	„ 26	938	+ 65	34	28,520	+ 120
Southend Corporation	„ 31	906	+ 117	22	15,059	+ 1,467
Southport Tramways	„ 26	363	— 11	34	10,227	+ 173
Stalyb'dge,Hyde,&c.,Jt.Bd.	Sept. 3	726	— 15	¶22	16,441	— 1,360
Sunderland Corporation....	„ 4	1,335	+ 100	23	26,960	— 198
Sunderland District	Aug. 31	485	+ 13	44	18,937	— 1,348
Swansea Trams	„ 26	1,197	+ 121	34	36,911	+ 4,201
Swindon Corporation	„ 31	153	— 1	22	3,161	+ 129
Taunton	„ 26	49	— 8	34	1,454	+ 98
Tynemouth and District....	„ 26	482	+ 35	34	9,202	+ 493
Tyneside Trams Co.	„ 31	458	+ 15	9	4,602	+ 335
Wallasey District Council ..	Sept. 3	1,017	+ 39	§22	22,121	+ 103
Walsall Corporation	„ 3	523	+ 22	35	18,763	+ 812
Warrington Corporation....	„ 1	397	+ 24	22	8,661	+ 184
West Ham Corporation	Aug. 25	2,451	+ 163	21	52,633	+ 2,136
Weston-super-Mare	„ 26	412	— 22	34	5,441	— 86
Wolverhampton Co.	„ 26	464	+ 32	34	14,535	+ 311
Wolverhampton Corpn.	„ 31	892	+ 121	..	..	..
*Worcester	„ 26	333	+ 13	34	9,684	+ 173
Wrexham	„ 26	103	— 10	34	3,307	— 21
Yorkshire W.R. Trams	Sept. 4	1,262	— 4	36	44,865	..
Yorkshire Woollen District.	Aug. 26	1,061	+ 85	34	33,534	+ 2,790

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shrs	Last Dividend	Name.	Price Wed., Sept. 7.	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 7. High-est.	Business Week to Sept. 7. Low-est.
		Electricity Supply.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	8¾—9¼	5 16 0	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.....	9 —9⅛	4 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 13 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	102¾	..
5	4/6	Brompton & Kensington Elec. Sup. Ord. ..	6⅞—7⅛	6 9 0	March....	7⅛	..
5	3/6	Do. 7 per Cent. Pref.....	6⅞—7⅛	4 15 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅜—3⅞	6 5 6	Feb, Aug	3½	..
5	2/3	Do. 4½ per Cent. Pref.	4⅛—4⅜	4 15 0	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deo. Stock (red.)	101 —103	4 7 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3⅛—4⅛	5 9 6	Jan, July	..	..
5	2/6	Chelsea Electric Supply Ord.....	3⅛—4⅛	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	City of London Electric Lighting Ord.	11⅛—11⅝	6 9 0	Feb, Aug	11⅛	11 5/32
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅝—12⅛	4 18 0	Jan, July	11⅛	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 —124	4 0 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99½—102⅛	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.....	1⅛—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2⅛—3⅛	7 14 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7⅛—7½	6 7 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½—11	5 9 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104½—107¼	4 3 6	Jan, July	..	..
St.	4%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4⅝	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	99 —102	4 8 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.....	7 —7⅛	5 9 0	April, Oct	7⅛	..
5	4/0	Kensington & Knightsbridge Ord	6⅞—7⅛	5 6 9	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅛—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜—2	4 10 0	Mar, Sept	..	..
5	3/0	†Do. 6 per Cent. Pref.....	4 1/16—5 1/16	5 15 6	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.....	90 —92	4 7 0	Jan, July	..	..
5	2/0	Metropolitan Electric Sup. Ord.	3⅛—3⅜	6 13 3	April, Oct	3 1/16	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	4 —4⅛	5 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	103	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95⅛—97⅛	4 12 6	June, Dec	..	..
5	1/6	Newcastle Elec. Supply Ord.....	3⅞—4⅛	4 11 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛—4⅜	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	100 —102	4 8 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6⅜—6⅞	5 2 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7⅛—8⅛	6 2 3	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.....	6⅞—7⅛	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1⅛—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2⅝—3	6 4 6	April	..	..
St.	5%	Do 5% 1st Mort. Stock (red.).....	99 —102	4 19 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅞—1	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1 1/16—1 3/16	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.).....	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	½—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.....	8 —8½	5 17 9	Mar, Sept	8⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5⅛	4 2 0	Jan, July	5 1/16	..
		Electric Railways and Tramways.					
1	..	Bath Elec. Trams Pref. Ord.....	⅛—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅜	6 12 9	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.).....	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6 —6½	9 4 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7⅛—7⅝	5 8 6	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅞ —1	..	June, Dec	⅞	⅞
10	..	Do. 6 per Cent. Cum. Pref.	2⅞—3	..	Feb, Aug	2⅛	2 1/16
St.	5%	Do. 5 per Cent. Perpetual Debs.....	89 —93	5 6 6	April, Oct	88	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	70 —75	6 0 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	63 —65	4 12 6	Feb, Aug	64⅛	..
St.	4%	Do. 4 per Cent. Pref. Stock	84 —86	4 14 6	Feb, Aug	85¼	..
St.	2%	Do. Deferred Stock	47 —49	4 2 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	..	..
5	2/6	City of Birmingham Trams, 5% Cum. Pref.	4¼—5⅛	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	98 —102	3 18 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	27½—28	5 5 0	Feb, Aug	28⅛	28
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1896)	102 —104	4 16 0	Feb, Aug	102½	102½
St.	5%	Do. (1901)	99 —102	4 18 0	Feb, Aug	101¼	101½
St.	5%	Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.....	99 —101	3 19 0	May, Nov	100½	100
10	6/0	Dublin United Trams. 6 per Cent. Pref.....	12½—13¼	4 6 6	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾—1	..	Feb, Aug	..	..
5	..	Hastings & District Elec. Trams, 6% C. P.	1 —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1⅞—1⅞	3 12 9	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —75	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅜—10	5 10 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2½	..	Jan, July	2⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	67 —71	5 12 6	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2½—3⅜	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.....	⅛—⅜	..	..	..	..
1	..	Do. Deferred	⅛—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—⅝	5 11 0	Feb, Aug	7/32	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	96 —99	4 11 0	Jan, July	..	..
St.	..	Do. 5 per Cent. Db. Stk	97 —99	5 1 0	..	97½	..
St.	1½%	Metropolitan Railway Consolidated.....	38¾—39	2 18 9	Feb, Aug	38¼	38
St.	2½%	Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	65	..
St.	3½%	Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	88½	87⅝
St.	3½%	Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	85¼	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	91½	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shre	Last Dividend	NAME.	Price Wed. Sept. 7.	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 7. High-est.	Low-est.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	90 —92	3 15 6	Jan, July	91	..
St.	..	Metropolitan District Railway Ord.....	21½—21¾	..	Feb, Aug	21½	21
St.	3%	Do. 4½% First Pref.	78 —80	1 17 6	Feb, Aug	79½	78½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 0	Feb, Aug	73	..
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	4 0 0	Jan, July	..	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	140 —142	4 4 6	Jan, July	140½	..
St.	4%	Do. 4 per Cent. Ditto.....	95 —97	4 2 6	Jan, July	..	..
1	4½d.	Potteries Electric Traction Ord.	½—¾	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	½—¾	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	½—¾	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoup5	39 —41	4 16 0	June, Dec	39½	39
..	5%	Do. 5% Prior Lien Bonds.....	103 —104	4 16 0	..	104	103½
..	4½%	Do. 4½% Bonds with coup. 6	92 —94	4 15 6	..	94½	91½
..	4%	Do. 4 per Cent. 1st Power Ho. Dbs. ..	98 —100	4 0 0	..	99½	99½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	½—¾	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2½	..	..	1½	1½
St.	4½	Do. 4½ per Cent. 1st Debs.....	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Anchor Cable Co. 4½ % Deb. Stock	100 —102	4 9 0	..	..	..
1	..	Aron Electricity Meter Ord.....	½—¾	..	..	..	..
1	1/9½	Do. 6% Cum. Pf.	½—¾	6 16 0	April, Oct	..	..
1	3/2½	Babcock & Wilcox Ord.....	5½—5¾	4 3 0	April, Oct	5½	..
1	0/7½	Do. Pref.....	1⅛—1⅜	3 16 3	..	..	..
5	6/0	British Insulated & Helsby Cables Ord...	7 —7½	6 13 6	July, Feb	..	7½
5	3/0	Do. 6 per Cent. Pref.....	6 —6½	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red)..	101 —104	4 6 6	Jan, July	..	..
St.	4½%	†British Thoms'n-Houst'n 4½% 1st Mt.Db.	98 —101	4 12 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	½—¾	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	100 —102	5 18 0	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	61 —63	3 3 6	Jan, July	..	..
St.	4½%	†BrushE. Eng. Co. 4½% Perp. 1st Deb. Stock	37 —42	10 14 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	22 —26	17 6 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9½—9¾	7 12 6	Jan, July	9½	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	4½—5½	4 15 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red)..	101 —103	4 7 0	Nov, May	101½	101½
1	1/3	Castner-Kellner Alkali Co.....	2½—3	4 16 0	May, Nov	3	2½
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red)..	104 —107	4 4 0	Feb, Aug	..	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	5 19 0	March ..	..	..
1	0/8½	Consolidated Electrical Co.....	½—¾	5 18 9	August ..	½	..
1	0/6	Consolidated Signal Co.....	½—¾	5 12 9	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.....	½—¾	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	½—¾	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red)..	83 —85	5 18 6	Jan, July	..	..
1	0/7½	Davis & Timmins	½—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	1 —1½	5 7 0	Sept.	1½	1⅜
5	0/7½	Do. 6 per Cent. Cum. Pref.....	1⅛—1⅜	4 12 0	Sept.	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	¾—⅞	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1½	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅞—1	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2	..	May, Nov	..	..
St.	4½%	Do 4½ per cent. 1st Mort. Deb. (red)..	75 —78	5 15 6	Jan, July	..	..
2	..	Electric Construction Co.....	½—¾	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1½—1¾	4 13 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	59 —61	6 5 0	Jan, July	59½	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	12½	12
5	5/0	†Henley's Telegraph Works Ord.....	12 —12½	5 17 6	Feb, Aug	..	..
5	2/3	†Do. 4½ per Cent. Pref.	4½—5½	4 8 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	106 —108	4 3 6	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works....	14½—15	6 12 0	Feb, Aug	14½	14½
10	5/0	Do 5 per Cent. Cum. Pref.	10½—11	4 14 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	..	..
1	..	National Elec. Construction Co.	½—¾	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	½—¾	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.	½—¾	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance..	34½—36½	4 15 9	Mar, July	36	35½
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	100½—102½	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 5 0	..	2½	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1⅜	4 1 0	..	2⅛	..
St.	5%	Do. 5 per cent. non-Cum. Preferred ..	107 —110	4 12 0	..	108½	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	105	104½
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	105 —107	4 13 6	..	105½	..
10	10%	J. G. White & Co. 6% Cum. Pref.	12½—13½	7 8 0	..	13⅛	..
1	..	Willans & Robinson Ord.....	½—¾	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1½—1¾	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3½—4	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan. July	..	..
St.	15/0	Anglo-American	68 —70	5 5 6	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	110 —112	5 7 0	F,My,Ag,N	111½	110½
St.	25/0	Do. Deferred	27½—27¾	4 13 9	F,My,Ag,N	28	27½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	84 —86	4 13 0	Jn,Ap,Jy,O	85½	84½
10	6/0	Cuba Submarine Ord.	8½—9½	6 10 0	Feb, Aug	8½	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 14 9	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3½—3¾	5 6 8	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	8 —8½	5 18 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	100 —102	4 18 0	Jan, July	..	..
20	6/0	Direct United States Cable.....	15½—16½	5 6 6	Ja,Ap,Jy,O	16½	15½
100	4½%	Direct West India Cable 4½% Rg.Db.(rd.).	99 —101	4 9 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	133 —135	5 4 6	Ja,My,Jy,O	134½	133½
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	84 —86	4 1 6	Ja,My,Jy,O	84½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red)..	102½—104½	3 17 9	May, Nov	104	103
St.	2/6	Eastern Extension	12½—13½	5 6 0	Ja, Ap, Jy,O	12½	12½
100	4%	Do. 4 per Cent. Deb. Stock	100 —102	3 18 6	Feb, Aug	..	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	100 —102	3 18 0	May, Nov	..	..
10	5/0	G.N (of Copenhagen), with Coupon 80 ..	30 —31	5 16 6	Jan, July	54½	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	Mackay Companies Common	86 —90	5 11 0	Ja,Ap,Jy,O	..	..
100	4%	Do Preference	74 —78	5 2 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅝—¾	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs.(red.)	97 —99	4 1 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1¼	4 7 0	May	..	..
100	4%	Do. 4 per Cent. Debs.	97 —99	4 1 0	Jan, July	..	..
10	..	West India & Panama	¾—1	4 0 0	May, Nov	⅞	⅞
10	6/0	Do. 6 per Cent. 1st Pref.	8½—9½	6 15 0	May, Nov	..	..
10	9/0	Do. 6% 2nd Pref.	8½—9½	6 10 0	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.	101 —103	4 19 0	Jan, July	..	..
10	3/0	Western Telegraph	13½—14½	4 16 9	Mr,Jn,O,D	13½	18½
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 —102	3 19 0	June, Dec	..	..
—	4%	Western Union Telegraph, $1,000 4% Bds	103 —106	3 15 3	—	..	..
..	4½%	Do. $1,000 4½% Fdg. & Rl. Est. Gd. Bnds.	99 —102	..	..	..	..

Shre	Last Dividend	NAME.	Price Wed., Sept 7.	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 7. High-est.	Low-est.
		Telephones.		£ s. d.			
St.	2$	Amer. Telephn. & Tsiegh. Cap. St.	139 —142	5 12 3	..	..	..
100	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 7 3	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	103 —108	3 14 0	..	..	..
St.	5%	†Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100½—102½	4 17 6	Mar, Sept	..	..
5	5/0	Chili Telephone	9½—9¾	4 2 0	August ..	9¾	..
1	0/7½	Monte Video Telephone Ord.....	⅞—1	6 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅞—1	5 12 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	104 —105½	6 1 0	Feb, Aug	105½	104½
St.	6%	Do. Def. Stock	123 —125	4 17 6	Feb, Aug	124	123½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 8 6	Feb. Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 8 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.....	5½—5¾	4 8 0	Feb, Aug	5¾	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.).....	98 —100	3 10 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	99 —101	3 19 0	Jan, July	99½	98½
..	..	New York Telephone Co. 30 yr. Bnds.....	98½—99½	4 12 0	..	..	..
..	..	Oriental	1⅛—1⅜	4 14 6	April, Oct	1⅛	..
1	1/0	Do 6 per Cent. Cum. Pref.	1⅛—1⅜	4 11 0	April, Oct	..	..
1	0/7½	Do. 4 per Cent. Red. Deb. Stock.....	86 —88	4 11 0	Jan, July	87½	..
St.	4%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	98½—100½	4 9 6	Jan, July	..	..
St.	4½%	United River Plate Ord. ex rights	6⅛—7⅛	5 11 0	July	7⅛	7⅛
5	5/0	Do. 5 per Cent. Cum. Pref.	5½—5¾	4 11 0	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.....	102½—104½	4 6 0	Jan, July	..	..
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2¾—3¼	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10½—11	5 7 6	Sp,DcMr Ju	10½	10½
10	3/0	Do. 6 per Cent. Pref.	13 —13½	4 9 0	Sp,DcMr Ju	..	..
10	6%	Submarine Cables Trust (Cert.)	132 —135	4 9 0	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4½—4¾	5 5 0	April, Oct	4¾	4½
5	2/6	Do. 5% Cum. 2nd Pref.....	4¼—4½	5 11 0	Jan, July	..	..
5	4%	Do 4% Deb. Stock	91 —92½	4 6 6	June, Dec	92⅛	91½
St.	4½%	Do. 4½% Deb. Stock	94 —97	4 13 0	..	96	95½
St.	5%	Auckland Elec. Trams. 5% Deb. (red.).....	103 —105	4 15 3	Jan, July	104½	103½
St.	4/6	Brisbane Electric Trams. Invest. Ord	5½—6½	5 19 0	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4½—5½	4 15 0	May, Nov	..	..
5	4½%	Do. 4½ per Cent. Db. Prov. Certs.....	99 —102	4 8 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	143 —147	5 9 0	Mar, Sept	144½	143½
St.	£3	Do. Pref. Ord. Stock 3d & bonus	124 —129	4 13 9	May, Nov	125½	125
St.	5%	Do. 5% Cum. Perp. Pref. Stock.....	111 —114	4 7 6	Jan, July	112½	111½
St.	4½%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
40	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
100	4½%	Do. 4½% Perp. Con. Deb. St.	105 —107	3 18 0	..	105	105½
St.	5%	Buenos Ayres Lacroze Trams 1st Mt. Db.	97 —100	5 0 0	Mar, Sept	..	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	96 —99	6 1 0	Feb, Aug	..	..
5	2/6	Calcutta Tramways (1 to 137,610).....	4¼—4¾	4 14 9	Mar, Sept	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5	5 0 0	Jan, July	..	..
100	4½%	Do. 4½% 1st Deb. Stock (red).....	96 —99	4 11 0	Jan, July	..	..
5	1/3	Cape Electric Tram Shares	⅞—1	..	..	..	..
5	4%	City of Buenos Ayres Trams Co. (1904) Sh.	5⅞—5⅞	4 5 6	F,My,A,N	..	..
100	4%	Do 4 per Cent. Deb. Stock.....	99 —102	3 18 0	June, Dec	..	..
100	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	97 —100	5 0 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5%, $1,000 50 year Coup. Bds.	93 —101	5 4 0	Feb, Aug	93½	..
1	..	Kalgoorlie Elec. Trams Sh.	⅞—1	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock.....	92 —95	5 5 0	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	Lisbon Elec. Trams. Ord.	1⅛—1¼	4 8 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1¼	4 16 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	98 —102	4 18 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	..	..
100	5%	Manaos Trams and Lt. Co. 5% Debs	86½—88	5 13 6	..	87½	..
100	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	97 —99	5 1 0	Feb, Aug	..	..
100	$1	Mexico Trams Co. Com. St.	122½—124½	5 4 6	..	124½	123½
100	$1	Do. Gen. Con. 1st Mort. 5% Gold Bds.	97½—98½	5 0 6	..	98½	97½
100	5%	Do. 6% 50 yr. Mort. Bds.....	100 —101	5 19 0	..	100½	99½
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	100 —102	4 8 0	Feb, Aug	..	..
100	$1	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	..	..
1	0/6	Perth Elec. Trams Ord.	⅜—½	5 14 6	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	100 —103	4 17 6	Jan, July	..	..
100	$1	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5¼—5⅜	5 3 9	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	101½	101½
100	$1	Rio Janeiro Tram, Lt. & P. Co.....	96 —97	4 7 6	..	97½	96½
100	5%	Do. 30 yr. Gold Bnds.	98½—99½	5 0 3	..	99½	98
100	5%	Do. 50 yr. Mt. Bnds	91½—92½	5 8 0	..	92½	91½
100	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	153½—155½	6 9 0	..	154½	150½
100	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102½	101½
100	4½%	†Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	99 —101	4 9 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	†Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5½—5¾	5 5 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.....	10½—11½	5 6 6	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red).....	93½—95½	4 14 0	Jan, July	..	..
5	4/9	Do. 5 per Cent. 2nd Mort. Deb. Stock..	97 —99	5 1 0	..	98½	..
100	7/2½	Calcutta Elec. Supply Ord.	6½—6¾	6 6 0	April, Oct	6¾	6½
100	$3½	Canadian Gen. Elec. Co. Com. St.....	110 —114	6 3 0	..	113½	109
100	5%	Do. 7% Cm. Pf. Stock	120 —123	5 14 0	..	122	121
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
100	$1	Elect. Development Co. of Ontario.....	82½—85½	5 17 0	..	..	..
100	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	85 —88	5 14 0	Jan, July	..	..
..	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
..	..	Kalgoorlie Elec. Power & Ltg. Ord.	⅞—1	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1	8 2 6	April, Oct	..	..
..	..	Kaministiquia Power Co. 5% Gold Bnds..	100½—102½	5 0 6	..	..	..
..	..	Madras E. S. Corp. Ord.	2½—3	..	..	..	..
..	..	Melbourne E. S. Co. 6% Cum. Pref.	33 —38	..	..	..	..
100	5%	Do. 5% 1st Mortg. Deb. Stock	90½—92½	5 9 0	..	93½	..
100	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	88 —89	5 12 0	..	88½	86½
100	$1	Mexican Lt. & Power Co. Com. St.	84 —85	4 13 0	..	85½	83½
100	5%	Do. 7% Cum. Pref. St.	107½—109½	6 8 0	..	109	108½
100	$1	Do. 5% 1st Mort. Gold Bnds.	93½—94½	5 7 0	..	95½	93½
100	$1	Montreal Lt. Ht. & Power Co. Cap. St.	132 —138	5 5 0	F,My,A,N	136½	134
St.	£9	River Plate Electricity Co. Ord. Stk.	210 —225	4 0 0	April	..	..
5	6%	Do. 6 per Cent. non-Cum. Pref. Stk. ..	105 —115	5 5 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
5	3/0	Rosario Ele. Co. Ord.	8½—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
5	3/0	Do. 2nd Pref.	8½—8¾	6 14 6	..	..	..
100	$1	Shawinigan Water & Power Co. Ca.	99½—101½	3 19 0	..	100½	99½
100	5%	Do. 5 per Cent. Bds.	108 —110	4 10 0	Jan, July	108	..
100	$1	Do. 4½ Per Con. Mt. Db. St.	101½—103½	4 7 0	..	..	..
100	5%	Toronto Power Co. 4½% Db. St.	99 —101	4 9 0	..	..	..
100	6d.	Victoria Falls Power Co. Pref. (1 to 808,000)	½—¾	5 6 6	Jan, July	..	..
..	..	Do. (803,081 to 1,700,000)	⅛—¼	..	..	..	..

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,687. [No. 23. Vol. LXV.] FRIDAY, SEPTEMBER 16, 1910. PRICE SIXPENCE (by post, 6½d.). Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Rail Corrugation.

ALTHOUGH no important pronouncements or new theories have appeared of late in regard to the origin of corrugation on tramway rails, the subject is of necessity uppermost in the minds of tramway managers, many of whom have adopted the expedient—a temporory one it is to be hoped—of grinding out such corrugations where they have become very pronounced. The origin of the trouble, which is probably due to several contributory factors, can be ascertained with most certainty by careful compilation and comparison of the results obtained in different undertakings. Early attempts in this direction led to no very satisfactory conclusions, the evidence being so conflicting that widely divergent theories were inevitable. The fact that in many undertakings corrugation was only just becoming noticeable, and that on routes with an infrequent service of cars the absence of corrugation was not conclusive evidence, increased the difficulty and resulted in theories which further experience showed to be untenable. As we have mentioned, it is by the systematic sifting of evidence that the correct explanation of the phenomenon is to be found, and in this direction much useful work is being done by a committee of the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Local. The more important answers to the *questionnaire* recently sent out by the Union will be found elsewhere in this issue, together with a report by Herr BUSSE, chief engineer of the Berlin Tramways, on the replies received. This report, which should prove of considerable interest to engineers generally, was presented at Brussels at the recent biennial meeting of the Union. Of the 75 towns from which replies were received, only 13 reported comparative freedom from corrugation.

A COMPARISON of the replies with those received two years ago (published in THE ELECTRICIAN of October 9, 1908) gives additional support to the theory that the primary cause of corrugation is to be found in the quality of the metal used for the rails and in the rolling process adopted. Herr BUSSE considers the evidence conclusive in support of these being the chief factors in the phenomenon. An interesting case in point is cited in which rails rolled in different years were laid alternately along the same route; and it was found that the rails rolled in one particular year corrugated much more than the others. Other factors, however, have to be taken into consideration, such as the construction of the rolling stock, the method of propulsion and the track foundation. These appear to influence very considerably the intensity of the corrugations and the rate at which the latter develop. In view of the increasing use of methods of rail welding, it is interesting to notice the experience at Magdeburg. This is to the effect that corrugation develops very rapidly and with great intensity on rails of great length or where rails are welded together. Further evidence on this point should prove valuable, and engineers will be anxious to know if experience in other towns supports that at Magdeburg. The advantages of welding are so many that it is to be hoped a greater tendency to produce corrugations will not have to be set against the smooth running provided by a continuous rail. Although attention hitherto has mainly been centred on the track, it must not be forgotten that corrugation is making its appearance else-

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where, about half the number of undertakings having experienced it in connection with their trolley wires and eight on their tyres, as well as on the rails.

Science and Industry.

In another column will be found an abstract of a Paper on "The Relations of Science to Industry and Commerce," read by Mr. R. Blair at the recent meeting of the British Association. It will be remembered that Mr. Blair is Education Officer to the London County Council, and is therefore interested in education in all its phases. The Paper is of more than usual interest because it includes the opinions of a large number of persons concerned, including students, professors, employers and consuls. Near the beginning of the Paper Mr. Blair refers to the importance of influence, a case being cited in which a well qualified man was only able to obtain a post through influence, but made rapid headway, justifying the confidence placed in him, as soon as he obtained a position. We think, however, that this must be a very isolated case. Generally speaking, we doubt if influence counts for very much, and more often than not a letter of introduction is viewed with suspicion. On the other hand, influence may be important with committees, and we quite admit that sometimes a little interest may make just the difference. But given a good man without, and an inferior man with, a letter of introduction, we think in ordinary commercial work the latter would not stand the best chance. Of course, this does not apply to the proverbial nephew of the managing director.

A point that must be regarded as unsatisfactory in the educational situation is the large proportion of students who take up teaching as a profession. Obviously the teacher who has been through the mill and has earned his livelihood at electrical engineering is better qualified to teach, from the engineering point of view, than a man who proceeds to teach as soon as he has passed through his college course. Another point to which Mr. Blair refers is the attitude of the employer towards the technical student. This is certainly much more favourable than it used to be, and probably a good deal has been gained by the professor realising what are really the needs of the employer as well as by the employer realising that there are considerable benefits in technical education. Nevertheless, we do not suppose that the college course has yet been standardised to the greatest advantage. As illustrating want of completeness we may refer to the question of cost in engineering: this is persistently neglected in many educational institutions, as is strongly emphasised in one quotation, and we hope that the necessity of bearing this important matter in mind will be taken to heart by those of our readers who are in a position to effect some reform.

A Useful Accelerometer.

One of the most interesting Papers read at the recent meeting of the British Association was that by Mr. H. E. Wimperis, an abstract of which we publish in this issue. By means of an extremely simple and ingenious piece of mechanism Mr. Wimperis has opened a way for the investigation of an enormous number of important problems. At the present time the Automobile Club are carrying out experiments on cars by means of a moving road carried on revolving rollers, an apparatus both costly and cumbrous; the new accelerometer will do much more than this machinery in a fraction of the time and at a trifling expense. As Prof. Perry remarked, it is an excellent example of what can be accomplished by the application of commonsense to scientific knowledge. Experiments with the new instrument on tramcars and electric railway trains should yield some interesting results, and we look forward to hearing a great deal more about the accelerometer before many months have past

Obituary.—V. A. H. McCowen.—We regret to record the death, which took place at Bath on the 8th inst., of Mr. Victor A. H. McCowen, late electrical engineer to Salford Corporation, and of the Gables, Higher Broughton. Mr. McCowen was only 44 years of age, and was appointed chief electrical engineer at Salford in March, 1907, in succession to Mr. C. D. Taite, who resigned. Prior to that time Mr. McCowen had been for many years city electrical engineer at Belfast, superintending the carrying out of the original gas engine scheme drawn up by Sir A. B. W. Kennedy in 1894. From the completion of this scheme until 1907 Mr. McCowen also acted as consulting engineer to the Belfast Corporation, designing the existing works, which supply current both for lighting and traction. He also acted as consulting engineer to the Urban District Council of Ballymena and other public bodies. In the early days of electric lighting Mr. McCowen was connected with the Sydenham District Electric Supply Co. (the first high-tension continuous-current system with rotary transformers in the United Kingdom) and the Killarney Electric Light Co. Within twelve months of his appointment as borough electrical engineer of Salford he had the misfortune to lose his wife. He felt this keenly, and shortly afterwards became ill, suffering from neuritis, which speedily developed into sarcoma of the spine. After being away from business for short periods, he left Salford to take up residence in a medical home at Bath, where he died, as mentioned above, last week. In April of the present year his resignation of his position at Salford was accepted by the Council with great regret.

William Finlay.—We also regret to record the death of Mr. William Finlay, of Edinburgh, who was president last year of the Electrical Contractors' Association. This occurred at his father's residence in Edinburgh, on the 7th inst. The immediate cause of death was a block in one of the arteries of the brain; this caused heart failure, and death took place 26 hours after the first symptom. Deceased was 38 years of age, and leaves a wife and family. The funeral took place on the 12th inst.

C. A. Brereton.—We also regret to record the death of Mr. C. A. Brereton who was for many years a partner of Sir John Wolfe Barry. He was connected with much railway and dock work, including the Llynvi and Ogmore Railways and Portcawl Docks, the Lewes & East Grinstead Railway, and the Inner Circle. In association with Sir John Wolfe Barry, he designed the Barry, Middlesborough and Surrey Commercial Docks and the new Kew Bridge. He also carried out work on many other railways, including the Metropolitan, Metropolitan District and the Piccadilly Tube.

N. J. A. Boex.—We regret to learn of the death on the 7th inst., after a short illness, followed by an operation in London, of Mr. N. J. A. Boex, London Superintendent of the Direct Spanish Telegraph Co. Mr. Boex was only taken ill on the night of the 4th. His remains were cremated at Golder's Green on Saturday last. Mr. Boex was one of the original members of the staff of the Submarine Telegraph Co., and entered the Direct Spanish Telegraph Co.'s service at Falmouth in 1881.

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Electrical Exhibition at Olympia in 1911.—We understand from the International Trades Exhibitions (Ltd.), who are taking up the work of organisation, that definite arrangements have now been made for the holding of an electrical exhibition at Olympia next year from September 23rd to October 21st. The exhibition will be promoted by the National Electrical Manufacturers' Association, as at Manchester.

Martyrs to Science.—Another alarming case of X-ray dermatitis has to be recorded. Mr. Ernest Wilson, one of the radiographers at London Hospital, has undergone a sixth operation, and has been compelled to retire from the field of active work. There are many hundreds of persons able to carry on their daily avocations who have to thank Mr. Wilson and other pioneers for their good health and strength. What is especially satisfactory is that the experience gained in the early days has been put to the best account, and the great risk has not now to be run by men who carry on this work.

Regulations for Electricity Supply in France.—According to the Paris correspondent of "The Times," a decree recently promulgated sets forth the conditions which must be observed in connection with the distribution of electric power when the lines touch public property at any point or pass in proximity to telegraph or telephone wires. This decree is in substitution of one that was promulgated in 1908, at the time when Government control over suppliers of electric power was being organised in a methodical manner. Certain of the rules then laid down have been shown by experience to be incompatible with the requirements of commercial operation, while others have proved ineffective as regards the public safety which they were designed to secure. The new decree is the result of exchanges of views between those engaged in the industry and the engineers which the State has charged with its control. The decree divides electrical supply systems into two classes. The first contains those in which, for continuous current, the voltage does not exceed 600 between the conductor and the earth, or for alternating current does not exceed 150 volts. The other class includes those supply undertakings that work with higher voltages. When a supply system of this second class serves several centres the undertaker is put under the obligation of establishing direct communication between each of these centres and the central station, and of providing an arrangement by which the current may be cut off from any of them whenever necessary. The insulators used for systems of this class must, if the voltage is less than 10,000, be tested to a pressure three times the normal, while if it exceeds 10,000 volts they must be tested at 30,000 volts plus twice the excess of the working voltage above 10,000 volts. Conductors for both classes must be placed at least 6 metres above the ground, and those for the second class 8 metres when crossing a public road. Underground conductors must be protected mechanically against damage, and if they are placed in a metallic conduit they must still be insulated as carefully as if they were laid directly in the soil. In the case of supplies intended for traction purposes the following regulations are among those laid down to prevent stray currents :—The conductivity of the track must be maintained as high as possible, and in particular the resistance of each joint must not exceed that of 10 metres of rail; those in charge of the line must periodically test the conductivity and enter the results in a register which is to be open to the inspecting officers; at places where there are points or crossings special precautions must be taken to maintain the conductivity, and where the track passes over metallic structures it is to be insulated electrically so far as is possible. Finally the decree states the conditions which must be observed when conductors, either overhead or underground, cross roads and railways. On the whole, our contemporary remarks, the new regulations seem much more liberal and less exacting than the old ones.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910
Cape St. James—Doson	Sept. 9, 1910

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. Wichi Torikata contributes an article on "Commercial Wireless Telegraphy in Japan," and describes the detectors which are there used, particularly the Teishinsho system.

At a recent meeting of the Union Internationale de Tramways et de Chemins de Fer d'Intéret Local a lengthy report was submitted on rail corrugation. This we give in abstract.

Mr. E. W. Cowan's Paper on "The Price of Electricity," read before the British Association, is concluded in our present issue.

We give abstracts of a number of Papers which were read at the meeting of the British Association last week, including "Utilisation of Solar Radiation and Wind Power," by Prof. R. A. Fessenden; "The Relations of Science and Industry to Commerce," by R. Blair; "The Laws of Electro-mechanics," by Prof. S. P. Thompson, F.R.S.; and "On the Use of an Accelerometer in the Measurement of Road Resistance and Horse-power," by H. E. Wimperis. We deal with the first of these in our Leading Article.

A letter has been issued by the Electric Supply Publicity Committee setting forth certain facts in relation to the position of electric street lighting in London.

The British Electrical Federation are to be congratulated upon their successful exposure of gross frauds to which electric tramway undertakings are particularly liable.

A proposal to acquire the National Telephone Co.'s undertaking in Jersey is being considered by the Public Works Committee of the States.

A further conversion of public gas lamps to electric lighting is being made at Poplar by which a saving of 6s. 8d. per lamp per annum is assured.

Edinburgh Corporation have decided to put down additional plant at Dewar-place at a cost of £45,000.

Arbitration.—Mr. Archibald Read this week commenced hearing arguments and evidence in the arbitration to decide whether the consent of Torquay Corporation to the substitution of the overhead for the Dolter surface contact system of traction on certain tramways is unreasonably withheld.

Loans for Electricity Supply.—At the L.G. Board inquiry last week into the application of Colwyn Bay Council for sanction to borrow £2,300 for cable extensions, the inspector, Mr. H. Ross Hooper, made an interesting statement as to the policy of the Board in regard to loans.

INSTITUTIONS AND SOCIETIES.

Institute of Metals.—The autumn meeting of this Institute will be held at Glasgow from September 21st to 23rd, both dates inclusive. A reception will be held by the Lord Provost of Glasgow at the Council House, George-square. The meetings will take place in the Lecture Theatre of the Natural Philosophy Building of the University of Glasgow.

Association of Engineers-in-Charge.—At the annual general meeting, which was held under the chairmanship of Mr. A. E. Penn, it was shown that the affairs of the Association were in a very satisfactory condition. Capt. H. Riall Sankey was elected president for the ensuing year.

ARRANGEMENTS FOR THE WEEK.

MUNICIPAL TRAMWAYS ASSOCIATION.

WEDNESDAY, September 21st.

11 a.m. Meeting in the Council Chamber, Town Hall, Bradford. Presidential Address by Mr. C. J. Spencer. Paper on "The First Decade of Municipal Tramway Working," by Alderman S. Flint.

3 p.m. Paper on "The Comparative Durability of Brake Shoes and Tyres," by Mr. J. W. Dawson.

THURSDAY, September 22nd.

10:30 a.m. Meeting in the Council Chamber, Town Hall, Bradford. Paper on "Tramways in Relation to Town Planning," by Mr. A. Baker; and Report on "Lubrication of Car Bearings," by Messrs E. Cross, R. L. Acland, P. J. Pringle and T. R. Smith.

FRIDAY, September 23rd.

10 a.m. Annual General Meeting in the Town Hall, Bradford.

SATURDAY, September 24th.

ASSOCIATION OF ENGINEERS-IN-CHARGE.

5:15 p.m. Reception at the Engineering Exhibition, Olympia. Lecture at 7:45 p.m. on "Wireless Telegraphy, its Maritime Importance," by G. Langler Bullocke (by special permission of Mr. Marconi).

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RAIL CORRUGATION.*

BY A. BUSSE.

Summary.—In this report the author points out that the conclusion that rail corrugation is due primarily to weaknesses in the rail metal or to peculiarities in the rails caused by the rolling is now being generally adopted. A summary of the opinions received from the members in answer to the *questionnaire* on this subject is given and the conclusion is again arrived at that in the rails is to be found the primary cause of this phenomenon.

Rail corrugation, which develops from year to year in ever-increasing proportions, causes not only an excessive wear of the wheels and rails, but is also a source of great annoyance to tramway managers from the secondary phenomena which accompany it. Where corrugation exists the track wears rapidly, the rails fall away from the paving and the vibrations that are set up soon tend to destroy the foundations, especially when asphalt or wood paving is used.

In the report presented at the Milan congress in 1908 it was remarked that corrugation might be due to something in rail metal itself, while in a report made by M. Petersen, of Dortmund, the same conclusion is also arrived at. Some further researches of M. Petersen are given in an appendix to the present report.

A very interesting result is provided by these tests. Rails, which were rolled in different years, were placed on a certain section of line so that the years of manufacture alternated, with a view to discovering whether rail corrugation was the same for all rails. As a result, it was found that rails rolled during one particular year showed much more corrugation than the others. All the others were, in fact, practically untouched. This anomaly is a good proof that the rolling and the nature of the metal may be considered as a principal cause of corrugation.

A similar result has been observed on the Prussian State Railways. A section over which heavy traffic was worked was made up of rails from two different rolling mills. These rails were placed in no particular order. But it was noticed that the rails from one of the mills showed a very large amount of corrugation, while those from the other were not touched. This seems to indicate conclusively that the phenomenon may be attributable to the quality of the metal and to the way in which the rails are manufactured.

Nevertheless, it would be well to carry out tests and observations on the construction of the rolling stock, on the method of propulsion and on the track foundation. It is, in fact, certain that these different factors have an influence on the appearance of the corrugations, especially on their intensity and on the speed with which they appear. This opinion was expressed at the Munich conference.

All these phenomena show that corrugation cannot be attributed to a single cause, but that it is the result of a blending of several factors, some of which are direct and others secondary causes. Certain methods of constructing the rolling stock cause corrugation on the rolling surface, if there exist certain conditions in the quality of rail or tyres, or in the track foundations.

The *questionnaire*, which has been addressed this year to the members of the Union, was answered by 75 members. Sixty-two of these noticed corrugation in a more or less pronounced way on their systems. Thirty-eight noticed it on their trolley wires, and eight on their tyres.

A number of the more important answers are then given in the report. Abstracts of these are set out below:—

Amsterdam.—Corrugation has been noticed wherever the flanges of the wheels are pressed against the head of the rail. It has not been noticed on curves of small radius where the rolling surface is much worn or the speed is low. The length of the corrugations increases with the speed. It is considered that the kinetic energy of the cars is primarily responsible for the phenomenon. On straight runs, too, the flange of one wheel hits the rail head and the whole car tends to lean over to that side. The axis of the car then takes up an oblique position to the direction of motion and this obliquity increases with the narrowness of the gauge. The wheel, whose velocity of rotation has been decreased by the lateral blow, endeavours to maintain a linear velocity corresponding to the kinetic energy. It is therefore submitted to a force of translation, while the rail itself begins to vibrate. As a result, periodic changes in the friction between wheel and rail are set up, and these changes may, it is considered, cause corrugation. On curves the phenomenon is similar, the car tending to run tangentially and thus giving a motion of translation to the wheels, while the speed of rotation tends to decrease owing to the friction, with the result that slipping occurs and vibrations are set up. Tests on this question are still being made in Amsterdam for different gauges, speeds and wheels, but it seems certain that the transverse component of the kinetic energy both on curves and on straight runs gives rise to vibrations in the rail.

Augsburg.—There is no corrugation on this system, but it is thought that, as this phenomenon does not appear on steam railways, it must be due in the first place to the geared drive employed on tramways, though high speed and difference in the quality of the rail are favourable to its propagation. The reporter, however, points out that corrugation has been noticed on steam railways and that this opinion is therefore untenable.

Bordeaux.—The opinion is expressed that the method of driving causes the wheel not only to hammer the rail, but also to slip along it, thus giving rise to a displacement of the metal and hence corrugation. This slipping is, in fact, they consider, the principal cause of corrugation. It occurs both on curves and on straight runs. On the latter it is due to the different length of paths which must be traversed by two wheels fixed to the same axle, while in the former it is due to the different rolling diameters caused by the horizontal motion of the car. Experiments on this point have shown that variations in the rolling diameters correspond with these horizontal movements and that the variations which they set up in turn in the rails cause corrugation. Corrugation only exists where slipping takes place. It is therefore caused by slipping and by suppressing this effect the production of corrugation can be avoided.

Two cars fitted with an arrangement by which the slipping of the wheels on the rails can be avoided have been placed in use at Bordeaux, the idea being to make the wheels on the same axle independent of one another. One of the wheels is keyed to the axle, while the other is fixed to a sleeve, which is loose on the axle. In the case of a trailing axle this sleeve simply moves backward and forward between two flanges so that the distance apart of the two wheels may remain the same. In the case of a motor axle a differential gear similar to that used on motor cars is employed. It is placed inside the first gear wheel, which is usually keyed to the axle and which instead now becomes loose on it. It is intended to introduce this arrangement on all the cars in Bordeaux.

In their answer to the *questionnaire* this company expressed the opinion that the composition of the rail metal has but a secondary effect on corrugation. This opinion cannot, in the reporter's opinion, be sustained. As regards horizontal movements it is thought that, as these are decreased, corrugation will be decreased. Attempts should, therefore, be made to reduce these movements as well as the conicality of the rails, which is not of great importance in tramway working. An elastic foundation may diminish corrugation.

Brussels state that on their system rail corrugation is general, especially on curves of large radius—where it occurs even when the traffic is small—on grooved rails, where the slot is used, and on ordinary tracks using grooved rails, where the quality of the soil or paving leaves anything to be desired. In some cases corrugation disappeared after the track had been rebuilt with transverse wooden sleepers. It has not been noticed on tracks where Vignoles rails are used, and did not appear at all until some years after the adoption of electric traction. According to the statement of this undertaking its appearance seems to have coincided with the abandonment of the Bessemer process for the Thomas process in the majority of steel works.

Dresden consider that corrugation is an effect of friction, and that its production and development is dependent on a number of circumstances. The method of rolling need not necessarily be the premier cause, while the employment of an elastic road bed, such as wooden sleepers, almost completely prevents its appearance. Its production seems to depend upon the reaction between the moving and the stationary masses constituting the track.

At *Ekaterinoslaw* corrugation has not yet been observed on their lines. They consider this to be due to the fact that their rails are of extra hard steel. The reporter, however, remarks that in Berlin corrugation has been noticed on rails made of very hard manganese steel where these have been used in places with heavy traffic.

At *Barmen-Elberfeld* the phenomena of corrugation has been noticed in places where the road is paved, but especially where the soil has been disturbed by the laying down of drains, electric light mains and gas pipes, but the reporter points out that the phenomena appeared on new rails immediately after they were placed in service and may be attributed without any doubt to the nature of the metal used.

* Abstract of a report by Herr Busse, chief engineer of the Berlin tramways, on the replies received by the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Local in response to the *questionnaire* sent out to the members, presented at the biennial meeting at Brussels (1910).

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At *Glasgow* it is thought that the phenomena could be avoided by coupling together the two motor axles by a crank, as is done on steam locomotives, so that both motor wheels would run at the same speed.

Hanover express the view that rail corrugation is due in the first place to the insufficient strength of the rail metal in relation to the force imposed upon it by heavy traffic. The phenomena apparently appears more rapidly when the rails are rigid, when they are not covered in by pavement, and on curves of large radius. These conditions are, however, not primarily responsible for the production of rail corrugation, but rather accessory causes which only intervene when the rails are not sufficiently strong.

Helsingborg have observed that when corrugations occur on straight sections the waves commence at the joints and diminish progressively in both directions. On the other hand, on curves the corrugations appear uniformly on the outer rail. This company consider the principal causes of corrugation to be: too rigid or elastic foundations, a car too rigidly hung, the rolling surface at the joints not perfectly flat, and the bad effect of places where corrugation already exists. They also indicate as a possible cause the gyroscopic effect created by the high speed at which the motor armatures run.

Cairo have especially noticed corrugation in places where the street is treated with asphalt and where, therefore, the tracks are less elastic. The waves are generally more numerous and smaller in such asphalted streets than in streets where macadam is used. The hardest rails show the shortest waves.

On the other hand, *Copenhagen* point out that corrugation occurs most often on macadam, less on asphalt and "English paving," and least of all on ordinary paving. The breadth of the wave seems to be greatest at places where the speed is highest. This undertaking seems to think that corrugation is due to laminations produced by the rolling action, but a longitudinal section tested with acid did not show any modification in the structure of the rail. Tests also showed that the hardness of the rail increases as time goes on, even on rails exempt from corrugation, and this is also considered to be due to the cold rolling. An increase in the width and length of the surfaces subjected to rolling occurs from the same cause.

At *Leipzig* it is considered that corrugation is due to a lack of homogeneity in the construction of the metal. This opinion is based on the fact that corrugation only occurs at certain places on the system and only on a part of the rail. If corrugation depended on the rolling stock it would be much more general, because, as a matter of fact, conditions under which vehicles operate are the same on all parts of the system.

At *Lyons* a number of different rails have been used and corrugation has been noticed more or less on all of them. In the opinion of this undertaking it is to be attributed to the quality of the metal and to the methods used in the manufacture.

At *Madrid* corrugation has been noticed, especially on the hardest rails. It occurs with the same frequency on tracks on elastic foundations as on those on rigid foundations, but it occurs less on single tracks over which the cars run in both directions. This is explained by the fact that one effect wipes out the other.

At *Magdeburg* it has been noticed that the phenomenon occurs very rapidly and with great intensity on rails of great length or on lengths of rails which are welded together. It is supposed that the tension generated in the rails by the welding causes them to rise up, thus favouring the production of corrugation. Corrugation appears more rapidly on hard than on soft rails.

Munich consider that the hammering of the rails, caused by the rigid coupling of the two wheels on the motor axles is sufficient to create corrugation. The propelling movement of the wheels is never uniform and they are thus made to jump along. The reporter remarks that if only one primary cause is to be allowed for rail corrugation a number of secondary causes cannot be admitted when the primary cause does not exist; in other words, that rigid coupling of the wheels will have to be abandoned. It should, however, be pointed out that Munich consider that unsurmountable technical difficulties prevent the realisation of this idea.

Nuremburg-Furth observe that corrugation is only produced at places where the traffic is very heavy. It generally begins quite close to the joint, and was not noticed formerly when the rolling stock was much lighter than it is now, although the rails were much less strong and of softer metal. This undertaking has noticed traces of corrugation on new rails coming direct from the rolling mill.

Vienna are not able to distinguish between the direct causes of corrugation and those which are rather a consequence of those direct causes. The shape of the rail profile has a particular influence on the development of the waves of the rolling surface. This circumstance might, it appears, be a primary cause. This undertaking base their remarks on observations made on their system of the way in which three different types of rails behave on considerable lengths of track. These rails are the grooved rail, through which the current is collected on conduit systems; the Hartwich rail, a modification of the Vignoles rail, which has a web of great height with a corresponding check rail, and the ordinary grooved rail. It is a remarkable thing that the first rail did not show any signs of corrugation, the second rail showed it but rarely and the third very frequently. The first two types of rails were nearly always of the same quality. Their superiority appears to be due to a better arrangement of the rolling surface, which would be facilitated by the shape of the Vignoles rail. The method of foundation has also some influence. These two kinds of rails may, in fact, be considered as of equal value. The Hartwich rails rest simply on gravel, whilst the others are fixed on cast-iron plates placed at equal intervals. The slotted rail seems to be superior to the Hartwich rail as regards corrugation, and this is probably due to the type of foundation used. An important cause of corrugation seems to be that, at starting and when the brakes are being used, the wheels do not turn uniformly, but are submitted to a partial sliding and to vibration at the same time. This sliding and simultaneous oscillation of bodies in contact (wheels and rails) is sufficient to give rise to corrugation or to phenomena of the same kind. It is this which has been observed, for instance, on the platforms over which the rails are drawn after leaving the rolling mill. It should be remarked that in these two cases there are no complex circumstances and that corrugation is produced just as well when the bodies submitted to skidding action and oscillations are of the same kind as when they are of a different nature; for instance, trolley bow and overhead conductor—that is, aluminium on hard copper.

It may be added that the majority of members not cited above considered the following as principal causes of rail corrugation: The nature of the rail metal, the methods used in rolling and the sliding movements of the cars.

The importance of the sliding movement, as regards the displacement of the metal and the production of corrugation which is the consequence, is shown by some results obtained at Berlin on tracks using a "third rail" where the speed is rather over 30 miles an hour. The pressure of the shoe is about 44 lb. and the displacement of the metal is nearly always visible on the third rail, while the running rails are often free from corrugation. When the rolling surface, on the other hand, is not quite flat, the metal, however hard, cannot resist the sliding action of the wheels, and corrugation and breaking up of the rails is the result.

As an example of this we may quote a station on the Berlin Elevated Railway where trains are braked and where nickel steel rails with a strength of 44½ tons per square inch, Bessemer steel rails with a strength of 50½ tons per square inch, and manganese steel rails with a strength of 76 tons per square inch have been put down for testing purposes. At the present time, while the Bessemer rails are but slightly corrugated, both the others showed corrugation quite soon after being placed in service. This is the more remarkable as Vignoles rails, which generally wear very well, are used.

As regards corrugation on the trolley wire, it seems to appear principally at places (1) where the acceleration is great and consequently the friction between collector and wire is submitted to continual variation; (2) where the trolley wire for short lengths is particularly restrained and where, in consequence, it is especially rigid, for instance, at the points of support, under bridges and in tunnels; (3) where the wheel does not move uniformly, owing to defective lubrication; and (4) where the existence of corrugation has been noticed on the wire ever since it was placed in service and where inequalities in the rolling surface of the rails exist, so that the cars and collecting apparatus are subjected to vibrations. Glasgow mention that trolley wire corrugation has not been noticed since they removed the rail corrugation by means of an emery wheel.

Tyre corrugation has only been noticed by a few tramway authorities. At Bale it has only been noticed on trailers. This is attributed to the variation in hardness of the tyre metal, to the formation of flats on the rolling surface by too energetic braking and to inequalities in the rail surface. At Dresden corrugation with waves corresponding with the division of the gear teeth has been noticed. At Frankfort the tyres often show very decided corrugations, though this is most certainly due to the nature of the metal.

From the answers received to questions on rail corrugation, it appears that recent observations and tests have added nothing, or very little, new to the conclusions formulated at the Congress at Munich in 1908. An important matter may, however, be noted: exhaustive researches prove that the rail metal contains in itself the "bacillus" which leads to rail corrugation. Further, sideways

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movements, wheel slippings and other causes have been abundantly shown to favour its production. The influence which these movements were shown to have has further incited members to suppress or diminish these phenomena. Work in this direction has already been taken up.

Attention may also be called to another important matter. Rails embedded in concrete on wooden sleepers, and grooved rails fixed to metal chairs on conduit system where the rails are firmly fixed to the foundation, are much less affected by corrugation than long lengths of rails obtained by welding or by the employment of the Melaun joint. It may be supposed that the tension generated in these rails causes them to rise, thus favouring the production of corrugation. It would be interesting to lay down rails on well-impregnated wooden sleepers fixed firmly to the foundations on metal sleepers, on blocks and sleepers of reinforced concrete in order to discover whether these arrangements diminish corrugation. The rails should be solidly attached to their supports, so as to damp out as much as possible any vibrations to which they are submitted.

It is not convenient at the present time to go further into the question of causes and remedies, for the Association Allemande de Tramways et de Chemins de Fer d'Intérêt Local has recently appointed a commission to carry out, in conjunction with Dr. Puppe, detailed investigations into the nature of rail metal and other causes of corrugation.

THE PRICE OF ELECTRICITY.*

BY EDW. W. COWAN.

(*Concluded from page 897.*)

Summary.—The author criticises the principles on which the charges for electrical energy are usually based, this basis being an equal rate of profit from every class of consumer. Although this principle is safe, the author argues that best economic results cannot be obtained because the factor of demand is entirely ignored. The demand for electricity is of a "composite" kind, energy being required for light, power and heat. Classified tariffs should be adopted so as to secure the greatest economic advantage. The author supports his views by reference to the adjustment of prices in railway freight charges and other lines of business.

In diagram No. 2 I have attempted to isolate and depict the characteristic features of the principle I am endeavouring to establish.

This diagram requires some explanation. In the first place, it should be pointed out that the curves representing the respective elasticities of demand for the three commodities, light, power and heat are not based upon any observed results, nor has any attempt been made to estimate their character in this respect. They are deliberately drawn to fit in with my argument. Important factors have been ignored, such as the effect of the load-factors of the different classes of supply and the effect of the diversity in incidence of the maximum demands of each class. In fact, a number of factors have been omitted in order to simplify the diagram, and, not only emphasise, but exaggerate the effects of the use of a "classified tariff." The ordinates represent price, the abscissæ quantity demanded. Three curves, representing the arbitrarily assumed elasticities of demand for electricity for light, heat and power at different prices, have been drawn.

Another curve (dotted black) represents the aggregate of these demands at different prices. This curve has been drawn for equal price for all classes of demand, that is, for equal profit or loss on the supply for each class of consumer.

The curve drawn chain dotted represents cost (including connection charges) plus a percentage of profit. At the point A, where this curve crosses the curve of aggregate demand, the aggregate demand at equal profit of all classes of consumers is found. In the diagram it is seen to be 2·7, the average price per unit of supply being 2.

The other points, C and D, respectively, represent the increase upon the demand which is obtainable (under the conditions shown in this diagram) if the different classes of demand are differently priced.

At A all classes are charged 2 per unit of supply.

At C the light consumers pay 2·5 per unit, the power consumers 0·9, and the heat consumers 0·8. The aggregate demand is increased under this differentiation to 4·0 and the mean price reduced to 1·49. This increased demand has been obtained without charging the light consumers a higher price than the price at which they could supply themselves collectively. Inspection of the diagram shows that they could not supply themselves at a lower price than 3·25 and clear their expenses of production. Therefore, light consumers are not being penalised and the power and heat consumers are not being subsidised at their expense.

At D the light consumers are charged 2, the power consumers 0·8, and the heat consumers 0·6, the average price per unit being 1·13. Here the light consumers obtain no benefit from the "classified tariff" compared with the "equal profit," but they are not penalised. A comparison of the results shows that at D, under the "classified tariffs," more than twice the demand is obtained, and at a lower price, viz., 1·13 per unit, as against 2 under the "equal profit" tariff, which lower price represents an advantage to the power and heat consumers, while the light consumers neither gain nor lose.

The power and the heat consumers both gain the advantage of obtaining a supply which would otherwise have been beyond their reach. In short, the benefits of electricity supply are extended to a larger area. From a subjective standpoint the light and power and heat consumers all stand in the same position. The "classified tariff" constitutes under the assumed conditions, subjectively speaking, an "equitable tariff."

It may be pointed out that the conditions of supply are often such that only a very small increase in capital expenditure is necessary for largely increasing the output. Mr. Arthur Wright, referring to Marylebone, said, in 1908, that they could double their output by an increase of 8 per cent. on their capital outlay, and if they could double their output, the average cost of their supply would be reduced from 4½d. to 2½d. per unit, a drop in price of 44 per cent. In the diagram doubling the output from 3 to 6 is made to show a reduction of cost of production per unit of about 37 per cent.

It will be noted that care must be exercised in determining the tariff, as, if the price is fixed too low for any one service, the demand at that price may exceed expectation and lower the mean price below mean cost. It is not likely that the course of demand can be

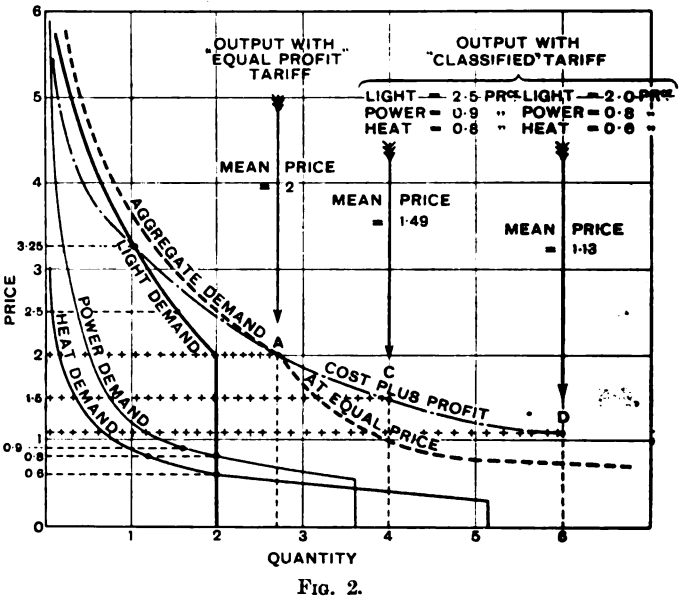

FIG. 2.

predicted with exactness, and consequently provision must be made for error of judgment. This can be done either by not attempting to obtain the maximum possible output or by adjusting prices for a rather larger profit than the normal and setting aside a reserve fund which will be available for making good any deficiency due to error, until correction can be made by price adjustment. The adjustment would generally take the form of deferring a reduction in price which would otherwise have been made.

The circumstances in every case will differ, and the diagram shown, depicting hypothetical conditions, only indicates the character of the problem and exhibits the possible effects of ignoring the factor of demand. In practice, the elasticity of demand can only be estimated, but a study of the market price of competing supplies and of the intrinsic advantages of electricity as a medium for the supply of light or power or heat, make it possible to arrive at useful approximations.

I think that engineers instinctively feel that they have a public duty to perform in protecting their industry from what they believe to be a vicious practice, viz., that of selling any commodity at a price below its cost. They feel that deliberately selling upon such terms tends to break the market price, and that it is therefore an illegitimate and injurious practice. They hold that for the sake of any temporary or individual advantage the gains would be ill-earned if the means adopted dislocated the machinery of the market. With this view we can be entirely in agreement. But is there really any element of unfair competition or any breaking of the market price in the adoption of a system of "classified tariffs".

* Paper (somewhat abbreviated) read before Section F (Economic Science and Statistics) of the British Association at Sheffield.

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Is any injury done to the theatrical business by charging for the seats in theatres in accordance with this system, that is, in adapting the prices according to demand for each class of seat without regard to making an equal profit from each class? (Diagram No. 2 is also applicable, *mutatis mutandis*, to a theatre economy.) Clearly both the theatrical proprietors and the public would suffer loss if the seats were sold at prices which contributed equal profits from every part of the house? It is the integrated cost which should be referred to the integrated demand and the integrated price adjusted to secure an equation. Such a process secures the emergence of the largest gain. On the other hand, the selling of any commodity strictly upon the basis of equal profit is, I submit, likely to be not only uneconomical but commercially injurious in many cases. The following diagram (No. 3) statically indicates the forces which, according to this conception, are at work.

As there cannot be two prices in one market, it follows that all the contributors producing at a relative advantage will make relatively larger profits, which are called "producers' rents" in the diagram. If the producers who contribute the portion OD_2 sell their product at the arbitrarily chosen price D_2D_1 without regard to the market price QQ_1, what will become of the surplus represented by the area CBD_1D? If the producers surrender this surplus will the consumers gain it? Clearly not, because the market machinery will not work with different prices for the same commodity. The surplus will be secured by middle men, possibly landlords, whose business it will be to equalise the market price and pocket the differences thus yielded by the producers. It will be admitted that if "rents" are unavoidable, they should accrue to the producers rather than to a class of interceptors who render no essentially useful service. Competition among producers will keep

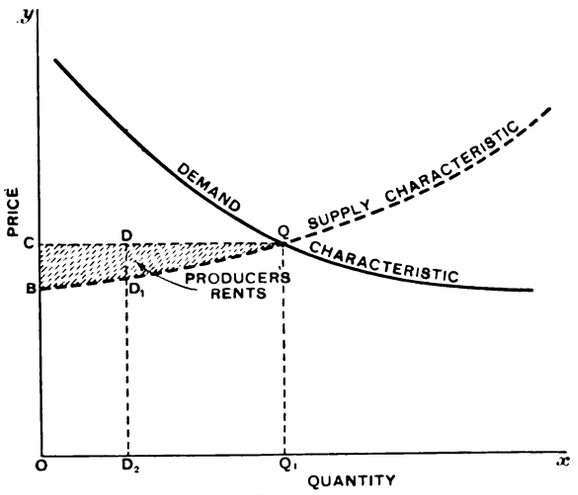

FIG. 3.

these rents pruned down to a minimum. We may or may not approve of the existing commercial system, but isolated attempts to amend it in accordance with abstract ideals are not unlikely to be mischievous in their effects.

Turning, now, to the practical import of the criticism of this Paper, what does it amount to? There exists a great potential demand for electricity for power and heat uses. This potential demand awaits the sufficient lowering of prices to render it active demand to the great advantage of the community from many points of view which affect its well-being. Some years ago I estimated that electricity at three units for a penny would compare favourably in the provision of useful heat, with coal burnt in open hearths at from 15s. to £1 a ton. The hygienic advantage and convenience of electric heating and cooking are generally realised, as also is the convenience of electric refrigeration. Rapid strides have been made in recent years in the direction of economy of production, and the effective demand for electricity for power use is already large and is daily increasing. Further progress in this direction may be expected, but the distribution of heat and cold by electrical means has scarcely commenced.

The undertaker, realising that the great potential demand cannot be rendered active for many years to come, if it is to await the results of progress in the development of economical method in the generating and distribution of electricity has endeavoured to reach it by means of various commercial expedients. The position to him is in some ways tantalising. Over 80 per cent. of the producing power of our electricity supply works lies inert owing to the irregularity of the incidence of demand, the use of storage batteries only being commercially possible to a limited extent in levelling the fluctuations in the "demand" characteristic. He sees all this producing plant lying idle and he knows that, though the storage of electricity may be commercially impossible, the storage of heat and of cold is comparatively cheap and efficient. There are therefore before him the three necessary factors:

1. A great demand
2. Idle producing power.
3. Means of storage of the objective of a great part of that demand, viz., heat and cold.

No wonder, then, that he asks himself—can no alchemy be found which may bring these factors into effective combination?

But at the outset of his inquiry he is faced with the difficulty that one possible means of operation is taken out of his hands. He may not adapt his supply to demand by any classification of his charges. The industry has established the principle that such a course involves inequitable treatment of the consumers and is therefore inadmissible. While admitting that perhaps the system of "equal profit" may have provided a good working hypothesis during the early stages of the development of a new industry, I do earnestly desire to see engineers emancipated from this restriction at the present time. I do not wish to exaggerate the importance of the views I hold, but I trust that it will be realised that there is a specific gain in the system of classification. Without saying that the adoption of the "equal profit" system has been a mistake in the past, I hold that accepting it as being a system essentially right in principle is due to a faulty conception of the complex of electricity supply, regarded as an organic whole.

The keystone of my position is this: that a system of graded prices can secure finer adaptation of supply to demand. I hold that the law of supply and demand is a natural law, and as such, may not be disregarded.

The objective of the law of supply and demand is the achievement of their closest incidence. It is this end which should be kept in view, viz., the attainment of the largest demand of the most profitable kind which pays the expense of production plus a reasonable margin of profit. With one exception, it does not matter in the least, from any other point of view worth taking into account, what is the relation between the cost and the sale of the various portions of supply which make up the whole. That one exception is that no class of consumer should be charged a price in excess of that at which it could supply itself. (A corollary follows from this principle, viz., that two classes may not be charged prices, the sum of which is in excess of that at which they could supply themselves in combination.) Adherence to this principle is essential from a juristic point of view. Any infringement of it constitutes an infringement of a prescriptive social right.

I plead for a due regard of two factors (1) the "character of demand," and (2) the "intensity of demand." Attempts are now made to allow for the influence of the former factor in adjustment of price in relation to diversity of maximum demands, &c., but the latter factor is entirely disregarded in pricing electricity supply. Though I have made little reference to it, I do not overlook the importance of the "encouragement" factor. It is right and proper to attract relatively profitable business, because it is in the common interest that this should be done.

It is the largest and best class of demand in respect to time, the achievement of which should be sought. I do not understand the oft repeated argument that supplying low-priced units displaces the supply of high-priced. There is no limit to supply other than the limits of demand, and it will pay to cater for all demand which can be supplied within the limits of the mean cost of production.

Inert plant is a bad thing, but is not inert power to supply a want an equally bad thing? The neglect to supply any possible demand is an abuse of the power of monopoly.

It is in the hope of giving some assistance towards the removing of an obstacle to the advance of the use of electricity that this Paper has been written. The practical effect of the removal of this obstacle may be large or it may be small, but economists are familiar with the fact that small price changes sometimes alter the channels of great volumes of trade. We cannot afford to disregard any principle, however small its dimensions may be, which is a principle of essential economy.

My thanks are due to Mr. William Schooling and to Mr. Mark Barr for useful criticisms and suggestions, and also to Mr. Sydney Morse, who has been good enough to express the opinion that "classified" tariffs are not illegal.

In an appendix the author reproduces the clauses in the Electric Lighting Acts referring particularly to prices charged, and then passes on to the Railway and Canal Traffic Act.

Railway and Canal Traffic Act, 1888. 51 and 52 Vict.

Definitions. Clause 55. "The term 'undue preference' includes an undue preference or unreasonable prejudice or disadvantage, in any

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respect, in favour of or against any person or particular class of persons or any particular description of traffic."

Ditto, *Clause* 2.

"In deciding whether a lower charge or difference in treatment does or does not amount to an undue preference, the Court having jurisdiction in the matter, or the Commissioners, as the case may be, may, so far as they think reasonable, in addition to any other considerations affecting the case, take into consideration whether such lower charge or difference in treatment is necessary for the purpose of securing in the interests of the public the traffic in respect of which it is made, and whether the inequality cannot be removed without unduly reducing the rates charged to the complainant."

The consideration of the legality of "classified tariffs" is a relatively unimportant one, because if such tariffs were found to be illegal, though advantageous to the community, the law could and would be altered in due course.

It does not appear to me, however, that "classified tariffs" are illegal, though the approval of the Board of Trade would be required. The term "undue preference" in the Electric Lighting Act, 1882, was translated from the Railway Acts, and the assumption is that it would bear the same meaning and significance in both cases.

We find that, in regard to railway rates, the system of classification is adopted and authorised in the face of the illegality of "undue preference." The conclusion appears to be that the preference given to some classes in the classification of rates is not an "undue" preference. And it seems to be a fair inference that if such preference is not "undue" in the case of railway rates, it would not be held to be so in the case of electricity supply rates.

Some light is thrown upon the question by reference to the treatment of the difficulty in America. There, after considerable controversy, the principle of "discrimination" (or classification) has been generally adopted, and H. R. Meyer in his work on "The Government Regulation of Railway Rates," says: "The effect of that discrimination was a heterogeneous mass of railway rates that knit the different producing, distributing and consuming sections of this country into a more compact trading unit than was to be found anywhere else in the world and carried the exploitation of our resources farther than has been carried the exploitation of the resources of any other country."

The above quotation shows that in America the beneficial character of discrimination or classification has been recognised. But the dangers of an abuse of the system were also recognised, A clause in an American "Act to Regulate Commerce" provides that discrimination must not be "undue or unreasonable."

On the Continent there has been considerable controversy on the same point and in the earlier days, before the essential economy of classification was recognised in connection with railway working, a system, of charging for rail transport was adopted which was practically identical with the "Hopkinson" method in the case of electricity supply. In the Alsace and Lorraine State Railways a fixed charge for terminal expenses was made, and thereafter an equal charge per ton-mile on all goods. The arguments which led to the adoption of this system were identical with those which have led to the adoption of similar systems in the electrical industry in this country. The method was abandoned when the benefits of classification were realised. The new tariff was called a "compromise tariff," but it was virtually a "classified" tariff. The above references seem to show that classification is regarded as being legal notwithstanding the illegality of "undue preference," and it seems to me that the Board of Trade would not withhold their consent to a system which was identical in principle with a system which has been accepted as being legal and beneficial in the case of railway working and which has been adopted in the face of the enactment that "undue preference" must not be given to any consumer.

We give below an abstract of Mr. S. L. Pearce's remarks in connection with Mr. Cowan's Paper, as these are of much interest and could only be referred to briefly in the B.A. diary last week.

Mr. S. L. Pearce (City Electrical Engineer, Manchester), after some appreciative remarks upon the value of the Paper as a contribution to the literature of the subject, said that he was considerably in accord with the abstract principles set forth, and he thought also there would be a considerable measure of agreement amongst engineers with the main argument of the Paper. The great difficulty lay, however, in the application of the principle of "classification" to actual tariffs—that is, in translating an admittedly beneficial principle into an equitable tariff—which could be arrived at on a scientific basis and one that would not be open to constant revision or adjustment. He held that all tariffs should be flexible as far as possible, but at the same time not open to the charge of "undue preference." He had advocated the remission of certain charges on capital in the case of new power consumers for the reason that the cost of modern plant on a kilowatt basis was only one-third that of plant installed, say, eight years ago. This enabled new business to be secured which would otherwise be lost, and at the same time broadened the basis over which all standing charges were spread, and so benefited other classes of consumers through a reduction in their tariffs. The remarks of the author (at the bottom of p. 11 and top of p. 12), in regard to the possibility not only of conferring benefits upon power and heat users, but of supplying light users at a lower price than would be possible if the principle of a uniform rate of profit from each class of consumer were adopted, were borne out by the speaker's actual experience with a large undertaking supplying various classes of demand. He thought the point to be emphasised was not the "equal profit" basis, which was more or less a fallacy, especially on "flat rate" sales, but that there should be a margin of profit on all sales, although the relative profits made on the various classes of supply might and would differ widely. Within the limits of this principle he thought there was considerable room for "classification." The introduction of the metal filament lamp had, he thought, impressed engineers more than anything else that they were selling light and not electricity, and he was in accord with the author in considering that the supply of electricity might fairly be considered as being "of a joint character." Mr. Cowan had pleaded for more consideration to be given to two factors, viz., "the character of the demand" and "the intensity of the demand." With regard to the former he (the speaker) thought that taking fully into consideration the effect of "diversity factors" met the first point. He would like to ask Mr. Cowan to explain more definitely and fully the exact meaning, however, of the expression "intensity of demand." The actual true cost to the undertaking of supplying some particular consumers was practically unascertainable, and he thought Mr. Cowan's explanation of the example given, in which a profit was apparently made by selling at a loss, was explained on this hypothesis. As far as municipal undertakings were concerned, he felt sure that most engineers would agree that the rendering of the largest service to the community generally, compatible with financial stability, was of greater importance than financial stability plus large profits.

THE RELATIONS OF SCIENCE TO INDUSTRY AND COMMERCE.*

BY R. BLAIR.

Summary.—The author in dealing with this subject gives an abstract of the views of students, university teachers, manufacturers and consuls on the present connection between science and industry. It is shown that, while matters are improving, higher education is of too theoretical and detached a nature to make its recipient immediately useful in the commercial world. Remedies to counteract this state of things are suggested.

In this Paper attention is restricted chiefly to the relation which exists between the scientific and technical education, provided at the higher institutions in this country, and the after careers of the students. The views of 150 students of university rank have been selected, while 500 letters of inquiry were addressed to teachers of repute at home, in France, Germany and America. Inquiries have also been made of manufacturers and British consuls.

First, as to the views of the 150 students. These students all belong to the class for whom the earning of a living is imperative, and in the main they represent Oxford, Cambridge and the London institutions of university rank. Among minor points made by them are these: The engineers emphasise the need of workshop practice under commercial conditions, finding that their future is in danger of being marred by lack of "works" experience, and some of those who have become industrial chemists express the need for a five years' training, three for the degree and two for research. The students also complain that posts are obtained not on merit, but through influence. This contention is pointedly illustrated by a university college professor, who states that he knows one man who holds a most important berth, and is undoubtedly a first-class man in every sense of the word. This man took his university training as a mechanical engineer and graduated with first-class honours, after having had "works" training extending over some eight years. On leaving college the man approached every mechanical firm of importance in Scotland in the hopes of getting a start. He found it impossible to do so. Finally, *through influence*, he did manage to obtain a junior berth, and is now the head of an important concern.

The most striking feature of the present occupations of the students is that only 10 per cent. have found their way into industry and commerce; another 10 per cent. have entered the higher ranks of the civil service, including technical posts. Some half-dozen are in the church; another half-dozen are practising medicine; the remainder have taken to teaching, and it was clear in a fair number of instances that selection of a profession was not a matter of choice, but one of necessity. Many a man towards the end of his university career discovers for the first time that he has nothing to offer in the industrial or commercial market in return for a salary. If he has no technical knowledge or skill he is, so far as his education helps him, in the same position as a secondary schoolboy, even if he is not handicapped on account of his greater age. Of those, also, who possess technical knowledge or skill, such as students of engineering or chemistry, a good many find themselves offered terms which pride or poverty, or both, forbid them to accept. Sometimes the shop, factory, or business house offers nothing, and occasionally a premium is required. It will easily be understood that under such circumstances an appeal is made by the students for more help in finding

* Abstract of a Paper read before Section D of the British Association.

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posts for university honours men, who are not eligible for the civil service and who do not care to turn schoolmasters; and it will not be difficult to appreciate that at the critical point in his career (the selection of a means of earning a livelihood) a man is apt to write harshly of the slackness of university life and to complain, as one of the most successful of them has done, that he wanted to be made a chemist, but his university insisted on his wasting his time on divinity, and did not even ask for German.

A great change in the relations of the university and the market has occurred during the last quarter of a century. The general advance in the standard of education has produced a larger sympathy on the part of the market for educational institutions and their products; and the movement in favour of technical education has widened the range of objects of university education, and has perhaps compelled the universities to have regard to the diversities of the world's work, and to the function they should discharge in preparing their students to live. During the period referred to, a large number of technical institutions have sprung up all over the United Kingdom, and within quite recent years there have been strong influences at work to bring about co-ordination, if not incorporation, of the greatest of the technical institutions with the universities within whose areas they have emerged. The danger in this process of amalgamation is that it may be premature. It may come about before the realisation of what each institution in its own way, and in its own time, has had to contribute to national problems, and before it has been fully recognised that the annexation of a technical school is not merely the end of a rival, but the beginning of a new public responsibility, and with the result that the vitality and, if you like, the harsh industrialism and commercialism of the technical institution may be too much submerged by "academic control."

The evidence placed at my disposal shows, on the whole, a tone of great hopefulness. This hopefulness of tone is common. It is displayed by the newest of the large municipal technical institutions in the heart of a great industrial centre, and by some of our oldest universities. It is becoming evident that the institutions are recognising that, however much the market, in its quest after cheapness, has failed to distinguish the real from the spurious article, the institutions themselves have not been without much blame for placing inefficient machines on the market. An eminent professor of chemistry tells me that his whole "professional life is strewn with examples of the unwillingness of industry and commerce, the State, and municipal authorities of this country to take advantage of the services of young men who have received the highest technical training as chemists." But, he adds, "there is a tolerably rapid improvement taking place," and "we who are urging the importance of employing these highly trained young men have to remember that there has been a great lot of poor stuff turned out from the universities and technical colleges, and that the British manufacturer has a good deal to say in his own defence."

The evidence from the engineering colleges and institutions is, on the whole, satisfactory. Here and there may be found somewhat doleful notes to the effect that the large majority of state and local authorities do not lay themselves out to take advantage of technically trained men, and, in one case, a view that has much popular currency has been put to me in fairly strong terms. It is to the effect that employers, especially those who have not very large and important undertakings, but who, nevertheless, would have their businesses improved by securing technically trained men, have an ignorant prejudice against such assistance. It is suggested as the possible explanation of their attitude that the employers fear that if they engaged men of greater attainments than themselves, they would simply be raising up possible opponents in their own line of business. There may be some truth in this view, which does not, of course, apply to first-class firms, but there is, I think, another view worth consideration: That the size of the business concern (the amount of capital sunk in it) has much to do with the employer's attitude. The employer does not possess the faith that will enable him to risk the addition of another salary to his working expenses; and no one, without a fair trial, is able to give him the mathematical demonstration, which he seeks, that the salary might often be saved merely out of the waste of materials which exists owing to the absence of scientific knowledge on the part of his men, of the materials they are handling, and to their having to feel their way by experiments that are more in the nature of guesses. Such firms will be converted only by the example of others.

There is abundant evidence, however, that there is much less prejudice than formerly, and that there is a growing tendency on the part of State and municipal authorities to secure for their services engineers who have received the highest training, and that this attitude is especially true of certain industries whose success depends absolutely upon highly competent trained scientific experts, as, for example, the steel industry. I suggest that the growth of this attitude corresponds generally in time with increased recognition on the part of the teaching institutions that engineers cannot be wholly made at college. The colleges have at length realised that the student must from the first learn the limitations of practical engineering, and that this can only be done by the introduction of a practical atmosphere and without sacrificing any of the physical principles of engineering already well taught at the colleges. One of our ancient universities says: "We have not now much reason to be dissatisfied with the attitude of employers towards our (engineering) students." Several of the largest of the technical institutions say they have no difficulty in placing their best students, and one university college states that there is a standing demand, as soon as the college year ends, from several of the heads of engineering establishments within the neighbourhood of the college for the best students. But these heads of firms demand the "best," and are willing to pay a living wage right off to youths who have never before been in works, and have only their college training as qualification. It is added that second or third rate men are in very little demand, and there is often a difficulty in not being able to recommend youths of sufficiently high standard to fill the vacant posts. This case recalls other colleges where students (the "best," at all events) have no difficulty in securing places owing to the personal connection established between the heads of the neighbouring works and the head of the engineering department.

It has been pointed out to me both by professors and the heads of large engineering firms that there is still a defect in the college training of young engineers which ought to be immediately remedied. The view is so well presented by one of the colleges that I give it *in extenso*: "There are certain defects in the average college training. I consider that the question of cost in design and the commercial side generally, receive quite inadequate attention in most colleges. Practically all engineering firms exist for making profit. Modern competition makes economic design, good efficiency and cheap upkeep absolutely imperative. The employer wants men who can in their designs give the most for the money. It is, therefore, insufficient to teach design on physical principles alone. Methods of production, ease of repair, depreciation, even conditions of transit in large machines, all these and more must be considered in effective design. Such limitations as these should, I think, be brought before the student in greater measure than they are attempted at present. This will tend to practicalise the student while his mind is still formative.

The case of chemistry is more difficult, since there is no doubt that the British chemical industry has suffered from German competition. Our manufacturers did not for some years understand the use to which the chemist could be put in their works, though it is gratifying to find there is now evidence of change. The tendency has been, especially among municipal authorities, to underpay such technically trained chemists and, as regards private employers, the author is of opinion that British manufacturers as a body are not yet fully sensible of the advantage which they might obtain by the employment of skilled chemists in manufactures in which chemistry plays a prominent part. Foreign chemists resident in this country recognise this, and there is no doubt that they have chosen for their sons a university education as a preliminary to business life.

As regards evidence of change. It appears that many of the largest technical institutions have no difficulty at the present time in placing their trained chemists in good posts. While an analysis of class lists of old chemical students shows that a large percentage is now engaged in industrial work.

Attention should, however, be drawn to the poor class of chemical teaching provided at the universities. Much of it is simply good secondary class work, and does not teach a student to think for himself. When entering a research laboratory after such a course a student is rarely an independent thinker, and has to struggle to develop his resources. Again the business faculties of students at this stage are poor, and they are not qualified to take up responsible positions. After the "research" years this is changed, the student thinks for himself and improves in business style. All this means time, however, and the British parent does not care to afford to keep his sons at the university until they are 24 to 25 years of age, especially as a period of probation has afterwards to be served in works, unless he sees that his money is going to be a good investment.

Industrial and commercial firms almost all express their preference for elementary school boys. A good many speak in high terms of the value of evening schools, while insurance companies especially seek for the secondary school product. There is some call for men trained at the highest institutions, but this call is so much confined to firms whose works or business require technical skill that it is fully evident that the others do not yet feel the need of such men, nor know how to use them.

A fairly common plan of training for those who will rise above the rank of "hands" is the elementary school education, combined with

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evening classes. There is a demand for the "practical" man, and a view, which is not altogether uncommon, is more sympathetic with higher education is that a man with practical training alone can do much; a man with technical training alone can do little; a combination is, therefore, essential. If only one of these can be had that must be the practical man.

Though in general the value of evening schools is recognised by employers, yet there is a fair amount of criticism; for instance, that they are not practical enough. They think that such schools may help individual pupils, but it does not enter their mind that they may also aid their industries. Evidence goes to show that the direct connection between the universities and industry is small, though many manufacturing and trading concerns recognise the value which a full university education affords in after life. It is felt that the present system of education in these institutions together with the length of the vacations and the great freedom enjoyed by the undergraduate are not altogether suitable preliminaries to a business life.

It, however, appears that many British manufacturers, especially those under younger management are displaying their economic sense in a new and interesting direction. Firms manufacturing common commodities and employing thousands of hands have shown that not only do they employ scientifically trained engineers, but they employ public school men as managers, they employ on their permanent staff doctors and dentists for the sake of their hands, they provide much for the social and economic welfare of their workers and generally show that they take as much interest in the human as in the other material which comes into their works. They find that in the interests of their business the human material, as much as the coal and the steel and the sugar and the flour, can respond with more efficiency to scientific and generally enlightened management.

(*To be continued.*)

ELECTRIC RAILWAY CATENARY TROLLEY CONSTRUCTION.*

BY W. N. SMITH.

Summary.—The author describes recent practice in catenary construction, discussing the various features of the different forms in use. He believes that the roller type of trolley may possibly prove a distinct improvement over the present sliding bow for trunk line work.

During the past 20 years the overhead trolley for electric railways has become such a familiar type of construction, and apparently so settled in practically all its details, that it is apt to be regarded as commonplace compared with many other features of electric railway equipment. As long as electric energy for train propulsion was everywhere standardised at 500 to 600 volts direct current, trolley construction practice followed a practically uniform line; but since 1904 wide departures have been made from the original forms of railway motors, both as to current and voltage. This advance, made entirely in the interest of economy in transmission, has been accompanied by radical changes in trolley construction, which have required the closest engineering attention and have lifted it above the level of the commonplace into which it had generally come to be relegated.

This Paper is intended to be a review of current practice in electric railway catenary construction. As interurban railways grew in importance, and in the size and speed of their equipment, not only did the necessity for economy in power transmission grow increasingly important, but the problem of collecting trolley current at high speed became more and more serious. The figure 8 and grooved types of trolley wire afforded some relief, but as supports were still 100 ft. or more apart the points of suspension caused slight changes in elevation of the wire, sharp enough to make trouble at high speed. It was not until 1904 that a new step was taken, namely, the elimination of the sag by means of more frequent points of support of the wire, resulting in the development of the so-called catenary type of suspension. This has come to be accepted as a practical solution for high-speed trolley operation. The principal features of this construction are the flat and smooth alignment of the trolley wire for high speed, the prevention of a trolley wire falling to the ground when broken (this is imperative at high potentials), and the use of a pneumatically-operated sliding bow for making contact. It has, however, the drawback of responding more sluggishly to unevenness of the trolley wire than the wheel and pole type of trolley, and this has resulted in a number of cases in the retention of the wheel trolley even in 3,300 and 6,600 volt lines. The writer's observation leads him to believe that the objections to the bow trolley have developed particularly where the catenary construction is defective.

Catenary construction is divided into three types as follows:—(1) The plain, single catenary, with the trolley wire hung directly from the messenger wire. (2) The compound or three-wire single catenary, in which the trolley wire is suspended by clips of uniform length from a tight secondary wire just above it, this secondary wire being supported by hanger rods of varying length from slack messenger wire above it. There are several variations of this type and it permits the use of devices which maintain a uniform tension on the trolley wire through any range of temperature. (3) Double catenary construction, consisting of two messenger wires and one trolley, the latter below and between the other two, the three wires being at the corners of an equilateral triangle and rigidly connected by triangular pipe spreaders varying from 6 in. to 6 ft. on a side according to the sag of the messenger wire. The excessive rigidity of this type has been found to be undesirable in practical operation, and it has been successfully modified on the New Haven railroad by stringing a second trolley wire and fastening it a few inches below the first by clips at points halfway between the original trolley wire hangers.

The second of these general types has been extensively developed in Europe, particularly that feature which enables the maintenance of uniform tension on the trolley wire. Conspicuous examples of this type are the single-phase lines of the Blankenese–Altona–Hamburg–Ohlsdorf line in Germany, and the Rotterdam–Haag–Scheveningen line in Holland.

Poles and Bridges.—Where wooden poles are used they should invariably be treated with some preservative, preferably of the creosote type, before being set. Steel poles can be had in three types. The familiar two or three-section tubular pole, in either

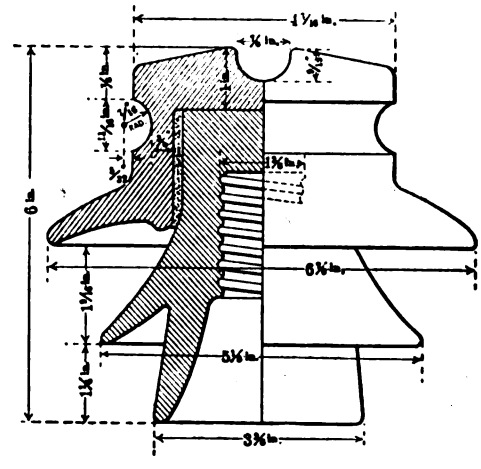

FIG. 1.—PORCELAIN INSULATOR.

standard or extra heavy pipe; the "tripartite" pole, built up of re-rolled Bessemer steel U-sections with malleable iron collars and spreaders; and the "diamond" pole which consists of two sheet steel V-shaped troughs tapered and flanged over the edges, one being driven lengthwise within the other to form, when assembled, a box shaped pole, the extra strength lying in the extra thickness of the overlapping flanges. The relative merits of these three types of steel poles may be briefly summed up by saying that the tubular type is the least economical of weight for a given strength, and that while the diamond pole is superior to the tripartite in the matter of weight economy, the tripartite has a great advantage in that the Bessemer steel composing it is almost rust-proof and that every inch of metal surface upon it can be reached with a paint brush. Its taper can also be varied to suit local conditions.

Reinforced concrete poles have come into use during the past few years for railway trolley construction. Under favourable conditions they can compete with cedar or chestnut poles as to first cost; they are, roughly speaking, about twice as stiff as a cedar pole and of 30 per cent. to 50 per cent. greater ultimate strength. Most important of all, they are practically indestructible. A considerable number of them are in use on the lines of the Fort Wayne & Wabash Valley Traction Co.

On account of the load being from two to three times that carried on a single bracket pole in standard direct suspension, it is necessary to use heavier poles for catenary work. If of wood, they should average 25 in. in circumference at the top, and should invariably be seasoned and treated with creosote, at least, at the butts. The standard setting should be 6 ft. for a 30 ft. pole and 6½ ft. for a 35 ft. pole where the wire is at a high elevation. Over highways,

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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19 ft. is usually high enough, but in the steam railroad electrification carried out in this country the standard height of trolley wire, except under low bridges, is 22 ft. above the rail. Bracket poles should be set with 14 in. or 15 in. rake, as they will pull up to about 1 ft. rake after the load has been applied. On steam railroads particular care must be paid to side clearances. 8 ft. from centre of track to the face of the pole is a minimum, and some roads require more. With an 8 ft. clearance, a bracket 10 ft. in length is sufficient. On curves, brackets must be so inclined from the horizontal as to be nearly parallel to the position taken by the pantagraph bow, the outer end of which will tilt up considerably, due to the elevation of the outer rail. For attaching bracket truss rods to pole tops, the three-part pole-collar is preferable to any other means, as a single-pattern forging is sufficient not only for the truss rod but for constraining the body of the bracket. Insulator pins should be tightly adjustable on the brackets and should be made with a two-part clamp base, which the writer believes preferable to one with a J-bolt base.

Porcelain insulators of the petticoat type, are now universally used, and even over steam railroad tracks they have given no special trouble from gathering soot. The types used on the Erie and the Denver and Interurban lines have been uniformly successful, for three years on the former and two years on the latter railroad. The general form of this insulator is shown in Fig. 1.

Brackets ought also to be stronger than are usually made in direct suspension, particularly if over steam railroads. In the equipment

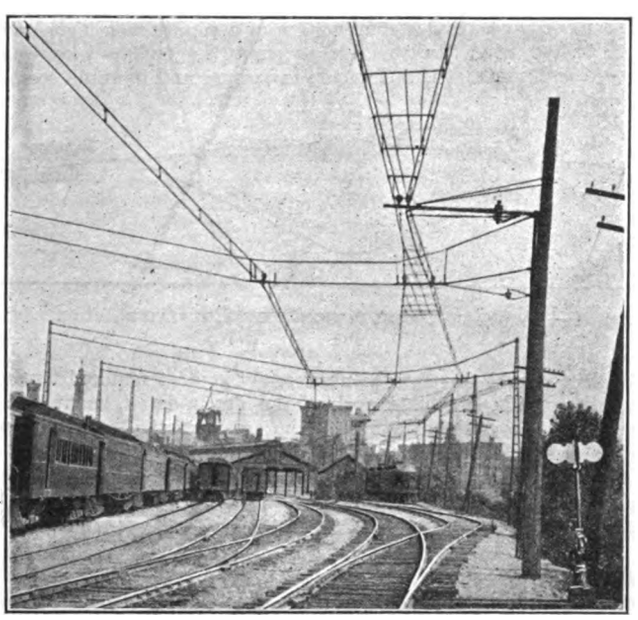

FIG. 2.—OVERHEAD CONSTRUCTION AT ROCHESTER TERMINAL OF THE ERIE RAILROAD.

designed by the writer for catenary construction on the Erie Railroad, two truss rods were used per bracket. Some forms of bracket are made with two horizontal members, one on each side of the pole. To guard against accidents and minimise breakage in case of accident, the writer believes that it is desirable to design the pole attachments to the bracket, so that if the trolley and messenger wire break, the bracket and truss rods may be swung around the pole as on a hinge, rather than be broken off or twisted out of shape. This is effected by using pole collars at the butt of the bracket and at the point of attachment of the truss rod, which have the additional advantage of obviating the boring of holes through the pole.

Catenary Spans and Bridges.—The expense of steel bridges for supporting catenary trolley wires over more than two or three adjacent tracks can be greatly reduced by using span wire construction. A number of spans constructed under the writer's supervision at the Rochester terminal of the Erie railroad are illustrated herewith in Fig. 2. In this design the span wires and all supporting fittings are earthed. The trolley wire is supported by suspending from the span wire a stirrup of the same size of tee iron as is used for the bracket. The same type of pin as well as insulator is used for the span as for the bracket construction on the remainder of the line. The voltage on this installation is 11,000. For lower voltages heavy wooden strain insulators are sometimes cut into the spans without any insulation between the span and the messenger wire at the point of attachment, but the advantage of entirely earthed span wires should commend itself so naturally that it does not seem worth while to go to the extra trouble of working various styles of insulators into them. This form of span is practically in duplicate, though it is intended that the upper should carry the load and the lower act to steady the stirrup sideways. It is hardly necessary to add that steel poles are necessary for catenary span construction of this character, unless there is ample room substantially to guy wooden poles. For this purpose the tripartite pole has been found very satisfactory. The illustration shows seven tracks spanned, being a distance of 96½ ft. across the tracks between poles, and four tracks of the seven electrified.

Some of the latest catenary construction for double track has been supported by a light bridge construction, the most recent example being that of the Rochester, Syracuse & Eastern Railway, recently completed, and illustrated in Fig. 3. This is for 600 volt direct-current construction with bridges 300 ft. apart. It is of the plain single catenary type, without any special adjustment or tension devices. The sag of the cables in a 300 ft. span is about 62 in., the maximum length of hanger being about 67½ in. and the minimum 5¼ in. in length. The form of bridge and foundation is stable and permanent. The side frames of the bridge are 28 ft. between the centres and the spread of each base is 4 ft. The insulators on top of these bridges are of porcelain moulded in a special saddle shape and set on treated timber. There is said to be comparatively little side swaying between bridges. On this particular line the messenger cables are of copper, constituting the feeders and are of 500,000 cir. mils. The feeder was necessary for power distribution

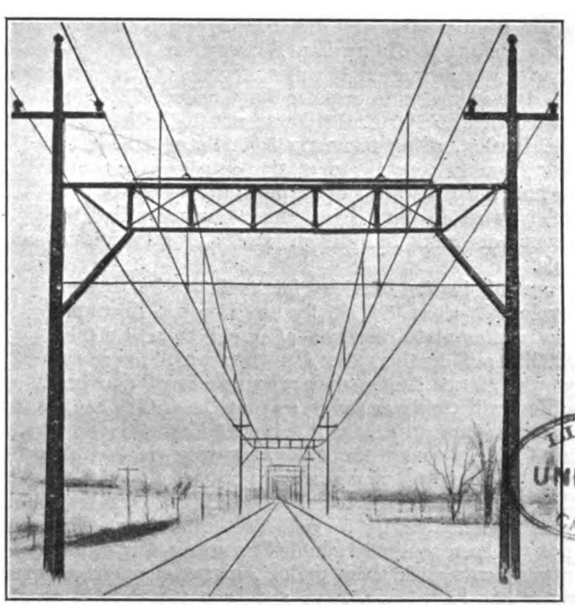

FIG. 3.—LIGHT BRIDGE CONSTRUCTION ON ROCHESTER, SYRACUSE & EASTERN RAILWAY.

and the cost of the steel messenger wire was saved by this combination.

Some figures were recently published showing the relative cost of this type of construction compared with the ordinary wooden pole and span wire construction for double track. The fact that the messenger wires were eliminated and the feeders made to do double duty enabled quite a saving to be made, and the cost of the supporting structures, exclusive of copper conductors, is reported for this particular line as being only £20 per mile of double track more than with wooden pole construction. It is hardly necessary to comment on the greater permanency of steel construction.

Messenger and Trolley Wires.—By reason of their somewhat intimate relationship, it is desirable to consider messenger and trolley wires together. The original and simplest form of catenary construction utilised a galvanised seven-strand steel cable of high strength steel, with hard-drawn grooved copper trolley wire. The messenger wire has varying sags, but a common sag was 10 in. to 12 in. for a 120 ft. span. The trolley wire, which is generally of 3/0 or 4/0 B. & S. gauge, is meant to be perfectly level at average temperature, but owing to the different coefficients of expansion of steel and copper, the trolley wire is relatively tighter at low and slacker at high temperatures than the messenger wire. With the plain type of catenary construction where no take-up devices are employed, the result is that in warm weather the 10 ft. sections between hanger points become slack enough to cause the sliding bows to pound kinks into the wires at the hanger points, and, at

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any considerable speed, mechanically pounding and electrical flashing are both injurious. The only remedy for this situation aside from providing over-lapping breaks, is to pull the wire sufficiently tight so that its strain at maximum temperature will not be less for a 4/0 wire, than 2,000 lb. If the minimum tension at 100°F. is to be 2,000 lb., at 0°F. it will run up to about 5,000 lb., and the elastic limit of the wire is reached at 5,817 lb. As 5,000 lb. is so close to the elastic limit it is to be expected that copper trolley wire pulled tight enough to be effective at maximum temperatures will be likely to get pulled beyond the elastic limit in the course of a season or two, particularly after the outer skin is somewhat worn down by the passage of the moving contact. These considerations may explain much of the trouble that has been experienced with plain catenary construction using hard-drawn copper trolley wire. It sometimes happens that when a road is quite crooked, the elasticity of the poles will do something towards maintaining the tension of the trolley wire at varying temperatures by giving sideways at the curves, but usually the only remedy is to pull out the slack as often as required. This warm-weather slackness can be obviated where a wire can be pulled sufficiently tight to be at a miniumm of 2,000 lb. at a high temperature and 5,000 lb. at low temperature. This can be done with "phono-electric," with steel wire, or copper-clad steel wire. The principal objection to the use of wire other than copper is the decreased conductivity. Phono-electric wire costs more than copper, while steel wire, of course, costs very much less. Both of these wires are so much stiffer than hard-drawn copper that there is a marked tendency to resist kinking. At 11,000 volts the conductivity does not greatly matter when dealing with the usual interurban train weights and distances of transmission.

On the Denver & Interurban Railway, in 1908, phono-electric trolley wire was strung on 45 miles of plain catenary construction, using a dynamometer to register the tension, which was so adjusted that at 100°F. there was not to be less than 2,000 lb. tension, rising to nearly 5,000 lb. at 0°F. This road has been in constant operation for two years and it has not been necessary to pull any slack out of the trolley wire in that time, thus demonstrating the correctness of both the design and the selection of materials.

The use of tension devices for trolley wire as thus far developed, which is chiefly in Europe, does not seem to contemplate tensions of more than 1,000 lb. to 1,500 lb., and furthermore the clips which hang the trolley wire from the secondary wire directly over it are of a type that will yield vertically, so that the trolley can, as it were, carry a wave along with it as it travels underneath the wire. It is the writer's belief that without the upwardly yielding hangers, it is necessary to maintain a minimum tension of at least 2,000 lb.; and that the only excuse for maintaining a lower tension is the ability of the trolley wire to yield at the hangers. Such hangers have not yet been generally adopted for use in this country and the only experiments with them under American conditions of which the writer has knowledge, have not been particularly conclusive. On the New Haven road good results have been effected by a maximum tension of about 5,000 lb. on the trolley wire, and without the use of automatic devices for producing uniform tension under all temperatures.

An excellent feature of the modified type of compound catenary construction used by the New Haven R.R. is the upward yielding made possible by suspending the contact wire from the old trolley wire at points half-way between the original hanger points. There is thus available a limited amount of upward yielding, depending somewhat on the temperature. The clips by which the working conductor is attached to the lower or secondary messenger are fast to both the wires and allow no vertical play other than that due to the yielding of the secondary wire. The European compound catenary, however, has these hanger clips so designed as to permit the trolley wire to yield vertically, and as all new European work seems to be designed along these lines the principle under European conditions seems to be successful.

The other principal feature of the compound catenary is the tension device placed at intervals to take up the expansion in the trolley wire due to temperature. This consists of a system of weights operating by chains over pulleys, pulling against the free end of the trolley wire at the end of each section, the consecutive sections overlapping so that the contact bow slides readily to one before leaving the other, there being, however, no electrical connection between the trolley wires of the overlapping sections except during the passage of the bow. These sections are from 3,000 ft. to 4,000 ft. long and the arrangement serves naturally as a section insulator around which a jumper can be placed if desired. On the line at Rotterdam the builders have cut the messenger wire at every bracket, inserting a strain insulator resting upon the bracket and composed of three insulators so that there are ordinarily two in series. Previous practice adhered to the continuous messenger, but presumably the change was made in the interest of diminishing the effect of changes in temperature of the continuous messenger.

The latest improvement introduced in Europe for eliminating unevenness of operation due to temperature changes is a new design in which there is included an equaliser wire, so-called, which runs above the catenary between brackets without any intermediate hangers, as shown in Fig. 4. Being somewhat shorter and with less slack than the messenger wire proper it tends to lift the catenary at points where it is anchored thereto a short distance away from the brackets, and thereby raises a short bight in the catenary directly under the bracket where the trolley is attached to it, thus lifting the trolley wire at the bracket when temperature is lowered, which would not be the case in the ordinary type of plain catenary construction. In this type of catenary the trolley wire is of hard-drawn copper, while the catenary and the equaliser are of silicon bronze, so that all three have similar coefficients of expansion. In several instances a copper messenger wire has been used instead of steel, this having been done on lines where low-tension direct current was used, requiring feeder copper. It has the advantage of saving the cost of a steel messenger. The fact that both the trolley and messenger are of the same material will greatly lessen the troubles that have been experienced with a steel messenger and a copper trolley wire.

The excellent service being rendered by steel trolley wire on the New Haven R.R. has suggested to the writer that it might be worth while to propose using a combination of a copper messenger and a steel trolley wire. In this arrangement the trolley wire would expand and contract less than the messenger and it would seem as

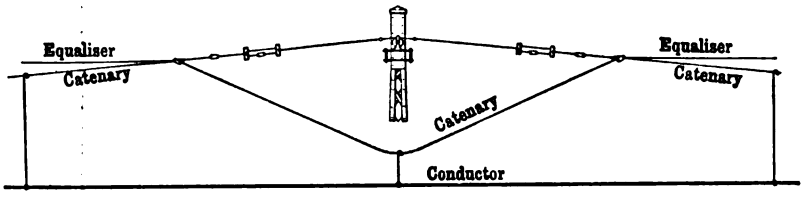

FIG. 4.—CATENARY CONSTRUCTION WITH EQUALISER WIRE.

though it should therefore be more easily kept at required tension. There has not been time to work up the idea in detail, but it is submitted for the criticism of those who are interested. It will probably be more suitable for the higher than lower voltages, but as it is no more difficult to insulate catenary trolley construction for 11,000 volts than for 2,200 volts, the extra cost of insulation due to carrying the higher voltage is insignificant.

(To be concluded.)

TESTING OF HEAT-INSULATING MATERIALS.*

BY F. BACON, M.A.

Summary.—The author describes apparatus he has prepared for calculating the loss of heat in heat-insulating materials. Particulars of tests on a number of materials are given, and also the effect of an air jacket.

The original object of the apparatus here described was to obtain some exact data for calculating the loss of heat through the walls of cold stores in which only a very thin layer of insulation could be allowed, so that surface effects were important, and to provide a conductivity test for heat-insulating material which could be carried out with sufficient ease and rapidity for commercial purposes.

In order to avoid the labour and difficulty of moulding the material to be tested into a shell or covering of complicated shape, recourse was had to the more direct "wall" method, in which the drop of temperature between the two faces of a thin slab transmitting a known heat flux is determined. The inherent sources of error to which such a simple method is liable are: (1) Leakage of the heat flux; (2) incorrect determination of the temperature of the surfaces. It is claimed that both of these errors have been rendered negligible. In fact, the accuracy with which the heat flux and temperature gradient could be determined was greater than could generally be turned to useful account owing to the want of uniformity existing between two specimens of the same material.

* Abstract of a Paper read before Section G of the British Association at Sheffield.

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Duplicate specimens of the material to be tested are obtained in the form of slabs measuring 18 in. by 18 in. and not more than 1½ in. thick. A thin, flat heating net of uniformly wound resistance wire, interwoven with asbestos, measuring 12 in. by 12 in., is sandwiched in between these slabs, the marginal crack left all round the heating net being filled up with strips of felt. Direct contact between the heating net and slabs of insulating material is avoided by interposing a thin sheet of asbestos millboard on each side. To measure the temperature of the faces of the slabs advantage is taken of the fact that there is no perceptible drop of temperature between a heat-insulator and a good conductor of heat in close contact with it. Sheets of zinc 12 in. by 12 in. are taken, and a flat resistance coil of fine double silk-covered wire wound uniformly over a central 6 in. square of one of their faces. The wire is wound non-inductively and secured to the zinc plates by stitches of thread passing through fine holes drilled in the metal. Zinc plates prepared in this way are inserted on each side of the slabs of insulation, the fine wire coils being in direct contact with the material to be tested. Thin wood covers are now put on both sides, and the whole is clamped firmly together by four bolts, with wing nuts passing through two skeleton frames of wood (Fig. 1). The apparatus is then hung in a vertical plane in a situation screened from draughts and sunlight. The terminals of the heating net are led away through an adjustable resistance and suitable switchgear to a battery of accumulators. A voltmeter and ammeter are connected up to the circuit, from the readings of which the watts dissipated can be obtained. As the arrangement of slabs is identical on both sides of the heating net, the heat generated will divide equally, half escaping through one wall and half through the other. The terminals of the resistances of fine copper wire are connected up to a Wheatstone bridge of the stretched-wire type through a system of plugs, which enables the ratio of resistances of either pair of coils to be determined.

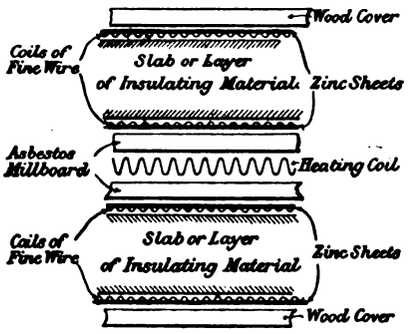

FIG. 1.—DIAGRAMMATIC SECTION FOR CONDUCTIVITY TEST.

By assuming a value for the temperature coefficient of the copper wire, of which the coils are wound, the excess of temperature of the inner over the outer faces of the insulating material can be immediately obtained. The system of plugs also allows of the resistance of any one of the four coils being compared with that of a fifth coil situated in the unheated surrounding air, the temperature of which is measured with an ordinary thermometer. This enables the absolute temperature at the inside or outside of either of the slabs to be determined.

Since the coils which give the temperature of the faces only measure 6 in. by 6 in., while the heating net measures 12 in. by 12 in., it is evident that there is a marginal guard ring of heat flux 3 in. wide all round the central area, through which the heat gradient is determined. As the heating net is wound uniformly, heat is generated uniformly all over its surface; the sheets of zinc, being also the same size as the heating net, help to spread the heat flux uniformly and maintain a direction of flow normal to the surface. With slabs of insulating material not more than 1½ in. thick there can be hardly any doubt that the flux of heat through the central 6 in. square over which the temperature of the faces is determined is uniform, normal to the surface and of density equal to half the watts dissipated in the heating net per unit area. With slabs 1 in. thick it will be seen that, although the total amount of material required for the test is small, the value obtained for the heat conductivity of each slab will really be the average of 36 cubic in. of the material. In all cases the difference of temperature between the faces was measured for each of the slabs, thereby making sure that the heat flow through each slab was approximately equal, and enabling the average coefficient to be determined for a total of 72 cubic in. of material divided between two separate specimens, although the total number of temperature observations involved is only two, and these can be taken immediately one after the other by simply changing over the plug connections to the Wheatstone bridge. When the apparatus is once got together the introduction of fresh specimens is only the work of a few minutes. If it is desired to test some loose material, such as powdered cork or silicate cotton, two similar wood frames are used for retaining it in position.

As soon as the material is in position and the heating coil and fine-wire coils are connected up, a suitable heating current is switched on and the apparatus left until the steady state is attained. The time necessary for this may be anything from 12 hours to two days, depending on the nature of the material and the magnitude of the heating current.

In Fig. 2 are shown the results of a series of tests on boards of yellow pine 1 in. thick. Curve 1 shows the mean difference of temperature between the inside and outside faces of the boards in an enclosed test, as shown in the diagrammatic section, Fig. 1. It will be noticed that the curve 1, in common with all similar curves obtained for other materials tested, is slightly convex to the temperature axis, thereby confirming Nusselt's result that the conductivity of heat insulators increases with rise of temperature. Curve 2 of Fig. 2 shows the difference of temperature between the inside faces of the boards and the external air when the apparatus is arranged so that the outside surfaces of the boards are uncovered; whilst curve 3 has been obtained by plotting the temperature intercepts between curves 1 and 2 for different heat fluxes, and the abscissæ of this curve accordingly represent the drops in temperature which occur at the outer surfaces. The way in which curve 3 bends up shows how very incorrect Newton's law of cooling becomes as soon as the drop in temperature exceeds 40°F. or 50°F. From these curves we can make an attempt to predict the amount of heat that will pass through a partition made of various thicknesses of this material, when certain specified differences of air temperature exist on the two sides. For any definite heat flux, the difference in temperature between the two faces of the partition will be the corresponding abscissa of curve 1 increased or decreased in simple proportion to the thickness; the corresponding abscissa of curve 3 is assumed to be the drop of temperature at the surface that will occur on each side of the partition, and the transfer of heat by air contact will be very sensitive to convection currents. Under conditions of cold-store construction doubtful surface effects on the calculated results have much less relative importance.

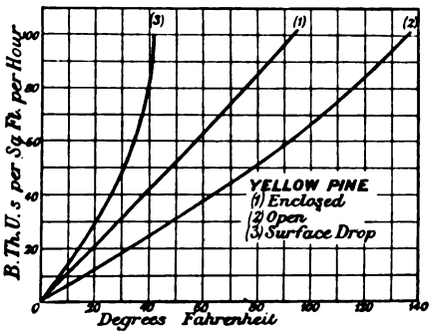

FIG. 2.

The following table shows the specific gravity and coefficient of heat conductivity as determined by the apparatus described for a number of different materials. To facilitate comparison with the results of Nusselt, the conductivities given in the table have been expressed in kilogramme-calories passing per hour through a cross-section of 1 sq. metre when the temperature gradient is 1°C. per metre. To convert the conductivities into B.Th.U. per square foot per hour for a temperature gradient of 1°F. per inch the figures given in the table must be multiplied by 8·05. Thus, for yellow pine, 0·13 × 8·05 = 1·04 nearly, as previously obtained from Fig. 2.

Material.	Spec. grav.	Coeff. of heat conductivity at 50°C. to 75°C.
Yellow pine across grain	0·360	0·13
Teak across grain	0·515	0·23
Expansit Schrot No. I.*	0·051	0·055
„ „ No. II.*	0·049	0·061
Compressed cork slabs	0·166	0·060
Silicate cotton or slag wool	0·330 0·256 0·141 0·113	mean value 0·07
Asbestos sheet, ⅛ in. thick	1·240	0·25
„ millboard, ⅛ in. thick	1·075	0·14 to 0·1
Air jacket in the vertical plane, 1 in. wide, walls of asbestos millboard	—	0·26 to 0·31

The somewhat higher conductivity of Expansit Schrot No. II. compared with No. I. is due to the larger size of the granules composing it.

* A special preparation of cork.

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The most efficient grain size is a point of much interest. The heat-insulating effect produced by a porous material is apparently due to the fact that the space which it occupies consists mainly of air split up into such a fine state of subdivision that convection is prevented by viscosity. The more minute the pores the more hampered will be the movement of the entangled air; but a limit will be reached when the pores are made so small that the benefit derived from this cause is counterbalanced by the increased conduction of heat that takes place through the substance of the material itself. From the researches of Clark Maxwell and Winkelmann it appears that the conductivity of perfectly still air is only about 0·02, which may be taken as the ideal towards which the conductivity of actual porus insulating

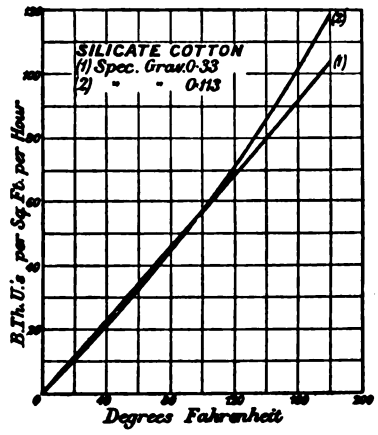

FIG. 3.

material can only approach. The author understands that a conductivity as low as 0·033 has been obtained for Expansit of very fine grain.

Silicate cotton was experimented with in four different densities. Results for the highest and lowest densities, representative of very loose and very firm packing, are shown in Fig. 3. It will be seen that loose packing makes slightly the best insulator for small differences of temperature; but firm packing is much the best when the temperature difference is considerable. On the whole, the results indicate that it is advisable to pack the silicate cotton as firmly as possible, especially as this ensures that the material will not afterwards subside so as to leaves holes which cannot afterwards be filled up.

The apparatus described above for measuring conductivity is also well suited for getting comparative values for heat insulators from the cooling point of view. A steady state is established with some

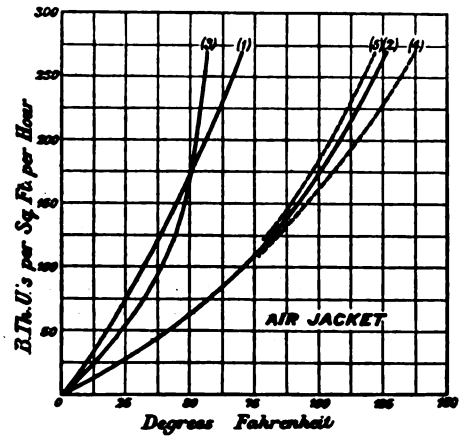

FIG. 4

specified internal temperature, the heating current is then switched off and the rate of fall of internal temperature determined by taking readings periodically.

Results for asbestos lead one to the conclusion that its value as a heat insulator is due rather to its fireproof qualities than to its low conductivity, which, indeed, appears to be no lower than the conductivity of wood. To make experiments on the conductivity of a simple air jacket, two double thicknesses of thin asbestos millboard were inserted in the positions usually occupied by the slabs of insulating material to be tested; curve 1 of Fig. 4 was obtained with this arrangement. Frames were now inserted so that a central air jacket 9 in. by 9 in. was introduced on either side, surrounded by a marginal dead air space about 1½ in. wide. With this arrangement curve 2 was obtained. Curve 3 was constructed by plotting the intercepts between the curves 1 and 2 and must represent very approximately the difference in temperature between opposite walls of the air jackets. It is at once evident that an air jacket of this description is a very poor insulator even for small differences of temperature, and that the conductivity increases enormously as the temperature difference is increased.

Curves 2 and 3 refer to an air jacket with vertical walls. The effect was tried of turning over the apparatus bodily from the vertical to the horizontal plane. The temperature differences for the jacket that was now uppermost rose from curve 2 to curve 4, while for the jacket that was underneath the temperature differences fell from the curve 2 to curve 5. The explanation of these results appears to be that currents of hot air rising freely from the upper horizontal surface of the apparatus enabled the heat to be carried off with only a small difference in temperature between the top of the jacket and the outside air. On the other hand, the hot air produced by the heat conducted through the bottom horizontal surfaces, instead of being displaced by cold air, remained in contact with the lower surface, with the result that the outside wall of the lower jacket rose in temperature, thereby diminishing the difference in temperature between the two walls of the jacket. The heat conductivity of the two jackets can no longer be calculated.

COMMERCIAL WIRELESS TELEGRAPHY IN JAPAN.

THE TEISHINSHO SYSTEM.

BY WICHI TORIKATA.

The investigation of wireless telegraphy in Japan has been continued for about 23 years, the first practical experiment being made by Dr. Rinzaburo Shida in 1886, in an attempt to communicate across the river Sumida. This experiment was carried out by the conduction method, but was not very successful.

After Prof. Hertz announced his epoch making discovery of the electric waves, Dr. Hantaro Nagaoka, Dr. Binnozio Midsuno, and Dr. Osuke Asano were greatly interested by the phenomenon, and the two former especially began their theoretical investigations. Dr. Asano intended to utilise the waves for signalling.

Dr. Osuke Asano is the Director of the Electro-Technical Laboratory of the Imperial Japanese Government, and is also a Professor of the Tokyo Imperial University. His investigation had so far advanced that at the beginning of November, 1897, he was successfully effecting experimental communication over several miles in Shinagawa Bay, near Tokyo. In April, 1900, he had succeeded in practical communication over 34 miles between Otsu and Funahashi. By these practical experiments, he gained much experience and effected improve-

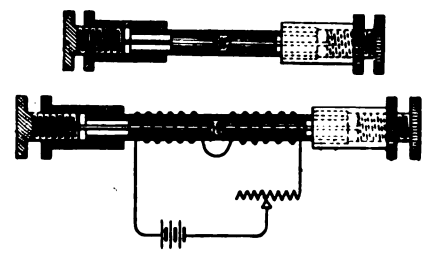

FIG. 1.—TEPPUN DETECTOR. FIGURE FROM THE JAPANESE PATENT SPECIFICATION NO. 11,849 (1907).

ments in his system, and in 1903, he intended to communicate between Formosa and Kyushu. The distance between these islands is 630 miles, and by using 15 kw. he was able to receive some signals at either station, but not yet to effect regular communication. Unfortunately war broke out with Russia before he could establish regular communication between these two islands, and he was obliged to stop his experiment to avoid interference with the wireless operations in our Navy.

During the war, he remained in his laboratory and continued his researches. He was not able to make any long distance

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practical experiments until July 1, 1908, when we began commercial wireless telegraphy. Nevertheless he made great progress by many inventions and improvements during his laboratory researches, and when we adhered to the Berlin Wireless Convention of 1906, we were able to open many public wireless stations at once, in accordance with his design and system. The wireless system is generally known as the Teishinsho system, or the system of the Department of Communication, for his laboratory as well as all commercial wireless stations in Japan belongs to this department.

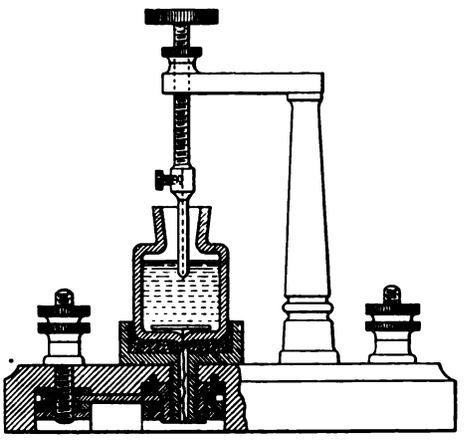

FIG. 2.—TANTALUM DETECTOR. FIGURE FROM THE JAPANESE PATENT SPECIFICATION No. 15,238 (1908).

Dr. Asano had many assistant engineers and among them Mr. Matsunosuke Matsushire and Mr. Mitsuru Saiki, especially the latter, gave great assistance in the work. Mr. Saiki is the most experienced and able wireless expert in Japan, and is the inventor and patentee of many inventions forming the most important details of the Teishinsho system now practically used in all stations.

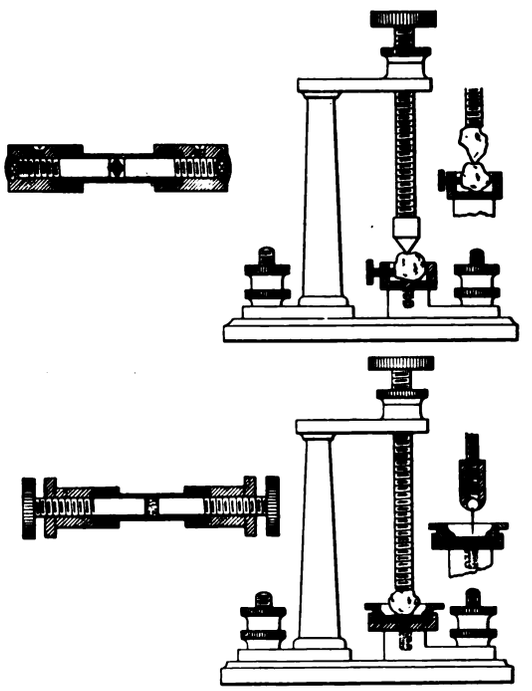

FIG. 3.—KOSEKI DETECTOR. FIGURE FROM THE JAPANESE PATENT SPECIFICATION No. 15,345 (1908).

All telegraphy and telephony in Japan are the monopoly of the Government, as is also the wireless branch. Dr. Asano was sent as our chief delegate to the Berlin Wireless Conference of 1906, and the Convention was fully ratified in our country. We have now five land stations and 11 ship stations, all open to the public day and night. Our commercial wireless business only began on July 1, 1908, and we are now about to instal many ship and land stations.

All the wireless installations and business are strictly in accordance with the Berlin Convention. The power used in our ship-stations is now generally 1 kw. or 1½ kw., and the maximum distance for regular direct communication between land and ship stations is nearly 1,500 miles at night and 400 miles in the daytime. All American liners with our wireless system, during their whole voyage of about 30 days between Hong Kong, Yokohama and Seattle or San Francisco, communicate directly with some land stations nearly every night; though this is generally impossible for one night (and sometimes for two nights) midway between Yokohama and Honolulu, which are 3,400 miles apart.

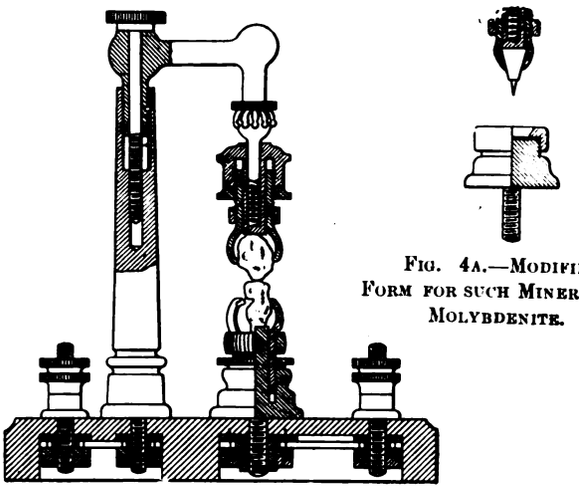

FIG. 4A.—MODIFIED FORM FOR SUCH MINERALS AS MOLYBDENITE.

FIG. 4. —KOSEKI DETECTOR.

The Teishinsho system is a spark system as regards its transmitter, and makes use of a telephone and detector for its receiver. Many special devices are used to minimise the damping and to get sharp tuning. Generally, the alarm device is not used, but the receiver is so arranged that we can use, by switching, either of two sets, one of which is arranged to be very acute in its tuning, but the other to respond to any waves over a certain wide range. All wireless stations are designed to use 300 metres as a standard wave length, and, by using the acute tuning set, we were able to cut off one wave from the other when the difference of the wave length reached 2 per cent. When we sent two signals simultaneously, with wave lengths of 300 and 306 metres respectively, from two stations in Tokyo, we received these two signals quite distinctly and independently with two receiving sets connected to one and the same aerial in Choshi station, about 60 miles from Tokyo.

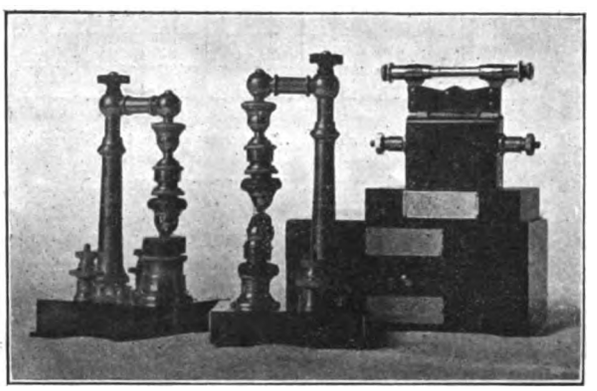

FIG. 5.—KOSEKI DETECTORS, PRACTICAL FORMS USED.

There are many kinds of detectors used in the system, but the following three have been the most successful: the Teppun detector, the tantalum detector, and the Koseki detector.

The Teppun Detector.—Up to about six years ago, a kind of mercury detector, devised by Dr. Asano, was used in many

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researches, but the Teppun detector is the first one used practically in our commercial wireless business. This detector was devised by Mr. M. Saiki, and was patented by him (Japanese patent No. 11,849). Fig. 1 shows the construction of the detector. Two steel poles are magnetised and arranged to be adjustable in their distance as in a coherer. Fine steel powder, oxidised on its surface by burning in a flame, is introduced between the poles, so that the powder makes a bridge between them by the magnetic field of the poles. The powder must not be in too great a quantity, and each granule must be neither too large nor too small. The sensibility of the detector depends mainly upon the degree of the oxidation and also upon the adjustment.

The adjustment of the detector is not so difficult, and when once adjusted, the position may be fixed by screws.

The detector, thus adjusted, is very sensitive and quite stable. The end of the steel pole must be well polished and there must be no rust. The stronger the magnetic force of the poles the better is the result, and the use of the magnetic force to arrange the steel powder is the best feature of this detector.

The Tantalum Detector.—The tantalum detector is quite different from that of Mr. L. H. Walter who used a tantalum

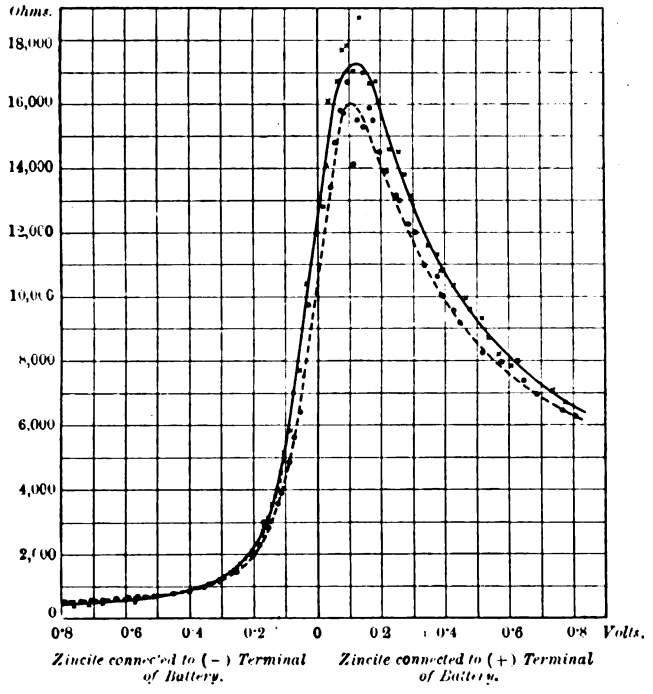

FIG. 6.—ZINCITE COUPLED WITH BORNITE.

point and mercury. Fig. 2 shows the construction of the detector. The device was invented by the writer, and was patented by him in Japan during 1908 (Japanese patent No. 15,238).

My tantalum detector depends upon dipping a tantalum point into some alkaline or acid solution. My first attempt was to get some detector utilising the rectifying property between some substance and vapour or solution. Mercury vapour was the first to be tried, for more than a year, but it gave no successful result as a sensitive detector.

The second idea was to utilise the aluminium rectifier, which is based upon some special insulating film between the aluminium and the solution. Various kinds of aluminium and aluminium alloy, as well as solutions, were tried, but though we got some result it was not so sensitive.

Besides aluminium, I tried many metals, like magnesium, which will give some rectifying phenomena, and finally arrived at tantalum. The rectifying property of tantalum is far quicker and more distinct than that of aluminium. Although the resistance in the direction of solution to tantalum is very low, that in the direction from tantalum to the solution is very high, and sometimes even a few hundred volts will scarcely produce any current.

The tantalum rectifier is quite sensitive as a wave detector. The surface of the tantalum may or may not be small, but a fine point like the platinum point in an electrolytic detector seems to be far the most sensitive. The principle of the tantalum detector is not yet proved, and there is some question whether the action as a detector is entirely due to the rectifying property of the insulating film or to phenomena something like the platinum point electrolytic detector as well as the rectifying property. The action of the tantalum detector with mercury, which seems to be another form of the utilisation of the surface tension of mercury, is quite different from this tantalum detector.

The tantalum detector is very sensitive, and many samples which I made in my laboratory were more sensitive than the glass-shielded platinum-point electrolytic detector. The tantalum is not acted upon by ordinary acid or alkali, and the life of the detector is very long.

Koseki Detector.—The Koseki detector, or mineral detector, was invented by the writer and was patented by him in Japan during 1908. The first idea underlying the investigation of minerals was the utilisation of magnetite as a powder in Mr. Saiki's Teppun detector. The degree of oxidation of the iron powder used in the detector has a great effect on the sensibility. Not only does it require skill, but the powder becomes more and more oxidised in the air, and finally becomes quite insensitive.

We tried to use natural iron oxide or magnetite instead of the

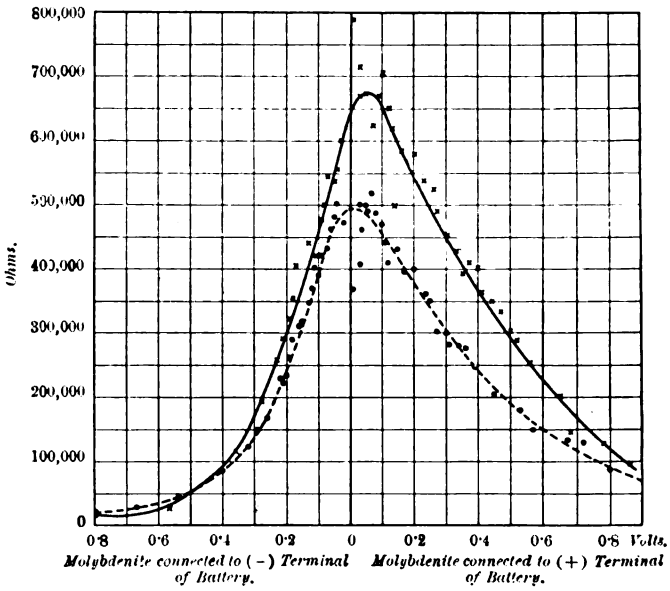

FIG. 7.—MOLYBDENITE COUPLED WITH BORNITE.

artificial oxide, and we found that magnetite is quite sensitive and durable when used as powder in a detector.

Besides magnetite, we found pyrohotite, arsenical pyrites, chromite, ilmenite, wolframite, iron glance, marcasite, &c., all quite satisfactory as a substitute for the iron powder in the Teppun detector. Mr. Saiki especially made an extensive investigation on the utilisation of ilmenite, and he found the ore very sensitive when used as powder, especially when used as a small piece burnt and pressed between the poles.

The sensibility of these iron ores depends upon the impurities in them, and therefore ores of the same kind have different sensibilities according to the mines where they were produced. Some of them are magnetic but others are not. Iron ore, which is not magnetic, is also quite sensitive as a powder or a block when used between two metal electrodes.

I tried about 200 kinds of minerals and found zincite, molybdenite, pyrolusite, iron pyrites, cassiterite, galena, &c., all very sensitive as wireless detectors, and the patent for the utilisation of these minerals which I thought to be the best was filed on August 12, 1908, and was granted on December 8, 1908, to the writer in Japan (Japanese patent No. 15,345).

Afterwards I made thorough investigations with Mr. E. Yokoyama, one of the electrical engineers in my laboratory,

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on all the mineral samples in the Mineral College of the Tokyo Imperial University, and we found that the following ores are quite responsive to electric waves :—

1. Ores quite sensitive with perfect contact.

(*a*) Oxides:—
Simple oxides:
Zincite.
Tenorite or melaconite.
Cassiterite.
Anatase.
Arkansite.
Pyrolusite.
Wad.
Complex oxides:
Micacious hematite.
Ilmenite, iserine, hystatite.
Magnetite.
Psilomelane.

(*b*) Sulphides :—
Simple sulphides:
Molybdenite.
Galena.
Zinc-blende.
Chalcosine.
Iron pyrites.
Pyrrhotine.
Complex sulphides:
Nagyagite.
Tennantite.
Enargite.
Boulangerite.
Schwatzite.

(*c*) Metallic combinations :—
Lollingite.
Meteorite.
Smaltite.

2. Ores sensitive with a light contact

(*a*) Sulphides :—
Simple sulphides:
Marcasite or kyrosite.
Covelline.
Complex sulphides:
Siegenite.
Copper pyrites.
Cobaltite.
Ullmanite.
Bornite.
Sylvanite.
Arsenical pyrites.

(*b*) Metallic combinations :—
Niccolite.
Domeykite.
Strutterudite.
Allemontite.
Iridosmine.
(*c*) Native elements :—
Graphite.
Arsenic.

Nearly all ores with good conductivity can be used as a detector, but some of them require very light contact and

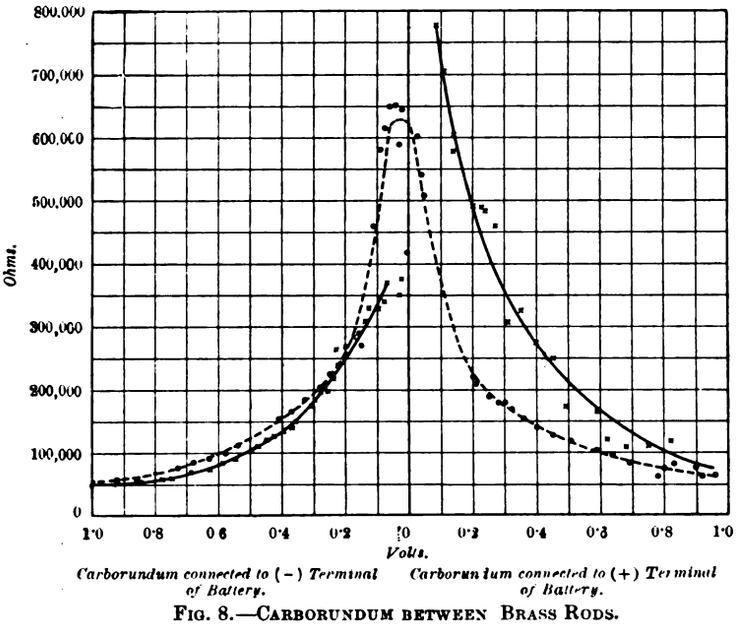

FIG. 8.—CARBORUNDUM BETWEEN BRASS RODS.

delicate adjustment and are not practicable. The action of mineral detectors seems to depend upon the chemical and physical properties of the ores, and also upon the condition of the contacts, but not upon the crystalline structure and axis of the ores. Generally the resistance of copper pyrites is very low and that of zinc-blende is very high, and they cannot be used as practical detectors when they are inserted alone between two metal poles, but their well-tarnished surface acts as a very sensitive detector. The zincite which I got at first time was a fine hexagonal crystal, and had the following component :— 93·9352 (ZnO), 5·0775 (Mn_2O_3), 0·5748 (FeS), 0·4125 (SiO_2). I tested the sensibility of the zincite by various methods, but could not find any difference depending on the axis of the crystal.

Fig. 3 shows the method used to test all minerals, and Figs. 4 and 5 is the actual form of Koseki detectors practically used in our commercial stations.

Every ore was tested in contact with a number of other ores as well as metals. Molybdenite does not give so distinct a result, but zincite gives a marked effect according to the ore in contact with it. Generally speaking, crystals which conduct electricity and heat very well seem to give better results than metals or other ores. Bornite, copper pyrites, or iron pyrites, give excellent results when in contact with molybdenite or zincite, especially with the latter. Copper pyrites and bornite are nearly equally good, but we always get better results with bornite. Bornite alone cannot be used as a detector, but when used with other minerals or crystals it greatly increases the sensibility. Mr. Saiki has devised the use of bornite with carborundum. The carborundum detector, which was invented by General Dunwoody, is very sensitive when used in contact with metals or carbon, but it is further improved by the use of bornite.

Molybdenite or iron pyrites make a very sensitive and practical detector when merely brought in contact with a metal point, such as platinum, steel, brass, &c.

As far as my experiments have gone, the zincite and bornite detector is the most sensitive, but is spoilt by strong waves and even by the induction from the sending waves of its own station. On the other hand, molybdenite and iron pyrites are not so sensitive as zincite but very steady, and are not affected by strong waves. The sound received with zincite is very loud ; that with molybdenite is not so loud, but both of them seem to respond to waves until the sound falls below the limit of sensibility of the human ear. Some kinds of detector give a very loud response when the energy received is within the limit of its sensibility, but no response at all after that limit. This

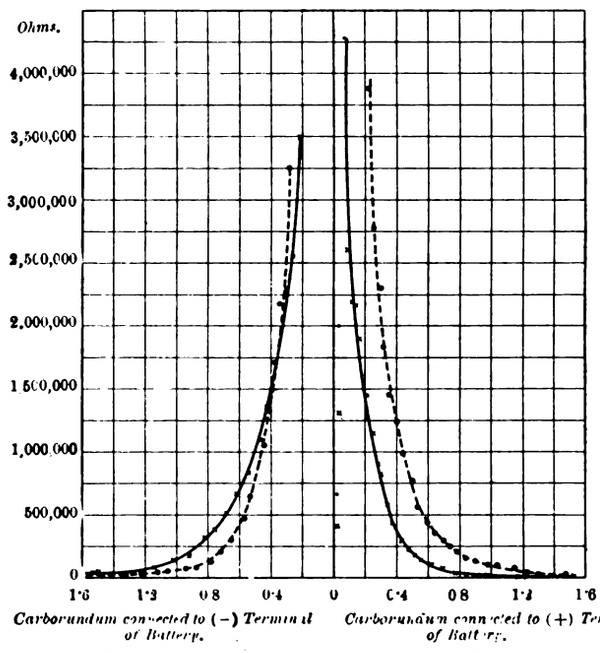

FIG. 9.—CARBORUNDUM COUPLED WITH BORNITE.

phenomenon was never experienced in the Koseki detector, and in some practical experiments between a land station and a ship leaving shore, those with sensitive ears were still able to hear when other people had ceased to perceive any signals. Magnetite, ilmenite and other iron ores may be used practically as detectors, but are much inferior to zincite, molybdenite and iron pyrites, both in sensibility, stability and durability. Following these investigations the use of zincite, molybdenite, iron stones, and mangan stones was claimed in the Koseki patent.

I found afterwards that Mr. Braun, many years ago, had made extensive investigations on various crystals, and also that Mr. G. W. Pickard is using the " Perikon " detector. The Perikon detector (U.S. trade mark No. 70,587) seems to have been the name given to the detector using the artificial solid solution of zinc oxide in readily fusible silicate (U.S. patent No. 886,154), and now the same name is used for the detector

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with zincite and copper pyrites (U.S. patent 912,726), patented February 16, 1909, by Mr. Pickard in the United States of America.

The volt-ohm curves of these detectors are given in Figs. 6 to 9. The detectors were adjusted to the most sensitive positions and then, without disturbing the conditions, the local voltage was gradually increased to 1 volt and then decreased to 1 volt in the opposite direction, and was again increased to zero voltage. The terminal voltage was accurately measured by the condenser discharge method, and the current through the contact by a sensitive galvanometer. The resistances calculated from these data are not always constant, even with the same local voltage. Thus the volt-ampere curve got is something like a hysteresis curve for iron. Generally the steepest point of these curves seems to be the point for the best local voltage.

It will be the best practice to arrange molybdenite and zincite so that either can be used by switching over, and to use the former for the short distance and the latter for longer distances, and when the signal is very faint.

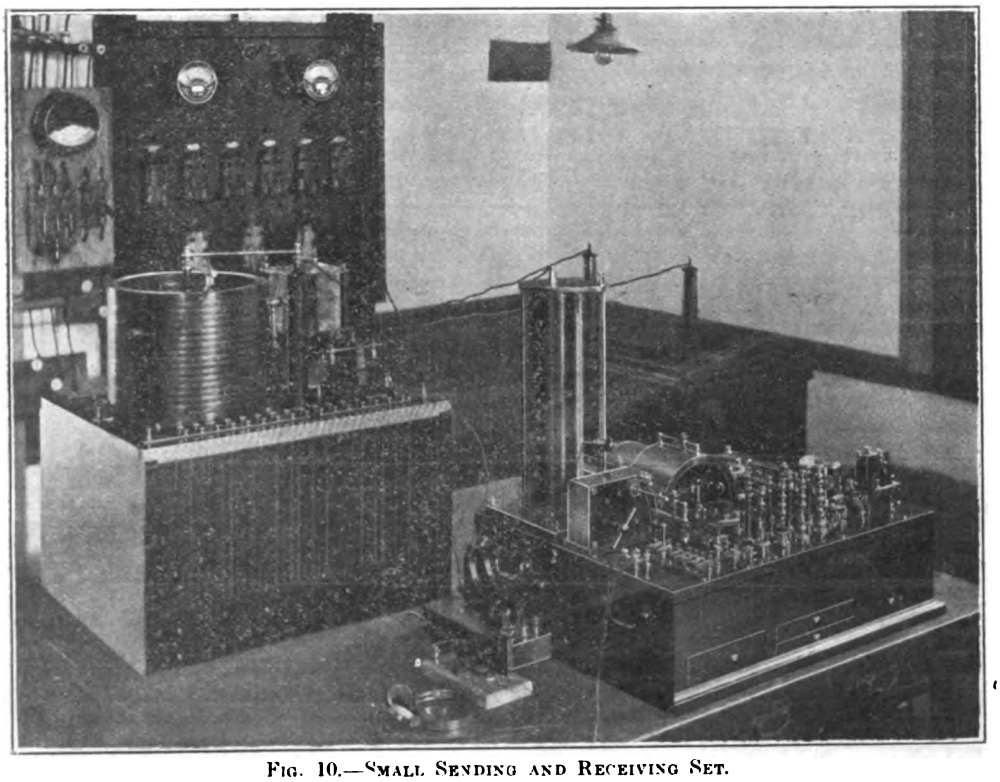

Fig. 10.—Small Sending and Receiving Set.

The wireless business in Japan is quite young, but even now, besides 11 Japanese ships with wireless, three ships with Marconi wireless and two ships with United wireless are coming every month to the Japanese coast. Moreover five more Pacific liners it is said are going to be installed with United wireless.

The communication between Hawaiian Island and the Pacific coast of the American Continent is quite easy even now, and it is said that the Kahuku station in Hawaiian Island has received signals from the Japanese coast during several months. When I was in Honolulu last September, I arranged to carry out experimental wireless communications between the Kahuku station and Japan. The distance between them is nearly 3,400 miles. The power used in Japan coast stations is all below 5 kw., and the signals with such a small power are said to have been transmitted over so great a distance as 3,400 miles. The power used in Kahuku station is 15 kw., and by arranging to make tests when both stations were quite dark, we carried out experiments twice last November and December.

Although we made the test very carefully, we were not able to get any result at either station, but we succeeded in receiving the ss. "Korea," which has occasionally called up the Kahuku station from the position (latitude 22° 23′ longitude 160° 30′), about 300 miles from Honolulu near Japan. Korea has a 5 kw. United wireless installation and sent her signals quite distinctly over 3,160 miles. We hope to make further experiments with increased power, and to establish the regular trans-Pacific wireless communication between Japan, Hawaiian Island and the Pacific coast of the American continent, and this third test will be made in the immediate future.

THE LAWS OF ELECTROMECHANICS.*

BY PROF. SILVANUS P. THOMPSON, D.SC., F.R.S.

In recent times many applications have been made of electricity to mechanism, by devices the earliest and simplest of which is the electromagnet. Mechanical movement is produced, or mechanical force is exerted in these mechanisms by switching on an electric current. The object of this brief communication is to present a simple summary of the laws which govern such electromagnetic apparatus, and to point out some of the relations between them.

In every electromagnetic apparatus or mechanism there are two parts—an electric circuit and a magnetic circuit—and these two are interlinked. This interlinked system in every case presents a certain initial configuration, the electric circuit being more or less interlinked with the magnetic circuit, and each circuit having its own configuration or disposition of parts. Whenever an action is produced in such a system there is some change of the configuration of the system as a whole, the change of configuration being such as to alter the amount of interlinkage between the two circuits which constitute the system. Let C stand for the amount of current (in C.G.S. units) in the electric circuit, let N stand for the amount of flux (*i.e.*, number of magnetic lines) in the magnetic circuit, and let S stand for the number of times that the electric circuit is interlinked with the magnetic circuit. Then the potential of the system is proportional to C, to N and to S severally, and is therefore proportional to the product CSN. The general law of electromechanics may then be stated as follows:—

Every electromagnetic system tends so to change its configuration that the product CSN tends to become a maximum. In other words, every electromagnetic system tends so to change its configuration as to bring about the greatest possible amount of interlinkage of the current in the electric circuit with the flux in the magnetic circuit.

The three quantities C, S and N are connected by certain physical relations as follows:—

(i.) *Law of the Magnetic Circuit.*

$$N = \frac{4\pi CS}{Z}, \quad \ldots\ldots\ldots \quad [I.]$$

where Z is the quantity commonly called the reluctance of the magnetic circuit, and is dependent on the configuration and materials (iron, air, &c.) of which the magnetic circuit is composed. If there be no magnetic leakage, that is, if the entire magnetic flux is interlinked with the entire electric current any integral number of times, then S, the numeric of interlinkage, is the same thing as the number of turns or spirals of the conductor which carries the current. If there is magnetic leakage, then the numeric of interlinkage is less than the actual number of turns.

*Abstract of a Paper read before Section G of the British Association at Sheffield.

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(ii.) *Law of Induction* (Faraday).

$$E=-\frac{dN}{dt} \text{ in one turn.} \quad . \quad . \quad . \quad . \quad . \quad . \quad [II.]$$

or $$E=-S\frac{dN}{dt} \text{ in S turns,} \quad . \quad . \quad . \quad . \quad . \quad . \quad [II.a]$$

where E is the E.M.F. induced in the electric circuit by a change in the interlinked flux such that during the time dt the flux decreases by the amount dN.

(iii.) *Law of the Electric Power.*

$$\frac{dW}{dt}=-CE, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [III.]$$

where dW is the amount of work done by the electromagnetic system in changing its configuration during the time dt, and E is the counter electromotive force developed during the movement.

(iv.) *Law of Work.*—Combining (ii.) and (iii.) we get

$$\frac{dW}{dt}=CS\frac{dN}{dt}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [IV.]$$

whence $$dW=CSdN, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [IV.a]$$

or, if CS be constant and N independent of C, we have

$$W=CSN. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [V.]$$

If any change of configuration occurs such that the initial flux N_1 is altered to the value N_2, then the work done by the system in this operation is

$$W=CS(N_1-N_2). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [V.a]$$

The general law of electromechanics, stated at the outset, may now be restated in the form that, C and S being constant, the system tends so to change its configuration the potential energy shall be a minimum, or that N_2-N_1 shall be a maximum. If S is not constant, then if S_1N_1 be the original amount of flux interlinkage, and S_2N_2 the final amount, the law may be stated in the form that the system tends so to change its configuration that $S_2N_2-S_1N_1$ is a maximum.

The law of work may be written also

$$W=\int CSdN, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [V.b]$$

and if CS is constant and N is an independent flux, the integral is simply W=CSN, as above. But if N is due solely to C, the integral has the value

$$W=\tfrac{1}{2}CSN.$$

(v.) *Law of Change of Flux.*—Any change in the configuration of the magnetic circuit produces a change in the reluctance, and the change in reluctance produces in turn a change of flux. The relation can be found by differentiating the equation for the flux (i.) with respect to the reluctance; giving us the result

$$dN=-\frac{4\pi CS}{Z^2} \cdot dZ.$$

Combining this with [IV.a] we get

$$dW=-\frac{4\pi C^2S^2}{Z^2}dZ \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [V.c]$$

$$=-\frac{N^2}{4\pi}dZ. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [Vd.]$$

In many electromagnetic systems, over a considerable part of the range of action the flux is nearly constant owing to magnetic saturation of the iron core, and in these cases dW will be practically proportional to $-dZ$. It also follows that for a given small change of reluctance, the work is proportional to the square of the flux present.

(vi.) *Law of Force.*

$$f=\frac{dW}{dx}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [VI.]$$

whence $$f=-\frac{4\pi C^2S^2}{Z^2}\frac{dZ}{dx}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [VI.a]$$

where f is the force and dx the elementary displacement. If C and S are constant, the force is dependent on the change of reluctance per unit of displacement, and is inversely proportional to the square of the reluctance. Another expression for the force, derived directly from equation [IV.a] is

$$f=\frac{dW}{dx}=-CS\frac{dN}{dx}; \quad . \quad . \quad . \quad . \quad . \quad . \quad [VI.b]$$

that is—assuming C and S constant—the force is proportional to the rate of decrease of the flux per unit length of the displacement.

In predetermining the performance of any piece of electromagnetic mechanism, the chief difficulties arise in estimating the probable values of the reluctance Z and of the numeric of interlinkage S. The value of this latter, as stated above, diminishes with magnetic leakage. Some assistance is afforded by considering the quantity called "coefficient of self-induction" and usually denoted by L. This coefficient is nothing else than the total interlinkage per unit of current, or in symbols,

$$L=\frac{SN}{C},$$

whence, if L and N are experimentally determined, S can be deduced. Substituting for N its value $4\pi SC\div Z$,

$$L=\frac{4\pi S^2}{Z} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [VI.c]$$

Various curves of performance have been given, by different authorities, for the pull of electromagnetic solenoids. These curves agree fairly with the predetermined values for those positions of the plunger where the reluctance is small, but differ often rather widely for large values of the reluctance. The discrepancy is traced to the assumption that S, the numeric of interlinkage, is usually assumed to be the same as the number of turns and to be constant.

ON THE USE OF AN ACCELEROMETER IN THE MEASUREMENT OF ROAD RESISTANCE AND HORSE-POWER.*

BY H. E. WIMPERIS, M.A.

Summary.—The author describes the construction and principle of the accelerometer which he has designed, and by means of which road resistances can be measured and compared. Some interesting figures are given in this connection.

The need has often been felt for some small portable instrument which would measure the resistance to the motion of any moving vehicle or train of vehicles, and enable a calculation to be made of the horse-power necessary for propulsion. If an instrument could be obtained which would show the negative acceleration of a vehicle when "coasting" with the power cut off, it would be quite easy to deduce from its readings the total amount of the force due to the resistances to motion. Those resistances are, of course, air resistance, road surface resistance and resistance due to the friction of the mechanism in motion. To measure these resistances the instrument used must be sensitive to very small accelerations, and must give a steady reading of the needle even when the jolting of the vehicle is considerable.

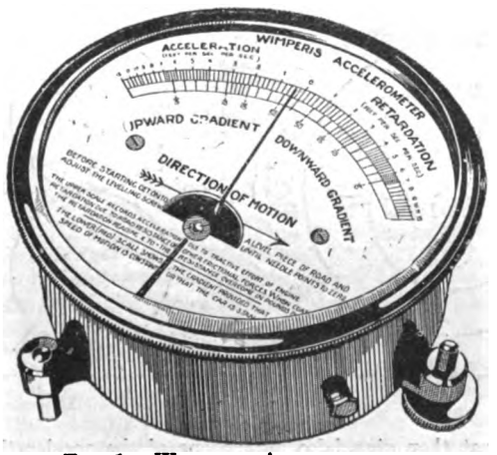

FIG. 1.—WIMPERIS ACCELEROMETER.

The instrument described in this Paper was designed by the author, and brought to a high state of mechanical perfection with the experienced aid of Messrs. Elliott Brothers, whose valuable assistance it is a pleasure to acknowledge. The general appearance of the instrument† is seen in Fig. 1, and a diagrammatic representation of its mechanism is given in Fig. 2. To make a measurement of the tractive effort necessary to overcome the resistance to motion the instrument is levelled on the floor of the car by means of the adjustable leg, and then, when the car is coasting, the indication of the needle gives the reading in "pounds per ton."

The general nature of the internal mechanism may be described as a lop-sided copper disc, mounted on a vertical axis and controlled in its rotation by a coiled spring. Any acceleration causes the heavier side of the disc to lag behind, and so partially wind up the spring. The degree to which the spring is wound up measures the acceleration. Any tendency of the disc to oscillate is checked by

* Abstract of a Paper read before Section G of the British Association.

† A brief description of the instrument appeared in THE ELECTRICIAN, November 19, 1909.

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a magnetic field at right angles to the plane of the disc. Besides these parts, there is what is called "the compensating balance," which causes the instrument to record absolutely correctly, even when travelling around railway curves, or when on a road heavily cambered to one side or the other. In Fig. 2 the copper disc is shown at D; it has a hole cut in it near the circumference, which has the effect of throwing the centre of gravity slightly out of the centre of figure. On the pivot of the disc is fastened a spur wheel which gears in with another equal spur wheel mounted on a parallel axis and carrying the pointer N. This pointer moves over the scale shown in Fig. 1. It will be seen that there is a small permanent magnet placed so as to "damp" the motions of the copper disc without having any of the "sticking" qualities which accompany frictional damping. The spring, which is coiled up by the rotation of the disc, is not shown, but it lies in the horizontal plane just above the disc. In later forms of the instrument the arrangement described above has been varied slightly, but not so as to affect in any way the general principle of working.

The forces acting at the centre of gravity of the disc are directly proportional to the impressed acceleration, but as the disc rotates through angles of 30 deg., 45 deg., 60 deg., &c., the "arm" gets less, and the couple twisting the spring does not rise so rapidly as the acceleration producing it. The scale has to be graduated in accordance with this fact, and the divisions close up when the angles get considerable. The law which governs this is that of the change of the ratio $\frac{\theta}{\cos\theta}$.

As to the mode of action of the compensating device, if, whilst the disc is deflected by an acceleration, a second acceleration (or slope) should be acting at right angles to the first, there will be an additional couple tending to wind (or unwind) the spring. The

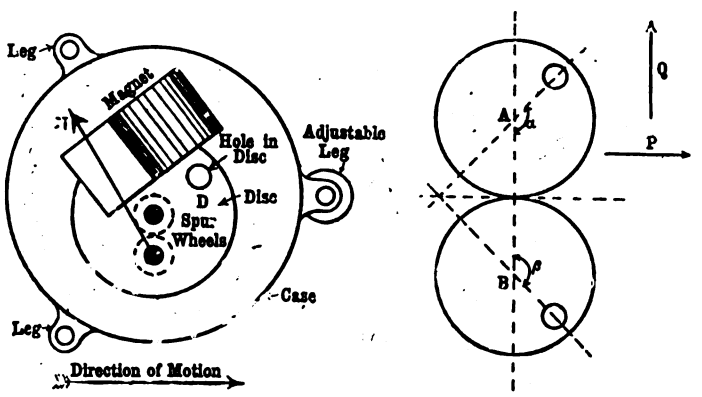

FIG. 2.

needle must then give false indications of the acceleration which it is desired to measure. This would be a very serious fault, since such transverse accelerations are very common in practice and often of considerable amount, sometimes as much as 10 ft. per second per second. (This type of error is noticeable in the pendulum forms of instrument, where the complicating vertical acceleration often far exceeds that of gravity itself.) To get over this difficulty the two gear wheels, already mentioned, were added, and it was so arranged that the moments of mass about the two respective axes should be equal. This equality of mass moments makes the system equivalent to two equal copper discs geared together at their circumferences, and each having their centres of gravity eccentric to the same extent. The effect of this is illustrated in the diagram to the right-hand side in Fig. 2. Inspection of this diagram will show that forces in the direction P will cause the two discs to roll together, whilst forces in the direction Q cause no rotation whatever. Forces perpendicular to the paper can, of course, produce no rotation of the disc, so that the instrument records the acceleration in one of the three directions of space only, and is not affected by whatever may be happening in the other two. Thus, the dial may even be tilted until it is vertical, so that the whole force of gravity acts across it without the readings being affected at all. The author believes that this is the first accelerometer instrument to read in one selected direction only.

It is evident that when the instrument is tilted in the direction of motion the needle will move through an angle corresponding to the angle of tilt, and this angle can be read from the (red) graduations on the dial. The instrument thus becomes a "gradometer," and it has the property that it can be used just at well for this purpose on a car which is climbing a slope as on one which is standing on the slope, always provided that the speed of the car is uniform. Although the instrument is thus sensitive to slopes, it is the fact that the "coasting resistance" readings do not need correction on account of the measurements having been made up or down hill. This appears at first sight surprising. The explanation is, however, that when coasting down a hill the slope tends to throw the needle forward, whilst the gravitational acceleration due to the slope throws it in the opposite direction, and by just an equivalent amount, so that the two effects neutralise one another; and were there no road resistance whatever the instrument would indicate zero. What, in practice, causes the needle to move away from the zero mark is the frictional resistances due to motion. The needle, therefore, shows the amount of this resistance, no matter whether the motion of the car is on a sloping road or not.

As a matter of practical convenience, it is best to make such measurements when on a slight downward slope of from 1 in 30 to 1 in 60, the reasons for this being that the speed then changes more slowly, so giving a longer time for taking the readings, and the complicating effect—so well known to railway engineers—of the change in the momentum stored in rotating parts is then insignificantly small. It may be mentioned that if the rotational momentum is c per cent. of the translational momentum, the true road resistance is c per cent. higher than that deduced from the negative acceleration induced by that resistance, and shown on the dial of the accelerometer, when running on a level road. When the road is not level the instrument reading shows the acceleration, or retardation, directly due either to the engine, to the brakes or to the road resistance (or a combination of them), and in all cases where these measurements are desired a knowledge of the slope is unnecessary (a proof of this is included in the Paper).

Whatever may be happening to the car the instrument records the net effect of engine effort, braking resistance and road resistance, and is not affected by hill slope. This fact it is that renders the instrument capable of reading the slope of any hill up which the car may be climbing at a steady speed, since the braking effect is then zero, and the reading is the difference between the effort of the engine and the road resistance. This amount must, however, be equal to the gravitational resistance overcome, or the speed would not be steady, and as the gravitational resistance is directly proportional to the steepness of the slope, it follows that the instrument reading is also proportional to that steepness.

Train and Road Resistance.—Many measurements with this instrument have now been made on roads and on railway lines; in the latter case a very fine spring is fitted, and readings can be made to ½ lb. per ton. In a recent case the author measured the train resistance at about 65 miles per hour as from 19 lb. to 21 lb. per ton, rising to 30 lb. on some curves and sinking to 10 lb. at about 10 miles per hour.

Table I. shows the results of a number of tests taken with the accelerometer on different kinds of road surface. Measurements of this kind are rare, since the dynamometer method of measurement is very clumsy, and is liable to inaccuracy if the slope of the road is incorrectly estimated. The present measurements are free from that type of error. Muddy roads, as might be expected, show higher resistance than dry ones, but the low resistance on granite setts would hardly have been anticipated, nor the great increase in resistance when travelling over sticky tar macadam roads with plain flat steel tyres. The author has not yet had opportunity to make measurements on pneumatic tyres which are comparable with any of these. So far as tests are available, however, they do not show any very great difference in the road resistance between these two types of tyre.

A series of tests taken on motor vehicles when running at different speeds on good hard main roads are also given in the Paper. Table II. herewith contains some of these figures.

The rise of resistance at higher speeds due largely to the growing importance of air resistance is very noticeable. To the author it was so unexpected that a waggon running at 15 miles per hour should be appreciably affected by air resistance that he at once attributed the rise to some other cause to be ascertained. Part of the rise is, no doubt, due to a term proportional to the speed and corresponding to the loss of energy through the bumpiness of even the best roads. The simplest formulæ to suit these curves are, however, of two terms only—a constant term and a term proportional to the velocity squared. Thus, for the motor waggon, if we call the resistance overcome at the clutch R in pounds per ton, we find that $R = 38 + 13\left(\frac{V}{10}\right)^2$, where V is speed in miles per hour. Also, for the touring car, $R = 47 + 11{\cdot}5\left(\frac{V}{10}\right)^2$. The author hopes to obtain values of these coefficients for various shapes of body, hood and screen.

Curves of brake horse-power based on the resistance at the clutch are given in the Paper. As the engine friction is well known to be independent of the load, provided the speed is constant, it is possible

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Table I.
Condition of wind on these various tests differed on each, but fairly still days were chosen.

Nature and condition of road.	Coasting resistance (declutched), lb. per ton.	Approx. speed, m.p.h.	Nature of motor vehicle.	Tyres.
Tar macadam, hard...	65	10	Motor waggon, total weight loaded 4·3 tons	Steel behind, solid rubber in front
Ditto, soft and cut-up	140	10		
Granite setts.....	50	10	Ditto	Ditto
Hard, dry main road	73	15	Heavy touring car total weight loaded 2·25 tons	Solid rubber
Half rolled road metal	150	15	Ditto	Ditto
Clean wood pavement with tram lines	70	10	Motor waggon, total weight loaded, 4·35 tons	Ditto
Tar macadam, dry and hard	70	10	Ditto	Ditto
Ditto, very muddy and sticky	95	10	Ditto	Ditto
Road metal, partly rolled	120	10	Ditto	Ditto
Ditto, unrolled.....	200	10	Ditto	Ditto

Table II.—*Coasting Resistance at Various Speeds on Heavy Touring Car fitted with Solid Rubber Tyres.*

Total weight loaded 2·25 tons. Car fitted with fixed canopy, glass screen (in use) and side curtains (end and last pair of side ones down). Engine speed at 20 m.p.h. = 970 revs. per min. Tests taken against a slight head wind. Roads good and hard.

Speed, m.p.h.	Coasting resistance in pounds per ton.		
	Ignition off.	Clutch out.	Neutral gear.
5	60	50	46
10	71	59	53
15	87	73	63
20	111	92	76
22	122	101	82
25	...	118	92
30	...	...	112

to calculate the indicated horse-power from the "ignition off" curves. The ratio of brake horse-power to indicated horse-power at any speed is, of course, the mechanical efficiency of the engine. The mechanical efficiency can also be obtained as the ratio of the height of the resistance curve when "declutched" to the height with "ignition off." It also follows that on any such test as those described a measurement of the amount of fuel used will enable a figure to be obtained for the mean thermal efficiency of the engine during the run. The figure in these tests came out at about 12 per cent., but it varies, of course, with the individual circumstances of the test; by keeping the speed nearly constant a good brake-efficiency test can be got under much more real conditions than on a test bench.

The horse-power is obtained from the road resistance and speedometer measurements from the following formula.

$$\text{H.P.} = \frac{\text{road resistance in lb. per ton} \times \text{car weight in tons} \times \text{m.p.h.}}{375}$$

After discussing engine friction and clutch resistance, the author sums up as follows:—

(1) By the use of the accelerometer the road resistance of different kinds of roads or tracks, under various weather conditions, can be measured and compared. (2) The amount of air resistance due to various forms of vehicle can be at once determined. (3) The mechanical and thermal efficiency of the engine at various speeds can be obtained under real working conditions. (4) The brake horse-power exerted by the engine when running at various speeds on the road can be easily obtained. (5) It is possible to trace step by step the losses of power in transmission. (6) It is possible to make a definite allowance for motor vehicles which are specified to show a given fuel economy (such as gross ton-miles per gallon of fuel), and which may have to run their tests on exceptionally heavy roads. (7) Lastly, the use of the accelerometer enables a useful interpretation to be given to speed and efficiency tests which are carried out on specially prepared motor tracks, having characteristics different from those of the ordinary highway, at unrestricted speeds.

PHOTO-ELECTRIC FATIGUE.*

BY H. STANLEY ALLEN, D.SC.

The observation of Hertz in 1887 that the electric spark passes more readily when the spark-gap is illuminated by ultra-violet light led to the discovery by Hallwachs of the photo-electric current. A negatively charged body often loses its charge rapidly when exposed to light, especially to ultra-violet light. The discharge is due to the emission of negative electrons from the illuminated surface. The photo-electric activity of a freshly polished metal surface diminishes with the time, falling off rapidly at first, more slowly later on. This is known as the "fatigue" of the Hallwachs effect. In the early literature of the subject the fatigue was attributed to the direct action of the light, but Hallwachs showed in 1904 that fatigue proceeds in complete darkness, so that light cannot be the primary cause of the change. This result has been questioned, but is now confirmed by the experiments of Bergwitz, Dember, Ullmann and Allen. Light can, however, set up secondary actions tending to accelerate or retard fatigue. Hallwachs has shown that at ordinary pressures fatigue is more rapid in a large vessel than in a small one. This also was called in question by Aigner, but is confirmed by Ullmann and by Allen. The fatigue is practically independent of the electrical condition of the plate. This was shown by v. Schweidler, and has received confirmation in the researches of Hallwachs, Sadzewicz and Allen.

Experiments in a vacuum have led to contradictory results. Lenard and Ladenburg found marked fatigue in certain cases, while for the alkali metals, first investigated by Elster and Geitel, several observers conclude that there is no true fatigue. Recent experiments by Millikan and Winchester show no fatigue with clean unpolished metal surfaces in a very high vacuum. To explain the fatigue found by other investigators we must take into account the mode of preparation of the surface (Ladenburg's plates were polished with emery and oil), the difficulty of removing air films from the surface, and the possibility of changes in the gas pressure.

Various theories have been advanced as to the nature of the change accompanying photo-electric fatigue: (1) A chemical change, such as oxidation of the surface; (2) a physical change of the metal itself, as, for example, a roughening of the surface; (3) an electrical change in the formation of an electrical double layer (Lenard); (4) a disintegration of the metal, due to the expulsion of electrons by light (Ramsay and Spencer); (5) a change in the surface film of gas or in the gas occluded in the metal (Hallwachs).

Hallwachs has shown from the photo-electric behaviour of copper and its oxides that oxidation cannot be the cause of fatigue, and the fact that fatigue is less in a small vessel may be interpreted by attributing it to some substance (*e.g.*, ozone, water vapour) present in small quantities in the surrounding atmosphere. The results recorded lead to the view that the main cause of fatigue is to be found in the condition of the gaseous layer at the surface of the plate.

The Electrical Operation of Goods Trains.—Our contemporary the "Elektrische Kraftbetriebe und Bahnen" mentions that a standard gauge light railway at Gummersbach has recently been electrified. The railway is intended principally for goods and carrying ore, but there will also be a few passenger trains. High-tension three-phase current at a pressure of 10,000 volts and a frequency of 50 will be obtained from the local electricity works and transformed by two 150 kw. motor-generators to continuous current at 750 volts for supply to the trolley wire. The railway is 10 miles long, the maximum distance from the transformer station being 5 miles. The goods consist for the most part of stone from the stone quarries which is only carried in one direction, so that only fairly empty waggons have to be drawn against the gradient. Owing to this circumstance the average consumption on the continuous-current side is only 160 watt-hours per ton-mile. The goods trains, which consist of six standard open waggons, are drawn by locomotives weighing 20 tons and fitted with two 60 H.P. motors, without causing any great variation of load at the transformer station. A comparison between the two systems of working—steam and electricity—shows that the latter is more efficient in every way. The passenger traffic is dealt with by means of motor cars and trailers. The total cost of conversion from steam to electric working was £100,000.

* Abstract of a Paper read before Section A of the British Association at Sheffield.

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(ONLY ADDRESS.)
Tel.: Holborn **6363** (Two Lines). *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

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"THE ELECTRICIAN" INDUSTRIAL SUPPLEMENT.

With "THE ELECTRICIAN" for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with "THE ELECTRICIAN." The fifty-third issue of the Supplement will be published (Gratis) with the number of "THE ELECTRICIAN" for Sept. 23.

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POWER FROM WIND AND SOLAR RADIATION.

One of the important subjects looming in the future is that of the production of power from the wind and solar radiation. For the moment it is not a problem pressing for immediate solution, but there is little doubt that when the exhaustion of the coal supply in this and other countries begins to be an actual fact the question of other sources of power will be taken up in real earnest. Apart from the question of tackling the problem sooner or later from sheer necessity, it seems highly unsuitable that we should burn coal and other combustibles for the production of power if this is obtainable commercially from natural sources which are running to waste. The amount of power that is running to waste in sunshine and in the energy of the wind is enormous, but there has always been a difficulty in utilising this power in such a way as to give a truly commercial result.

The problem was raised last week at the meeting of the British Association by Prof. R. A. FESSENDEN, who claimed that he had now solved the problem in a commercial way. Briefly, his plan is to use the energy of solar radiation in combination with wind power, so that when one fails the other is likely to be at hand. It is, of course, no new thing to attempt the raising of steam through the agency of sunlight. Hitherto, however, attempts so made have restricted themselves to the production of the usual high steam pressures, such as 100 lb. per square inch or more, for use in reciprocating steam engines. Such attempts have not led to commercial results, and appear to be doomed to failure. The exhaust steam turbine, however, among its many virtues, holds out the possibility of another solution of the

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problem before us. By taking advantage of this prime mover Prof. FESSENDEN makes use of steam at very much lower pressures: in fact, his suggestion is to raise steam merely at atmospheric pressure, and this at once gets over the difficulty of heating a boiler which has to withstand pressure. If the steam is used at the pressure of the atmosphere a thermal tank can be used with merely a covering of glass through which the solar radiation will pass and a large area of water will be exposed to its heating influence. The details proposed seem to be ingenious, but results are not given of actual working, so that it is difficult to judge of the practicability of such a scheme under actual working conditions. Unfortunately, there is no guarantee of continuous sunshine in any one day, at least in this country, and there is the further difficulty that more power may be required in the winter time when there is a minimum of sunshine than in the summer time when the sunshine is at its best. So far as this country is concerned, we must turn to the second proposition, viz., the utilisation of wind power. Here the difficulty is very largely one of storage. The most obvious system of storage is that by means of water, but the construction of reservoirs in elevated positions is generally a costly process, and therefore such schemes hitherto have not received serious consideration, though it will be remembered that a scheme of this kind was proposed in connection with the utilisation of the Victoria Falls. Prof. FESSENDEN proposes to get over this difficulty by placing his reservoirs underground instead of in an elevated position, the advantage being that the work of excavating a shaft to a depth of 1,000 ft. and making reservoirs at that depth is comparatively inexpensive.

Turning to the details given in the Paper we find it a little difficult to judge of the value of the scheme, as very few details are given, and the Paper seems to bear evidence of having been written in haste. There appears, for example, to be some confusion between horse-power and horse-power-hour, though we do not doubt that the distinction is perfectly clear to the author himself. A comparison is first made with storage by means of an electric accumulator. The statement is made that a lead battery costs approximately £10 per horse-power-hour. Considering that batteries for work of this kind—if the plant is capable of doing serious work—would have to be of considerable size, we think it will be admitted that this figure is unduly high. Even at a one-hour rating, including boosters and switchboard, the figure seems to be high, and when it is considered that a battery for this class of work would certainly not be used at the one-hour rate the figure is very much higher than need be taken. For this reason we think that £5 per horse-power-hour would be ample. We also notice that a charge of 10 per cent. on the first cost is to be made for depreciation, and a further charge is made for upkeep. This also is considerably higher than that at which battery companies are willing to maintain a battery subjected to ordinary station use. Then we notice that Prof. FESSENDEN provides storage for a fortnight. The amount of storage will, no doubt, depend very largely upon the locality, and we suppose that in some parts of the world it may be quite necessary to provide storage to this extent. In this country, however, a week would appear to be sufficient, though the allowance would, doubtless, have to be on the safe side. Even allowing storage for a fortnight the capital cost per horse-power-hour should be considerably less than the £140 taken by Prof. FESSENDEN. If we understand Prof. FESSENDEN aright, the annual charge of £26 which he mentions is for $\frac{1}{24}$ H.P. year, assuming a 24-hour day, and seems to us too high, though correspondingly low for 1 H.P. year, which is the usual unit.

With regard to the particulars of the cost given for the water-storage scheme, these are too scanty for a detailed criticism. We are inclined, however, to think that they are on the fine side, and they do not seem to be entirely accurate; for example, a cubic yard of water falling through 1,000 ft. does not give so much as 1 horse-power-hour, as assumed. The energy efficiency of a storage battery might be as low as 65 per cent. as assumed, though we should certainly expect to find it somewhat higher. Thus, Mr. J. S. HIGHFIELD mentions a case in which a station battery gave an efficiency of 74 per cent. over a period of 12 months. On the other hand, we are somewhat doubtful whether the efficiency, viz., 80 per cent., assumed for the water plant would be obtained when the necessary gearing and pipe work is taken into account. Final figures put the cost per horse-power-year at 18s. This, of course, is extremely low, and is compared with steam at £3 per horse-power-year, which is also extremely low, if not impracticable. Considering that the plant for utilising the energy of the water has to be practically duplicated in the form of a prime mover, pumps and pipe work, in order to bring the water to the required level for utilisation, it seems offhand extremely doubtful whether such a low figure could be obtained, even where the conditions are so favourable as to provide sea water at the foot of a cliff 1,000 ft. high.

We do not, however, wish to throw cold water upon such projects, and we are very glad to hear that Prof. FESSENDEN actually has a plant of 3,000 H.P. in hand, the site being a disused mine. Everyone will await the results with keen interest, though meanwhile we may perhaps be pardoned for being a little sceptical as to the results in the general case being quite so good as the figures that are suggested. Nevertheless, even if the results are not so good, there is no doubt that they will be important as a basis for further progress in a most fascinating subject.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Electrical Distributing Networks and Transmission Lines. By ALFRED HAY. (London: Cassell & Co.) Pp. xiii. + 234. 8s. 6d. net.

The subject is treated by this well-known writer from a technical and theoretical rather than a commercial standpoint. The arrangement of the subjects is excellent, and mistakes have been carefully guarded against. Every point dealt with has a boldly printed headline which permits of quick reference to the information desired. Each question dealt with by the author has his conclusions tersely put and printed in italics. It is a book more suited to the mains engineer and advanced student than to the beginner.

Glancing through the book, we notice that the use of "back E.M.F. cells" on short feeders is mentioned on p. 7. We

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fancy that few, if any, generating stations use cells for this purpose. On p. 8 the effect that increase of the supply pressure has on the cost of the distributing system is very clearly shown, but the statement made on p. 23, that most types of metal filament lamps must be run two in series if the supply pressure is 200 volts or more, is incorrect.

The spirality effect of a stranded conductor when carrying alternating currents mentioned on p. 39 is very interesting and will be new to most readers. A few pages further on the question of aluminium as an electrical conductor as compared with copper is discussed. This question has aroused great interest of late. The distribution of electrical stress in the insulation of a cable and the effect that the shape and size of a conductor have on this is ably demonstrated on pp. 47 to 49. Mervyn O'Gorman dealt with this subject very fully in a Paper before the Institution some time ago. One of the advantages of tinning the conductors of a rubber-insulated cable is shown to be that the pure rubber in contact with the core does not deteriorate through the absorption of oxygen. This point should be investigated with regard to aluminium, which is much more liable to be oxidised on its surface than copper.

As might be expected from this author, the chapters on the effect of capacity, inductance and power factor on the working of an alternating-current network are especially good. The chapter on voltage drop and current distribution is not so good from a practical standpoint, as an engineer might spend a great deal of time arranging for a certain voltage drop on all parts of a network only to find that the variation of loads at different periods of the day, the wholesale adoption of metal filament lamps, or the unexpected increase of the heating or power load upset all his calculations.

It is rather a pity that the author has passed over fault finding on cable networks so briefly, and the same remark also applies to the chapter on the methods of laying cables. The chapter dealing with electrical resonance and surges will prove of great interest to those who are employed in high-tension alternating-current stations. The author states very clearly the precautions that should be taken in order to prevent the abnormal rises in pressure that occasionally occur on networks. He deals a little further on with the protection of high-voltage networks by means of maximum current and reverse-power relays, and shows how, unless these are arranged properly, sound feeders may be disconnected and rotary convertors, that are free from faults, cut out of circuit. The author concludes by describing the Merz-Price system of protecting high tension networks.

Of late years there has been such a universal scrapping of private electrical plants and changing over from steam and gas to electrical driving of machinery, that electrical distribution, especially high-tension, has become of great importance, and we therefore welcome the present volume.

W. A. TOPPIN.

Wireless Telegraphy and High Frequency Electricity. By H. L. V. TWINING. With a chapter on "Wireless Telephony," by WM. DUBILIER. (California: the Author.) Pp. 202.

This is a book for amateurs, written by an amateur. It is intended to appeal to all those whose hobby lies in the study of any application of high-frequency electricity. The part of the book dealing with wireless telegraphy is thoroughly practical, and consists mainly of a description, rather long-drawn-out, of the making of the author's own apparatus by himself and his boy pupils. Pretty well every detail is treated, but the author's circuits are a little old-fashioned—for example, the receiving circuits have conductive coupling, and inductances are varied by sliding contacts. The "high-frequency" part of the book introduces the reader to the abstract theory of electrical oscillations and waves: "Electricity is a form of energy . . . some form of moving matter," we learn in the first paragraph. Corpuscles, atoms and ether are discussed in a manner that the over-educated reader will quite fail to appreciate. The American atmosphere of the book is very pleasing, and the spelling of "Poulson," "Flemming," "impedence," &c., is very original.

W. H. E.

Direct and Alternating Current Testing. By F. BEDELL, assisted by C. A. PIERCE. (London: Constable & Co.) Pp. x+256. 8s. net.

Few books have been more needed than a comprehensive, and at the same time compendious volume, dealing with the practical testing of electrical machinery on sound scientific lines, and the present volume goes a long way towards satisfying this want. The only point of general criticism is perhaps that it has been written too much from the college laboratory standpoint, and that an attempt has been made to combine theoretical instruction and experiments of educational value with the testing of machines, which has resulted in an insufficient treatment from both sides. But a certain amount of overlap in dealing with these subjects is inevitable, and in a great many cases the practical methods of test can only be understood with direct reference to the assumptions made as to the theory of the machine. One cannot help feeling, however, that a certain amount of the descriptions of the winding and behaviour of machines, which are already to be found in plenty, might have been dispensed with in favour of a short account of the principal instruments and devices used in testing, with some indication of their errors and of the types to be chosen for various purposes.

The book is divided into seven chapters, each containing a certain number of experiments with explanations, notes and references. In the first two, direct-current generators and motors are dealt with, and it is here especially that one would prefer to see the theory curtailed, and a more detailed account of apparatus and methods. For example, on p. 8 the armature resistance of a generator is directed to be taken by fall of potential with the armature stationary, without any hint that with modern machines the resistance so taken may be two or three times that under working conditions, which is, of course, most serious in connection with the losses. On p. 43 there is a slight allusion to the matter when it is stated that no account will be taken of a *possible* difference between the contact resistance under test and working conditions. The direct efficiency test, the Kapp-Housman method of indirect testing, and the Kapp-Hopkinson combined test are all briefly described, but one would have liked to see some practical descriptions of brake tests, of the short-circuit and acceleration methods, and of the analysis of the results of the Hopkinson test.

The remainder of the volume deals with alternating-current testing, and is very interesting. Chapter III. is devoted to alternator characteristics and their predetermination, and the author's clear indication of the distinction between total and leakage inductance, and between armature reaction and leakage reactance, which are so necessary for the appreciation of methods of predetermination. It is satisfactory also to see that the authors, in common with Behrend, avoid wasting time over attempting the accurate prediction of regulation at other than zero power factor, which must remain impracticable in all cases where salient highly saturated poles are employed. Chapter IV. describes some general experiments on series and parallel circuits with alternate currents, preparatory to the testing of other machines; and the experimental determination of the circle diagram for a single resistance reactance combination, which forms an admirable introduction to the various circle diagrams in machines. The following chapter is devoted to transformers, and here again the student must be greatly helped by the process of reducing the even ratio transformer to three or two choking coils, which immediately shows the basis of the no-load and short-circuit tests. In the last two chapters the study of polyphase connections and power measurement, and of polyphase transformers and regulators is dealt with. Induction and commutator motors are not referred to, but the author promises to do this in a later edition.

We have no doubt that the book will be greatly appreciated by many teachers and engineers, and hope that it will soon reach its second edition, and that the authors may find themselves able to give it either a more definitely educational or a more definitely practical aspect.

C. V. DRYSDALE.

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THE COMMERCIAL SOLUTION OF THE PROBLEM OF UTILISING, FOR THE PRODUCTION OF POWER, THE ENERGY OF SOLAR RADIATION, THE WIND AND OTHER INTERMITTENT NATURAL SOURCES.*

BY R. A. FESSENDEN.

The problem of the commercial utilisation, for the production of power, of the energy of solar radiation, the wind and other intermittent natural sources is a double one. The energy of the sources must first be changed so as to be available in form; it must next be stored so as to be available in time.

Both these problems were solved by me in 1899, but owing to pressure of other work it is only within the past year that the commercially operative plant has been put under construction. The time has, however, not been entirely wasted, as a considerable number of experiments have been made and data obtained which have demonstrated conclusively that the method is a commercial one and applicable on a large scale and under a great variety of conditions.

Details of the operation of the plant above referred to will be furnished in a later Paper, but the results so far obtained justify me, I believe, in publishing a description of the method and of some of the data. It will be noted that the methods employed are extremely simple, and but for the fact that the construction involved is exactly the opposite to that which would naturally suggest itself, they would probably have suggested themselves to others. While the figures given may be subject to some slight modification, they are believed to be substantially correct.

The method of storage will be described first. A storage battery cannot be used. A lead oxide storage battery costs approximately £10 per horse-power hour. Measurements made during the past 10 years show that it is necessary to provide storage capacity for at least two weeks, except under abnormally favourable conditions. The capital cost per horse-power for a storage battery would, therefore, be £140. Taking the interest at 4 per cent., depreciation at 10 per cent. and the upkeep and labour at 5 per cent., the annual cost of storing power with a storage battery would be approximately £26 per horse-power. Doubtless some storage battery companies will claim that these figures are too high, but they are believed to be substantially correct. As, however, 1 H.P. can be produced by a steam plant for not more than £10 per annum it is evident that storage by storage batteries is entirely uncommercial for this purpose.

The method employed is storage by gravity. Two reservoirs are constructed, one at a considerable height above the other, and the water is first pumped up and then allowed to flow down as desired and to actuate a turbine. A cubic yard of water falling through 1,000 ft. is capable of giving out energy equivalent to 1 H.P.-hour.

This is a method of storing power which doubtless occurred to many. There were, however, two practical difficulties in the way. First, if the fall be small, say, 10 ft., the quantity of water used must be very large and the reservoirs must be very expensive. Also the turbines are less efficient. On the other hand, to construct a tower 1,000 ft. high capable of supporting a reservoir of any size would require such a large initial capital outlay and such a large interest and depreciation as to render it impracticable.

For many years these figures appeared to me to act as a bar to the use of gravitation for storage, and I was working along other lines, when one day the idea suggested itself to me of using a negative instead of a positive gravitational potential. That is to say, that the second reservoir should be constructed under ground instead of above ground. The upper reservoir would then lie on a surface of the earth. A shaft would be excavated 1,000 ft. deep, and at the bottom of this shaft, chambers hollowed out and ferro-concreted for the machinery and for the lower reservoir.

Some figures to the effect that the cost of excavating a cubic yard of quartz and bringing it to the surface did not exceed 2s. per cubic yard suggested that the idea was worth looking into. Estimates were obtained from three different firms of mining engineers in Philadelphia which showed that a shaft 1,000 ft. deep could be dug, properly timbered, and the necessary chambers hollowed out at the bottom and ferro-concreted so as to withstand the water-pressure, at a cost not to exceed 8s. per cubic yard, and tenders were made at that price for a 5,000 H.P. plant. Assuming as before, two weeks' storage and an efficiency of 75 per cent., the capital cost per horse-power-hour will be £7. 10s., as against £140 for the storage battery. Assuming interest at 4 per cent. and depreciation at 2 per cent., which latter is a fair value for ferro-concrete work of this character, the total annual cost of the water storage will be approximately 9s., as against £26 in the case of the storage batteries.

As regards efficiency, the water storage has an advantage over the storage battery. The energy efficiency of a storage battery is generally given as 65 per cent.—*i.e.*, approximately 80 per cent. on charge and 80 per cent. on discharge—the current efficiencies on charge and discharge being slightly over 90 per cent.

With the water storage the efficiency of the pumps raising the water may be very high. Figures given in the "Engineer," March 26, 1909, show that pumps lifting 200 ft. may have an efficiency of 97·6 per cent. The efficiency of a water wheel of the Pelton type working at a pressure equivalent to 1,000 ft. is quite high, and such turbines are guaranteed with efficiencies of 91 per cent. This would give an energy efficiency for charge and discharge of 89 per cent., so that the efficiency which I have taken of 80 per cent. is probably conservative. It is probable that as the system comes into extensive use the efficiencies of the turbines will be increased.

Tenders for the pumps and Pelton wheels for a 3,000 H.P. plant show that the cost of this is approximately £2. 10s. per horse-power. Allowing 4 per cent. interest and 4 per cent. depreciation, this makes a total annual cost for pumps and turbines of 4s. per horse-power. The total annual cost of storing 1 H.P. per annum by the negative gravitational method is, therefore, 4s. + 9s. = 13s., as against £26 for storage by storage battery. It will be noted that this figure of 13s. is a conservative one, and might be much higher without rendering the method commercially impracticable.

To consider next the method of obtaining the energy from the sources. There are two main sources available, the solar radiation and the wind. Tidal energy may be neglected as, except in abnormal cases such as that of the Bay of Fundy, the rise is too small to permit of commercial utilisation. There is, however, no reason why, with this method of storage, the tides of the Bay of Fundy should not be utilised, or why some future Commission should not lay out a system of power generation and distribution which shall do for the provinces on the Bay of Fundy what the system laid out by the Ontario Power Commission, of which I had the honour to be the engineering member, has done for the Province of Ontario.

The solar constant is the number of gramme-calories of radiation which would be received from the sun on 1 sq. cm. of area at the earth's surface per minute, the area lying in a plane at right angles to the line joining the earth and sun, if there were no atmospheric absorption. (This is an inconvenient unit, and I have proposed as an alternative unit the number of ergs per second received on the horizontal surface of 1 sq. cm. The usual unit is, however, used here.) This value of the solar constant is equivalent to about 150 ft.-lb. per square foot per second. On an area 100 metres square the total power received will be approximately 20,000 kw.

This figure, however, is to be reduced for four different reasons. First, because the Langley value of the solar constant is probably too high; it would appear that 2 calories is more nearly correct. Secondly, because on account of the atmospheric absorption the number of gramme-calories actually available at the surface of the earth is less than the solar constant. Thirdly, because the actual absorbing area seldom or never faces directly to the sun, on account of its latitude and the rotation of the earth. Fourthly, on account of clouds.

The only safe way, therefore, is to take an actual location and measure the actual amount of radiation received during the entire time for a number of years.

Unfortunately until recently no reliable automatic recording apparatus was available. I have, however, recently obtained a number of such recorders from the Cambridge Scientific Instrument Co., and these are being set up at different points, and will undoubtedly give very valuable information.

Meantime, in order to obtain the necessary data, a former assistant of mine, Prof. Very, whose work in connection with Prof. Langley and whose own researches are well known to all physicists, was kind enough some years ago to investigate the matter for me. As the result of his investigations he found that for Central Europe, averaging a number of entire years, the number of gramme-calories per annum received on a surface of 1 sq. cm. varied between 37,000 and 54,000, the variation being due to the variation in the amount of annual cloudiness. For the Northern United States he found the values to vary between 42,000 and 65,000. For the arid South-western States he found a value of approximately 100,000. Reducing this to kilowatt-hours, we obtain the following values for the amount of solar energy received on an area 100 metres square per annum at the earth's surface:—

Central Europe	4,000,000 to 6,000,000	kw.-hours
Northern U.S.	5,000,000 to 7,500,000	,,
South-western U.S.	10,000,000 to 15,000,000	,,

i.e., the average is only from 4 to 10 per cent. of the maximum radiation.

As regards the amount of power to be derived from the wind, I have a steel tower at Brant Rock, Mass., 420 ft. high, erected in 1905.

* Paper read before Section G of the British Association at Sheffield.

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My tests show that a windmill 300 ft. in diameter is capable of delivering on an average during the entire year 800 H.P. on the shaft. By a windmill 300 ft. in diameter I mean either a single wheel or, what would probably be more efficient and cheaper, a number of smaller windmills mounted in a steel frame and revolvable on a circular track so as always to face the wind. These figures are approximately 30 per cent. higher than those obtained by the Danish experimenters, but I attribute this to the fact that the amount of power available increases quite rapidly with the height, and the Danish experiments were made at levels nearer the surface of the ground.

The method of utilising the power of the wind is very simple. A number of steel rope drives run from each of the small windmills mounted in the frame to the main shaft which has its bearings fastened to the frame so that when the frame is turned round to face the wind the main shaft moves with it. The main shaft drives the pump, the pump rod being revolvable as the axis is shifted in position. The Pelton wheel drives the dynamo. The Pelton wheel may also be driven directly by a rope drive from the main shaft of the windmill, the Pelton wheel being disconnected, or left connected.

To utilise solar radiation, a solar tank is used containing water which is heated until the steam reaches approximately the pressure of the atmosphere. The steam so generated at atmospheric pressure drives a low-pressure steam turbine or a special type of engine, which will be described in another Paper. The turbine operates the pump. From Provost's law it should be possible by solar radiation to raise the temperature of the water to 473 deg. absolute, though I am not aware that this temperature has ever actually been reached.

To attempt this would, however, be impracticable for a number of reasons, and the working would be irregular. In addition the pressure of the steam would be such as to necessitate a strong containing chamber for the working fluid. As the result of experiments it was found best to sacrifice a certain amount of thermo-dynamic efficiency for practical reasons. A working temperature of 100° C. was chosen, because with the steam at atmospheric pressure the transparent top of the chamber containing the working fluid could be made very thin and would not have to withstand any pressure. The pressure of the steam is automatically kept very slightly above atmospheric pressure in order to prevent any air leaking into the condenser. The transparent roof is of double thickness, and contains wire netting embedded in the glass as a protection against hail. The supports for the glass are made of wood and no special attempt is made to render them tight. The working fluid flows in a thin stream across the bottom of the solar tank, and the thickness of the stream is varied automatically with the amount of radiation received.

The working fluid contains a small amount of bichromate of potash. The glass forming the transparent covering contains a small amount of sulphate of iron, sufficient to give it a pronounced greenish tinge. It has been found that by this means the glass can be made metallicly reflecting for wave-lengths corresponding approximately to those emitted by the heated water, while remaining fairly transparent to the radiation from the sun. The solar tank is made to have as little specific heat as possible, and, what is more important, to be protected from convection and conduction losses. The thermodynamic efficiency of the system is approximately 15 per cent., and it is anticipated that approximately 10 per cent. will be obtainable on the shaft of the steam turbine.

From tenders made the costs per horse-power have been found to be approximately as follows:—

Solar tank	£2
Low-pressure steam turbine and condenser	5
Dynamo	3

Adding to this the cost of the pumps and Pelton wheel, we obtain a total of £12. 10s. for the first cost per horse-power for the machinery exclusive of the reservoirs. Allowing interest at 4 per cent. and depreciation at 4 per cent. and 2 per cent. for labour, we obtain a value of £1. 5s. per annum per horse-power-hour as the cost, exclusive of the reservoirs. Adding the cost per horse-power of the reservoirs we obtain a total of £20 for first cost and £1. 14s. as the annual cost per horse-power.

It will be seen that these figures compare quite favourably with the present cost of producing power from coal. Moreover, these figures are too high, for the reason that it is proposed to operate a windmill plant in conjunction with each solar radiation plant. The load will be greatly evened up, and a much better all-day and all-year efficiency obtained, because the wind is, as a rule, most effective during cloudy weather and at night time—*i.e.*, at the time when the solar radiation plant will nor be operating. Not only will the storage plant with its accessories be smaller for a given output of power, but in addition the steam pumps and turbines and storage reservoirs employed for the solar radiation method will be available without additional cost for the wind method.

Assuming a solar tank covering an area of 200 metres square we may expect to receive a total radiation of approximately 20,000,000 (20 million) kw.-hours per annum. Assuming an efficiency of 10 per cent. we should get 2,000,000 kw.-hours on the steam turbine shaft. Assuming a seven-hour day, we would get an average of 800 H.P. of power from the solar radiation plant. Adding to this the energy derivable from the windmill we obtain a total of approximately 1,500 H.P. The total cost of generating and storing this power will be in the neighbourhood of £1. 10s. per annum.

It is hoped that an opportunity will be afforded at a later date of giving the exact figures obtained in practice from the 3,000 H.P. plant. In the meantime, however, it is believed that the present communication will be of interest as showing that for many classes of work the problem of obtaining power from intermittent natural sources has been solved.

The figures given above are for average conditions. The location of the first plant is, however, much more favourable. It is situated at a copper mine, where the vertical shaft is already available and where worked out lateral chambers are available for the lower reservoir, and a portion of the pumping machinery is also available.

In addition the average solar radiation has rather more than twice the value taken above. Also the cost of producing the power from steam is considerably higher than the average on account of the difficulties of transportation and the high price of coal.

The following is a comparison between the cost of producing 1 H.P. for a year by steam, gas engine, water-power at Niagara Falls and by the present method. The estimates are based on a plant having a capacity of 100,000 H.P., and operating under average conditions.

The estimates for the costs of steam and gas-engine power have been prepared from data gathered in connection with the preparation of the plants for a number of power propositions during the past 20 years. The data for the cost of producing power at Niagara Falls was obtained in connection with my work as Technical Commissioner for the Ontario Power Commission. The data for the cost of obtaining power from intermittent natural sources was obtained by substituting for the values of the machinery necessary for the 3,000 H.P. plant above referred to the values which these items would have in the case of 100,000 H.P plant.

Method of generating power.	Cost per H.P. per year.
Steam	£3 0 0
Gas engine	2 0 0
Water-power at Niagara Falls	0 15 0
From intermittent natural sources	0 18 0
Water-power, exceptionally favourable conditions	0 10 0

It will be seen that while this method of producing power is much cheaper than those of steam or gas engine, it is approximately the same as that of water power under fairly favourable conditions, such as at Niagara Falls. This is because in the present method and with water power the capital first cost is the determining factor. The capital first cost per horse-power by the present method using a solar tank alone is approximately £12. 10s., and using windmills in conjunction with the solar tank approximately £9. The capital first cost at Niagara Falls is approximately £8.

The present method gains chiefly from the higher fall and from the cheaper and more efficient water motor, also from the fact that only one-seventh as much water has to be handled, and there are no dams to build or large buildings to erect. It loses from the fact that a pump has to be supplied, also a steam turbine and solar tank or windmill. The method, therefore, will not be of so much value in places favourably situated for obtaining water power. Localities so favoured are, however, comparatively few in number.

In addition, under exceptionally favourable conditions, such as when used in conjunction with mines, the cost of the present method may be considerably less than 18s.

For example, England is not well situated for the use of the solar radiation method. But the average wind value is fairly high, and the coast is lined with high cliffs. A rough estimate shows that by excavating reservoirs on the top of the cliffs, mounting windmills there, pumping the water up from the sea to the upper reservoirs and letting it run back through turbines and dynamos placed on the beach, that the cost would be considerably lower than that given above. Also that by this means more than sufficient power can be generated to supply all the factories, lighting plants and railroads in Great Britain. There will be no difficulty about distributing the power, as where the amount of power is sufficiently large, voltages of 500,000 can be used efficiently, safely and cheaply.

The method is, of course, not applicable for water transportation.

A thorough investigation into the possibilities of storage made a number of years ago showed that no electric-chemical method of storing energy could possibly compare as regards weight and first cost with the use of a hydro-carbon such as alcohol in a gas engine. Investigations as to the cost of producing alcohol from bananas and

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other tropical fruits show that with the manufacture conducted on a sufficiently large scale, alcohol can compete very favourably with petroleum and petrol at their present prices.

It is not without the bounds of possibility that this industry may be developed into an exceedingly profitable one, and that the West Indian islands may regain the position which they occupied at the time when they were the chief producers of sugar.

MAGNETIC HYSTERESIS IN A ROTATING FIELD.*

BY M. G. LLOYD.

Many investigators have studied the phenomenon of hysteresis, using magnetising fields which could be increased or decreased by steps, or else using fields which rapidly reverse in direction, as produced by an alternating current. The most notable results are those of Ewing and of Steinmetz. The latter established the approximate relation $W = nZVB^{1.6}$, where V is the volume, B is the maximum flux density and W the power transformed when the frequency is n cycles per second. Z is a constant depending upon the material used. This formula holds fairly well for iron and steel through the range of flux density used mostly in industrial applications, but it does not hold for very high or low flux densities, and the exponent is seldom exactly 1·6 even in moderate fields, but varies for different specimens.

If instead of using a field which simply alternates in direction we subject the magnetic specimen to a rotating field, such as may be produced by polyphase currents, there is again a lag of magnetisation behind the magnetising field, but the lag is a lag in direction, not in magnitude. This rotary hysteresis requires an expenditure of

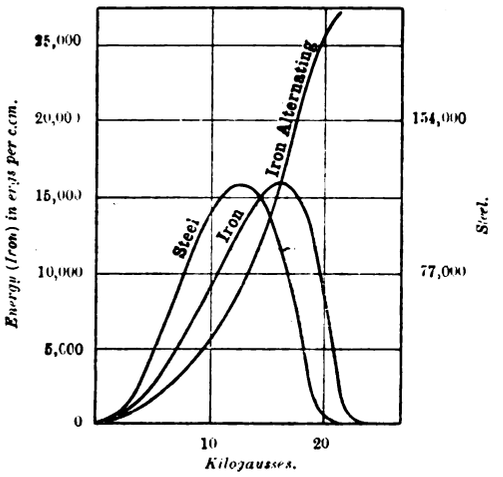

FIG. 1.—ROTARY HYSTERESIS FOR IRON AND STEEL.

energy, as in the other case, but the amount of energy transformed is not the same. Eddy currents are produced in both cases, and aid the transformation of energy into heat; but the two sources of energy loss can be distinguished by taking observations at two different frequencies.

The hysteresis in a rotating field was first observed by Baily, who showed, in 1894, by rotating a magnet about an iron armature and measuring the torque, that the hysteresis increased with the flux density in moderate fields, but finally reached a maximum and decreased to zero when the field was made sufficiently intense. This result was obtained with both soft iron and hard steel, and was a confirmation of Ewing's theory. Beattie made similar experiments upon nickel and cobalt, with similar results. In nickel, a maximum hysteresis loss of nealy 10,000 ergs per cubic centimetre per cycle was observed with a magnetising field of 340 gausses. In cobalt a maximum of about 36,000 ergs per cubic centimetre per cycle was observed, and in both cases the plotted curves indicated that the hysteresis would reach zero if the flux were carried to the saturation value. Beattie and Clinker found that for iron the hysteresis reached a maximum for a flux density of 16,000 gausses, and then decreased, reaching zero at about 25,000 gausses. Schenkel experimented by rotating the specimen in a steady field, and measured the torque by a form of transmission dynamometer. His results were similar to the above. Grau and Hiecke found a maximum hysteresis in iron at a flux density of 13,600 gausses.

In 1908 Weiss and Planer conducted some experiments with a rotating magnet which were somewhat more refined than the previous work. The specimens were in the form of discs, and when placed horizontally were subjected to a rotating field, but when placed vertically the effect was the same as an alternating field. Observations were made upon steel, iron, nickel and pyrrhotite. They found, like previous observers, that for low fields the hysteresis was greater in the rotary field than in the alternating, but after passing a maximum the hysteresis in the rotating field finally decreased to zero, as the material reached saturation. Fig. 1 shows some of their results. The ratio of rotary to alternating hysteresis was found to be largest for the weakest fields, and had a value of 3·6 for nickel.

During the past year two researches have appeared showing the variation of rotary hysteresis with temperature. Fuller and Grace used two-phase alternating current to produce the rotary field, while Perrier used apparatus similar to that of Weiss and Planer. Both used electric heating coils to obtain the higher temperatures. Both sets of experiments show that the maximum hysteresis in the rotary field decreases with increasing temperature, and that this maximum is reached with a lower flux density. Thus for iron at 580 deg. this maximum occurs at 10,500 gausses, while at temperatures below 340 deg. it occurs at about 16,000 gausses. Since the saturation value is also reduced by increasing the temperature, it was to be expected that the hysteresis would decrease to zero for a lower magnetisation, and this was found to be the case.

Perrier worked with nickel, magnetite and three kinds of iron, and concluded that the ratio of the maximum values of the two kinds of hysteresis was characteristic of the material and independent of the temperature.

In some recent experiments Herrmann has adopted a different method of measuring the energy and gets results entirely different

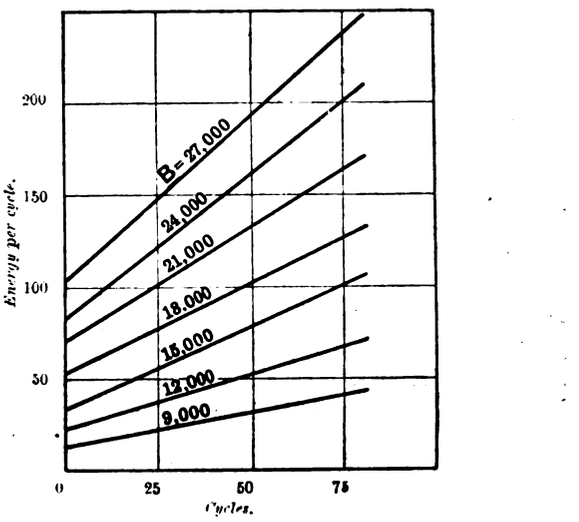

FIG. 2.—ENERGY PER CYCLE.

from previous observers. By means of a thermo-couple he observes the rise of temperature in the specimen in a given time, usually 15 minutes, and takes this as a measure of the energy expended due to hysteresis and eddy currents. He does not claim high quantitative accuracy for this method, but insists that it would indicate a maximum and a later lowering of the curve if such existed. No maximum, however, is evident in his curves. In Fig. 2 the energy per cycle is taken as ordinate, and the separation of hysteresis and eddy current losses thereby effected. The intersection of each curve with the vertical axis gives the hysteresis for that particular flux density, and these intercepts are seen to increase with the flux density up to 27,000 gausses, the highest value employed. He concludes that the hysteresis in a rotary field is therefore no different from the hysteresis in an alternating field.

* Abstract of an article in the "Electrical Review and Western Electrician."

CORRESPONDENCE.

THE PRICE OF ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am very glad to read in your present issue that you welcome my Paper on the above subject.

I entirely agree with Mr. Pearce that the interpretation of right principle in the form of practical tariffs is a process hedged about with many difficulties. To have got rid of error in our conception of principles is, perhaps, to have won less than half the battle, but it is a step, and not only a step, but a necessary step. I do not propose now to travel beyond

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it, because I fear that doing so would almost certainly obscure this essential preliminary, and also because there are so many who are much better equipped than I can be for dealing with that part of the problem.

I am writing this letter in order to question the wisdom of regarding electricity supply as a "by-product" supply in regard to any of its uses. I am sorry that my Paper evidently conveys the impression that I so regard it, but my use of various "by-product" examples was intended to expose the fact that "demand" could be a very potent factor of price, so great indeed, as entirely to swamp the "cost" factor. It is true that I point out, incidentally, that electricity supply has something in common with such jointly-produced commodities. A restricted-hour demand is, in a sense, a demand for a by-product, but my Paper does not deal, excepting incidentally, with that aspect of electricity supply. On page 7 of the Paper I expressly limit the application of the conception of "joint" production to variations in demand "in respect to time" in the case of electricity supply. I desire to see engineers anxious and ready to seize an opportunity, the circumstances of nature has placed in their hands, viz., that of utilising the fact that electricity is in demand for different purposes as the means adapting or adjusting supply to the varying intensity of demand as expressed by the varying market prices of the different uses of electricity.

My diagram, No. 2, exhibits, I think, the beneficent effect of that process to all concerned. I accept your distinction between the production of beef and hides, and of electricity, and I should like to emphasise it. I think that it will be safer to clear the mind of the conception that the dividing up of electricity supply into different classes of supply, some of which may be considered as by-produced relatively to others, is equivalent to the production of gas and coke or of beef and hides. It is better, I think, to confine that conception to such divisions as are represented by a "restricted-hour" demand, &c., and to picture the dividing up of supply into different classes, according to the different uses of electricity, as simply a means of gaining the advantage of adaptation of supply to demand, through the operation of corresponding "classified" tariffs.—I am, &c.,

EDW. W. COWAN.

4, Queen Victoria-street, Sept. 12.

ON METALLIC RADIUM.*

BY MME. P. CURIE AND A. DEBIERNE.

In order to obtain metallic radium we employed the methods described by M. Guntz for the preparation of barium. Some preliminary experiments were, in fact, made on barium with a very small quantity of matter (about 0·1 gramme), thus rendering the operations very delicate. These experiments enabled us to determine the method which should be used in the preparation of radium.

The principle of the method consisted in preparing an amalgam and in expelling the mercury by distillation under favourable conditions. The amalgam was obtained by the electrolysis of a perfectly pure solution of radium chloride, with an atomic weight of 226·5, a mercury cathode and platinum-iridium anode being used. The amount of salt employed was 0·0085 gramme. This amalgam decomposes in water and alters very quickly in air. It was quite liquid; while under the same conditions we obtained an amalgam of barium containing numerous crystals. The dry amalgam was quickly placed in an iron boat, which had been previously reduced in pure hydrogen. This boat was placed in a quartz tube, and a vacuum created inside the apparatus.

The distillation of the mercury was a very delicate operation. It should be carried out without ebullition being allowed to occur even momentarily. The distillation was finally made in pure hydrogen, the pressure of the gas being always higher than the pressure of the saturated mercury vapour at the temperature of the boat. This temperature was determined by means of a thermo-electric couple whose junction was fixed in the metal of the boat.

Owing to the small quantity of matter on which we worked, we particularly required pure hydrogen for the operation. We noticed that hydrogen which had been purified or dried by the ordinary means might still alter the amalgam. In order to obtain further purification, therefore, the hydrogen was admitted into the apparatus through a platinum tube, which was heated to a high temperature in the electric furnace. This method of purification seemed to leave nothing to be desired.

The greater part of the mercury had been distilled at 270 deg., the temperature being increased proportionately with the pressure of the gas in the apparatus. In order to be able to observe the contents of the boat during the operation, gas heating was employed. At a temperature of 400 deg. the amalgam was solid, but melted as the temperature increased, the mercury being driven off. The melting point could be determined very accurately, as it increased progressively until it reached 700 deg. At this temperature it was no longer possible to see the distillation of the mercury, no condensation being produced on the cold surface. On the contrary, the metal began to volatilise in great abundance, and the vapour energetically attacked the quartz tube, so that the operation was then stopped. This metal seemed to be fairly pure radium. It adhered closely to iron and could not be easily detached.

The metal radium alters very rapidly in air, it blackens immediately, probably owing to the formation of a nitrate. Some particles of the metal were detached, and falling on paper caused a blackening like burning. When brought into contact with water the metal decomposed with violence, most of it dissolving, thus indicating that its oxide is soluble. There remained a blackish residue, which was almost wholly dissolved by hydrochloric acid. This residue might be a nitrate, resulting from the exposure to the air. As dissolution in the dilute acid was almost complete, mercury could not have been present in any appreciable quantity.

The boat with the metal in it was closed up in a tube, which was evacuated in order that the penetration of the radiation might be measured. Its properties seemed to be such as would be supposed.

Radio-active equilibrium has not yet been reached, but the first measurements show that the increase in activity follows closely the law of production of emanation, and the radio-active limit of the metal should be practically normal.

Metallic radium being much more volatile than barium, it is proposed to purify it by sublimation on to a plate of cooled metal in vacuo.

* Translated from the "Comptes Rendus."

ELECTRIC POWER IN AN OIL MINE.

On Saturday, 10th inst., the annual excursion of the Mining Institute of Scotland took place to Broxburn where the members were the guests of the Broxburn Oil Co. During the day a visit was paid to the New Dunnet mine, in which an electrical installation has just been completed. This interesting installation was described in a Paper read by Mr. W. Clark, of the Broxburn Oil Co., who mentioned that the mines, which are situated about a quarter of a mile north-east of Broxburn village, are only 160 yds. distant from the shale breakers and retorts. The motive power chiefly employed is electricity, obtained from a power station placed alongside the works boilers and within a few yards of the retorts in which all the exhaust steam from the engines is utilised. The steam, instead of being supplied direct to the retorts, first passes through the engines, thus saving fuel.

The generating plant at present consists of a Belliss & Morcom engine, working at a boiler pressure of 90 lb. per square inch, with 1 lb. back pressure, for forcing the exhaust steam into the retorts for the production of ammonia water. The engine is coupled to a Siemens three-phase alternator, which furnishes current at 525 volts and 50 cycles, giving 470 k.v.a. at 300 revs. per min. There is a direct-current exciter on the engine shaft of a capacity of 245 amperes at 110 volts. This exciter gives more current than is required for the machines, and the surplus is used to supply the various lamps in the works during the day. The power station building is constructed to hold two more 575 H.P. generating sets.

The alternating current is delivered to a remote-control switchboard. All the panels are fitted with oil switches, and the high-tension connections are in white brick cells. Current is distributed to the various points by paper-insulated armoured cables. One panel of the switchboard supplies current to a 185 H.P. Siemens-Sulzer pump, a 50 H.P. motor-generator for electric drills, a 150 H.P. double drum haulage, a 25 H.P. dook pump and a 7 H.P. hutch creeper. The Dunnet mine endless rope haulage gear is driven through belts by two motors, each of 110 H.P. and controlled by oil switches, each with a maximum cut-out time relay and no-volt release. This no-volt release is so arranged as to stop the motors automatically in case of runaway hutches, and by push buttons from various convenient points in the mine. The breaker panel supplies a 110 H.P. motor for driving the shale breakers, a 50 H.P.

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endless rope haulage motor for filling a 2,000-ton bunker with broken shale, and one 25 H.P. motor for hauling shale from the Stewartfield mine to the breakers, and from the Dunnet mine main haulage to the breakers. All the motors for this work are of the slip-ring type, with liquid starters, except the motors driving the high-speed turbine pumps, which are squirrel-cage wound, with star-delta starting arrangement. The lighting of the works is provided for by a 75 H.P. Belliss-Siemens set giving 455 amperes at 110 volts and 525 revs. per min.

There is one earth 'bus bar in the power house connected by cable to an earthing plate, which is laid in clay, and also to the earth plates of two adjoining chimneys. All earth connections to the various switches, motors and starters, &c., are made on to the armouring of one or other of the main cables, and these are in their turn connected to the common earth bar in the power station.

The permanent pumping plant consists of a Sulzer high-lift centrifugal pump, direct coupled to a Siemens-Schuckert electric star-delta motor of 185 B.H.P. running at 1,470 revs. per min. when supplied with alternating current of 525 volts and 50 periods. The combined set is capable of pumping 400 gallons of water per minute to a head of 780 ft., plus the friction of 1.740 ft. of 7 in. pipes and 10 ft. for suction lift. The guaranteed efficiency of the pump is 70 per cent. and of the motor 92½ per cent. A small sinking pump of the same type, capable of delivering 150 gallons per minute against a head of 210 ft., has been provided to deal with the dook water below the main lodgment.

The author, towards the close of his Paper, mentioned that a motor-generator was being installed capable of supplying power to 10 Jeffrey electric drills to be utilised for boring shot-holes in the shale.

STREET LIGHTING IN LONDON.

Owing to numerous inquiries received, and in the interest of supply undertakers generally, the Electric Supply Publicity Committee have sent the following letter (of which we have received a copy from Mr. H. B. Renwick, chairman of the Committee) to all the principal papers throughout the country.

LIGHTING OF LONDON.

A most misleading impression has recently been created by certain paragraphs appearing in the press under the above heading. The impression given was that London, instead of continuing an electrically lighted city, as at present, was about to revert to gas. I need hardly say that nothing is further from the truth. The case, however, presents an interesting example of how easily an erroneous impression can be set afloat. The facts are as follows:

One of the 29 London authorities, influenced by conditions which were purely local, decided to alter a few of their numerous electric lamps to gas lighting. The number of the lamps involved is quite small compared with the total number of lamps in the borough in question, and is altogether negligible in comparison with the total electric lighting of London. The whole case, in fact, is simply a local matter, confined to one authority only, and is quite undeserving of the wide publicity, were it not for these incorrect rumours, which have given rise to so much misunderstanding.

For corroboration of the facts, reference need only be made to the official statistics of the London County Council, where it will be seen that the use of electric street lighting has more than doubled in half-a-dozen years, and that only 10 out of the 29 London authorities are wholly without electric street lighting.

As to the relative cost of electricity versus gas for street lighting, I need only mention that in St. Marylebone the saving effected last year was £1,500 in respect of a portion of their area only, and that this has encouraged them to convert the whole of the remaining gas lamps to electric light, which will bring the saving up to £2,600 per annum.

Further, the Boroughs of Hampstead and Shoreditch—already extensively electrically lighted—are extending electric lamps practically throughout the whole of their areas.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Automatische Fernsprechsysteme." By A. B. Smith and F. Aldendorff. (Berlin: S. Heimann & Sohn.) Part I., 3s.; part II., 5s. Complete in cloth, 10s.

"Power and its Transmission." By T. A. Smith. (London: E. & F. N. Spon.) 2s. net.

"Continuous Current Machine Design." By Wm. Cramp. (London: Harper & Brothers). 5s. net.

"Windmills and Wind Motors." By F. E. Powell. (London: Percival Marshall & Co.) 6d. net.

"Motor Boats Simply Explained." By J. Douglas. (London: Percival Marshall & Co.) 1s. net.

REINFORCED CONCRETE FOR CHIMNEY CONSTRUCTION.*

BY P. S. SHEARDOWN.

The two chimneys at the Ringsend power station were built in 1898; they are each 200 ft. above the brick bases, which are themselves 25 ft. high. The stacks above the bases are constructed of steel plates, the bottom 50 ft. being $\frac{3}{8}$ in. thick, the next 50 ft. are $\frac{5}{16}$ in. thickness, and for the top 100 ft. the plates are $\frac{1}{4}$ in. thick. They are lined to the top with fire brick, but as it was anticipated, owing to the height of the chimney, that trouble might be experienced through unequal expansion if the brick work was set hard against the steel work, the linings were built independently, leaving a space of about 3 in. between the brickwork and the steel shell. The chimneys for some years appeared to be doing well, but as a case was brought to the writer's notice of a small works in Dublin where a steel chimney had to be replaced after a life of four or five years, a second one at the same works only giving a similar life to the first, it was considered desirable to make a careful examination of the tramway company's chimneys, more particularly in view of the fact that an inspection of the small chimneys referred to showed that the corrosion of the plates seemed to take place from the inside. As they were not provided with brick linings, like the tramway company's chimneys, corrosion from the inside was not anticipated in these latter. However, when a careful inspection came to be made, it was found that in the case of the east chimney the plates had rusted away until perforation had occurred in several of the plates, corrosion taking place entirely from the inside. The exterior of the plates was well protected by paint, and no deterioration had been noticed at the previous painting of the chimneys. The plates in each chimney were carefully tested by drilling holes and callipering for thickness, when it was found that in many parts of both chimneys the plates had rusted away to an extent that materially reduced their strength, and it was obvious that some method of strengthening them and preventing further corrosion would have to be taken in hand. After carefully considering various methods suggested, it was decided to reinforce both the chimneys with a ferro concrete lining. In the case of the east chmney, which has a diameter at the base of 10 ft. 8 in., it was decided to build a ferro concrete lining 10 in. thick inside the existing brickwork, reducing the diameter of the chimney to 9 ft. It was decided to remove only the top 20 ft. of the original brick lining, so as to get a bond for this length between the ferro concrete lining and the steelwork, in order to prevent deleterious gases or damp from getting between the brickwork and the steel shell. It was intended also to fill in the space between the steel shell and the original brick lining with a liquid cement grouting, but this was not found to be practicable as explained later on.

The lining was designed by the Weber Chimney Construction Co., of U.S.A., and the work was carried out by their licensees, Messrs. J. Jarvis & Sons. The concrete mixture consisted of three parts of fine sand to one part of cement; the vertical reinforcements consisted of steel tee bars 1¼ in. by 1¼ in. by $\frac{3}{16}$ in., and the horizontal reinforcements of $\frac{5}{8}$ in. round steel. These horizontal rings were put in 18 in. apart, the number of vertical steel bars being 300 at the base of the chimney, the number being gradually diminished until at the top there were only 12. The lining is designed to withstand a wind pressure of 56 lb. per square foot (or a velocity of 112 miles per hour) without help from the original steel shell.

The lining of the first chimney was completed in January, 1909, and has been repeatedly inspected from the inside since being put to work, and, so far, the lining seems to stand the heat and other stresses splendidly, as, beyond some small hair cracks, which are always noticeable in this class of construction, the lining is in excellent condition. A couple of months after being put to work it was noticed that the rivets had pulled out of a horizontal section of the steel chimney about half way up, and that the top half had risen about ¾ in. This was caused by the greater expansion of the ferro concrete lining due to its higher temperature compared with the steel shell. The steel shell is, therefore, now in practically two pieces, the overlapping where the rivets have pulled out acting as an expansion joint, the ferro concrete lining, therefore, taking the whole of the wind pressure.

When the proposed grouting between the steel shell and the original brickwork lining was put in hand, it was found that, owing to the quantity of soot that had fallen down between the brickwork

* Some notes (slightly abbreviated) on the reinforced concrete lining of the steel chimney shafts at Ringsend generating station of the Dublin United Tramways Co., and on reinforced concrete for chimney construction. Presented at the Dublin congress of the Tramways and Light Railways Association.

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and lining, a satisfactory job could not be made, and in consequence of this the west chimney, in which the plates were not so much corroded, was differently treated, the whole of the original brick lining being removed and the ferro concrete lining filled in hard against the steelwork, which enabled the Company to have a chimney with an inside diameter of 10 ft. in place of only 9 ft., as is the case with the east chimney, besides allowing a much greater thickness of concrete in the lower part of the chimney stack. The west chimney has been at work since the beginning of March, and so far with satisfactory results, having been inspected once since it was put to work. The writer is not aware, however, of any case similar to this where a ferro concrete stack has been built inside an existing steel one. The alternative that faced the Company in this case was completely to remove the steel stacks, and build brick or entirely new ferro concrete ones in their place, which would have cost two or three times what the ferro concrete lining cost, without being any more durable or efficient.

Reinforced concrete has been largely used in America for chimney construction, and in the case of tall chimneys this form of construction comes out much cheaper than for brickwork. There have been a number of failures, but it appears that they were all due to the neglect of some of the now well-known conditions which are necessary to insure satisfactory results with all types of ferro concrete construction. The usual practice in chimney construction is to use a mixture of one part of high-class cement to three parts fine clean sharp sand. The sand should be free from any fine silt, and from the fact of it being fine sand requires more careful mixing than where a coarser mixture is used, and for the same reason the sand should preferably be fairly dry when first mixed with the cement, then turned over at least three times when it is being moistened. In order to get a good bond between the concrete and the steel reinforcements, it is absolutely necessary that the concrete should be put in wet, as the failure of several chimneys have been due to the fact that the mixture was put in dry, the result being that the concrete did not adhere to the steelwork, and also formed a weak porous concrete.

With regard to the design of concrete chimneys (independent of outside steel casing) this differs from the design of brick chimneys, due to the fact that the stresses are met in quite a different way. A brick chimney stands because of its weight, the outside diameter of the base being made so large that it cannot blow over, the stresses in the brickwork being entirely compressive. A reinforced concrete chimney is of much smaller size at the base, and would topple over it if could not sustain a tensile strain. A ferro concrete chimney may, therefore, be treated as a beam fixed at one end and loaded on the side on which the wind is blowing, this side being in tension and the opposite side in compression; therefore, the steel reinforcement should be designed to withstand the maximum tensile stresses that are likely to occur. It is customary to assume a pressure of 50 lb. per square foot of vertical surface, which corresponds to a wind pressure of 100 miles per hour. It is, therefore, necessary to have a proper number of vertical steel rods or bars all round the chimney to resist the pull caused by the wind pressure, and steel hoops must also be placed at intervals to stiffen the vertical steel, and prevent cracks due to difference in temperature between the interior and exterior, and especially to resist the vertical shear which corresponds to the horizontal shear in a beam.

With regard to the effect of exceedingly high temperatures on concrete, there seems to be hardly enough experimental data to decide what effect these will have on concrete after long periods of time, but temperatures up to 700 or 800 F. do concrete no harm; in fact, concrete that has been subjected to such temperatures seems to set particularly hard, and as the boiler gases in most stations are usually nearer 500 F., no trouble should be anticipated from this cause, provided the chimney is properly designed. As concrete is a bad conductor of heat, the two or three inches next the surface exposed to the heat of the gases tend to expand to a greater extent than the outer surface, consequently it is not unusual to find small cracks on the outside of concrete chimneys due to this cause. This may be to a certain extent overcome by placing the horizontal reinforcements nearer to the outer surface, but these small cracks are not considered of any consequence, provided they do not run into one another for any great distance. A large number of chimneys are built with a special lining for a third of the height from the bottom of the chimney, the object in view being to overcome this unequal expansion between the inner and outer surfaces, but care has to be taken to strengthen up the reinforcement at the point where the double wall becomes a single one, otherwise cracks are likely to occur.

The method of constructing a new ferro concrete chimney is very simple. Two sets of inner and outer moulds are employed which are connected together by means of latches, enabling the moulds to be easily taken to pieces; after the first two sets of moulds, which correspond to the first two courses of concrete, have been filled in, the lower moulds are taken away and placed on the top of the moulds that were above them, the frictional resistance between the concrete and these upper moulds being sufficient to hold the weight of the next course. As soon as this is set the then bottom set of moulds are taken away and placed on top again, arrangements being made to do this as the construction proceeds from the inside of the chimney, hence no scaffolding is required, except a light scaffolding as the chimney goes up to allow a rough ladder to be erected and sufficient to support the gear for hoisting the material.

ELECTRICITY FOR FARM WORK AND IRRIGATION.*

BY H. RUSSELL.

The Rochester Railway & Light Co. supplies Rochester, N.Y. (200,000 pop.) with electric light and power. The electric development of the Company is both steam and hydraulic, supplemented by a purchase of Niagara power. It has generating apparatus for the production of 38,000 H.P., and the necessary equipment to distribute this. From April 1st to October 1st of every year 10,000 H.P. lies idle (representing an investment of £500,000). This represents the amount necessary to take care of the heavy peak loads in November, December and January. During these months, from 10 p.m. to 6 a.m. there is 10,000 H.P. waiting for a consumer.

The conditions as outlined above are true of every service company in the United States, and it is probably a conservative statement that during these months 40 per cent. of the plant capacity is producing no revenue, and that 75 per cent. is non-productive during six hours of every 24. The problem that confronts the companies is to find a market for this power during these months; in other words, a summer customer, who stays off the peak both daily and seasonly. In searching the field for a possible consumer of this character, the attention of the Rochester Company was attracted to the growing use of power on the farms, and especially to the increased use of power for irrigation pumping in the West, and the very attractive load features that this business offers. The question at once arose, "Is there not a market for this power in rural sections, and should not irrigation be practised by the farmers of the East as well as of the West? If so, can we not extend our lines into the country and sell the power now idle for irrigation pumping at special rates, and incidentally secure much additional farm business?"

The modern farmer wants electric power on his farm, and he is willing to pay for it. That this is the case is shown by the increased use of electricity in rural districts. Here and there all over this country (in New York, Illinois, California, Colorado, and in fact in almost every State) are to be found farms partially or completely equipped with electric power. The reasons for this wonderful growth of electric use on the farm are not hard to find or difficult to understand. The improvement in country roads, the growth of the automobile, the extension of the telephone and rural delivery service, have brought the city and the country closer and closer together, with the result that a farmer and his family are no longer an isolated set of individuals, out of touch with the world and modern progress.

Electric light means comfort in the farmhouse and a lessening of the fire hazard. By providing suitably lighted buildings, work can be done more efficiently; that is, more work and fewer hours. Electric power with its factors of safety, reliability, cleanliness, flexibility and ease of application is peculiarly adapted to pumping water, driving conveyors, running churns, separators, feed cutters, milking machines and grinders; to operating hoists, spraying machines, saws and machine tools; even to doing the household washing and ironing and providing a cold-storage plant. For these purposes, and many more, electric power is now used on the farms of the country. In Europe, where much greater progress has been made than in this country, ploughing, cultivating, &c., are being done with the aid of electricity

At present most of the electric service on the farm is being supplied by the farmer himself, the gasoline, steam or suction-gas plant usually furnishing the motive power, with an occasional hydro-electric private development. A beautiful example of the latter is to be found on the farm of Mr. W. H. Miner, at Chazy, N.Y. Two streams have been dammed and hydro-electric equipment of 192 kw. capacity with storage battery has been installed; transmission lines are 1¼ and 2¾ miles long. There is also a small steam reserve unit operated in connection with the heating system. There are 25 motors aggregating 123½ H.P., doing the farm work at the present time. Three years' operation has proved the efficiency and economy of the undertaking.

* Abstract from "Engineering News" of a Paper read before the National Electric Light Association.

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The use of gasoline engines for driving small generators, which in turn are used to charge storage batteries supplying electric light, is becoming very common. The advent of the tungsten lamp has aided materially in making this development possible. Manufacturers of farm machinery have taken up the subject, and the makers of electrical machinery are paying especial attention to the rural field.

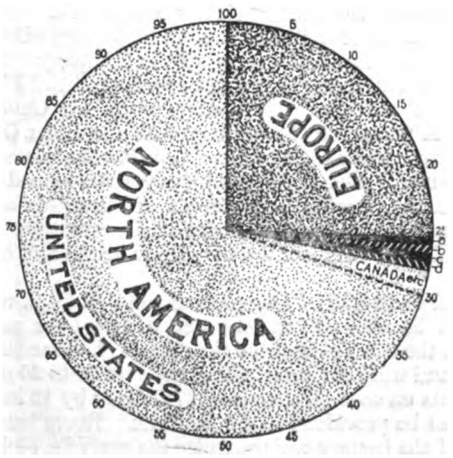
Recently there has sprung up in many sections, especially in the Western States, a demand for power on the farms, which is so large and the nature of which is so atractive from a load standpoint, that it promises to justify for its satisfaction a very large expenditure on the part of service companies. I refer to the use of electric power for pumping water for irrigation purposes. All over the West water is being pumped electrically from wells, rivers, lakes and ditches for irrigation use. Large Government and private company undertakings are now supplying water in this way for thousands of acres. Individual farmers, wherever electric power can be obtained, are installing pumping outfits and irrigating their own land, thereby saving the cost of water rights and maintenance charges, while obtaining water at a very reasonable cost when they want it and where they want it—a condition not always reached with gravity systems.

The electric development for irrigation pumping is proceeding in two ways: (1) A large pumping plant suitably located is installed, and all the water for a given acreage is pumped at this point to a higher level and then distributed by gravity—the power used being electric, with either steam or hydraulic generation; or (2) electric power is furnished from a central plant to the individual farmers, who supply their own water, either from streams, wells, gravity ditches or lakes, as the case may be. The irrigating pumping load is especially attractive to a central station, because it means a large power consumer who is strictly an off-peak customer. Power is used entirely during the summer months, and by special rates is in many cases used during hours of the day when there is almost no other load.

The considerations outlined above have caused the Rochester Railway & Light Co. to inaugurate a novel new business campaign. The writer has been delegated to give special attention to the subject of irrigation for the purpose of demonstrating to the farmers around about Rochester that it is to their interest to practise supplemental irrigation. A pumping plant has been installed on a fruit farm near the city, and experiments are being conducted. Last summer a peach orchard was irrigated with such remarkable results that already a great deal of interest has been aroused, and a number of farmers along the shore of Lake Ontario are installing pumping plants to supply water for irrigating their farm this summer. At Irondequoit, a market-garden town adjacent to Rochester, the Company is now supplying current at regular rates to more than 40 motors for farm use, most of which are for pumping water. The demand is increasing rapidly, and promises to reach large proportions this summer.

TELEPHONE INDUSTRY OF THE WORLD.*

The following figures have been obtained from various reports issued by telephone companies in all countries, and are believed to be the most complete *résumé* that has ever been published.



a = Africa, b = Australasia, c = Asia, d = America.

DIAGRAM SHOWING THE PERCENTAGE DISTRIBUTION OF TELEPHONES THROUGHOUT THE WORLD.

There were in use in the world on January 1, 1910, 10,269,000 telephone stations and 24,075,000 miles of wire, two-thirds of the telephones and wire mileage being in the United States. This is clearly shown by the diagram herewith. There is a race between Los Angeles, in the United States, and Stockholm, Sweden, for the honour of first place in the number of subscribers per inhabitant, Los Angeles leading with 61,000 stations and 240,000 inhabitants, and Stockholm following with 58,000 stations and 340,000 inhabitants.

The telephone investment of the world amounted on January 1, 1910, to £300,000,000, or nearly £30 per station, 65·5 per cent. of this total being on account of U.S.A. stations and 30·8 per cent. for Europe. The telephone conversations of the world for the year 1909 numbered 19,178,500,000, of which the United States used nearly 2½ times those of all other countries in the world.

The following table is of interest as showing the estimated number of stations per 100 population in the various countries at January 1, 1910:—

United States	7·6	Belgium	0·6
Canada	3·7	Argentine	0·5
Denmark	3·3	France	0·5
Sweden	3·1	Uruguay	0·5
New Zealand	2·6	Austria	0·3
Norway	2·3	Transvaal	0·3
Switzerland	2·0	Cuba	0·3
New South Wales	1·6	Hungary	0·2
German Empire	1·5	Italy	0·2
Great Britain	1·3	Cape of Good Hope	0·2
Luxembourg	1·2	Natal	0·2
Hawaii	1·2	Japan and Formosa	0·1
Victoria	1·0	Mexico	0·1
Finland	0·9	Porto Rico	0·1
Netherlands	0·9	Russia	0·1
Paraguay	0·9	Roumania	0·1
Venezuela	0·9	Spain	0·1

At the same date the number of telephone stations and miles of wire was distributed among the continents as follows:—

	Stations.	Miles of wire.
North America	7,342,700	16,167,300
South America	72,100	150,100
Europe	2,627,200	7,269,400
Asia	105,100	242,300
Africa	26,000	67,300
Australasia	79,500	149,200
Oceania	3,800	12,400
West Indies	12,600	17,000
Total	10,269,000	24,075,000

The countries with the largest number of telephone stations were the following:—

	Stations.		Stations.
United States	7,083,900	Norway	54,500
German Empire	910,900	Netherlands	52,600
Great Britain	615,900	Hungary	50,000
Canada	239,200	Belgium	42,600
France	211,600	Argentine	33,400
Sweden	171,400	New Zealand	26,800
Russia and Finland	155,715	New South Wales	25,000
Austria	99,500	Spain	22,000
Denmark	86,000	Victoria	12,500
Switzerland	73,300	Mexico	13,000
Japan	71,400	Brazil	11,900
Italy	56,400	Roumania	10,700

A comparison between the United States and Europe shows that Europe, with five times the population of the United States, has an estimated station development per 100 inhabitants of 0·6 against 7·6 in the United States; in other words, the telephonic development of Europe is one-twelfth that of the United States.

The difference in development between European countries and the United States is furthermore shown by the development of the German Empire, which leads all European countries with 910,900 stations, as compared with the development of New York State with 745,900. The latter exceeds by over 130,000 stations the development of Great Britain, which has the second largest number of stations.

The following table gives in detail the development of eight of the leading cities of Europe from 1894 to 1909. It should be noted, however, that while in most of the European countries the number of stations quoted corresponds to the area covered by the municipal

Telephones per 100 Inhabitants.

Jan. 1.	Stockholm.	Copenhagen.	Christiania.	Berlin.	Hamburg.	London.	Paris.	Vienna.
1894	3·5	1·0	2·6	1·2	1·2	0·1	0·6	0·5
1899	8·0	2·3	4·7	2·3	2·0	0·3	1·0	0·7
1904	13·0	4·4	5·4	3·3	3·5	1·2	1·7	1·0
1909	17·2	6·9	6·5	4·8	4·7	2·5	2·3	1·8

* Abstract of an article in the "Electrical Review and Western Electrician."

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boundary of a given city, this is not true of the English cities included in the above comparison. There the stations quoted correspond in each case to a telephonic area, and the population figures are but approximate.

The gross revenue in Europe from telephone service for 1907 (latest figures obtainable) was about £15,000,000, and for the United States for that year £37,000,000. Most of the European countries, in which the telephone is a monopoly of the State and conducted as a branch of the postal and telegraph service, estimate that the telephone service *per se* produces a net revenue.

Comparing the telephone traffic of Europe and the United States with the first-class mail and the telegraph traffic for the year 1907 shows that in the United States, with a population about one-fifth that of Europe—

First-class mail traffic is 2·4 times that of Europe per 1,000 inhabitants.

Telegraph traffic is 1·2 times that of Europe per 1,000 inhabitants.

Telephone traffic is 12·8 times that of Europe per 1,000 inhabitants.

THE ELECTRIC VEHICLE OPPORTUNITY.*

BY H. EAMES.

The author points out the wonderful possibilities of the electric vehicle for central stations, showing that in the city of New York if only one-half of the horse-drawn vehicles were substituted by electric vehicles, the income from the current at 2d. per kilowatt-hour would amount to over £10,000,000 per year.

The electric vehicle business has inherited a great many things from other businesses that are more or less analogous to it, but which are, by no means, exactly similar. The consequence is, if you act on impressions, you may get momentary advantage at the expense of ultimate success. During the 15 years that the manufacturers have been engaged in pushing that business they have had occasion to know what the real problem is. The assertion that business waggons have not improved in an engineering way in the last 10 or 15 years would not be true. They have improved, but the point that impresses one upon an investigation of the history of their improvement is that as much as 10 years ago the power electric waggon had already reached the degree of economy that made it more economical than horses for all service—for all service within certain limits. It is because the people have failed to take the next step that it has been kept back all these years, and is still being kept back.

The author next dwelt at some length on the extreme measures necessary to educate the public in the use of electric vehicles, and said that the bulk of this work would necessarily fall upon the central station. When these organisations have informed themselves on these questions, have recognised their great importance, and have made it their business to see that the first local power waggon shall be carefully bought and intelligently used, they will have made a long stride towards getting the benefit of this new market for current. These things are intangible, but, after all, the whole thing is mental, and these are mental problems, the solution of which will produce an immediate and tremendous demand for current for power waggons. To make this education effective, to be in a strong position to regulate local introduction, to see that a proper application of vehicles is made, to see that, for instance, electric waggons are not used where gasolene waggons would give better satisfaction, and vice versa, it is essential that central stations maintain a judicial position. While, no doubt, every manufacturer would be glad to have the direct aid of central stations in the local distribution of his vehicles, this could not fail to retard local educational work. It would undoubtedly stimulate large competitive interests to an active propaganda in favour of independent power stations, and these, in many cases, would be amply justified by the amount of power-waggon current required. Under existing conditions, the most healthy, strongest and most promising line of action for central stations will be to establish themselves as sources of information and to use the moral influence this will create to insure for their localities, always under their own tacit control and direction, the full benefit of the efforts of all competitive electric waggon manufacturers. Central stations must also see that owners of electric vehicles don't want to put in independent plants.

DISCUSSION.

Mr. P. D. WAGNER (General Vehicle Co.) said that one reason why the electric vehicle had not received the support of the central station had been because in the past, after the electric vehicle was sold, the purchaser was left to work out his own salvation, the result of which had been a dissatisfied customer. He said that there was an honest attempt on the part of all vehicle manufacturers to-day not to sell an electric vehicle unless they honestly believed that it was fitted to do the work.

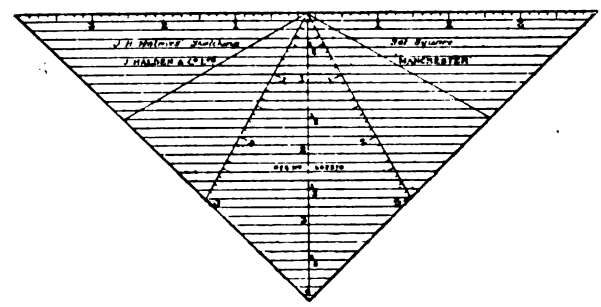
Mr. W. H. BLOOD, Jr., said that the electric vehicle business and the charging of storage batteries for them was to-day the best undeveloped prospective load in sight for the central station. Besides being a load of large proportion, it was an off-peak load. He explained the functions of the Electrical Vehicle and Central Station Association which has recently been formed in Boston and spoke of its future prospects. He also refered to a co-operative movement on foot between vehicle manufacturers to advertise the electric vehicle extensively.

Mr. G. H. JONES (Chicago) said that the Commonwealth Edison Co. believed very earnestly in the great future of the electric vehicle business. He said that in order to bring this matter before the people, the Company was carrying on two forms of educational campaign: One, to bring the matter before the non-users, and the other to educate those who had machines to operate them correctly.

* Abstract of a Paper read before the National Electric Light Association.

A NEW SET SQUARE.

Messrs. J. Halden & Co., of Manchester, have sent us a sample of a new set square they have just placed upon the market. It is made of celluloid, and comprises in one instrument straight-edge and parallel ruler, scale, protractor and set square. It should be specially useful for drawing centre lines and lines at right angles to them, series of parallel lines at definite distances apart, lines at various angles, and for making drawings in isometric projection. The "apparatus" is shown in the accompanying illustration.



NEW SET SQUARE OF MESSRS. HALDEN & CO.

The usefulness of this design of set square is dependent upon the transparency of the celluloid of which it is made. By reason of the transparency it is possible to lay the set square down upon any line already drawn so that some line ruled upon the set square exactly coincides with it, and then, by using some edge of the set square as a ruler, other lines may be drawn at definite angles to, or at definite distances from, and parallel with, the line first drawn.

ACCUMULATOR CARS FOR TRAMWAYS.*

In the latter part of March of this year the Third Avenue Railroad of New York placed in service a storage battery equipment on a converted horse car. This pioneer car has been so successful that an order has now been placed for 30 similar equipments. Twenty-five new car bodies are to be built and five old horse-car bodies are to be rebuilt for this purpose in the shops of the Company. The motor equipments and control will be furnished by the General Electric Co., and the storage batteries will be supplied by the Gould Storage Battery Co. A feature of the contract with the latter C mpany is an agreement to maintain the accumulators for five years at a fixed price per car-mile. The battery company have agreed to do all necessary cleaning, furnish all renewals of chemicals and water, make repairs and generally maintain the efficiency of the cells in good operating condition. This contract is said to be the first of the kind ever made.

The cars will be 26 ft. 5 in. long over all and 6 ft. 5½ in. wide. The platforms will be about 4½ ft. long and designed for prepayment operation like the other cars of the Company. The car body proper is 18 ft. long and will have longitudinal seats for 24 to 26 passengers. Under the seats on each side, a space 17 ft. long by 12 in. wide by 15 in. deep will be provided for the batteries. Room has also been left in front of the battery casings under the seats for piping in case it is decided to use hot-water heaters in these cars. These pipes would be covered by perforated iron sheets. In general, the car bodies will be constructed of wood throughout, and will be mounted on single trucks.

The storage battery equipment will consist of 58 cells of the Gould 29 T.-H. type, having a capacity of 420 ampere-hours when discharged at a 70-ampere-rate and at a temperature of not less than 80° F.

* Abstract of an article in the "Electric Railway Journal."

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It is defined in the contract that "battery operating condition" means maintaining the efficiency of the batteries to at least 75 per cent. of their rated capacity. The motor equipment per car consists of two G.E. automobile type motors rated at 30 ampere capacity at 125 volts. The motors and the trucks will be furnished with ball bearings. The type of silent chain drive has not yet been selected. With this electrical equipment it will be possible to maintain a regular schedule speed of 7 miles per hour, allowing eight stops per mile. The total weight of the car body, truck and equipment will be approximately 6 tons. The cars will be operated on practically level streets now served by horse-cars.

LEGAL INTELLIGENCE.

Torquay Tramways Arbitration.

Mr. Archibald Read sat in London this week to arbitrate between Torquay Corporation and the Torquay Tramways Co. as to whether the consent of the Corporation to the installation of the overhead system of traction on Nos. 5 and 5A of the tramways is unreasonably withheld. The Board of Trade had previously approved plans submitted by the company for the overhead system, so far as the safety of the public is concerned, and without prejudice to any legal questions as to the proposed change.

The ARBITRATOR said the Torquay Tramways Act, 1904, provided that the consent of the Corporation to the use of any system other than the Dolter surface contact system shall not be unreasonably withheld, and the tramways above referred to, and which were transferred to the Torquay Tramways Co. under the Torquay and Paignton Tramways Act, 1909, came into dispute, as the company wished to adopt the overhead system thereon and the Corporation did not assent.

Mr. H. LLOYD, K.C. (with him Mr. Courthope-Munroe), for the Corporation, protested that the arbitration was asked for under sec. 61 of the 1904 Act, whereas it should be under sec. 58, sub-sec. 15, which was the only section for settling disputes of the nature now under discussion. An agreement dated Jan. 2, 1906, between the Dolter Co. and the Corporation also provided that tramways 5 and 5A should not be constructed on the overhead trolley system without the consent of the Corporation, and he submitted that that was not subject to any arbitration. He, therefore, proceeded under protest. The Corporation claimed the absolute veto, and he would ask the Arbitrator to either state a case at once or to give his decision in the form of a special case.

Mr. VESEY KNOX, K.C., who (with Mr. Phillips) appeared for the company, said they had had no notice that any objection to the arbitration would be taken by the Corporation. Unless the company had some other system substituted before the end of October next they would have to stop running their tramways. The Corporation had had two months' notice of these proceedings. The Corporation ought to have had this question of jurisdiction settled long ago. It was clear that an arbitrator could be appointed under sec. 61, which said "Where the consent or approval of any local authority is by this Act required before the exercise of any powers by the company such consent shall not be unreasonably withheld." That was in general terms, and there could be no justification for assuming that Torquay Corporation was excepted. The agreement mentioned by Mr. Lloyd could not add any force to the Act of Parliament. He would be content to go on with the proceedings and leave the question of the section which applied to be settled hereafter. Mr. J. Swinburne, an expert witness, had to go to America, and it would be convenient that his evidence should be taken now. The bulk of the expense had already been incurred, and it would be more convenient if the proceedings went on, subject to the question raised by Mr. Lloyd. The company attached great value to the evidence of Mr. Swinburne, and they could not get it unless they took it now.

The ARBITRATOR said he would go on with the arbitration and state his decision in the form of a special case.

Mr. VESEY KNOX said Mr. Waller drew up a tramway scheme originally on the overhead system. In 1902 the Corporation took a postcard poll, which resulted in a majority in favour of the construction of tramways, but against the Corporation carrying out the work themselves. There was no question then as to the system of traction. The overhead system was cheap, reliable and safe, but the conduit system was much more expensive.

Mr. LLOYD: I am not going to suggest the conduit system.

Mr. KNOX said the first cost of the surface contact system did not, perhaps, exceed that of the overhead by more than £1,000 per mile, but it was not reliable, and cost much more for upkeep. The Board of Trade had never given more than a provisional approval to the use of the Dolter system in Torquay. There were provisions as to poles, brackets, &c., in the 1904 Act which could be applied in case of the surface contact system proving to be a failure. It was to the interest of the Corporation to keep the company's system at the lowest value until they bought it up in 1914, and, therefore, he could not help thinking that was in their minds when they withheld their consent to the change of system.

Mr. LLOYD said sec. 30 of the 1909 Act gave the company a longer period.

Mr. VESEY KNOX: Only if the Corporation did not exercise their right to purchase in 1914.

Mr. LLOYD thought it might shorten the proceedings if he interrupted to state his position. Having regard to the particular route, the feeling in Torquay, the possibility of the amendment of the Dolter system, and the availability of other surface contact systems, the Corporation had not been unreasonable. He said the Dolter system, plus the Mitchell stud, was perfectly satisfactory, and the Lorain and G.B. systems would also be satisfactory.

Mr. VESEY KNOX said the Board of Trade would not sanction the G.B. system. He went on to say the Board of Trade were forcing them to remove the Dolter system, and he submitted that the company were entitled to put down the overhead system, which had been approved by the Board of Trade for all the lines except 5 and 5A. Mr. Mitchell had invented five forms of stud which the company had tried without success. At Mexborough the overhead system, which was substituted for the Dolter system, used 1·7 units per car-mile, compared with the previous figure of 2·3, cost of maintenance went down from 3d. to 1d., and the average takings rose from 7½d. to 10d. At Hastings the Dolter system was still worked, but under specially favourable conditions and at double the cost of other parts of the line for maintenance. The company had prepared a financial scheme for the proposed overhead system which would cost about £60,000 in all, but it had been proved that no financier would touch a surface contact system. The great point of Mr. Mitchell's latest invention seemed to be that one pot only would be used to enclose the mechanism operating the stud to keep out water, instead of two as formerly, which seemed to him to be bad on the face of it. Another difficulty was that when the oil used in the pots to keep out water became carbonised it became alive, causing the stud to be continuously alive. The new invention would only lengthen the period in which the oil would become carbonised. A third trouble was the formation of gas (the cause of which had not been discovered) and consequent explosions. Since a specification for this invention was filed in 1908 Mr. Mitchell seemed to have abandoned the single pot to some extent, and adopted a compromise between a single and double pot, which he (counsel) thought would permit still more readily the infiltration of water.

Mr. W. B. COWNIE, a director of the Torquay Tramways Co. and secretary and general manager of the National Electric Construction Co., said the surface contact system was estimated by engineers to cost £1,000 per mile more than the overhead (or £2,000 per mile in all), but it had cost them considerably more. The conduit system had cost £18,000 per mile in London. Mr. Mitchell was formerly the National Co.'s chief engineer, and afterwards left them and went to the Dolter Co. At Mexborough about £10,000 was spent on trying to improve the Dolter system after the construction was finished.

Mr. PHILLIPS read a letter (dated Sept. 10, 1910) from the Board of Trade to the company's solicitors, stating that the Board would not approve the use of the G.B. system at Torquay, and they were not prepared to say that they would approve of the Lorain system.

Mr. COWNIE (continuing) said it cost about £8,000 to put up the overhead system in Torbay-rd. If they were compelled to have surface contact or conduit on the Torbay-road he did not think they would go on with the Paignton extension. The Corporation seemed to think that if the company used the overhead system they would not be such good customers for current as at present. That was a fallacy, as they would increase their service. Their current at Taunton cost them 1·6d. per unit, and the units used per car-mile were 2·3.

Mr. LLOYD said there was nothing in that agreement about the Corporation's consent being unreasonably withheld. In another agreement in 1906, which gave some concessions to the company by allowing them to proceed with certain lines earlier than they could have done under the act, there was again no reference to unreasonable withholding of consent to the overhead system on tramways 5 and 5A.

Mr. COWNIE said he had come to the conclusion that the Dolter system was pretty well doomed. If, however, the Corporation were satisfied with the Dolter system he was. But for the action of the Board of Trade they would have had to go on, and would have gone on as long as they could. The Lorain system seemed to work all right when he was on it. The G.B. system at Lincoln did not work all right when he was on it. One of his objections to the Lorain system was that he could not get any one to put it down, and after his experience he had no faith in any surface contact system. The overhead was the only feasible system for them. A constructing company would give a guarantee at once for the overhead system, but no contractor would guarantee a surface contact system.

Mr. VESEY KNOX contended that, as a matter of law, the provision in the agreement of 1906 that certain tramways should not be constructed on the overhead system without consent was ultra vires. It had been held that a company had not power to bar themselves of a statutory right, and moreover the Torquay Co. did not know of the agreement when they took over the Dolter Co.'s undertaking, and these facts would rule out the necessity of the arbitrator's considering the agreement from the point of view of reasonableness. It seemed that they could have as much overhead as they liked if they gave every councillor a direct route to the new town hall. The best terms they could get from the Lorain Co. were £2,681 per mile of single track. The Lorain Co. also declined to give a guarantee, and it was absolutely impossible to raise the money for putting down the Lorain system without such a guarantee.

Mr. JAMES SWINBURNE said he was familiar with the Dolter system. Overhead tramways were constructed in beautiful cities on the Continent while the objection to overhead wires was still being persisted in by manufacturing towns in England. The conduit system was quite practicable from an engineering point of view; it was only a question of expense. There had been an enormous number of patents for surface contact systems. It could not be said that surface contact had been proved satisfactory, although a particular man might be found who was satisfied with it. He thought the Dolter system had proved a decided failure. It was particularly difficult to design a satisfactory surface

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contact system for Torquay, because the roads were sometimes flooded and at other times they were watered with sea water, and he also understood the road was not very firmly constructed. It was very difficult to find oil of sufficient specific gravity to keep out water and also with so slight a viscosity that the lever would work in it. Water probably got into the pots because any air underground was probably saturated with moisture, so that any reduction of temperature would cause a little moisture to condense, and if the water got down in the inner pot under the oil it had not a chance of evaporating, and so it was a kind of water trap. The water would make contact with the two parts in the pot and cause a short-circuit. Witness was shown a drawing of Mr. Mitchell's latest modification of the pots to suit the Torquay track, and said it might have some advantages and some disadvantages. It did not, in his opinion, show sufficient improvement to make the difference between success and failure. It was quite unreasonable to come to the Torquay Co. and say, "Here is a system which exists on paper. You must put this down." The improvement, if any, in the pots would probably not be sufficient to induce the Board of Trade to sanction its use at Torquay. He could not think of any oil which would be sufficiently thin to allow the lever to work and yet be of sufficient gravity to keep out sea water. In his opinion it was unreasonable to object to the overhead system in Torbay-road. It would be a great drawback to have the Lorain and also the overhead systems. He did not remember that Mr. Mordey's report mentioned any oil suitable for the pots. He was not satisfied with Mr. Mordey's recommendation of Mr. Mitchell's system. The carbonisation must take place in the one pot as it did in the two pots. He had not investigated the Lorain system. It had received careful attention by electrical people, but it had not been adopted except (he believed) at Wolverhampton. He thought if the Lorain system had been a practical success it would have forced its way to the front.

Mr. J. L. BRIMAVESIN, assistant engineer to the National Electric Construction Co., said they had tried several oils for the pots. They got one which was heavier than water and allowed the lever to work, and they got a guarantee that it would not affect the bitumen, but they found that it did after a time. He confirmed Mr. Cownie's statements as to the current used per car-mile and the traffic receipts at Mexborough. The maintenance cost per car-mile was 2·5d. for the Dolter, compared with 0·106d. for the overhead.

Mr. J. S. BRAITHWAITE said he had no connection with the Torquay system. He did not think it would be possible to raise money for a surface contact system.

Mr. BRIMAVESIN, cross-examined, said the composition of the oil used in the pots had been altered from time to time. Some of their accidents were caused by the oil escaping from the outer pot either owing to the breakage of the pot or its breaking through the seal at the bottom. The faults were apparently increasing in the present year.

Mr. H. HOLLIDAY, engineer and manager of the Torquay Tramways since March, 1907, confirmed statements by previous witnesses as to various modifications of the studs introduced by Mr. Mitchell, and subsequently abandoned by the Torquay Co., and also as to the company's experience with the oils used. They had tried widening the brush used to detect live studs, so that it would operate at curves, but when they widened it to more than 50 in. it touched the stud (which might be alive) and also the rail, and the result was that the current did not ring the alarm bell on the car but went direct to the rail. Compensation paid for accidents other than those caused by live studs was £45 in 1908, £31 in 1909 and £3. 13s. up to August this year. For the week ended Sept. 1 the units per car-mile registered by meters on the cars were 1·94, but the units per car-mile as measured at the station were 2·20. This meant a loss of £679 a year.

Mr. W. H. PATCHELL said alterations had been made in the Dolter system at Torquay which had been beneficial, but there were radical defects which never could be improved. In the commercial and every other sense he thought the system hopeless. He saw no way of dealing with the trouble of the water in the pots. He did not think the live studs could be eliminated.

Mr. LLOYD, in his address on behalf of Torquay Corporation, said he had to register a protest against the arbitration taking place, as there was an important question of law which his clients wished to raise. He contended that the Corporation's right, under the Act of 1904, to consent or not to consent to tramways in Torbay-road was absolute, and not subject to the control of anybody. It was not correct to say the ratepayers decided to have tramways on the assumption that they should be on the overhead system. In the agreement dated Jan. 14, 1904, the Corporation waived their claim for a financial guarantee for the Dolter system in consideration for their being given the option of having or not having a tramway on the Torbay-road, and secondly if they decided to have such a tramway that it should be on the Dolter or other surface contact system, but now that the Board of Trade said the system was inefficient and unsatisfactory the company were going to say not that they would go away or wait and see if they were required by the Corporation to put in another system, but that they would force upon Torquay that to which the Corporation had said they would never submit. Supposing that, as a matter of law, were decided in the company's favour, the question was to be considered whether the Corporation were acting unreasonably in saying they would not have that to which from the outset they said they would never consent. The Corporation preferred the Lorain system to the overhead, and it was not a question whether the company was making a profit or whether the surface contact system cost more to work than the overhead.

Mr. C. E. C. SHAWFIELD, borough electrical and tramway engineer, Wolverhampton, stated that the Lorain system at Wolverhampton, of which there were 21¾ miles of track in operation, had worked entirely satisfactorily. The first portion was opened in May, 1902. The average working costs for the last three years were 6·4d., and total costs including capital charges 9·37d. Live studs (giving a reading of 100 volts or over) were only equivalent to half a stud per mile of track per annum. During the last seven years the total live studs, including those below 100 volts, averaged two studs per mile of track per annum. The live studs at Wolverhampton were often due to the picking up of scrap iron by the cars, which caused a short-circuit between the stud and the rail. So far as his acquaintance with Torquay went he saw no reason why the Lorain system should not be suitable for Torbay-road, although the flooding of the road by sea water would be detrimental to the working of any electric tramway system. His present knowledge would not justify him in recommending the laying down of the Dolter system. Before he adopted a system in which a switch had to work in oil, he would require a very wide evidence that such a thing was possible. He regarded the Lorain as the safest and most reliable system. At Wolverhampton they had never had a car stopped owing to defects of the surface contact system, but they had had a stoppage from failure of the feeder cable, which would have occurred equally on the overhead system.

Mr. W. A. LUNTLEY, general manager of the Wolverhampton Corporation tramways, confirmed Mr. Shawfield's evidence as to the working of the Lorain system, and the arbitration was adjourned until to-day (Friday).

Bogus Claims for Compensation.

At the New Bailey (London) on 9th inst., three men, named Weller, Smith and Hodder, were sentenced to six months, four months and one month respectively (with hard labour in each case), for obtaining money by false pretences and for conspiring to attempt to obtain money in connection with compensation claims for bogus accidents. The prosecution was at the instance of the British Electrical Federation, and was in connection with the Metropolitan Electric Tramways (Ltd.) operating in the north and north-west London districts.

Mr. J. RATCLIFFE COUSINS (instructed by Mr. Hugh C. Godfray) prosecuted, and gave an outline of the operations of the prisoners, who form part of a gang which has been perpetrating these fraudulent claims for the past five or six years. The leader of the gang was Weller, who had a permanent injury to his right wrist, and with this asset has been able not only to get a good living for himself, but has assisted others of the gang to obtain considerable sums of money from insurance companies, brewery companies, tradesmen and others, in addition to the tramway companies. So far as the tramway companies claims are concerned Weller's method was to board one of their cars and secure a seat on the top deck. When the car got to its destination he would allow the other passengers to alight, when by means of some weapon which he carried in his pocket he would break away a piece of the wood slatting or beading which is nailed across the top deck, and would then pretend to fall, and proceeding downstairs would inform the conductor that he had met with an accident through falling over the defective slatting. His name and address would be taken, and in due time his claim would be received for compensation. Weller would, in the meantime, attend one of the London hospitals, where the practice is as follows: If a person wants medical attendance as an out-patient he simply sees the hall porter and states the nature of his injury, the porter fills in a form recording this injury, and with this the patient is directed to attend the house surgeon at the out-patient department between certain hours for treatment. Hitherto these documents have been regarded as certificates showing that the claimant was actually suffering from the injury stated. It is clear, however, that a fraudulently disposed person can make use of same in promoting the claim against his victims. From the evidence given by the police Weller has successfully carried on this practice for a number of years by simply appearing at different hospitals under different names and at intervals securing a fresh document when required. The other members of the gang came into the conspiracy from time to time, as it was obviously impossible for Weller to appear more than once at the offices of the various firms he defrauded without fear of detection. He conspired, therefore, with the other prisoners that he would when necessary give their names and addresses as his own, and when the company or firm on whom he claimed sent their representative to interview the claimants Weller had meantime bandaged their right arms in correct hospital fashion and provided the conspirators with this useful hospital document in order that the chain of evidence would be complete. As the sum claimed was usually small, varying from £2 to £15, it was an easy matter for the frauds to be successful. In the case of the Metropolitan Tramways Co. they had in one accident a report from the conductor of the car in which Weller travelled and also a detailed report from an inspector who happened to be travelling on the car at the time of the alleged accident, and when the company's representative saw the prisoner Hodder he was bandaged up in this fashion and produced the hospital document in his own name, stating the injury as a fractured right wrist. The whole case appeared to be genuine, and a prompt settlement was made in order to avoid legal proceedings which were threatened unless the company agreed to pay quickly.

Although the British Electrical Federation were only victimised in a few cases they considered it their duty in the interests of the public to institute proceedings, as although several of the large insurance companies in London had been aware that a gang had been at work for some years past and they had been victimised to a much greater extent, they had been unable so far to detect the offenders. The fraud was discovered in the following manner: Weller, writing in the name of Smith from an addressat Walthamstow, informed the Metropolitan Tramways Co. that he had met with an accident on June 20 last and made a claim for compensation. A report had in the meantime been received from the conductor of the tramcar, and these documents were in due time forwarded to the

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department which deals with claims against the companies in the Federation. The claims officer made inquiries, and discovered that a similar claim had been settled a few days previously by a local tradesman, the claimant being of the same name, but giving an address at Wood Green. This address happened to be that of the prisoner Hodder, who had been paid compensation some six months previously for an accident identical in its nature to the one now claimed for. In response to a letter Weller called at the Federation offices, and was interrogated about the accident. He produced the hospital document describing the nature of his injury, and it was noticed that the date on same had been altered. He was induced to make a statement in writing, in which he asserted that he had never met with an accident before and had never been paid compensation by any other firm. He was told to come back again to receive the money which he claimed as compensation, and in the meantime inquiries were made which proved that the certificate had been issued on May 30 last to Weller in the name of Smith, but the address given was Wood Green, and on the strength of this certificate he had already been paid compensation by a local outfitter for injuries said to have been sustained through falling over his sunblinds, which were projecting at the doorway of his shop. It was also ascertained that his statement was false in other particulars, and when he appeared at the Federation offices next day two Scotland Yard detectives, who were present in an adjoining room, overheard Weller repeat the false statements made on the previous occasion, and he was arrested. On being searched documents were found in his possession which led to the arrest of Hodder, who made a confession showing how the conspiracy had been worked. Smith was meanwhile actively engaged in endeavouring to obtain money from tradesmen in other accidents for which Weller had provided him with the useful hospital document, and he was in due time arrested.

A warrant was obtained for the arrest of a fourth member of the gang, but he had in the meantime decamped.

The publicity given to the cases in which these men have been concerned will have a useful effect, and in passing sentence on the prisoners Judge Rentoul stated that if the press would give more prominence to such frauds, which have become very frequent of recent years, it would act as a deterrent on others.

Mining Regulations.

Application has now been made to the Sheriff of Linlithgow on behalf of the Home Office to state a case with the view of appealing to the High Court of Justiciary in the recent prosecution against John Leckie, mine manager at No. 3 Pit, Blackridge, belonging to the United Collieries (Ltd.). Respondent was charged with having failed to see that a competent person was on duty at the pit when the electrical apparatus and machinery were in use at the pit, as required by Rule 11 of the special rules for the installation and use of electricity in mining, but Sheriff-substitute Macleod found the charge not proven.

The case was reported in THE ELECTRICIAN for Sept. 2.

Valuation Appeal.

On Tuesday the Lochleven Water Power and Electric Company (Limited) appealed to the local Valuation Appeal Court against their assessment (£35,000) for last year. The Court fixed the valuation at £30,500, being 5 per cent. of total capital expenditure, but on account of the works not being fully completed at August 12, the Court restricted the valuation to £10,170 for last year. In respect to this year's valuation the assessors explained that they had fixed it on the principle of taking 5 per cent. on the total capital expended, admitted by appellants as heritage, and applying the principle of last year, they estimated the valuation this year at £35,000, which they were willing to restrict to £32,000 on an adjustment of total capital expenditure with appellants up to date. Appellants claimed to be rated on profits of one year, and gave evidence in support.

The Court, in giving their decision, stated that last year in fixing the value at £10,170 the committee proceeded upon the only method then open to them, namely, a percentage on capital outlay. It had been represented to them that the condition of working during the past 12 months had resulted in a profit of £20,450, against which certain figures had been set that more than absorbed the profit. The committee were of opinion that the figures relating to the last six months, compared with the first six months of the year, along with other evidence in the case, showed the prospects for the year 1910-11 were better than for the year that ended on May 15 last, and accordingly they felt justified in coming to the conclusion that the current year would be more successful, and, keeping that in view, they fixed £7,500 as a fair assessable value, which sum compared with a rate of 1¾ per cent. upon the capital expenditure on the works.

The assessors asked for a stated case to be laid before the Court of Session.

Village Lighting.—The village of Askrigg, which has for many years been lighted by oil lamps, is now brilliantly illuminated by electric lamps.

Mr. W. F. Burton, of Millgill, had a water-power plant put down for his own use, and having a reserve of power, offered Askrigg Parish Council to provide the public with electric light. After consideration the offer was accepted, and the main street and several places are now illuminated with lamps of 50 c.p. The Wesleyan Chapel, the school-room, the Hotel, and many private houses are also lighted electrically.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the position of resident engineer for one of the electricity works under the control of the County Borough of Stoke-on-Trent. Applicants must have a thorough mechanical training and experience in a three-wire d.c. station. Salary £180. Forms of application from the chief electrical engineer, Mr. C. H. Yeaman. Applications to the town clerk, Mr. E. B. Sharpley, by 26th inst. See also an advertisement.

There is a vacancy for an improver (without salary) at the Watford electricity works; also for a premium pupil. Applications to the Chief Electrical Engineer. See advertisement.

Wireless telegraph operators are required for the Canadian Navy; must be experienced men of good character. Particulars from the Captain, H.M.C.S. "Niobe," Devonport. See an advertisement.

An assistant engineer is required by an English company operating in South America; must have had experience in station running and three-phase h.-t. working. Commencing salary £250 per annum. See an advertisement.

A telegraph and electrical instrument inspector is required for the Baro Kano Railway (Northern Nigeria) for two tours of 12 months' residential service, with possible extension. Salary £250 a year, rising to £300 by annual increments of £10. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, by 17th inst.

The Yorkshire Electric Power Co. has a vacancy for an assistant engineer in the construction department. Salary £156 per annum. Applications to the company at Thornhill, Dewsbury.

An electrical engineer is required to take charge of the Cambuslang electricity and refuse destructor works of Lanark County Council. Commencing salary £160. Applications by Sept. 26.

Three professors of physics are required for the Government colleges at Rangoon and Dacca. Particulars from the Secretary, Board of Education, Whitehall, London, S.W. Applications should be marked "C.A."

Mr. W. Gallow Duncan, M.I.M.E., late head of the Indian Government Engineering College (Dacca), has been appointed lecturer in heat engines and applied electricity at the Modern School, Bedford.

"The Electrician" Electrical Trades Directory and Handbook.—For the examinations of the Insurance Institute of Great Britain and Ireland, which will be held in March, 1911, "The Electrician" Electrical Trades Directory and Handbook is one of the text books recommended for the examination in the fire branch.

EDUCATIONAL NOTICES.

University of London, University College.—The 1910-11 session begins on Monday, Oct. 3. Complete courses of study, extending over three years, are arranged in mechanical, electrical, civil and municipal engineering. Students desirous of entering the faculty of engineering with the view of taking a full degree or diploma course must have passed the matriculation examination or some other examination accepted in its stead. Students who have already attained a sufficient standard may enter for a course occupying less than three years, and may obtain a general certificate of engineering after not less than two consecutive sessions. Graduates in science or engineering, or students who have done the work equivalent to a degree, may be admitted to special courses of study or to prosecute original research. Intending students should communicate with the Provost as soon as possible, and in any case not later than Sept. 20. Full particulars from the secretary, Mr. Walter W. Seton, M.A., Gower-street, London, W.C.

University of London, Goldsmiths' College.—The new session commences on Monday, Sept. 26, and the enrolment of students commences on 19th inst. Complete courses of instruction are provided in mechanical, electrical and constructional engineering, telephony, fitting and machine pattern making and smithing, land surveying, &c. Students are prepared for the London University degree of B.Sc. in engineering, for the examinations of the Institution of Civil Engineers, Board of Education and City and Guilds of London Institute and for the National and Whitworth scholarships. There are reduced fees to course students if paid by Sept. 23. Particulars of fees, &c., from the Warden, Goldsmiths' College, New Cross, S.E.

University of Edinburgh.—The next session opens on Oct. 4, and the preliminary or entrance examination is held in September. In

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the engineering department of the University complete courses of instruction are provided in civil, mechanical and electrical engineering, qualifying for the degree of B.Sc. in Engineering, and extending over a period of three years. Particulars of entrance examination scholarships, fees, &c., can be obtained from the Matriculation Office of the University.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. The matriculation examination takes place on Sept. 20-23. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

Sir John Cass Technical Institute.—At this institute there are evening classes in chemistry, metallurgy, physics and mathematics, and the courses are designed to meet the requirements of those engaged in chemical, metallurgical and electrical industries, and in trades associated therewith. Facilities are given for special and advanced practical work in well equipped laboratories both in the afternoon and evening. The instruction in general physics and mathematics will prepare for the final B.Sc. examination of London University, and there are special courses on general physics and electricity and magnetism for the honours B.Sc. on induction in gases and radioactivity and on the differential and integral calculus for science students. The new session begins on Monday, 26th inst. Particulars of the courses can be obtained at the offices of the Institute, Jewry-street, Aldgate, London, E.C., or by letter of the Principal.

King's College (University of London).—In the Faculty of Engineering complete courses of study, extending over three or four years, are arranged in civil, mechanical and electrical engineering for the engineering degrees of the University of London and for the diploma and certificate of the College. There will also be special courses of advanced lectures on "Internal Combustion Engines" and "The Theory and Practice of Construction." The entrance day for new students is Tuesday, Oct. 4.

University of Bristol.—At this university complete courses of instruction in electrical, mechanical and civil engineering are given, and also instruction in the evening classes. The 1910-11 session in the faculties of arts, science and medicine will commence on Oct. 3, and in the faculty of engineering on Sept. 13. Particulars and prospectuses from the registrar, Mr. James Rafter.

Merchant Venturers' Technical College. Bristol.—We have received a copy of the calendar for the 1910-11 session of this college, which now provides instruction in the faculty of engineering in the University of Bristol. The calendar gives full particulars of the courses of instruction, fees, scholarships, examinations, &c. There are day and evening classes, and well-equipped laboratories for practical work and research. Copies of the calendar can be obtained at 6d. each.

Battersea Polytechnic (London, S.W.).—The day courses at this Polytechnic prepare for the B.Sc. degree (in engineering) of the University of London, and for the Polytechnic diploma in mechanical, electrical, civil and constructional engineering. The day courses commence on 22nd inst. and the evening courses in the same subjects on 26th inst. Prospectuses from the Secretary.

The calendar of the polytechnic for the coming session indicates an increase of work in all departments. In connection with the engineering and building department, new evening classes are being commenced in pattern making and architectural measurements. The chemistry department is extending its work by providing more advanced instruction in paper making and bacteriology, and new classes in soap manufacture. The mechanical and electrical and physics laboratories, built last year, are now being equipped, and these (with the extension of the art and women's departments) will provide more extended and complete work in these departments than was formerly possible. The new library, presented by Mr. Edwin Tate, at a cost of £8,000, to be opened by the Archbishop of Canterbury on Oct. 21, will be a valuable addition, and will render the Battersea Polytechnic one of the most complete educational institutions in this country.

Borough Polytechnic Institute.—The new session begins on 26th inst. There is a four years' course of instruction in electrical engineering, and in electric wiring there is a three years' course. There are day and evening classes. Further particulars and detailed syllabus are given in the prospectus, which can be obtained from the Principal, Mr. C. T. Millis.

Northampton Polytechnic Institute.—At this institute there are day and evening courses in engineering (mechanical and electrical), electrochemistry, technical optics, in artistic crafts and in horology. The engineering courses include in sub-sections automobile work, aeronautics and radio-telegraphy. In addition, there are evening courses in metallurgy and domestic economy. The classes of the day courses commence on Oct. 3 and those of the evening courses on Sept. 26. Enrolments for the latter commenced on the 12th inst. Full details of the syllabuses and the equipment are given in the "Announcements" for the 1910-11 session, which has just been issued.

The new building at Clerkenwell, London, the pending utilisation of which was notified a year ago, has proved a very valuable addition to the accommodation of the Polytechnic, and has allowed developments in several directions which have been previously hampered by lack of space. In the electrical engineering department the new generating station, which has been installed during the spring and summer of this year at a cost of about £6,000, will be available for the instruction of senior students. This station, which will be opened on Oct. 12 by the Chairman of London County Council, is thoroughly equipped in all details for the generation and distribution of continuous and alternate currents. The work of the department, hitherto in charge (under the personal direction of the principal) of Dr. C. V. Drysdale, will, during the coming session, be in charge of his successor (Mr. F. M. Denton), whose appointment as associate head of the department was announced last Easter. In the department there are also consolidations in the courses in telegraphy and telephony. The classes in submarine cable work are being continued, and more advanced classes are projected in radio-telegraphy, although this subject has been treated hitherto as an advanced subject in the work of the Polytechnic.

In the mechanical engineering department the success of the pioneer courses in aeronautics which were given last winter has been so marked that the subject is being developed for the coming winter and extended to the day courses. In the evening courses and classes, the subject of aeronautics will be placed in the charge of Mr. F. Handley Page, of the firm of Handley Page (Ltd.), aeronautical engineers.

In the technical chemistry department there are modifications in the day courses which are intended to bring the instruction in electroplating more into line with the actual requirements of the trade. These modifications have been made in consultation with some of the leading employers. The pioneer evening class in metal colouring which was held last session having proved a success, is being continued this session with some developments.

In technical optics arrangements have been made to extend the advanced work in sight testing and physiological optics and to develop the classes in other directions.

BRITISH NOTES.

Belfast.—For a long time complaints have been made of the inadequate lighting of some of the business thoroughfares in this city, and the Corporation recently decided to do something to improve matters, and resolved to light the High-street and Castle-place by flame arc lamps.

The lamps will be suspended from a main wire carried upon special span wires, along the centre of the street about 2 ft. higher than the tram trolley wires; these span wires being stretched from the tops of the tram poles. The wires and feeders have been erected by the electric supply department, and the lamps are ready to be placed in position.

Bradford.—A new electric lighting installation is being fitted in the old portion of the Town Hall by the Bradford Electrical Co. There will be about 380 lamps in all, and a complete system of telephone intercommunication is also being provided.

Braunton (Devon).—The Parish Council have adopted the electricity supply scheme drawn up by Messrs. Crompton & Co.

Hitherto oil has been used for street lighting, but under the arrangement with Messrs. Crompton electric current will be supplied for street lighting at 2·15d. per unit, and a supply will also be available for private lighting at a moderate charge.

Burnley.—The Electricity committee have entered into an agreement with Brierfield Council as to the working of the tramways in Brierfield for 14 years from March 31, 1909.

Burnley Corporation will supply the power and lay a cable from the electricity works to Brierfield Centre at a cost of £1,800. The rent of the lines in Brierfield will be £1,000 a year.

Colchester.—The electrical engineer has been given authority to suspend or dismiss any member of his staff if he deems it necessary, the circumstances to be fully reported to the ensuing meeting of the Council.

Colwyn Bay.—An inquiry was held last week into the application of the Council for sanction to borrow £2,300 for extending their electric supply cables to Old Colwyn.

The electrical engineer (Mr. A. R. TUDMAN) stated that there was a reasonable prospect of extensions to Old Colwyn being remunerative, especially as the trustees of the new sanatorium, which is being built in connection with the Cheadle Hulme asylum, were arranging to take current for lighting.

The inspector (Mr. H. Ross HOOPER) suggested that no further loans should be obtained for services or meters, but that for the future these should always be paid for out of revenue as required. He also stated that before any additional loans would be sanctioned the Board would require the amount borrowed on an engine now scrapped to be deducted from the capital account. He advised that £1,000 should be obtained for further expenditure on mains to render applications to the Board for small loans unnecessary.

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Conciliation and Arbitration Boards.—The Labour Department of the Board of Trade have issued their report on strikes and lock-outs and on conciliation and arbitration boards in the United Kingdom in 1909. The present is the 22nd annual report, and in a prefatory memorandum the Secretary of the Department (Mr. G. R. Askwith) states that

Although the number of workpeople involved in disputes in 1909 (300,819) was the highest recorded since 1894, the working time lost was comparatively small. The aggregate duration of all the disputes in progress amounted to about 2,750,000 working days, which was little more than one-fourth of that recorded in the previous year, and was well below the average of the 10 years 1899-1908. Spread over the whole industrial population, exclusive of agricultural labourers and seamen, the working time lost in 1909 averaged only about one quarter of a day per head. The coal-mining industry was more affected than any other trade, accounting for 90 per cent. of the total number of workpeople affected and 78 per cent. of the time lost.

Questions of wages accounted for only 25 per cent. of the workpeople directly affected, while questions of hours of labour involved 51 per cent., largely due to differences arising out of the adjustment of working hours after the passing of the Coal Mines Regulation Act. Methods of conciliation and arbitration continue to be more and more generally employed, the number of disputes settled by these means in 1909 being the highest recorded. The number of cases settled by joint boards composed of employers and workpeople showed a considerable increase, due to the activity of the boards formed in 1908 for the principal railways of the United Kingdom. During the year the machinery for conciliation was extended by the formation of boards for the printing trades of the United Kingdom, the Birmingham brass trades, the pottery trade in Scotland and the London County Council tramway workers. Of the 59,945 workpeople directly involved in disputes settled by conciliation or mediation 56,882 were in the coal-mining industry, and 847 in the metal, engineering and shipbuilding trades. The proportion of workpeople involved in disputes beginning in 1909 which were settled by arbitration was 11 per cent., compared with 3 per cent. in the previous year. The proportion of workpeople whose disputes were settled by conciliation or mediation was 35 per cent., as compared with 67 per cent. in 1908. Of the cases considered by permanent boards 698 were settled by the boards or their committees and 327 by umpires or arbitrators appointed by them.

Cookstown (Ireland).—At the last meeting of the Council a motion to adopt a municipal electricity supply scheme was rejected, but it was decided to ask Messrs. Adair, who have an independent generating plant, if they are prepared to supply electricity for private and public lighting, and on what terms.

Dalkey.—The Council have decided not to apply for a provisional order, but are disposed to make arrangements with the Dublin United Tramways Co. for supply of electricity if the company obtains powers.

Dunfermline.—Treasurer Harley reported on Monday an interview with the Board of Trade on the proposal to transfer the Corporation's electric lighting order to the Fife Electric Power Co.

The Board objected to a proposal of the company that in 30 years the Council could take over consumers up to a certain limit, the company retaining the larger power consumers. The Board's objection was to a partial transfer of the business. A further conference is to take place.

East Molesley.—The electric light installation at the fire station is to be extended.

Edinburgh.—The question of the disposal of the surplus (£7,300) on the past year's working of the electric supply department was considered by the Electric Lighting committee on Tuesday.

A communication was considered from the consulting engineer (Sir Alex. Kennedy), in which he recommended to the committee, in view of the resolution of the Council to replace by newer and more economical machinery part of the plant at Dewar-place station, that the surplus be devoted to wiping off the unpaid portion of the original cost of the old machinery. That cost was £21,000, and of that amount about one-half had been paid off by the ordinary operation of annual payments towards sinking fund. The committee agreed that the balance be so applied.

In connection with the extension of plant at Dewar-place, the committee unanimously approved of specifications for the new work, and agreed to advertise for estimates. Sir Alex. Kennedy stated that he hoped to produce a type of cooling tower which would not in any way be detrimental to the amenity of the district. The cost of the new plant, consisting of high-pressure turbines and of cooling towers, will be £45,000, and the work will be completed by next autumn.

Electrical Exhibition.—Mr. H. D. Wilkinson, 4, Queen-street-place, London, E.C., advertises for novel appliances for consumers for lighting, heating and power, required for a colonial electrical exhibition.

Fair Wage Dispute.—The next engineering central conference will consider a novel reference from Manchester.

Manchester Electricity committee recently recommended the acceptance of a particular tender, and the City Council was about to adopt the recommendation when the District committee of the Federation of Engineering and Shipbuilding Trades objected, on the ground that the tenderers did not conform to the local fair-wage clause. As a federated firm the contractors took up the position that if the conditions in their shops conformed to the terms of agreement the men had no occasion to complain. Of the 17 affiliated trades six are covered by the terms of agreement. But the local representatives of the half-dozen proceeded to insist for their own part that the fair-wage clause of Manchester Council was better than the provisions of the terms of agreement.

Farnworth (Lancs.).—The public library is to be wired.

Felixstowe.—The L.G. Board have sanctioned the borrowing of £4,260 for the purchase of a Diesel engine and other plant for the electricity works, the loan to be repaid in 15 years.

Application has been made for sanction to a loan of £3,000 for mains extensions, &c., during the next three years.

Glasgow.—A new tramway route, between Hyndland to Alexandra Park, was opened for traffic on Monday.

Glastonbury.—Messrs. J. & W. Purves propose to apply for a provisional order, and a special meeting of the Council will be held to consider the draft order submitted by the firm.

Greenock.—The Admiralty have informed the Corporation that the supply of electricity required for the torpedo factory at Battery Park will be equal to about 400 kw., or double the original contract.

Hackney (London).—The showroom of the electricity department is to be opened on 22nd instant.

In connection with the opening of the showroom two additional clerks are to be permanently engaged. A lady demonstrator and two canvassers are also to be employed, their appointments to be temporary so that their capabilities be ascertained. The lady demonstrator will be engaged in the kitchen of the showroom for exhibiting the use of the cooking apparatus. In addition to her salary she will be allowed commission on sales effected by her in the showroom. The fitting up of the premises has been carried out by Messrs. Maple & Co. at £427. 13s. 6d.

Tenders are to be invited for the supply of 80,000 pairs of white arc lamp carbons.

Harbour Lighting.—Whitehaven Harbour Commissioners have agreed with the local Council to light the harbour with Osram lamps for five years at £230 per annum.

Heanor.—The engineers of the Notts & Derbyshire Tramways Co. are making surveys and preparations for the construction of tramways which will connect Heanor with Nottingham, Ripley and Derby.

Hendon.—At the last meeting of the Council it was reported that Major Pringle, of the Board of Trade, had inspected the route over which it was proposed that rail-less cars should run, and a map of a section of the proposed route is to be forwarded to the Board of Trade.

Manchester.—The City Council adopted on Tuesday a recommendation of the Tramways committee to make arrangement with the general manager of the tramways, Mr. J. M. McElroy, under which he is to agree to remain in the service of the Corporation for five years from the present time, and his salary of £1,000 per annum is to be increased by annual sums of £50 up to £1,250. The first annual increase takes effect from Jan. 1, 1910.

Marconi Marine Progress.—A circular issued by the Marconi International Marine Communication Co. is an interesting document in several ways, and particularly as showing the large number of marine telegraph stations controlled by, or operated in connection with, the company. The list gives a good idea of the number of these stations at the time when it was issued, but it is even more interesting in the case of the copy we have under notice from the large number and additions which have been interpolated since the list was first issued. Page after page is filled with the names of vessels in all the leading steamship lines, and the list indicates that the time will soon come, even without legislation, when all vessels, except perhaps those which are purely cargo carriers, will automatically fall into line and be equipped with wireless apparatus.

Marylebone (London).—The latest of the well-known "Borough" series of Guides deals with St. Marylebone, and is in no way behind its predecessors in illustrations and general get up. Photographs of Oxford-street at night and of the interior of the borough generating station are given, while opportunity has been taken by Mr. A. H. Seabrook of bringing before his readers the great advantages attendant on the use of electricity for all purposes. A very good description of the generating station is included.

Municipal Wiring Bill.—In addition to the Local Authorities already published, the Corporations of Burton-on-Trent, Luton, South Shields and Nelson have decided to support financially the proposal of the Municipal Electrical Association to promote a bill to confer powers upon local authorities for wiring premises, &c., and Oban, Redditch and Neath Councils will give it their moral support.

Newport (N.B.)—Recently the Council refused to allow the Tayside Electric & Gas Light Co., of Wormit, to extend their electric supply mains to Newport, but a number of influential residents have petitioned the Council to grant the company the necessary permission.

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Norwich.—The Council are recommended by the Electricity committee to apply for sanction to a loan of £18,790 (instead of £17,783, decided upon by the Council on March 15 last) for mains, services, exhaust steam turbine, pipes, centrifugal pump, balancer, coal elevator, &c.

Poplar (London).—The supply network in Gale-street is to be strengthened at a cost of £795.

32 street gas lamps are to be converted to electric lighting at a cost of £128. The charge for gas, attendance and mantles now amounts to 58s. per lamp per annum; and the charge for current, renewals and attendance when the lamps are converted to 50 c.p. electrics will amount to £2. 11s. 4d., or a saving of 6s. 8d. per lamp annually (equal to 11½ per cent.), which will gradually increase as the life of metal filament lamps is improved, and the cost reduced.

Presentations.—On his marriage Mr. Herbert Jackson has been presented by Manchester tramway traffic department staff with an oak clock and by the Tramway Employé's Athletic Society (of which he is hon. sec.) with a bookcase and bureau.

Bournemouth tramway staff have presented a gold watch and chain to Mr. J. H. Chick, station engineer, who is leaving for Ceylon.

The staff of the Bath Electric Tramways (Ltd.) have presented a Chippendale grandfather's clock, and the engineering staff a recording barometer to Mr. W. E. Hardy, manager and engineer, on his marriage. The directors of the company have also presented Mr. Hardy with a silver salver.

Sevenoaks.—The Council, who have decided to proceed with an electricity supply scheme, have appointed a sub-committee to select a suitable site for a generating station. Messrs. Mordey & Dawbarn are consulting engineers to the Council.

Sheffield.—The Electric Light committee are inviting tenders for additional generating plant for the Neepsend power station.

A loan of £2,500 is required for the purchase of electric motors to be let on hire.

Swansea.—The local tramways company is about to double the whole of its line on the Morriston section, from the Imperial to the Duke Hotel.

Watford.—At the last meeting of the Council the clerk stated that a communication had been received from the L.G. Board enclosing five sanctions for electric lighting loans.

Coun. Goodrich, chairman of the Electricity committee, said he objected to the letter being read. There were some comments in the letter concerning public lighting and suggesting that the Council should look further into the question of using gas. The answer to that was that 150 street lamps had been converted to metal filament lamps and between 30 and 40 were being changed. No good purpose would be served by making the letter public.

Coun. Rider said he was opposed to municipal trading on principle, but it would be absurd for the Council to reveal their secrets to their commercial rivals.

Mr. J. Gowers, hon. sec. of the Watford Tradesmen's Association, wrote enclosing resolutions which had been passed by that body, deprecating any further delay in carrying out the original tramway scheme and opposing a railless system.

The Tramways committee recommended that the Council appoint delegates (on condition that there was no cost to the Council) to investigate, with representatives from the County Council, the systems of railless traction in operation in Berlin and Vienna. This report was considered in committee.

Wells.—The City Council have been informed by Messrs. J. & A. Purves of their intention to apply for a provisional electric lighting order.

West Bromwich.—An unopposed inquiry was held on Friday into the application of the Corporation for sanction to borrow £11,386 for extensions of the electricity undertaking.

The Town Clerk said the loan was for an extension of the plant at the electricity works, to enable them to supply the Spon-Lane district during the winter.

The Inspector (Mr. H. Ross Hooper) said he was in doubt as to the advisability of spending nearly £12,000 in extending the undertaking upon the direct-current system, and he suggested that the Corporation should consider whether it would not be the wiser to adopt the alternating-current system, under which electricity for power could be generated at a cheaper rate. He pointed out that the low-tension direct-current system was not being extended in the country for power purposes. At West Bromwich they had gone on very well with their electricity undertaking up to the present, but it was for them to consider whether the money which they were now going to spend for power users would not be better spent on a different system. He suggested if they were prepared to spend nearly £12,000, whether it would not be wise for them to see if the alternating-current system was not the more suitable for the supply of their district. It was for the Council to consider the position. Power was no use unless it was cheap, and the question was whether they were going to have a cheap supply in future. If so, then the supply would be the cheapest if the district was such that the alternating-current system could be introduced. He did not want them to find out two or three years hence that they would have been better off if they had put in and extended the alternating-current instead of the direct-current system.

The borough electrical engineer (Mr. W. A. Jackson) said they had considered that question carefully, and they thought it advisable at present to go in for a direct-current plant.

West Ham—*Correction.*—The amount of the loan recently sanctioned by the L.G. Board for extensions of the electricity undertaking was £53,500, and not £55,000, as stated in our last issue.

Willesden.—The Council will supply electric current to Mr. J. B. Mulholland's new theatre at 1d. per unit between midnight and 6 p.m. and at the ordinary lighting rates between 6 p.m. and midnight, provided a minimum consumption of 20,000 units a year is guaranteed.

Wireless Telegraph Notes.—A disaster happened to one of the huge train-ferryboats operating on Lake Michigan on Friday last week, which, but for timely warning by wireless, would have resulted in a larger loss of life than actually occurred. The ferry was 350 ft. long and carried the trains of the Père Marquette Railroad across the Lake. In the train and ferry at the time of the disaster 62 persons were being carried across; 29 were drowned, but the arrival of assistance, due to the wireless message, caused the lives of 33 others to be saved. The wireless operator on the ferry, who stuck to his post, was amongst the drowned.

It is announced that the Marconi International Co. has secured an order for equipping 11 Turkish battleships with wireless installations, together with a coast station to be situate at San Stefano.

The leading public journals are taking advantage of the equipment of the popular lines of steamers with wireless telegraph apparatus to institute a general scheme of receiving and publishing news from ships at sea, and it seems likely the arrangement will become general.

The most important matter in relation to wireless telegraphy just now is its effectiveness in establishing intelligible communication with submarine vessels. The naval experiments which are being conducted in British waters at the present time, it is stated, although of little comparative value so far, have improved so rapidly that much greater success in the early future is anticipated.

Workhouse and Infirmary Lighting.—Canterbury Guardians have decided to substitute electric for gas lighting at the workhouse and infirmary.

The Lighting committee went into the matter fully and obtained a report from the city electrical engineer (Mr. C. A. Blaschek) who estimated the cost of the wiring at £165. This sum would include replacing all lights at present in existence, besides lighting several places which have no light, but where a light is required. In all the installation will be equivalent to 366 8 c.p. lamps. The gas account for the last financial year was £216, but £36 of this was for cooking and heating. The estimated cost of electric lighting would be £100, so that by adopting electric lighting they would be saving £80 a year, and would have a better light.

The L.G. Board have anthorised Tipperary Guardians to borrow £2,280 for electric lighting plant, the loan to be repaid in 20 years.

The new infirmary, Newton Abbot, is to be wired.

COLONIAL AND FOREIGN NOTES.

Argentina.—Paquet y Cia. have obtained a Government concession for the construction and working of an overhead electric conveyor across the Riachuelo river and a six months' option to construct a second conveyor.

Austria-Hungary.—Vienna-Neustadt Municipality have obtained powers to borrow £23,600 for erection and equipment of electricity works.

Brussels Exhibition Awards.—The following are amongst the awards to British exhibitors at the Brussels Exhibition, as set out in "The Times" yesterday (Thursday):—

Class 15.—Mathematical and Scientific Instruments; Coils, &c. *Grand Prix.*—F. Darton & Co., Kelvin and James White, W. F. Stanley & Co. *Silver Medal.*—Gambrell Bros., John J. Griffin & Sons, Townson & Mercer.

Class 19.—Steam Plant. *Grand Prix.*—E. Green & Son, J. Hopkinson & Co., Marshall, Sons & Co., J. & H. McLaren, Ruston, Proctor & Co. *Diploma of Honour.*—Underfeed Stoker Co., G. & J. Weir. *Gold Medal.*—Holden & Brooke, National Gas Engine Co.

Class 21.—General Machinery. *Grand Prix.*—Appleby Crane & Transporter Co., J. & H. McLaren, Hans Renold (Ltd.), R. Waygood & Co. *Diploma of Honour.*—Marryatt & Place, Reavell & Co., G. & J. Weir. *Gold Medal.*—Aerograph Co., Coventry Chain Co., Lacy Hulbert & Co., Ruston, Proctor & Co., Sturtevant Engineering Co.

Class 23.—Mechanical Production and Utilization of Electricity. *Grand Prix.*—Kelvin & James White, Morgan Crucible Co., C. A. Parsons & Co., Reflector Synd., R. Waygood & Co. *Diploma of Honour.*—Marryatt & Place. *Gold Medal.*—Lancashire Dynamo & Motor Co.

Class 24.—Electro-Chemistry. *Gold Medal.*—John J. Griffin & Sons, Reflector Synd.

Class 25.—Electric Lighting. *Gold Medal.*—Faraday & Son. *Bronze Medal.*—J. Dugdill & Co.

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CLASS 27.—MISCELLANEOUS APPLICATIONS OF ELECTRICITY. *Grand Prix.*—Kelvin & James White, R. W. Paul. *Diploma of Honour.*—Gambrell Bros., Nalder Bros. & Thompson, Synchronome Co.

CLASS 87.—APPLIED CHEMISTRY AND PHARMACY. *Grand Prix.*—Johnson, Matthey & Co., Thermal Synd.

The Cambridge Scientific Instrument Co. were placed *hors concours* in Class 15 (Mathematical and Scientific Instruments).

Italy.—The Società Anon. Tranvia Elettrica Valle di Gressoney is to be formed with a capital of £60,000, to construct and work an electric tramway from Pont S. Martin to Gressoney la Trinité.

Jersey Telephone System.—The Jersey Chamber of Commerce has petitioned the States to acquire the present National Telephone system, and the proposal has been referred to the Public Works committee.

Perth (W.A.) Tramway Strike.—The strike of the tramway employes on the Perth (W. Australia) tramways has been settled.

South Africa.—Electrical plant is being installed in the Utrecht (Natal) Colliery for light and power purposes and also for lighting the town of Utrecht.

Spain.—The August report of the British Chamber of Commerce for Spain says there is an opening in Madrid for electric pumps for raising water to tanks on the roofs of houses, as building is proceeding rapidly and many of the houses are at such an elevation that the pressure in the mains is not sufficient to raise the water above the first floors.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Ayr.—The annual report of the tramways manager (Mr. W. Grant) for the year ended May 15 shows that 3,588,628 passengers were carried (decrease 21,909), and the total car-mileage run was 387,704 (decrease 2,401).

The total revenue was £15,007. 8s., a decrease of £73. 19s. 7d., and after paying expenses and capital charges the net balance was £2,491. 0s. 6d., of which £1,962. 0s. 10d. was carried to depreciation fund, and £528. 19s. 8d. to burgh assessment.

The report of the burgh electrical engineer (Mr. R. Marshall) stated that the number of equivalent 30-watt lamps connected was 68,250, an increase of 6,558. The units generated were 1,763,835, an increase of 77,902. The capital expended was £102,329, an increase of £1,713, and the sinking fund now amounts to £24,060. Mr. Marshall states that Ayr has now a larger number of electricity consumers per 1,000 of population than any other city or town in Scotland. The increase in the number of units sold for private lighting was small, in spite of the fact that a larger number of additional lamps were connected than in some previous years. This was undoubtedly due to the extended use of metal filament lamps. The revenue from private lighting was £8,150; power, £804; public lighting, £3,454; tramways, £2,237; other sources £221, or a total of £14,867, an increase of £1,020. The expenditure amounted to £6,753, leaving a gross profit of £8,113. After paying interest and sinking fund charges (£5,669), there was a surplus of £2,444, which exceeded the surplus of the previous year by £1,020 and was the largest surplus made by the department. Of the surplus £1,200 has been allocated to relief of rates, and the remainder to reserve fund, which now amounts to £1,777. Mr. Marshall is of opinion that all future surplus revenue should go to augment the reserve fund until it reaches a sum sufficiently large to ensure the financial stability of the undertaking.

Both reports have been approved by the Corporation.

Bermondsey (London).—The capital expended on the electricity department at March 31 was £168,134, an increase of £13,024 during the past year.

Revenue from sale of current was £15,831 nett, and total receipts £21,744. Cost of generation was £6,397 (including £2,544 for coal and £1,229 for calorific power derived from the dust destructor), and total expenses £10,948, leaving gross profit £10,796. After providing for interest, instalments of money repaid, &c., and taking into account balance from last account there was a deficit of £1,277. 3,612,558 units were generated, and 3,183,691 units sold (2,626,130 to private consumers and 557,561 to public lamps). There are 175 arc lamps, 217 110-watt, 49 Nernst and 2 carbon filament lamps for street lighting. The total maximum supply demand is 1,445 kw. The estimates for 1910-11 put the anticipated net profit at £666, against £500 in 1909-10.

Cardiff.—The city treasurer (Mr. John Allcock) has issued the accounts of the city for the year ended March 31.

The traffic receipts of the tramways department were £114,306, against £110,489 in 1908-9. The revenue from advertising increased by £784 to £1,879. The revenue for energy supplied to electric lighting account increased from £12,120 to £14,188, the total income being £130,565, increase £6,714. On the expenditure side there was an increase of £845. The gross profit was £56,187, against £50,318; the loan charges amounted to £45,394, and the net profit was £11,032 (an increase of £5,077), of which £6,037 was transferred to depreciation fund and £4,094 to reserve. The total capital expenditure was £778,017, and the net liability £645,024. During the year capital was increased by £45,624.

On the electricity supply department the capital expended was £268,429, an increase of £5,067 during the year. The excess expenditure on capital account is £9,254. The past year's income was £43,195, an increase of £1,219. The expenditure amounted to £28,108, an increase of £2,255, due mainly to the increased supply of energy obtained from the tramways department. The gross profit was £15,087, compared with £16,122. The loan charges amounted to £16,211, leaving a net deficit of £1,124, but there had, on the other hand, been extraordinary items of expenditure, and, taking these into consideration, the surplus for the year was £94.

SPECIAL NOTICE.

NOW READY.—Vol. LXIV. of "THE ELECTRICIAN" (1,085 pages), bound in strong cloth. Price 17s. 6d.; post free, 18s. 6d. Now ready. Cases for Binding. Price 2s.; post free, 2s. 3d.

A complete set of "THE ELECTRICIAN" can be supplied. A number of odd volumes and some odd old back numbers, to help in making up complete sets, are also available.

Handsworth.—The accounts of the electric supply department for the year ended March 31 show a total annual income of £7,813 (against £6,777), including £3,044 from sale of current for private lighting, £1,386 for power, £1,843 for traction and £1,490 for public lighting.

Total expenditure was £3,806, leaving gross profit £4,007, against £3,265. Interest on loans (including tax) was £2,653 and repayment of loan £1,580, leaving (after taking into account £434 from 1909) a balance of £208. The total capital expenditure is £73,478, an increase of £3,076 during the past year. 851,430 units were sold (721,254 to private consumers and 130,176 supplied to the public lamps), against 731,465 in 1909. There are 124 arcs and 247 incandescent lamps for public lighting, and the total maximum supply demanded was 602 kw., against 469 kw.

In the report of the chief engineer and manager (Mr. F. A. Nixon) it is stated that the most prominent feature of the past year was the large increase in the number of consumers connected to the mains—131 against 87 in 1909. Owing to the extended use of metal filament lamps the units consumed had not increased in the same ratio. Efforts are being made to popularise the use of electricity for domestic purposes, and a considerably increased demand for cooking and heating is expected. The hiring and purchase schemes, for which a small loan was sanctioned, have been put into operation, and many residents have availed themselves of the facilities offered. The total works costs per unit sold was 0·67d. (against 0·73d.), the coal cost being 0·28d. (against 0·33d.)

Newcastle-on-Tyne.—The annual report of the general manager of the tramways (Mr. E. Hatton) states that the gross receipts for the year ended March were £209,676, against £209,541.

Working costs were £115,920, against £121,076. Gross capital expenditure (exclusive of public lighting) is £1,170,234, or with public lighting, £1,184,644. Traffic revenue amounted to £203,339, against £203,302, other revenue amounting to £6,337. Operating costs (including lighting) were £117,593, or 56·08 per cent. of total revenue. Gross profit was £92,081 (7·77 per cent. per annum on the average capital), compared with £86,931 (7·35 per cent.). The total amount repaid (by sinking fund instalments, &c.) was £262,144. After contribnting £1,538 to relief of rates, against £1,551, there was a surplus of £15,121 (against £7,558). At the end of the financial year the total of reserve and renewals fund was £72,257 against £62,699. The car-miles run were 4,430,085 against 4,289,997, and the number of passengers carried was 44,516,958, against 44,439,282.

Peterborough.—The total receipts of the electricity department for the year ended March were £7,098. 2s. 1d.

Total expenses were £3,872. 5s. 11d.; and after allowing for bad debts, paying interest and repayments of principal (£3,524. 15s. 5d.), costs of arbitration case with local Electric Traction Co. (£1,016), and for works of extensions, &c., not charged to revenue (£476), the total deficit was £1,801. 1s. 6d. Under the agreement with the Corporation, the Traction Company have the right to demand every five years a revision of the charges for electricity consumed, and as the Corporation and the Company were not able to agree, the case was referred to an arbitrator. That gentleman decided in favour of the Corporation's charge for electricity, but mulct the Council in the costs.

Swindon.—There was a net profit of £717 on the past year's working of the electricity undertaking.

The income showed an increase of £328 over 1909; the working expenses were £4,827 (decrease £992), interest £1,821, sinking fund £1,795, and contribution to reserve £443. There was an increase of revenue from public lighting of £470, and a decrease of £325 on current supplied to the tramways. There were 838 consumers on March 31, and this number had increased to 862 on August 15, the equivalent 8 c.p. lamps being 32,489 and 32,936 respectively. There is also 371¼ H.P. of motors connected. There was a large decrease in the expenses, coal being 0·08d. less per unit sold.

Warrington.—The total revenue of the tramways department for the year ended March was £20,169, including £19,862 traffic revenue.

Total working expenses were £11,406 (6·281d. per car-mile), and gross profit £8,764 (4·827d. per car-mile). Interest was £3,007 and sinking fund £3,007, leaving net profit £2,750, of which £1,000 was applied to relief of rates and £1,750 carried forward. The gross capital expended was £102,128, the same as in 1909. 5,206,980 passengers were carried, and 435,774 car-miles run, and 528,139 units of electric current (1·212 per car-mile) were consumed.

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TRADE NOTES AND NOTICES.

TENDERS INVITED.

Tenders are invited by EDINBURGH Corporation for three steam turbines and d.c. generators, each of 1,200 kw., and condensing plant and interior parts of cooling towers, for their Dewar-place electricity station. Copies of specification, forms of tender, &c., from the engineer, Mr. F. A. Newington, Dewar-place, Edinburgh, and specifications, conditions and drawings may be seen at, but not obtained from, the offices of the consulting engineer, Sir Alexander Kennedy, 17, Victoria-street, London, S.W. Tenders must be delivered at the office of the town clerk, Mr. Thomas Hunter, W.S., City-chambers, Edinburgh, by Monday, Oct. 10. See also an advertisement.

The Electric Light committee of the City of SHEFFIELD invite tenders for supply of steam turbine alternator, exciter, condensing plant, pumps and other accessories, and three water-tube boilers, economisers, induced draught fan, steel chimney, &c. Specifications, forms of tender and general conditions from the general manager and engineer, Mr. S. E. Fedden, Corporation Electric Supply Department, Commercial-street, Sheffield, where tenders are to be delivered by 10 a.m. of Friday, Sept. 30. See also an advertisement.

The Directors of the METROPOLITAN RAILWAY Co. are prepared to receive tenders for the supply of general stores during 12 months ending Oct. 31, 1911. Forms of tender (No. 13, electric wires and cables; No. 14, electric lamps, carbons, switches, fuses, telephones, coils, &c.; and No. 15, insulating materials) from the Secretary, 32, Westbourne-terrace, London, W., on or after Sept. 23. Tenders to the Secretary by 10 a.m., Oct. 3. See also an advertisement.

Tenders are invited for supply of telegraph and telephone cable (schedule No. 284) and insulators (schedules Nos. 373 and 374) to the Postmaster-General's Department, VICTORIA. Tender forms at the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

The Electricity and Tramways committee of the County Borough of NEWPORT (Mon.) invite tenders for material required for the extension of the works in hand, including rubber cables of various sizes, single-phase l.t. and h.t. paper lead-covered cable and e.h.t. cable, welded steel, or solid drawn steam pipes, valves and cast-steel tees, rolled steel girders, c.i. and w.i. switch gallery railing, two c.i. stanchions, motor starters and other switchboard apparatus (l.t.) and c.i. flanged water pipes. Particulars from the borough electrical and tramways engineer (Mr. H. Collings Bishop). Tenders must be delivered to the Town Clerk, Town Hall, Newport, Mon., by first post Tuesday, Sept. 20.

By command of the POSTMASTER-GENERAL tenders will be received until noon, Monday, Sept. 26 for supply of Swedish, Norwegian, Finland or Russian red fir telegraph poles to be delivered at certain ports in the United Kingdom. Forms of tender from the Controller of Stores (Mr. G. Morgan), Stores Dept., G.P.O., 17-19, Bedford-street, London, W.C.

The POSTMASTER-GENERAL also requires tenders (by noon Sept. 26) for creosoting, &c., telegraph poles. Forms of tender, &c., from the Controller of Stores, 17-19, Bedford-street, London, W.C.

BIRMINGHAM electric supply department want tenders by Sept. 30 for 12 months' supply of coal (about 78,000 tons) to the generating stations. Further particulars from the City Electrical Engineer.

RHYL Council invite tenders for 12 months' supply of fuel oil from Oct. 1. Tenders to the Clerk by 26th inst.

Tenders are invited up to noon Oct. 17 for the supply of telegraph and telephone instruments and material (as per schedules 1 to 9) to the Postmaster-General's Department in TASMANIA. Tender forms and specifications at the office of the High Commissioner, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, MELBOURNE, will receive tenders until 3 p.m. Oct. 18 for supply of 23 miles of telephone cable (specification 284) and 500 composition insulators (specification 374) and until 3 p.m. Oct. 25 for 10,000 Cordeau insulators (schedule 373). Specifications, &c., from 72, Victoria-street, London, S.W. Local representation is necessary.

Tenders are invited up to Oct. 5 for the supply of 5,000 porcelain insulators to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone insulators to the Postmaster-General's Department in all the States of the Commonwealth of AUSTRALIA. Tender forms at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 27 for the supply of electric lamps to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to Sept. 20 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA (Australia). Tender forms and specifications from the Commonwealth Office, 72, Victoria-street, London, S.W.

ADELAIDE (S. Australia) Municipal Tramways Trust want tenders by Oct. 11 for supply of 1,750 tons of tramrails, 150,000 dogspikes and 1,200 tiebars and by Oct. 18 for bonding material.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W., and also from Messrs. R. W. Cameron & Co., 23, South William-street, New York, and Mr. H. Stephenson Smith, 244, California-street, San Francisco, Cal. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

The Ministry of Public Works, CAIRO, require tenders for electrical installations and refrigerating plant for the lunatic asylum in course of construction at Khanka. Specifications from the Chief of the Administrative Service, Ministry of Public Works, Cairo. Stamped paper for tenders is obtainable from Mr. A. L. Webb, Westminster, S.W. Tenders by noon Oct. 20. Legal domicile at Cairo is necessary in the case of this contract, and to obtain temporary domicile British firms must, before electing such domicile, formally advise the Consulate at Cairo of intention to do so, formally authorise the Consulate on their behalf and inform the Consulate of the address to which documents should be forwarded.

Tenders are wanted by noon Oct. 31 for supply and erection of machinery, &c., for electricity supply and water supply systems for the town of BENI-SOUEF (Egypt). Particulars may be obtained from Mr. A. L. Webb, C.M.G., Queen Anne's-chambers, London, S.W. Local representation is necessary.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

MOSTAR (Austria-Hungary) Municipality require tenders by Oct. 1 for the installation of electrical generating plant. Specification (in German) can be seen at 73, Basinghall-street, London, E.C.

The "North China Herald" states that SHANGHAI electricity department require tenders by noon Oct. 10 for supply of electric heating and cooking appliances, and by noon Oct. 20 for 10,700 carbon and 15,000 metal filament lamps. Specifications from the Electricity Works, 31, Fearon-road, Shanghai.

TENDERS RECEIVED AND ACCEPTED.

Stockport Council have accepted the following tenders:—

Dussek Bitumen Co., bitumen, £5. 10s. per ton; Morgan Crucible Co., carbon brushes; H. Hollingdrake & Son, 50 draw chairs, 16s. per cwt., iron tubing, nuts, bolts, &c.; J. G. Bradwell, iron castings; British Insulated & Helsby Cables, overhead line materials; Wilkinson, Heywood & Clarke, paints and varnish.

Bradford Corporation are recommended to accept the following tenders for electrical equipment for the Technical College:—

Bruce, Peebles & Co., motor-alternator set, £190; British Westinghouse Co., shunt machine set, £75; Greenwood & Batley, series motor, £29; Lancashire Dynamo & Motor Co., single-phase commutator motor, £53; Phœnix Dynamo Mfg. Co., motor converter set, £105.

Bristol Electrical committee have recently let the following tenders:—

City Glass Co., supply of arc lamp globes for 1910-1911 (£38. 15s.); Siemens Bros.' Dynamo Works, supply of three-phase, e.h.t., l.t. and d.c. switchgear at Dock sub-station (£204. 15s.); Slaughter & Bray, constructional work, &c., at the Exchange, in connection with the offices, show-rooms and stores scheme (£1,372).

The contract for the complete electrical equipment of the Palladium Theatre of Varieties (Argyll-street, London) has been placed with Messrs. Siemens Brothers Dynamo Works, who have sublet the wiring work to Messrs. Rashleigh Phipps & Co.

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Walsall Council have accepted the tender of the British Westinghouse Co. for supplying and fixing rotary converters and switchgear at £1,145, and that of Callender's Co. for supplying and laying h.t. mains at £5,026.

Bristol Electricity committee have accepted the tender of the British Westinghouse Co. for two three-phase 3,000 kw. turbo-alternators at £25,290.

Elland Council have accepted the tender of the Gath Electrical Engineering Co. for tantalum and sun lamps for a year; and that of Sykes & Sugden for 12 straight through boxes.

Whitehaven Corporation has placed an order with Ed. Bennis & Co. for supply of four "Bennis" stokers and self-cleaning natural draught furnaces for B. & W. boilers.

Lowestoft Council have accepted the tender of the Standard Cable Mfg. Co. for a mile of overhead trolley wire at £67, and that of Walter Scott (Ltd.) for 50 tons of tramway rails at £6. 15s. per ton.

Skipton Council have placed an order with J. Banks for an electric lighting installation (including gas engine and dynamo, wiring, fittings, &c.) for the Town Hall.

Stretford Electricity committee have accepted the tender of Bertram Thomas for a battery panel at £36. 15s.

Gosport Council have accepted the tender of W. M. Walters for wiring the Council offices at £56.

BUSINESS NOTICES.

Messrs. Preece & Cardew have made arrangements for Messrs. J. F. C. Snell and S. S. Moore Ede to join them on Oct. 1. Mr. J. H. Woodward, who has been upon the staff of Messrs. Preece & Cardew for the past 12 years, will also become a partner. The partners will be Sir W. H. Preece, K.C.B., F.R.S., A. H. Preece, M.Inst.C.E., J. F. C. Snell, M.Inst.C.E., Llewellyn Preece, M.Inst.C.E., J. H. Woodward, A.M.Inst.C.E., and S. S. Moore Ede, A.M.Inst.C.E. The name of the new firm will be Preece, Cardew & Snell, and the office will remain at 8, Queen Anne's-gate, S.W.

Messrs. Snell & Moore Ede also notify that they have amalgamated with Messrs. Preece & Cardew, and after Sept. 30 all communications for them should be sent to 8, Queen Anne's-gate, Westminster, S.W.

The A.E.G. Electric Co. (Ltd.) are removing to Pembroke House, 133-5, Oxford-street, W. Telegrams: Galvanolon, London; telephone: 8,848 Gerrard.

The Union Electric Co. have transferred their head office to 109, Pitt-street, Sydney, and Mr. E. H. W. Westwood, A.M.I.E.E., has been engaged to control their present Melbourne offices, at 33, William-street.

We are informed that Mr. T. W. Vaughan, who has for the last year acted as works manager to the Vaughan Engineering Installations (Ltd.) has now no connection with the company, and has no authority to act for it in any way.

E.M.F. (Ltd.) have removed to 212-3, Upper Thames-street, E.C., where the business (office, showrooms and stores) is centralised.

The Metallic Seamless Tube Co., Wiggin-street, Birmingham, have made arrangements with the manufacturers to act as wholesale selling agents for "Brimsdown" metal filament lamps. The company will hold stock at their works and at their London and provincial depots.

The London offices of the Rangoon Electric Tramway & Supply Co. have been removed to 3 and 4, Great Winchester-street, E.C.; and Mr. R. L. Spicer has been appointed secretary.

Sale by Auction.—Messrs. Horne & Co., 35, Old Queen-street, Westminster, S.W., will sell by public auction at the Royal Arsenal, Woolwich, on Thursday, 22nd inst., at 11 a.m., unserviceable and obsolete stores, including quantities of iron and steel, brass, copper, gunmetal, lead and antimony alloy, zinc, mixed metal, &c., electric generator, lifting jacks, telegraph and electric light fittings and instruments, 650 electric lamps, 43,450 electric lamp bases, tools, &c. The lots may be viewed at the Royal Arsenal, Woolwich, on Monday, Tuesday and Wednesday, previous to and on morning of sale. Catalogues from the War Office, Whitehall; the Ordnance Office, Tower; and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Business for Sale.—A heating, lighting and ventilating engineering business is advertised for sale in another column.

Plant for Sale.—Northampton Electric Light & Power Co., Northampton, advertise for sale two exhaust steam feed water heaters and two battery charging boosters.

Holophane Reflectors.—Messrs. Siemens Bros. Dynamo Works (Ltd.), Tyssen-street, Dalston, London, N.E., will shortly place on the market a series of 18 new prismatic reflectors of the holophane type, specially suitable for metal filament lamps, and more particularly for "tantalum" lamps. These reflectors will be of handsome appearance and of novel design, the prisms thereupon being of a new shape, ensuring great efficiency as well as good appearance. The reflectors will range in price from 3s. to 12s. each, and the larger and more expensive sizes will be suitable for Messrs. Siemens' new "Onewatt" 100 c.p. lamps, as well as for "Onewatt" lamps of higher c.p. which they hope to place on the market shortly.

CATALOGUES, &c.

Dry Cells and Dry Cell Batteries.—Messrs. Siemens Bros. & Co. have issued a new catalogue dealing with this subject which supersedes that brought out in April of this year. The present issue has been re-arranged and the notes on the employment of dry cells for ignition purposes have, to some extent, been rewritten. New illustrations drawn to scale have been employed throughout.

Optical Pyrometers.—Messrs. Siemens Bros. & Co. have also issued a pamphlet dealing with optical pyrometers, in which they describe the principles of construction of their well-known instruments Besides the standard type, a portable pattern has now been listed.

Union Continuous-Current Motors.—In a pamphlet which they have just sent us the Union Electric Co. describe in great detail the various types of continuous-current motors made by them. These include all sizes from ¼ to 50 h.p., and embody the latest improvements in this class of machine.

Benjamin Wireless Clusters.—The Benjamin Electric Co. have sent us a list which contains illustrations and details of their well-known wireless clusters. The various points of these, which allow efficient and cheap wiring fittings to be obtained, should not be forgotten in the coming lighting season.

Moving Coil Instruments.—We have received from Messrs. Elliott Bros. a leaflet giving details of their portable moving coil instruments. The instrument is contained in a wooden box with a flap lid, and seems to be quite suitable for the work it is designed to do.

Tramway Controllers.—We have received from Messrs. Dick, Kerr & Co. details of their new tramway controller which they have just placed on the market. This contains several points of interest, and we shall hope to describe it in more detail in a later issue.

Sealing-In Machines.—The Foster Arc Lamp & Engineering Co. have sent us a pamphlet dealing with a sealing-in machine which they have just introduced for the manufacture of electric incandescent lamps. This machine is being used by them in their own works for the manufacture of metal filament lamps.

Centrifugal Pumps.—We have received from Messrs. Ernest Scott & Mountain a pamphlet giving full details of their well-known centrifugal pumps.

BANKRUPTCIES, LIQUIDATIONS, &c.

The public examination of Fredk. Peacock, electrician, 59, North Station-road, Colchester, took place last week. Liabilities £228, assets nil.

Debtor had carried on electrical installation business in Colchester for nine years, but had never had any business premises. He had done work for Williams & Co. who supplied him with materials for jobs which he did on his own account, and the work he did for them was set off against cost of materials supplied. They claimed £235, but debtor counter-claimed for £85.

James D. M. Morton, electrical engineer, Nettleton-road, Mirfield, has been adjudicated bankrupt.

The discharge of Alfd. Jas. Hollington, electrical engineer, late of 37, Walbrook, London, E.C., has been granted, subject to debtor's consent to judgment for £25.

The discharge of Geo. Kaye Spivey, formerly electrical engineer, of Market-place, Wakefield, and Bradford-road, Batley Carr, is suspended for two years.

A first dividend of 5s. will be payable on Sept. 21 at 4, Castle-place, Nottingham, to creditors of Thos. Louis Callender (formerly trading as the Shamrock Cycle Co.), electrical engineer, late of Grove-place, St. Heliers, Jersey.

A first and final dividend of 3½d. will be payable at 4, Charter-house-square, London, E.C., on Sept. 26, to creditors of Charlotte Rix (trading as or one of the partners of Bridgewater & Wright), electrical engineer, 78, York-road, King's Cross, London, N.

A first and final dividend of 4s. 10d. will be payable at 1, Cloth Hall-street, Huddersfield, on Sept. 23, to creditors of Harry Graham, electrician, &c., Albion-street, Huddersfield.

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A dividend is to be paid to creditors of Harold Bristow, electrician, &c., 368, Hessle-road, Hull. Claims to Mr. G. H. Acheson, York City Bank-chambers, Hull, by Sept. 20.

The S.M.H. Tramway Synd. (Ltd.) is being wound up voluntarily. Mr. C. Whensa-Nicholl, 13, St. Helens-place, London, E.C., is liquidator.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

*NOTE.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

July 4, 1910.

15,929 NASMITH. (Tito Livio Carbone, Germany.) Enclosing the arc of arc lamps. (Addition to No. 17,448/09.)*
15,933 RUSSELL & HUTSON. Holders for electric incandescent lamps.*
15,938 HOSKINS. Rotary transformer.*
15,977 LEWIS. Electrodes for arc lamps. (Date applied for, 10/8/09, comprised in Application No. 18,649, dated 10/8/09.)

July 5, 1910.

15,988 RAILING & GARRARD. Electric cut-outs.
15,993 ELECTROMOTORS & GREENHALGH. Controlling the speed of electro motors.
15,996 THOMSON. Insulated metallic cable suspender.
16,017 SHAW & GREEN. Detachable power handle for controllers on electric cars, cranes and the like.
16,019 BRITISH INSULATED & HELSBY CABLES & REDFERN. Telephone exchange systems.
16,063 APOSTOLOFF & KARAVODINE. Manufacture of electrodes for secondary batteries or storage cells.

July 6, 1910.

16,093 HALL. Electric ignition apparatus for internal-explosion engines.
16,113 WILKES. Electric switching device.
16,152 MURRAY. Electrical switching mechanism.*
16,172 REEVE. Electrical apparatus.*

July , 1910.

16,211 TAYLOR. Limiting the flow of current on a short circuit.
16,253 CERREOTANI & SILBERMANN. Printing telegraph. (Date applied for, 7/7/09.)*†
16,256 16,259 & 16,260 LAKE. (Standard Chemical Co., U.S.) Production of resinous derivatives for insulating electric cables.
16,257 MERZ. Electric switches.
16,258 KALLMANN. Electric safety-fuses.*

July 8, 1910.

16,329 FRANCIS. Central energy electrical signalling system.*
16,330 & 16,334 GOLDSTEIN & POOL. Central energy electrical signalling system.*
16,331, 16332, 16333 & 16,336 GOLDSTEIN. Electrical signalling system.*
16,337 BRADY & HATRY. Electrical insulators.
16,342 SIEMENS & HALSKE AKT.-GES. Frequency meters for direct reading of or recording the frequency in alternating-current circuits. (Date applied for, 24/7/09.)*†
16,354, 16,356 & 16,364 EISENSTEIN. Producing electrical impulse charges for wireless telegraphy and telephony. (Addition to No. 10,019/08.)*
16,360 CERREOTANI. Wireless-operated electrical signalling indicating or like means. (Date applied for, 24/2/10.)*†
16,367 KELLER-DORIAN. Composite magnets.*

July 9, 1910.

16,404 HILL. Electric cut-outs or fuse switches.
16,419 KRAMER. Inductive wireless telephone installations.
16,424 MILCH. Alternating current dynamo-electric machines of the commutator type.
16,444 HEURTLEY. Telegraphy.
16,541 GRIMM. Electric glow lamps.

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

7,121 BERRY. Distribution of alternating electric current.
12,685 FIELD & FERRANTI. Generation, transmission and distribution of electricity.
14,833 HOLGRAVE-GRAHAM. Electric switches.
14,937 GRÜNWALD. Electrical induction furnaces. (Date applied for, 2/10/08. Addition to 3,599/09.)
15,167 PITTS. Telegraphy.
15,319 PÖHL & PHŒNIX DYNAMO MFG. CO. Dynamo-electric machines constructed with commutators.
15,325 LEITNER. Systems of train lighting.
15,494 CROMPTON & CO., MACFARLANE & BURGE. Motor-control systems and rotary electric transformers or motor-generators therefor.
15,647 LESSING. Manufacture of electric carbons.
15,899 LEITNER. Electric regulators.
15,896 KUTTNER. Insulation of electric conductor windings or coils made of aluminium or aluminium alloys.
16,076 PÖPE'S ELECTRIC LAMP CO. (Trenzen). Production of a metallic connection between incandescent filaments and their leading-in wires.
16,273 FEWTRELL. Electric switches.
17,254 HOFFER & GREENWOOD. Windings for the armatures of dynamo-electric machines and the like.
18,965 B.T.-H. Co. (G.E. Co., U.S.) Electrodes for arc lamps.
19,045 CONRADE. Wall sockets for electric couplings.
21,180 BARBOUR. Flexible electrical brushes or collectors.
22,087 MUNRO & RAILLESS ELECTRIC TRACTION CO. Trolley-arms or collectors for electrically-propelled vehicles running without rails.
22,454 ROYCE & HUTLEY. Electrical capstans, electrical cranes and other electrical hitting, winding or hauling appliances.
23,504 FREDERICKS, FREDERICKS, RUSSELL, WEDDING & CONNELLY. Trolleys for use on electric tramways on the overhead conductor system.
24,373 COLLINS. Electrical switches.
24,735 HARRIS. Electro-deposition apparatus.
25,577 WESTINGHOUSE. Conduits or castings.
28,532 REINISCH & KYNOCH. Electric fuses and detonators.
28,941 B.T.-H. Co. (G.E. Co., U.S.) Systems of electric motor control.
30,142 B.T.-H. Co., GRAY, ROGERS & HOLDEN. Electric meters. (Addition to 12,689/09)

1910 SPECIFICATIONS.

1,611 SIEMENS SCHUCKERTWERKE GES. Alternating-current polyphase commutator dynamo-electric machines. (Date applied for, 16/2/09.)
4,318 THOMSON. Electric circuit-closers.
5,261 ADAMS MFG. CO. (Cutler Hammer Mfg. Co.) Multiple switch devices for electric motors.
7,860 B.T.-H. Co. (G.E. Co., U.S.) Electric heating apparatus.
10,607 ALLGEMEINE ELEKTRICITÄTS GES. Control of electric motors. (Date applied for, 30/4/09.)
12,522 SCHULTZ. Electric switches. (Date applied for, 24/7/09.)

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

ELECTRIC FIRE PREVENTION APPLIANCES & GENERAL MFG. CO. (LTD.) (111,671)—Reg. Sept. 9, capital £1,000 in £1 shares, to carry on the business of electricians, mechanical engineers, manufacturers and generators of electricity, manufacturers of and dealers in apparatus and appliances, &c. Private company.

ELECTRIC POWER PLANTS (LTD.) (111,672.)—Reg. Sept. 9, capital £15,000 in £1 shares, to carry on business of manufacturers of, dealers in and contractors for electric plants, turbines and apparatus, suppliers of electricity, &c., and to adopt an agreement with A. H. Gibbings and P. J. Mitchell. First directors, P. J. Mitchell, C. O. Bastian and A. H. Gibbings. Reg. office, Caxton House, Westminster.

FURNACES (LTD.) (111,612.)—Reg. Sept. 5, capital £12,000 in £1 shares, to carry on the business of furnace manufacturers, electrical and general engineers, founders, &c. Private company. First directors, J. P. O'Donnell and F. E. Jones. Reg. office, Palace-chambers, Westminster.

MORTGAGES AND CHARGES.

ELECTRICAL CONTRACTS & MAINTENANCE CO. (LTD.)—Issue on Aug. 4 of £200 debentures, part of a series of which particulars have already been filed.

CITY NOTES.

MEMORANDA (Sept. 15).—**Bank rate 3 per cent. (since June 9, 1910). Price of silver,** 24½d. per oz. Consols 80¼—80⅜ for money; 80⅜—80⅝ for **account. Consols** Pay Day, Oct. 5; **Stock and Shares Continuation Days,** Sept. 27 and Oct. 12; **Ticket Days,** Sept. 28 and Oct. 13; **Pay Days,** Sept. 29 and Oct. 14; **Mining Shares Carry Over Day,** Sept. 26.

PRICES OF METALS (London).—*Copper*, cash, 55⅛; three months, 55⅛. *Lead*, English, 12¾—13; foreign, 12⅝—12¾. *Spelter*, 23—23¼. *Tin*, English, 156—158; foreign cash, 158; three months, 157¼. *Iron*, Cleveland, cash, 49/3, three months, 50/1.

BROMLEY (KENT) ELECTRIC LIGHT & POWER CO. (LTD.)—The directors have declared a dividend at the rate of 4 per cent. (2s. per share), less tax, on the ordinary shares.

DIRECT SPANISH TELEGRAPH CO. (LTD.)—The directors have decided to pay, in addition to the dividend at the rate of 10 per cent. on the preference shares, an interim dividend at the rate of 4 per cent. (tax free) on the ordinary shares, both for the half-year ended June 30, payable on 1st prox.

MANILA ELECTRIC RAILROAD & LIGHTING CORPN.—A dividend of 1 per cent. has been declared for the quarter ending Sept. 30.

NEW SUPERHEATER CO. (LTD.)—At the statutory meeting on Tuesday the chairman (Sir C. E. Knox) gave particulars of the progress made. He said the Furness Railway Co. had four locomotives fitted with their system, and the company were more than satisfied with the working of the apparatus. The engines so fitted showed a remarkable gain in efficiency, and the coal saving effected was slightly over 18 per cent. The Furness Railway had recently decided to fit up four more locomotives. At present they were in negotiation with about a dozen railway companies English, Colonial and foreign. He looked forward with confidence to big developments in the future.

PUEBLA TRAMWAY, LIGHT & POWER CO.—The report for 1909 states that the results show a considerable improvement over those for 1908, the net profits in Mexico having been £48,677, against £27,354. The development of the Tuxpango Falls has not yet been commenced, but cannot be longer delayed. The growing demands of the City of Puebla, the absorption of the power at present available, and the terms of the company's concession from the city of Puebla make it essential that 15,000 H.P. should be available for sale within the city boundaries by 1913.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted quotations to £3,150,000 4 per cent. preference stock and £3,791,106 4 per cent. debenture stock of the *London Electric Railway Co.* (in lieu of the securities of the Baker Street and Waterloo, the Charing Cross, Euston & Hampstead and the Great Northern, Piccadilly & Brompton Railways, and a further issue of £186,433 Metropolitan District guaranteed stock of the *Metropolitan Railway Co.* The committee have been asked to appoint a special settling day in, and grant a quotation to, a further issue of 62,500 $100 shares of the *Rio de Janeiro Tramway, Light & Power Co. (Ltd.)*

UNITED ELECTRIC CAR CO. (LTD.)—The directors' report for the year ended June 30 states that the works have been efficiently maintained out of revenue. After paying debenture interest (£2,475) and charging £5,586. 15s. 3d. for depreciation, the profit for the year is £8,478. 4s. 1d., to which is added £5,333. 9s. brought forward, making £13,811. 13s. 1d. After deducting the preference dividend for the six months ended Dec. 31, 1909 (£3,000) the available balance is £10,811. 13s. 1d. The directors recommend payment of the preference dividend (less tax) for the half-year ended June (£3,000) and a dividend of 2½ per cent. (less tax) on the ordinary shares for the year (£3,750), carrying forward £4,061. 13s. 1d.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 7	1,509	+ 18	14	22,019	+ 244
Airdrie	„ 2	243	+ 25	35	7,618	+ 49
Anglo-Argentine	„ 9	47,392	+ 6,799	36	1,591 134	+ 189,082
Ayr Corporation	„ 10	337	+ 6	17	7,154	+ 281
Barnsley	„ 2	167	− 6	35	6,072	+ 175
Barrow	„ 2	297	+ 40	35	9,525	+ 1,387
Bath Electric Trams, Ltd..	„ 7	1,035	+ 135	36	29,763	+ 1,563
Birmingham Corporation ..	„ 10	6,688	+ 254	23	156,360	+ 1,918
Birmingham & Midland....	„ 2	874	− 12	35	29,877	+ 450
Blackburn Corporation	„ 7	1,176	+ 24	‡24	26,019	− 1,016
Blackpool and Fleetwood ..	„ 10	1,694	+ 190	..	..	..
Bolton Corporation.....	„ 11	2,838	+ 269	24	56,922	+ 125
Bombay	Aug. 12	2,572	+ 4	32	86,175	+ 6,143
Bournemouth Corporation..	Sept. 7	2,268	+ 189	23	46,721	+ 4,180
Bradford Corporation.....	„ 10	5,315	+ 419	24	121,509	+ 4,033
Brighton Corporation.....	„ 11	1,239	+ 71	§23	25,617	+ 27
Bristol Trams & Carriage ..	„ 9	6,451	+ 925	10	65,395	+ 3,999
Burnley Corporation	„ 10	1,454	+ 57	10	12,965	− 38
Burton Corporation	„ 11	276	+ 9	23	6,427	− 3
Bury Corporation	„ 11	1,253	+ 3	§23	28,118	− 402
Calcutta Tramways Co.....	„ 10	₹54,842	+ ₹3,756	10	₹534,554	+ ₹38 885
Camborne-Redruth	..	..	..	..	..	..
Cardiff Corporation.....	„ 3	2,479	+ 227	23	52,009	+ 211
Cavehill.....	„ 2	93	+ 2	35	3,280	+ 135
Central London Railway ..	„ 10	5,352	+ 384	10	52,212	+ 3,045
Chatham & Dist. Lt. Rys. ..	„ 8	936	− 12	36	30,633	+ 1,015
City & South London Rly...	„ 11	3,165	− 46	10	30,717	+ 158
City of Birmingham	„ 2	2,768	− 21	35	99,829	+ 2,229
Colchester Corporation	„ 7	217	− 2	..	..	..
Cork Electric Trams Co.....	„ 8	593	+ 82	46	17,711	+ 1,718
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams ..	„ 2	456	+ 72	35	14,860	+ 1,960
Dover Corporation	..	..	..	..	..	..
Dublin & Lucan Railway ..	„ 9	178	+ 40	10	1,809	+ 110
Dublin United	„ 9	6,032	+ 615	10	62,633	+ 1,311
Dudley-Stourbridge	„ 2	836	− 56	35	28,005	− 702
Dundee Corporation	„ 7	1,242	+ 35	§16	20,325	+ 318
East Ham Council	„ 10	1,042	+ 31	¶23	24,560	+ 634
Exeter Corporation.....	„ 9	366	+ 3	23	7,878	− 686
Gateshead & Dist. Trams ..	„ 2	1 009	+ 14	35	34,529	− 182
Glasgow Corporation	„ 10	18,626	+ 1,123	15	257,666	+ 13,373
Glossop Trams.....	„ 10	116	− 4	36	4,225	− 257
Gloucester Corpn.....	„ 7	352	+ 57	..	..	..
Gravesend-Northfleet.....	„ 2	226	− 18	35	7,328	− 24
Great Northern & City Rly..	„ 10	1,348	+ 45	10	12,945	+ 444
Greenock & Port Glasgow ..	„ 2	686	+ 54	35	22,173	+ 2,899
Hartlepool Tramways	„ 2	307	+ 41	35	8,819	+ 570
Hastings Elec. Trams Co. ..	„ 8	1,423	− 18	10	14,441	+ 76
Hong Kong	„ 10	$8,368	+ $154	10	$87,569	+ $4 052
Huddersfield Corpn.	„ 10	1,721	+ 35	24	41,424	+ 2,060
Hull Corporation.....	„ 10	2,636	− 3	23	63,144	+ 3,436
Ilford District Council.....	..	..	..	..	..	..
Ilkeston District Council ..	„ 7	133	− 3	23	3,017	− 188
Ipswich Corporation	„ 10	468	− 13	23	10,761	+ 585
Isle of Thanet Co.	..	..	..	..	..	..
Jarrow	„ 2	130	+ 7	35	4,393	+ 245
Keighley Corporation.....	„ 8	189	+ 16	23	4,218	+ 155
Kidderminster & District ..	„ 2	125	− 17	35	3,977	+ 90
Kilmarnock Corporation ..	„ 10	151	+ 5	17	2.697	+ 75
Lanarkshire Trams Co.	„ 8	1,534	+ 103	36	49 981	+ 3,756
Lancashire United	„ 7	1,575	+ 108	36	47,362	− 569
*Leamington	„ 2	185	− 40	35	5,929	− 249
Leeds Corporation	„ 10	7,174	+ 242	23	167,031	+ 5,296
Leicester Corporation.....	„ 10	2,316	+ 153	..	..	..
Leith Corporation	„ 10	629	+ 8	17	11,069	+ 22
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	„ 3	11,077	+ 359	35	391,540	+ 14,197
Liverpool Overhead Rly. ..	„ 11	1,498	+ 79	11	16,343	+ 137
Llandudno&ColwynBayRy. ..	„ 9	589	− 8	§40	12,021	+ 40
*London County Council	Aug. 31	40,468	+ 3,423	¶22	921,566	+ 121.892
London Elec. Ry. Co.....	Sept. 10	11,415	− 20	10	114,145	+ 365
London United	„ 10	6,610	+ 131	36	232,016	+ 9,593
Lowestoft	..	..	..	..	..	..
Maidstone Corporation	„ 10	188	− 29	23	4,291	− 281
Manchester Corporation....	„ 10	16,110	+ 479	23	362,067	+ 6,530
Mersey Railway	„ 10	1,951	+ 5	10	19,431	+ 259
Merthyr	„ 2	212	− 8	35	7,267	− 249
Metropolitan Dist. Railway..	„ 10	10,073	+ 730	10	100.053	+ 6,323
Metropolitan Elec. Trams ..	„ 2	7,740	+ 723	35	260,774	+ 44,673
Middleton	„ 2	306	− 61	35	11.203	− 744
Nelson Corporation.....	„ 10	176	+ 27	§23	3,492	+ 130
Newcastle-on-Tyne Corp. ..	„ 10	3,716	− 34	¶23	92,980	+ 1,040
Newport (Mon.)	„ 10	699	+ 65	24	16,745	+ 680
Northampton Corporation..	„ 9	486	+ 1	§23	11,825	+ 47
Oldham, Ashton & Hyde ..	„ 2	560	− 37	35	19.480	− 143
Oldham Corporation	„ 11	1,859	+ 134	24	45.393	− 884
Perth (N.B.) Corporation ..	„ 7	181	+ 28	§16	3,029	+ 227
Perth (W.A.) Elec. Trams ..	..	..	..	..	..	..
Peterborough	„ 2	130	+ 2	35	4,036	− 71
Portsmouth Corporation ..	„ 10	2.615	+ 130	23	52.743	− 1,568
Potteries	„ 2	1,765	− 65	35	60.994	− 702
Preston Corporation	„ 7	823	+ 39	23	17,212	− 302
Rotherham Corporation....	„ 8	654	+ 72	23	14.473	+ 668
Rothesay	„ 2	345	− 26	35	8,413	+ 23
Salford Corporation	„ 12	4,783	+ 235	†24	111.253	+ 1,608
Sheerness	„ 2	65	− 1	35	1,800	− 13
Sheffield Corporation	„ 11	5,909	+ 409	¶24	145,144	+ 8.580
Singapore Trams.....	„ 10	$10,395	+ $65	10	$91,106	+ $7,508
South Metropolitan.....	„ 2	857	− 84	35	29,206	+ 1,122
South Staffs.....	„ 2	852	− 7	35	29,372	+ 113
Southend Corporation	„ 7	833	+ 124	23	15,893	+ 1,592
Southport Tramways	„ 2	318	− 38	35	10,545	+ 135
Stalyb'dge, Hyde, &c., Jt.Bd.	„ 10	819	+ 23	¶23	17.260	− 1,332
Sunderland Corporation....	„ 11	1,192	+ 101	24	28,152	− 97
Sunderland District	„ 7	438	− 35	45	19,375	− 1,384
Swansea Trams	„ 2	1,173	+ 83	35	38,081	+ 4,234
Swindon Corporation	„ 7	163	+ 22	23	3.325	+ 161
Taunton	„ 2	48	− 8	35	1,502	+ 90
Tynemouth and District....	„ 2	333	− 35	35	9.535	+ 458
Tyneside Trams Co.	„ 7	417	+ 9	10	5 018	+ 344
Wallasey District Council ..	„ 10	1,168	+ 96	§23	23.189	+ 199
Walsall Corporation	„ 10	540	+ 26	36	19,303	+ 833
Warrington Corporation....	..	..	..	..	..	..
West Ham Corporation	„ 1	2,471	+ 59	22	53,105	+ 2,198
Weston-super-Mare	„ 2	322	− 40	35	5,763	− 126
Wolverhampton Co.	„ 2	423	+ 2	35	14,958	+ 313
Wolverhampton Corpn.	„ 7	940	+ 164	..	..	..
*Worcester	„ 2	318	..	35	10.003	+ 172
Wrexham	„ 2	101	− 9	35	3.409	− 30
Yorkshire W.R. Trams	„ 11	1,242	+ 43	37	46,107	..
Yorkshire Woollen District.	„ 2	1.020	− 2	35	34.554	+ 2,788

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Shre	Last Dividend	NAME.	Price Wed., Sept. 14.	Rate per cent. Yielded. £ s. d.	Dividend Due.	Business Week to Sept. 14. Highest.	Lowest.
		Electricity Supply.					
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	8¾—9¼	5 16 0	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.....	9 —9⅛	4 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 13 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	102	..
5	4/6	Brompton & Kensington Elec. Sup. Ord. ..	6¾—7¼	6 9 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.....	6¾—7¼	4 15 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾—3¾	6 5 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 14 0	Feb., Aug	4⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 0	..	102½	101½
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¾—4¼	5 9 6	Jan, July	3¾	..
5	2/6	Chelsea Electric Supply Ord.....	3¾—4¼	5 4 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	City of London Electric Lighting Ord.	11¼—11⅝	6 9 0	Feb, Aug	11½	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11½—12¼	4 18 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 —124	4 0 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99½—102½	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.....	1¼—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾—3¼	7 14 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7¾—7¾	6 7 6	Feb, Aug	7⅞	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅜—11½	5 8 0	Mar, Sept	11	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104½—107½	4 3 6	Jan, July	106½	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	102½	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4¼—4¾	5 15 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5¼	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	99 —102	4 8 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.....	7 —7¼	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.....	6½—7¼	5 6 9	Feb, Aug	7	..
5	6%	Do. 6 per Cent. 1st Pref	5¼—6¼	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1¾—2	4 10 0	Mar, Sept	..	..
5	3/0	†Do. 6 per Cent. Pref.....	4⅜—5⅜	5 15 6	Mar, Sept	4⅜	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/0	Metropolitan Electric Sup. Ord.	3¼—3¾	6 13 3	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	4 —4½	5 0 0	Jan, July	4⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95½—97½	4 12 6	June, Dec	..	..
5	1/6	Newcastle Elec. Supply Ord.....	3¼—4¼	4 11 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾—4¾	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	100 —102	4 8 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	..	..
5	4/6	Oxford Electric Ord.	6¾—6¾	5 2 0	March	6¾	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7¼—8¼	6 2 3	Feb, Aug	7⅛	7¼
5	3/6	Do. 7 per Cent. Pref.....	6¾—7¼	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1¾—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2¾—3	6 4 6	April	2¾	..
St.	5%	Do 5 % 1st Mort. Stock (red.).....	99 —102	4 19 0	..	..	..
1	..	¶South Metrop'n Elec. Lt. & Power Ord.	⅞—1	..	..	..	..
1	0/8½	†Do. 7 per Cent. Cum. Pref.	⅞—1⅛	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.).....	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	¾—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2¼	..	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.....	8 —8½	5 17 9	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5¼	4 2 0	Jan, July	5⅛	..
		Electric Railways and Tramways.					
1	..	Bath Elec. Trams Pref. Ord.....	⅞—⅞	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	¾—⅞	6 13 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)‡	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	80 —83	5 8 6	Jan, July	82	..
10	6%	Bristol Tramways & Carriage Ord.	6 —6½	9 4 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7¼—7¾	5 8 6	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¾—1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅛—2⅝	..	Feb, Aug	2⅝	2⅞
St.	5%	Do. 5 per Cent. Perpetual Debs	89 —93	5 6 6	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	70 —75	6 0 0	May, Nov	74½	£3
St.	3%	Central London Ordinary Stock	63 —65	4 12 6	Feb, Aug	£3½	£3
St.	4%	Do. 4 per Cent. Pref. Stock	84 —86	4 14 6	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	47 —49	4 2 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	101⅛	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5¼	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	98 —102	3 18 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord. ..	27½—28½	5 3 0	Feb, Aug	28¼	27⅞
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —105	4 15 6	Feb, Aug	104½	1.4½
St.	5%	Do. (1901)	99 —102	4 18 0	Feb, Aug	..	..
St.	5%	Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.....	99 —101	3 19 0	May, Nov	..	..
10	6/0	Dublin United Trams. 6 per Cent. Pref....	12½—13½	4 6 6	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾—1	..	Feb, Aug	⅞	..
5	..	Hastings & District Elec. Trams, 6% C. P.	¾—1¼	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3¼—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	65 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1⅛—1⅜	3 12 9	Mar, Sept.	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —75	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅞—10	5 10 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan, July	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2¼	..	Jan, July	2⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	67 —71	5 12 6	Jan, July	70½	67½
St.	..	Mersey Con. Ord. Stock	2¼—3½	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.....	⅝—¾	..	..	..	..
1	..	Do. Deferred	⅜—½	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—⅞	5 6 8	Feb, Aug	⅞	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	98 —99	4 11 0	Jan, July	97½	97½
St.	..	Do. 5 per Cent. Db. Stk	97½—99½	5 0 6	..	97½	..
St.	1½%	Metropolitan Railway Consolidated.....	37¼—39½	2 19 0	Feb, Aug	38½	37⅜
St.	2½%	Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	65½	65⅜
St.	3½%	Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	88⅜	87½
St.	3½%	Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	85	84
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	92½	91⅛

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

LAST DIVIDEND	NAME.	Price Wed. Sept. 14.	RATE PER CENT YIELDED	DIVIDEND DUE.	BUSINESS WEEK TO SEPT. 14. High- est.	Low- est.	SHARE	LAST DIVIDEND
	Electric Railways and Tramways— *Continued.*		£ s. d.					
3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock.	90 —92	3 15 6	Jan, July	..	..		
..	Metropolitan District Railway Ord.	21½—21¾	..	Feb. Aug	21½	21¾	100	2$
3%	Do. 4½% First Pref.	78 —80	1 17 6	Feb, Aug	79½	78½	..	4%
3½%	Do. Assented Ext. Pref. (Int. Guar. b)				..	..	St.	4%
	Und. Elec. Rlys. Co. of London, Ltd.				..	..	St.	5%
3%	Do. 3 per Cent. Consoltd. Rent-charg	71 —73	4 16 0	Feb, Aug	78	73	5	5/0
4%	Do. 4 per Cent. Midland Rent-charg.	74 —76	3 19 0	Jan, July	74½	73½	5	5/0
6%	Do. 6 per Cent. Perp. Deb. Stock	100 —103	4 0 0	Jan, July	..	..	1	0/7½
4%	Do. 4 per Cent. Ditto	140 —142	4 4 6	Jan, July	..	..	1	0/6
4½d.	Potteries Electric Traction Ord.	95 —97	4 2 6	Jan, July	95½	..	St.	6%
0/6	Do. 5 per Cent. Cum. Pref.	½—¾	..	April, Oct	..	..	St.	6%
4½%	Do. 4½ per Cent. Deb. Stock	½—¾	..	Feb, Aug	..	..	10	6/0
7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref	82 —85	6 14 0	May, Nov	..	..	10	6/0
4%	Do. 4 per Cent. Deb. Stock	½—¾	5 5 3		..	..	5	2/6
5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb	66 —70	..		..	..	St.	3½%
	Undergd E. Rys. Lon. 6% In. bds. withcoup.	38 —40	5 14 0	Jan, July	..	..	St.	4%
	Do. 5% Prior Lien Bonds	103 —104	8 4 0	Jan, July	39½	38½		4½%
	Do. 4½% Bonds with coup. 6	93 —95	4 16 0	June, Dec	103½	103½	1	1/0
	Do. 4 per Cent. 1st Power Ho. Dbs.	98 —100	4 16 0		..	..	1	0/7½
	Yorkshire (W.R.) Elec. Trams. Ord.	½—¾	4 0 0		94½	93½	St.	4%
	Do. 6 per Cent. Cum. Pref.	½—¾	..		..	..	St.	4½%
	Do. 4½ per Cent. 1st Debs.	1½—2½	..	March ..	1½	..	5	5/0
		77 —80	5 12 6	Jan, July	..	..	5	2/6
							St.	4½%
	Electric Manufacturing, &c.							
4½%	Anchor Cable Co. 4½ % Deb. Stock	100 —102	4 9 0		..	..	5	3/0
..	Aron Electricity Meter Ord.	¾—¾	..		..	..	10	5/9
1/9½	Do. 6% Cum. Pf.	¾—¾	6 16 0	April, Oct	..	..	10	3/0
3/2½	Babcock & Wilcox Ord.	5½—5¾	4 5 6	April, Oct	..	..	10	6%
0/7½	Do Pref.	1¼—1⅜	3 16 3		..	..		
6/0	British Insulated & Helsby Cables Ord.	7 —7½	6 13 6	July, Feb	..	..		
3/0	Do. 6 per Cent. Pref.	6 —6½	4 12 0	Jan, July	102½	..	5	2/6
4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	..	..	5	2/6
4½%	†British Thoms'n-Houst'n 4½% 1st Mt. Db	98 —101	4 12 0	Mar, Sept	..	..	St.	4½%
6%	British Westinghouse 6 per Cent. Pref.	⅞—1	..	Feb, Aug	..	..	St.	4½%
4%	Do. 6 per Cent. Prior Lien Dbs. (rd.).	100½—103	5 17 6		..	..	St.	5%
4½%	Do. 4 per Cent. Mort. Deb. Stock	61 —63	3 3 6	Jan, July	..	..	5	4/0
4½%	†BrushE. Eng. Co. 4½% Perp. 1st Deb. Stocl	37 —42	10 14 0	Mar, Sept	..	..	5	2/6
4½%	Do. Perpetual 2nd Deb. Stock	22 —26	17 6 0	Jan, July	..	..	St.	4½%
4½%	Callender's Cable Con. Ord.	9½—9¾	7 12 6	Jan, July	..	..	St.	8%
10/0	Do. 5 per Cent. Cum. Pref.	4½—5¼	4 15 0	Jan, July	..	..	St.	£3
2/6	Do. 4½ per Cent. 1st Mort Debs. (red.).	102 —104	4 6 6	Nov, May	3½	2½	St.	5%
4½%	Castner-Kellner Alkali Co.	2½—3½	4 14 6	May, Nov	106	..	40	4½%
1/3	Do. 4½ per Cent. 1st Mort. Deb. (red.).	101 —107	4 4 0	Feb. Aug	..	..	100	4½%
4½%	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	5 19 0	March ..	..	..	St.	4½%
1/0	Consolidated Electrical Co.	⅛—¼	5 18 9	August ..	..	..	St.	5%
0/8½	Consolidated Signal Co.	⅛—¼	5 12 0	April, Oct	..	..	St.	6%
0/6	Do. 6 per cent. Cum. Pref.	⅛—¼	6 8 0	April, Oct	..	..		
0/7½	Crompton & Co (Nos. 1 to 85,000)	½—¾	15 0 0	Jan, July	..	..		
..	Do. 5 per Cent. 1st Mort. Debs. (red.).	83 —86	5 16 0	Jan, July	..	..	5	2/6
5%	Davis & Timmins	½—1½	..	Mar, Sept	..	..	100	2/6
0/7½	Dick, Kerr & Co. Ord.	1 —1½	5 7 0	Sept. ..	..	..	1	4½%
1/2½	Do. 6 per Cent. Cum. Pref.	¾—1⅛	5 1 0	Sept ..	1⅛	..	St.	5%
0/7½	Do. 4½ per Cent. Deb. Stock	98 —101	4 9 0	Jan, July	..	..	5	1/3
4½%	Edison & Swan United ("A" Sh.) (£3 pd.	⅛—¼	..	Feb, Aug	..	..	St.	4½%
..	Do. (£5 paid)	1 —1½	9 3 0	Feb. Aug	..	..	St.	5%
4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..	100	5%
5%	Do. 5 per Cent. 2nd Deb. Stock	79 —82	6 2 0	Mar, Sept	..	..		
..	Edmundson's Elec. Corp. Ord.	⅛—¼	..	Jan, July	1½	..	1	5%
..	Do. 6 per Cent. Cum. Pref.	½—2	..	May, Nov	..	..	1	..
5	Do 4½ per cent. 1st Mort. Deb. (red.).	75 —78	5 15 6	Jan, July	..	..	100	5%
4½%	Electric Construction Co.	⅛—¼	..	Jan, July	..	..	5	6%
2	Do. 7 per Cent. Cum. Pref.	1½—1¾	4 13 6	J ily	..	..	5	0/7½
2/9½	General Electric (1900) 5% Cum. Pref.	59 —63	6 5 0	Jan, July	..	..	100	0/7½
4%	Do 4 per Cent. 1st Mort. Debs.	7½—8	6 5 0	June, Dec	..	..	St.	5%
5/0	†Henley's Telegraph Works Ord.	82 —86	4 13 0	Mar, Sept	12½	12½	St.	5%
4%	†Do. 4½ per Cent. Pref.	12 —12½	5 17 6	Feb, Aug	..	..	100	5%
5/0	Do. 4½ per Cent. 1st Mort. Deb. Stock	4½—5½	4 3 0	Feb, Aug	..	..	100	5%
4½%	India Rubber, Gut. Per., &c., Works	105 —103	4 3 6	Mar, Sept	14½	..	100	$1½
5/0	Do 5 per Cent. Cum. Pref.	14½—15	6 12 0	Feb, Aug	..	..	St.	5%
5/0	Do. 4 per Cent. Debs. (red.)	10½—11	4 14 0		..	..	St.	6%
4%	National Elec. Construction Co.	97 —99	4 1 0	April. Oct	..	..	St.	4½%
..	Richardsons, Westgarth & Co., Ltd. Ord	⅛—¼	..	April	..	..		
..	Do. 6 per Cent. Cum. Pref.	⅛—¼	..	Nov	..	..		
..	Do. 4½ per Cent. Perp. Deb. Stock	⅛—¼	..	May, Nov	..	..	St.	4½%
4½%	Simplex Conduits Ord.	78 —83	5 8 6	Jan, July	..	..	1	0/6
..	Do. 6 per Cent. Cum. Pref.	1½	..	..	..	..	St.	5%
2/0	Telegraph Construction & Maintenance	5 —5½	..	..	..	..	5	3/0
4%	Do. 4 per Cent. Deb. Bonds (1909)	35 —37	5 10 3	Mar, July	..	..	36	35½
5/0	Vickers, Sons & Maxim, Ltd., Ord.	101 —103	3 17 6	Jan, July	..	..	St.	4½%
1/0	Do. 4 per Cent. Deb. Stock	2¼—2⅜	4 5 0	..	..	..	100	$1½
0/6	Do 5 per Cent. non-Cum. Preference	1⅝—1¾	4 1 0	..	..	..	100	5%
5%	Do 5 per Cent. non-Cum. Preferred	107 —110	4 12 0	..	..	..	100	5%
4%	Do 5 per Cent. 1st Mort. Db. Sk. (red	102 —104	3 17 0	June, Dec	..	..	..	$2½
4½%	Do 4 per Cent. 1st Mort. Deb. (red.	104 —106	4 5 0	June, Dec	165½	..	..	5%
5%	Do. 4½ per Cent. 2nd Mort. Deb. (red.	105 —107	4 13 6	..	..	..	100	4½%
10%	Do. 5 per Cent. 3rd Mort. Debs Scrip	12½—13½	7 8 0	..	..	..		
..	J. G. White & Co. 6% Cum. Pref.	⅛—¼	..	Apr, Oct	..	..		
1/6	Willans & Robinson Ord.	1½—1¾	10 13 6	Apr, Oct	..	..		
4%	Do. 6 per Cent. Cum. Pref.	60 —70	5 14 0	May, Nov	..	..		
	Do. 4 per Cent. 1st Mort. Debs.						5	3/0
							10	6/0
	Telegraphs.						St.	4½%
		3½—4	..	..	..	..	St.	5%
10 ..	Amazon Telegraph	95 —97	4 17 6	June, Dec	..	..	5	4/9
100 20/2	Do. 5 per Cent. Debs. (red.) Scrip	68 —70	5 5 6	Jan, July	68½	67½	5	7/2½
St. 15/0	Anglo-American	110 —112	5 7 0	F,My,Ag,N	111½	110	100	$3½
St. 30/0	Do. Preferred	27½—27¾	4 12 6	F,My,Ag,N	27½	27½	100	5%
St. 25/0	Do. Deferred	85 —87	4 12 0	F,My,Ag,N	85½	85½	100	
St. 4%	Commercial Cable 4 per Cent. Deb. Stk.	8½—9½	6 2 6	Jn,Ap,Jy,O	8½	..	500	5%
10 6/0	Cuba Submarine Ord.	16½—17½	5 15 0	Feb, Aug	..	..	St.	5%
10 10/0	Do. Preference 10 per Cent.	3½—3¾	5 13 0	Feb, Aug	..	..	St.	5%
5 2/0	Direct Spanish Ord.	8½—8¾	5 8 0	April, Oct	..	..	5	..
5 5/0	Do. 10 per Cent. Cum. Pref.	100½—102½	4 17 6	April, Oct	..	..	5	..
50 4½%	Do. 4½ per Cent. Deb.	16½—16¾	5 8 0	Jan, July	16½	16	10s	1
20 6/0	Direct United States Cable	101 —102	4 8 0	Jan,Ap,Jy,O	..	..	1	0/7½
100 4½%	Direct West India Cable 4½% Rg. Db. (rd.).	133 —136	5 4 6	June, Dec	134½	133½	..	5%
St. 25/0	Eastern Ordinary	8½ —86	4 1 6	Ja,My,Jy,O	84½	..	5	..
St. 17/6	Do. 3½ per Cent. Pref. Stock	102½—104½	3 17 9	Ja,My,Jy,O	..	..	St.	5%
St. 4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	12½—13½	5 6 0	May, Nov	13	12½	St.	5%
St. 2/6	Eastern Extension	130 —102	3 18 0	Ja, Ap, Jy, O	101½	100½	500	5%
100 4%	Do. 4 per Cent. Deb. Stock	100 —102	3 18 0	Feb, Aug	100	..	..	
25 4%	Eastern and S. Af., 4% Mauritius Sub. Debs	30 —31	5 16 6	May, Nov	54½	..	St.	$1
10 5/0	G.N (of Copenhagen), with Coupon 80	53 —55	5 18 6	Jan, July	..	..	St.	$3½
25 52/6	Indo-European	96 —90	5 11 0	May, Nov	..	..	500	5%
100 5%	Mackay Companies Common	74 —73	5 2 6	Ja,Ap,Jy,O	..	..	100	$1½
100 4%	Do Preference	½—¾	..	Ja,Ap,Jy,O	..	..	St.	£9
1 ..	Marconi's Wireless Teleg. Co.	98 —100	4 0 0	April	..	..	St.	6%
100 4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	1½—1¾	4 7 0	June, Dec	..	..	St.	5%
2½ 1/3	West Coast of America	9⅝—100	4 0 0	May	..	..	5	3/0
100 4%	Do. 4 per Cent. Debs.	1½—1¾	..	Jan, July	1½	..	5	3/0
10 6/0	West India & Panama	9 —9½	6 0 0	May, Nov	9½	8½	5	3/0
10 9/0	Do. 6 per Cent. 1st Pref.	9 —10	6 0 0	May, Nov	..	..	100	$1
100 5%	Do. 6% 2nd Pref.	101½—103½	4 16 6	May, Nov	..	..	..	5%
10 3/0	Do. 5 per Cent. Debs.	13½—14½	4 16 9	Jan, July	14½	13½	St.	4½%
St. 4%	Western Telegraph	100 —102	3 19 0	Mr, Jn, O, D	..	..	St.	4½%
	Do. 4 per Cent. Deb. Stock (red.)	103 —106	3 15 3	June, Dec	..	..	St.	6d.
	Do. 4 per Cent. Deb. Bds							

NAME.	Price Wed., Sept. 14.	RATE PER CENT. YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO SEPT. 14. High- est.	Low- est.
Telephones.		£ s. d.			
Amer. Telephn. & Telegh. Cap. St.	138 —141	5 13 6	Jan, July	..	..
Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 7 3	..	..	..
Do. 4% Cons. Bonds 1936	102 —104	3 15 6	Mar, Sept	102⅜	..
†Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —103	4 17 0	August ..	..	..
Chili Telephone	9⅛—9½	4 1 0	Nov	..	..
Monte Video Telephone Ord.	⅜—½	6 0 0	May, Nov	..	..
Do. 5 per Cent. Pref.	⅜—½	5 12 0	Feb, Aug	105½	104⅜
National Co. Pref. Stock	104½—106	5 13 6	Feb, Aug	123½	123
Do. Def. Stock	123 —125	4 17 6	Feb, Aug	..	..
Do. 6 per Cent. Cum. 1st Pref.	10 —10½	5 8 6	Feb, Aug	..	..
Do. 6 per Cent. Cum. 2nd Pref.	10 —10½	5 8 6	Feb, Aug	..	..
Do. 6 per Cent. non-Cum. 3rd Pref.	5⅛—5⅜	4 8 0	June, Dec	..	..
Do. Deb. Stock 3½ per Cent. (red.)	98 —100	3 10 0	Jan, July	99⅜	..
Do. 4 per Cent. Deb. Stock (red.)	99 —101	3 19 0		99½	99
New York Telephone Co. 30 yr. Bnds.	99 —100	4 10 0		1⅜	1⅜
Oriental	1¼—1⅝	4 13 9	April, Oct	..	..
Do 6 per Cent. Cum. Pref.	1¼—1⅝	4 11 0	April, Oct	..	..
Do. 4 per Cent. Red. Deb. Stock	8⅝—8¾	4 10 6	Jan, July	..	..
Telephone Co. of Egypt 4½% Db. Stk. (red.)	99 —101	4 9 0	Jan, July	..	..
United River Plate Ord. ex rights	7⅛—7½	5 8 9	July	5⅛	5⅛
Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 9 9	June, Dec	..	..
Do. 4½ Deb. St. Red.	102½—104½	4 6 0	Jan, July	..	..
Financial, Investment, &c.					
Elec. & Gen. Investment 6% Cum. Pref.	2⅝—3⅛	9 4 6	Jan, July	10⅛	10⅛
Globe Telegraph & Trust	10½—11	5 7 6	Sp, DcMr Ju	13⅛	13⅛
Do. 6 per Cent. Pref.	13½—13¾	4 7 0	Sp, DcMr Ju	..	..
Submarine Cables Trust (Cert.)	132 —135	4 9 0	April, Oct	..	..
Colonial and Foreign Electric Railways, Tramways, &c.					
Anglo-Argentine 5% Cum. 1st Pref.	4½—4¾	5 5 0	April, Oct	4½	..
Do. 5% Cum. 2nd Pref.	4½—4¾	5 11 0	Jan, July	..	..
Do. 4% Deb. Stock	91⅜—93	4 6 0	June, Dec	92½	92
Do. 4½% Deb. Stock	94 —97	4 13 0	..	96	95½
Auckland Elec. Trams. 5% Deb. (red.)	103 —105	4 15 3	Jan, July	105	..
Brisbane Electric Trams. Invest. Ord	5⅛—6½	5 19 0	May	..	..
Do. 5 per Cent. Cum. Pref.	4½—5¼	4 15 0	May, Nov	..	..
Do. 4½ per Cent. Db. Prov. Certs.	99 —102	4 8 6	Jan, July	..	..
British Columbia El.. Rly. Df. Ord.	143 —147	5 9 0	Mar, Sept	145½	144
Do. Pref. Ord. Stock and bonus	124 —129	4 13 9	May, Nov	126	..
Do. 5% Cum. Perp. Pref. Stock	111 —114	4 7 6	Jan, July	112½	111½
Do. 4½ per Cent. 1st Mort. Debs.	102 —104	4 6 6	April, Oct	..	..
Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	105	105
Do. 4½% Perp. Con. Deb. St.	105 —107	3 18 0	..	98½	98½
Buenos Ayres Lacroze Trams 1st Mt. Db	98 —100	5 0 0	Mar, Sept	..	..
Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	96 —99	6 1 0	Feb, Aug	..	..
Calcutta Tramways (1 to 137,610)	4½—4¾	4 12 6	Mar, Sept	4⅜	..
Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	Jan, July	..	..
Do. 4½% 1st Deb. Stock (red)	96 —99	4 11 0	Jan, July	..	..
Cape Electric Tram Shares	⅝—⅞	..	..	⅝	..
City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 5 6	F,My,A,N	5⅛	5⅛
Dc 4 per Cent. Deb. Stock	99 —102	3 18 0	June, Dec	..	..
Colombo Tr. & Ltg. 5% 1st Mt. Db.	97 —100	5 0 0	May, Nov	..	..
Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	93 —101	5 4 0	Feb, Aug	..	..
Kalgoorlie Elec. Trams Sh.	⅜—⅝	..	..	..	..
Do. 5 per Cent. "A" Deb. Stock	92 —95	5 5 0	Jan, July	..	..
Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
Lisbon Elec. Trams. Ord.	1⅛—1⅜	4 8 0	July	..	..
Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 16 0	Jan, July	..	..
Do. 5 per Cent. Reg. Mort. Debs.	98 —102	4 18 0	Jan, July	..	..
Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	88	..
Manaos Trams and Lt. Co. 5% Debs	86½—88	5 13 6	..	..	..
Manila Elec. Ry. $1,000 Gold Bonds	97 —99	5 1 0	Feb, Aug	129½	123⅜
Mexico Trams Co. Com. St.	127½—129½	5 0 6	..	98½	97½
Do. Gen. Con. 1st Mort. 5% Gold Bds.	97½—98½	5 0 6	..	101	100½
Do. 6% 50 yr. Mort. Bds.	100½—101½	5 18 6	..	..	..
Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 0	Feb, Aug	103½	..
Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	..	..
Perth Elec. Trams Ord.	⅜—½	5 14 5	May	..	..
Do. 1st Mt. Db. Stock	100 —103	4 17 6	Jan, July	..	..
Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 3 9	..	..	..
Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	101½	99⅛
Rio Janeiro Tram, Lt. & P. Co.	103½—101½	4 9 0	..	99½	99
Do. 30 yr. Gold Bnds.	98½—99⅜	5 0 3	..	93½	91½
Do. 50 yr. Mt. Bnds	92½—93½	5 7 0	..	..	..
Sao Paulo Tramway, Light & Power Co. $100 Stock	156 —158	6 6 8	June, Dec	156½	154½
Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	Feb, Aug	102	101½
†Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	..	..	..
Colonial and Foreign Electricity Supply, &c.					
†Adelaide Elec. S'ply Co. 6% Cu. Pr.	5½—6	5 0 0	Mar, Sept	..	..
Bombay E.S. & T. 6% Cm. Pf.	10⅜—11½	5 6 6	Jan, July	..	..
Do. 4½ per Cent. 2nd Mort. Deb. Stock	93½—95½	4 14 0	..	..	..
Do. 5 per Cent. 2nd Mort. Deb. Stock	97 —99	5 1 0	April, Oct	6⅜	..
Calcutta Elec. Supply Ord.	6⅛—6⅜	6 6 0	..	11⅜	..
Canadian Gen. Elec. Co. Com. St.	110 —114	6 3 0	..	..	..
Do. 7% Cm. Pf. Stock	120 —123	5 14 0	..	121½	..
Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	85½	85½
†Elect Development Co. of Ontario	82½—85½	5 17 0	..	..	..
Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	85 —88	5 14 0	Jan, July	..	..
Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
Do. 6 per Cent. Cum. Pref.	8 —8½	5 2 6	April, Oct	8⅜	..
Kaministiquia Power Co. 5% Gold Bnds.	100½—102½	5 0 6	..	102	..
Madras E. S. Corp. Ord.	2¾—3	..	..	..	..
Melbourne E. S. Co. 6% Cum. Pref.	33 —38	..	..	..	..
Do. 5% 1st Mortg. Deb. Stock	90½—92½	5 9 0	..	..	..
Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	89½—90½	5 11 6	..	99	88⅜
Mexican Lt. & Power Co. Com. St.	88 —90	4 9 0	..	85⅜	85
Do. 7% Cum. Pref. St.	108 —110	6 7 0	..	109½	109
Do. 5% 1st Mort. Gold Bnds.	94½—95½	5 5 0	..	95	95
Montreal Lt. Ht. & Power Co. Cap. St.	135 —140	5 0 0	F,My,A,N	139	..
River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	216	..
Do. 6 per Cent. non-Cum. Pref. Stk.	105 —115	5 5 0	May	..	..
Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
Rosario Ele. Co. Ord.	8½—9	..	..	..	..
Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
Do. 2nd Pref.	8½—8¾	6 14 6	..	..	..
Shawinigan Water & Power Co. Ca.	103 —105	3 15 0	..	109½	109
Do. 5 per Cent. Bds.	108 —110	4 19 0	Jan, July	..	..
Do. 4½ Per Con. Mt. Db. St.	102 —104	4 6 0	..	..	..
Toronto Power Co. 4½% Db. St.	100 —102	4 8 0	..	..	..
Victoria Falls Power Co. Pref. (1 to 808,000)	⅜—½	5 6 6	Jan, July	..	..
Do. (80 1 to 1,700,000)	..	..	..	..	..

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,688. [No. 24. Vol. LXV.] FRIDAY, SEPTEMBER 23, 1910. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 12 cents, or 90c., or 80pf.

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NOTES.

Tariffs and Metal Filament Lamps.

THE announcement that the Metropolitan Electric Supply Co. have decided to raise the price of electrical energy, supplied on the flat rate, from 5½d. to 6d. will probably come as a surprise. The reason given for taking this step is that consumers making use of metal filament lamps require so much less energy than hitherto that it has become necessary for the price to be raised. We cannot help thinking that this is a retrograde step, more particularly as 5½d. cannot be considered a low price. As an alternative—and perhaps this step has been taken partly to force attention to the alternative—it is announced that a "telephone tariff," somewhat similar to that in force in St. Marylebone, is to be available to consumers. There is, however, rather an important difference between the proposed tariff and that in St. Marylebone, for in addition to the fixed annual charge payable in quarterly instalments a predetermined number of units, depending on the installation, is to be charged at 2d. per unit, and all additional units will then be charged at 1d. This complicates matters somewhat. It has the advantage, presumably, that the quarterly instalments are lower, and, consequently, the consumer will feel that he is not parting with too much money in advance. On the other hand the complication is a disadvantage. We incline to the view that if the telephone form of tariff is to be modified it would be much better to omit the fixed annual charge, and merely to charge a predetermined number of units per quarter at a higher price, such as 6d. per unit, all units in excess being charged at 1d. In any case the fixed annual charge depends upon the character of the installation, and therefore there is very little to support the criticism that the fixed number of units cannot be equally well so determined.

Science and Industry.

IN the concluding portion of his Paper on "The Relations of Science to Industry and Commerce," of which we give an abstract in our present issue, Mr. R. BLAIR makes a suggestion with the object of bringing technical colleges into closer touch with industrial works. The suggestion is that an Advisory Committee should be attached to all specialised faculties or departments, such committees to consist of industrial leaders or experts of the highest reputation. By so doing, the curriculum and examinations would be subjected to sympathetic criticism by experts of the first rank, and a medium of communication would be provided between the college and the workshop. Mention is made that on the Examining Committee of the Glasgow and West of Scotland Technical College are the engineering director of the Fairfield Shipbuilding & Engineering Co. and the engineering director of Messrs. John Brown & Co., who own the Clyde Bank Shipbuilding and Engineering Works. We think there is much to be said in favour of the suggestion, provided it is not carried too far and that it does not produce a committee which is unwieldy for the purpose.

FOR this method to be successful it would be essential that the right men should be upon the committee. If an attempt were made to obtain the services of what may be termed the engineering leaders in large manufacturing concerns, it is possible that such men would not be the most suitable for the purpose, because they might be out of touch with the students entering their works. The men whose opinions are really most desirable in this connection are those in contact with the students during their first few years in the works. For this reason it is just possible that a better result would be obtained if the teacher himself were enabled to get into touch with members of the staff occupying lower positions than the directors contemplated by Mr. BLAIR.

IN the discussion which followed the Paper it was noticeable that speakers were inclined towards the idea that our employers are not so bereft of science as some critics would have us believe, and that irritation is often created by the idea that the scientific man can merely, on account of his science, instruct the manufacturer as to how

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his business should be run. This attitude of mind is not favourable to progress, and we are glad to see that it is breaking down. Among the suggestions made during the discussion, the remark of Sir WILLIAM WHITE, that post-graduate courses were often better taken in the works themselves, is worthy of notice. Sir WILLIAM also strongly advocated the multiplication of research laboratories in the works, and quoted, as a striking example of the success of this system, the research laboratories at Essen, in which Sir WILLIAM ROBERTS-AUSTEN'S classical researches on the treatment of steel were turned to very profitable account by Messrs. KRUPP. Obviously the research laboratory at a works, if properly equipped and properly run, has the important advantage over a college laboratory that it necessarily imbues the student with the importance of the commercial aspects of the results obtained, and therefore a turn of mind is developed which is not too academic.

Increasing Tramway Revenue.

ALTHOUGH the majority of tramways have hitherto been solely concerned in the conveyance of passengers, there does not appear to be any reason why a tramway should be confined to passenger traffic. This question was raised last Wednesday, at Bradford, by Mr. C. J. SPENCER, in his Presidential Address to the Municipal Tramways Association. As regards the delivery of parcels, considerable success has already attended experiments in this direction on a few undertakings. Amongst these, mention may be made of the Manchester Corporation tramways, which last year dealt with, on an average, over 16,000 parcels per week. In some cases, however, the proposal to undertake work of this nature has aroused considerable opposition; and an application to Parliament by the Bradford Corporation to grant further goods-carrying powers was recently unsuccessful, owing largely to the small use made of such powers in the past by other undertakings. It is, however, interesting to notice that large contracts for the carriage of material have been entered into by the Leeds Corporation Tramways. Other managers will, doubtless, watch with interest this experiment, as it may lead to greater financial success in the smaller class of tramway undertaking. The conveyance of mails for the Post Office authorities is another means of profitably utilising the tramway track. The whole question, in fact, requires the careful consideration of tramway committees, especially in those small towns where the traffic revenue per car-mile is low.

The Industrial Outlook.

IN another column we give a brief account of the proceedings at the Trade Union Congress, which was held at Sheffield last week. More than usual interest attached to its deliberations, as it was known that several questions of importance in the industrial and commercial world would be debated. One of the leading topics under consideration was the attitude of the boilermakers, who had thrown over their leaders and had refused to allow their executive to open negotiations with the masters. As is well known, this attitude, and especially the tendency of the boilermakers to indulge in sectional strikes, compelled the masters to give notice of a general "lock-out" unless the men gave an undertaking that they would abide by the terms of the agreement made some time ago between the representatives of both masters and men. The executive of the men's union appear to have been willing to give the required guarantee, but, when consulted, the men refused by a substantial majority to allow their executive to deal with the masters' representatives. Of course, the success of trade unionism is dependent upon what is termed the collective contract, but which we prefer to term collective bargaining It is obvious that if a bargain is only carried out by one of the parties so long as they derive full benefit from it, or so long as it is convenient to abide by the terms, the other will rightly refuse to negotiate in future. It is necessary to have discipline in large industrial establishments, and to have some certainty as to the future where large contracts are concerned. Therefore, it seems to us that the masters were justified in seeking a guarantee from the boilermakers that the men would refrain from starting sectional strikes without notice.

IT is greatly to be regretted that the present "lock-out" has entailed considerable suffering on many innocent persons who have no sympathy with the short-sighted policy of the men, and it is also to be regretted that the trouble should have arisen at this time when trade had begun to revive, when the shipyards were busy on home and foreign contracts, and when everything pointed to a period of prosperity which is much needed after the recent depressed condition of business in this country. It is not alone in the shipbuilding industry that there is evidence of industrial unrest. The cotton and the mining industries are also affected, but it is to be hoped that the leaders will be able to infuse a spirit of discipline into the ranks of the men, and that masters and men will be able to settle their differences by arbitration or some such peaceable means. The strike and the "lock-out" are economically indefensible, and, moreover, they are barbarous methods of settling differences. We should like to see the principle of arbitration extended to all disputes between masters and men. It would be better for both sides, and it would be better for the trade and industry of the country.

Antennæ of German Military Wireless Stations.—According to the "Elektrotechnische Zeitschrift" the 300 ft. masts which carry the antennæ of the military wireless stations at Göttingen, Metz and Strassburg are giving every satisfaction, in spite of the violent storms and the large amount of ice and snow that has clung to them during the year. These masts are of wood, the accessories by which they are assembled being of cast iron, while the tension cables, which are fitted with bell insulators every 30 ft., are of steel. The larch beams are so arranged that the finished mast represents a truncated pyramid of rectangular section with 2 ft. 8 in. sides at the bottom and 12 in. sides at the top. The beams are prepared for use and impregnated with carbolineum at Berlin, so that at the place where they are to be used only assembling is necessary. The masts are carried on concrete blocks of square section 4 ft. 6 in. high. The cost of a mast, including all accessory expenses, is about £400.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Assab—Perim	July 8, 1909 ...	—
Malta—Tripoli	April 20, 1910 ...	—
Reunion—Mauritius	May 20, 1910 ...	—
Latakia—Palura	May 26, 1910 ...	—
Obock—Djibouti	June 24, 1910 ...	—
Cape St. James—Doson	Sept. 9, 1910 ...	Sept. 14, 1910

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Metal Filament Lamps for Street Lighting in Chicago.—According to the "Electrical Review and Western Electrician" the installation of special tungsten clusters along the outlying business streets of Chicago is progressing steadily. There has just been completed the installation of 51 posts on West Chicago-avenue between Ashland and Western-avenues, and 50 posts on East Thirty-first-street between Michigan and South Park-avenues. These posts carry four tungsten lamps each and are installed, lighted and maintained by the Commonwealth Edison Co. Over 1,000 of these posts have now been placed along the Chicago streets in front of the premises of such merchants as have agreed to pay the low rental charge.

Hydro-Electric Plant on the Hudson River.—The "Electrical Review and Western Electrician" states that a hydro-electric power house is to be erected on the west side of Green Island on the Hudson river, the capacity of which will be about 6,000 H.P. This power will be available not only for the present industries on the Troy side of the Hudson River, but will also offer exceptional advantages to other industries both in Troy and Green Island, which at present use purely hydraulic power. The amount of electrical energy thus generated will, in fact, be equivalent to a three-fold increase compared with the present hydraulic supply. Electrical energy will be sold to consumers by the Government (who own the plant) at the cost of production, or about a third of the cost of the power generated at Niagara Falls. It is mentioned, however, that it will be necessary for the companies using the power to meet the cost of constructing the power house.

Electricity Supply in Paris.—In a recent issue of "L'Industrie Electrique" is given a short account of two new generating stations which are to be constructed, one in the north and the other in the south of Paris, in connection with the new combined scheme which was formulated some time ago. The construction of these stations, which will be built at Saint Ouen and Issy-les-Moulineaux, will shortly be begun. The generator sets will each consist of a steam turbine, with surface condenser, direct coupled to a two-phase alternator supplying current at 12,300 volts, and a frequency of 41·66. The output of these sets will be 10,000 kw. There will also be two continuous-current generators mounted on the same shaft as the alternator, the purpose of these generators being to supply energy to the condenser motors, and for excitation purposes respectively. Each turbo-generator will be capable of taking a load of 12,500 kw. for two hours after having run fully loaded, and a load of 15,000 kw. for half an hour directly after the smaller overload.

An Electrically Driven Rolling Mill.—According to the "Revista Tecnica d'Elettricità" the Terni steel works have just decided to erect a mill for rolling armour plates to take ingots weighing up to 100 tons. It will consist of a double reversible train, 5 ft. in diameter and 15 ft. wide. The steel works in question are at present employing water power, but as turbines are not reversible electrical driving had perforce to be used. The rolling train is driven by two continuous current motors which are coupled together and develop a horse-power of 15,000 when running at 90 revs. per min. These motors are fed from three dynamos working in series and directly connected to a hydraulic turbine of 2,600 H.P. capacity. In order to equalise the peaks in the demand this set is fitted with a flywheel weighing 70 tons. The turbine runs at a speed of from 360 to 450 revs. per min. The prompt way in which the mill can be reversed by the use of the electric drive is the special feature of this new installation. Very rapid rolling can be obtained, while excessive wear on the rolls and uneveness in the work due to sudden stopping can be avoided.

Re-opening of the British Section at the Brussels Exhibition.—The new British section of the Brussels Exhibition which has just been built to replace the buildings destroyed by the fire of August 14th were opened on Tuesday last by the King of the Belgians. It will be remembered that the Board of Trade and the British Commission were unanimous in deciding to restore the British section as far as possible to its former excellence. The response to the appeal for fresh exhibits was so spontaneous that only a portion of those anxious to be represented could be accommodated with space. The new section now fills the Salle des Fêtes, a much smaller space than was originally occupied, but still sufficient to admit an admirable selection of British exhibits. We understand that the most stringent regulations have now been enforced to prevent any further outbreak of fire. One of the few firms whose exhibits came to no injury was the Thermal Syndicate, who were showing crucibles and other silica apparatus. This firm were thus provided with an entirely unsolicited testimonial to the worth of their goods.

Casualties on American Electric Railways.—According to the "Electrical Review and Western Electrician," the report of the Interstate Commerce Commission relative to railway accidents for the first three months of the present calendar year shows a material increase in the number of persons killed and injured. During the first three months of 1910 the number of persons killed on electric railways throughout the United States was 19, and the number of injured 669. This is but a very small fraction of the loss of life and injury reported for the steam railways of the country for the same three months. For the steam lines the number of persons injured during January, February and March of the current year was 21,232, as against 6,110 in the corresponding three months of 1909, and the number of persons killed, 1,100, as against 466 in the same period of 1909. These figures deal only with employés on duty and passengers, and take no cognisance of trespassers. Attention is especially called to the fact that the number of casualties for the quarter above referred to were materially swelled by two great disasters, the avalanche in the State of Washington and a derailment in Iowa.

Mains Extensions in Northumberland and Durham.—In the counties of Northumberland and Durham some very important extensions of the network of the Newcastle-on-Tyne Electric Supply Co. and the County of Durham Electric Power Companies have recently been carried out. Some particulars of these may be of interest. Upon the route from Holywell to Seghill a 12,000-volt feeder has recently been erected in order to duplicate the existing supply. The normal span between poles on this feeder is 80 yds., each pole carrying three conductors, each of 0·05 sq. in., the conductors being of copper. For roads and railways catenary guarding has been adopted, while lace guarding is used for footpaths. The feeders commence by a junction with the underground cable near the Holywell Colliery, and a three-cored lead-covered pilot cable is also carried along the route. The work has been done by the British Insulated & Helsby Cables Ltd. The same Company has also erected a pole line from the Rising Sun pit to Backworth in the County of Northumberland, in connection with the same mains system. The Newcastle-on-Tyne Electric Supply Co. has also ordered a new 12,000-volt feeder to run from the Newsham switchhouse to Seaton Delaval, a distance of 3½ miles. The line is of the same dimensions as the one mentioned above, and also carries lead-covered pilot and telephone cables slung from the catenaries. Another important extension which is in prospect and has just been placed on order, is a new 20,000-volt pole line from Carville power station to Burradon. This line is a three-phase supply with 0·1 sq. in. copper conductors, a pole line joining the underground cable at a point just outside Wallsend. The purpose of this pole line is to duplicate the existing supply.

Music by Wireless.—A recent issue of the "Electrical World" states that the method of reproducing by magnetic induction musical and vocal sounds in a pair of telephone receivers connected to a coil of wire held in the hands of the auditor, which was first publicly demonstrated at the Louisiana Purchase Exposition at St. Louis in 1904, is being revived as an amusement feature among a number of summer parks of the country. Entering the enclosure or building in which the "wireless" is installed, the visitor is handed a basket containing a coil of wire, to which a head-receiver is connected.

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On placing the receivers to his ears he hears accurately the telephoned phonographic selections of his favourite band or opera singer. The method employed in these amusement devices is to string round the outside of the room or building from 80 to 100 turns of wire, the ends of which are led out to a telephone transmitter in series with a strong battery of dry cells. A phonograph horn is directed into the telephone transmitter, and currents corresponding to the sound waves are set up in the large coil, which in turn induces a varying magnetic field throughout the building. The small hand-loops connected to the telephone receivers then act as the secondaries of the air-core transformer or repeating coil thus produced. The phonograph attachment and transmitter may be located in a building at some distance from the wireless pavilion.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. K. M. Faye-Hansen contributes an article on "Voltage Drop of Transformers having a Poor Regulation."

At the Conference of the Municipal Tramways Association, held at Bradford this week, the presidential address was delivered by Mr. C. J. Spencer. An account of the proceedings, together with an abstract of a Paper on "The First Decade of Municipal Tramway Working," by Alderman S. Flint, are given in another column.

We conclude our abstract of the Paper on "The Relations of Science to Industry and Commerce," read by Mr. R. Blair at the recent meeting of the British Association. An interesting discussion, of which we give an abstract, took place.

We give an account of recent developments in the use of metal filament lamps for street lighting and other purposes. Several central station engineers have supplied us with particulars of the progress made in their districts, whilst some interesting information has also been obtained as to the use of metal lamps by the railway companies.

The important subject of the electrification of the Melbourne suburban railways was advanced a stage by a declaration in the Victoria Legislative Assembly by Mr. Murray, the Premier, to the effect that there was no question now as to the electrification of these railways. That must come. The Railway Commission that was appointed to consider the general question of electrification was not to enquire into this particular matter, as sufficient information was available in Mr. Merz's report. (See THE ELECTRICIAN for Sept. 18 and 25 and Oct. 2, 1908).

The Institute of Metals has reached a membership of 1,000, and has now been registered without the word "limited" by licence from the Board of Trade.

A proposal put before Weymouth Council by the Electric Lighting Committee to obtain powers for the construction of tramways in the borough, at an estimated cost of £27,000, has been withdrawn. Another scheme is to be prepared.

We give in another column an abstract of an interesting report by the British Commercial Attaché at Peking.

It is announced that Mr. J. E. Kingsbury has joined the board of the Western Electric Co.

An Indian company has been formed with a capital of £1,250,000 to carry out the Bombay hydro-electric scheme.

Ganz & Co. have secured the concession for the erection of electricity and gas works at Constantinople.

Keighley Council have decided to promote a bill to authorise the running of railless trolley cars.

Loans for Electricity Supply.—Manchester Corporation have applied for sanction to a loan of £30,000 for additional generating plant for Stuart-street station.

Norwich Council have applied for sanction to a loan of £18,790 for extensions of the electricity works.

Arbitration.—The arbitration proceedings between the Torquay Tramways Co. and Torquay Corporation to decide whether the latter have unreasonably withheld their consent to the reconstruction of certain surface-contact tramways on the overhead system, were concluded on Saturday. The arbitrator (Mr. Archibald Read) reserved his award.

Directors' Reports, &c.—The report of the directors of the British Thomson-Houston Co. states that extensions and improvements of the main factory and the incandescent lamp factory have been made, and the company has exchanged licences with the Osram Lamp Works (Ltd.) of all its metal filament lamp patents.

The Allgemeine Elektricitäts Gesellschaft, Berlin, have declared a dividend of 14 per cent. for the year 1909-10, compared with 13 per cent. for the previous year. Orders in hand show a considerable increase over those of the previous year.

At the meeting of the Underground Electric Railways Co. of London on Wednesday Sir Edgar Speyer stated that the tube railways continued to make steady progress, and there was a considerable decrease in expenses, due to the reduction of price of electric current.

INSTITUTIONS AND SOCIETIES.

Association of Mining Electrical Engineers.—In connection with the efforts which have recently been made to form in Scotland two branches of this Association—one for the East and the other for the West of Scotland—a representative meeting of those engaged in the application of electricity to mining was held in the Grosvenor Restaurant, Glasgow, on Saturday evening last. Mr. H. W. Clothier (Newcastle-on-Tyne) presided, and was supported by Mr. J. Glynn Williams (Whitehaven), both gentlemen being present as a deputation from the General Council of the Association. After the chairman had explained the objects of the Association Mr. J. Glynn Williams read a communication from the President of the Association, Mr. Wm. Maurice, in which the latter mentioned that every miner who was studying to qualify for the position of a mines inspector or colliery official would find it greatly to his advantage to join, and every acting colliery official ought to take advantage of the opportunity which the Association offered, even if he did so only on the ground of self-preservation. The following officials were then elected by the members of the West of Scotland branch present:—*Chairman*, Mr. Alexander Anderson (Motherwell). *Vice-President*, Mr. Matthew Brown (Dennyloanhead). *Secretary*, Mr. D. Martin (Glasgow). *Treasurer*, Mr. D. Landale Frew (Glasgow). *Members of Council*, Messrs. J. Thomson (Hamilton), W. Cairns (Glasgow), J. R. Benson (Dennyloanhead), C. W. Holman (Glasgow), F. Anslow (Glasgow), H. A. McGuffie (Glasgow), D. M. Mowat (Coatbridge), R. Edwards (Glasgow), J. C. McCallum (Kilmarnock), W. A. Wilson (Glasgow), R. Robertson (Stonehouse) and A. Power (Uddingston). In intimating that as the outcome of the meeting the membership of the Glasgow branch had been increased to upwards of 50, Mr. Williams called attention to the meeting which it was proposed to hold in Dunfermline on the 24th inst., with a view to forming a further branch in the east of Scotland.

The Tramways and Light Railways Association.—The "Official Circular" of this Association for September contains several matters relating to the work of the Association, an article on "Car Meters," and full translations of two reports submitted at the recent International Tramway Congress in Brussels on the same subject, giving the results obtained all over the Continent from the use of these instruments on tramcars; a table is also given showing the financial results achieved in concise form.

Manchester Section of the Institution of Electrical Engineers.—The committee of this section of the Institution of Electrical Engineers has decided to open the coming session with a conversazione, as it is felt that this will be the most convenient way for the incoming chairman to meet the members of the local section, while it will also afford a suitable opportunity for members and friends to meet and discuss matters of interest. The conversazione will be held on Friday, October 14th, at the Manchester Whitworth Institute, Whitworth Park, Manchester, commencing at 7:30 p.m. After the reception by the chairman there will be instrumental and vocal music, and refreshments will be provided. Applications for tickets should be made to the honorary secretary, Mr. H. W. Wilson, or to members of the committee.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, September 23rd (to-day).

MUNICIPAL TRAMWAYS ASSOCIATION.

10 a.m. Annual General Meeting in the Town Hall, Bradford.

SATURDAY, September 24th.

ASSOCIATION OF ENGINEERS-IN-CHARGE.

5:15 p.m. Reception at the Engineering Exhibition, Olympia. Lecture at 7:45 p.m. on "Wireless Telegraphy, its Maritime Importance," by G. Langler Bullocke.

IRON AND STEEL INSTITUTE.

Autumn Meeting at Buxton (Monday, September 26th to Friday, September 30th). Among the Papers to be read are: 'On Electric Steel Refining," by Mr. D. F. Campbell; and "The Utilisation of Electric Power in the Iron and Steel Industry," by Mr. J. J. E. Schuurman.

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THE USE OF METAL FILAMENT LAMPS FOR STREET LIGHTING AND IN RAILWAY WORKING.

In former years it has been our custom to enquire of supply engineers as to the results they have obtained from the use of metal filament lamps in their districts, when employed both for street lighting and other purposes. The results of these enquiries have been satisfactory; metal filament lamps, we have been told, are eminently suited for this purpose and afford a very efficient means of illuminating streets and districts where high-power flame arc lamps would be out of place.

This year we have again made enquiry of a number of engineers who are employing this type of lamp for street lighting purposes and the answers are again satisfactory, from the electrical point of view. A pleasing absence of detail is to be noticed. Many of our correspondents inform us that there is little to add to what they said last year, nothing sensational having happened, but, on the other hand, the employment of the metal filament lamp for street lighting is steadily increasing and both by its long life and efficiency this type of illuminant is proving itself eminently suitable for the purpose.

Street Lighting.

Turning to the actual replies we have received, one well-known engineer, who is for ever waging war against the claims of the gas companies, informs us that by the use of metal filament lamps, instead of gas, a saving in running costs of £1,500 per annum has been effected, while the candle-power has at the same time been improved, and that his council have decided to spend £20,000 in converting the whole of the gas lamps in the borough for electric lighting. Great care has been taken so to arrange the lamps and reflectors that an even distribution of light between the posts is obtained, and the bright spot at the foot of the post, which is so often found in the case of gas, is thereby altogether avoided.

Mr. A. C. Cramb, of Croydon, informs us that since the end of September, 1909, the number of metal filament lamps used for side street lighting in that borough has been increased from 265 to 330, while special street lighting mains have been also laid in certain streets, and that here some gas lamps are being replaced. For side-street lighting the unit is one 200-volt 77-watt lamp, which is fixed in a fitting with a specially designed reflector. These lamps have given very satisfactory results, an average life of nearly 3,000 hours being obtained.

As showing the way in which metal filament lamps have replaced arc lamps, Mr. Cramb informs us that during the past year he has scrapped 255 450-watt and 650-watt alternating enclosed arc lamps. These have been replaced by lanterns having a large vitreous enamelled reflector and containing three 100-watt metal filament lamps. As approximately half of these are fixed on the tramway poles, the lampholders are provided with an anti-vibration holder. The average life obtained from these lamps so far is approximately 2,200 hours, but it is anticipated that this will be increased at the end of the year as many of the lamps are still running. The main London to Brighton road, on the other hand, has flame arc lamps installed throughout the greater part of its length, and the remainder is illuminated by Osram lamps. The centre part of the town is about to be changed to flame arc lamps.

Mr. Geo. Wilkinson, of Harrogate, sends us some very interesting information. He informs us that the cost of gas from the gas company to the Corporation, including everything except labour, cleaning and lighting, is 17s. per lamp per annum, and the lamps are extinguished about 12:30 a.m. The electricity department have, nevertheless, received instructions to change 500 gas lamps to electricity. They will be able to provide a better light, furnished by means of metal filament lamps, at an actual cost to the Corporation of 11s. 2½d., including lamp renewals and everything except cleaning and lighting, or a reduction on the former price of 33⅓ per cent. There will be some saving also in the cleaning, as electric light does not coat the glass with a smoky film as does gas; furthermore, in most of the lanterns there will be no glazing, excepting in the nature of a reflector over the lamp itself. The Corporation are paying the electricity department 17s. per annum, the same price as to the gas company excepting that the 17s. per post for electric lighting includes lamp renewals, and the difference in the actual cost and the amount received will pay for the cost of the conversion in a very few years. The 500 new electric lamps referred to are to be located in positions where there are already low-pressure electric mains, and the estimated cost of fitting the existing gas lamps complete is £800.

With regard to photometric tests, Mr. Wilkinson has made some interesting investigations in the streets of Harrogate. Two separate tests were taken on the metal filament lamps and on an "alleged" 60 c.p. gas mantle. These were taken at random in the street with the following results: The metal filament lamp gave actually 54·5 c.p., while the gas mantle actually gave only 25·3 c.p. A month later the metal filament lamp gave 54·6 c.p., while candle power of the gas mantle had increased to 36·1 c.p. The gas mantle had, Mr. Wilkinson remarks, evidently been changed during the interval. These tests were made on posts and lanterns of exactly the same type, one carrying the latest form of gas mantle and the other a tungsten filament lamp. It will be seen, therefore, that, as Mr. Wilkinson points out, the electric lamp gives a very much better illumination than does the gas mantle. The photometric tests were taken with a Haydn Harrison portable photometer. The tests were all taken at one angle, and the posts were of the same height.

Mr. Christie, of Brighton, informs us that he now has got 1,834 old gas lamps converted and connected to the network in such side streets which are not of sufficient importance to justify arc lighting. When electricity was first employed for this purpose, the lighting consisted of two 8 c.p., two 16 c.p., or two 32 c.p. carbon filament lamps. When metal filament lamps first came in, where these posts were situated in the 230-volt area, the holders were arranged to take two of these lamps working at a pressure of 115 volts in series. During the past year, however, the whole of these posts have been altered to a single point on the 230-volt system, so that high voltage metal filament lamps in units of 32, 50, or 100 c.p. can be employed.

Mr. Christie's experience with the leading makes of these lamps is that they are steadily improving, both as regards efficiency and life, and in many cases individual lamps are actually burning for upwards of 5,000 hours without any apparent diminution in the candle power. The average life of the best makes of these lamps, however, is, he considers, not so good as it might be, and he thinks the high efficiency of a little over 1 watt per candle-power might be sacrificed to a small extent with advantage both to the lamp making industry and to the user if a longer life could be assured.

The economies which the consumer has been able to effect in his electricity bill by their use have been so great that it does not appear that he would grudge paying the supply undertaking a little more if he could prolong the life of his lamps, and thus reduce the cost of renewals. Mr. Christie considers few users would object to 1½ watts per candle-power as a standard, and the extra 0·3 or 0·4 watts would give the makers a wider margin to work on, which, in time, should tend to reduce the cost of manufacture.

Mr. H. D. Munro, of Exeter, informs us that he has now some 500 metal filament lamps in Exeter in use for street lighting. These have been working for some three years, as Exeter was among the first stations in the country to adopt them. The supply being at 100 volts, no trouble whatever has been found from vibration effects, although 100 c.p. lamps are attached to the tramway poles, and no special anti-vibration fittings have had to be used. An average life of more than 2,500 hours is obtained for the whole of these lamps, and experience goes to show that a better average light than is obtainable from low-pressure gas mantles can be given by electric metal filament lamps at a cheaper rate without unduly cutting the price of the supply. The introduction of this large amount of street lighting, Mr. Munro continues, has undoubtedly improved the estimation in which electricity

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is held by the public, and private consumers have noticeably increased in consequence. The general adoption of metal filament lamps has, of course, cut into the revenue, and will continue to do so as the smaller size lamps are taken up, but he finds that the increasing popularity of the light has practically made up the loss occasioned by the great economy of the metal lamps.

Mr. C. A. L. PRUSMANN, of Swansea, informs us that during the past 12 months he has every reason to believe, both from an illumination and financial point of view, his Council have been very well satisfied with street lighting carried out by means of metal filament lamps. He further adds that he has received instructions to replace existing gas lighting by means of metal filament lamps in those streets where distributing cables are already laid.

A large amount of gas lighting has been replaced during the past 12 months in the main thoroughfares by means of arc lighting, and he anticipates a considerable increase in the near future in electric street lighting both by means of arc and metal filament lamps. He is strongly of opinion that the introduction of metal filament lamps has had a beneficial effect on the general working of the station. At the present moment there appears to be no reason why this effect should not continue in the future.

Mr. A. DIMMACK, of Swindon, gives us the following information regarding the metal filament lamps at use in Swindon. Since March, 1908, the following is a record of lamps that have failed :—

Between	0	and	110	hours	27	lamps
,,	100	,,	200	,, ...	23	,,
,,	200	,,	500	,, ...	61	,,
,,	500	,,	1,000	,, ...	59	,,
,,	1,000	,,	2,000	,, ...	76	,,
,,	2,000	,,	3,000	,, ...	62	,,
,,	3,000	,,	5,000	,, ...	45	,,

There are a number of lamps which have burnt over 5,000 hours and are still burning. The average life of the lamps has been 1,534 hours.

Mr. H. CAMERON, of Penarth, informs us that since last October he has increased the number of metal filament lamps that he is using for street lighting to a small extent. The life of these lamps is still satisfactory, and he has at present at work three lamps which have already been burning over 6,000 hours. The average life, however, appears to be between 1,500 and 2,000 hours. Very few carbon lamps are now being supplied by his Company, their place having been almost wholly taken by 55-watt metal filament lamps.

OPINIONS FROM RAILWAY ENGINEERS.

Next to electricity supply authorities it may be said that those most intimately connected with the use of metal filament lamps for all purposes are the railway companies. Such concerns have a great variety of places to light—offices, stations, goods yards, running sheds and even the trains themselves, so that the experience railway electrical engineers have obtained with metal filament lamps should be of very great value. Such experience is, however, of slow growth, and although many railway engineers have informed us that they have replaced carbon by metal filament lamps practically all over their systems and that the new lamps seem to do their work very well, yet it is too early for them to give us the information we require in any great detail.

The CALEDONIAN RAILWAY are using these lamps for the lighting of railway stations, goods yards, shops and running sheds; the LANCASHIRE & YORKSHIRE RAILWAY are using them for the lighting of the first-class carriages on their system, and also largely for general lighting instead of arc lamps. In fact, it would seem, we are informed, that these lamps will supplant the arc lamp very largely, if not entirely, in railway working. The SOUTH EASTERN & CHATHAM RAILWAY are also using this type of lamp extensively for the lighting of station platforms, and offices, goods yards and houses.

Again, Mr. VINCENT L. RAVEN, chief mechanical engineer of the North-Eastern Railway, informs us that metal filament lamps are largely being used on that system in connection with ordinary office lighting, suburban station platform and siding lighting, hotel lighting, loco., carriage and wagon works lighting and signal cabin lighting. The platforms of large stations where electricity is used are lighted by arc lamps, as are the goods yards and running sheds. The North-Eastern Railway have not found metal filament lamps suitable for such places for general illumination. Their experience of metal filament lamps, for the places where they are in use, is, however, now very favourable since improvements in the life of filaments have been made, and the lamps have been available for the higher pressures without alterations to the wiring. The advent of the low candle power, high-pressure lamp, has, Mr. Raven considers, also considerably increased the utility of the metal filament lamp. The saving in consumption is very considerable, and even with the high prices now obtaining, the use of metal filament lamps is more economical than the carbon filament lamp at about one-fifth the price of the metal filament lamp. The economy, of course, is greatest at the places where the price of energy is high.

Mr. H. W. FIRTH, Electrical Engineer of the Great Eastern Railway, tells us that this Company have several thousand tungsten and tantalum lamps in service under various conditions, as regards vibration and rough usage. The results obtained as far as the actual average life of lamp is concerned have been highly satisfactory, the burning life usually amounting to some 1,500 hours. Considerable use has been made of 100 c.p. and 200 c.p. tungsten lamps for the displacement of high power incandescent gas in goods and shunting yards. As a rule there has been no need to fit these lamps with spring suspensions, but this precaution has been taken in places where pronounced vibration obtains. Enclosed and open type arc lamps are also being displaced with satisfactory results from the economical point of view by metal lamps in positions where head room is limited—for instance under station awnings and so forth—and where the distribution of light can be much improved by increasing the number of units. At busy goods yards where carboning of lamps is difficult and expensive owing to the heavy van traffic in the roadways, considerable economy can be effected over arc lighting (if conditions as regards distribution of light, &c., are not unfavourable) by the installation of metal lamps. Tungsten lamps in small units are successfully employed at certain stations, advantage being taken of the alternating system of distribution to step down the lamp voltage to 55 volts. At country stations beyond the reach of a distribution system supplied from a central source, the low-voltage wire lamp is being used in conjunction with paraffin electric generating sets and batteries. The first plant of this kind on the Company's system will be running shortly, and it is anticipated that this method will prove more economical for isolated stations than any other system of illumination, while the capital cost will be quite moderate when it is remembered that even at small country stations the lighting load factor is comparatively high.

On the TUBE RAILWAYS, too, metal filament lamps are being extensively used, and in this connection we may deal with the experience of Mr. E. P. Grove, of the Central London Railway. Mr. Grove points out that in considering the use of metal filament lamps, probably the point which most concerns engineers of railway companies generating their own electricity is the price at which they are to estimate the current used for lighting purposes. In the case of the Central London Railway about 16 per cent. of the output from the power house is for lighting purposes, and were this to be reduced by 50 per cent. by the use of metal filament lamps the load factor would not be improved, while the load would become more variable by reducing the steadiest portion of it. This, therefore, would not tend towards economy in the power house, while, in the case of the Central London, at any rate, capital charges have not to be taken into consideration, as these are now practically fixed whatever the output. Really, then, the only saving made by reducing the current consumption would be in coal, and possibly very slightly in oil and water and small stores. Sub-station charges would not be reduced by the change, but the cost per unit would rather be increased; thus no allowance is made for sub-station charges, so that ,

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when arriving at the total cost of lighting by the two systems, carbon and metal filament lamps, the coal cost only is considered. In the case of the Central London this would be about 0·215d. per unit delivered at the lamp terminals.

With the present price of metal filament lamps and a 5 per cent. increase on this price, due to requiring the lamps for series burning, the saving is questionable, as from experience obtained so far on the Central London Railway the life of the metal filament lamp is considerably below that of the carbon filament lamp using, say, about 4 to 4·5 watts per candle.

Recently the lamp bill on the Central London was considerably reduced by specifying lamps of medium, if not low, efficiency, and this without increasing the cost of lighting.

In the case of the Central London the lighting nearly all consists of either five 110-volt, four 135-volt or two 275-volt lamps in series, on a 550-volt continuous-current system, and the standby lighting is supplied from batteries. To alter this to a lower voltage continuous-current system would, of course, be out of the question. To alter it to an alternating-current low-tension system with transformers at the sub-stations would mean some other provision for a standby.

Suitable terms from a public electric supply company could hardly be obtained for merely standby energy in the case of momentary failure, with the prospect of having to take on 300 kw. or 400 kw. of lighting load at any moment without warning, possibly at the time of their peak, besides the fact that an alternating-current standby is not feasible at all points of the Central London system.

An alternative to this is a standby in the form of a few lamps supplied by a public supply company and kept always in use, for which, no doubt, reasonable terms could be arranged.

The question then arises as to whether this is as satisfactory as the present battery standby, which is capable of taking care of the whole of the lighting, including the arcs. Except for this feature, with 100-volt metal filament lamps, possibly even at the lower candle-power, Mr. Grove thinks it quite likely that these would show an all-round economy, provided the lamps did not have to be run in series, and he is about to make some tests in this direction.

As far as regulation of voltage is concerned, Mr. Grove does not think that has much effect in this case, as he is sure the regulation on the Central London is better than on many of the public electricity supply companies' mains, judging from the reports which have reached him from friends who have given up metal lamps on account of the enormous variation which they have experienced in the voltage of their supply mains.

With regard to the lighting of trains, some tests have been made in this direction, but these are not completed. As far as they have gone they have been in favour of the carbon filament lamps on account of the much longer life. These tests are being made with 110-volt lamps run five in series.

Tests are also being made as regards the use of the new lamp for sign lighting where the metal filament lamp has an advantage quite irrespective of its economy in current consumption, due to the fact that it dissipates so much less heat, than do carbon filament lamps when boxed up, which have a comparatively short life.

As compared with arc lighting, Mr. Grove considers there does appear to be some economy by the use of high candle-power metal filament lamps with suitable shades, due not to the fact that there is a reduction in the current per candle-power but to the fact that it is possible to use less total candle-power with metal filament lamps on account of the better distribution as compared with arc lighting. It is very questionable, however, whether the general appearance is as cheerful or as satisfactory from the public point of view.

As regards the DISTRICT & LONDON ELECTRIC RAILWAYS, Mr. A. R. Cooper, engineer, informs us that the arc lamps are being replaced at the lower stations of the tube, and the majority of the arc lamps at top stations, by metal filament lamps of 100 c.p. in connection with the replacement of carbon by metal lamps. Further the Eastern Joint and Whitechapel and Bow stations, as well as several stations on the District Railway, have also been lighted with metal filament lamps. The question of voltage supply is, Mr. Cooper thinks, one of importance, and it has been decided to adopt that of 60 volts throughout the system, except at the general offices, where, in view of the more delicate handling and the absence of vibration, a 100-volt circuit has been arranged for. A feature of the installation—particularly so far as the large units are concerned—has been the obtaining of reflected light, or more correctly the keeping out of direct vision of the lamps themselves, by large shades, frosting of the bottom portion of the lamp bulb, and other means. Mr. Cooper states that the saving in current consumption, especially so far as the arc lamps are concerned, has been considerable. On test many lamps show a life of 5,000 hours.

There is much to be said, Mr. Cooper thinks, for arc lighting in yards or at stations where they can be placed at a sufficient height to get an equal diffusion of light. On the tube railways, however, the arc lamps could only be fixed 11 ft. above the platforms.

Mr. R. P. Brousson, of the GREAT NORTHERN & CITY RAILWAY, informs us that metal filament lamps have been used on the Great Northern & City Railway for train and station lighting for the past two years with very good results, both from the financial and illuminating points of view. The lamps used for train lighting have an efficiency of 1·7 watts per candle, and an average life of 2,000 hours has been obtained, which compares favourably with the 800 hours of useful life obtained from carbon filament lamps. The lamps used for station lighting have an efficiency of 2·2 watts per candle, and the average life is from 4,000 to 5,000 hours as compared with 1,000 to 1,200 hours of the carbon lamp previously used; a considerable number of lamps (about 10 per cent.) have given a life of from 8,000 to 10,000 hours.

The above lamps are run five in series on a 550-volt traction circuit, but in all cases lamps rated for a pressure 10 per cent. above that of the declared pressure have been used, *i.e.*, five 120-volt lamps are used on a 550-volt circuit, as this can be done without materially affecting the illuminating power of the lamp. Undoubtedly, he thinks, the long burning hours are largely due to this precaution.

From the point of view of illumination, Mr. Brousson finds the metal filament lamp is unquestionably an improvement on the carbon lamp due to its whiter light; moreover the fluctuations in pressure, which exist on a traction circuit, are not so perceptible with metal filament lamps. In addition to tantalum lamps, several small experiments have also been made with tungsten filament lamps, but not with satisfactory results. The longest life that was obtained from these tests was 400 hours. This result is no doubt due to the filaments not being mechanically strong enough to withstand the vibration which exists on an underground railway. At the present moment a more extensive trial of tungsten lamps is being made. The platform arc lighting (5-ampere enclosed continuous-current lamps) at one of the underground stations has been recently replaced by high candle-power drawn tungsten metal filament lamps. Each arc lamp has been replaced by two 100 c.p. metal filament lamps. The better light distribution has led to a distinct improvement in the general illumination of the station.

Mr. Brousson has noticed an interesting point in connection with the train lighting, viz., in cold weather the metal filament lamps are more liable to fail than at normal temperatures.

From the above opinions on the working of the metal filament lamps, taken from the experience of those who have them operating under a number of varying conditions, it would seem that the initial stage in its development has now been passed. Though its average life is not perhaps so long as that of the carbon lamp, yet individual members of the tribe hold out well. There is no doubt about its efficiency, and the only thing that seems to be required is that it should be a little cheaper. This will doubtless come in time. Meanwhile we may congratulate ourselves on the fact that far from the metal filament lamp causing the disruption of the electrical industry, it has enabled the industry to extend its borders.

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SOME NOTES FROM MAKERS OF METAL FILAMENT LAMPS.

In the following article we give some of the experiences of metal filament lamp makers during the year. They are rather meagre, for it is evident that the makers have very little to tell us, except that they are making and selling the lamps at a great rate. This is satisfactory as far as it goes, but does not provide us with very much to say on the subject.

The Osram Lamp.

The General Electric Co., however, send us a brief history of the "Osram" lamp, from which it appears that it was commercially introduced to the English market in the early part of 1907. It was then only possible to make it for use on circuits whose pressure did not exceed 120 volts and of candle power not over 50. This necessitated the lamps being restricted to low-voltage circuits, except in instances where they could be run two in series on high-voltage mains. For house and shop lighting a 50 c.p. lamp was sometimes found to provide too high an illumination.

The huge factory that has recently been erected at Hammersmith for the manufacture of Osram lamps is now employing over 1,100 hands, so that it is evident rapid progress has been made; and, after various stages of improvement, lamps suitable for burning on pressures not exceeding 260 volts are now being produced. The company have also been successful in making lamps suitable for pressures up to 135 volts in 16 c.p. and lamps suitable for pressures up to 200 to 260 volts as low as 25 c.p. This has enabled the Osram lamp to be used in practically any building where the old form of carbon lamp has already been at work. It might be of interest to point out that the Osram lamp has now been brought to such a stage of perfection that the current consumption is only approximately 1 watt per candle-power, which is about 75 per cent. less than that taken by carbon filament lamps—in other words, an Osram lamp only takes approximately one-quarter of the current of a carbon filament lamp.

The Osram lamp, it is claimed, is unaffected by vibration, and these lamps have been used for a considerable time in all the leading railways in England as well as in the colonies. Also in many instances Osram lamps have been used, with great success, fitted in clusters on fittings suspended from tramway poles. They are in use for street lighting at Hampstead, Hammersmith, Marylebone, Wimbledon, Canterbury, Exeter, Acton and many other towns, no complaint being received from these places that they do their work inefficiently. The great efficiency and the long life of the lamps have, in fact, enabled the Corporation authorities, we are informed, to compete successfully with gas, and in most instances the corporations are able to show a great saving in yearly cost after receiving an increased illumination. The life is three or four times as great as that obtained from carbon lamps.

Amongst recent installations where Osram lamps have been utilised mention may be made of the Maida Vale Skating Rink, the London Hippodrome, the People's Palace (Mile End), the Empire (Leicester-square), the Theatre Royal (Hanley), Stoneleigh Abbey, Cobham Hall, the leading London stores (Messrs. Warings, Harrods, Selfridges, &c.), certain sections of the Houses of Parliament, the Law Courts, Wormwood Scrubbs Prison, as well as most of the leading hospitals, asylums and many churches and other places of worship.

The English factory of the Osram lamps has, we may mention, already proved too small for these requirements, and rapid extensions are being made to cope with the demand. Osram lamps can now be had in all sizes from ½ c.p. to 1,000 c.p. The 400, 600 and 1,000 c.p. lamps have quite taken the place of the old arc lamps in many instances.

A "Tantalum" Advertising Campaign.

Though all readers of The Electrician are, of course, convinced of the benefits obtainable from the use of metal filament lamps, there are others of the inhabitants of these isles who are living in outer darkness from this point of view. To change this state of things a vigorous advertising campaign is necessary. The advantage of metal filament lamps must be blazed forth from hoardings, railway carriages, roofs, "front pages," and any other places which come immediately under the notice of the general public. Messrs. Siemens Bros. Dynamo Works have heartily undertaken this spade work. "Tantalum" lamp advertising has, in fact, always been distinctive and effective. Contractors and the trade generally will doubtless be glad to hear that this year Messrs. Siemens Brothers Dynamo Works have arranged for a wider and more comprehensive scheme than in the past. In addition to their usually large scheme of trade paper advertising, some newspapers will also be included. We reproduce herewith (Fig. 1) an illustration of the new design of "Tantalum" lamp show card. The design is one of the "Satisfied Consumer" series, and is a follow-on to that well-known poster, "My Electric Light Bill Halved." It is of small size, 12 in. by 9 in., printed in five colours, with the main features embossed, the lettering being glazed to make it stand out very prominently. Posters of the same design—80 in. by 60 in. and also 120 in. by 80 in.—will be supplied to any person who has a suitable space for displaying them about his premises.

The same firm are also supplying a five-coloured card giving reduced facsimiles of all the types of literature which they overprint in quantities with the contractor's name and addresses free of charge. These include post-cards and three or four types of adhesive labels for attaching to correspondence. We should like particularly to draw attention to the picture post-cards. These are all printed with the same design, while on the back the contractor's name and address can be overprinted, so that they may be used as correspondence cards. The adhesive labels are well-known and widely used, the latest production of the firm in this direction being a "sticky-back" in the shape of a "Tantalum" lamp, which has been lithographed in colours and on which the words "Use 'Tantalum' Lamps" appear. By fixing these to all outward correspondence contractors can obtain an effective method of advertising "Tantalum" lamps. A reprint of the well-known Hassall design, the "Brilliant Passage" stamp, has been obtained, and these will again be supplied during the forthcoming season. A reprint has also been obtained of the Dalston Works adhesive labels, and these will also be supplied to all who desire to attach them to their correspondence.

Fig. 1.—New Design of "Tantalum" Poster.

With reference to "Tube" railway advertising, a very wide scheme has been arranged. Many people have noticed the present card in the trains which states "Watch this Space for 'Tantalum' Lamps," and there are thousands of people who are on the look-out for the design which is to appear in the space indicated. Large posters are also appearing on the majority of the London tube and railway stations. We think such an extensive scheme of railway advertising must reach many people who are actually using electricity as an illuminant. In connection with poster advertising, Messrs. Siemens Bros. have arranged a very extensive programme, and posters will appear on many hoardings in all the large provincial towns, whilst in and around London there will also be a representative display. In conjunction with these large schemes of general advertising to the public, there are also several special schemes by means of which consumers will be approached direct. Although the sales of "Tantalum" lamps have been steadily increasing during the present year, yet under such a wide publicity campaign they must be still further increased. Messrs. Siemens suggest that all contractors should take advantage of these generous offers, and we may also be permitted to suggest that this very enterprising firm should be supported in their campaign in favour of a wider use of electric lighting.

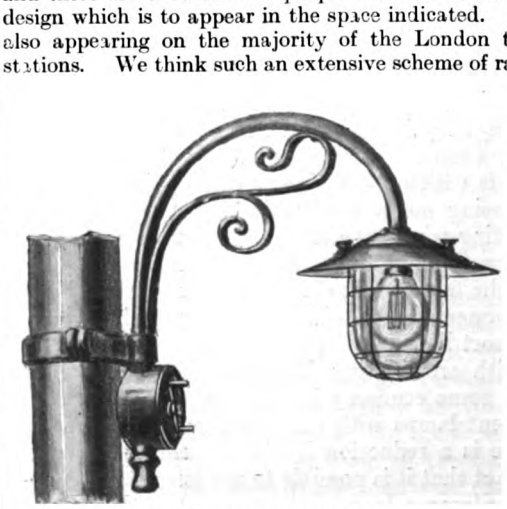

Fig. 2.—Street Lighting Fitting, with 100 c.p. "Onewati" Lamp.

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Our illustrations (Figs. 2 and 3) show "Tantalum" lamp fittings of two kinds, from which it will be seen artistic design is combined with general utility. It may also be of interest to mention that the filament used in "Tantalum" lamps is stronger than mild steel of the same gauge. With regard to recent installations, "Tantalum" lamps are now being employed for the lighting of many of the City & South London Railway's carriages, and the complete change-over to the new lamps is being undertaken as quickly as possible.

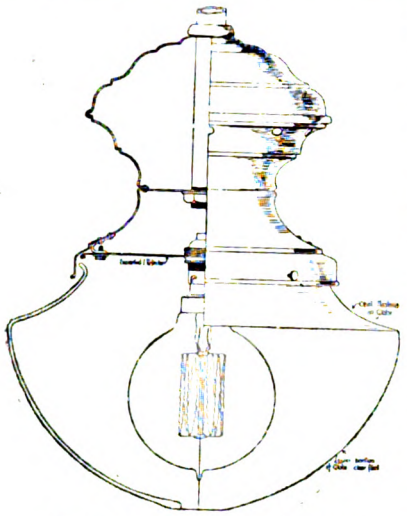

FIG. 3.—LANTERN FOR 100-WATT "ONEWATT" LAMP.

Messrs. Siemens also inform us that they have scored a notable success with their drawn tungsten "Onewatt" lamps. These have in many cases displaced gas, a state of things which is not surprising considering their strength and that they only consume 100 watts.

As regards the lamps themselves, "Tantalum" are now being made in all candle-powers from 5 to 50 and for all voltages between 20 and 250. They are made in several different types, including candle, tubular and focus lamps. The "Onewatt," besides being specially designed for use with batteries—that is, for burning on voltages from 4 to 8 volts and in candle-powers from 3 to 6—is, of course, made in moderate sizes of 10 c.p. and 16 c.p., and in the large sizes of 100 c.p.

B.T.-H. EXPERIENCE.

Anyone who has followed the development of the electric lamp from its inception until the present time will have noticed that the changes and improvements, though few, have been of a very important and distinctive nature. Doubtless this shows that we may still expect substantial improvements.

The last few years have witnessed what is undoubtedly the greatest advance ever made in electric lamps, and it may be said that the metal filament brought about the dawn of a new era in lighting. Certainly the "Mazda" lamp manufactured by the British Thomson-Houston Co. is an excellent representative of the new type of lamp which is now becoming so deservedly popular.

FIG. 4.—50 C.P. "MAZDA" LAMP.

The problems involved in the metal filament have been exceptionally difficult, and it may be said that the essence of inventive genius and modern manufacturing skill available to the large lamp manufacturers of the world has been recently concentrated upon the difficulties involved. We need scarcely remind our readers that the mere manufacture of the filament itself is a very difficult matter when it is considered how exceedingly fine is the wire employed. Owing to the fineness of this wire and the refractory nature of the materials, there has been great difficulty in making filaments of sufficient strength to withstand everyday use. Experience, however, has shown the way to surmount these difficulties, so that the filament has become stronger as time has gone on. Certainly one of the most remarkable achievements is the drawing of such filaments instead of the use of sintering processes. The "Mazda" lamp is one of those in which a drawn filament is used, and we think we are right in saying that the British Thomson-Houston Co. were the first to place such a filament upon the market.

To their many advantages of convenience, safety, adaptability, low maintenance cost, cleanliness and reliability, Mazda metal filament electric lamps have added a threefold improvement in efficiency. In addition to saving over 70 per cent. in current consumption, they give a most agreeable and attractive light, approaching to sunlight in its clearness, whiteness and healthfulness.

With all its many advantages its true economy, its long useful life and inexpensiveness, it cannot be denied that the Mazda lamp is one of the most efficient and best forms of lamp to use wherever artificial illumination is required, whether in the home, factory or workshop.

SOME EXPERIENCES WITH "AEGMA" LAMPS.

The Electrical Co. inform us that their lamps are now being pushed forward for street lighting purposes, and are being used at

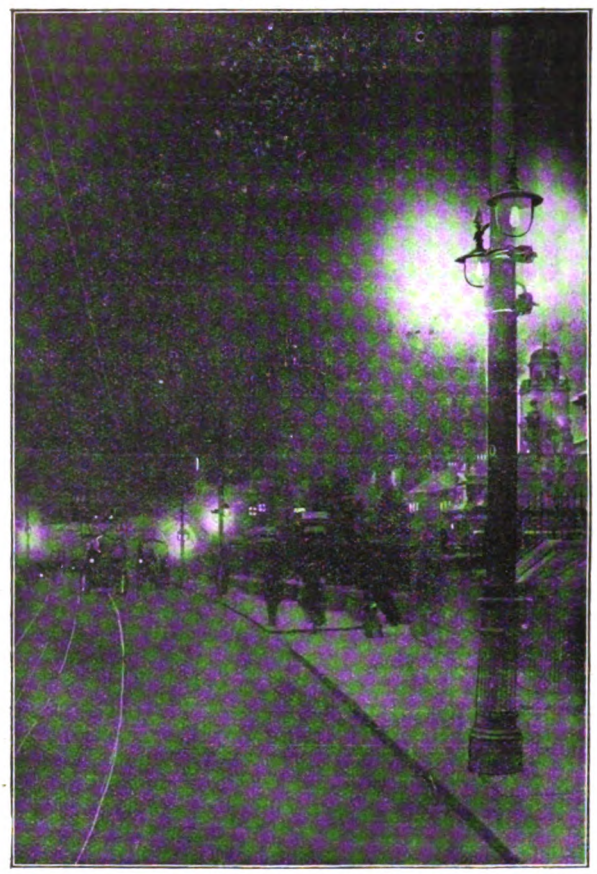

FIG. 5.—"AEGMA" LAMPS AT NIGHT.

many towns in the United Kingdom, amongst which we may mention Barnsley, Brighton, Barnes, Colchester, Gillingham, Gravesend, Portsmouth, &c. Excellent results are being reported. At Colchester there are 250 fittings which contain two 210-volt lamps burning in parallel. The life of the lamps at this town has given, we understand, every satisfaction.

At Eccles some 300 50 c.p. lamps have been in use for the past 15 months, burning approximately 3,800 hours per post. An average life of nearly 2,000 hours has been obtained at this town, though the voltage is 200 alternating.

Barnsley also report, we understand, very satisfactory results, although at the moment no actual figures are obtainable; but the lamps installed have burnt well over 1,000 hours, and most of them are still in service.

The all-important point of delivery must not be overlooked. The Electrical Co., in fact, have made arrangements this year for carrying a huge stock of lamps in London, and with this stock in London and with the works behind them turning out 30,000 lamps per day, they can with assurance guarantee immediate despatch, not only in September, but throughout the whole season. The works have been extended con-

FIG. 6.

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siderably, and are now said to be one of the largest in the world, having a daily output of between 25,000 and 30,000 metal lamps.

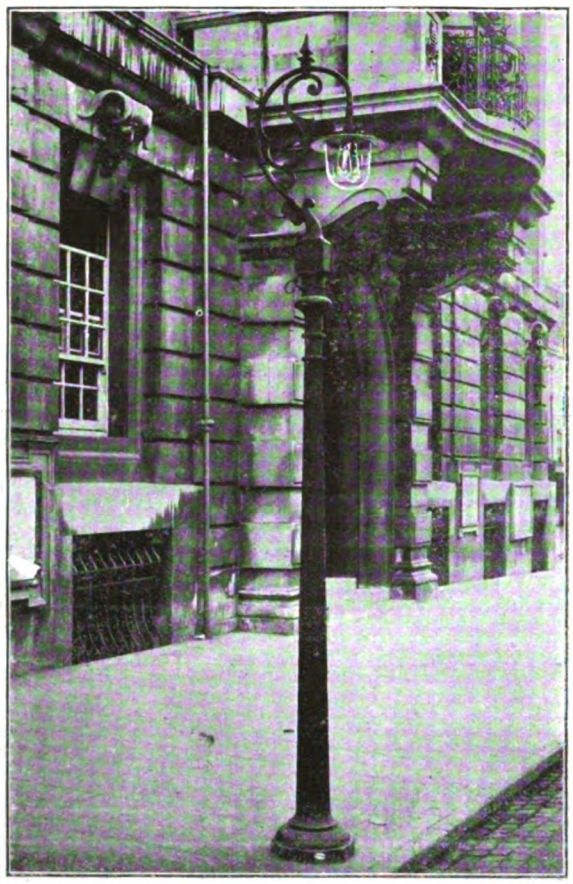

FIG. 7.—STREET LIGHTING FITTING AT COLCHESTER.

The candle lamp, shown in Fig. 6, is a new addition to their list. These lamps are made in 5, 10 or 16 c.p. for pressures varying from 20 to 130 volts.

"LEUCONIUM" LAMPS.

The "Leuconium" lamps, which are manufactured by the Stearn Electric Lamp Co., are made in all shapes and candle-powers. Special mention may be made of the low candle-power high-voltage lamps which are a speciality of this Company's manufacture. These are supplied in three candle-powers (16, 18 and 22), and are suitable for burning on all voltages up to 250. The ordinary metal filament lamps for the usual voltages and candle-powers are also supplied. Mention may also be made of the "Leuconium" cluster lamp, made up of five tubular units containing one or two filaments, according to the voltage. These are connected in series, and the tubes can be renewed at a very small cost, thus effecting a great economy over the usual method, where if one filament breaks the whole lamp is useless.

"MASCOT" METAL FILAMENT LAMPS.

One of the greatest difficulties with which all manufacturers of metal filament lamps are faced is the spacing of the many filaments which must necessarily be used for high-voltage lamps. When it is realised that for metal lamps five times the length of filament must be used as for carbon lamps of equivalent voltage the reason why such large and unsightly bulbs were at first used in the making of these lamps becomes evident. The size of the bulbs was strongly objected to by the consumer, so makers were obliged to reduce the size, and this entailed the placing of filaments closer together. However, as is so often the case, one difficulty was overcome only to encounter another. It is generally admitted that the chief cause of failure with the high-voltage lamp is caused by the short-circuiting of the filaments, which creep together when burning, thereby cutting out whole sections and over-running the remainder of the lamp, thus considerably shortening the life. To overcome these difficulties Mr. Horvath, of Southfields, has designed the "Mascot" lamp. By an entirely new arrangement of filaments, for which he has been granted a patent, it is now, he claims, practically impossible for the filaments to be drawn one to the other. They are arranged on a double frame in two rows, one circle of filaments being placed directly inside a larger or outer circle, thus enabling each filament to be spread out to twice the usual width at its base. Such a saving of space is effected by this arrangement that a 25 c.p. 200-volt lamp is mounted in a bulb very little larger than a 16 c.p. carbon lamp of equal voltage.

FIG. 8.

Mr. Horvath has also patented the "Metaflect" lamp. This is a combination of a tubular metal filament lamp and reflector. The tubular lamp is fitted with a special cap having ventilated holes. It is made suitable for pressures up to 55 volts and the lamps are grouped in series for running on high voltages. The reflector consists of a flattened oval glass bulb, one side of which is silvered, and which cannot easily tarnish or oxidise, the actual shape of the reflecting surface being a special feature of this lamp. Whilst distributing a good general light at a wide angle, it also gives out a concentrated light of high value; in other words, 60 c.p. may be obtained from a 12 c.p. lamp in a concentrated beam. Another advantage consists in being able to direct the light to any desired spot merely by turning the reflector round in the lamp gallery. The accompanying illustrations show two cheap forms of fittings suitable for use with these lamps. That in Fig. 8 consists of a thin tube with four short arms on to which the "Metaflects" are attached. This can be fixed into the corners of shop windows and similar positions. Fig. 9 shows a ceiling fitting with arms set at an angle so that the light is well distributed over a large area. When this is realised it is readily understood what enormous possibilities this lamp has for shop lighting, show-cases, concealed lighting and many similar purposes.

FIG. 9.—GALSWORTHY'S REFLECTOR FITTING.

The sale of these lamps and the "Mascots" is in the hands of Messrs. Galsworthy, 15 and 16, Newman-street, London.

BRIMSDOWN LAMPS.

The Imperial Lamp Works, of Brimsdown, are now making colloid-tungsten lamps, which are, it is claimed, second to none in strength, reliability and efficiency. They can be supplied with either pear-shaped, round or candle-shaped bulbs, suitable for burning on all pressures up to 260 volts and in candle-powers from 9 to 900.

"METALIK" LAMPS.

The "Metalik" lamps made by Messrs. G. M. Boddy & Co. have also been receiving an extended application during the past year. They are now in use for street lighting in both St. Paul's Churchyard and Queen Victoria-street, while, as examples of places where they are being used for other purposes, we may mention Messrs. Pawson & Leaf's works and "The Times" office.

Earth Wires to Telephone Lightning Arresters.—The "Electrical World" states that it has recently been decided in the Courts that it is negligence for a telephone company to fail to have its lightning arresters equipped with earth wires. The plaintiff was using his telephone in the ordinary manner when lightning struck the instrument and inflicted injuries for which he was awarded £1,000 damages. The evidence showed that there was no earth wire attached to the lightning arrester on the telephone in question.

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THE RELATIONS OF SCIENCE TO INDUSTRY AND COMMERCE.*

BY R. BLAIR.

(*Concluded from page 936.*)

Summary.—The author in dealing with this subject gives an abstract of the views of students, university teachers, manufacturers and consuls on the present connection between science and industry. It is shown that, while matters are improving, higher education is of too theoretical and detached a nature to make its recipient immediately useful in the commercial world. Remedies to counteract this state of things are suggested.

It is impossible to ignore the unanimity of the story told by H.M. consuls. The main question submitted to them was as to whether there was any truth in the statement that British firms did not sufficiently apply scientific methods to the canvassing of foreign markets, that their agents did not know the language of the country in which they were working, and that generally there was a want of activity and enterprise of the right kind. This indictment seems to be to a large extent true. British manufacturers having had till about 30 years ago rather more than their share of the world's trade made money so easily that they relaxed their efforts and have not yet adapted themselves to altered conditions of strong competition from Germany and the United States. There is not enough co-operation amongst the smaller firms, while there is a distinct lack of enterprise in sending out travellers, the number not the quality being at fault. Until by scientific education the British realise that commerce means an intricate and complex organisation of intimately inter-connected parts, they will lose many an opportunity and their consulates and chambers of commerce will be unable to do for them the work which could easily be done. Engineering, it is pointed out, is looked upon as a science, but commerce is not. Failure to adopt the metric system and to print catalogues and price lists in the language of the country in which it is intended they should be circulated is another reason why more progress is not made. Enough stress cannot be laid on the vital importance of personal acquaintance with the country, the people, their customs, needs, weaknesses, likings and prejudices and also with the local methods of doing business—in short, with everything and anything that can and does affect the market.

If the requirements of any country are to be thoroughly understood, a knowledge of the language of that country is essential. Much stress is laid by the consuls on the importance of this point, which aids in no uncertain manner the worker and the seller of goods. In this respect the English system of teaching languages is much at fault and a case is called to mind where children of a consul, who were able to converse comfortably in four or five languages, on being sent to an English school, promply forgot all they knew in this direction, though two of the said languages were in their regular school course. Too much attention seems to be paid to the learning of grammatical rules and not enough to conversation and other methods of adding to their vocabulary.

In fact, although the universities have done great work in the formative life of this country the modern world needs something more, especially from the departments of applied science. More is to be learnt from American than German methods, for there it is realised that whatever training of the highest kind a man may have he must still begin in the ranks and climb his way to the top. It has been said that British character and methods produce a few brilliant units and a mass of mediocrities. The surest road to success would probably be for the mass of mediocrities to adopt the methods of the brilliant units.

The normal attitude of the employers, if not of the public, may be expressed in three sentences: (1) Only those value higher education who have felt the need for it. (2) The purely practical man can do much, the purely theoretical man can do little; a combination is therefore necessary. Should one quality only be obtainable, which would be regrettable, that quality should be the purely practical. (3) Teaching institutions may assist individuals to get on; they form no essential part of our industrial or commercial system.

For these three sentiments I suggest that we are all anxious to substitute three others: (1) Setting aside exceptions, every man who achieves success must give a certain amount of time to fit himself for his work, whether the time is given in college under guidance and discipline, or is expended in self-education. (2) In the end, and again setting aside exceptions, the man who has received the highest training in college under guidance and discipline will, other things being equal, achieve by far the greatest success. (3) The work of research and training as carried on in technical school and university college is an integral part of any nation's successful industrial and commercial organisation.

How is the substitution to be accomplished? The demand of the shareholders of an industrial or commercial concern for dividends forms a great stimulus to intelligence and activity on the part of the staff. Without such stimulus in a technical school or faculty of applied science, there is a tendency for things to become too comfortable.

I suggest the following:—The management of all technical institutions and departments of applied science should, therefore, be put on a business footing. The ordinary governing bodies, as a rule, serve for ordinary governing purposes. The chief need is that of consultative committees attached to all specialised faculties or departments, such committees to be advisory and to be composed of industrial or commercial leaders or experts of the highest reputation. This is probably the best and surest means of enlisting the full sympathy of industrial and commercial leaders. The faculty or department, the curriculum and the examinations, would benefit by having its work and methods criticised sympathetically by experts of the first rank. Such a committee would form the surest medium of communication between the college and the workshop; and its formation would certainly be followed by a wide extension of the appreciation of the advantages of technical education because the captains of industry would learn exactly the character of the work done in college and how in practice to utilise it. The head of the teaching department and his staff would by this means gain easy access to factory and workshop, and bring back some of the atmosphere to the laboratory. On the examining committee of the engineering department of the Glasgow & West of Scotland Technical College are the engineering director of the Fairfield Shipbuilding & Engineering Co. and the engineering director of John Brown & Co., Clydebank Shipbuilding & Engineering Works. Such men would probably be generally recognised as the leaders in their particular profession on the Clyde. I understand that it is their practice to look in great detail through worked papers and designs and to give the engineering department of the college the benefit of their criticisms. Employers, parents and students cannot but have faith in the instruction given in an institution so aided. Let me make it quite clear that I am not advocating a mixed governing body, but an advisory committee of experts attached to each technical department. Governing bodies should consult such advisory committees before appointing the head of a department or even the principal of a college or technical institution. In the qualifications of principals and heads of departments it is customary to give too much consideration to academic status and too little to industrial experience and business capacity. Such a consultative body as I have referred to would act as a corrective in this respect.

A connection should be maintained with old students and a record kept of their after careers. One of the means of success of the American colleges is the list of after careers of their students. It is almost incredible how little has been done in Britain in this respect. I hope parents and the public generally will develop a habit of asking for such a list.

At each technical institution and university there should be an organisation to assist students in getting placed. The Blue Book recently issued by the Board of Education shows how much English universities have in the past neglected this aspect of their work and how much there is still to be done to establish appointments committees or bureaux. I am not overlooking the fact that much excellent work has been done by individual professors and occasionally by the secretary or the principal. But this was unorganised. I am asking for an organisation. The manufacturer and the merchant have been denounced in no measured terms by representatives of learning for their short-sightedness in not applying scientific methods to manufacturing and business processes; could not the manufacturer and the business man retaliate that not only have university and technical college goods been of such various qualities that it is impossible to discriminate, but also that scientific principles—even common business empirical methods—have not been applied to the marketing of school and college products? It is a discredit to the universities and technical colleges that they have so long neglected this obvious means of assisting students, this obvious means of promoting the cause they proclaimed.

A change in curriculum and in degree requirements. Let me read some remarks on American colleges which I wrote in 1904:—"Again, there is in each American institution a considerable 'mortality' or shedding of students. Some students find their general preparation insufficient; some find the pace too great; others find their funds give out; and some are advised that they have made a bad selection. In such cases the American student accepts advice, and acts promptly. At every step a student's work is known, and the faculty—staff of professors in each department—every four

* Abstract of a Paper read before Section D of the British Association.

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months discuss fully a student's work. The middle of the third year is the critical point in a student's career. At this stage the requirements of the Institute of Technology demand a final decision as to choice of work. Fifteen men in one department were, at this point, recently advised to change their courses or to withdraw from the institute. I was informed that, as a rule, 25 per cent. of the civil engineering students drop off at the same stage. These numbers have to be added to those who have previously 'fallen by the way.' The greatest patience is extended to the students, and the best advice is offered to them; but in the interest of the individual, as of the standing of the institute and of its influence on industrial work, such shedding of students is regarded as inevitable, and is acquiesced in. It does not follow that the men are 'wasted.' As a rule they find employment of a lower character than they were aiming at; they change the directions of their careers to their own great advantage; or they pursue a course of studies on the same lines at a secondary institution—a two-year course school."

It appears to me that such kind of advice and action is necessary in British teaching institutions, but it can hardly be done under existing conditions.

Another means of bringing the college classroom and laboratory nto closer connection with factory, workshop and office would be more liberal provision of short, cheap and specialised courses, suitable to the heads of firms or their successors. I am not referring to that provision of evening courses which is made in technical schools and schools of art, but to provision, whether day or evening, of advanced courses for industrial and commercial leaders or their successors in institutions which there could be no presumed loss of self-respect in attending. Such courses are provided at several colleges; they need multiplication. I know that a large number of able men obtain, at much expense, instruction through private agencies because the best institutions do not appear to cater directly for their needs under suitable conditions.

As to modern languages, three things are necessary for the majority of students: (1) Less the scholar's and more the utilitarian point of view. (2) More concentration during the later school and college years. (3) Speaking generally, a better class of teachers.

In conclusion, let me say that this preliminary study of a very large question has disclosed much hopefulness for the future. The obstacles which university and other highly trained men encounter in getting a footing in the industrial world are still formidable; and the breaking down of the barriers between our highest teaching institutions and commercial life forms a specially difficult task. But there is plenty of need for first-class men, and there is not much difficulty in getting the exceptionally good man placed. It is gratifying, too, to find that His Majesty's consuls speak in the highest terms of the personal qualities of our foreign commercial travellers.

On the side of education, too, there is much hopefulness. A distinguished university writer not long ago stated that the object of university education "was not how to keep our trade but how to keep our souls alive." Between such a representative of university education and the business man who inquires what is the money value of a degree, there is little room for accommodation. But the writer did an injustice to the universities, and the facts as to the objects of university education are against him. It may be true that in the long view the keeping of our souls alive is the object of university education, but even the oldest of our universities are becoming conscious that the immediate condition of saving our souls alive is that of saving our trade.

DISCUSSION.

Dr. H. T. Tovey, F.R.S., said he knew that in many works the principles of science were taken advantage of, and skilled men of ability were employed in testing the output and keeping it up to the standard, and also in experimenting with new methods. He was strongly of opinion that the application of science to industry should be universal. He thought the reason of the neglect of the possibilities of its application might perhaps be found in the lack of organisation of our national resources as applied to the training in technical knowledge and skill. He advocated the organisation and centralisation of technical education.

Dr. Griffiths (Cardiff) remarked that they had definite data now to work upon. The Paper convincingly showed that there was something very unsatisfactory in the present condition of things. The speaker could sum up the whole case in one sentence—want of communication—the extraordinary aloofness which existed between the men who conducted the universities and the men in the market place. It was not a want of sympathy, but a want of communication. The great question was how they should establish an easy means of communication and an interchange of views. There were faults on both sides. They had seen a good deal of the professors denouncing all the business communities. But looking at the matter dispassionately he fancied that business men knew their own business better than did the professors. If they (the professors) had not been able to find out yet exactly what these business men wanted there was no use in continually anathematising them. It was their business to try and find out what these men wanted and to see if they could supply it. He did not think that business men had given the system a fair trial. He believed that the man of business was in the habit of looking for immediate results. No one could guarantee that technical training, however excellent, would have that effect. Nor could they turn out from the technical institutions men who were fully acquainted with all the intricacies of the workshop. It was the business of teachers to instil into the students principles which they would afterwards be able to carry into practice. He did not believe that the business of the workshop could be taught except in the workshop. A fault of the teachers had been that purely scientific men insisted too much on technicalities of their own. They did not enter sufficiently into the points of view of the man in the market place. The top and bottom of the whole business was that at present the people did not believe in science. They believed it should be encouraged in an academic kind of way. But he did not think the British manufacturer in his heart believed in science. And no amount of talking would alter this. They must bring home to the people the advantages of research, the advantages they had gained from the laboratory in the past—advantages which to business men represented hard cash, and which to the people at large meant health and happiness. They must teach them what they had profited from a man like Faraday; what they had gained in the matter of health from Lister; they must teach them how such work as the building of the Panama Canal was done in the laboratory—largely through a close and almost indecent examination of the mosquito. They must in this way bring home to the people the advantages of pure science and their manufacturers would soon wake up. They would not attain their end by abusing industrial men, but by educating the people. The author had spoken of the preference of some manufacturers for the lad from the elementary school. In South Wales the view held was quite different. He heard one manufacturer say they were good for nothing except to lick stamps. They could not spell, they could not write, and they most probably did not know what the capital of France was.

Dr. Bielby (Glasgow) said the keynote of Mr. Blair's communication was one of hope. He agreed with Mr. Blair that it was necessary to educate the manufacturers, to educate the public, in fact, and he strongly supported the suggestion in favour of co-opting business and commercial men on the committees of their colleges and universities, thus bringing about better means of communication between those institutions and the men in the market place.

Sir Wm. White said he did not believe that in the application of science to commerce and industry we were so far behind other countries as was often asserted. There were directions in which this country led, and, of course, directions in which other nations had the lead, but, taking the position in the aggregate, we did not compare badly. We were not organised so thoroughly as was the case in some other countries, but it was possible to carry organisation too far and paralyse effort, and that had been the result in some cases abroad. There seemed to be a general impression that if a young man received a high technical or scientific training, he was at once fitted to apply his knowledge in practical work or manufacture. But that was not so. In engineering there were many young men who could get through the theoretical side of their training with complete success, but who would never be engineers, because they did not possess the necessary practical tendencies. This was, unfortunately, discovered too late, and therefore it was that a committee on engineering education, over which he presided, advised that a certain period of experience in shops should precede the advanced theoretical training, in order that, if it was found that young men did not possess practical capabilities, they might turn their attention in some other direction. There was a tendency on the part of those who had been scientifically trained to treat the business man and the manufacturer as if he only needed to be told what he had to do. Now, they might take it for granted that these men did know their own business best, and that they resented this attitude. When they got a man fresh from a scientific institution, who had been admitted into a works as what was really an improver, assuming the attitude that not a few misguided young men had assumed within his own personal knowledge, it was not to be wondered at that he did not go on and make a position. They wanted a better understanding between those who studied science and those who were concerned in its applications, and that understanding was not to be attained by telling the men who were engaged in the practical side of the business that they knew nothing and wanted to go to school again. He agreed with the suggestion that post graduate courses should be taken, but he could not help thinking that, on the whole, they were best taken, for many branches of industry, in the works themselves. He strongly advocated the multiplication of research laboratories in the works. He quoted a striking instance of the success of this system—how, as the result of research in the laboratories at Essen, based on Sir Wm. Roberts Austen's classical researches in the heat treatment of steel, a process was devised which had been enormously profitable to Messrs. Krupp, chiefly in the manufacture of armour. From that time onwards, they had received royalties which had repaid them a thousand times for what they had spent in the maintenance of the laboratory. Mr. Blair had referred to the statement that British character and methods produced a few brilliant units and a mass of mediocrities. He (the speaker) believed that in this matter, as in all others, there must be a process of natural selection, and that, in order to discover those who would be leaders and captains on the scientific side they must be content to train a great many, the bulk of whom would not rise to the highest standard. The waste was only apparent, because any man was made all the better for whatever walk in life he might follow by attaining greater knowledge.

Mr. J. E. Stead, F.R.S. (Middlesbrough) uttered a protest, so far as metallurgists were concerned, against the idea that science was neglected.

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He said manufacturers of steel did recognise very fully the value of original research. At present, however, they had got into the state of wanting a little too much in too short a time. Manufacturers must not demand so high a standard. They ought to be satisfied with a man who was thoroughly grounded in education, and prepared to let him supplement that education by a couple of years' training in their own works.

Prof. ARMSTRONG (London) remarked that the university system could be supplemented by the works laboratory. He agreed with Sir William White that we in this country were not so far behind as we were painted to be, and if we could organise our forces more thoroughly we should get better co-operation and better results.

Sir W. TILDEN, F.R.S., (in a written communication) spoke of the general scientific ignorance of employers and employed, especially in the chemical and electrical industries. He contended that not only employers, but also the State, were largely to blame for the present neglect of science by commerce and industry. From the members of the present Cabinet downwards, it would be difficult to find in Whitehall any official holding a superior administrative post who had received an education of which physical science formed any substantial part. Heroic speeches were delivered in Parliament in regard to the importance of science, but the measure of Parliamentary interest was shown by the extremely moderate character of the grants made to the universities. As a matter of fact, the new Imperial College of Science and Technology was inadequately endowed.

THE FIRST DECADE OF MUNICIPAL TRAMWAY WORKING.*

BY ALDERMAN S. FLINT.

(Chairman, Leicester Corporation Tramways Committee.)

The author here confines his remarks to municipal tramways. At the present time there are in this country 176 tramways owned by municipalities, only 84 of which, however, are worked by the same authority that owns them, and it is with these that I am only going to deal. The statistics I have prepared are as follows:—

	1899.	1909.
No. of undertakings	6	81
Miles of track	52	2,422
No. of cars	197	7,986
No. of miles run	3,371,806	197,938,433
No. of passengers	38,432,470	1,933,118,206

These figures show an enormous increase of municipal ownership and working in 10 years, and it is very doubtful if it would have been as great and as rapid under private control. As to the financial aspect, I will call your attention to some further figures.

	1899.	1909.
Capital invested	£697,270	£40,436,350
Annual income	179,585	8,780,542
Annual expenditure	112,093	5,487,291
Amount paid in interest	20,597	1,150,905
Amount paid in sinking fund	16,907	1,005,758
Income tax	848	54,026
Sundries	1,432	107,713
Net profit in year	£32,927	£974,949
Disposed of as followed:—		
To reserve fund	£26,762	£750,176
To relief of rates	6,167	303,412
Less paid out of rates	5,211	78,639
Total reserve fund to 1909		£4,200,462
Total to relief of rates to 1909		2,481,760
Total to sinking fund to 1909		6,619,450
		£13,301,672

I make no point here of the amount paid in interest during the past 10 years, because any private company would have had to meet the same charges, but I do say that the thirteen millions would have been available for dividends to shareholders, and further that the six millions placed to reserve and to the relief of rates might have been added to the sinking fund, had the various corporations so willed, and to that further extent would have reduced the liabilities under that head. But in my opinion every corporation would have been well advised in placing all net profits to reserve until there was amply sufficient to meet every emergency that might arise, and so make it practically impossible for any claim to be made on the rates. I am afraid that some of our committees will find they have made a mistake in handing over large sums to relieve the rates except in those cases where there is already a large reserve fund. I am well aware of the temptation and the pressure brought to bear, but in some cases, at any rate, it should have been resisted. I may be reminded of the amounts that have had to be paid from the rates to meet capital charges. Well, that is somewhat of a set-off, and not to be omitted. I have not the actual figures, but do not think it would reach nearly half a million during the 10 years.

In nearly all the towns that have shown a deficit, it will be found that their power costs are very high, or that they have but small populations. It will also be found that towns with separate power stations show better results than those with combined power and lighting stations, that is, where tramway committees have to buy their current. It is, perhaps, a delicate point for me to touch upon, but I doubt whether it was wise to start tramways in some of the very small towns, where the population is not sufficiently dense to make them pay either under public or private control. If, however, the people, with all the facts before them, are prepared to pay adequate fares, or even a small rate, then we need not complain. Anyway, such cases do not in any degree vitiate the policy of municipalising the tramways. That policy has been amply justified by the results, and the above figures show that the municipal tramways of the country are in a sound financial condition, and need not cause the ratepayers any fear or misgiving, except in a few isolated and unimportant cases. I am certain of this, if there was the least desire to sell them, either separately or *en bloc*, they could be sold at a handsome profit, and that is a fair test of their value. I may also remind you that many tramway undertakings have had to bear all or part of the expence of valuable street improvements, in some cases improvements that were not really necessary for tramway purposes.

The author next refers to the improved conditions enjoyed by all classes of tramway employees. These improved conditions have no doubt been facilitated by the introduction of electric, for horse-drawn cars, but it is very doubtful if they would have been granted to anything like the same extent by private or company undertakings. It may fairly be claimed that this Association has contributed in no small degree to the success of this policy. The progressive and enterprising spirit of the various committees, managers and engineers has also done much to popularise the municipal tram services. An important point to consider is what can be done to make our trams still more useful and popular, as we have not yet reached finality, although there seems to have been a lull lately. Reasonable care, however, must be taken not to make doubtful or risky experiments. I venture to suggest, as I have suggested at previous conferences, that an effort should be made to secure some degree of uniformity in regard to wages and conditions of tramway men.

Although nearly all the large municipal undertakings are in a sound financial position, some are not so placed. Whilst every tramway committee, through its manager, should keep a strict eye on its expenditure, I consider it equally important to try and increase the revenue. There is ample scope for improvement in this direction. Conductors require to be further educated in the matter of looking out for passengers, and motormen also must be trained to avoid waste of current. The difficulties of some undertakings have been caused by the price they have to pay for current. The ideal arrangement, of course, is for each tramway committee to generate its own current, especially in large towns. Where this is done the undertaking is found in a good financial position as a rule, but in small places, and even in large towns where there is a combined station and where the tram committee has to purchase the current, the price should be fixed at a reasonable figure. Where this does not prevail the committee should persistently press for a reduction of the price per unit.

Another common mistake is to run more cars on a given route than is justified by the needs of the district, resulting in very low receipts per car-mile. The old custom under which all tramway committees have to keep in repair the centre of the track and 18 in. outside the rails is also one that calls for reconsideration and revision. A first step should be to relieve tramway committees of the duty of maintaining the 18 in. outside the rails. The wider question might then be left for open a time. One point more I should like to suggest for consideration, viz., that wherever there is a desire for co-operation between adjacent towns it should be fostered and encouraged, and especially when overtures are made by county authorities for joint action with the borough authorities. I believe there is a large amount of good to be done in that direction, although care must be taken to protect the interests of our corporations and the ratepayers in the boroughs.

Included with the Paper are several tabulated statements, these give statistics of municipal tramway undertakings in 1899 and 1909, a comparison of the wages, hours of labour, &c., on the Leicester tramways in 1899 and 1909; a list of towns with combined power stations and the price paid per unit for tramway current, a list of towns with separate power stations and the total cost per unit, and lists of towns showing the financial results obtained.

* Abstract of a Paper read on Wednesday at the Conference of the Municipal Tramways Association.

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ELECTRICITY *VERSUS* GAS FOR STREET LIGHTING.

At last our gas friends have forsaken some of their vagueness and have actually descended into figures. The reason for their recent reticence can easily be surmised, and the present lapse into figures on their part is therefore the more noteworthy. Where statements are made to the effect that electricity is very many times dearer than gas—the figures varying at the discretion of the writer—the absurdity of the comparison is obvious to the man in the street; but since the introduction of metal filament lamps and flame arcs, gas enthusiasts have been more vague in their statements as to the performance of gas lamps, and have been content to criticise the figures put forward by electrical engineers. The latter have always given the fullest particulars as to the cost and energy consumption of electric lamps, so that gas engineers have had the advantage of knowing the "best" that electricity as applied to lighting can do.

As to possible developments in gas lighting the public are generally given profuse information of a kind, but the great difficulty of verifying statements as to the relative cheapness of gas and electric lighting must not be forgotten. In the case of street lighting this is particularly the case, for

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it is obvious that the measurement of the gas used in public lighting is no easy matter. This consumption must be more or less conjectured from laboratory experiments, whereas what electrical engineers would like to see are a few figures of gas consumption under actual lighting conditions.

But to return to the figures which have now been let slip by the "Journal of Gas Lighting." Our contemporary has recently been much disturbed by criticisms in the electrical press, and by the London Electric Supply Companies, as to the prices at which the Gas Light & Coke Co. have offered to supply the street lighting in the City of Westminster. The defence has, we believe, been put forward that the Gas Company can please themselves what price they care to charge for the lighting of these streets, though at the same time no hesitation is shown in declaring the supposed economy which gas lighting is showing as compared with electric lighting. On the other hand, our contemporary has recently been indignant at the idea of street lighting by gas being carried on for the sake of advertisement at a figure which is unremunerative.

We are quite prepared to accept the figure of 60 c.p. per cubic foot mentioned by our contemporary for the consumption of the new 3,000 c.p. gas lamps. For 3,940 hours per annum this comes to 197,000 cubic ft. per annum. Having regard to the conditions of the contract, the average candle-power must exceed 3,000, and for that reason we think it permissible to add 10 per cent. to the gas consumption, giving, say, a round figure of 215,000 cubic. ft. Now the Gas Light & Coke Co. have been selling gas for street lighting to the Corporation of London at 2s. 4d., which last October was reduced to 2s. 2d. Presumably this is a price which the Company feel they ought to obtain. Yet if this price were demanded for the new 3,000 c.p. lamps the cost of gas alone would be £23. 6s., whereas the contract price for 15 years is £20. 5s., including maintenance and all other charges as well as gas. Indeed this sum would be wholly accounted for by gas at less than 1s. 11d., and if these other charges merely came to such a modest sum as £5 the price for gas would fall to 1s. 5d. This does not look like running at a profit.

We may look at it in another way. Neglecting tenths of a penny, it may be said, if we accept the figure given by the "Journal of Gas Lighting," that the net cost of gas into the holders (*i.e.* cost of coal and manufacturing charges, less residuals) is 1s. per 1,000 cubic ft. On this basis the gas at cost would amount to £10. 15s. We think, however, that even our contemporary will admit that this is too low a basis on which to supply gas for public lighting. On the other hand, if we go further we find that the cost of gas to the Company, including manufacture (less residuals) and management, but excluding distribution entirely (as this is less for public lighting than for private consumers) is 1s. 4½d. per 1,000 cubic ft. sold. This figure is based on the accounts of the Gas Light & Coke Co. for the six months ended December 31, 1909. The gas at cost would thus amount to £14. 16s. To this must be added a number of charges. There is, for example, the cost of upkeep. In Mr. FRANK SUMNER'S last annual report, which includes figures relating to street lighting in the City of London, the price for upkeep and lighting of a Keith high-pressure inverted gas lamp of 1,500 c.p. is given as £3. 6s. 9d. One might, therefore, anticipate the corresponding charge for a 3,000 c.p. lamp to be somewhere in the neighbourhood of £4. 10s. Then there is the cost of the lamp, which is approximately £20, and which must be wiped off during the period of the contract. The interest and sinking fund for this purpose is not negligible, and doubtless accounts for the difference between the £22 and £20. 5s. quoted for 5 years and 15 years respectively. Further, there is the cost of special mains and compressing plant (which although available for other purposes will, no doubt, be used chiefly for street lighting) and the cost of compressing. Now, when all these items are added together we have at least just cause for suspicion that the margin of profit is negligibly small, if not negative. This remark applies even if gas is taken at a considerably lower price than 1s. 4½d. Unfortunately, figures for these costs are not available, and therefore it is very easy for the supporter of gas to exclaim that the cost of maintenance or some other item for the new lamps is much lower than hitherto, that the price of gas is really much higher than would appear at first sight, or to state that the cost of gas is really so small that there is plenty of room for maintenance charges.

We do not think we need labour the point further. Either the Gas Light & Coke Co. have been making an enormous profit out of gas supplied for street lighting hitherto, or they are supplying on an uncommercial basis for the Westminster contracts. Everything points to the latter. Of course, the Gas Company are quite within their rights in following this policy, and doubtless they feel there are compensating advantages. We cannot complain of this kind of warfare. What we wish to emphasise, however, is that our contemporaries have no right to claim, as a result of these contracts, that street lighting by gas is cheaper than by electricity. Comparisons of this kind should only be made under commercial conditions; otherwise they become more than proverbially odious. We do not, however, impute "dishonesty" to the "Journal of Gas Lighting," and we would merely suggest that it is scarcely necessary for our contemporary to use such a forcible term when criticising our columns.

Meanwhile, events in St. Marylebone, Hampstead, Brighton, Croydon, Exeter, Harrogate, Swansea (to mention a few among many) and on the networks of several railway companies show the other side of the picture. The gas lamps in St. Marylebone are being rapidly replaced by electric lamps, the energy for which is being supplied at a profitable rate, the same as to other consumers of the same class, and the last report of the Council showed that a saving of £1,630 per annum has resulted by so doing up to March 31st. We do not doubt that this saving will be much increased during the present year. Electric street lighting is also advancing rapidly elsewhere, and therefore we see no reason for the electricity supply industry to be cast down by a reverse brought about by the conditions in the Westminster contracts, which were obviously extremely adverse to the electricity supply companies.

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VOLTAGE DROP OF TRANSFORMERS HAVING A POOR REGULATION.

BY K. FAYE-HANSEN.

Summary.—The author discusses the testing of transformers for voltage drop, and emphasises the desirability of using Prof. Bragstad's method for this purpose. A number of test results are given for transformers having high reactance.

By the "voltage drop" of a transformer is understood the alteration of the secondary voltage due to the load when the primary voltage remains constant. When we speak simply of voltage drop we mean the algebraic difference between the secondary voltage at no load and at full load, and not the vectorial voltage drop, or, as it is also called, the geometrical voltage drop or the impedance voltage.

The vector diagram, Fig. 1, which is a modification of the well-known Kapp's transformer diagram, will more clearly show the meaning of the expressions used above. In this diagram the following notations are used :—

I_2 the secondary current.
OA equal to V_1, the primary terminal voltage.
OB the secondary terminal voltage at no load.
OC ,, ,, ,, ,, load.
BD the vectorial voltage drop due to the reactance.
DC ,, ,, ,, ,, ,, ohmic resistance.
BC equal to V_2, the total vectorial voltage drop.
OB—OC the algebraic voltage drop.

The algebraic voltage drop is, from the point of view of the voltage delivered to the lamps or motors, the more important, while the banking of transformers is dependent upon the vectorial voltage drop.

Three test methods have been used to determine the voltage drop of transformers :—

1. The secondary voltage is measured at different loads and power factors, while the primary voltage is kept constant.

2. The primary voltage required to force the full load current through the windings when the secondary is short-circuited is measured and also the losses which then take place. By means of the ordinary transformer vector diagram the voltage drop is then calculated for different loads.

3. The magnitude of the vectorial voltage drop is directly measured when two identical transformers are connected in parallel on the primary side, while one of them is loaded and the other unloaded. By means of a wattmeter the phase of the vectorial voltage drop can be determined, and the algebraic voltage drop can then be calculated.

The diagram of connections (Fig. 2) shows, for instance, how the phase difference between the secondary current (measured by the ammeter A) and the vectorial voltage drop (measured with the voltmeter V_2) can be determined by means of a wattmeter, W. This wattmeter reading gives also the copper losses, in a similar way to the normal short-circuit test. If the voltage is zero, the test described above is the same as the ordinary short-circuit test with the only difference that a shunt transformer is used for the measurements of the voltage.

The first method has the disadvantages that the algebraic voltage drop only is measured, and this very inexactly, however carefully the measurements may be made, because it is obtained as a difference between two nearly equal voltages.

The second method is in this respect very much better, but it rests on the assumption that the magnetic conditions for the leakage lines are independent of the voltage, that is, of the induction in the iron of the main magnetic circuit.

The third method is without doubt the best, and is absolutely correct as long as the high harmonics are not sufficiently predominant to make it unallowable to work with the ordinary vector diagrams. This method was, as far as I know, first proposed by Prof. Bragstad in 1901, and it can with small modifications be used for nearly any conditions. With this method, I have previously found that the induction in the iron of the main magnetic circuit has some influence on the voltage drop of transformers. This is due to the fact that the leakage flux has partly to go through the iron carrying the main flux and the magnetic resistance offered to this part of the leakage flux will alter with the induction. For ordinary transformers, however, having less than 4 to 5 per cent. reactance, this influence is too small to be of any practical value.

During the last few years, however, I have designed a number of transformers having a high reactance of 10 to 30 per cent., and have made some similar tests on these. These transformers (being both of the core and of the shell type) were designed to work in conjunction with rotary converters, and were provided with a high reactance to enable a voltage regulation on the direct-current side to be obtained by means of alteration of the excitation of the rotary converter without the use of boosters, &c.

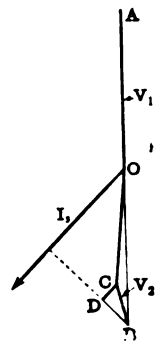

Fig. 1.

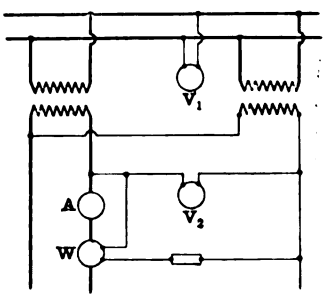

Fig. 2.

The measurements were made in the ordinary transformer test room, and it was not possible to keep the conditions absolutely stable, so that the measurements are not claimed to be very exact, nor had I sufficient time to make them as complete as I should have wished. Notwithstanding this, however, they very clearly show the voltage drop conditions of transformers having a very high reactance.

The tests hereafter described were made with three 100 k.v.a. single-phase transformers of the shell type, having a ratio of turns corresponding to 149 to 6,600 volts, at 50 periods and no load. At this voltage the induction in the iron was about 12,500 lines per square centimetre (special alloyed iron was used), the short-circuit voltage at full load current (15·15 amperes) was, for the transformer on which the measurements were made, 1,584 volts on the high-tension side—that is, 24 per cent.—and the loss measured on the short-circuit test was 1,450 watts. The copper loss calculated from the resistance

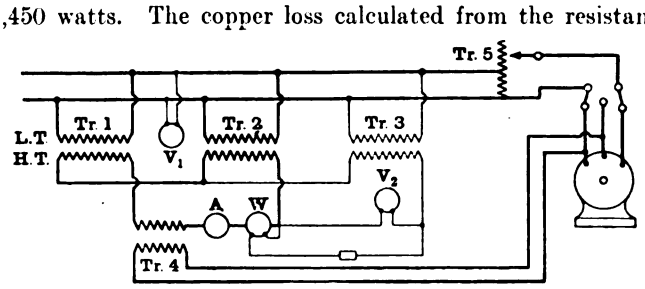

Fig. 3.

measurements was 1,150 watts, while the iron loss during short-circuit was calculated to be about 140 watts, so that the actual eddy losses were about 160 watts—that is, only 12 per cent. of the copper loss. The high reactance in this case was obtained by subdividing the coils once only (HLH) and putting iron laminations between the high-tension and low-tension coils, leaving an air-gap between the main core and these laminations to prevent them becoming saturated.

The connection during the test was as shown in Fig. 3. Tr 2 is the transformer on which the measurements were made, while transformers 1, 2 and 3 are all similar. Different phase angles between current and voltage were obtained by connecting the primary side of the regulating transformer Tr 5 to the different phases of the three-phase generator, while the phase and magnitude of the current through transformers 1 and 2 were kept practically constant. The diagram of connections

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shows that the regulating transformer Tr 5 was delivering the current and output required for the magnetisation of all three transformers, while the transformer 4 was delivering the current and output required to force the full-load current (15·15 amperes) through the windings of transformers 1 and 2. Tests with six different phase angles were made in the manner described above, giving the results shown in the following table:

L.T. voltage, V_1.	Phase diff. between L.T. voltage and vectorial voltage drop (deg.).	Vectorial voltage drop, V_2.	Wattmeter reading, W.	Phase diff. between H.T current and vectorial voltage drop (P.F.).	Induction inside the L.T. coils calculated from V_1.	Induction inside H.T. coils.
0	0	1,590	1,400	0·058	180	3,000
25	0	1,584	1,400	0·058	2,100	5,100
149	0	1,364	1,250	0·0605	12,500	15,100
0	180	1,584	1,400	0·058	180	3,000
25	180	1,584	1,410	0·058	2,100	900
149	180	1,580	1,200	0·050	12,500	9,500
0	60	1,584	1,490	0·0615	180	3,000
25	60	1,584	1,470	0·0605	2,100	4,400
73·5	60	1,560	1,600	0·068	6,150	8,000
127	60	1,500	2,290	0·100	10,650	12,400
149	60	1,456	2,450	0·111	12,500	14,150
0	120	1,584	1,440	0·060	180	3,000
25	120	1,584	1,450	0·060	2,100	2,700
149	120	1,550	1,800	0·077	12,500	11,300
0	60	1,580	1,450	0·0605	180	3,000
25	60	1,574	1,440	0·0605	2,100	4,400
73	60	1,562	1,310	0·055	6,100	8,000
127	60	1,530	590	0·025	10,650	12,450
149	60	1,500	380	0·017	12,500	14,200
0	120	1,586	1,460	0·0605	180	3,000
25	120	1,580	1,450	0·0605	2,100	2,700
73	120	1,576	1,450	0·0605	6,100	5,350
127	120	1,560	1,180	0·050	10,650	9,600
149	120	1,504	1,011	0·044	12,500	11,350

The phase difference between the high-tension current A and the vectorial voltage drop V_2 was determined from the equation $P.F. = W/AV_2$. The phase difference between the low-tension voltage V_1 and the vectorial voltage drop V_2 was determined from the connection and checked by means of measurements of the high-tension voltage. The induction within the low-tension coils is calculated from the measured low-tension voltage V_1 taking the ohmic resistance of the low-tension winding into account. The induction within the high-tension coil was determined from the high-tension voltage calculated from the low-tension voltage, the vectorial voltage drop and the phase angles. For the calculation of the induction I assume sine waves and the weight of iron to be 0·275 lb. per cubic inch. The high-tension voltage, which was in several cases checked, proved within the limits of accuracy to be the same as that determined from the measurements of the low-tension voltage and the vectorial voltage drop.

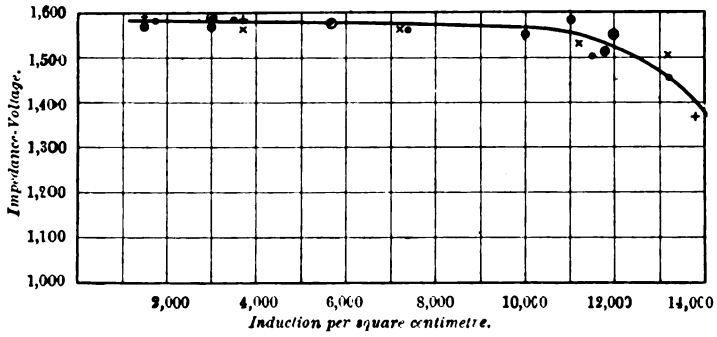

FIG. 4.

The vectorial voltage drop is, in Fig. 4, shown as a function of the average induction within the high-tension and the low-tension coils. Under average induction I understand here the mean between the induction within the high-tension and the low-tension coils as given in the table. It will be seen that for an induction up to 10,000 lines per square centimetre the vectorial voltage drop remains about the same as the short-circuit voltage. At higher inductions, however, the voltage drop is comparatively rapidly reduced. This way of drawing the curve has been chosen because if the vectorial voltage drop were shown as a function of the induction calculated either from the high-tension or the low-tension voltage, or as a function of the highest of these two inductions, the curves would not be so good.

Of further interest is the alteration in the wattmeter reading, and therefore in the phase difference, between the high-tension current and the vectorial voltage drop, dependent upon the induction in the iron and the phase difference between the voltage drop and the no-load voltage. The differences in the wattmeter readings are much too large to correspond to a real difference in losses, especially as this would in some cases mean negative eddy losses; the cause must therefore be that the watts taken from the low-tension side alter with the magnitude and the phase of the leakage field. Unfortunately, the conditions made it impossible to confirm this in my tests. It was, however, ascertained that the current taken for all three transformers on the low-tension side, which must be considered as a sum of the three no-load currents, increased when the current through the windings of transformers 1 and 2 were increased.

I hope that other engineers who have time and opportunity to make similar tests on transformers with a high reactance in a more complete manner will not fail to do so, especially as in ordinary transformers, of course (as well as in three-phase induction motors), the same conditions prevail, but to so small an extent that it is very difficult to obtain good test results.

It would also be of great interest if similar tests were made in three-phase slip-ring motors, as such tests would show how the reactance and the losses due to the load currents alter with the induction in the iron, and also how the "no-load current" and the "no-load losses" are altered with the load currents. In this way it would probably be possible to find an explanation for differences in the results which are obtained with measurement of the no-load and short-circuit currents and of the brake tests on three-phase induction motors.

NINTH ANNUAL CONFERENCE OF THE MUNICIPAL TRAMWAYS ASSOCIATION.

The proceedings of the ninth Annual Conference of the Municipal Tramways Association, which this year is being held at Bradford, were opened on Wednesday by the reading of the Presidential Address by Mr. C. J. Spencer, general manager of the Bradford Corporation Tramways.

There was a good muster of members, including Messrs. A. Baker (Birmingham), J. B. Hamilton (Leeds), J. M. McElroy (Manchester), J. Aldworth (Nottingham), A. L. C. Fell (London) H. E. Blain (West Ham), H. Mozley (Burnley), A. A. Day (Bolton), A. R. Fearnley (Sheffield), J. Dalrymple (Glasgow), and many other engineers and chairmen of tramways committees.

We give below an abstract of Mr. Spencer's address.

PRESIDENTIAL ADDRESS.*

We occasionally hear grave doubt expressed as to the commercial soundness of municipal tramway undertakings. The accounts are freely published in great detail each year, yet our critics say that if our accounts were kept on right lines, and a proper amount put away each year for obsolescence and depreciation, things would appear very different, and sometimes the methods of a well-managed company undertaking are held up as an example of how things ought to be done. From the Board of Trade returns I find that last year company and private tramway concerns put by for depreciation, obsolescence, &c., £251,052 on a capital of £23,888,485, or 1·05 per cent. For the same period municipal tramways put by for the same purpose into sinking fund, reserve and renewals accounts, £1,644,212 on a capital of £47,134,754, or 3½ per cent. Whether municipalities are thereby adequately meeting their obligations is a question which has, on more

* Abstract.

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than one occasion, been fairly well discussed; but having regard to the above figures, it does not seem that the advocate of private ownership methods has much reason to compare company as against municipal practice with any deprecatory sentiments to the latter. Having regard to the above figures, there seems little reaon to doubt that municipal tramways in the mass are commercially sound.

There does not appear to be any general desire on the part of Corporations to turn their backs on the policy of public ownership and hand over their tramways to private enterprise. The fact of the matter is that experience has proved, in the great majority of cases, that the tramway transit facilities are operated and controlled to the best public advantage by the local authorities in whose area the tramways are located.

Passing from the commercial aspect of the matter, I am not at all sure that citizens have fully realised the immense benefits that a tramway in the hands of a progressive Corporation may have, and probably has, conferred upon the populations of towns, cities, or urban districts. It has not, however, in my judgment, been yet fully utilised for the public good. In the main we, as operators, have devoted all our energies to the carriage of passengers. We have heard on various occasions in the past, for many years, the possibilities of tramways handling local goods traffic, and it is astonishing to find, notwithstanding all that has been said on this subject, that the amount of revenue received from other than passenger receipts is in the ratio of 38 to 1.

One is accustomed to see in our large towns long rows of heavily-laden horse-drawn vehicles moving along the streets at from three to four miles an hour, impeding the fast-moving traffic, and generally reminding one of the dark ages, and yet at the same time we have a metal track capable of carrying vehicles up to any reasonable weight, and an almost unlimited supply of tractive power at our disposal, whereby we could transmit these particular goods at four or five times the speed, with greater safety to the public, and with greater expedition and despatch as compared with present methods.

My own Corporation has this year drawn to itself some amount of attention by asking Parliament to grant further goods-carrying powers to its tramway system. We were not successful in our plea, it being urged against us that so many Corporations already possessed the powers for which we asked, who had not exercised them to any material extent. It was certainly difficult to place evidence before the House of Commons Committee to show any extended business in this direction under the control of municipalities. There may be, and probably are in some cases, very good reasons for not undertaking this class of traffic, but in the majority of cases it seems to me that the matter should receive careful study and consideration. I am pleased to hear that the Corporation of Leeds are going into this matter with their usual thoroughness, and have entered into some large contracts for the carriage of material.

In some towns there is, I believe, a want of cohesion between the streets department and tramways department in cases of snow-storms. Experience seems to have proved that the tramways department has in its hands the most effective instrument for the clearing of the streets of snow, and it certainly only looks to be a matter of organisation for a much better state of affairs to exist in our towns in respect of this item. The practice of some of the Continental cities in this respect is worthy of attention.

Trackless Trolley.—The introduction of this new method of transit into this country will certainly not, as some people seem to think, cause the tramway proper to be an obsolete piece of apparatus, but it will undoubtedly extend the sphere of usefulness of the trolley system. The tramway construction boom has stopped, not because every district that needed better travelling facilities was supplied, but because financial reasons made it impossible to proceed any further into districts where the population was so thin as to be unable to support a capital expenditure of £14,000 to £15,000 per mile of tramway laid.

The petrol-propelled vehicle came along to meet this want, but owing to the operating costs of a petrol motor omnibus service being so high per 'bus-mile, not much advantage, if any, is gained over the ordinary tramway, including its capital charges. The trackless system, however, provides a vehicle as reliable as a tramcar, and at least as cheap to operate, but with a capital expenditure on street work so low that the bugbear of heavy interest and sinking fund charges is practically non-existent. As a result of the report of a deputation to the Continent my Corporation are now the proud possessors of powers for the installation of what they hope will be the first line of trackless trolley in this country.

Other Possible Developments.—Aerial navigation is progressing at a great rate, and whilst I cannot yet even dream of tramcars becoming really trackless, yet not so long ago many wise men proved to their own satisfaction the impossibility of even the present-day achievements of aerial navigation. Coming a little nearer, however, to practical politics, one is reminded of the development of the mono-rail system. The use of the gyroscope opens up possibilities in certain directions that are certainly worthy of the attention of railway and tramway men. Again, the accumulator phase of development is perhaps worthy of more than passing attention.

On the other hand, the traction motor and car equipment is also showing signs of improvement in several directions, but chiefly in the increase of efficiency so far as power consumption is concerned. Reputable makers are now prepared to guarantee 10 to 12 per cent. higher electrical efficiency of equipments than formerly. Truck development is also proceeding, and we have truck makers who tell us that with their particular trucks they will guarantee a saving of 10 to 15 per cent. in electrical energy, and so on. In various directions the tendency is to reduce the power used per ton of material propelled, and I do not think it at all unthinkable that we shall be able to propel our cars in the future with, say, 50 per cent. less energy than at present. If, then, the accumulator of the future is, say, half the weight for the same capacity, there should be interesting possibilities. Lest 50 per cent. saving of power should be thought rather high, I would mention that we are wasting by wearing away brake shoes and tyres about 40 per cent. of the energy we supply to our cars. Regeneration or recuperation is not, in my opinion, quite dead, and the future should see progress in that direction.

In the main, tramways have been very successful in attracting short distance traffic, and undoubtedly the railway companies have felt the pinch of our competition very severely, so far as short distance traffic is concerned. Many railwaymen, however, have realised that tramways are not solely competitors, but act as very valuable feeders for the long-distance traffic. The travelling habit has been considerably developed, and tramway enterprise is largely responsible for it.

Reference was next made by the President to the work of the Association during the past year in connection with, amongst other things, rail corrugation, the price charged for current and assessment; and he finally mentioned that the work immediately in front of the tramway manager seems to be in the close study of those small items of administration that may have played the part up to the present of "unconsidered trifles," such as the wear and tear of brake shoes and tyres and car lubrication, Papers on both of which subjects were being presented at the Conference.

A hearty vote of thanks to the president having been proposed and seconded, Alderman S. Flint (Leicester) read his Paper entitled "The First Decade of Municipal Tramway Working." An abstract of this Paper is given on p. 983 of this issue, and the following is an account of the discussion.

Councillor RODGERS (Newcastle) remarked upon the fact that out of 176 municipal tramways only 84 were worked by municipal bodies, the balance being leased. The rabid municipalist was more harmful to municipal trading than the advocates of private enterprise. He thought that tramcar drivers as compared with mechanics who had served their time, were overpaid. Co-operation was needed among municipalities, and if Manchester and Salford gave the tramway employés the 48-hour week, other bodies should follow suit.

Mr. H. MOZLEY (Burnley) remarked that 'the' examination' of the undertakings in bulk was not strictly fair. He had analysed the Board of Trade returns and found that the whole of the undertakings averaged 7 per cent. on the capital expenditure. The individual returns showed:—

	Per cent.		Per cent.
19 undertakings under ...	4	4 undertakings between	8 and 9
10 ,, between	4 and 5	7 ,, ,,	9 ,, 10
14 ,, ,,	5 ,, 6	4 ,, ,,	10 ,, 11
12 ,, ,,	6 ,, 7	2 ,, ,,	11 ,, 12
12 ,, ,,	7 ,, 8	1 ,, ,,	13 ,, 14

In steam tramway days the average wage of the drivers was £2. 3s. 10d. per week.

Mr. C. F. SPENCER (Halifax) thought that if the tramways were sold much more money would be realised on them than had been expended. In Denmark tramways were run at a loss, the companies recouping themselves by the increase in land values.

Mr. H. E. BLAIN (West Ham) thought that the tramway manager's views should be given entirely irrespective of party bias. He felt that the reserve funds were quite adequate.

Mr. J. M. MCELROY (Manchester) advocated the extension of the tramways beyond the municipal boundary, in spite of the veto of small outlying townships.

The members then adjourned for luncheon in the Banqueting Hall, at the invitation of the chairman and members of the Bradford Corporation Tramways committee. At the afternoon session of the Conference the discussion on Alderman Flint's Paper was resumed.

Mr. J. DALRYMPLE (Glasgow) put in a special plea for uniformity in matters of tramway management and operation, and hoped that active steps would be taken to obtain this.

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Councillor TRUMBLE (Croydon) complained of the price paid by most municipal bodies for current for the tramways. At Croydon, though they were unable to get a reduction in price for energy, they had used meters on the cars, and by this simple expedient were saving £6,000 a year.

Mr. J. R. SALTER (South Lancashire Tramways), in a mild criticism of municipal tramways, remarked upon the heavy burdens for street improvements under which the company tramways were being operated. The London United Tramways had expended as much as a million of money in this way, and his own undertaking was saddled to the extent of £100,000; his system served 26 municipal districts, none of which could have had its own tramway. He felt that there was no comparison between the returns upon the capital of company and municipal undertakings. It was a mistake to suppose that where current was purchased from a combined station that the electric light department was making all the money out of the tramways. Further, he could not support the policy of separate stations for lighting or trams, a combined station was the right thing.

Mr. H. E. YERBURY (Sheffield) and Councillor FLINT (Birkenhead) also spoke.

Alderman FLINT, in reply, said that his figures were based on Board of Trade returns, and he regarded them as accurate enough for his purpose. Municipal tramways were not purely financial undertakings, there were other considerations which had first to be taken into account. As to street improvement charges imposed on companies, in many cases these charges were taken over by the municipal authority when it took over the trams from the company.

A hearty vote of thanks was then accorded Alderman Flint for his Paper.

Mr. J. W. Dawson next read a Paper on "The Comparative Durability of Brake Shoes and Tyres." An account of this Paper and of Thursday's proceedings will be given in our next issue.

SMOKE ABATEMENT EXHIBITION AT GLASGOW.

An exhibition of apparatus having "smoke abatement" as its object was formally opened on Friday, September 16th, by Lord Pentland, Secretary of State for Scotland, who was accompanied by the Lord Provost of Glasgow and the Provost of Paisley, and numerous other civic officials, magistrates and councillors. The promoters of the Exhibition are the Corporation of Glasgow; and the collection of exhibits to be seen at the American Skating Rink, Victoria-road, Glasgow, reflects the greatest credit on all concerned, including Councillor D. M. Stevenson, the convenor of the special committee.

On entering the building, the visitor is immediately attracted towards the "Electric House," the exhibit of the Corporation Electricity Department. This is a typical three-room and kitchen house with laundry and bathroom. All the lighting, heating and cooking is carried out by means of some electrical appliance. There is even no necessity to strike a match to light the ubiquitous cigarette, as that is done electrically. The idea has been to demonstrate the use of electricity without going to any extravagance, the lighting being calculated not to exceed 30s. per annum; and efficiently illuminated it is at that by the use of metal filament lamps.

The furnishings and decorations, a feature of which is their light colours, have been lent by Messrs. A. Gardner & Sons, Glasgow. The heating is carried out by means of Murray's new luminous radiators, which radiate the heat on to the floors, &c., the latter acting on the convection principle to heat the rooms. The ventilation is on the Glover-Lyon system, and the small fans have been lent by Messrs. Matthews & Yates and Messrs. Keith, Blackman & Co.

Among the electrical cooking appliances we may mention the General Electric Co.'s oven, the "Phœnix" oven, the Lancashire electric oven (Gray's system) of Messrs. Bertram Thomas, "Silundum" ovens of Messrs. Simplex Conduits, a Bastian oven, and a "Tricity" range of the Berry Construction Co., through their local agents, Messrs. Malcolm & Allan. The latter have a chef in attendance cooking all sorts of edibles.

Electric irons are exhibited by Messrs. Eastman & Warne, the General Electric Co., Messrs. Simplex Conduits, Bastian Co., and the British Thomson-Houston Co. Various kettles, grills, &c., were also on show by the General Electric Co., the B.T.-H. Co., Messrs. Simplex Conduits, and others, whilst in the bath room there is a "Therol" water heater. The "Stannos" and "Simplex" methods of surface wiring are also shown. Laundry demonstrations are being given throughout the day.

With regard to current consumption of the various appliances, some tests were taken which may be of interest. The "Therol" heater for 25 gallons took 200 watts, and fitted with the accelerator (a new attachment to heat 50 gallons) took 1,000 watts. The G.E.C. oven, on which three heats can be obtained, took 3¼ units per hour, the grill 1,400 watts and the hot plate 1,223 watts. The Bertram Thomas oven has two heats, taking 700 watts and 2,500 watts respectively, inclusive of the small pilot light inside, which admits of inspection of the contents of the oven without opening the door. The "Tricity" oven has also two heats, the low requiring 250 watts and the high 900 watts.

In close proximity to this house is an information bureau, with a huge map of the city showing all the street mains, so that intending consumers can be informed "while they wait" the probable costs of anything they should fancy. An artistic 70-page booklet, forming at the same time a compendium, both for power users and householders, and an interesting souvenir, is freely given to all visitors to the house.

Mr. W. W. Lackie, city electrical engineer, Glasgow, and Mr. Davis of his "publicity department" are to be congratulated on the excellent exhibit which has been got together and on the determined effort they have made to increase the consumption of current.

Elsewhere in the show Messrs. Mavor & Coulson are exhibiting 40 H.P. and 70 H.P. totally enclosed motors. The feature of these is the system of ventilation. At the commutator end is a fan, in a separate chamber but driven by the same armature shaft, forcing air through a series of tubes crossing the interior of the motor after the principle of the well-known surface condenser. The cold air is drawn in by the fan and forced out at the pulley end of the tubes perceptibly warmer. It is claimed that these motors will be particularly suitable for fiery mines, flour mills and other places where there is a lot of fine dust, as the outer atmosphere is not allowed to mix with that inside the motor carcase while running. The inspection holes over the commutator have wide, machined metal to metal joints on the principle now advocated for fiery mines. They also exhibit a handy form of vacuum cleaner. Messrs. Drake & Gorham, Spagnoletti & Co., Alston Scott & Co., Watson & Whyte and Potter & Co. have a combined display, the most interesting among numerous appliances being the "Telewriter."

The Beck Flame Lamp Co. are showing 12 of their lamps. By means of a specially made screened box fitted with suitable lenses they also demonstrate the feeding of the arc in one of their lamps, the glare of the arc being reduced so as to allow of its being seen without discomfort.

The Westinghouse Co. and Messrs. Woodward & Co. have a combined display of lamps and well-known gear, while Mr. Alex. Lindsay and the B.T.-H. Co. also combine in a similar manner, making in both cases an effective display, including a country house generating set.

Simplex Conduits, Ltd., exhibit their well-known system of conduits, also metal lamps, surface wiring and other specialities, the show of Holophane shades and globes being very effective and pleasant.

The General Electric Co. exhibit a range of nearly all their productions, the blaze of light impressing the word "Osram" before all others. The first 1,000 c.p. "Osram" to be seen in Glasgow is on this stand. The inverted shade reflectors for use with metal lamps are also shown as well as a 25-lamp country house set. Attention is also drawn to a set of gear consisting of an electric iron which when not in use as an iron can be used to boil a kettle, heat a saucepan or a frying pan, the whole arrangement, including the stand, iron kettle and pans, selling under a sovereign. The new Zig-Zag radiator lamps used in the Murray radiator are also exhibited.

The remainder of the exhibits deal mainly with such apparatus as Anthracite stoves, gas fires, &c., having the object of the exhibition in view.

One interesting fact, however, is apparent to all, namely, that it takes the four 48 in. Blackman electrically-driven fans running continuously to prevent suffocation from gas fumes in the hall.

NEW G.P.O. TELEPHONE EXCHANGE, GLASGOW.

At the invitation of the Postmaster-General of Glasgow and the Peel-Conner Telephone Works a party of technical and daily press men visited Glasgow on Monday, and were conducted round the new P.O. telephone exchange. We have already given a full technical description of this exchange and commented upon its principal electrical and mechanical features.

The company included a number of distinguished engineers, among whom we may mention Sir John Gavey, Mr. A. M. Ogilvie, Mr. H. Hirst, Mr. M. S. Conner, Mr. P. P. Kipping, Mr. C. H. Wordingham and Mr. Chas. Bright.

The visitors were given special facilities for a private and detailed inspection of the exchange during the morning, when

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they were conducted round by the members of the staff of the engineering department, who courteously explained the principal items of interest. Subsequently a luncheon was given to the party, which by this time had included among its number representatives from the Scottish daily press. During the afternoon an official reception was held by the Postmaster-General at the telephone exchange, and an opportunity was also afforded the company of going over the P.O. trunk telephone exchange, which has been in operation for some years past. The postmaster courteously extended the programme to the telegraph instrument room, which is in the same building as the trunk exchange. This room provided many objects of interest, which the visitors did not fail to appreciate fully.

At the luncheon at the Central Station Hotel the chair was taken by Mr. H. HIRST, who, after the loyal toasts had been honoured, referred briefly to the enterprise of the Post Office engineering department in bringing its Glasgow exchange equipment up to date, and also in placing the contract for the manufacture and installation of the equipment with a British firm. He regarded this step as a healthy sign, and one which indicated a tendency in the direction of encouraging home manufactures, particularly in branches of industry which have previously been regarded as the monopoly of American firms.

Mr. A. M. OGILVIE, replying for the Post Office engineering department, recalled the early telephone experience of the Glasgow Corporation, and also referred to the function which marked the transfer of the Corporation undertaking to the General Post Office. At that particular time the Post Office had pledged itself to the Corporation to do their utmost to improve the telephone facilities of Glasgow, and to bring the entire city installation into line with modern practice. He felt that the new exchange fully testified to the fact that the promise of the department to the Corporation had been well kept.

Bailie DUNLOP, who represented the Corporation of Glasgow in the unavoidable absence of the Lord Provost, spoke in appreciative terms of the new exchange, and also gave it as his opinion that the transfer of the Corporation undertaking to the Post Office had relieved the apprehensions of many of Glasgow's citizens regarding the advisability of the Corporation indulging in telephone enterprise.

Mr. M. S. CONNER, who was enthusiastically received, gave a number of interesting details of the construction of the new exchange, and directed attention to many items of technical and general interest. He commented specially upon the fact that, whereas many telephone manufacturers had sunk a large amount of capital in expensive tools for the production of standard telephone parts, the Peel-Conner Telephone Works had started *de novo*, and were able, therefore, to design afresh a quantity of the special apparatus which was commonly used in telephone work, such as plugs, jacks, keys and relays. He referred particularly to the internal construction of the plugs, which was such that the body was only slightly cut away for attaching the cord. This design eliminated plug breakage due to the weakening of the body near the top of the sleeve. His company has submitted plugs of this kind to extremely severe tests, and they had found that plugs were never broken, but remained serviceable after more than 300,000 insertions in the jacks. As far as the jacks were concerned, springs were employed on each side of the plug, and, further, these springs were placed on edge, so as to avoid the accumulation of dust. Again, there was a positive stop for each spring, which dispensed with adjustments and prevented worn plugs from damaging the jacks by getting on the wrong side of the spring. They were able to say that this design of jack was in a good serviceable condition after more than half a million insertions of the plugs. He wished specially to remark upon the design of the relays. The framework formed no part of the circuit, and the armature springs were not affected by vibration. The armature also formed a magnetic return outside the coil, and during operation shortened the magnetic circuit. By this means the leakage which must exist in single coil relays helped to operate that relay. He stated that this type of relay was 10 per cent. more efficient than those patterns employing a stationary magnetic return, and 20 per cent. more efficient than the type in which the armature formed the return but lengthened the magnetic circuit during operation, being, in fact, attracted away from the coil. He felt confident in stating that the central battery equipment of the new Glasgow telephone exchange was the best in the world, and he thought that, with reasonable care, it would continue to do duty for at least 30 years. He regarded it as an important advance in telephone work that the voltage employed was raised from the formerly accepted standard of 22 volts to 40 volts, and he also considered that, in the provision of the Stone transmission system, using retardation coils and condensers instead of the Hayes system with repeating coils, the articulation was improved, and on short lines anything in the nature of unduly loud speaking was avoided. He considered that the Hayes system was devised for the purpose of facilitating the connection of earth circuit lines with metallic circuit lines; but, as earth circuit lines were now regarded as in the past, he thought that the use of the older Stone arrangement resulted in clearer transmission of speech.

From our inspection of the exchange we cannot speak too highly of the arrangement of the equipment or the manner in which the work has been carried out. The building in West Campbell-street was designed specially for parcel service, but the third floor, upon which the whole of the exchange and its equipment has been installed, affords ideal accommodation. It would be difficult to conceive of a more roomy, better ventilated operating room. Although the work of the exchange girls is not, on the average, of an arduous character, at the same time it must become very tedious at times. For this reason the operators must appreciate the provision of bright and spacious surroundings. We have already commented upon the unique arrangement of the exchange upon a single floor, and we were much impressed with an inspection of the actual equipment. The work which has been put into the cabling, from the point of entry into the building of the lead-covered cables right away through the various racks to the subscribers' and trunk sections, cannot be praised too highly. Praise is particularly due to the engineers for the manner in which the multiple has been carried out.

We can only conclude by expressing our thanks to the management of the Peel-Conner Telephone Works for the opportunity of inspecting the exchange, and we may further express the wish that interested telephone engineers will apply for permission to be shown over the equipment.

THE "SUN" SCREWED TUBE SYSTEM.

The wiring systems that have recently been placed on the market have all been conspicuous on the side of cheapness. Their avowed object has been to overcome the difficulties inseparable from the installation of electric lighting in small houses, if heavy screwed conduit has to be used; and to provide a system which is at once cheap and durable.

There are some, however, who prefer the old systems, and to whom the extra expense is no objection. For these people the Sun Electrical Co. are now catering. In order that the unique benefits of the

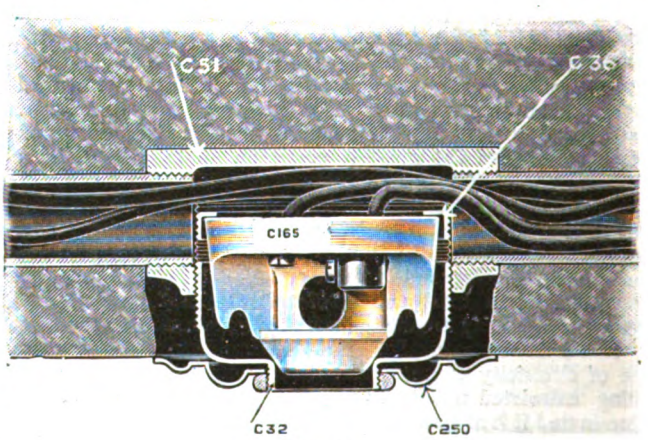

FIG. 1.

"Kalkos" patent box may be still further extended, this piece of apparatus is now being manufactured in malleable iron to take all the standard sizes of screwed steel conduit.

As is well known, the prominent feature of the "Kalkos" box, the new type of which we show in section in Fig. 1, is the adjustment ring. Every contractor is aware of the many difficulties which arise in wiring new buildings in which conduits are buried, when the switches and other fittings have to be fixed. There is always some adjustment to be made in order to bring the switch plate flush with the finished wall, the plaster may not have worked to schedule, with the result that the box is left, perhaps, ½ in. or so deeper than anticipated. In the past this has always been a difficulty hard to overcome. With the patent boxes, it is claimed, it is simplicity itself. The adjustment ring is rotated forwards or backwards as desired, in order to attain the desired level at the front of box. Nearly $\frac{5}{8}$ in. adjustment is thus obtained with any cover. The adjustment obtainable is unlimited, if the correct cover is selected. In flush work a further adjustment is also possible on the switch plate. To fix this the plate is slipped over the projecting male thread on the cover (C32). It automatically adjusts itself to the level of the plaster or wall panel, irrespective of the angle at which the box happens to be fixed, and is securely fastened by means of the milled ring provided. Our illustration shows the component parts of the box in detail with a ceiling rose; C51 being the "Kalkos" iron box, C36 the adjustment ring, C165 the ceiling rose, C32 the cover, and C250 the flush plate. All boxes are

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of the double compartment type, giving a clear space between the bases of the switches, plugs, or ceiling roses. The bottoms of the boxes can be used as distribution or joint boxes, and thus the number of junction boxes can be reduced to a minimum. By this arrangement joints are accessible at any time by unscrewing the cover and taking out the fittings, the wires behind thus being exposed without disturbing either floors or decorations. A general view of a three-way box is given in Fig. 2, one-way and two-way boxes are also made. An

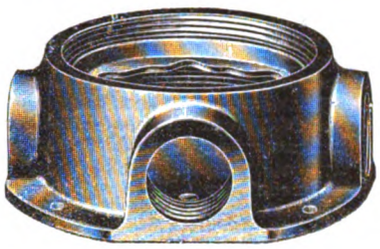

Fig. 2.

important feature of the double compartment type of box is that it gives a clear run through for wires to other points, thus making possible a great saving in material.

Two interesting pieces of apparatus have been introduced in connection with this system. The first of these is the switch shown in Fig. 3. It has been designed to eliminate the difficulties hitherto experienced when using ordinary panel switches in a system which is earthed throughout. It will be noted that in the "Kalkos" switch all current carrying parts are enclosed in a porcelain well. It is, therefore, impossible for any live metal to come into contact with

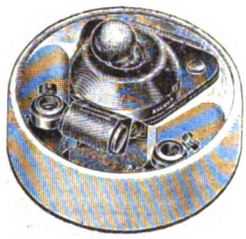

Fig. 3.

Fig. 4.

the switch cover. And when breaking circuit with a switch carrying its full capacity of 5 amperes, there is no risk of an arc being drawn and set up between the terminals and earth. The screws of terminals are so protected by porcelain that even when right out it is claimed they cannot touch the box or cover. Terminals can be tightened up after the switch has been placed in the box, there being channels in the porcelain to admit of the use of a screw-driver. An important feature is that the dolly is effectively earthed to the system only when the cover is screwed into position, but is always automatically earthed as soon as the cover is fixed, there being no connections to make. The

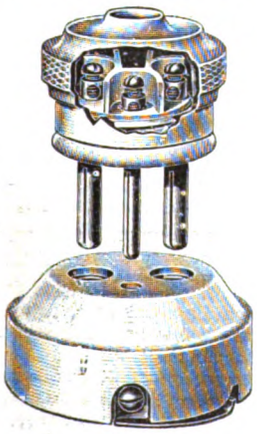

Fig. 5.

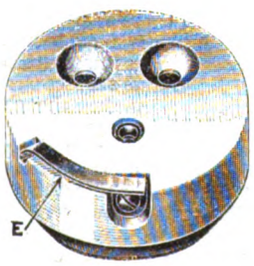

Fig. 6.

switch is both water tight and air tight; this very desirable result is effected by means of the collar, C (see Fig. 4), which keeps the packing, P, tightly pressed round the back of the dolly, D. The entire hole of the cover is coned to take the collar, C, making a gland joint, the whole switch being therefore watertight. The collar and packing is fitted to the switch, there being no loose parts. The base has been designed to check accurately into and fit the adjustment ring, so that no lateral movement can take place. The contact arm of switch is enclosed in marmorite, thus effectively insulating it from the operating mechanism, and at the same time placing an insulated barrier between the two poles of switch when the circuit is broken. The special construction of the contact arm, whereby this moves independently of all other parts of the switch, enables it to roll into position when switching on, the movement being particularly easy. It affords also a very large contact, ensuring as it does the whole of its surface for this work.

Another piece of apparatus is the wall socket and plug, shown in Fig. 5. It has been designed to comply with the requirements of the Factory and Workshop Acts, 1901 and 1907.

The connection to earth is made automatically as soon as the socket is inserted in the box, by means of a spring contact, E (Fig. 6). It is said to be impossible for wiremen to omit to make this connection when fitting. The third pin of the plug is available for the earth wire or sheathing of the flexible and for portable fittings. It is impossible for the "earth" pin to be inserted into a live socket or vice versâ. If this plug is used on three-wire systems, where the tube is used as the neutral, the third pin can be employed to carry current, the pressure between this pin and either of the others being half that of the total voltage of installation.

NEW WATKIN SWITCH.

At the Engineering and Mercantile Exhibition which is at present open at Olympia, the Adams Watkin Co. have an extensive exhibit which demonstrate in a practical manner the application of this well-known switch to the control of lighting, heating and small power circuits. One of the features of the exhibit is a tumbler pattern Watkin switch which has a maximum capacity of 64 watts. This has been brought out to meet the demand for a switch to control one or two metal filament lamps. The switch is very little

Tumbler Pattern Watkin Switch.

larger than the ordinary tumbler switch and is as easily operated. Further, the special carbon resistance element is contained within the circular cover of the switch, so that its external appearance is in no way impaired (*see* illustration). We understand that the Company is experiencing a big demand for this pattern of switch. The exhibit at Olympia is of more than ordinary interest, because the Company has taken special pains to wire up carefully the various sections so that they can explain to the public the value of the switch as a current economiser when used in connection with lamps, fans, irons, electric kettles, radiators, &c. Those of our readers who are unable to visit the Olympia Exhibition, but who are interested in this pattern of switch, can inspect it under actual working conditions at a specially fitted out showroom at the Company's offices in Victoria-street. Here a large office has been fitted up as a modern dining room and practically every application of the Watkin switch can be actually demonstrated.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent, for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Notions Générales sur La Télégraphie sans Fil et La Téléphonie sans Fil." By R. De Valbreuse. 4th edition. (Paris: "La Lumière Electrique.") F. 12.

"London University Guide and University Correspondence College Calendar" for 1911. (London: University Correspondence College.)

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CONFERENCE OF GOVERNMENT TELEGRAPH AND TELEPHONE ENGINEERS.

A list of the subjects which were discussed at this Conference appeared on page 785 of THE ELECTRICIAN of Feb. 25 last. The Conference was held at Paris from the 4th to the 11th inst. inclusive. The members present were as follows :—

GREAT BRITAIN.—Major J. A. O'Meara, C.M.G., Engineer-in-Chief of the G.P.O.; Messrs. J. A. Stubbs, J. E. Taylor, F. L. Henley, F. Addey, H. R. R. Moore, H. Brown and J. G. Lucas, engineers of the Telegraph Department; and M. Gill, engineer-in-chief of the National Telephone Co.

GERMANY.—Prof. Dr. Strecker, Prof. Dr. Breisig, Dr. Ebeling and Herren Herren, Kuhlmann, Vittichen, Herz, Läschen and Gut.

Bavaria.—M. Bredauer and Dr. Steidle.

Wurtemburg.—Herr Ritter.

FRANCE.—MM. Estaunié, Seligmann-Lui, Frouin, Dennery, Thevenin, Thomas, Tongas, Bouchard, Sins, Lorain, Maureau, Massin, Devaux-Charbonnel, Larose, Pomey and Milon, and J. Carpentier, Meyer-May (Société Industrielle des Telephones), G. Rechniewski (Société Thompson-Houston), Welles (Société Aboilard), Scimia, Viardot and Welles.

AUSTRIA.—Herren Arthur Linninger, Ernst Petritsch, and François Stecher de Sebenitz.

HUNGARY.—MM. André Kolossvary, Jos. Hollos, Samuel Haltenberger, Béla Gáti, Béla Julcher, Ennó Berdenich, Augustin Major, Miksa Dénes, and Eugene Fritz.

BOSNIA-HERZEGOVINA.—Col. H. Goiginger and M. Ad. Daninger.

BULGARIA.—M. Vassil Chlébaroff.

ITALY.—Prof. Giovanni di Pirro and Signori Enrico Mirabelli and Salvatore Montinari.

HOLLAND.—MM. A. E. R. Collette and V. C. Proper.

DENMARK.—M. W. G. Thomsen.

BELGIUM.—MM. Roosen and Colson.

RUSSIA.—MM. Evangoulow, Louis Tolloczko, Centkowski and Roubanovitch.

SERVIA.—MM. Milan Georgevitch, D. R. Dimitrievitch and Miloutin Vouiadinovitch.

ROUMANIA.—MM. Vidic and Jancolesco.

NORWAY.—MM. Sivert Rasmussen Abild and Léonhard Iversen.

SWEDEN.—MM. Landstrom, Pleijel, Carl Egner, Gunnar Hólmström and Kinmanson.

TURKEY.—MM. Mehmed Emin-Bin Ali and Mehmed Sabri Effendi.

UNITED STATES.—Messrs. C. E. Scribner, and John J. Carty (American Telegraph and Telephone Co.)

BUREAU INTERNATIONAL DE L'UNION TELEGRAPHIQUE.—M. Crescitz.

LEGAL INTELLIGENCE.

Torquay Tramways Arbitration.

On Friday last week Mr. Archibald Read resumed the arbitration between the Torquay Tramways Co. and Torquay Corporation as to whether the Corporation are unreasonably withholding their consent to the adoption of the overhead system of traction on a length of tramway in substitution for the present Dolter system.

Mr. STANLEY CLEGG, city electrical and tramway engineer, Lincoln, said five years ago his Corporation adopted the G.B. system. A guarantee was given that the current consumption should not exceed 1·337 units per car-mile, and that not more than 18 studs per annum should be left alive and undetected by the car. If undetected by the car they could not be left in such a state as to be dangerous. The earthing strip carried away any surface leakage to the rails, so that it was impossible for a stud to charge itself up and cause damage. The current consumed was 1·219 units per car-mile in the first year and 1·075 in the year ended March last. The current necessary to excite the magnets was guaranteed at 580 watts. It had been reduced to 260 watts. In the whole five years no stud had been left alive and undetected, and there had been no accident either to persons or to animals. Car-miles run last year were over 156,000, working expenses were ½d. per car-mile below those of all other municipal electric tramways. The G.B. system had some advantages over the overhead system as regards quiet running, safety and sightliness. They had had three bad winters which brought down telegraph wires in the neighbourhood. Their line was flat and straight. They had an increasing number of live studs, but it had not exceeded the guarantee. Last year the guarantee as to maintenance cost was exceeded, but the average for the five years had not exceeded the guarantee.

Mr. W. M. MORDEY said he had studied all the systems of surface contact traction. His firm advised the original Dolter Co. n July last he was called in by Torquay Corporation to report as to the system. He had had nothing to do with the Dolter Co.'s work for eight years. He reported that the system could be improved so as to be satisfactory and also that other surface contact systems could be used satisfactorily. He found the system was working very well, although the line had not been kept up so as to satisfy an engineer. The thing was, to the public, a complete success; but to the company it was not. He felt that it could be saved comparatively easily. He examined very few studs under the road. He then explained improvements proposed by Mr. Mitchell and approved by himself. Most of the troubles came about through the inner vessel, and Mr. Mitchell proposed to do away with it. Mr. Mitchell had also introduced a more powerful armature and a longer lever, which would enable a better contact to be made by the contact bases beneath the stud with the same excitation of the skate, even with the skate quite clear of the road. The longer lever would also make a clearer break. The single pot arrangement would permit of the whole apparatus being easily withdrawn and examined. The interior of the pot would be filled up with oil and be open at the top, and, not being gas-tight, the danger of explosions would be minimised. He produced a sample of oil such as is used on the Hastings tramways, and which he said was thin enough to allow the lever to work and yet of sufficient specific gravity to keep out sea water. It was 8·8 per cent. heavier than fresh and 6 per cent. heavier than sea water. He exhibited a model which showed that the proposed new armature for making the contact under the stud would make a better contact with the skate 3 in. above the stud than the old apparatus would make with the skate touching the stud. The inner vessel becoming loose, the contact bases might not remain opposite one another, and that was likely to lead to arcing and increase the carbonisation of the oil. Another trouble with the two pots was that the thick oil from the outer pot got into the inner pot, but with the single pot only the thin oil was used. He did not think water would creep down the inside of the single pot. He thought Mr. Mitchell had now, at one blow, solved a great many of the difficulties. The total current loss, including all losses between the station and the car, and also on the return, was 11·9 per cent. He would expect the current used on the overhead system to be from 6 to 7 per cent. less. There was not much cause to complain of the cost of the energy at Torquay. On some of the lines he should say that more than half of the studs were out of order when he inspected the tramways, and the system had not had a fair chance. At Torquay (one of the hilliest tramway systems in the country) the current consumed was 2·24 units per car-mile, and at Huddersfield, which was also hilly, the current used on the overhead system was 2·25 units. At Lincoln the current used on the G.B. system was only 1·1 units, but the line there was flat. Even after the Board of Trade's final intimation that they would not renew their order permitting the working of the Dolter system at Torquay after the date previously fixed, he would still, if he had been the engineer of the system, have spent more money on improvements, as he believed that the Board of Trade were a reasonable body, and that they would have withdrawn their decision if the line had been made to work reasonably well. He thought the contact parts would make a better break in oil which was partly carbonised if the magnetism were great than if it were small, because with a good contact there was less tendency to heating. Although he had not made any tests on the tramways of the oil he had produced, he had had experience of the working of switches and other electrical apparatus in oil, and upon that he based his opinion that the levers and contacts in the pots would work in the oil submitted. He did not know that the creeping action of water was greater along porcelain than on other substances. He thought it would be greater on less highly glazed surfaces. This, and the fact that Mr. Holliday had said that on scraping the outer surface of the inner pots, which had become conductors owing to the carbonisation of the oil, they had again become non-conductors, led to the conclusion that the water crept down on the outer surface of the inner pot, rather than the inner surface of the outer pot.

Col. SPRAGGE (mayor of Torquay) said the Torbay-road was regarded as one of the most beautiful marine parades in the kingdom, and they were averse to anything that would interfere with its beauty. The vote in the Council was almost unanimous against permitting overhead tramways.

Mr. VESEY KNOX said the Council were not only considering the beauty of the town, but their action was an attempt to squeeze the company. He asked the arbitrator to order the Corporation to produce the Tramway committee's report of May 14.

The ARBITRATOR said he would consider the point.

Mr. F. S. HEX (town clerk of Torquay) said the Corporation thought that with proper attention the Dolter system could be made to work satisfactorily, and they continually communicated with the company upon matters that they thought would result in the improvement that the Board of Trade said must take place. If it had not been for the assurances the Corporation had received from the company as to the continuance of the surface-contact system they would not have supported the 1909 bill authorising the Paignton extension.

Mr. VESEY KNOX said the company were authorised by Parliament to work the tramways, and the Corporation were not justified in exercising their veto to prevent them from being worked at all. Finding they could squeeze nothing more out of the company the Corporation said, "Let them stew in their own juice." He submitted that the authority's action was cruel and unreasonable.

The hearing was concluded on Saturday, and the arbitrator reserved his award.

Mining Regulations.

On Tuesday the Sheriff of Linlithgow heard a charge against James Jones, jun., and Scott Lees (agent and manager respectively of the Dalmeny Shale Mine of the Dalmeny Oil Co.) for having (1) on June 20,

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1910, failed to maintain the electrical apparatus in the Douglas Dook part of the mine in such a condition as to reduce the danger through accidental shock to the minimum, in respect that the casing of the motor working the pump in the dook was alive; (2) for having failed to protect the terminals on the motor and controller either with insulating covers or metal covers connected to earth, notwithstanding that protection in one or other of these ways was practicable; (3) for failing to maintain the conductors to the motor completely insulated from earth; (4) for failing to make the roof and sides of the travelling road to the motor secure, and allowing an electrician at the mine, who was not a person appointed for exploring or repairing, to travel on the road on the date in question; (5) for failing to have the terminals and commutator contacts, which were dangerous and exposed parts of the motor, securely fenced; and (6) for allowing on the dates mentioned the wires lighting the circuit at the east side haulage motor to rest on an iron girder, and, further, in one place allowing a staple to be used as a fastener, all in contravention of the Coal Mines Regulation Act and the Special Rules of the Home Office as to the use of Electricity in Mines.

Mr. JAMES KIDD, solicitor, who appeared for respondents, took exception to the relevancy of the complaint in respect that the execution of the electrical rules being in the hands of an electrician, it must be specified wherein the manager or agent had done or omitted to do something in the way of supervision which involved them in the offences charged, and that in any case the manager, who was technically qualified, and technically guaranteed by his certificate, was responsible primarily in a question between him and the agent, the latter of whom did not require any technical qualification, and therefore in such a question it must be set forth clearly how the agent was involved in responsibilities. He submitted that the manager and agent appearing on the complaint as framed were mutually exclusive of each other, and if that point were sustained the whole complaint must drop.

Sheriff MACLEOD indicated that with regard to the general objection based on the relative positions of the agent and the manager he confessed that he would have preferred to see them treated separately, as having been guilty of separate offences. However, he thought that that might be inferred from the reference to the different rules, and if that might be so he was not inclined at that point to sustain the objection and dismiss the case. The other objections he dismissed, with the exception of an objection taken to the libel in so far as it charged the respondents with allowing a man to walk in an insecure road. He agreed with the construction put upon the section by the accused's agent as being the correct one, and he held the complaint in that respect irrelevant.

Respondents tendered a plea of not guilty, and proof was fixed.

Workmen's Compensation.

At Birmingham County Court on Monday Judge AMPHLETT, K.C., heard an application by the British Thomson-Houston Co. for the review of a memorandum of agreement (filed Nov., 1909) for the payment of £1 a week to George Mackenzie, an electrician, of Handsworth.

Mr. CAVE (for applicants) said respondent was employed by them in Dec., 1905. On the 24th of that month he met with an accident through the bursting of a naphtha can, which inflicted burns on his body. He was unable to work for some time, and was allowed £1 a week down to May 2, 1908. On July 28, 1908, respondent re-entered their employment, and did the same work at the same rate of wages. He remained until Dec., 1908, when the job came to an end. There was a question whether applicants had entered into an agreement which settled the whole case. The agreement, by which he accepted £12, was signed by respondent. Apparently respondent's contention was that, though he signed the agreement, he did not read it, and, therefore, was not bound by it. Mr. Cave read letters which had passed between the parties, and said that at a previous hearing Judge Ruegg decided that respondent did not think he was settling his claim when he signed the agreement, but, because of his carelessness, deprived him of his costs. That decision came before the Divisional Court, when it was decided that the matter should be referred back to the County Court, with liberty to set up the agreement as the reason for demanding the termination of compensation.

Dr. LEONARD GAMGEE said he considered respondent was now able to do the work of an electrical engineer. There was a slight loss of agility, but he did not think there would be any loss in ability. He did not consider respondent was quite so capable of doing constructional work which necessitated the use of scaffolding.

Mr. ARTHUR TURNER, in the employ of the B.T.-H. Co., said he handed over £12 to respondent, and had no doubt he read the agreement before signing it. The work on which respondent was engaged from July to Dec., 1908, was precisely the same as that he had done up to the time of the accident.

Respondent stated that since the accident he had not been able to earn anything at his own trade. He had opened a little newspaper shop, but had made an average of only 6s. 7d. a week. A large part of the exterior of one of his legs was practically insensible to pain, and the sole of the foot was practically dead. He was claiming £12 arrears, and he understood it was a receipt for that sum, and, therefore, he did not read it.

Dr. E. RUSSELL HENNESSEY said he had had respondent under his care. In July, 1903, when respondent was asked to go back to work, witness did not consider him fit to undertake the duties of an electrical engineer as he understood them. He still held that opinion. There was a contraction of the left leg, which was about ¾ in. shorter than the right.

The hearing was adjourned until to-day.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A leading draughtsman is required for designs of starters, rheostats, iron-clad switchgear, &c. See an advertisement.

A draughtsman is wanted for a.c. and d.c. generators and motors. See an advertisement.

Test-room assistants are required, used to calibrating m.c. and e.m. instruments. See an advertisement.

Applications are invited for the position of resident engineer for one of the electricity works under the control of the County Borough of Stoke-on-Trent. Applicants must have a thorough mechanical training and experience in a three-wire d.c. station. Salary £180. Forms of application from the chief electrical engineer, Mr. C. H. Yeaman. Applications to the town clerk, Mr. E. B. Sharpley, by 26th inst.

An electrical engineer is required to take charge of the Cambuslang electricity and refuse destructor works of Lanark County Council. Commencing salary £160. Applications by Sept. 26.

Mr. Ingram has been promoted to the position of second engineer at Bermondsey (London) electricity works, in place of Mr. Cragg resigned, at £120, rising by annual increments of £10, to £140 per annum. It was recommended that Mr. Oake, jun., engineer in charge and switchboard attendant, should be appointed third engineer, at £110, rising to £130 a year, but the Council rejected the recommendation and decided to advertise for applicants for the position.

Mr. T. J. Considine has been appointed charge engineer at Taunton electricity works, in place of Mr. E. B. Barton resigned.

Mr. W. A. Scott, assistant works manager, has been promoted to the position of works manager to Bruce Peebles & Co., in succession to Mr. W. V. Waite, resigned.

EDUCATIONAL NOTICES.

University of London, University College.—The session in the faculty of engineering begins on Oct. 3. The provost and the dean will attend on Monday and Tuesday (Oct. 3 and 4) from 10 a.m. to 1 p.m for the purpose of interviewing students and advising them as to their courses.

In addition to the regular undergraduate courses, the following post-graduate courses (which will include lectures, drawing office work and demonstrations) will be given during the coming term: Electrical design, by H. M. Hobart, B.Sc., M.Inst.C.E., M.I.E.E., on Mondays from 5 to 7, beginning Oct. 10. Steam turbines (supplementary to course in session 1909-10), by Mr. E. G. Izod, on Fridays at 5:30, beginning Oct. 21. Railway engineering, by H. Deans, M.A. (Cantab.), M.Inst.C.E., on Mondays and Thursdays at 5, beginning Oct. 6. Photographic surveying, by M. T. Ormsby, M.Inst.C.E.I., on Fridays at 4, beginning Oct. 14.

University of London, Goldsmiths' College.—The new session commences on Monday, Sept. 26, and the enrolment of students commenced on 19th inst. Complete courses of instruction are provided in mechanical, electrical and constructional engineering, telephony, fitting and machine pattern making and smithing, land surveying, &c. Students are prepared for the London University degree of B.Sc. in engineering, for the examinations of the Institution of Civil Engineers, Board of Education and City and Guilds of London Institute and for the National and Whitworth scholarships. There are reduced fees to course students if paid by Sept. 23. Particulars of fees, &c., from the Warden, Goldsmiths' College, New Cross, S.E.

University of Edinburgh.—The next session opens on Oct. 4. In the engineering department of the University complete courses of instruction are provided in civil, mechanical and electrical engineering, qualifying for the degree of B.Sc. in Engineering, and extending over a period of three years. Particulars of entrance examination scholarships, fees, &c., can be obtained from the Matriculation Office of the University.

University of Bristol.—At this university complete courses of instruction in electrical, mechanical and civil engineering are given, and also instruction in the evening classes. The 1910-11 session in the faculties of arts, science and medicine will commence on Oct. 3, and in the faculty of engineering began on Sept. 13. Particulars and prospectuses from the registrar, Mr. James Rafter.

Armstrong College, Newcastle-on-Tyne.—The next session commences on Sept. 26. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

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Battersea Polytechnic (London, S.W.).—The day courses at this Polytechnic prepare for the B.Sc. degree (in engineering) of the University of London, and for the Polytechnic diploma in mechanical, electrical, civil and constructional engineering. The day courses commenced on 22nd inst. and the evening courses start on 26th inst. Prospectuses from the Secretary.

Borough Polytechnic Institute.—The new session begins on 26th inst. There is a four years' course of instruction in electrical engineering, and in electric wiring there is a three years' course. There are day and evening classes. Further particulars and detailed syllabus are given in the prospectus, which can be obtained from the Principal, Mr. C. T. Millis.

The prospectus for the 1910-11 session, which commences on the 26th inst., gives particulars of the varied work carried on in the Institute. Amongst the alterations are the re-arrangement of the electric wiring courses, and there are some new classes in mechanical engineering. There has been an extension and development of the work in nearly all departments. Copies may be obtained from the Principal.

Northampton Polytechnic Institute (London).—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Monday, Oct. 3.

The courses in mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include specialisation in radio-telegraphy. The entrance examination takes place on Sept. 28 and 29. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in engineering at the University of London. There are full and part time courses in all branches of technical optics. Particulars as to fees, &c., can be obtained at the Institute, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

South-Western Polytechnic Institute (London, S.W.)—At this Institute a complete three years' course in electrical engineering is held during the day, and a four years' course in the evening. Courses of lectures and practical work are given in a number of subjects, including elementary, intermediate and advanced electrical engineering, electrical design, instruments and lamps, alternating and polyphase currents, wiring and fitting, and the calculus for engineers. Particulars from the Secretary, Manresa-road, Chelsea, S.W.

The prospectus of the day and evening courses which are provided at this Institute (for men and women) has been issued.

The evening classes commence on 26th inst. and the day college opens on Oct. 3. The institute is provided with well-equipped electrical, mechanical and physical, chemical and metallurgical laboratories, and wood and metal workshops, &c., with a well-qualified staff of lecturers, demonstrators and instructors. The full course of instruction in electrical engineering extends over three years, and affords a theoretical and practical training for those who intend to take up electrical engineering as a profession. The courses of instruction provided at the polytechnic also prepare for the degrees of the University of London. Further particulars may be obtained at the polytechnic, or Manresa-road, Chelsea, London, S.W.

Sir John Cass Technical Institute.—A course of evening lectures and practical work on "Fuel" will be given at this institute during the session 1910-11, including one on "Liquid, Gaseous and Solid Fuel," by Mr. J. S. Brame, on Monday evenings, 7–8 p.m., commencing Oct. 17; one on "Fuel Analysis" (and course of laboratory work), by Mr. C. O. Bannister, during the summer term on Monday evenings, 7–10 p.m., commencing April 24; and a course of laboratory work on "Gas Analysis" in the summer term, by Mr. Chas. A. Keane, D.Sc., Ph.D., F.I.C., on Wednesday evenings, 7–10 p.m., commencing April 26. The courses of instruction are arranged to meet the requirements of those engaged in chemical and engineering works, or who are concerned with the use of fuel for motive power. Detailed syllabuses of the courses may be obtained at the offices of the institute, Jewry-street, Aldgate, London, E.C., or by letter to the Principal.

Electrical Standardising, Testing and Training Institution.—This institution has two departments—viz., a training department and a standardising and testing department. We have received the electrical engineering syllabus, which gives particulars of the courses of instruction, fees, exhibitions, &c.

The training department provides students with a thorough training (theoretical and practical) in electrical engineering. The full course occupies four years, arranged so as to combine theoretical training with practical experience. The first year is spent at Faraday House, the second at engine manufacturer's, the third at Faraday House, and the fourth at an electrical manufacturer's or power house. The institution has a permanent staff of well-qualified teachers, and there are also special lecturers on certain electrical engineering subjects. In order to keep the instruction abreast of modern developments, frequent lectures are given during the advanced year by engineers in practice upon the branches of electrical engineering in which they have specialised. The special lecturers include Mr. W. R. Cooper, M.A., B.Sc., Mr. W. H. Eccles, D.Sc., Mr. H. M. Hobart, B.Sc., Mr. J. Rennie and Mr. R. J. Wallis-Jones. Further particulars from the Secretary, Faraday House, Southampton-row, London, W.C.

Bradford Technical College.—The calendar of the day section for the 29th session (1910-11) has been issued, and contains particulars of the courses of instruction in engineering, chemistry and dyeing, &c.

Rutherford College (Newcastle-on-Tyne).—Yesterday (Thursday) Prof. M. Sadler inaugurated the new wing extension for technical instruction which has been erected at this college.

BRITISH NOTES.

Assessment of Machinery.—The Machinery Users' Association write reminding our readers who are manufacturers and machinery users in the London area, that the quinquennial re-valuation of London is not yet completed notwithstanding that the lists were sent in as long ago as June 1. The Association notify that a great number of assessments will be altered and increased when the valuation lists are readjusted, and there will then only remain seven days before they will be irrevocably closed for the next five years. Persons who may not be members of the Association are informed that information for their guidance will be provided if they will communicate with the secretary at 22-23, Laurence Pountney-lane, London, E.C.

Belfast.—The arc lighting of High-street and Castle-place was inaugurated on 15th inst. "Sunræ" flame arcs of 2,000 c.p. each are used.

Bermondsey (London).—A special meeting of the Council will be held on Oct. 18 to consider the question of applying for a provisional electric lighting order for the district of the late St. Olave Board of Works. Two companies already supply electricity in the district.

Bishop's Stortford.—The Board of Trade have been inquiring into the steps taken to carry out the provisions of the electric lighting order, 1905, and the Lighting committee have been instructed to report upon the matter.

Cable Rates within the Empire.—At a conference of the Institute of Journalists last week the subject of an electrical girdle of cheap cables was introduced by Mr. R. McMillan, of Sydney, N.S.W., in its relation to cable rates within the Empire.

Mr. McMillan moved: "That the time has arrived for binding the Empire together with an electrical girdle of cheap cables." He asked that some of the money expended on ironclads should be spared to bring the oversea dominions into closer communication with the Motherland. What was wanted was a Government cable across the Atlantic.

Mr. Henniker Heaton, M.P., of course supported the motion, using the familiar formula "that the cables of the world were now in the hands of monopolists or cable rings." He contended that these undertakings should be bought out at the market price of the day by the Governments of the civilised world. [He did not say whether he had gone into the figures of the proposal.] This great Empire (he continued) would never be perfect until they made communication with the Fijis and New Zealand as cheap as it was to-day with Ireland. It only meant the expenditure of a few thousand tons of copper wire. He did not wish to do injustice to anyone, but if by some miracle the whole cables of the world were melted, or if they were destroyed to-morrow by some great earthquake, they could be reconstructed at one-third the original cost. It was advisable at all costs to put an immediate end to all cable monopolies. The excuse that merchants had so built up their codes that they were able to send even to Australia at the rate of 1d. per word was no reason why the masses of the people who could not arrange codes or anything of the kind should be debarred from being able to communicate by telegraph. There were about 16 lines to America—13 from this country—and he had published the statement, and it had not been contradicted, that 10 of these lines were kept idle by the ring.

Mr. D. H. Maling, of Melbourne, hoped that the extension of cheaper cables would not be confined to Australia, and disclaimed any idea to press forward any scheme which would add to the taxation of this country. Australia should itself pay for every facility obtained.

The President (the Hon. H. Lawson) gratefully acknowledged the manner the Pacific Cable Board and the Eastern Telegraph Co. had offered the Cable committee and the Imperial Press Conference reductions in rates for Press messages. These reductions would be extended under guarantee of a larger amount of telegraphic business. With regard to the Atlantic cables, he had reason to know that last year the Government of Canada was moving in that direction, and he thought the mission of the Postmaster-General of Canada to this country at the present time would also have some bearing upon this question. The whole problem had to be dealt with in a broad and statesmanlike way. There was the alternative of wireless telegraphy, but while wireless telegraphy did not fulfil all their requirements they were still dependent upon cable communications.

Mr. McMillan's resolution was then adopted.

Croydon.—The Tramways committee have been authorised to prepare specifications, &c., for new tramcars.

Dublin.—The Lighting committee have been instructed to provide in their estimate for 1911-12 for the electric lighting of the New Kilmainham Ward.

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Eastbourne.—From the electricity supply department we have received the revised scale of charges which comes into force on Oct. 1.

Lighting supply will be given at 5½d. to 5d. per unit, outside arc lamps or incandescent lanterns from 4½d. to 4d. per unit, heating and cooking from 2½d. to 1½d. per unit, power (as heretofore) on sliding scale, 2½d. to 1d. per unit.

Edinburgh.—On Tuesday the City Council were recommended by the Electric Lighting committee to apply the surplus on the past year's working of the electricity undertaking (£7,300) towards the reduction of the capital moneys borrowed.

The Lord Provost said it was most unusual to apply to the engineers for advice. He thought as that was an important matter, and a new departure, that they ought to have a report from the Town Clerk and the Chamberlain upon it.

After a brief discussion, the suggestion of the Lord Provost was agreed to.

The Electric Lighting committee are considering the question of extending the mains to Barnton district.

Electric Power in Bootmaking.—Manchester Guardians have decided to instal electric power at the bootmaking department of the industrial schools.

Engineers' Wages.—A conference took place on Monday at Newcastle-on-Tyne between members of the Federation of Engineering Employers and representatives of the Amalgamated Society of Engineers, the Steam Engine Makers' Society, the United Machine Workers' Association, the Electrical Machine Workers, and the Smiths and Strikers' Society, with respect to an application by the men for an advance in wages of 10 per cent. on piece rates and 2s. per week on time rates.

The last change of wages was a reduction in 1908. Mr. Summers Hunter presided, and about 15,000 men were represented. For the men the advance was demanded on the ground of improved trade, and the reduction of their unemployed from 2,000 last year to 650 in August. The employers contended that trade did not warrant the advance, and stated that fewer men were employed in the federated shops than in 1906. The advance was finally refused after a two hours' conference, but the employers intimated that if the men thought it desirable they would be willing to have another conference later.

Exhibitions.—The ninth international motor exhibition will take place at Olympia (London, W.) from Nov. 4 to 12. Further information from the Exhibition Manager, Society of Motor Manufacturers & Traders, Maxwell House, Arundel-street, London, W.C.

An international exhibition of iron and metal wares and machinery will be held at Budapest in May next. Particulars from the Ausstellungs bureau, Gyarutcza 38, Budapest. Applications for space by Nov. 30.

Gateshead.—The extensions of the tramway system were officially inspected yesterday (Thursday).

Grimsby.—At the meeting of the Lighting committee on Monday the chief electrical engineer (Mr. W. A. Vignoles) reported the completion of the installation of Jandus enclosed arc lamps in place of the old street arc lamps. The lamps were working satisfactorily, and giving much less trouble than the old lamps. It was decided to place a contract for the supply of metal filament lamps for street lighting at £15 per gross. 20 new consumers have been connected during the past month.

Hammersmith (London).—The Council recently approved a proposal to permit the New Olympia Co. to generate current at Olympia for the electrical exhibition to be held in September, 1911, the company to pay to the Council a royalty of ¾d. per unit generated. As the company now desire the Council to fix a lump sum the Electricity committee recommend that an alternative charge of £1 per kilowatt installed during the period of the exhibition be offered.

Harrogate.—The suggestions of the electrical engineer (Mr. G. Wilkinson) as to the heating of sulphur water by electricity are to be embodied in a letter and submitted to the Wells and Bath committee.

Application is to be made to the Board of Trade for consent to supply electric current to certain premises outside the present limits of supply.

Ince.—Wigan Corporation have received sanction to borrow money for extending the electric lighting mains to the Ince district.

Keighley.—On Tuesday the Tramways committee recommended that a bill be promoted to authorise the equipment of a trackless trolley system connecting the borough with Crosshills and Sutton Mill with Stockbridge and Nab Lane, with Oxenhope, and penetrating the Fell Lane district.

The chairman of the committee (Mr. J. Mitchell), who moved the adoption of the report, pointed out that from April 1 to Sept. 15 the motor 'buses had earned £2,507, or 11·78d. per mile, on a run of 51,000 car-miles. The cost had been about 9d. per car-mile, and he argued that they might save 3d. per mile under the new system. He was perfectly satisfied that it would pay the Corporation to go to Parliament for those powers alone. The system under consideration would cover a distance of about 23 miles.

Mr. A. Smith seconded, and gave figures as to the improvement in the traffic and profits of the existing Keighley tramway system, which had managed to get rid of the debt inherited from the old horse-car tramway. The Keighley lines had cost £4,480 per mile, while the trackless system could be put down at £1,200 to £1,500 per mile. He thought the cost of a bill would be recovered in a single year.

The recommendation was adopted by 16 votes to 5.

Library Lighting.—Deptford (London) Public Libraries committee report that, having obtained advantageous terms from the London Electric Supply Corpn., they have decided to adopt electric lighting in the New Cross branch library. The committee add, "This form of illumination is the most suitable for library buildings."

L.C.C. Tramways.—It is announced that necessitous blind persons, properly authenticated and accompanied by a guide, will be carried free on the Council's tramcars, but the guide will be charged the usual fare. Authorities of institutions at which such blind persons live or are employed should apply for free passes to the Chief Officer of Tramways, 62, Finsbury-pavement, E.C.

Manchester.—In reference to the recent sanction to a loan of £40,000 for extensions of the electricity department, the L.G. Board have informed the local Ratepayers' Association that the question of holding a local inquiry into the application was a matter entirely within the Board's discretion.

Of the amount sanctioned, £30,000 was required in respect of motors, switch-gear and transformers, and was based on average expenditure of the Council for those purposes, while the balance (£10,000) was for substation plant required to cope with the anticipated demand for lighting, power and traction during the forthcoming winter. The Board have received a further application by the Council for sanction to a loan of £30,000 for a turbo-alternator at the Stuart-street station, and have decided to hold a local inquiry into this application.

The Ratepayers' Association have also challenged the right of the Tramways committee to manufacture electric tramcars. The Town Clerk claims that the power to manufacture is conferred by sec. 8 of the 1899 and sec. 32 of the 1900 Corporation Tramway Acts; but the association claims that these sections only give authority to provide cars. The matter is to be considered by the committee.

Market Lighting.—Swansea Market committee, who are reorganising the local market, are considering the question of re-arranging and improving the electric lighting installation.

Melrose (N.B.).—The Electric Supply Corpn. intend to lay electric lighting mains across the Tweed to Gattonside.

Morecambe.—Mr. W. R. Wright writes, in reference to the blowing of the new cooling tower, to say that the design upon which the tower was constructed was neither prepared nor approved by him and that he has terminated his agreement with the Council.

Municipal Wiring.—The Corporations of Ayr, Wakefield and Manchester have agreed to give financial support to the scheme of the Incorporated Municipal Electrical Association to promote a bill to authorise local authorities to undertake wiring work, to let motors on hire, &c. Northampton, Chester, Shrewsbury and Burnley Corporations and Radcliffe and Leyton Councils will give it their moral support. Sunderland Corporation are in favour of the proposal. St. Anne's-on-the-Sea Council have decided to take no action, and Bexley Heath Council will consider the matter again.

Norwich.—Application has been made to the L.G. Board for sanction to borrow £18,790 (instead of £17,783 authorised by the Council on March 15 last) for extensions of mains and services, and for an exhaust steam turbine, with condenser, steam exhaust, water pipes, &c., centrifugal pump, balancer, coal elevator, &c.

Oldham.—The borough electrical engineer (Mr. S. Wilmott Newington) has reported that extensions of generating plant will be necessary in order to meet the demand for the winter of 1911-12.

Negotiations are proceeding between the Corporation and Chadderton Council as to the terms upon which a supply of electrical energy is to be given in Chadderton district, and pending a definite agreement Oldham have obtained permission to supply eight consumers in the district.

Personal.—Mr. H. L. Tyson-Wolff (electrical engineer to the East Indian Railway Co.) returns to duty in India on Nov. 1 next.

Perth.—The city electrical engineer (Mr. J. Lambert) has been asked to report upon the question of providing mechanical stokers at the electricity works.

Portsmouth.—An inquiry was held on Friday into the application of the Corporation for sanction to borrow £24,000 for extensions of the electricity undertaking.

The town clerk (Mr. G. Hammond Etherton) said the amount required was for expenditure on mains, transformers, meters and house services during the next three years. Of the previous sanctioned loan of £22,288, there was an oustanding balance of £1,914, and assuming the Board would deduct that sum from the present application, the present sanction would be £22,086.

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The INSPECTOR pointed out that the L.G. Board preferred that meters should be paid for out of revenue and not out of loans.

The superintendent (Mr. W. S. FOALE) said the revenue for the last year showed a decline, owing to concessions to consumers, the more general use of metal filament lamps and reduction in charge for public lighting (from £18 to £16 per arc lamp per annum). Instead of the flat rate, a sliding scale had been introduced, and the amount of rebates to consumers was £2,595 for last year, against £1,860 in previous year. The units sold had slightly increased by the further use of power units, but private lighting had slightly decreased. The reserve fund had nearly reached the statutory limit of 10 per cent.

Presentations.—Mr. W. Vincent Waite, late works manager to Messrs. Bruce Peebles & Co. was the guest at a dinner given in Edinburgh on 14th inst. on the occasion of his leaving the firm to start business on his own account in Cardiff. Mr. Waite was presented with a sideboard and Mrs. Waite with a silver salver as a token of appreciation from the workmen and staff. The presentation was made in the main shop by Mr. Lee Murray, general manager of the Company, and Mr. Waite feelingly acknowledged the gifts.

Mr. F. R. Batty, late manager of the Northallerton Electric Light & Power Co., who has obtained a position in London, has been presented by the directors with a cheque and by the staff with silver flower vases.

Rochdale.—In June an inquiry was held into the application of the Council for sanction to borrow £13,940 for extensions of the electricity undertaking, and the L.G. Board have now written to say that the unexpended portion of the previous loan must be used first.

The Council are recommended to double the track of the Blackwater-street tramway.

St. Pancras (London).—The chief electrical engineer (Mr. S. Baynes) has reported that for the year ending March 31, 1911, £2,000 will be required for mains, £1,700 for services and switches, and £800 for meters and indicators.

Seaton Delaval (Newcastle-on-Tyne).—Electric lighting mains are being laid in this district, and current will be supplied by the Seaton Delaval Co-operative Society, who have made arrangements with the Newcastle-on-Tyne Electric Supply Co.

School Lighting.—The Bilton Council school and the new infant school, Harrogate, are to be wired for the electric light.

Seghill.—The Council have made an agreement with the Seghill Village Coal Co. for the electric lighting of the streets.

Southampton.—The auditors (Messrs. Cash, Stone & Co.) have reported that the sums standing to credit of depreciation and renewals fund of the tramway and electric light departments on March 31 were £20,263 (increase £5,190 on previous year) and £9,815 (increase £1,925) respectively. £2,000 has been appropriated to relief of rates from the tramways and £2,424 from the electricity department.

Stoke Newington (London).—An additional transformer is to be provided at Edward's-lane sub-station, at an estimated cost of £100, and mains are to be extended at a cost of £75.

The Electricity committee has been in negotiation with the North Metropolitan Electric Power Supply Co. on the subject of a revision of the charges to private lighting consumers, and the company has agreed to the following variation, viz.: That the present rates of 7d. and 2d. on the maximum demand system be continued, and apply to the whole borough, with the proviso that, if during the six months ending March 31 next, or any subsequent year ending March 31, the average charge to the consumer shall exceed 5d. per unit, he shall be entitled to a credit (off the March quarter's account) of the amount by which his total charge for the whole period has exceeded an average of 5d. per unit. The committee has provisionally approved.

Trade Union Congress.—Several important questions affecting the engineering industries were discussed at the Trade Union Congress held at Sheffield last week. There were 501 delegates present, representing 210 societies and 1,620,715 members.

In the course of his presidential address Mr. J. HASLAM, M.P., said the present unrest in the trade union world, while a matter with which the Congress could not deal directly, was of sufficient importance to warrant him in saying a few words upon it. The principle underlying the trade union movement was that of collective bargaining, and whether that might be refused by individual employers in these days or whether the principle so almost universally accepted was put in jeopardy by sections of the men in various unions, the essential point to them was that they must do all that they could to maintain the power of collective bargaining, which, on the one hand, demanded recognition from the employers, and, on the other, equally demanded confidence in the leaders of the trade unions and the officers of the various organisations. The year had been eventful in the coming into operation for the first time in the history of the civilised world of a national system of labour exchanges. No doubt a newly established organisation, with officials fresh to the work, would have made mistakes. Criticism should be reasonable and fair, and backed up with facts which would assist the Parliamentary Committee to secure the necessary alterations in its administration and regulations which should secure to the trade unions of the country that the labour exchanges should not be used to their detriment. The Government had indicated their intention of dealing with the question of insurance against unemployment. The country had had the opportunity of reading the pronouncements made by the Permanent Secretary of the Board of Trade (Sir H. Llewellyn Smith), from which it would be gathered that the Government had some data upon which to base their calculations, and whilst they recognised that it would be impossible to establish a scheme applicable to the whole of the trades of the country, they were pleased to notice that a start had been made with those trades which were most liable to and suffered most from unemployment. That the scheme must be compulsory he thought they would all have to admit. Contributions would no doubt be asked for from the employers and from the workers, with a State guarantee and a State subsidy added, in order to make up the necessary funds for the management of a scheme applicable to the building trade and the great engineering and allied trades of this country.

Mr. Haslam also criticised the Osborne judgment and dealt with the situation created by the judgment at some length.

Resolutions were passed instructing the Parliamentary committee to circularise the unions affiliated to the Congress with a view of obtaining opinion and suggestion as to the practicability of a national federation or confederation of all trades; and to request views on the possibility of determining all industrial agreements on a given date for each year; and also to consider and report to the next Congress upon the possibility of amalgamating by industries all existing unions, with one central executive elected by the combined unions and with power to act unitedly whenever there is a strike or lock-out in any industry.

Resolutions were adopted in favour of the nationalisation of the railways, and of bringing all offices and shops under the Factory Acts.

A long discussion took place on the Osborne judgment, and eventually a resolution was adopted protesting against the judgment and claiming legislation to restore to trade unionists the right to levy contributions for the support of their Parliamentary representatives.

In regard to labour exchanges, the Parliamentary committee were instructed to take steps to secure the following regulations for their administration:—

(1) That a recognised trade union official shall, on making application to the superintendent of any labour exchange, be supplied with the name and address of, also the wages paid by, any firm offering employment through the medium of the exchange. (2) That under no circumstances should applications for situations be sent outside their own district, unless the superintendent of the exchange is first assured that the firm offering employment recognise the trade union rates and conditions of the district. (3) That the regulation governing the administration of the exchanges should stipulate that under no circumstances should the divisional superintendent or the superintendent of any exchange cause to be exhibited any notice of or entertain in any way whatever applications from firms who may have a dispute with their workpeople after such dispute has been officially notified by the trade union concerned.

Resolutions were also passed in favour of an amendment of the Trade Disputes Act so as to make it illegal for an employer during a pending strike or lock-out to house persons other than the caretaker and his family in any premises not certified as a dwelling-house, and the granting of old age pensions to foreigners who have resided for 20 years in this country.

A resolution in favour of the establishment of a central legal defence fund was carried, as was one claiming adequate representation for trade unions in the management of any scheme of compulsory State insurance for unemployment.

Truro.—Messrs. J. & W. Purves will apply for a provisional order for this district, the Council offering no opposition.

Twickenham.—The Lighting committee are considering letters from the Twickenham & Teddington Electric Supply Co. as to terms upon which they would contract for lighting the whole or a portion of the street lamps in the district.

Wakefield.—The charge for electric current for private lighting has been increased to 4½d. per unit.

Walthamstow.—The Electricity committee have decided that a 1,000 kw. mixed pressure turbine with tandem generators of 500 kw. each, condensing plant and pipe work, cooling tower, switchgear, &c., be installed at an estimated cost of £9,500. The car shed is to be extended and the alterations required to the overhead equipment are to be carried out by the tramways engineer, Mr. G. R. Spurr.

Will.—The will of the late Mr. George Flett (managing director of Dick, Kerr & Co.) has been proved, and the estate is valued at £111,653 gross, with net personality £88,775.

Wireless Telegraph Notes.—Again wireless telegraphy has been used in the capture of a "wanted," this time in home waters. A criminal lunatic escaped from the Dumfries Asylum, walked to Liverpool, and then took passage in the "Viking" for Douglas. He was recognised on the vessel by a Manx police inspector, who sent a wireless message from the ship in mid-channel to Douglas, where the prisoner, a desperate man, was seized on the pier by the police.

In the military manœuvres which have been carried out in Hampshire wireless telegraphy has formed a prominent feature, and the Wireless Telegraph Company of Engineers has been provided with one of the most effective field station equipments of its kind in existence. This equipment is extremely portable (it can be erected in

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17 minutes and dismantled and removed in even less time), has a radius of 60 miles and has been found to work with extreme simplicity and accuracy.

It is now reported that in the attempts made during the nava manœuvres in Torbay, S. Devon, communication was well established between the cruiser "Bonaventure" and a submarine vessel, and that by this success the utility of the submarine in actual warfare is largely increased. The submarine with which communication was satisfactorily established was the "D1," built by Messrs. Vickers, Sons & Maxim, and delivered to the Admiralty 12 months ago. This vessel, which is the largest British vessel of the kind, and the first to be fitted with a wireless installation, was submerged during the experiment as far down as the periscope, which reaches about halfway up the vessel's mast. The labours of all concerned are now being devoted to perfecting a means by which the submarine boat can establish communication with other ships, and so become, as it were, self-reliant. An excellent view of submarine D1 appeared in the "Daily Telegraph" for Sept. 21.

Weymouth.—The Electric Lighting committee recommended that application be made for a provisional order to authorise the construction of tramways in the district at an estimated cost of £27000. The report was, however, withdrawn and another scheme is to be prepared.

Workhouse Lighting.—Owing to the cost of gas lighting at Hastings workhouse the Guardians have instructed the Building and Repairs committee to obtain an estimate for wiring the whole of the workhouse buildings, and the Clerk has been requested to ascertain if the Corporation would be prepared to supply electric current for lighting at the same cost as is now paid for gas.

Llandilo Council have decided to extend the electric light mains to the new workhouse infirmary at a cost of £100, provided the Guardians guarantee to take a minimum of 500 units per annum for at least five years, and pay 6d. per unit, subject to a reduction to 4½d. per unit in the event of 1,000 units per annum being consumed.

Yeovil.—The Council will take no action in regard to a proposed application by Messrs. J. & W. Purves, for a provisional electric lighting order.

Social Reunion.—The employés of Dublin Corporation electricity supply department held their social reunion on the 15th inst., when the Lord Mayor presided over a good attendance. Among those present were the chairman of the Lighting committee (Ald. Dr. McWalter), the city electrical engineer (Mr. Mark Ruddle), Mr. G. Archer (chief assistant), Mr. L. J. Kettle (superintendent of Pigeon House generating station) and Mr. E. Mayne (mains engineer).

The CHAIRMAN congratulated the company on the fact that their first "smoker" was so well attended. Mr. Jas. Lurring was accompanist, and a number of talented artistes lent their assistance to make the evening a very enjoyable one. In bringing the proceedings to a close the Lord Mayor paid a special tribute to the energy displayed by the managing committee and its assistants, and to the splendid talent procurable in the Dublin electricity department. A vote of thanks to the Lord Mayor was heartily accorded and his health was drunk. The healths of Ald. McWalter, and Messrs. Ruddle, Archer, Kettle and Mayne were also drunk and responded to. The managing committee were Messrs. T. H. Lurring, F. Foster, and F. Sheehan, with Messrs. H. J. Mayne and J. McNamee hon. secs. The stewards were Messrs. H. Donohue, J. Melia, J. Keogh and J. Reilly.

COLONIAL AND FOREIGN NOTES.

Australasia.—The "Australian Mining and Engineering Review" says *Bunbury* (W. Australia) municipality have purchased the Bunbury electricity works of Messrs. Splatt, Wall & Co., at £7,374.

Wordend and Newham (Victoria) Shire Council have decided to equip electricity works at a cost of about £2,000.

The superintendent of *Sydney* tramways recently presented to the Public Works committee statistics showing that in the year 1909-10 traffic receipts were £1,016,724 (compared with £315,930 in 1900), the miles open being 94 (against 43½); 174,001,848 (53,470,533) passengers were carried and 17,742,500 (3,106,185) car-miles run. By including North Sydney the total number of passengers carried is increased by 48,978,286.

Perth (W. Australia) City Council are promoting a Bill authorising them to borrow money for purchasing the undertaking of the Perth Gas Co., which also supplies electrical energy.

The electric lighting of *Nhill* (Victoria) railway station is to be undertaken by the local electric light company.

A recent plebiscite of the ratepayers resulted in 917 votes for and 1,664 against the installation of steam auxiliary plant at *Launceston* (Tasmania) electric power station at a cost of £6,000. The Council therefore decided not to proceed with the installation of the steam auxiliary and invited the advice of the Government hydraulic engineer, Mr. W. Reid Bell, on the best means of increasing the water power. It is understood Mr. Bell will go into the matter in due course.

Creswick (Victoria) Council have decided to approve a proposal submitted by Mr. Buchanan Black for the generation of electrical energy by means of the water power available at Braggs' Flat. At this place (6 miles east of Creswick) there is a natural reservoir which would permit of sufficient storage to supply 3,000 H.P. during four months in the year. It is proposed to instal two 3,000 H.P. Pelton turbines each coupled to a 2,500 kw. generator.

Tatura (Victoria) Butter Factory Co. are applying for an Order in Council authorising them to supply electrical energy for public and private purposes, the estimated capital expenditure being £2,000.

The "Australian Mining Standard" states that Mr. Donald Mackinnon recently referred (in the Victoria Legislative Assembly) to the subject of the electrification of the Melbourne suburban railways, and demanded prompt action. The premier (Mr. Murray) replied that electrification could not be applied immediately. Mr. Mackinnon retorted that electricity would have to come, whatever predilections one might have about any particular form of power. Mr. Prendergast (Leader of the Opposition) said the Commissioners talked of doubling the railway system, but he hoped no expenditure in that direction would be permitted until they had come to a decision as to electrification. Mr. Murray said whatever improvements were made would be of such a character that they might be used when the electrification came. There was no question about the electrification of the suburban railways—that must come. They did not propose to appoint a commission to inquire into that, as they had sufficient information in Mr. Merz's report. The Government were alive to the question, and as little delay as possible would occur.

Ararat (Victoria) Council are considering the question of establishing municipal electricity works.

At a meeting of the local butter company at *Mortlake* (Victoria) a resolution to undertake the supply of electrical energy in the town was lost because it was not supported by a three-fourths majority. There were 58 votes for and 33 against.

The Bellambi Coal Co. have offered to supply to *Bulli* (N.S.W.) Shire Council electrical energy for lighting in Wallongong, and also to supply *North Illawarra* Municipality with current for use in Corrimal.

Manly (N.S.W.) Council are proceeding with the erection of the generating plant for supplying current for working the tramway extension to the Spit, which will connect up with the North Sydney tramways, and is expected to be ready for working in December.

Footscray (Victoria) City Council recently decided to adopt the electric light and power scheme recommended by their Lighting committee. The Council will purchase and erect the poles, wires, lamps, &c., at a cost of £8,000, and take current from Melbourne Council. The prices to be charged to private consumers will be 5d. per unit for lighting and 2d. for power.

Dr. Alex. Graham Bell recently gave evidence before the Postal Commission, at the Federal Parliament House, *Melbourne*, on the Sydney telephone service. While admitting that his observations of the Sydney service showed that much was still desired to make it efficient, many of the complaints of delay were due to the tardiness of subscribers in replying when called up. The average time occupied in giving the connection was 8 seconds, but the average time before a reply was obtained was 32 seconds. Dr. Bell considers metallic circuits and underground wires essential to successful telephony in a city. He considers that the proposed toll system is on a fair basis, but thinks it necessary, before judging of the justice of the rates, to overhaul the departmental accounts (as was done for New South Wales recently) to ascertain what the system has cost.

The Premier of South Australia (Mr. Verran) recently promised to obtain a report as to the suitability of the Brennan monorail system for a light railway for the carriage of farm produce.

The Corporation of St. Peter's (a suburb of *Adelaide*) recently passed a resolution in support of proposed amendments of the Tramway Trust's Act to enable the trust to sell electrical energy for lighting and power. Coun. Crowley, who moved the resolution, said Adelaide Council had acted unfairly to outside municipalities in suggesting that it should purchase the Electric Light & Supply Co.'s works. Adelaide Council should have all the surburban Corporations in with it in the purchase scheme.

Naurkah (Victoria) Council are obtaining a report from an expert on the subject of electricity supply.

The Victorian Institute of Electrical Engineers has now over 100 members and associates.

A bill has been introduced in the Tasmanian Parliament to authorise the Derwent Mfg. Co. to generate and supply electrical energy at any place in Tasmania outside a radius of 10 miles of Launceston. It is proposed to use water power from the river Derwent, near Macquairie Plains station, and to manufacture carbide of calcium in addition to generating and supplying electric power.

The Tasmanian Parliament has passed a resolution to advance the money necessary for constructing electric tramways from Hobart to Huonville, with a branch to Kingston, and from Huonville to Lovett and Geeveston, provided the local authorities accept certain responsibilities. At a recent public meeting Geeveston ratepayers decided not to support the scheme in its present form, and Mr. Bennett, who supported the motion, said if the scheme was so good as had been stated in Parliament it needed no guarantee from the ratepayers, and he thought that it would not be fair to ask the Huon ratepayers for a guarantee, as they had contributed towards the cost of other railways in central and north Tasmania.

Longford (Tasmania) electricity works were formally opened on Aug. 8.

Kadina (S. Australia) Council are advised to put in an additional 100 H.P. of generating plant, as the present sets are fully loaded.

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Bombay Hydro-Electric Scheme.—It is announced that the Ghats hydro-electric scheme will be carried out and financed by an Indian company. The capital is set down at Rs. 1,70,00,000 (£1,250,000), of which nearly three-quarters have been subscribed. The Maharaja of Bhaunagar has taken up 20 lakhs and the Gaekwar of Baroda 10 lakhs. The scheme provides for the utilisation of two or three large lakes at Lanauli and the installation of an electric power plant at the bottom of the ghats, and the energy will be transmitted to mills and factories in the Bombay district. Originally it was proposed to carry out a much larger scheme, which has now been divided into sections each of 10,000 H.P. The present proposal is to instal three units (one in reserve) and to extend the plant as circumstances require it. The cost of providing 50,000 H.P. would be about Rs.1,1,00,00,000. The Bombay Electric Supply & Tramway Co. owns and works an undertaking for supplying electricity in Bombay, but the new company will only supply electricity in bulk and for power.

Brazil.—Since the electrification of the Porto Alegre tramways the Companhia Força e Luz has found it necessary to double a portion of the lines, owing to increased traffic. The company has contracted with the British firm who carried out the electrification of the tramways for the erection and equipment of electric lighting and power works for private supply. The new works will compete with the present lighting company and the municipality. Underground distribution will be adopted.

China.—Mr. W. P. Ker (Commercial Attaché to the British Legation at Peking), in his report on the foreign trade of China for 1909, writes :—

The Chinese are convinced that foreign imports drain their country of its wealth, and they seek to curtail the privileges of the foreign trader, but the establishment of factories affords an ever-widening opening for the use of imported machinery. The imports of electrical materials and machinery have been considerably reduced. Progress, however, continues to be made throughout the Empire in undertakings requiring machinery. During 1909 electric lighting contracts were given out for new installations at Chungking, Chengtu, Changsha, Nanking and Ningpo and for extensions at Shanghai, Hankow, Peking, Swatow, Moukden and other places. Negotiations were going on at the beginning of 1910 for a large installation at Hangchow and for installations in several cities in Manchuria. Indeed, there may be said to be an electric lighting project in every city in China, the only difficulty being to find funds for carrying such projects into execution. Almost all contracts require to be financed by the contractors, and British firms, finding British manufacturers unwilling to supply plant except for cash down, have sometimes co-operated with German firms, the latter arranging the finance in return for being allowed to participate. Thus several of the contracts mentioned above are for British engines and boilers and German dynamos. Payment is generally spread over a period of two or three years on proper security being given.

An electric tramway scheme for Canton is under contemplation, a considerable extension of the telephone system in that city has been recently carried out, and preparations are being made for inaugurating telephone services at Chengtu, at Wuhu and in the provinces of Kiangsi and Chekiang. All the private shares in the Imperial Chinese telegraphs have now been redeemed, and the administration is completely under Government control, partly Imperial and partly provincial. Extensions of the system continue to be made, the most important effected during 1909 being the direct Peking-Hankow line along the railway, on which fast automatic Wheatstone working has been established. The statistics for 1909 show that there are 1,099 miles of submarine lines and 25,273 of aerial line. The head office staff number 112, the general staff 3,473 and the line staff 2,833. 807,841 telegrams were handled. The receipts were $838,733, and the expenditure $479,816. There are 1,171 instruments in use, of which 22 are Wheatstone automatic and five wireless. A reduction of telegraph charges by 20 per cent. was effected in 1909. The programme of the Board of Communications for 1911 includes preparations for installing wireless telegraphy along the coast.

Chinese imports in 1909 included electrical material and fittings to the value of £177,676 (39 per cent. from the United Kingdom and the remainder from Germany, Japan and Belgium), compared with £232,571 and £189,871 in 1908 and 1907; machinery and fittings £733,567 (47 per cent. from the United Kingdom and the remainder from Germany, U.S.A. and Belgium); telegraph materials £45,199 (from the U.K. and Japan), compared with £47,611 and £60,237.

Consul Hausser (Swatow) writes :—

Instead of the electric tram line mentioned in last year's report, it is now proposed to construct a light railway to connect Swatow with the neighbouring city of Ch'eng-Hai, about 10 miles distant. The cost is estimated at $230,000, not including bridge work. No foreigner is to be allowed to be a shareholder of the company. Similar restrictions are made in the case of other native companies.

Inquiries have been made with a view to the extension of the telegraph line from Chao-chow Fu to Kia Ying Chow, a distance of 40 miles. The Swatow Electric Light Co., capital $175,000, has completed its buildings and the plant is in working order and giving satisfactory results.

Constantinople.—It is announced that the concession for the erection of electricity supply and gas works has been given to Messrs. Ganz & Co., Budapest.

India.—"Indian Engineering" says the Burma Public Works Department have created a special subordinate establishment for carrying out electrical work in Government buildings in Rangoon, Maymyo and Mandalay. The sanctioned staff includes two senior electricians each at R270 per month (rising to R420), one assistant R160 (rising to R260), and one junior assistant R100 (rising to R160), in addition to the allowances granted to upper subordinates of corresponding rank.

Swiss and German Electrical Engineering Combine.—It is stated that it has been arranged to make an exchange of capital at the rate of one 1,250 fr. share of Brown, Boveri & Co. of Baden for four 500 fr. shares of the Elektrizitats-Gesellschaft, Alioth, Basle (provided 60 per cent. of the latter company's shares are so transferred), and one share of the Brown, Boveri Co. for one share of the Isaria Co., Munich. It is thought that the acquisition of the Isaria Co. will be of considerable assistance in dealing with the South German trade. The capital of the Brown, Boveri Co. is to be increased from 20 to 28 million francs.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Bradford.—The accounts of the electricity department for the year ended March 31 have been published and show a total annual income of £113,983, of which £107,222 was received from the sale of current for private and public lighting, power and traction, £2,861 from rental of meters, cables, &c., and £6,756 from the hire of motors, arc lamps, &c.

The total working expenses (£50,847) included £25,915 for cost of generation (of which £11,856 was for coal and £978 for steam supplied by destructor department), £4,574 for distribution, £5,485 for wages, materials, &c., of motor hiring department, £501 for public lamp maintenance, £253 for rent, £6,817 for rates and taxes and £6,272 for management expenses. The gross profit was £63,135, out of which interest on loans, income tax, &c. (£22,333), and sinking fund contributions (£33,403) were paid, leaving a net profit of £7,399. The gross capital expended is £796,722, an increase of £27,362 on the year. There are 2,570 consumers, with the equivalent of 469,352 8 c.p. lamps connected. 21,521,007 units were generated and 18,737,857 units sold, including 2,717,315 for private and 134,410 for public lighting, 2,725,858 units for power and heat, 9,582,103 for traction (including 141,709 for lighting sheds, &c.) and 3,578,171 bulk supply. The maximum simultaneous load was 5,839 kw. for lighting and power and 2,083 kw. for traction, a total of 7,922 kw. The capacity of the generating plant is 8,180 kw., but in addition a 700 kw. turbine has been installed temporarily pending completion of two 3,000 kw. Curtis turbines and equipment. There are 69 public arc lamps. The number of motors connected is 1,769 (of 9,582 H.P.), of which 858 (of 3,776 H.P.) are on hire. There are 224 motors (2,812 B.H.P.) which are supplied with energy on bulk supply terms.

Greenock.—The total revenue of the electricity department for the year ended June 30 was £29,017, including £7,834 from the sale of current for private lighting, £15,168 for power, £947 for public lighting and £4,220 from the Greenock & Port Glasgow Tramways Co.

Total expenses were £14,672, leaving gross profit £14,345. Interest on loans and mortgages came to £4,155, instalments of loan, &c., repaid to £5,863, and depreciation to £3,248, and after placing £1,000 to reserve the balance in hand was £2,026. The total capital expended was £192,192, an increase of £15,384 during the past year. 5,727,183 units were generated and 5,096,128 units sold, including 69,645 units supplied for public lighting, 4,326,841 sold to private consumers by meters, and 699,642 to the local tramway company. There are 53 public arc lamps and the total maximum supply demanded was 2,590 kw., against 2,320kw.

Newport (Mon.).—The accounts of the electricity supply and tramways departments for the year ended March 31 have been issued, and in the accompanying report of the borough electrical engineer and tramways manager (Mr. H. Collings Bishop) it is stated that both departments made good progress during the year.

The revenue of the electricity department from the sale of current was £30,043 (1·80d. per unit sold), against £27,710 (1·84d.), and the total costs were £13,526 (0·81d.), against £13,130 (0·86d.). The gross receipts (including meter rent, sales, &c.) were £35,328, and the total expenditure £16,671, leaving a gross profit of £18,657. Interest absorbed £8,871 and sinking fund, &c., £9,410, leaving a net profit of £376, against a deficit of £1,469. The capital expenditure is £278,887, an increase of £6,904 during the year. 4,012,909 units were sold (against 3,615,783), including 916,979 for private lighting (974,721), 701,178 for power (915,601), 537,770 for public lighting (468,885), 1,320,393 for traction (1,215,794), 50,278 for heating (40,782) and 486,311 bulk supply. The equivalent of 187,703 8 c.p. lamps is connected (against 161,773); the maximum load was 2,324 kw. (1,950 kw.), and the load factor 19 per cent. (21 per cent.).

The total receipts of the tramways department were £35,109, and the working costs £23,687. The gross profit was £11,422, and after paying interest (£5,829) and sinking fund (£3,271) there was a net profit of £2,322. The total passengers carried 8,134,845, and the total car-miles run 810,359. The capital expended is £192,828, an increase of £2,566.

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TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

Tenders are invited by EDINBURGH Corporation for three steam turbines and d.c. generators, each of 1,200 kw., and condensing plant and interior parts of cooling towers, for their Dewar-place electricity station. Copies of specification, forms of tender, &c., from the engineer, Mr. F. A. Newington, Dewar-place, Edinburgh, and specifications, conditions and drawings may be seen at, but not obtained from, the offices of the consulting engineer, Sir Alexander Kennedy, 17, Victoria-street, London, S.W. Tenders must be delivered at the office of the town clerk, Mr. Thomas Hunter, W.S., City-chambers, Edinburgh, by Oct. 10.

The Electric Light committee of the City of SHEFFIELD invite tenders for supply of steam turbine alternator, exciter, condensing plant, pumps and other accessories, and three water-tube boilers, economisers, induced draught fan, steel chimney, &c. Specifications, forms of tender and general conditions from the general manager and engineer, Mr. S. E. Fedden, Corporation Electric Supply Department, Commercial-street, Sheffield, where tenders are to be delivered by 10 a.m. Sept. 30.

The Directors of the METROPOLITAN RAILWAY Co. are prepared to receive tenders for the supply of general stores during 12 months ending Oct. 31, 1911. Forms of tender (No. 13, electric wires and cables; No. 14, electric lamps, carbons, switches, fuses, telephones, coils, &c.; and No. 15, insulating materials) from the Secretary, 32, Westbourne-terrace, London, W., to whom tenders by 10 a.m. Oct. 3.

By command of the POSTMASTER-GENERAL tenders will be received until noon, Monday, Sept. 26 for supply of Swedish, Norwegian, Finland or Russian red fir telegraph poles to be delivered at certain ports in the United Kingdom; also for creosoting, &c., telegraph poles. Forms of tender, &c., from the Controller of Stores, 17-19, Bedford-street, London, W.C.

LONDON County Council require tenders by 11 a.m. Oct. 11, for the road work and platelaying required for the reconstruction of the Highgate-road tramways for the conduit system, and for paving works of street widenings. Specifications from the Chief Engineer.

LONDON County Council also want tenders by 11 a.m. Oct. 5 for electrical installation work at the Poplar Coroner's Court and Hoxton House Schools, Shoreditch. Specifications, &c., from the Chief Engineer, Spring Gardens, S.W.

YORK Electricity committee want tenders by Oct. 7 for 12 months' supply of carbons, carbon brushes, carbon filament lamps, meters and time switches, motors, &c. Forms of tender, &c., from the City Electrical Engineer.

FOLKESTONE Electricity Supply Co. want tenders for the erection of natural draught cooling tower. Particulars from the Manager, at Folkestone.

HACKNEY (London) Council require tenders by 7 p.m. Oct. 13 for supply of 90,000 pairs of white open-type arc lamp carbons. Specifications, &c., from the Town Clerk.

ISLINGTON (London) Guardians want tenders (by 4 p.m. Oct. 6) for supply and fixing of bells, fire alarms and telephones at the Workhouse, Upper Holloway, N. Specification from the Master of the Workhouse.

The Isle of Thanet Electric Tramways & Lighting Co. (ST. PETERS, Kent) want tenders for 12 months' supply of stores. Forms of tender from the Engineer and Manager.

RHYL Council invite tenders for 12 months' supply of fuel oil from Oct. 1. Tenders to the Clerk by 26th inst.

Tenders are invited for supply of telegraph and telephone cable (schedule No. 284) and insulators (schedules Nos. 373 and 374) to the Postmaster-General's Department, VICTORIA. Tender forms and particulars at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to noon Oct. 17 for the supply of telegraph and telephone instruments and material (as per schedules 1 to 9) to the Postmaster-General's Department in TASMANIA. Tender forms and specifications at the office of the High Commissioner, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, MELBOURNE, will receive tenders until 3 p.m. Oct. 18 for supply of 23 miles of telephone cable (specification 284) and 500 composition insulators (specification 374) and until 3 p.m. Oct. 25 for 10,000 Cordeau insulators (schedule 373). Specifications, &c., from 72, Victoria-street, London, S.W. Local representation is necessary.

Tenders are invited up to Oct. 5 for the supply of 5,000 porcelain insulators to the Postmaster-General's Department in NEW SOUTH WALES. Tender forms and specifications from the Commonwealth Office, London.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone insulators to the Postmaster-General's Department in all the States of the Commonwealth of AUSTRALIA. Tender forms at the Commonwealth Offices, London.

Tenders are invited up to Oct. 4 for the supply of telegraph and telephone material to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, London.

Tenders are invited up to Sept. 27 for the supply of electric lamps to the Postmaster-General's Department in VICTORIA. Forms of tender, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

ADELAIDE (S. Australia) Municipal Tramways Trust want tenders by Oct. 11 for supply of 1,750 tons of tramrails, 150,000 dogspikes and 1,200 tiebars and by Oct. 18 for bonding material.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

The Ministry of Public Works, CAIRO, require tenders for electrical installations and refrigerating plant for the lunatic asylum in course of construction at Khanka. Specifications from the Chief of the Administrative Service, Ministry of Public Works, Cairo. Stamped paper for tenders is obtainable from Mr. A. L. Webb, Westminster, S.W. Tenders by noon Oct. 20. Legal domicile at Cairo is necessary in the case of this contract, and to obtain temporary domicile British firms must, before electing such domicile, formally advise the Consulate at Cairo of intention to do so, formally authorise the Consulate on their behalf and inform the Consulate of the address to which documents should be forwarded.

Tenders will be received at the Ministere des Colonies, rue Oudinot, 27, Paris, until Oct. 14 for the supply and laying of a submarine cable between LIBREVILLE and LOANGO (French Congo). Deposit of £2,000 required with all tenders, to be increased to £4,000 with successful tender.

Tenders are wanted by noon Oct. 31 for supply and erection of machinery, &c., for electricity supply and water supply systems for the town of BENI-SOUEF (Egypt). Particulars may be obtained from Mr. A. L. Webb, C.M.G., Queen Anne's-chambers, London, S.W. Local representation is necessary.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representa-

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tion is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

MOSTAR (Austria-Hungary) Municipality require tenders by Oct. 1 for the installation of electrical generating plant. Specification (in German) can be seen at 73, Basinghall-street, London, E.C.

The "North China Herald" states that SHANGHAI electricity department require tenders by noon Oct. 10 for supply of electric heating and cooking appliances, and by noon Oct. 20 for 10,700 carbon and 15,000 metal filament lamps. Specifications from the Electricity Works, 31, Fearon-road, Shanghai.

The NORWEGIAN STATE RAILWAYS DEPARTMENT require tenders by 3 p.m. Sept. 30 for the supply of two 35-ton electric cranes. Specifications, &c., (in Norwegian) may be seen at 73, Basinghall-street, London, E.C.

Tenders are invited for the electric lighting of NAGYAROVAR (Hungary). Tenders to the Town Hall by Sept. 27.

Tenders are invited for the supply to the Danish State Railways Administration of 1,656 accumulators for the lighting of railway carriages. Tenders, marked "Tilbud paa Levering af Akkumulatorer," will be received at "Direktören for Maskinafdelingen, de Danske Statsbaner, Gl. Kongevej 1D, 3 Sal," COPENHAGEN, up to noon on Sept. 26. Specification, &c. (in Danish), may be seen by British makers at the Board of Trade offices, 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

London County Council received the following tenders for wiring the central car repair depot (second section):—

E. Lawrance & Sons (*accepted*), **£1,702. 17s. 3d.**; Barlow Bros. & Co., £2,425. 16s. 4d.; Gordon Lawson, £2,320. 2s. 6d; G. Weston & Sons, £2,043. 12s. 9d.; Pinching & Walton, £2,035. 10s.; E. Newbald & Co., £2,024. 8s. 5d.; Tilley Bros., £1,888. 12s. 6d.; Johnson & Phillips, £1,877. 3s.; G. E. Taylor & Co., £1,863. 19s. 6d.; Central Motor Engineering Co., £1,571. 8s. 3d.

Sydney (N.S.W.) Electric Lighting committee have accepted the tenders of Babcock & Wilcox for coal and ash-handling plant, £5,887. 5s.; Bullivant's Australian Co., steel suspension cable, £306; Stewarts & Lloyds, 75 steel poles, £103. 2s. 6d.; W. T. Henley's Co., 15 miles of cables (for 11,000 volts), £4,495 (instead of the original quotation of £4,760).

Siemens-Schuckert Werke have the contract for the 1,200 kw. Zoelly steam turbine and electric generator to be put in at the Drammen (Norway) municipal electricity works. The turbine will be supplied by Escher, Wyss & Co.

West Ham Education committee have accepted the tender of J. T Halsey (at £287. 17s. 6d.) for wiring West Silvertown school, and that of Mayfield & Co. (at £21. 7s. 4d.) for the extension of the telephone service in the municipal central secondary school.

Southwark Council has accepted the tender of the British Insulated & Helsby Cables Co. for 220 yds. 0·3 triple concentric cable (£105. 7s. 6d.), and that of the Western Electric Co. for 440 yds. 0·1 triple concentric cable (£88) and 440 yds. 0·05 cable (£60).

Sydney Corporation have received the following tenders for h.t. and l.t. switchgear: Ferranti Limited £2,719 16s. 8d. Noyes Bros., £2,813, Australian General Electric Co., £3,137, Siemens Bros. Dynamo Works £3,561.

Melbourne Corporation have accepted the tenders of Bevan & Edwards for machine tools (£122), Evershed & Vignoles, one bridge megger (£38), and E. Campbell & Son, hot well tank and staging (£83).

Rawtenstall Council have accepted the following tenders:—

D. P. Battery Co., maintenance of battery for 10 years; Crompton & Co., negative booster; Whipp & Bourne, switchboard panels.

Birkenhead Council have accepted the tender of Willans & Robinson for a mixed pressure turbine, coupled to an Electric Construction Co. dynamo, at £2,917.

Newcastle Emlyn Council have accepted the tender of the local Electric Supply Co. for public lighting from Sept. 1 until April 30, 1911.

Crewe Council have accepted the tender of Carrington & Button for wiring the new boys' school and extensions, at £147.

Brighton Guardians have accepted the tender of Adams Bros. for electrical fittings, at £32. 4s.

Hitchin Council have accepted the tender of J. Smallwood for wiring the Town Hall at £65.

Yarmouth (I.W.) Town Trust have accepted the tender of the Isle of Wight Electric Light & Power Co. for public lighting.

Wakefield Guardians have accepted the tender of the Wakefield Electrical Engineering Co. for electrical works for six months.

"Francis" Turbines.—Messrs. Jas. Gordon & Co. report that they have received orders from British Columbia for three spiral case Francis turbines (each to give 950 H.P. under a fall of 120 ft.). They are being supplied with patent oil-pressure governors, throttle valves and other accessories for direct coupling to a.c. generators.

Government Contracts.—The following tenders were accepted during August by the British Government Departments:—

War Office.—Babcock & Wilcox, water-tube boilers; H. Morris & Bastert, cranes; Lancashire Dynamo & Motor Co., re-winding of crane motors, &c.; British Westinghouse Co., switchboards, &c.; and Electric & General Lighting Engineering Co., internal wiring.

India Office.—Lancashire Dynamo Co., carbon brushes; Laurence Scott & Co., motors; Worthington Pump Co., pumps; British L. M. Ericsson Co., telephones; Elliott Bros., transmitters, &c.

General Post Office.—Callender's Co. and Johnson & Phillips, paper-core cable; Western Electric Co., retardation coils; T. Bolton & Sons, British Insulated & Helsby Cables, Elliotts' Metal Co., R. Johnson & Nephew, Shropshire Iron Co., F. Smith & Co. (London Electric Wire Co. & Smiths, Ltd.), and Wilkes, Son & Mapplebeck, copper wire; Davidson & Co., 11 electric fans for new G.P.O. building, London; A. W. Penrose & Co., eight electric lifts for head P.O., Edinburgh; W. Dobson, laying and jointing cast-iron pipes and earthenware ducts in Glasgow and Bennie & Thompson and Hodge & Sons for similar work between Worcester and Gloucester.

H.M. Office of Works.—Siemens Bros. & Co., electric mains for Victoria and Albert Museum and new Meteorological Office, London; and Browett, Lindley & Co., generating set for South Kensington generating station.

Commonwealth Tenders.—The Postmaster-General's Department (Perth) have accepted the following tenders:—

Unbehaun & Johnstone, telephone switchboard cable; Thornton & Watson, wooden spindles for insulators; India Rubber, Gutta Percha & Telegraph Works Co., resistance coils; Western Electric Co., main distributing frame for Cottesloe telephone exchange; Jas. Vincent, filling manhole covers in Trinadad composition; and J. M. Ferguson (Ltd.), extension bells, condensers, carbon diaphragms, generators, microtelephones, nuts, metallic plugs, receivers, registers, portable telephone sets and telephone operators' outfits.

BUSINESS NOTICES.

The Vieta Electrical Co. have moved their works and offices to 60, Queen's-road, Battersea, S.W.

The Cie Watt Appareillage pour Lumière et Force (soc. anon.) inform us that their manager (M. L. Flesch) has resigned in order to take up consulting work and to act as representative of industrial firms. M. L. Sogue! succeeds M. Flesch as manager of the company.

Sale by Auction.—Messrs. Fuller, Horsey, Sons & Cassell will sell by auction at H.M. Dockyard, Devonport, on Tuesday, Oct. 11, and following days, at 11 a.m. each day, quantities of scrap iron, mild scrap steel, brass, copper, manganese bronze, zinc and other metals, 106 tons electric cable, 26 boats' boilers and engines, three engines and dynamos, electrical gear and stores, two overhead travellers, machine tools, lathes, &c. May be viewed three working days prior to and on mornings of sale. Catalogues (6d. each) at the Dockyard, or of the auctioneers, 11, Billiter-square, London, E.C. See also an advertisement.

Patents Development.—The owners of patents No. 23,501/1899, relating to "Improvements in vacuum table lighting," and No. 12,582/1902, relating to an "Improved system of electric lighting," desire to negotiate with electrical engineers with the view of granting licences. Information from Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C.

The proprietor of patent No. 20,324/1902, for "Improvements in conduit for electric cables," desires to grant manufacturing licences to interested parties. Applications to Mr. C. Lean, 231, Strand, London, W.C.

Theatre Lighting.—As stated in our last issue (p. 966) the contract for the complete electrical equipment of the Palladium Theatre of Varieties, London, has been secured by Messrs. Siemens Brothers Dynamo Works. The theatre will be lighted throughout by Siemens fittings and Tantalum lamps, and the circuits protected by Siemens "Zed" fuses. "Stannos" wires have been specified for the wiring, which has been sublet to Messrs. Rashleigh Phipps & Co. It is intended that the theatre shall be equipped with the most up-to-date and efficient system of illumination and lighting effects.

G.C.R. Journal.—The "Great Central Railway Journal" is a monthly publication which deals with the happenings and with the business of the railway whose title it bears, and the information contained in the September issue which we have before us is of more than G.C. interest. The correspondence is a very healthy item, and the liberty to discuss questions of interest to the officials, staff and operators on the line is, apparently, unlimited. There are many more pretentious publications which can show less reason for their existence than the "Great Central Railway Journal," the get-up and arrangement of which reflects credit upon all concerned.

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CATALOGUES, &c.

ELECTRIC MOTOR SYREN.—We have received from Messrs. Siemens Bros. & Co. a catalogue dealing with this subject in which the various apparatus coming under this heading is briefly described. These syrens are motor driven and can be fitted with devices by means of which a code of signals can be given if desired.

LIGHTNING PROTECTOR.—Messrs. Siemens Bros. & Co. have ready a pamphlet describing an instrument protector which secures telephone instruments against damage by lightning discharges and high tension currents.

GILBERT ARC LAMPS.—The Gilbert Arc Lamp Co. have issued an artistic catalogue dealing with the various types of their arc lamps. The chief features of this catalogue are dealt with at some length on page 138 of the INDUSTRIAL SUPPLEMENT published with this issue of THE ELECTRICIAN.

VENTILATORS FOR UNDERGROUND CABLE BOXES.—Messrs. Bullers (Ltd.) are issuing a pamphlet describing the various details of a ventilator they have designed, by the use of which it is claimed underground cable boxes and pits and transformer chambers may be kept clear of explosive gases, while at the same time good ventilation is secured, and the boxes are not flooded by surface water.

HAND-SHIELD PLUGS.—We have to acknowledge from the British Central Electric Co. details of a new three-pin hand-shield plug, designed to comply with Home Office Regulations. It is provided with ordinary terminals, and is so designed that it can only be inserted into the socket in one way, so that all danger of shock is avoided.

MINING EQUIPMENT.—The Adnil Electric Co. forward a catalogue illustrating and describing numerous apparatus which they manufacture for use in mining work.

BANKRUPTCIES, LIQUIDATIONS, &c.

The first meeting of creditors of Jas. D. M. Morton, electrical engineer, Nettleton-road, Mirfield, will take place on Sept. 27 at Bank Chambers, Corporation-street, Dewsbury, and the public examination on Oct. 4 at the County Court House, Dewsbury.

A dividend is to be paid to creditors of Joseph Grace Cunnington and Harry P. Allison (trading as Laing, Wharton & Cunnington), electrical enigneers and contractors, 7, Great Newport-street, London, W.C. Claims to Mr. A. Page, 28, King-street, Cheapside, London, E.C., by Sept. 30.

A dividend is to be paid to creditors of Alan McAlpin, electrical engineer, 44, Cank-street, Leicester, and Cumbergate, Peterborough. Claims to Mr. L. V. Wyke, 24, Friar-street, Leicester, by Oct. 4.

The trustee (Mr. W. F. J. Hunt, Cambridge Junction, High-street, Portsmouth) in the bankruptcy of Hy. K. P. Barham (trading as the South of England Electrical Engineering Co.), 60, Fratton-road, Portsmouth, has been released.

The trustee (Mr. Chas. Scott, Station-road, Gloucester) in the bankruptcy of Walter S. Jenkinson, electrical engineer, Rodborough, near Stroud, has been released.

The trustee (Mr. E. W. C. Whittaker, 3, Portland-street, Southampton) in the bankruptcy of Wm. Thos. Harris, electrical enigneer, 460 and 464, Commercial-road, and 47, Emanuel-street, Portsmouth, has been released.

The liquidator (Mr. H. de V. Brougham, 33, Carey-street, London W.C.) in the winding-up of Improved Electric Supplies (Ltd.), 7, Great Newport-street, London, W.C., has been released.

Bankruptcy Petition.—A bankruptcy petition against Morris Zains, electrical engineer, &c., 98 and 105, Wardour-street, London, W., will be heard on Oct. 6 at the London Bankruptcy Court.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

July 11, 1910.

16,478 THOMSON. Anchor insulator for metallic cable suspender.
16,485 LITTLER, jun. Quick-break switch or circuit-breaker.
16,486 PATON. Interlocking switch or fuse or gate-end box.
16,501 HILL. Electromagnetic friction clutch.
16,522 SERPEK. Electrical resistance furnaces. (Addition to No. 12,601/10.)*

July 12, 1910.

16,575 LEASON. Electric-lighting cable slip-plug connector for electrically-lighted trains.
16,626 DAVIES. Electromagnetic lock.

July 13, 1910.

16,763 KLEIN. Alternating current and alternating and direct-current machines.*

July 14, 1910.

16,796 HARDY. Double-pole sparking plugs for use chiefly with internal-combustion engines.
16,841 AUGUST SCHWARZ BOGENLAMPENFABRIK. Arc lamps for two or more pairs of electrodes. (Date applied for, 28/7/09.)*†
16,844 SIMMS & SIMMS MAGNETO CO. High-tension magneto-electric apparatus.

July 15, 1910.

16,904 LICHTENFELD. Switch devices for electric circuits.
16,933 SYKES, COOKE, JOHNSON & SYKES. Insulated rail-joints.

July 16, 1910.

16,947 ROMER. Intercommunication telephone systems and apparatus therefor.
16,997 SIEMENS SCHUCKERTWERKE G.M.B.H. Electric speed regulation of machines. (Date applied for, 17/7/09.)*†
17,010 ROSENBERG & PECK. Braking induction motors.

July 18, 1910.

17,047 SIEMENS-SCHUCKERTWERKE G.M.B.H. Electric fuses. (Addition to No. 14,622/08. Date applied for, 23/7/09.)*†
17,052 MERZ. Switches.
17,091 WESTON. Electrical measuring instruments.*
17,107 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*
17,110 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Electromechanical controlling-devices.*

July 19, 1910.

17,141 RICHARDSON. Gauge or indicator for denoting electrically any degree of vacuum or pressure or both.
17,148 MONRO. Conduits or casings for electric conductors.
17,156 ALLGEMEINE ELEKTRICITATS GES. Circuit-closing device for electric signalling devices. (Date applied for, 19/7/09.)*†
17,166 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Starting devices for electric motors.*
17,177 B.T.-H. CO. & WHITCHER. Protective devices for electric distribution systems.

July 20, 1910.

17,227 KNUDSEN. Telegraphic apparatus.
17,235 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany.) Means for working two motor controllers by a single operating handle or for like purposes.*
17,236 WATKINS. Device for grinding the contact surfaces of carbon brushes for dynamos or other purposes.
17,247 JAMES. Means for electrically-driving machines at variable speeds.
17,249 STIRK. Switchgear for controlling motor driven planing machines and the like.
17,278 B.T.-H. CO. (G.E. Co., U.S.) Electrodes for arc lighting.*

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

13,443 BERRY & MARKHAM. Protected or armour-clad electric switch fuses.
15,888 LEITNER. Automatic battery overcharge-preventer.
15,960 FLOOD. Electrolytic cell.
16,547 ROSS. Electric heaters.
16,630 AKT.-GES. BRCWN, BOVERI ET CIE. Regulation of electric installations. (Date applied for, 16/9/08.)
16,682 JACKSON. Trolley heads.
16,624 PROCTOR. Arc lamps.
18,624 VIRY. Devices for controlling movements from a distance. (Date applied for 14/8/08.)
18,934 EDWARDS. (Rosen.) Telegraph sending-machines.
20,587 LIVESAY. Electric generating systems.
20,780 JONES & NELSON. Actuating tramway rail points.
20,786 WALKER. Means for making and breaking electrical circuits or contracts.
22,827 PODSZUS. Vapour electric apparatus. (Date applied for, 7/10/08.)

COMPANIES' MEETINGS AND REPORTS.

ALLGEMEINE ELEKTRICITATS GESELLSCHAFT (BERLIN).—The directors' report for the year ended June 30 states that, after deduction of expenses, debenture interest and depreciation, 18,425,000 marks (£921,250) remains, compared with 16,385,000 marks (£819,250) in preceding year. The annual general meeting will be invited to approve a dividend of 14 per cent., compared with 13 per cent. for 1908-9. Besides the usual sums written off, 1,000,000 marks (£50,000) are to be added to general reserve and another 1,000,000 marks (£50,000) as special reserve to meet coupon tax. The turnover for the first two months of the current year, together with orders booked runs up to 247,000,000 marks (£12,350,000), compared with 214,000,000 marks (£10,700,000) for the corresponding period of 1909. The directors' and supervising committee's proposals concerning the Felten & Guilleaume-Lahmeyer Works Co. (THE ELECTRICIAN, Sept. 9, 1910) will be put before the meeting.

BRITISH THOMSON-HOUSTON CO. (LTD.).—The directors' report for the year ended March 31 states that the buildings and machinery have been maintained in first-class condition during the year. A number of improvements and additions have been made, the most important being an extension to the incandescent lamp factory costing £19,000, practically doubling its size and capacity, and an extension to the main factory (largely to take care of the increase in the turbine business) now approaching completion, costing approximately £30,000. Another building is being enlarged, the estimated cost being about £11,000. The turbine business continues to give satisfactory results, and many important orders have been executed during the year. The company has made further satisfactory progress in the development of metal filament (tungsten) lamps, and, to meet the increasing demand, has extended its manufacturing facilities. Following the example of the General Electric Co. of (New York), the company has adopted and registered "Mazda" as its trade mark for tungsten lamps. The company has exchanged licences with the Osram Lamp Works (Ltd.) on all its metal filament lamp patents. Under the terms of the trust deed securing the issue of the debentures, the company had to pay to the trustees on Feb. 28 last £3,339 to be applied by them in purchasing debentures in the market. Since the closing of the books debentures of the par value of £3,361 have been purchased, making the total par value of debentures retired to date £10,421. The directors have followed their usual practice of making reserves to cover risks in connection with bad debts, depreciation of shares held by the company and for other contingencies. There was a

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profit of £10,932. 8s. 11d. as the result of the year's working, after paying interest on debentures and on loans. The appropriation of this sum is mainly to depreciations, and £248. 0s. 10d. is carried forward, making with previous year's balance, £2,599. 3s. 9d.

DICK, KERR & CO. (LTD.)—The profits earned during the 12 months' trading to June 30 amounted to £22,820. 19s. 2d. Debenture interest, trustees' fees and the sum required to provide for premium payable on redemption of the debenture stock have been met, and absorb £12,404. 8s. 7d., leaving £10,416. 10s. 7d., added to £63,141. 10s. 1d. brought forward, making £73,558. 0s. 8d. available for appropriation. Preference dividend requires £18,300, a dividend of 5 per cent. on the ordinary shares (less tax) £13,000, and the carry forward £42,258. 0s. 8d. The severe competition referred to in the last report has continued throughout the past year. The directors refer with regret to the death of their friend and colleague, Mr. George Flett, the managing director. Mr. Walter Rutherford, who was assistant managing director, has been appointed to the position.

MANILA ELECTRIC RAILROAD & LIGHTING CORPN.—Of the many American enterprises which have sprung up in Manila since the annexation of the Philippines by the United States this corporation is one of the most important. It was incorporated in 1903 and has an issued capital of $5,000,000 with a bonded debt of $5,512,000, and owns the entire stock and bonds of the Manila Electric Railroad & Light Co., all the capital stock of the Manila Suburban Railways Co., and more than 98 per cent. of the capital stock of La Electricista, a Spanish company conducting an electric lighting business in Manila. The Manila Electric Railroad & Light Co. is the ower of a 50-year franchise granted in March, 1903, by the municipality of Manila, and operates all the electric railways in Manila, in which city it is also authorised to carry on a general electric lighting business. The Manila Suburban Railway has a 47-year franchise from January, 1906, and its lines are a part of the system of the Manila Electric Railroad & Light Co. providing connecting links to the suburbs with that company's system. Manila, which is the social, political and business centre of the Philippines, has a population of about 300,000, and transacts about 80 per cent. of the entire commerce of the Archipelago. As regards the earnings of the company, statistics show that while profits fell off slightly in the first half of 1909, owing to a strike which was successfully overcome after lasting a considerable time, they recovered substantially in the corresponding period of the current year, and amounted to $313,277 against $242,046 in 1909, and $262,045 in 1908, and the company has increased its surplus from $342,492 as at Dec. 31, 1907, to $433,374 at Dec. 31, 1909. The corporation paid 3 per cent. on its common stock for 1906 and 1907, and 4 per cent. for each of its following years. During 1910 a distribution of 1 per cent. per quarter has been made. The price of the stock has risen within the past three months from $59.50 to $65 ex div. This latter figure yields to the investor on the present dividend £6. 3s. per cent.

UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)—At the meeting on Wednesday Sir Edgar Speyer, who moved the adoption of the report, said he was glad to be able to record results which, although not yet satisfactory, were considerably better than was anticipated several years ago. The dividends paid on the share capital of the railway companies concerned did not yet represent anything like a fair and adequate return on the large amount invested in those enterprises. Administration expenses showed a saving of over £4,000. The increase in income from the operation of the power house was due to £3,000 interest on increased expenditure (of which £2,500 referred to the period ended Dec. 31 last), and the balance of £1,700 represented additional profit. The income from investments increased by nearly £13,000, due not so much to an expansion of traffic receipts as to a reduction in working expenses of the London Electric Railway Co. The decrease in costs had been brought about almost entirely by a reduction in the price paid for electric current. The traffic could not, in the nature of things, grow in the same quick manner, and they must look forward to a somewhat smaller expansion of earnings than was the case during the first two or three years after the railways were opened. The Charing Cross line had to contend with the competition of the London County Council tramways, which, together with a reduction in fares on the railway, forced upon the company by the low fares inaugurated by the L.C.C., had resulted in a decrease of traffic receipts during the half-year under review. The London Electric Railway Co. was asking Parliament for fresh powers to build the Charing Cross extension on modified plans. The amalgamation of the three tube railways should result in economies in working and in higher credit.

UNITED ELECTRIC CAR CO. (LTD.)—At the meeting on Wednesday Mr. Geo. Richardson said the result of the past year's working had been most satisfactory in view of the continual slackness of the works and the small output, although the company had received a good share of the work which had been given out and which was worth having during the year. The net profit, after allowing for depreciation, debenture interest, &c., was £8,478, or about £400 less than the previous year. The balance to be disposed of amounted to £10,811, and the directors considered themselves justified in declaring a dividend of 2½ per cent. on the ordinary shares. He was glad to see signs that their reputation for good work was extending, and had become established both at home and abroad. That was borne out by repeat orders received, as well as small orders not previously solicited. The directors were hopeful that English corporations and others would soon again be in the market, as many of the cars in use had now been running eight or 10 years, and the directors did not think that large corporations, as a rule, would find it convenient or advisable to build their own. There was no immediate sign of any improvement, but the directors were doing all they could to secure orders

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

INSTITUTE OF METALS.—This institute was registered on Sept. 10, and the word "Limited" is omitted from the title by licence of the Board of Trade. There are 1,000 members, each liable for £1 in the event of winding-up. The objects are to take over all or any of the assets and liabilities of the unincorporated society known as the Institute of Metals, and to adopt an agreement with G. Shaw Scott. The management is vested in a Council.

NUNEATON ELECTRICAL CONTRACTING CO. (LTD.) (111,703.)—Reg. Sept. 12, capital £1,000 in £1 shares, to carry on in Nuneaton or elsewhere the business of dealers in electrical fittings and appliances, electrical engineers, &c. Private company. First directors, F. Frankland and G. Cross. Reg. office, Abbey Gate, Nuneaton.

STATUTORY RETURN.

CROMPTON & CO. (LTD.)—Return to Aug. 11 gives capital as £300,000 in £3 shares. 85,000 shares taken up, £3 per share called up, and £249,000 paid. £6,000 considered as paid on 2,000 shares. Mortgages and charges, £175,000.

MORTGAGES AND CHARGES.

CHURCH STRETTON ELECTRIC SUPPLY CO. (LTD.)—Further charge on freehold hereditaments at Church Stretton, dated Sept. 9, to secure £120. Holder, E. Bond.

FOSTER ARC LAMP & ENG. CO. (LTD.)—Charge on certain land, &c., in Morden-road, Merton, dated Sept. 2, 1910, to secure all moneys due or to become due from company to London County & Westminster Bank.

CITY NOTES.

MEMORANDA (Sept. 22).—**Bank rate 3 per cent. (since June 9, 1910). Price of silver,** 24⅞d. per oz. Consols 80¼—80½ for money; 80⅝—80⅞ for account. **Consols** Pay Day, Oct. 5; **Stock and Shares Continuation Days,** Sept. 27 and Oct. 12; **Ticket Days,** Sept. 28 and Oct. 13; **Pay Days,** Sept. 29 and Oct. 14; **Mining Shares Carry Over Day,** Sept. 26.

PRICES OF METALS (London).—*Copper*, cash, 54⅛; three months, 53½. *Lead*, English, 12⅛—13½; foreign, 12⅛—12⅞. *Spelter*, 23½—23½. *Tin*, English, 155—156; foreign cash, 155⅜; three months, 155½. *Iron*, Cleveland, cash, 49/1, three months, 49/11.

CHADBURN'S (SHIP) TELEGRAPH CO. (LTD.)—The directors have declared a dividend on the preference shares of 6 per cent. per annum (less tax) for the half-year ended 30th inst.

CITY OF CARLISLE ELECTRIC TRAMWAYS CO. (LTD.)—Messrs. Balfour, Beatty & Co. have acquired a controlling financial interest in this company, and it is proposed to extend and improve the system.

DUNDEE, BROUGHTY FERRY & DISTRICT TRAMWAYS CO. (LTD.)—The directors' report for the year ended July 31 states that the profit (including sum brought forward), after providing for interest, amounts to £5,070. The directors propose to pay a dividend on the ordinary shares of 2 per cent. for the year (£574), carrying forward £296.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) The directors have declared an interim dividend for the quarter ended June 30 last of 2s. 6d. per share (tax free), payable on Oct. 15. The share register will be closed from 7th to 14th prox. inclusive.

FOLKESTONE ELECTRICITY SUPPLY CO. (L'D.)—The directors have declared an interim dividend at the rate of 4 per cent. (2s. per share), less tax, on the ordinary shares for the past half-year.

KALGOORLIE ELECTRIC POWER & LIGHTING CORPN. (LTD.)—The directors have declared a dividend on the preference shares at the rate of 6 per cent. per annum for the six months to Sept. 30.

MADRAS ELECTRIC TRAMWAYS (1904) (LTD.)—The directors have declared an interim dividend at the rate of 4½ per cent. (2s. 3d. per share) less tax, on the preferred ordinary shares for the past half-year, payable 30th inst.

PERTH (W.A.) ELECTRIC TRAMWAYS (LTD.)—This company announce that the recent strike of their motormen and conductors has come to an end, and the directors have received a cablegram from the manager that there would be no more trouble.

SAO PAULO TRAMWAY, LIGHT & POWER CO. (LTD.)—A quarterly dividend of 2½ per cent. is announced.

SHAWINIGAN WATER & POWER CO.—A quarterly dividend of 1 per cent. has been declared.

SIR W. G. ARMSTRONG, WHITWORTH & CO. (LTD.)—An interim dividend is announced at the rate of 10 per cent. per annum on the ordinary (tax free) and 4 per cent. on the preference shares, less tax.

WESTERN ELECTRIC CO. (LTD.)—Mr. J. E. Kingsbury, formerly general manager in London of the Western Electric Co., has joined the board of directors of the Western Electric Co. (Ltd.).

WESTERN UNION TELEGRAPH CO.—The directors have declared a quarterly dividend of ¾ per cent. The net quarterly earnings (partly estimated) amount to $2,000,000, an increase of $71,000, and the surplus amounts to $819,000

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 14	1,459	+ 66	15	23,478	— 178
Airdrie	„ 9	232	— 9	36	7,850	+ 39
Anglo-Argentine	„ 16	41,986	+ 2,720	37	1,633 120	+ 190,802
Ayr Corporation	„ 17	695	+ 24	18	7,850	+ 305
Barnsley	„ 9	167	— 9	36	6,239	+ 166
Barrow	„ 9	326	+ 62	36	9,851	+ 1,448
Bath Electric Trams, Ltd.	„ 14	960	+ 98	37	30,723	+ 1,661
Birmingham Corporation	„ 17	6,859	+ 357	24	163,219	+ 2,275
Birmingham & Midland	„ 9	890	+ 44	36	30,767	+ 495
Blackburn Corporation	„ 14	1,206	+ 26	‡25	27,225	— 1,000
Blackpool and Fleetwood	„ 17	1,347	+ 134	..	..	..
Bolton Corporation	„ 18	2,340	— 25	25	59,262	+ 99
Bombay	Aug. 19	2,646	+ 29	33	88,821	+ 6,172
Bournemouth Corporation	Sept. 14	2,111	+ 174	24	48,833	+ 4,554
Bradford Corporation	„ 17	5,001	+ 112	25	126,511	+ 4,146
Brighton Corporation	„ 18	1,136	+ 23	§24	26,753	+ 49
Bristol Trams & Carriage	„ 16	6,230	+ 459	11	71,625	+ 4,458
Burnley Corporation	„ 17	1,387	+ 50	11	14,352	+ 12
Burton Corporation	„ 19	260	— 3	24	6,687	— 6
Bury Corporation	„ 18	1,254	— 12	§24	29,373	— 413
Calcutta Tramways Co.	„ 17	₹55,798	+ ₹3,134	11	₹590,352	+ ₹42,019
Camborne-Redruth	„ 17	127	— 4	37	4,555	— 114
Cardiff Corporation	„ 10	2,379	+ 199	24	54,389	+ 199
Cavehill	„ 9	124	+ 33	36	3,403	+ 169
Central London Railway	„ 17	5,393	+ 354	11	57,605	+ 3,399
Chatham & Dist. Lt. Rys.	„ 15	940	+ 32	37	31,574	+ 1,048
City & South London Rly.	„ 18	3,091	+ 78	11	33,808	+ 236
City of Birmingham	„ 9	2 953	+ 177	36	102,782	+ 2,406
Colchester Corporation	„ 14	217	+ 6	..	..	..
Cork Electric Trams Co.	„ 15	534	+ 30	37	18,245	+ 1,749
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams	„ 9	497	+ 114	36	15,356	+ 2,074
Dover Corporation	„ 17	239	+ 9	24	5.894	+ 154
Dublin & Lucan Railway	„ 16	159	+ 5	11	1,968	+ 115
Dublin United	„ 16	5,503	+ 236	11	68,107	+ 1,487
Dudley-Stourbridge	„ 9	880	+ 12	36	28,885	— 690
Dundee Corporation	„ 14	1,226	+ 28	§17	21,552	+ 347
East Ham Council	„ 17	1,078	+ 76	¶24	25,639	+ 704
Exeter Corporation	„ 16	352	..	24	8,231	— 686
Gateshead & Dist. Trams	„ 9	1,014	+ 25	36	35,543	— 157
Glasgow Corporation	„ 17	19,271	+ 1,332	16	276,938	+ 14,962
Glossop Trams	„ 17	119	— 15	37	4,344	— 272
Gloucester Corpn.	..	..	..	..	..	..
Gravesend-Northfleet	„ 9	222	— 19	36	7,551	— 39
Great Northern & City Rly.	„ 17	1,338	+ 53	11	14,283	+ 497
Greenock & Port Glasgow	„ 9	754	+ 104	36	22,927	+ 3,003
Hartlepool Tramways	„ 9	306	+ 41	36	9,126	+ 612
Hastings Elec. Trams Co.	„ 15	1,335	— 38	11	15,776	+ 38
Hong Kong	„ 17	$8,983	+ $708	11	$96,552	+ $4 760
Huddersfield Corpn.	„ 17	1,717	+ 96	25	43,141	+ 2,156
Hull Corporation	„ 17	2,565	— 21	24	65,710	+ 3,415
Ilford District Council	„ 17	523	+ 38	24	13,185	+ 775
Ilkeston District Council	„ 14	135	..	24	3,153	— 187
Ipswich Corporation	„ 17	468	+ 14	24	11,229	+ 593
Isle of Thanet Co.	„ 17	1,183	+ 168	¶50	32,982	+ 2,191
Jarrow	„ 9	135	+ 12	36	4,528	+ 257
Keighley Corporation	„ 15	180	+ 22	24	4,398	+ 178
Kidderminster & District	„ 9	143	+ 25	36	4,120	+ 115
Kilmarnock Corporation	„ 17	161	+ 8	18	2,858	+ 83
Lanarkshire Trams Co.	„ 15	1,501	+ 48	37	51.482	+ 3,804
Lancashire United	„ 14	1,398	+ 73	37	48,765	— 497
*Leamington	„ 9	171	— 19	36	6,101	— 268
Leeds Corporation	„ 17	7,056	+ 161	24	174,087	+ 5,465
Leicester Corporation	„ 17	2,423	+ 167	..	..	..
Leith Corporation	„ 17	610	+ 25	18	11,679	+ 46
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	„ 10	11,432	+ 362	36	401.975	+ 14,558
Liverpool Overhead Rly.	„ 18	1,395	+ 21	12	17,738	+ 158
Llandudno&ColwynBayRy.	„ 16	677	+ 209	§41	12,698	+ 249
*London County Council	„ 7	41,443	+ 4,611	¶23	963,010	+ 126.503
London Elec. Ry. Co.	„ 17	11,935	+ 260	11	126,080	+ 625
London United	„ 17	6,672	+ 37	38	238,688	+ 9,630
Lowestoft	..	..	..	..	..	..
Maidstone Corporation	..	..	..	..	..	..
Manchester Corporation	„ 17	15,500	+ 638	24	577,567	+ 7,230
Mersey Railway	„ 17	1,980	+ 59	11	21,411	+ 318
Merthyr	„ 9	235	+ 14	36	7,502	— 236
Metropolitan Dist. Railway	„ 17	10,215	+ 568	11	110.268	+ 6,891
Metropolitan Elec. Trams	„ 9	8,731	+ 1,766	36	269,501	+ 46,438
Middleton	„ 9	341	+ 9	36	11.549	— 734
Nelson Corporation	„ 17	156	+ 13	§24	3,648	+ 143
Newcastle-on-Tyne Corp.	„ 17	3,741	+ 75	¶24	96,721	+ 1,116
Newport (Mon.)	„ 17	675	+ 41	25	17,420	+ 720
Northampton Corporation	„ 16	493	— 18	§24	12,318	+ 29
Oldham, Ashton & Hyde	„ 9	623	+ 11	36	20,103	— 131
Oldham Corporation	„ 18	1,799	— 31	25	47,192	— 915
Perth (N.B.) Corporation	„ 14	176	+ 8	§17	3,205	+ 236
Perth (W.A.) Elec. Trams	„ 16	1,097	— 220	..	..	..
Peterborough	„ 9	124	..	36	4,210	— 70
Portsmouth Corporation	„ 17	2,292	+ 56	24	55.040	— 1,511
Potteries	„ 9	1,846	— 46	36	62,840	— 748
Preston Corporation	„ 14	738	+ 6	24	17,950	— 296
Rotherham Corporation	„ 15	640	+ 77	24	15,114	+ 683
Rothesay	„ 9	316	+ 35	36	8,733	+ 58
Salford Corporation	„ 19	5,013	+ 140	†25	116,238	+ 1,733
Sheerness	„ 9	65	+ 5	36	1,864	— 8
Sheffield Corporation	„ 18	6,014	+ 323	¶25	151,158	+ 8,903
Singapore Trams	„ 17	$9,823	+ $458	11	$99,929	+ $7,966
South Metropolitan	„ 9	860	+ 12	36	30,066	+ 1,135
South Staffs	„ 9	917	+ 13	36	30,289	+ 125
Southend Corporation	„ 14	782	+ 146	24	16,676	+ 1,738
Southport Tramways	„ 9	373	— 32	36	10,918	+ 167
Stalyb'dge,Hyde,&c., Jt.Bd.	„ 17	728	— 12	¶24	17,988	— 1,344
Sunderland Corporation	„ 18	1,144	— 10	25	29,296	— 108
Sunderland District	„ 14	455	+ 18	46	19,830	— 1,366
Swansea Trams	„ 9	1,179	+ 166	36	39,260	+ 4,450
Swindon Corporation	„ 14	160	+ 2	24	3,486	+ 154
Taunton	„ 9	43	— 9	36	1,544	+ 80
Tynemouth and District	„ 9	348	+ 25	36	9,883	+ 482
Tyneside Trams Co.	„ 14	417	+ 5	11	5.465	+ 349
Wallasey District Council	„ 17	987	+ 31	¶24	24,177	+ 232
Walsall Corporation	„ 17	533	+ 23	37	19.836	+ 855
Warrington Corporation	„ 8	403	+ 22	23	9,064	+ 207
West Ham Corporation	„ 8	2,505	+ 196	23	57,610	+ 2,395
Weston-super-Mare	„ 9	337	+ 67	36	6,103	— 59
Wolverhampton Co.	„ 9	431	+ 18	36	15,389	+ 332
Wolverhampton Corpn.	„ 14	906	+ 25	..	..	..
*Worcester	„ 9	337	+ 16	36	10.339	+ 188
Wrexham	„ 9	103	— 13	36	3,509	— 43
Yorkshire W.R. Trams	„ 18	1,204	— 60	38	47,311	..
Yorkshire Woollen District	„ 9	993	+ 39	36	35,546	+ 2,830

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed., Sept. 21	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 21. Highest.	Lowest.
		Electricity Supply.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	8¾—9¼	5 16 0	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9 —9⅜	4 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 13 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	6⅞—7⅛	6 9 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7⅛	4 15 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅜—3¾	6 5 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 14 0	Feb., Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	97⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 0	..	101⅛	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¾—4⅛	5 9 6	Jan, July	..	..
5	2/0	†Chelsea Electric Supply Ord.	3½—4	5 12 6	March	3⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	City of London Electric Lighting Ord.	11¼—11⅝	6 9 0	Feb, Aug	11⅛	11
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅝—12¼	4 18 0	Jan, July	11⅛	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.)	120 —124	4 0 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	99½—102½	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.	1⅛—2	..	April, Oct	..	..
5	5%	†Do. 5 per Cent. non Cum. Pref.	2⅜—3⅛	8 0 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7⅜—7⅝	6 7 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½—11¼	5 6 6	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104½—107¼	4 3 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	101⅜	..
5	2/0	†Folkestone Electricity Supply Co. Ord.	4¼—4⅝	5 19 0	April, Oct	4 3/32	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	4⅞—5⅛	4 13 0	Mar, Sept	5	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	99 —102	4 8 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.	6¾—7⅛	5 6 9	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅞—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅛—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4⅛—5⅛	5 15 6	Mar, Sept	5⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/0	Metropolitan Electric Sup. Ord.	3⅛—3⅜	6 13 3	April, Oct	3⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4 —4½	5 0 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	95½—97½	4 12 6	June, Dec	..	..
5	1/6	Newcastle Elec. Supply Ord.	3¼—4⅛	4 11 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛—4½	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	100 —102	4 8 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.	12 —13	6 0 0	March	..	..
5	3/0	†Oxford Electric Ord.	6⅛—6½	5 4 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	7⅛—8⅛	6 2 3	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7⅛	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.	1⅛—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.	2⅝—3	6 4 6	April	..	..
St.	5%	Do 5 % 1st Mort. Stock (red.)	99 —102	4 18 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅜—½	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	⅞—1 1/16	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.)	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	¾—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	2⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8 —8½	5 17 9	Mar, Sep:	8⅛	8
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5⅛	4 2 0	Jan, July	5	..
		Electric Railways and Tramways.					
1	..	Bath Elec. Trams Pref. Ord.	⅞—1	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅞—1	6 13 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock	80 —83	5 8 6	Jan, July	..	..
10	6%	Bristol Tramways & Carriage Ord.	6 —6½	9 4 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7¼—7⅝	5 8 6	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.	¾—1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅜—2⅝	..	Feb, Aug	2⅝	2⅜
St.	5%	Do. 5 per Cent. Perpetual Debs.	89 —93	5 6 6	April, Oct	91¼	91
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	70 —75	6 0 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	63 —65	4 12 6	Feb, Aug	64¼	64
St.	4%	Do. 4 per Cent. Pref. Stock	84 —86	4 14 6	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	46 —48	4 3 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.	100 —102	3 18 6	Jan, July	..	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5¼	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	98 —102	3 18 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	27½—28½	5 3 0	Feb, Aug	27⅛	27⅛
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —105	4 15 6	Feb, Aug	..	..
St.	5%	Do. (1901)	99 —102	4 18 0	Feb, Aug	101⅛	..
St.	5%	Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	99 —101	3 19 0	May, Nov	..	..
10	6/0	Dublin United Trams, 6 per Cent. Pref.	12½—13½	4 6 6	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)	¾—1	..	Feb, Aug	..	..
5	..	Hastings & District Elec. Trams, 6% C. P.	⅛ —1⅛	..	Mar. Sept	..	..
St.	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1⅛—1⅜	3 12 9	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —75	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅛—10⅛	4 19 0	Feb, Aug	10⅜	10
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
St.	..	London Electric 4% Deb. St.	94½—95½	..	..	95⅜	95
..	..	Do. 4% Pref.	84 —85	..	..	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	67 —71	5 12 6	Jan, July	68⅛	68⅛
St.	..	Mersey Con. Ord. Stock	2½—3⅛	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.	⅝—¾	..	..	..	..
1	..	Do. Deferred	⅜—½	..	April	½	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	5 6 8	Feb, Aug	¾	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	90 —99	4 11 0	Jan, July	98	97½
St.	..	Do. 5 per Cent. Db. Stk	97½—99½	5 0 6	..	..	..
St.	1½%	Metropolitan Railway Consolidated	38 —39½	2 18 6	Feb, Aug	38⅛	37⅜
St.	2½%	Do. Surplus Lands Stocks	65 —67	4 2 0	Feb, Aug	65⅛	..
St.	3½%	Do. 3½ per Cent. Preference	87 —89	3 18 9	Feb, Aug	87⅛	87⅛
St.	3½%	Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	91⅛	..

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs	Last Dividend	NAME.	Price Wed. Sept. 21.	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 21. High-est.	Low-est.
		Electric Railways and Tramways— *Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	90 —92	3 15 6	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.....	21½—21¾	..	Feb, Aug	21⅝	..
St.	3%	Do. 4½% First Pref.	78 —80	1 17 6	Feb, Aug	79½	78
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	71 —73	4 16 0	Feb, Aug	72⅛	72⅛
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	4 0 0	Jan, July	..	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	140 —142	4 4 6	Jan, July	140½	..
St.	4%	Do. 4 per Cent. Ditto.....	95 —97	4 2 6	Jan, July	97	95½
1	4½d.	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅛—¼	6 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	82 —85	5 5 3	May, Nov	82	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅛—¼	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 —70	5 14 C	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E.Rys.Lon. 6% In.bds.withcoupt	38 —40	..	June, Dec	38½	..
..	5%	Do. 5% Prior Lien Bonds.....	103 —104	4 16 0	..	..	..
..	4½%	Do. 4½% Bonds with coup. 6	92 —94	4 15 9	..	94½	92
..	4%	Do. 4 per Cent. 1st Power Ho. Dbs. ..	98 —100	4 0 0	..	99½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	⅛—¼	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1¾—2¼	..	..	..	..
St	4½	Do. 4½ per Cent. 1st Debs.....	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Anchor Cable Co. 4½ % Deb. Stock	101 —103	4 7 6	..	..	..
1	..	Aron Electricity Meter Ord.....	⅛—⅜	..	..	..	..
1	1/9	Do. 6% Cum. Pf.	⅝—¾	6 16 0	April, Oct	..	..
1	3/2	Babcock & Wilcox Ord.....	5⅛—5¼	4 5 6	April, Oct	5⅛	..
1	0/7½	Do Pref.....	1⅞—1⅞	3 17 0	..	..	..
5	4/0	†British Insulated & Helsby Cables Ord..	7 —7⅛	6 13 6	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.....	6 —6⅛	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	101 —104	4 6 6	Jan, July	103⅛	103
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	98 —101	4 12 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	⅛—⅜	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	100½—102½	5 17 6	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	61 —63	3 3 6	Jan, July	..	..
St.	4½%	BrushE.Eng. Co. 4½% Perp. 1st Deb.Stock	37 —42	10 14 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	22 —26	17 6 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9½—9¾	7 12 6	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	4½—5½	4 15 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	103 —105	4 5 9	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.....	3⅛—3⅜	4 7 1	May, Nov	3⅜	3⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	104 —107	4 4 0	Feb, Aug	..	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅛	5 19 0	March ..	..	..
1	0/8½	Consolidated Electrical Co.....	⅛—⅛	5 18 9	August ..	..	..
1	0/6	Consolidated Signal Co.....	¼—¼	5 12 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.....	¼—¼	6 17 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	¼—⅜	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	83 —86	5 16 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¼—1⅛	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	⅛—1⅛	5 13 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	⅛—1⅛	5 1 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅛—⅜	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1⅛	9 3 0	Feb. Aug	1⅛	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅛—¼	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1⅛—2	..	May, Nov	1⅛	..
St.	4½%	Do 4½ per cent. 1st Mort. Deb. (red.)..	75 —78	5 15 6	Jan, July	..	..
2	..	Electric Construction Co.....	¼—½	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1¼—1½	4 13 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	59 —64	6 5 0	Jan, July	61	..
10	5/0	General Electric (1900) 5% Cum. Pref..	7½—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	5/0	Henley's Telegraph Works Ord.....	12½—12¾	5 16 6	Feb, Aug	12½	..
5	2/3	Do. 4½ per Cent. Pref.	4½—5⅛	4 7 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	10⅛—10⅝	4 3 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works....	14¼—15	6 12 0	Feb, Aug	..	..
10	5/0	Do 5 per Cent. Cum. Pref.....	10¼—11	4 14 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	97 —99	4 1 0	April. Oct	..	..
1	..	National Elec. Construction Co.....	⅛—¼	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—¼	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.....	1/16—⅛	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	76 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	5 —5⅛	..	..	..	..
12	12/0	Telegraph Construction & Maintenance..	35⅞—37½	5 12 0	Mar, July	36⅞	35⅛
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2⅛—2⅜	4 12 0	..	2⅜	2⅛
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅝—1⅞	4 1 6	..	1⅞	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	107 —110	4 12 0	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	105½	105½
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip..	105 —107	4 13 6	..	106½	105½
10	10%	J. G. White & Co. 6% Cum. Pref.	12½—13½	7 8 0	..	..	..
1	..	Willans & Robinson Ord.....	⅛—¼	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1½—1¾	10 13 6	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3¾—4¼	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan. July	..	..
St.	15/0	Anglo-American	67 —69	5 8 9	F,My,Ag,N	68	67½
St.	30/0	Do. Preferred	109 —111	5 8 0	F,My,Ag,N	111½	110
St.	25/0	Do. Deferred	26½—27½	4 12 6	F,My,Ag,N	27⅛	26½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk...	85 —87	4 12 0	Jn,Ap,Jy,O	86½	85½
10	6/0	Cuba Submarine Ord.	8½—9¼	6 6 0	Feb, Aug	9¼	9
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 13 9	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3¼—3½	5 3 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	8½—8¾	5 13 9	April, Oct	8⅝	..
50	4½%	Do. 4½ per Cent. Deb.	102½—102¾	4 17 6	Jan, July	..	..
20	6/0	Direct United States Cable.....	15¼—16⅛	5 19 0	Ja,Ap,Jy,O	16⅛	15⅛
100	4½%	Direct West India Cable 4½% Rg.Db.(rd.).	102 —102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	133 —136	5 4 6	Ja,My,Jy,O	134½	133
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	84 —86	4 1 6	Ja,My,Jy,O	84½	84
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	102½—104½	3 17 9	May, Nov	102½	..
St.	2/6	Eastern Extension	12½—13½	5 6 0	Ja, Ap, Jy, O	12⅝	12½
100	4%	Do. 4 per Cent. Deb. Stock	100 —102	3 18 6	Feb, Aug	100⅛	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	100 —102	3 18 0	May, Nov	..	..
10	5/0	G.N (of Copenhagen), with Coupon 80 ..	30½—31½	5 16 0	Jan, July	30½	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	†Mackay Companies Common	89 —93	5 7 6	Ja,Ap,Jy,O	..	..
100	4%	†Do. Preference	74 —73	5 2 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛—¼	..	April	⅛	..
100	4%	Pacific & Europe'n Tel.4%Guar.Dbs.(red.)	98 —100	4 0 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1¼	4 7 0	May	..	..
100	4%	Do. 4 per Cent. Debs.....	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	1¼—1½	..	May, Nov	1⅛	..
10	6/0	Do. 6 per Cent. 1st Pref.	9⅛—9½	6 3 9	May, Nov	9⅛	9⅛
10	6/0	Do. 6% 2nd Pref.	9½—9¾	6 2 6	May, Nov	9½	9½
100	5%	Do. 5 per Cent. Debs.....	101½—103½	4 16 6	Jan, July	..	..
10	3/0	**Western Telegraph**.....	13⅜—14½	4 16 9	Mr,Jn,O,D	14	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 —102	3 19 0	June, Dec	..	..
—	4%	Western Union Telegraph, $1.000 4% Bds	103 —106	3 15 3	—	—	—
..	4½%	Do. $1,000 4½% Fdg. & Rl. Est.Gd.Bnds	99 —102	..	..	..	..

Shrs	Last Dividend	NAME.	Price Wed., Sept. 21.	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 21. High-est.	Low-est.
		Telephones.		£ s. d.			
100	2$	Amer. Telephn. & Telegh. Cap. St.	138 —141	5 13 6	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	93 —95	4 7 3	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	102 —104	3 16 6	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —103	4 17 0	Mar, Sept	..	..
5	5/0	Chili Telephone	9½—10	4 0 0	August ..	9⅝	9⅜
1	0/7½	Monte Video Telephone Ord.....	⅜—½	6 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅜—½	5 12 0	May, Nov	..	..
1	0/6	National Co. Pref. Stock.....	104½—106	5 13 0	Feb, Aug	104½	..
St.	6%	Do. Def. Stock	123 —125	4 17 6	Feb, Aug	123½	123
St.	6%	Do. 6 per Cent. Cum. 1st Pref.....	10 —10⅜	5 8 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10⅜	5 8 6	Feb, Aug	..	..
10	6/0	Do. 5 per Cent. non-Cum. 3rd Pref.....	5⅛—5⅜	4 8 0	Feb, Aug	..	..
5	2/6	Do. Deb. Stock 3½ per Cent. (red.).....	98 —100	3 10 0	June, Dec	..	..
St.	3½%	Do. 4 per Cent. Deb. Stock (red.).....	99 —101	3 19 0	Jan, July	99⅜	..
St.	4%	New York Telephone Co. 30 yr. Bnds.....	99 —100	4 10 0	..	100	99½
1	1/0	Oriental	1⅛—1⅜	4 19 6	April, Oct	..	..
1	0/7½	Do 6 per Cent. Cum. Pref.	1⅛—1¼	4 11 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock.....	86⅛—86¾	4 10 6	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	99 —101	4 9 0	Jan, July	..	..
5	5/0	United River Plate Ord. ex rights	7⅛—7⅜	5 8 6	July	7⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 9 9	June, Dec	5⅛	..
St.	4½%	Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan, July	104½	104
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2⅝—3⅛	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10½—11	5 7 6	Sp,DcMrJu	10⅜	10⅛
10	3/0	Do. 6 per Cent. Pref.	13⅛—13¾	4 7 0	Sp,DcMrJu	13⅜	13⅛
10	6%	Submarine Cables Trust (Cert.)	133 —136	4 8 3	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
5	2/6	Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅜	5 5 0	April, Oct	4⅜	4⅛
5	2/6	Do. 5% Cum. 2nd Pref.....	4⅛—4⅜	5 11 0	Jan, July	..	..
St.	4%	Do 4% Deb. Stock	92 —93½	4 5 6	June, Dec	93	92½
St.	4%	Do. 4½% Deb. Stock	94 —97	4 13 0	..	96½	95
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)....	103 —105	4 15 3	Jan, July	..	..
St.	4%	Brisbane Electric Trams. Invest. Ord	5⅞—6⅛	5 19 0	May	6⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅛	4 15 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.....	99 —102	4 8 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	141 —145	5 10 0	Mar, Sept	146	142
St.	£3	Do. Pref. Ord. Stock 3d & bonus	124 —128	4 13 9	May, Nov	125	124½
St.	5%	Do. 5% Cum. Perp. Pref. Stock.....	110 —113	4 8 6	Jan, July	112½	110½
St.	4½%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
40	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
100	4½%	†Do. 4½% Perp. Con. Deb. St.	103 —105	4 5 0	..	104½	103½
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db	98 —100	5 0 0	Mar, Sept	98½	98½
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	97 —100	6 0 0	Feb, Aug	98½	93½
5	2/6	Calcutta Tramways (1 to 137,610).....	4⅛—4¼	4 12 6	Mar, Sept	4⅛	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4⅛—5⅛	4 17 6	Jan, July	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red).....	96 —99	4 11 0	Jan, July	..	..
		Cape Electric Tram Shares	⅛—⅜	..	..	..	..
St.	..	City of Buenos Ayres Trams Co. (1904) Sh.	5⅜—5½	4 5 6	F,My,A,N	5⅜	..
St.	4%	Do 4 per Cent. Deb. Stock.....	99 —102	3 18 0	June, Dec	..	..
100	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	97 —100	5 0 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	93 —101	5 4 0	Feb, Aug	..	..
1	..	Kalgoorlie Elec. Trams Sh.	⅛—⅜	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock.....	92 —95	5 5 0	Jan, July	..	..
100	6%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	Lisbon Elec. Trams. Ord.	1⅛—1⅜	10 2 0	July	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 16 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	98 —102	4 18 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	..	..
100	5%	Manaos Trams and Lt. Co. 5% Debs	87 —89	5 12 0	..	..	..
100	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	97 —99	5 1 0	Feb, Aug	98⅛	..
100	$1⅛	Mexico Trams Co. Com. St.	128½—130½	5 0 0	..	129½	128½
100	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	97½—98⅛	5 1 6	..	98⅜	97⅛
100	5%	Do. 6% 50 yr. Mort. Bds.....	100½—101½	5 18 6	..	101⅛	100⅛
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 0	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 3	..	..	..
0/6		Perth Elec. Trams Ord.	⅛—1⅛	2 4 6	May	1⅛	..
St.	5%	Do. 1st Mt. Db. Stock	100 —103	4 17 6	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 3 9	..	..	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	134½	100½
100	$1⅛	Rio Janeiro Tram, Lt. & P. Co.....	102½—103½	4 2 0	..	99⅛	98½
100	5%	Do. 30 yr. Gold Bnds.	98½—99½	5 0 3	..	95⅛	93
100	5%	Do. 50 yr. Mt. Bnds	94 —95	5 4 6	..	101⅛	100⅛
100	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	154 —156	6 8 0	..	155	..
100	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102½	101½
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5½—5¾	5 4 0	Mar, Sept	11½	11
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	10½—11½	5 6 6	..	95⅛	95
St.	4½%	Do 4½ per Cent. Deb. Stk. (red).....	94 —96	4 13 6	Jan, July	..	..
5	5%	Do 5 per Cent. 2nd Mort. Deb. Stock..	97 —99	5 1 0	..	..	..
100	$1⅛	Calcutta Elec. Supply Ord.	6½—6⅞	6 6 0	April, Oct	11⅛	11⅛
100	5%	†Canadian Gen. Elec. Co. Com. St.....	108 —112	6 5 0	..	118½	117½
100	5%	†Do. 7% Cm. Pf. Stock	117 —120	5 16 9	..	..	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
500	5%	Elect Development Co. of Ontario.....	82½—85½	5 17 0	..	84	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	85 —88	5 14 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	..	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—⅜	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅜—½	8 2 6	April, Oct	⅜	⅜
St.	5%	Kaministiquia Power Co.5% Gold Bnds..	100½—102½	5 0 6	..	..	..
		Madras E. S. Corp. Ord.	2½—3	..	..	..	..
		Melbourne E. S. Co. 6%Cum. Pref.	33 —38	..	..	..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock	90½—92½	5 9 0	..	93⅛	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	90½—91½	5 9 6	..	91	88⅛
		Mexican Lt. & Power Co. Com. St.	87½—99½	4 9 6	..	89⅛	88⅛
		Do. 7% Cum. Pref. St.	108 —110	6 7 0	..	109½	108½
St.	83⅛	Do. 5% 1st Mort. Gold Bnds.	94½—95½	5 5 0	..	95	94⅛
500	5%	Montreal Lt. Ht. & Power Co. Cap. St.	143 —146	4 14 9	F,My,A,N	153⅛	146
100	$1⅛	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	217	215
St.	£9	Toronto Power Co. 4½% Db. St.	105 —115	5 5 0	May	..	..
St.	6%	Do. 6 per Cent. non-Cum. Pref. Stk. ..	100½—102½	4 17 6	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	8⅛—9	..	..	..	..
5	3/0	Rosario Ele . Co. Ord.	6 —6⅛	4 12 0	April, Oct	..	..
5	3/0	Do. 6% Pref. (1-20,000)	8⅛—8⅜	6 14 6	..	..	..
5	3/0	Do 2nd Pref.	109 —111	3 12 0	..	110⅛	109½
100	$1	Shawinigan Water& Power Co.Ca.	108 —110	4 10 0	Jan, July	109	..
St.	4½%	Do. 5 per Cent. Bds.	102 —104	4 6 0	..	..	..
St.	4½%	Do. 4½ Per Cen. Mt. Db. St.	100 —102	4 8 0	..	..	..
500	5%	Victoria Falls Power Co. Pref.(1 to 808,000)	⅜—½	5 6 6	Jan, July	⅜	⅜
		Do. (803,081 to 1,700,000)	⅜—½	..	..	..	..

* In calculating the yield allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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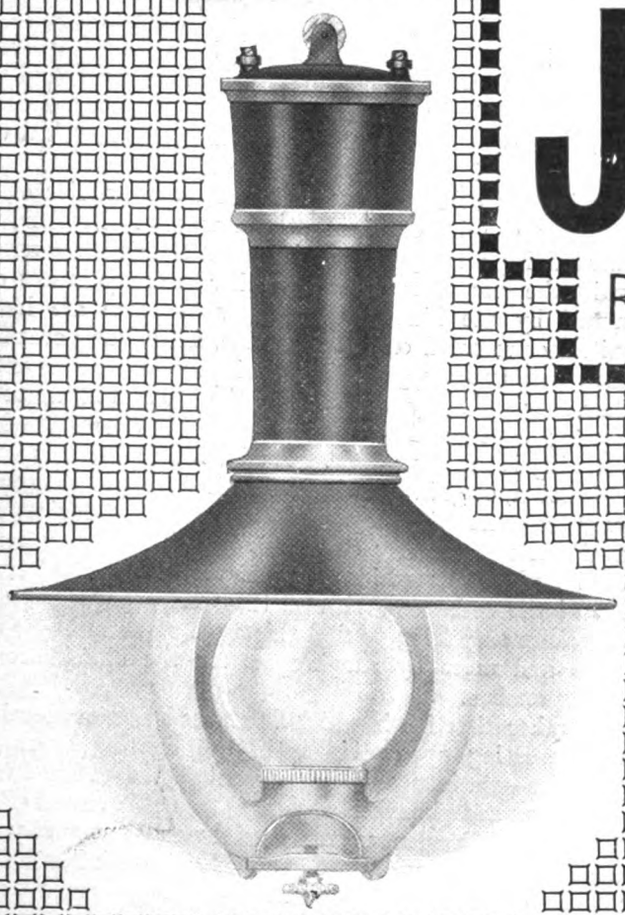

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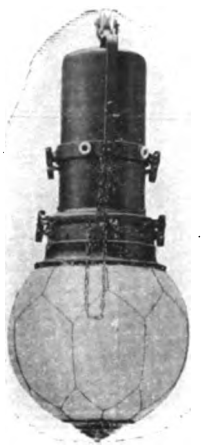

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Flame Arc Lamp Progress.

WE have again to report substantial progress in flame arc lamp development during the past 12 months. Such a statement may seem exaggerated to such as are confirmed pessimists, among whom we are sometimes classed, and to those who, lacking perspective, see too clearly the happenings of the past few months—a state of mind which is known in some circles as a "pitiful continuation of irritation." We would ask electrical engineers and contractors not to take too seriously the result of the competitive tenders between the gas and electric lighting authorities in Westminster. It has already been amply shown that matters quite apart from the relative efficiency of the two illuminants were determining factors, while even the results published do not indicate that overwhelming superiority in favour of gas which some would have us believe.

A man who continually reads journals of one political colour cannot help becoming partisan. The obvious way to prevent this is to study both sides of the question; even then the issue is complicated by the introduction of matter quite irrelevant to the subject. If we are to believe our gas contemporaries, flame arc lighting must hide its diminished head when compared with high-pressure gas, and take its place along with such "back numbers" as the bat's-wing burner. But, it should be noted, while electrical papers freely publish figures relating to the consumption, candle-power and efficiency of flame arc lamps, similar figures dealing with high-pressure gas lamps are singularly absent from the columns of our contemporaries, and must generally be obtained from independent sources. Instead, we are treated to bald "statements of facts," or results are given without those intermediate steps which would make the argument intelligible to us. When one thing is vastly superior to others it is generally found that unquestionable proofs of this superiority are forthcoming from its supporters. We should like our gas contemporaries to give us in full detail the *cost* of illuminant and of running and maintaining one of those famous 3,000 c.p. lamps which we hear so much about.

As a matter of fact, except in London's streets, where, as already pointed out, the issue has been confounded in a number of ways, flame arc lighting has made steady progress. The number of shopkeepers who are employing this form of illumination has been, and is gradually increasing. This seems at first sight peculiar; for a shopkeeper should above all things have a commercial mind. Yet apparently thousands of this class of citizen are using what we are told is an inferior form of lighting, and have even complained in certain cases when this unsatisfactory type of illuminant has been temporarily superseded in the streets in which they carry on their business.

As a matter of fact, flame arc lighting is eminently suitable for shop lighting, which is perhaps why shopkeepers use it. The colour of the light allows materials to be matched with the same facility as in the daytime, while a general and good illumination of both the interior and the exterior of the premises can be obtained at a low cost. Further, the surrounding atmosphere is not heated to any great extent, while the oxygen required for other purposes is not consumed by the illuminant. A row of flame arc lamps, suitably protected on the road side, when hung outside a shop shows up the goods in the window to such an extent that they are easily visible from the top and inside of the passing 'buses, and thus an increase in the range of advertising is made possible. Again, if long-burning lamps are chosen, even in the winter months they will not require very frequent trimming, while the dust-free devices now available prevent any obscuration of the globe, and thus the illumination remains the same throughout the burning life of the carbons. With all these advantages it is not, therefore, surprising to find this type of lamp being used more and more by shopkeepers for the illumination of their premises.

Another direction in which flame arc lamps are receiving an increasing application is in the lighting of railway premises—stations and goods yards. We rather expect this sentence to be received with shouts of "Victoria," and may, in anticipation, express a mild wonderment why such a go-ahead railway as the London, Brighton & South Coast should have so far fallen from grace in this respect as to employ a second-rate illuminant at a number of its large stations when, both from theoretical and practical data, flame arc lamps are more suitable for the purpose. In a railway goods yard a fair general light is the chief desideratum—sufficient illumination to render the trucks visible without that amount of glare which makes work near moving vehicles dangerous. A few high-power flame arc lamps placed well above the ground level admirably fulfil this condition. As an example of this class of work we may quote the Paddington goods station of the Great Western Railway. A light of 3,000 c.p. can now be produced at the same cost as 300 c.p. in former days. Thus illumination of large areas can be carried out with a proportionate reduction in capital cost and in the charges for current. The same arguments apply to the lighting of passenger stations, where a good general illumination can be obtained by suspending a few lamps from the roof. Paddington and Charing Cross passenger stations are examples of this class of work.

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In factories, again, much progress has been made, and it is in these cases that well-thought-out schemes of combined lighting have an advantage. General lighting can be efficiently provided by flame arc lamps, while each tool or bench may be fitted with its own adjustable metal filament lamp, the light from which may be thrown just where it is required. Mention should be made in this connection of the benefits obtainable in factories by the use for general lighting of mercury vapour lamps. The absence of red rays in the light from these lamps does not matter in such a case, while they give a restful light which is eminently suitable for the work performed.

We may, therefore, say that good progress has been made during the past 12 months in the use of flame arc lamps for a variety of purposes. Their use, or rather the use of electric lighting, is recommended by H.M. Inspectors for factory work, as "not seldom is it found that the necessity for artificial light is the excuse put forward for an unreasonably high and a vitiated atmosphere." It will, therefore, be seen that it is recognised, in some circles, at any rate, that the use of gas for lighting leads to a contamination of the atmosphere which would be avoided were electricity employed.

As will be seen from a perusal of the columns of this issue, there is ample example to encourage manufacturers, shopkeepers and street authorities to employ flame arc lamps for illuminating purposes. By so doing they will obtain a cheap and efficient light, easy to upkeep, requiring no skilled attendance, economical to maintain and in every way fit for their purpose.

Gushem's Gas Arcs.*

DRAMATIS PERSONÆ.

Mr. H. S. GUSHEM, *a successful draper, but weak on the point of safety of his premises and his employees.*
Mr. T. GASCHWANK, *a pushful gasman.*
Mr. J. P. PHILPOCK, *an enterprising insurance agent.*
FOREMAN.
WORKMAN.
MATE.
Mrs. GASCHWANK, SHOPWALKER, CLERK, SHOP ASSISTANTS.

ACT. I.

SCENE. *Gushem's Emporium. Gushem's Office. Mr. H. S. Gushem seated at his desk. Time,* 10 *a.m.* (*any morning*). *Enter clerk with card.*

Clerk. Gentleman to see you, Sir.

Gushem (*reading card*). Theodore Gaschwank, Canvasser-in-Chief Risington Gas Corporation. (*To clerk*) What does he want?

Clerk. He said his card explained everything, sir!

Gushem. Let him cool his heels a bit, then let him in. Carefully, mind—in ten minutes.

Exit Clerk.

Gushem. Gas! Whew! Fancy I can smell it already. And this after using electric light for ten years. (*Goes to letter file, takes out letter, and reads.*)

Dear Sir: Why do you continue using electric light when gas is ten times cheaper? Do you know, sir, that we will replace your existing inefficient shop lights with modern gas arcs—inside and outside the shop—absolutely free of charge? This remarkable proposal must appeal to you as a business man. Our Mr. Theodore Gaschwank will call on you to-morrow morning to give you full details and to obtain your consent to the suggested alteration.

Sits down after laying letter before him.

Enter clerk, followed by Mr. T. Gaschwank.

Clerk. Mr. Theodore Gaschwank.

Gushem waves him to a chair.

Gush. Now, sir, I can spare you very little time. I am busy.

Gas. I see you have our letter. Our plan is simplicity itself. Gas burned in inverted burners placed in a suitable lantern can make electricity look sick anyway.

Gush. You notice we are lighted throughout with electric light.

Gas. More fool you!

Gush. Mr. Gaschwank, sir, how dare you?

Gas. I'll dare anything. Aren't you a fool to pay ten times more than you need for your light? Why, my dear sir, you are just casting your golden quids before greedy electric light shareholders, and they don't appreciate it a bit. What's more, you know it.

Gush. Your manners are most offensive, but with regard to the electric light companies, I must admit that you are not altogether in the wrong.

Gas. Of course I am not. They take your money and glad to do it. But otherwise they look upon you as an unmitigated nuisance. Your use of electric light shows you have an unbusiness like mind.

Gush. Indeed, sir, and will you kindly leave me to judge of my own affairs.

Gas. Gas is ten times the cheaper, and you can't get away from it.

Gush. I don't think so. But anyway, price is not everything.

Gas. Look at our offer again. (*Takes up letter and reads.*) "We will replace your existing inefficient shop lights with modern gas arcs."

Gush. Gas doesn't arc!

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Gas. Figure of speech, my dear sir.

Gush. Conveniently so. No electric light man talks about "an electric mantle." If you can't be original, don't copy.

Gas. Well, sir, I will shortly put before you the advantages which we claim for gas. And we are quite right in claiming them. We are driving electric light out on every side. It will soon be as much a back number as the horse 'bus. And why? Gas is cheaper, cleaner, cooler and gives a better light.

Gush. I don't believe all that. But I will give you gas people the credit for one thing: You know how to push your wares, and I am not at all sure that you don't really believe all you say. What you said about the electric light companies was not far wrong. They are too lackadaisical; and would certainly never think of sending a representative to invade a business man's sanctum at this hour in the morning. I repeat I don't believe all you say, but, as a sportsman, I am a good mind to accept your offer and hang the consequences.

Gas. Isn't it a good proposal?

Gush. (*rising*). Yes sir, it is, and damme, sir, you're going to carry it through, whether you like it or not. (*Stands over Gaschwank, who begins to squirm.*) Now, sir (*banging letter on the table*), you will keep to the terms of this arrangement?

Gas. Well, of course, that's what I'm here for.

Gush. Well, in that case, I'll put in your gas arcs and see whether your deeds are as magnificent as your words. You'd better set to work at once, before I repent.

Gas. This is just bully.

Gush. I am glad you think so. Well, hurry up! Bring the agreement round here this afternoon for signature and complete the change over within next week. To-day is Thursday.

Gas. (*aside*). Isn't he just a peach. I'll make some capital out of this. (*To Gushem.*) Good-day, sir, our secretary will bring you the agreement this afternoon at four o'clock.

Gush. Shall be out then. Tell him to come at three.

Exit Gaschwank with a nod.

Gush. Well, I'm sure I don't know whether I've done the best thing. But, at any rate, I shall be able to test for myself whether there's anything in these wonderful claims that Gaschwank makes. And it's the best time of year for testing, too, with the Christmas season coming on. We shall be able to see whether the shops really are any cooler when gas is used. They were hot enough last year, with flame arcs, in all conscience.

Enter clerk. Presents card.

Gush. Hallo! What's he want? More expense, I suppose. Show him in.

Enter Philpock.

Gush. What do you want? I sent you a cheque for your premium last week.

Philpock. I know that, my dear Mr. Gushem, but news travels fast.

Gush. What news?

Phil. You are putting in gas.

Gush. Certainly.

Phil. And you are prepared to meet the larger premium which the greater—I might say infinitely greater—risk entails?

Gush. Well, Gaschwank says not. But anyhow, I suppose your idea is always to make a bit when you can—like everyone else. How much do you want?

Phil. I'm afraid we shall have to double your premium. There is a greater risk, you see; our statistics show it.

Gush. Statistics will show anything, even that calico's silk. There's no help for it, I suppose. I'm not going to risk my buildings, and even with this extra cost gas will be cheaper than electric light on Gaschwank's showing.

Writes cheque.

Phil. Yes; but it costs them more. Gaschwank's idea is to get hold of a few big shops like yours, offer them a cut price and use them as an advertisement. They can't really sell at that price.

Gush. Well, anyhow, the thing's done now. I can't back out. Here goes. Have a drink, Philpock. (*Whisky, siphons and glasses are produced, and the votive operations usual to the occasion duly performed behind a large screen*).

Gush. Well, you must excuse me now, I am busy. (*Exit Philpock. Gushem settles himself down at his desk. 'Phone bell rings.*)

Gush. Hello! The Fire Brigade office? Oh, yes. What, Mr. McWash? Morning. What's that. Hear I've decided to put in gas arcs and want to know if—(*Curtain is here seen slowly descending*)—you can have a few more——oh, confound it all! (*Bangs receiver on hook, and as the curtain falls Gushem is last seen staring at the telephone with a look of great disgust on his face.*)

End Act I.

Act II.

Scene I. *Outside Gushem's shop. Workman busy with step ladders. A high wind blowing. On right, workman on ladder working at "gas arc." His mate below.*

First Workman. Gimme them mantles.

Mate. Orright, cockey, wot's the 'urry?

Workman. Naa then, look lively.

Mate (*mounting steps*). Keep yer 'air on, wiskers. Don't be so frisky.

Workman (*reaching down and snatching box*). Wy doncher 'urry? Look at the time.

Small crowd gathers.

Mate. Get awiy you boys. (*Workman opens box and extracts inverted mantle carefully, but high wind blows it out of his hand. Great scramble among small boys for the support on which the mantle had been.*)

Workman (*looking daggers*). Drat the wind. (*Takes out another mantle and shields with his body while he reaches out to the lantern. Wind gust shakes the steps and mantle is broken against side of glass. Workman throws the support down with an oath on to heads of small boys.*)

Workman (*to his mate*). 'Old the steps, can't ye. Ye young cub. That's two gone. Drat the wind. (*Turns round on the steps and another wind gust makes him clutch at the mantle box, which comes away in his hands, and workman falls backwards with box in his extended arms on to the pavement. Workman gets up, kicks box of mantles in his disgust, and then chases and cuffs his mate.*)

Enter Foreman.

Foreman. What's this hullabulloo?

Workman. It's this 'ere infernal wind. Me an' my mate 'as bin tryin' to get these mantles on, but the wind blows them an' us all over the place. Don't it matey?

Brief consultation, after which Workman and Foreman exit.

Mate. These 'ere bloomin' mantles, they're allus a blowin' away or blowin' off or summut like that. I shawn't be 'arf glad when I starts wiv the Electric Company. (*Soliloquising.*) Yer kno', between you and me, these 'ere diverted mantles is no good. Look at to-day. 'Ow are we a-goin ter get 'em on those lanterns wi' this 'ere wind. W'en Bill ses d— the wind, I ses 'ere, 'ere! becos it means another mantle busted. (*Taking the audience into his confidence.*)

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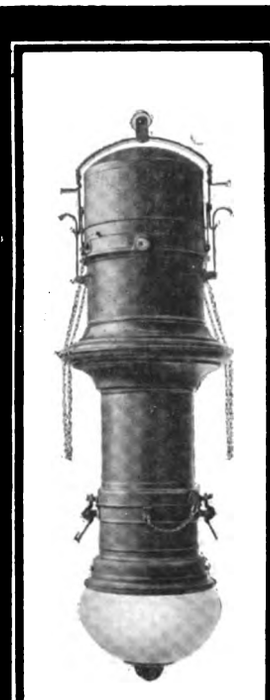

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UNIQUE
TWO YEARS' WARRANTY.

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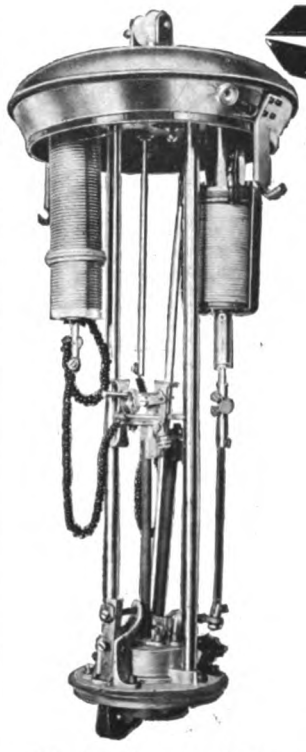

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REGD TRADE MARK

It's Wonderfully Simple.

'Ave yer ever tried litin' these mantles in yer 'and. I'll jes' show ye, just ter demonstrate 'ow them advertisements is all lies. Yer know these pikshers on the 'ordings—Servant girls a-trying to 'it the mantles off the 'ooks and breaking everything except th' mantles. Ladies and gentlemen, as the cheap jack ses, it's all kid. Lemme show yer. (*Takes new mantle, mounts steps, carefully strikes match and fires the mantle.*) That comes of smokin' Woodbines. I can allus lite up in a wind. Naa then, ladies and gentlemen, I 'old in my 'and the 'ead of a 'ard and 'orny beetle, as the perfessor ses. (*Waves mantle, which is puffed away into dust by the wind.*) There you are. You see they're not as strong as some would like to make out. I tell you they're an awful job to get on, even on a quiet day, and when they are up it's ten to one they'll bust almost directly they're lighted. The 'ole thing's a blooming swindle, and what's more they're losing by it. I'm leaving before I get the sack, as they're turning off men somethin' awful. Well, any'ow, I'll soon be out of it now. Thank goodness! 'Ello, 'ere they come!

Re-enter Foreman and Workman, smacking their lips.

Workman. I think the screen will do it; it'll keep off the wind while the mantles are bein' put on.

Foreman. Yes, get it up at once, and do hurry with the rest of the lanterns. We shan't be alight to-morrow night if you go on at this pace. *Exit.*

Workman. Naa then, matey, get that 'ere screen out and we'll 'ave these mantles on in no time.

Large screen is brought out from truck and wind proceeds to play havoc with it. Assistance is brought and with some difficulty the screen is placed round the lantern. More mantles are brought, and the curtain descends on Workman triumphantly placing the first mantle in position.

SCENE II. *Another view of Gushem's office, through door and glass screen of which can be seen the long drapery counter. Time, 8 p.m. Monday in Christmas week. Shop brilliantly lighted by "gas arcs." One of these hangs in centre of Gushem's office. Gushem discovered at his desk, writing with his coat and vest off and frequently mopping his brow.*

Gush. By Jove! Snow and frost outside and the temperature in here up to summer heat. By the look of the shop, though, we are doing well. We can't get 'em away fast enough. *Answers telephone. Enter Gaschwank, who helps himself to a cigar from a box on the table.*

Gush. (*turning round in his chair*). No smoking allowed, sir. Ah, of course, I forgot we altered the rule when gas was put in.

Gas. Say, now, sirree, I guess your store looks just top hole.

Disturbance in shop. Assistants rushing hither and thither. Group seen approaching Gushem's office. Enter clerk.

Clerk. Lady fainted sir, they're bringing her in here.

Gush. (*leaving telephone*). In here. Why in here?

Crowd round office door pushes in and lady is laid on a couch. Gaschwank stoops over the prostrate figure.

Gas. Skiooka! (*Aside.*) My wife! (*Hurriedly leaves through door.*)

Gush. Let's have some air. Boy, get a hook and pull down that window at the top. Never mind the snow. Ask the telephone girl to ring for a doctor. (*Turning to group.*) Poor thing! What's the trouble do you think?

Shopwalker. The heat, sir. It's just terrible in the shop. People are crowding in and they get so baked they've got no strength to get out. I wish you 'adn't put in these gas arcs.

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£4 15 0 Complete (subject).

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CONTA PATENT.

.td.,

DUBLIN—16, St. Andrew Street.
BELFAST—13, Queen Street.
BRISTOL—2, Bristol Bridge.

Gush. Silence, sir, that's my business.

High wind blows across the office through open window and blows out the gas arc in the centre. Office remains lighted from shop through glass screen. Gushem seen rushing about.

Gushem (shouting). I knew it! I might have guessed it; no weather proof lanterns on these inside lamps. Boy! Boy! Bring that lamp hook. We'll have the place full of gas in no time.

Boy, in his hurry, breaks glass screen with the lamp hook and several panels fall out. Gushem rushes at the boy, snatches the hook from him and breaks another panel in his hurry. He reaches up to the extinguished lantern and endeavours vainly to pull the chain controlling the tap.

Shopwalker. Hurry up, sir. The gas is escaping and ther'll be an explosion in a minute.

In the excitement no one thinks of shutting the window, and the draught blows through the broken glass panes into the drapery department. Just outside is an ordinary gas mantle fitted with chimney and fixed on a bracket. The escaping gas is seen to flare over this chimney and ignite with a flop a quantity of curtains near by. This is instantly noticed by a section of the crowd in the shop who immediately begin to crowd together in an alarming fashion and try their best to get out into the open air.

Gush. (who has not noticed the fire). At last, though I ought not to have pulled that chain so hard; it's broken off, but the gas can't come out now. *(Turns and looks into shop.)* Good heavens! Oh, my hat. Where's that poor lady. Here you, shut that window! We're in for it now. Gaschwank! Where's that bounder?

Rushes to telephone.

Gush. (frantically, with receiver first to his mouth, then to his ear). FIRE!

Curtain descends for some seconds, then rises again to discover Gushem's office in ruins and fire brigade in possession of drapery department. In the distance can be seen ambulances at work. On the right, party bears off the still prostrate figure of Mrs. Gaschwank.

Gush., holding his head and wringing his hands alternately, is led off by fireman, and is heard muttering "Gaschwank Gaschwank."

CURTAIN.

The MSS. of the foregoing tragedy has reached us from a reliable source and is accompanied by the following cutting from the "Risington Trumpeter," which will doubtless not be without interest to our readers.

FIRE AT GUSHEM'S.

The drapery department of Messrs. Gushem (Ltd.), The Emporium, Broad-street, was, we regret to announce, entirely burned out during the early part of last evening. The shop was crowded at the time of the outbreak, but happily the emergency exits allowed of the public leaving the building with great ease, and fortunately the disaster was not increased by any loss of life. Several ladies were, however, trodden on during the rush, but after medical attention were able to proceed to their homes. The cause of the fire should, we understand, be attributed to the fusing of an electric wire in Mr. Gushem's office.

! ! ! ! ! !

OSRAM LAMPS

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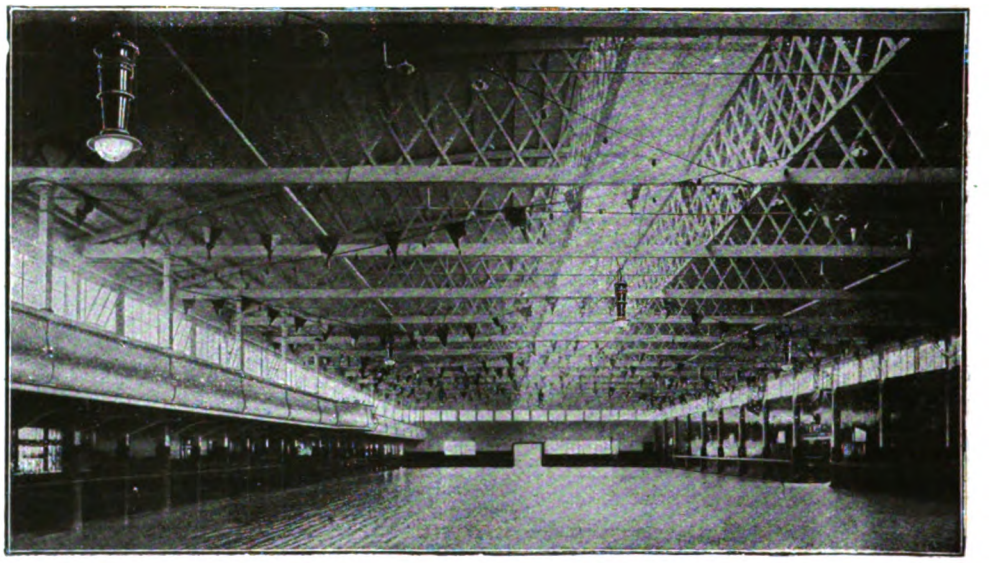
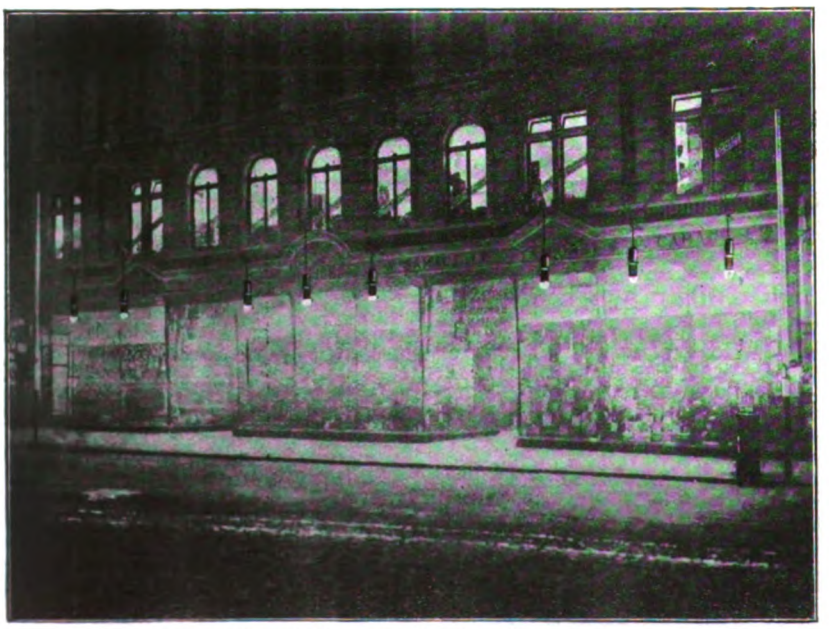
"Metroflam" Lamps at Leyton.

"Excello" Lamps in Lord Street, Southport.

Interesting Arc Lamp Installations.



Westinghouse Flame Lamps in a Skating Rink.



"Excello" Lamps for Shop Lighting.

"Excello" Lamps in Oxford Street looking West.

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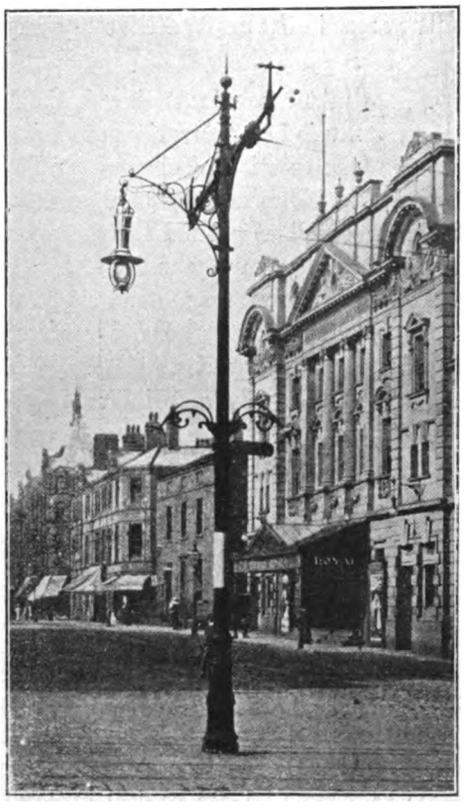
Jandus Lamps at Bradford.

Crompton Flame Lamps for Arcade Lighting.

Interesting Arc Lamp Installations.



Another Example of Jandus Lamps for Street Lighting.

Foster Lamps for Shop Lighting.

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THE ELECTRICIAN INDUSTRIAL SUPPLEMENT
ISSUED MONTHLY with "THE ELECTRICIAN"
Telegraphic Address "ELECTRICIAN NEWSPAPER LONDON" Telephone No. 949 HOLBORN

All communications should be addressed to the Editor, "The Electrician" Industrial Supplement, 1, 2 and 3, Salisbury Court, Fleet Street, London, E.C.

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

Engine-Room Illumination.

With the lighting season imminent, much is heard at this time of year about the way in which certain particular types of areas should be illuminated. Engineers know just which is the best way to light, say, a shop, a street or a factory (although this way is not always employed), but there are certain other places where the methods adopted are to some extent, even now, experimental, and among these are engine rooms. This does not imply that engine rooms are always badly lighted, but too often the method of simply putting in a few candle-power without considering what that candle-power is to do is followed,

An engine room is essentially a place where one should be able to see well at the darkest time of day or night The switchboard, for instance, should be well illuminated, so that the switches can be easily handled and the instruments easily read. This, of course, predicates an absence of glare, and the best way to carry out the work is doubtless to place the lamps on brackets sprouting from the top of the board and carefully shaded on the outer side. The provision of plugs and sockets to which portable lamps may be attached should not be forgotten, as this precaution does much to lighten the work of the attendant in his peregrinations behind the board. But, after all, the switchboard is only a part of the engine room, and it is to the lighting of the other and greater portion that we wish to call attention.

It would seem only natural that in designing the lighting of an engine room the possibility of having to do repairs or removals at night should have been considered. But in too many cases this possibility appears to have been altogether forgotten, and machinery parts, such as main bearings, governing gear and brushes, left in a gloom, which requires other means than the general lighting of the engine room for its dispersal.

It is satisfactory to the worker on plant, especially if this be in motion, when he is provided automatically, as it were, with sufficient lighting for his job without it being necessary for him to employ continually portable lamps and other similar apparatus, which at best is much in his way.

More attention might, therefore, be paid to the lighting of engine rooms, keeping these points in mind. High candle-power metal filament lamps suspended from the roof girders are excellent for this purpose, or if something more ambitious is desired, flame arc lamps may be used. These, if suspended at a sufficiently great height, give a very good general lighting with a small expenditure of energy. In considering this question of engine-room illumination the benefits derived from the use of reflectors and by having the walls of the engine room the proper colour should not be overlooked. White tiling, though expensive, is of course excellent from the reflective point of view, and where this method is used the same intensity of illumination may be obtained with many fewer lamps than when dull painted walls are employed. In the same way with reflectors; the light is, in general, required on the floor of the engine room, so that means for throwing down the rays are both useful and efficient. In cases where a travelling crane is used, means should be provided for hauling up the lamps out of reach when required. In this way the lamps can generally be burnt at the most efficient height, and only need be moved out of the way for the crane to pass. These are a few of the problems which must be solved before the engine room can be said to be properly lighted, and in thus searching for the best way to illuminate these places opportunity may also be taken to carry out experiments, the results of which will doubtless be useful when it is required to light halls and other similar areas in the most satisfactory way.

Electricity and the Cinematograph.

At the present time both theatrical and music hall enterprises are being hard hit by the erection of cinematograph palaces. It is an ill wind that blows nobody good, and these "electric theatres" offer excellent ground for the operations of an enterprising electricity supply undertaking. This is certainly one of the cases where gas cannot be used, in spite of its "safety," but even so there is no reason why the prices for electrical energy should be raised unduly, as these places, both directly and indirectly, advertise the benefits of electric lighting. It may be argued that the load they afford is small and peaky, so that they are not entitled to any particular preference. But this is not altogether the case. Most of these "theatres" open at an early hour in the afternoon and continue until late in the evening, so that what peak there is is spread over a fairly long period, while the cinematograph arcs are by no means the whole load from these places, a very steady demand being made during the dark hours by the signs and other exterior lighting by which they are lavishly decorated. Even if the shows are too ephemeral in character to warrant large capital outlay, surely it is worth the risk on account of the advertisement obtained.

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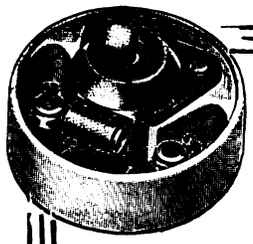
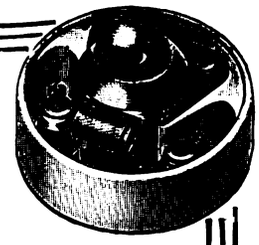


Satisfactory earthing
is ensured by use of



THE "KALKOS" SWITCH

¶ It ensures automatic and sure earthing of the dolly.

¶ It is absolutely watertight without the knob being enclosed.

¶ It is suitable for BOTH the "Kalkos" tinned tube and the "Sun" screwed steel conduit systems.

THE SUN ELECTRICAL CO., LTD.,

118-120, CHARING CROSS ROAD, LONDON, W.

Telegrams—"SECABILIS LONDON." Telephones—GERRARD **2291** and **2292.**

The blaze of electric light outside, the easy working of the machinery inside, and the coolness of the internal atmosphere, all help to draw attention to the advantages of electric lighting, not only for cinematograph theatres, but also for domestic purposes. An advertisement which costs nothing, and may even show a profit, is worth having.

Two Complaints.

It has often been our unpleasant duty to complain of the slow progress which the use of electrical energy is making for domestic purposes. In so doing we have tried to keep even the scales of argument and to apportion in a judicial way praise and blame on the two sections—manufacturer and supplier—whose business it is jointly to bring the advantages of electrical apparatus before the public.

The manufacturer considers that his business is done when the finished article is on view in the show-rooms; it is then that the seller and canvasser must step in; and persuade, wheedle or otherwise induce the public to purchase. In fact, he laments that the seller and canvasser do not take their responsibilities seriously enough. The public do not use electrical apparatus, he says, simply because they do not know there is electrical apparatus to use; and the unsatisfactory state of the business is due alone to slackness on the selling side.

On the other hand, the seller points out that it is difficult to sell apparatus which is flimsy, badly constructed and totally unsuited for the work it is supposed to do. He says that, if the manufacturer would supply him with a strong article which looked as if it had been designed to be used by the ordinary female cook instead of by a laboratory professor, he might have less difficulty in persuading the ladies resident in his area of operations that electrical cooking is really a good thing; and the *one* way of preventing the horrible smell and heat which seem inseparable from all other methods now in use. Our seller complains that before much can be done the manufacturer must recognise that the proper way to remove a plug from its socket is to pull on the "flex," and must design his apparatus accordingly. He must provide a kettle which, destitute of water, will not burn out when left in circuit. In fact, his domestic apparatus must no longer have as its chief characteristics flimsiness, bad workmanship and a tendency to go wrong on every conceivable occasion.

How are we to judge between so much conflicting evidence? Doubtless excuses and refutations are to be found for the details of both these complaints. But, to the unbiassed observer, it will be evident that neither side is wholly wrong in what it alleges concerning the other. It is a case of stalemate or "dishonours even," for neither side can truly claim to be free from fault. Both sides might with advantage pay attention to their own faults, for while it is impossible to sell shoddy apparatus, the days when good wine needed no bush are unfortunately over. It is only in this way, we are certain, that the present unsatisfactory state of business may be remedied.

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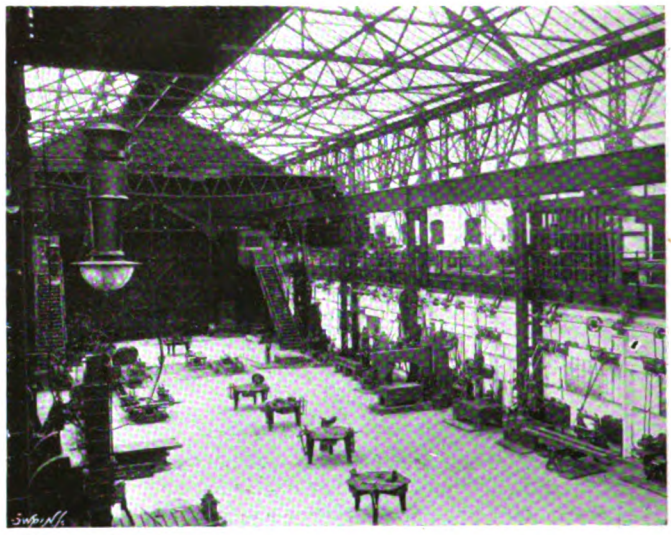
Westinghouse Magazine Flame Arc Lamps. . .

THERE has been a great demand of late for arc lamps of the flame type with long burning hours. This has been met in a variety of ways, but the British Westinghouse Co., after exhaustive experiments, gave their vote in favour of a lamp in which converging carbons are used. The excessive length of carbon necessary for the single carbon lamp makes it impossible, for various reasons, the principal of which is, perhaps, the brittleness of a long thin carbon rod, to effect long burning hours with this type; but with the Westinghouse magazine lamp now put on the market a burning of 45 to 50 hours can be guaranteed. The lamp is of the inclined carbon type, containing magazines holding 10 pairs of carbons. The use of these magazines enables, it is claimed, the employment of carbons smaller in diameter and of cheaper quality than those used in an ordinary flame lamp.



Figs. 1 and 3.—Westinghouse Flame Lamp for Workshop Lighting.

The lamp is controlled electrically by means of shunt and series solenoids, as is the case with their standard "Arcturus" flame lamp. The carbons are positively fed downwards by means of a carrier which is moved by a single endless chain. The chain is operated by a ratchet wheel and pawl, the pawl being actuated by a solenoid. As one pair of carbons is consumed the second pair is automatically pushed into position and fed downwards. The horizontal feed of the Westinghouse Bremer lamp is retained.

By means of a special ventilation and deposit-free cover all fumes and products of combustion are carried into the open air, thus keeping the globes perfectly clean and unaffected by the arc fumes throughout the run.

The mechanism of the lamp is entirely isolated from the arc fumes; but is, on the other hand, easily exposed for inspection, as only two screws need to be withdrawn when it is required to inspect any part of the lamp.

Each lamp is fitted with a substitutional resistance and cutout, so that the failure of one lamp does not interfere with the working of the rest of the series. In addition, an automatic arrangement is fixed to the lamp that cuts off the current from the ratchet coil when all the carbons are consumed. This enables a lamp to be trimmed while the rest of the series is burning.

Engineers and others responsible for effective public lighting by arc lamps have experienced trouble arising from constant renewal of contacts. The simple ratchet of the Westinghouse lamp, it is claimed, completely solves this difficulty, for it may be at work many months without showing any sign of wear. Attention, too, may be drawn to the chain. Instead of adopting a complicated lever action, necessary in the design of most makes, the Westinghouse lamp has an ordinary roller chain. The cost of general upkeep is remarkably low. In one case 10 of the Westinghouse magazine lamps that had superseded another make saved £5 in four months in upkeep alone.

All parts of the lamp are made to template and are interchangeable.

In summarising the special features of this lamp we may

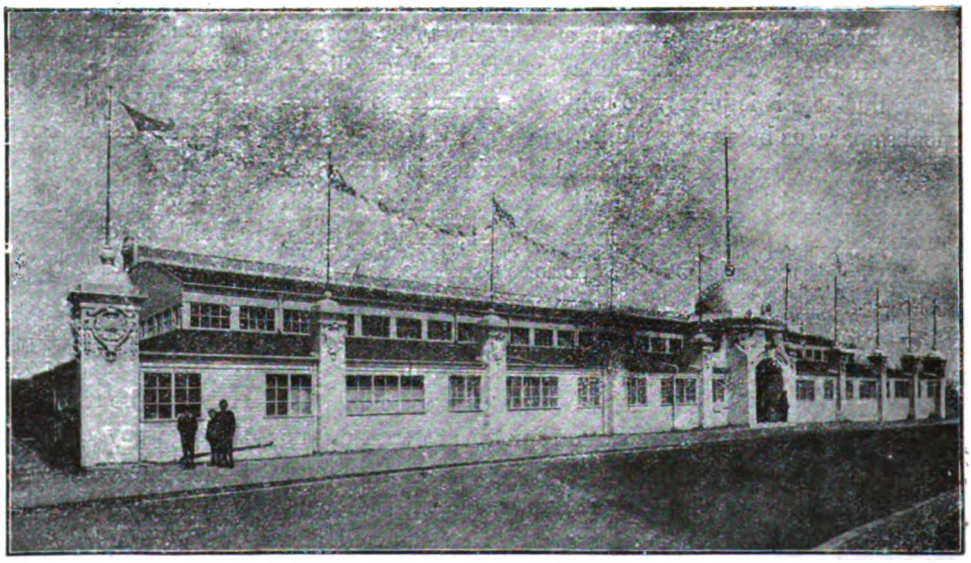


Fig. 2.—Westinghouse Flame Lamps Outside a Skating Rink.

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mention the low upkeep costs, low carbon and trimming costs, low watt consumption, long burning hours (45 to 50 hours are guaranteed under this head), and that the working parts are isolated from fumes.

As showing the wide application which Westinghouse flame arc lamps are receiving at the present time, we may mention that they have recently supplied 180 to the Great Central Railway, 32 to the North British Locomotive Co., 12 to the Maypole Dairy Co., 10 to Jacksons (Ltd.), hatters; 12 to the Empire Skating Rink, Birmingham; 20 to the Birmingham Arcade; 12 to R. O'Brien & Co., for Blackpool South Shore fair ground; 8 to Whipp & Bourne, for Rawtenstall street lighting; 5 to the Lancashire & Yorkshire Railway, Horwich; 120 to the Hang Yeng Iron & Steel Works, China; 32 to the Challenge Cycle Co., Coventry; 8 to the Llandudno Pier Co.; 288 to the Humber Cycle Works; 14 (magazine type) to the Stretford U.D.C.; 10 to Robson & Coleman, of Newcastle, for skating rink lighting; 4 to the Buenos Ayres & Pacific Railway; 10 to Pease & Partners, Darlington, for colliery lighting.

Crompton Flame Arc Lamps, Some Typical Applications.

IT is practically three years ago since the Crompton-Blondel flame arc lamp was placed on the market, and in that time it has made substantial progress and is being used for the illumination of shops, streets and many other places where a good artificial light is a necessity.

The Lighting of Shieldhall Sewage Works by Crompton Lamps.

The essential features of this lamp are, it will be remembered, heavy mineralised carbons placed in a vertical position, the positive being more heavily mineralised and larger than the negative. It is also always placed below the negative. The mechanism of the lamp is very similar to that employed in the well known Crompton open type lamp, though it has a somewhat longer stroke and a more delicate feed. By means of a specially ventilated corona and ash pan the proper supply of air is admitted to the globe and the burnt gas and fumes are carried away, so that they cannot damage the mechanism in any way.

As showing the wide application of Messrs. Crompton's lamps, mention may be made of a few installations recently carried out by Messrs. Crompton & Co. The first of these is the Shieldhall sewage works of the Glasgow Corporation, and is shown in the accompanying photograph. The installation consists of 35 "SS" pattern lamps, ordered in January. They take, when burning, 5 amperes and are arranged five in series on a 250 volt circuit, burning for 32 hours without recarboning. They were ordered through the Glasgow Corporation Electricity Department for the Shieldhall sewage works in connection with the new Glasgow main drainage scheme, which has cost the City of Glasgow over £2,000,000 sterling. These lamps are similar to some previously supplied by Messrs. Crompton to Dalmuir for the drainage tanks on the north bank of the Clyde. These lamps have now been burning for some years without cutouts or substitutional resistances and have given, we understand, every satisfaction. An installation at Messrs. Charles L. Reis & Co. of 10-ampere flame lamps, ordered in January last year, may also be mentioned. These lamps burn five in series on 250 volts for 10 hours without recarboning and are fitted with internal automatic cutouts and independent substitutional resistances. They are in a prominent position in a chief thoroughfare in Glasgow and have proved, we are glad to hear, a good advertisement for Messrs. Crompton.

Another somewhat similar instance of lighting of the quasi-outdoor kind is supplied by B 12 7-ampere flame lamps, burning five in series on 250 volts for 18 hours without recarboning and fitted with internal automatic cut-outs and hooded type substitutional resistances, which were ordered in September, 1909, through Messrs Anderson & Munro, for lighting the Arcade in Glasgow. Messrs. Crompton obtained this order in competition with a number of other makers and were able to show that their carbon cost was lowest, and as a sample circuit of each of the other lamps were burning for a month alongside them, it was shown that their 7 ampere lamp gave a better distribution and a better all-round lighting effect

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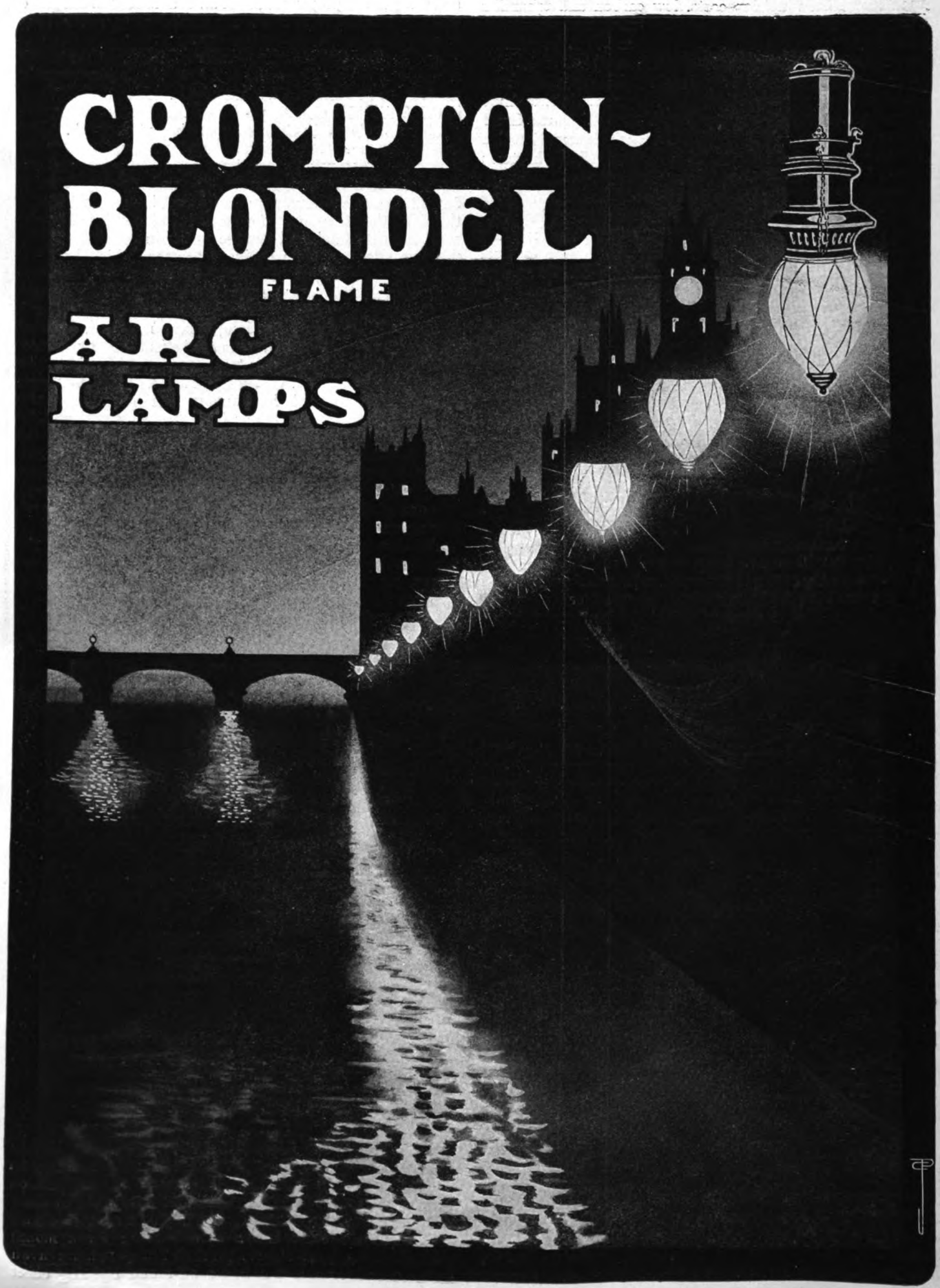

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than their rivals' which were consuming considerably more current.

Mention may also be made of 5-ampere B 12 lamps, ordered in August, 1908, by Messrs. John Irwin, which have been so successful that Messrs. Crompton have this month received a repeat order for these lamps. The lamps will then be run six in series on 250 volts. They are fitted with internal cutouts and independent substitutional resistances. The lighting of the street is also carried out by means of the same lamp.

An example of shop lighting at Forsyth's, Glasgow, may also be mentioned. This consists of ten B 12 10-ampere lamps which were supplied in March of last year. These lamps are burning five in series on 250 volts, using white flame carbons, and are burning without cutouts or substitutional resistances, and have given every satisfaction. There are in addition a large number of Messrs. Crompton's enclosed lamps used for the lighting in the interior of this shop, and they recently received an order for 38 further enclosed lamps for interior lighting from the same firm.

These are merely a few detailed instances of recent installations of the Crompton-Blondel flame arc lamp, but as showing the extent of its success the following instances may be cited of its wide application in the lighting of factories, streets, shipyards and other open spaces. Messrs. Marshall, Sons & Co., of Gainsboro', have just put in over 500 of these lamps for shop and yard lighting, and altogether over 1,000 Crompton flame arc lamps are now in these works. Messrs. Armstrong, Whitworth & Co. have just ordered 50, bringing the number of Crompton lamps in their works to considerably over 300. Other recent orders comprise 28 flame arcs from Messrs. W. E. O. Williams & Co., of Newport; 25 from Messrs. Humphries & Sons, of Kidderminster; 40 from Messrs. Balfour, Beatty, for the lighting of Llanelly; and a large number for Messrs. Dorman Long's works at Middlesbrough, Messrs. Ruston Proctor of Lincoln, the Avonside Engine Co., Southampton Docks, Swansea Harbour Trust, and Boston Harbour where the lighting is completely carried out by Crompton lamps. Town lighting, too, is well represented, and in the case of Lincoln and Yarmouth the Corporation recently decided, after careful experiments, to instal the Crompton-Blondel flame arc lamp, which, in each case, is replacing the old Crompton P. type lamps which have been running in these towns with considerable success for a number of years. It would seem, therefore, that the Blondel lamp is assured of a large measure of the success which signally marked the open and enclosed type Crompton lamps, which have held the market for so many years.

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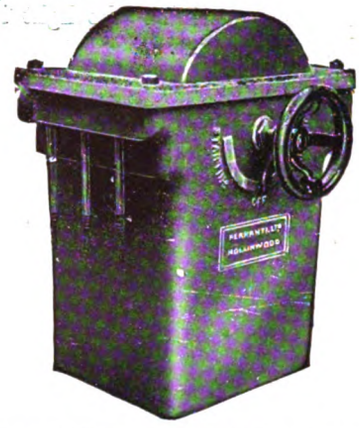

THREE-PHASE
AUTO-TRANSFORMER
STARTERS.
TOTALLY-ENCLOSED. 245

The "Metroflam" Lamp.

A FIRM who have long been known as pre-eminent in the arc lamp world are Messrs. Johnson & Phillips, of Old Charlton. They were among the earliest to manufacture this type of lamp and, keeping pace with modern developments, now turn out an efficient magazine flame lamp, known as the "Metroflam." This lamp burns for 70 hours at one trimming. There is, it is claimed, no period of extinction, as the carbon changes, while no cleaning of the working parts is necessary, though the globe and furnace, of course, require wiping. The efficiency is 6 c.p. per watt, the cost of the carbons is low, and they are supplied in short lengths, so there is no wastage due to breakages in trimming, while their first cost is also moderate. It may, in passing, be mentioned that the distribution of light required for a particular purpose can easily be effected by adjusting the lamp to a suitable height.

Turning to details, the non-extinction of the "Metroflam" lamp is secured by arranging that before one pair of carbons has ceased to burn, another pair comes into contact; the arc is therefore at once formed between them, simultaneously disappearing from between the ends of the

Fig. 1.—"Bell" Arc Lamp Lowering Gear.

old pair. This process is effected by dividing both the positive and negative magazines into two separate compartments (four in all), having an endless chain passing down between the two sets of carbons. Tappets on the sides of this chain push down one carbon from one side and

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from the other alternately, that is to say, one carbon is fed from one side of the magazine and then another from the other side, and so on until all the carbons have been used. The chains are driven simultaneously by a simple ratchet, actuated by the falling weight of a small shunt solenoid core, the circuit of which is completed by the action of the differential regulating coils when the voltage becomes too great across the arc. The feed produced by this arrangement is almost imperceptible; the light is therefore extremely steady and constant.

The gear is, it is claimed, effectively protected from deposits and interference, and the magazine chamber is so

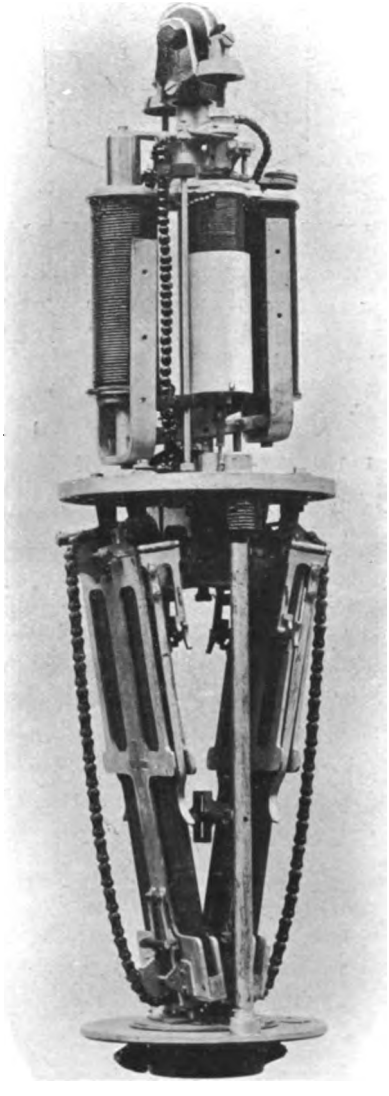

Fig. 2.—Interior of the "Metroflam" Lamp.

constructed that, as explained before, no cleaning is necessary except at long intervals. The general construction of the lamp embodies a main and shunt solenoid, which operate the two magazines sufficiently to obtain the arc. This, however, is done by means of a special toggle, which permits great delicacy of movement when the magazines are near each other, so that, however heavy the magazines may be, or should they become accidentally stiff, the feed remains still as delicate and reliable as ever.

A cut-out of solid design is also provided in the lamp, which puts in a substitutional resistance of ample proportions as required, it being impossible, it is claimed, for the arc and the resistance to remain in parallel, as the contact must be broken before the carbons begin even to separate. This is made possible by the toggle previously mentioned. Each lamp contains (in a well-ventilated chamber at the top) a substitutional resistance of ample area to prevent undue heating.

In connection with this lamp Messrs. Johnson & Phillips have been good enough to send us particulars of the Gravesend Corporation flame lamp installation. In the original scheme single-carbon open-type lamps, burning nine in series on 480 volts with a current of 12 amperes, were adopted, and these were mounted on central carriers secured chiefly to cast-iron columns, and in some cases to the steel posts used in connection with the trams. The new system embodies the use of "Metroflam" magazine lamps with swan-neck brackets and "Bell" raising and lowering gears in place of the open lamps and fittings. The flame lamps are coupled 12 in series on a 480-500 volt circuit, the current consumption being 8 amperes. Each lamp is provided with a self-contained auto cut-out and substitutional resistance, together with an isolating switch, the latter being fitted in a cast-iron box within the pillar base. The line resistances are mounted behind one of the switchboard panels at the station and are coupled to multi-contact regulating switches.

The energy consumed by the flame lamps is only 333 watts each, against 640 watts with the original open lamps. The life at each trimming is 80 hours, *i.e.*, five times as long as the older lamps, so thus a large saving is effected on these two heads alone, in addition to which the maintenance costs are practically negligible. The employment of contact gears for lowering the lamps for trimming is another factor which conduces to the economical working of the installation.

The "Metroflam" lamp and "Bell" contact device, referred to above, have both been designed by Mr. James Brockie. This contact gear is an up-to-date device taking the weight of the lamp off the lifting rope, and making electrical contact between the supply mains and the lamp terminals. In construction it is quite simple, a well-known and proved principle being employed in an entirely novel manner. It contains no springs or pawls. The lamp is suspended from a strong malleable iron hanger, and its weight is carried by substantial lugs. Electrical spigot and socket self-cleaning contacts of ample size are employed, insulated in the very best manner with steatite cones, only one size of insulator being used. The action of the gear is, it is claimed, absolutely reliable, and the lamp always returns to its original position. Reversal of polarity is thus impossible. A patent self-locking winch is also used in connection with this gear.

For the public lighting in the Leyton district a large number of Messrs. Johnson & Phillips' "Metroflam" magazine lamps and "Bell" contact gears and accessories have recently been installed. These lamps are identical with those in use at Gravesend and elsewhere, but they are coupled three in series on a 150-volt circuit. Although many of the lamps are fixed to the tramway columns the vibration due to passing cars does not, Messrs. Johnson & Phillips inform us, affect the efficient performance and steady burning of the lamps in the slightest degree.

It is interesting to note that before the placing of the order for the Leyton lamps, the engineer for the U.D.C. (Mr. F. Harman Lewis) carried out a lengthy and severe elimination test with a number of the best known lamps,

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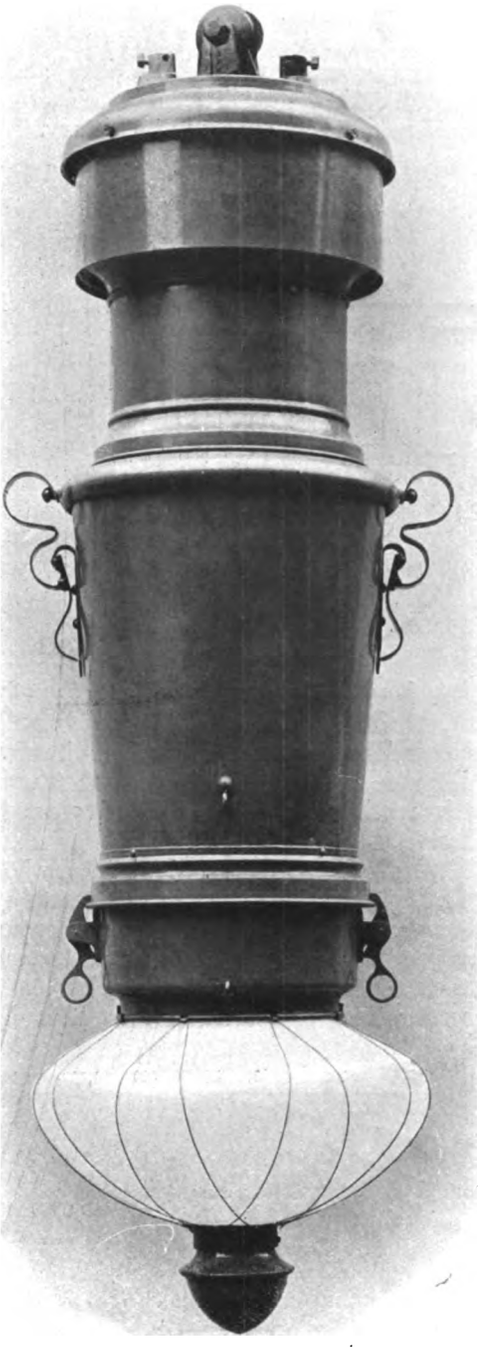

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and after a careful comparison of the actual results obtained, the "Metroflam" was selected, being placed first on the list of "suitability for public lighting."

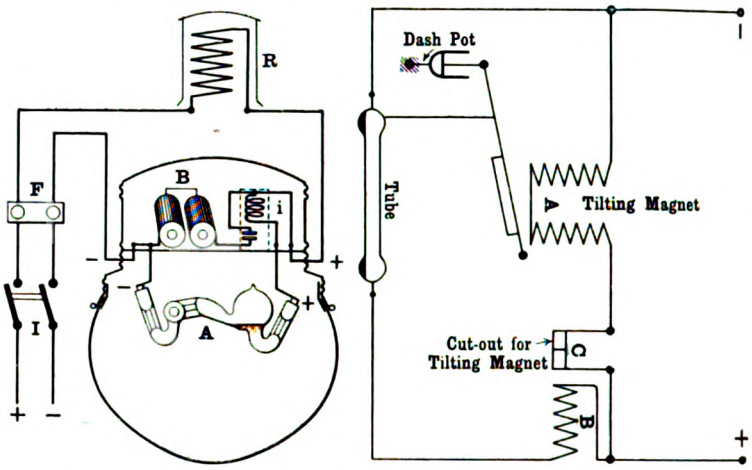
One very important feature which is much appreciated in this and other "Metroflam" installations is the absence of deposit in the interior of the lamps even after many months' operation, no cleaning of the mechanism by the trimmer being needed. A photograph of the Leyton lamps taken at night appears on p. 120.

The "Metroflam" lamp has been placed on the market to meet the requirements of corporations and contractors who require a lamp which is absolutely dependable, economical to run (both as to current and carbons), has a really long duration, burns with perfect steadiness—yielding a light that does not emulate the chameleon—and costs little or nothing to maintain. For these reasons it is specially suitable for street, railway station and goods yard lighting, harbour and dock illumination and similar services. The convenience of the lamp is greatly enhanced by the use of the "Bell" contact gear, which, together with the exceptionally long duration obtained, reduces the cost of attendance very appreciably, so that only a single trimmer is required to attend to all except the very largest installations.

OSRAM-LAMPS

Westinghouse Silica Lamp.

ELECTRIC lighting always seems to be in a state of development. Sometimes its progress is slow, and over a period of, say, 12 months we can only point to improvements in the working details of the apparatus used, which, though leading to increased efficiency, mark no great turning point in its history. At other times progress seems to take place by leaps and bounds. One of



Figs. 1 and 2.—Diagrams of the Westinghouse Silica Lamp.

these occasions was doubtless when the flame arc lamp was introduced, and, it is claimed, that now the vapour lamp is receiving a wide application we have reached another.

The Westinghouse Cooper-Hewitt Co., who manufacture the Westinghouse silica lamp in this country, claim that it provides an ideal light for railway depots, docks and wharves, streets and public places, factory yards, as well as for the interior lighting of markets, sheds, machine shops, foundries and steel works. This lamp has the

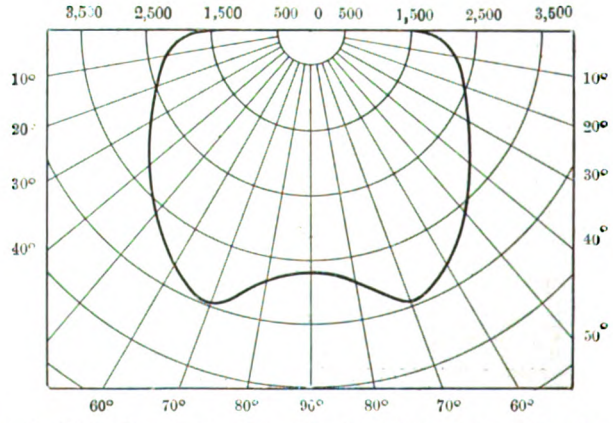


Fig. 3.—Light Distribution Curve for the Westinghouse Silica Lamp.

further advantages that it requires neither re-carboning or cleaning, so that its maintenance is very low, while, unlike many vapour lamps, the light given out is of an agreeable bluish-white colour which allows globes of clear and very slightly opal glass to be used. In this way a maximum of the light produced is available for useful purposes.

The Westinghouse silica lamp may be divided into two parts—(1) the base, on which, and totally enclosed, is the mechanism; (2) the vapour tube, mounted underneath the base and enclosed by an opal or clear globe. In the 3,000

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c.p. lamp the luminous portion of this tube is about 4 in. long. The tube is held in a tilting cradle, and is operated by a link projecting through the base. The upper end of this operating link is connected to the magnet of a large solenoid mounted on the upper side of the base and is coupled to a dashpot arrangement. A general diagram of the arrangement is shown in Fig. 1, while photographs are reproduced showing the actual appearance.

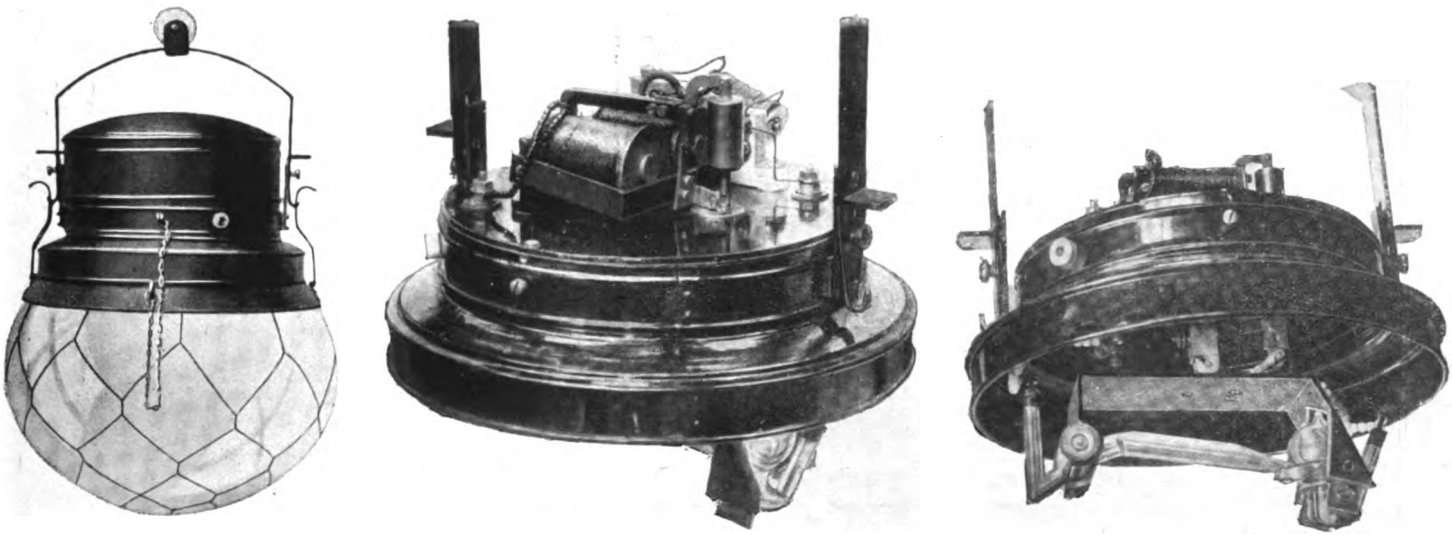
The tilting operation necessary to produce the mercury arc is automatic, and is performed by the large solenoid fixed in the centre of the base, working in conjunction with an automatic cut-out arrangement, in which is embodied the smaller coil B. In the diagram the tilting solenoid is represented by A and the cut-out coil by B. On switching on, the current flows through the cut-out contacts C, and through the coils of B, to the negative main. The energising of the coils at A causes the magnet to lift, thus tilting the cradle and lamp-tube. The tilting of the quartz tube causes the mercury contained at the right-hand end to flow down towards the other end, completing the tube circuit. The coil B is in series with the tube, and now comes into operation, breaking the solenoid circuit at C. This de-energises the solenoid A. The magnet then falls away into a slanting position, the balance-weights fixed to the cradle being large enough to ensure this. The tube remains in this position while burning and when switched off, and is tilted automatically once only at starting. The source of light consists of vaporised mercury, a continual cycle of vaporisation and condensation proceeding while the lamp is burning. The resulting light is of a bluish-white character, the temperature of the quartz tube being such that it glows and provides rays, which, to some extent, correct the pronounced colour of the ordinary mercury-vapour light.

As it is essential that the correct polarity should be observed, in order to prevent damage to the tube, a simple automatic device is introduced into the mechanism to ensure this. This consists of a small permanent magnet suspended from the arm which carries the dashpot cylinder. If the polarity is correct, the lower end of this permanent magnet is repelled from the locking-piece on the magnet arm below, and the lamp is tilted. If, on the other hand, the polarity is incorrect, the permanent magnet is attracted to and fouls the locking-piece, and the lamp-cradle cannot be drawn up. The lamps are fitted with clear or opal globes, and in outward appearance do not differ greatly from arc lamps. All the mechanism is entirely enclosed and protected from dust. The globes are provided with chains, and for inspection purposes can be lowered away from the base to the length of these chains.

The quartz tubes, which form the most expensive part of the lamp, are guaranteed by the makers for 1,000 hours. The average life is, however, much higher, and 3,000 hours is commonly experienced. Tubes that have given out through loss of vacuum can be repaired. The lamps have the low consumption of 0·25 watt per candle-power. They are intended for direct-current circuits for working in parallel. The light is steady, and as all the parts are above the source of light, which is of comparatively large area, no shadows are thrown on the globe and the diffusion is good.

The light-distribution curve for a lamp taking 3·5 amperes at 250 volts is given in Fig. 3, and shows a mean hemispherical candle-power of over 3,000, with a maximum illumination of 4,500 c.p. at 65 deg. to 70 deg. to the horizontal. The running costs of a 1,200 c.p. Westinghouse silica lamp, taking 4 amperes at 100 volts, work out, it is claimed at 1·1d. per hour, when energy costs 3d. per unit. This sum includes an allowance for replacement of tubes. This is calculated on a 2,000-hour life for the tubes. If the life is cut down in the calculation to the 1,000 hours for which the tubes are guaranteed, the cost per hour is 1·54d. These figures compare with 2·565d. for the flame arc, and 2·88d. for the enclosed arc, using ordinary carbons of similar candle-power on line voltages of 65 and 110 respectively. In the case of the Westinghouse silica lamp the figure of 1·20d. is given as the cost for current, and 0·17d. as the allowance for the replacement of the tube on the 2,000-hour basis. The comparative figures for the flame arc are given as 0·975d. for current, with 0·29d. for cost of carbons, in addition to which 1·2d. is included as the cost of maintenance, cleaning, labour, &c. In the case of the enclosed arc the cost of current is placed at 2·64d., of the carbons at 0·04d., and of maintenance, cleaning, &c., per hour at 0·2d.

Owing to the high efficiency, combined with the long life of the burners, together with the fact that the lamps require no attention during running, the total running cost per hour works out considerably less than that of ordinary or flame arc lighting. Further, no hoisting winches or contact suspension gear need be provided. This type of lamp is, it is claimed, unique in so far that a single lamp can be provided for use on a 200-250 volt circuit.



Figs. 4, 5 and 6.—Exterior and Interior Views of Westinghouse Silica Lamp.

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FLAME ARC LAM

Westinghouse

No Carbons.

No Winches.

No Suspension Gear.

Diameter o
Bottom of globe t

EFFICIENCY

0·25 watt per C.P.

Enquire for List No. 0012 and full particulars from

WESTINGHOUSE COOPER HEWITT Co.,

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IPS SUPERSEDED

Y

Silica Lamps.

globe 14 in.
top of casing 19in.

No Trimming.

No Cleaning.

No Flickering.

CONNECTION IN PARALLEL

on 110 v. or 250 v.

Ltd., 151-2, Gt. Saffron Hill, London, E.C.

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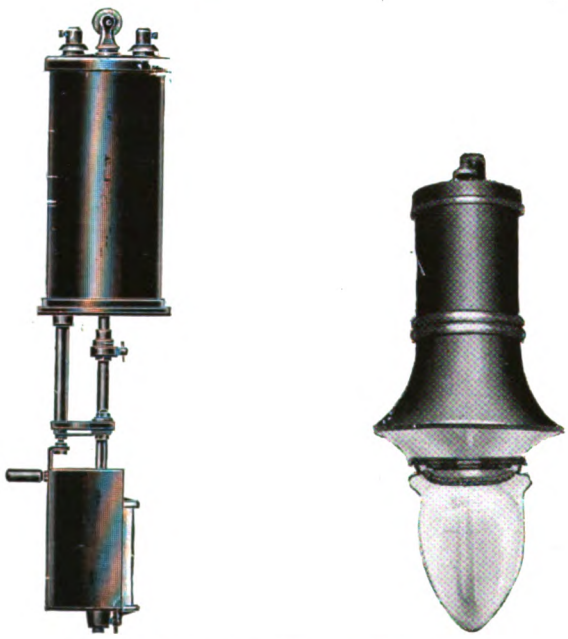
Foster Arc Lamps.

THE Foster Arc Lamp & Engineering Co. have been good enough to supply us with details of a number of places where their lamps are in use. The lamps made by them include a "hot-wire" lamp, operating on the well-known principle of the expansion and contraction of a hot wire, and a flame lamp of the most modern kind. They are also in process of amalgamation with the Brockie-Pell Arc Lamp Co. with the result that this firm's lamps will also come under their control.

Turning to the installations themselves, we may first mention that of Mr. R. W. Oates, a draper, in Regent-street, round the lighting of which district much controversy has raged. Mr. Oates is doubtless one of those shopkeepers who protested against the adoption of gas for the street lighting and he has evidently had experience with electric light, for our contemporary, the "Drapers' Record," stated that these premises were the best lighted in Regent-street last Christmas. He is using the standard enclosed lamp of the Brockie-Pell Arc Lamp Co.,



Figs. 1 and 2.—Two Types of Foster Lamp.

the lamps being adjusted to burn two in series on a 240-volt continuous-current circuit, the consumption being 6 amperes and the hours of burning 75.

Mr. Wickham, a draper, of Tunbridge Wells, is also in favour of this type of lamp. He is employing two standard enclosed B.P. lamps in series on a 200-volt alternating-current circuit. In his new extension he is burning the above lamps in series parallel off a two-way compensator.

The lighting at Messrs. Guest, Keene & Nettlefold, Dowlais Works, Cardiff, also deserves mention. It is effected by means of the B.P. open-type lanterns, double-carbon style, 38-hour type, fitted with substitutional resistance and cut-out, the current per lamp being 10 amperes, with a voltage of 43 across the arc. Messrs. Foster have also received repeat orders for their standard enclosed lamp for use on the Royal yacht "Alexandra."

Messrs. J. Lyons & Co. (Ltd.), the caterers, are extensive users of the Foster lamp at their headquarters, Cadby Hall, and a large number of their branches, the "A" style enclosed lamp and the F.C. flame lamps are fitted, the former in single parallel on a 110-volt alternating-current circuit, the frequency being 50 and the current per lamp being 8 amperes, the hours of burning about 50. The F.C. flame lamp is running on a 110-volt circuit, two in series parallel on a two-way transformer. Each lamp takes 10 amperes, with 45 volts across the arc.

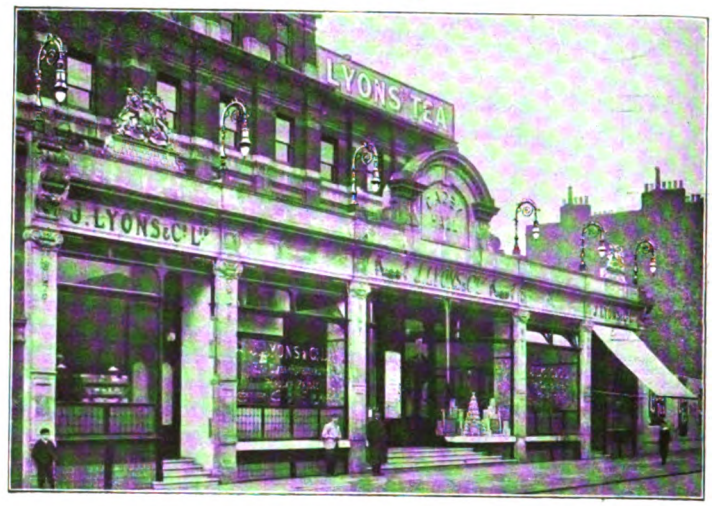


Fig. 3.—Foster Lamps at Cadby Hall.

American Photo Co. (Ltd.) use in their studios the S.P.A. lamp, and also an inverted photo lamp. The latter lamp is similiar to that shown in Fig. 1, and is simply the usual photo process lamp with a few slight alterations to allow of it being burnt upside down, *i.e.*, the carbons burning uppermost. Both these types are used for exposures.

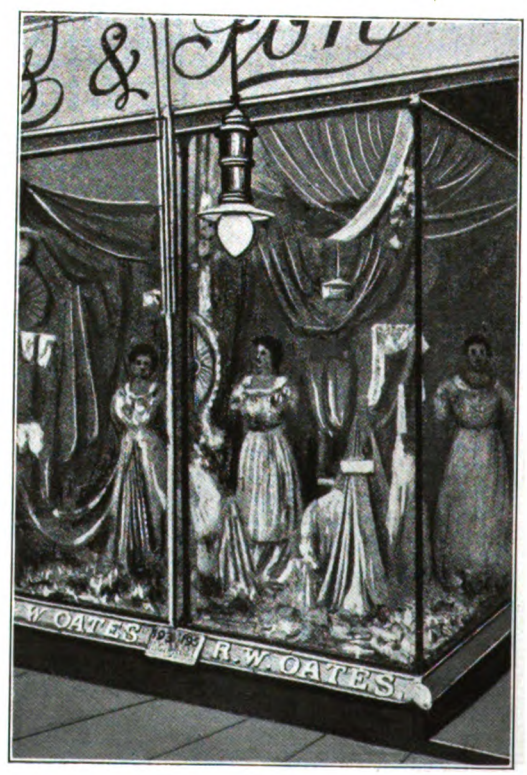


Fig. 4.—Foster Lamps for Shop Lighting in Regent Street.

The Borough of Wimbledon public street lighting is carried out by means of Messrs. Foster's well-known G.A. flame lamps. Anyone who visits Wimbledon or Raynes Park district after dark must be struck with the very brilliant lighting of that part of the world.

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EXCELLO
FLAME ARC WITH UNIQUE
TWO YEARS' WARRANTY

The Post Office, War Office and Admiralty are, we are informed, all warm supporters of the Foster "A" style hot-wire lamp. This is shown in one of the accompanying illustrations. Foster's "A" style lamp burns at 6 amperes on either alternating or direct current, singly on 100 volts, or two in series on 200-220 volts, the hours of burning being from 50 to 60.

Jandus Regenerative Flame Arcs.

AMONG the recent places where the Jandus Arc Lamp & Electric Co. have introduced their well-known regenerative flame arc lamps we may mention the town of Grimsby, where 80 lamps of this kind, adjusted to burn four in series on a 230-volt direct-current circuit, have just been erected. In connection with this installation a special panel arrangement for fixing on the arc lamp column and containing line resistances, substitutional resistances, cutouts, line switches and fuses has also been supplied. These lamps have a current consumption of 8 amperes and a life per trim of 65 hours, the carbon cost per hour being only 0·116d. Fig. 2 shows some of these lamps in position at Grimsby.

The same company have also completed the lighting at the Middle Docks in the same town, 10 of the regenerative lamps being arranged for burning five in series on 500 to 550 direct-current circuit. These lamps have a consumption of 6·5 amperes and are fitted with cutouts and substitutional resistances. They have a life per trim of 75 hours with a carbon cost per hour of 0·116d.

A unique lighting scheme at Margate, which has been carried out in connection with the new Glass Concert Pavilion at Westgate, may also be mentioned. In this case five regenerative lamps have been installed to burn five in series on 240-volt direct-current circuit, with a consumption of 5 amperes. The lamps, of course, are fitted with cutouts and substitutional resistances, and have a life per trim of 80 hours, the carbon cost per hour being 0·095d. At Halifax the Jandus Co. have installed 30 lamps with a current consumption of 8 amperes. These are arranged to burn five and four in series on a 230-volt direct-current circuit and have a life per trim of 65 hours, the carbon cost per hour being 0·116d. For the lighting of the Mercantile Dry Docks, Jarrow, they have just supplied 30 regenerative lamps adjusted to burn singly off internal choker on a 110-volt alternating-current supply, the frequency being 40. These lamps consume 7·3 amperes and have a life per trim of 65 hours and a carbon cost of 0·116d.

Further, at the foundry of Sir B. Samuelson, Middlesbrough, 21 lamps burning singly off a transformer on an alternating-current supply of 440 volts, with a frequency of 40, have been supplied. These lamps have an adjustment of 8 amperes and a life per trim of 65 hours with a carbon cost per hour of 0·116d. Quite a number of lamps for street lighting have been supplied to Bradford Corporation.

Fig. 1.—Photo. of Jandus Lamps, showing the Excellent Horizontal Distribution.

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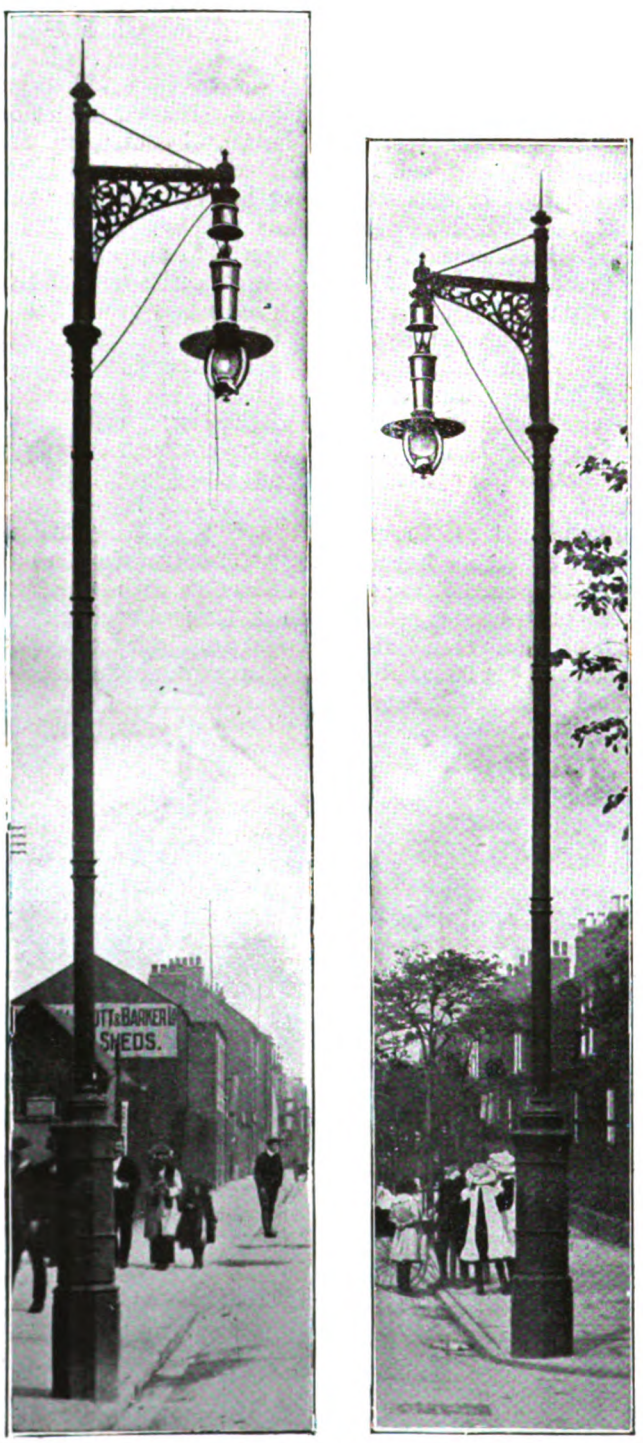
These are adjusted to burn two in series on a 230-volt direct-current circuit with an adjustment of 5 amperes. They have a life per trim of 75 hours and a carbon cost per hour of 0·1d.

Fig. 1 shows the excellent horizontal distribution obtained with a Jandus 8-ampere lamp. This photograph was taken between 12:30 and 1 o'clock in the morning and no other lamps but the two arc lamps shown in the photo-



Jandus Lamp for Street Lighting at Grimsby.

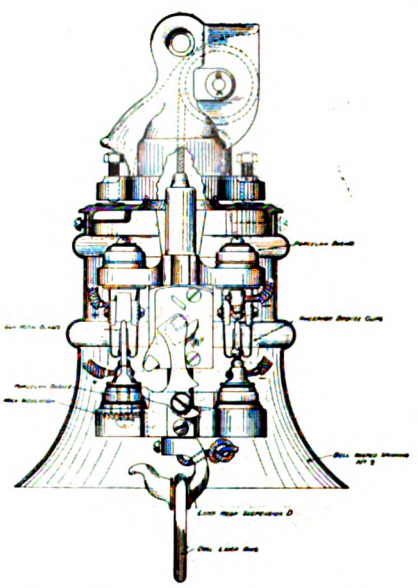
graph were alight. Mention may also be made of the bandstand lighting in Lister Park, Bradford. This has just been executed by the Corporation Electricity department, and the cost of the installation has been defrayed by the Lister Park committee. The lighting is effected by four new Jandus regenerative flame arc lamps of 3,000 c.p. each—12,000 in all. They work in series on 230 volts and consume 5 amperes.

Arc Lamp Lowering Gear.

THE North Western Electrical Appliance Co., of Cathcart, Glasgow, who have made a speciality of lowering gear, have introduced during the year several improved types of gears, to meet different requirements, necessitated by the advent of flame lamps and the general advancement in arc lighting.

The increased necessity of greater efficiency and reduced maintenance economies has necessitated to a large extent the adoption of raising and lowering gear. During the past year the demand has, we understand, exceeded all previous records.

This firm have new types for two, three and four connections and also for two and three contacts with switch clip spring contacts for short-circuiting lamps or connecting the lamp through its substitutional resistance while down



Section of North Western Co.'s Arc Lamp Contact Gear.

for cleaning or repairs. Such an arrangement has considerable advantages beyond keeping the series lamps burning, in that faults can readily be detected by simply lowering the lamp slightly till the faulty lamp is located.

The North Western Co. have also introduced new types for high-tension work and central carrier lowering heads, both of the swing out type and the span rod type. They have gears for span wire and all classes of private and public installations, and are suitable for practically any make of lamp or fixings.

Their self-sustaining positive-acting safety winch is an ideal type for arc lighting, as the lamp can be readily got up and down quickly without damaging the globes in high winds. The direct action also gives a sensitive feel and thus prevents over-straining of the rope which is liable with geared winches where only a fraction of the weight is felt. The winch, although direct-acting, has an automatic smooth continuous secure clutch which will maintain without jar any weight required for arc lamps. They are tested up to 200 lb. The weight of the lamp is not on the hanger when lowered but is so in raising, which gives a sensitive feel.

This firm has adopted throughout hard-drawn phosphor bronze clip-knife contacts. They maintain that by this design there is less liability of the lamp breaking contact in high winds, and a strong sliding spring cleaning contact is always assured. There is no movement at the pillar end of their gears and only a slight oscillation at the foot, which is operated by inclines and is direct, positive in its action and cannot get out of order.

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Long Burning Flame Arc Lamp.

THE long burning flame arc lamp just placed on the market by the Electrical Co. gives 80 to 100 burning hours with one pair of carbons. That means that if the lamp be used in a street during the winter months only one trim per week instead of per day would be required. Besides this the cost of the expensive flame carbons is reduced to an insignificant amount, because the new lamp is a carbon saver? It only consumes one pair, not a dozen or more pairs like a magazine lamp.

The small current consumption of modern flame arc lamps, and the tendency of the price of current to fall has had the unfortunate effect of making those electricity supply companies who have to deal with street lighting, actual buyers and sellers of carbons and labour, for use with their arc lamps. The new lamp reduces the cost of these maintenance charges to about one-third, and enables the most economical relations between cost of current and upkeep to be obtained.

Fig. 1.—External View of Electrical Co.'s Flame Lamp.

The principle adopted in this lamp to secure long-burning periods is the total enclosure of the arc. The difficulty, however, that has to be overcome, is satisfactorily to dispose of the fumes resulting from the arc, which, owing to enclosure of the latter, cannot be disposed of by ordinary methods of ventilation. This is effected by an entirely novel arrangement of the globe and burning chamber. The globe is divided into two parts. The upper portion is clear, to allow of the light being distributed. The lower portion is opaque, as clear glass would serve no useful purpose. The appearance is also better. Naturally this lower portion is cooler than the upper, which is heated by the arc. Consequently all the heavy ash sinks to the bottom.

Above the arc itself a deposit chamber is arranged which, owing to its large radiation surface, causes all the lighter gases to condense inside it. A constant circulation is thus set up, and the ash or deposit is so completely got rid of, that the loss of light through the clear portion after 100 hours of burning is insignificant.

The mechanism in the direct-current lamp is of the differential pattern, while in the alternating current it is of the motor type. The latter is strengthened to give a rapid ignition. Both types are, it is claimed, the most perfect that can be produced.

The arc voltage is about 45, so that two lamps can be burnt on 110 volts, four on 220 volts, and five on 250 volts. It is recommended that a series of over two lamps should be fitted with automatic safety devices.

The curve in Fig. 2 shows how the light is distributed. The maximum is at an angle of 20 deg. under the horizontal, so that the lamps need not be hung so high as an ordinary flame arc with converging carbons. Thus the cost of poles and installation is reduced. The power-factor of the alternating-current lamp is 0·86, and the mean hemispherical candle-power in Hefner candles is 800 for the 8-ampere lamp, and 1,500 for the 12-ampere lamp. The practical specific energy consumption being of the order of 0·33 to 0·36 watts per candle-power.

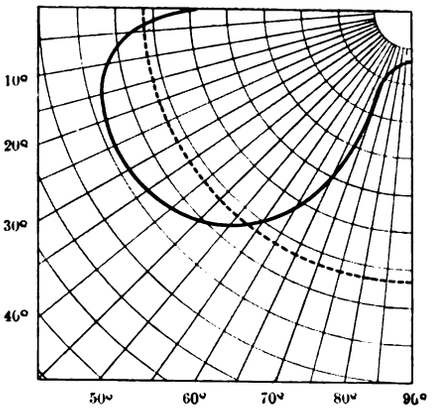

Fig. 2.—Distribution Curve from Electrical Co.'s Flame Lamp.

The lamp is intended for the illumination of open spaces of all sorts. First and foremost comes street lighting, where it will be specially useful to compete successfully against gas. Then, naturally, it will be used for railway yards, sidings, &c., factories, machine shops, shipbuilding yards and such places.

The "Butt" Arc Lamp.

A GLANCE through the articles which appear on other pages of this issue will clearly show that the mechanism of the flame arc lamp is going through a period of transition. Many "fakements" have been introduced with a view to simplifying the working of the lamp, and, though these are often of a different nature, they all tend towards the same end.

One of the most interesting of these developments is elimination of clockwork mechanism. This is exemplified in the "Butt" lamp recently placed on the market by the General Electric Co. This lamp is, it is claimed, entirely devoid of complicated mechanism, and is self-regulated, though without regulating coils. It has one vertical carbon, while the other is slightly inclined to the vertical, the pair converging to the points where the arc is struck.

Fig. 1 shows a diagram of the mechanism at the base of the lamp. The inclined carbon is swung from striking and regulating by means of a sliding collar, *a*, on the base plate *b*. This collar is pivoted at *c*, and is swung by the rod *e*, which is attached to the plunger of the series solenoid. The holders of the two carbons are mechanically linked together, and feed down as the carbons are consumed. The tip of the perpendicular carbon rests on a swinging support, *f*, which is pivoted at *h*. Between the upper arm of the support and

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the carbon is a pin, and this allows the carbon to feed slightly, so that the tip again rests on the support. By supporting the carbon chiefly from the side in this manner the breakage of the point is avoided. The support is very massive, and thus the heat is conducted away quickly from the end, while the arc being some way from it, it does not require frequent renewal. The fireclay economiser is supported from the base plate by a metal ring. On the left of this plate is an electromagnet, which provides the necessary weak field to steady and expand the arc.

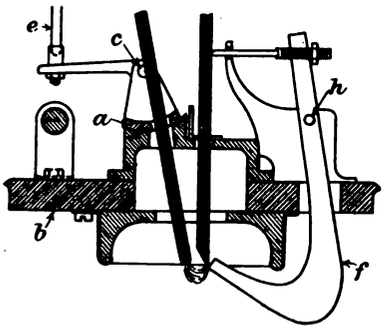

Fig. 1.—Diagram of Mechanism in Base Plate of "Butt" Lamp.

The "Butt" lamp is recommended for burning singly on 65 volts, two in series on 110 volts or four in series on 220 volts. Ordinary round-cored carbons are used, thus overcoming the great disadvantage of employing special ribbed carbons. The maintenance costs are said to be small, while there is one pattern of lamp made which is so designed and constructed as to give equally good results irrespective of the nature of the supply and current intensity. The lamp is but little affected by voltage variations, and instruments for equalising any fluctuations are quite unnecessary.

Gilbert Arc Lamps.

A VERY complete catalogue dealing with all the different variations of arc lamps made by the Gilbert Arc Lamp Co., of Chingford, has just reached us. These lamps are now in use for street lighting in over 100 towns in Great Britain, while they are also extensively employed for the illumination of goods yards, shops, skating rinks and docks.

As regards the flame arc lamps made by the company, we may first mention the "Flamme" type, which is of the four-carbon converging pattern, and can be used on either continuous or alternating-current circuits. This lamp is designed after the pattern of the "Gerrard" lamp of 20 years ago, and the mechanism is exceedingly simple. Two negative and two positive carbons are used, all converging towards one another. The carbons are simply pushed up four tubes into their holders, without removing the cover. The two negatives and two positives are then treated as one carbon, and the positives are separated from the negatives by suitable mechanism to strike and control the arc. As the carbons burn away they fall together, the converging points remaining in the same position, so that no feed mechanism is required, and when the carbons are burnt out the arc extinguishes itself.

Another type of flame lamp made by the Gilbert Company, and specially designed for use where very uniform burning is essential, is the "Beacon." It is quite free from clockwork. The feeding mechanism is, it is claimed, very sensitive, and the lamp is put into action by means of a starting resistance and switch.

Besides these lamps, mention may also be made of the standard rod feed enclosed lamps manufactured by the Gilbert Company. The various details of these are, of course, well known to our readers. Other lamps turned out by them are the photo-printing lamp, the "Trudaylyte" lamp for colour matching, and miniature lamps of various kinds.

The Development of "Excello" Lamps.

DIRECTLY the flame arc lamp was introduced its great suitability for the illumination of streets, railway stations, goods yards and other large areas was recognised, and though satisfactory from the very first it is not surprising to find that improvements have constantly been made in the details of construction, in accordance with the dictates of practical experience.

The development of this progress is of interest and we may point the remarks we have to make on the subject by giving some details, kindly supplied us by the Union Electric Co., of the improvements effected in their well-known "Excello" flame arc lamps. Among the first and greatest disadvantages of the flame arc lamp was the way in which the fumes from the carbons deposited on the globes of the lamps, with the result that extra trimming costs became necessary, while it was found that the loss of light during a 17-hour run was not less than 30 per cent. Further, the deposit adhered to the globe and effected an etching action so that the loss in light gradually increased, often reaching so high a figure as 40 per cent.

In the "Excello" lamps these difficulties were overcome by re-arranging the globes and by providing a new ash-

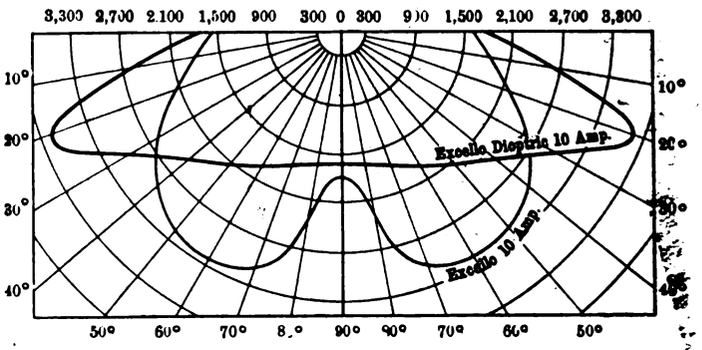

Fig. 1.—Horizontal Distribution from an "Excello" Lamp with and without Dioptric Globe.

tray. In the old lamp the air entered through the ash tray, and not only gradually circulated along the sides of the globe, but also rose direct to the arc. It here became charged with the fumes and deposit given off from the arc, and, as the arc was partially enclosed by the economiser, was deflected sideways towards the cooler parts where it met with air cooled by contact with the globe surface. Under these conditions the circulation was not continuously upwards, and the cooled air tended to pass over the inner surface of the globe, leaving in its path some of the fumes and deposit with which it was charged. These rapidly attacked and coated the inner surface of the globe rendering it more or less opaque.

In the new design of deposit-free cover an inner and outer globe are provided; these are connected together at the top by a diaphragm, thus forming an enclosed air space between the two globes. The air enters through the ash tray, is slightly heated in the space between the two globes, and rising through the inner globe to the arc, is charged with the fumes and deposit from same, and then deflected sideways towards the inner surface of the inner globe. If these surfaces were as cool as the outer globe the same course of circulation would be followed as previously mentioned, and deposit would be formed on the inner globe,

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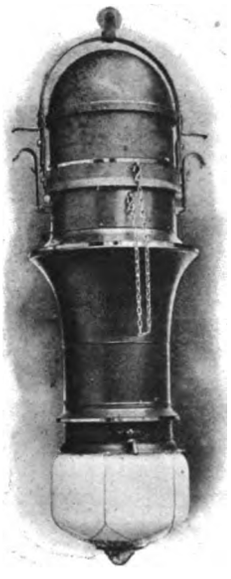
UNIVERSITY OF CALIFORNIA

"SUNSHINE"

FLAME ARC LAMPS.

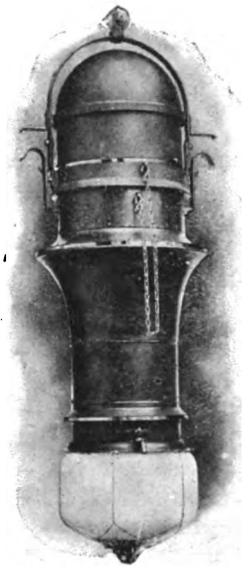


They are Flame Lamps with a character.

The character is supported by many years' reputation.

It is the result of years of experience and of scrupulous attention to essential details.

If you have not adopted them, follow the leading Electrical Houses and do so at once.



Do not forget:

(1) There is no other lamp so perfect in every detail.

(2) The "Sunshine" Mechanism is differentially controlled by both pressure and current. No flickering like non-mechanism lamps.

(3) The "Sunshine" finish is as handsome as the design and workmanship. It is the lamp for the man of good taste. It costs nothing extra to have a handsome lamp.

(4) Trimmers like "Sunshines" because they are easy to clean, easy to trim, and are thoroughly reliable.

THE ELECTRICAL CO., Ltd.,

MACHINE AND APPARATUS DEPT.,

122/124, CHARING CROSS ROAD, LONDON, W.C.

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but, owing to the proximity of the inner globe to the arc the temperature is much higher, and this temperature is easily maintained due to the stagnant air between the inner and the outer globe forming the best heat insulator. The effect, therefore, is that the course of the air through the lamp is practically continuously upwards, and both globes remain free from deposit or etching action. The patent ash tray is designed to act as a wind trap, deflecting any air which impinges on it upwards into the globe and distributing under a disc inside the globe. The relative

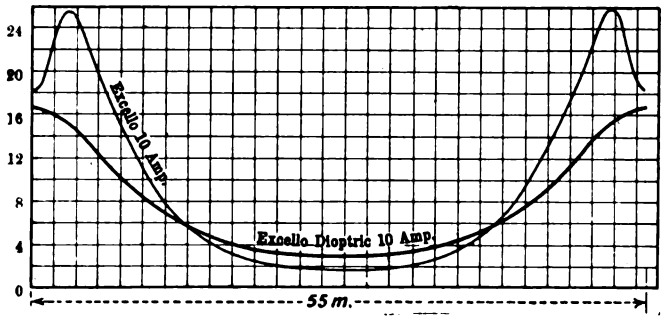

Fig. 2.—Surface Distribution from "Excello" Lamps with and without Dioptric Globes.

proportion of the deflecting surfaces in the ash tray are so arranged that the air pressure in the desired direction inside the lamp is greater than the opposing pressure produced by the same air current acting through the aperture at the top of the globe carrier. This ensures, it is claimed, a constant air circulation in the desired direction even in violent storms, and practice has shown that this arrangement of the globes and ash tray ensures clear glass globes under any conditions of wind and weather.

The arrangement of globes mentioned above enabled a further step in the improvement of the lamp to be taken.

Fig. 3.—"Excello" Lamps for Shop Lighting.

It is well known that the distribution of light from inclined carbons is not very satisfactory for the illumination of large areas, as the maximum light is emitted at 60 deg. below the horizontal plane, giving rise to an unequal surface illumination. This disadvantage has been overcome by the provision of dioptric prisms arranged on the outer side of the inner globe. The alteration in distribution obtained with a 10 ampere "Excello" lamp with the new arrangement is shown in Figs. 1 and 2.

The Union Electric Co. guarantee all Excello, Kohinoor and other arc lamps sold by them to be free from all infringement of patents, and undertake to defend all claims or actions for infringement of British patents in respect of their sale or use. They also guarantee that expert skill has been used in the selection of the materials and in the construction and testing of their arc lamps; and will, subject to conditions as to proper maintenance, make good, free of cost to the user, any defects which may occur during a period of two years from the original date of despatch of any arc lamp, and which are due to any faulty materials or workmanship. This guarantee includes the replacement or repair of the defective parts, but does not admit liability for any indirect, consequential or contingent losses or damages.

Drake & Gorham's Arc Lamps.

THE profession and trade of electrical engineering is now getting on in years, and one may, therefore, now look back to 15 years ago and yet find a time when the ideas of to-day were still in existence, present day development being foreshadowed in the work of that time. In the present issue of the INDUSTRIAL SUPPLEMENT we are dealing more particularly with arc lamps. The development of this type of illuminant during the past 15 years has been great, and this satisfactory state of things has, we think our readers will agree, been due in no little part to the efforts of Messrs. Drake & Gorham. This firm has, in fact, been closely associated with arc lamps over the period mentioned, and from their present range of lamps it is evident that they intend to remain in the front rank of this section of the business. They claim to have attained the ideal—low price and running costs combined with simple yet substantial construction—in both their flame and enclosed types of lamps. These lamps are free from clockwork, and, what is even more important, shunt coils—the weak part of most arc lamps. Large numbers of lamps are in use throughout the United Kingdom working under a variety of conditions in a satisfactory manner, as the various repeat orders testify.

Messrs. Drake & Gorham's latest venture is the "Butt" lamp, which is being made under the "Conta" patent. The external and interior views of this lamp are shown in the accompanying illustrations. This lamp, it will be remembered, is devoid of complicated mechanism and clockwork parts, and is self-regulated though without regulation coils. It has one vertical and one converging carbon. The "Butt" lamp is recommended for burning singly on 65 volts, two in series on 110 volts or four in series on 220 volts. Ordinary round-cored carbons are used, thus overcoming the great disadvantage of employing special ribbed carbons. The maintenance costs are said to be small, while there is one

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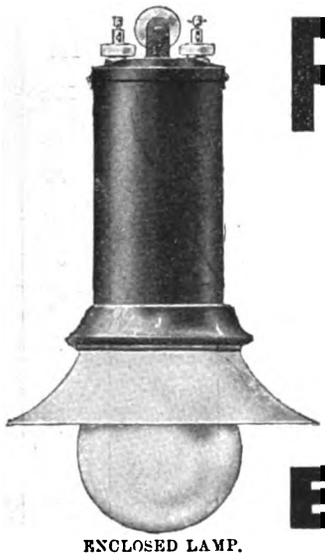
ARC LIGHTING.



ENCLOSED LAMP.

FLAME LAMPS.

No Shunts. No Clockwork.

Low Maintenance Charges.

Factory, Shop, Dock Lighting, &c.

ENCLOSED LAMPS

BUTT FLAME LAMP
(Conta Patents).

TELEGRAMS:
"ACCUMULATOR,"
LONDON,
MANCHESTER, or
GLASGOW.

DRAKE & GORHAM, LTD,
66, Victoria St., London, S.W.
47, Spring Gardens, Manchester.
50, Wellington St., Glasgow.

TELEPHONE:
893 Westminster.
P.O. 1218 Victoria.
3700 City, Manchester.
3858 Corporation and
2198 Argyle, Glasgow

pattern of lamp made which is so designed and constructed as to give equally good results irrespective of the nature of the supply and current intensity. The lamp is but little affected by voltage variations, and instruments for equalising any fluctuations are quite unnecessary.

Butt Flame Lamp (Conta Patents).

An important feature of the "Butt" lamp is its simplicity and solidity of construction. The rods are strongly dimensioned, brass nickel-plated and highly polished in order to limit the friction of carbon guides for the feed. The clutched carbon is in a vertical position in the centre of lamp, whilst the striking (inclined) carbon is under the influence of a magnet by which it can be moved laterally in order to strike and to form the arc. As the carbons are always in the same position, and do not move horizontally after the arc is struck, the arc chamber is very effectively sealed against the rod chamber, and the guide rods are, therefore, kept free from deposit. The clutched carbon which controls the feed touches the incombustible lower arm of the clutch lever in the economiser. This lever is pivoted, and presses with its small upper arm above the lamp plate against the carbon. As long as the slightest weight bears on the incombustible arm the lever grips the carbon sideways, thus relieving the fine carbon point. By progressive consumption the carbon becomes shorter, the pressure of the point on the lower lever arm decreases, and through that also the side pressure of the upper lever arm against the carbon becomes less and less, until finally the weight of the carbon overcomes the break action, so that it can slide.

The fact that the point of carbon is relieved eliminates, it is claimed, the danger of it being broken. It forms into a longer and longer point, thus raising the arc away from the lower lever arm, so that the latter cannot be burnt. The current is interrupted by the automatic discharge of the clutched carbon when consumed down to a small stump. All lamps are fitted with conical-shaped inside globe, the use of which prevents, it is claimed, the outside globe from becoming dirty, and thus effects a considerable saving in time and labour by dispensing with the necessity of cleaning.

This lamp is made in two types, the "long-hour" and "short-hour," both of which are suitable for burning on either continuous or alternating current.

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"THE ELECTRICIAN" TABLES OF

No.	Supply Authority.	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit. H.P.	Max. demand Kw.	H.T. motor (if any).
1	**Aberdeen Corporation**	J. Alex. Bell	Granite quarries, eng. works, shipyards, ice factories, fish-curing and preserving wks., paper wks., woollen and jute wks.	400	220, 440 three-wire 230 2-wire	4,400 31/7/10	778	104	745 at 11.0 a.m.	...
2	**Acton Council**	J. Martin Blair	Laundries, motor works, dyeing and cleaning, printing	...	230, 460 three-wire	639 30/7/10	77	170	174	...
3	**Aston Manor Corporation**	R. Foster	General	400 3-phse. 50 ∿	460 three-wire	5,120 31/7/10	280	500	2,300 *	550 H.P.
4	**Ayr Burgh Council**	Roland Marshall	Principally residental, building trades, laundries, small eng.-works, shipyard, carpet works, boot factory	100, 200 Single phase	250 500	472 31/8/10	129	30	...	...
5	**Barnes Urban District Council**	C. S. Davidson	Gas mantle works, sawmills, brewery, golf-club making, laundries, printers	..	210, 420 three-wire	458 31/8/10	55	20	535	...
6	**Barnsley Corporation**	E. A. Barker	Foundries, laundries, builders and joiners, linen manufacturers, paper mill, &c.	...	230 460	1,698 31/8/10	120	30	822	...
7	**Barrow-in-Furness Corporation**	H. R. Burnett	Shipbuilding, iron, steel and engineering works	...	220, 440	840 30/6/10	172	25	925	...
8	**Bath Corporation**	Francis Teague	Engineering, cabinet-making, clothing and corset factories	110 single-phase	220, 440 three-wire	606 31/7/10	173	72	454	..
9	**Battersea Borough Council**	F. A. Bond	Soap and candle works, engineering works, millers, railway goods yards, stone yards	...	230*, 460†	2,571 19/7/10	..	50	500 lay load *	...
10	**Belfast Corporation**	T. W. Bloxam	Shipbuilding, spinning and weaving, ropeworks, handkerchief making.	...	220, 440 three-wire	5,875 31/5/10	714	70	...	...
11	**Birkenhead Corporation**	W. Wyld	Shipbuilding and ship repairs, laundries, leather works and foundry	...	230, 460 three-wire	866 31/7/10	152	120	649*	...
12	**Birmingham Corporation**	R. A. Chattock	Metal, cycle and jewellery trades	5,000	220, 440 three-wire	21,077 31/6/10	2,549	350	10,060 l. & p. 5,200 tr.	5-726 H.P.
13	**Blackburn Corporation**	P. P. Wheelwright	Cotton manufacture and general industries	220	220 440	2,712 31/8/10	629	120	...	...
14	**Blackpool Corporation**	C. Furness	Joinery works, bakeries, bottling stores, laundries, cinematogrphs & entertainmts	200	500	1,200 31/8/10	171	80	...	...
15	**Bolton Corporation**	Arthur A. Day	Cotton spinning and engineering works	100, 200* 400†	230, 460	9,654 31/7/10	927	150	6,441	...
16	**Bootle Corporation**	T. Dawson Clothier	Timber, engineering, dyeing, pumping, tin smelting & general	...	220, 440 three-wire	2,267 31/8/10	...	60	1,260	...
17	**Bournemouth & Poole Electricity Supply Co.**	E. Ll. Ingram	Boarding-houses and hotels	100,200,400 three-wire	250, 500 three-wire	527 6/6/10	203	25	...	...
18	**Bradford Corporation**	Thomas Roles	Textile works, dye works, mechanical and electrical engineering, miscellaneous.	230, 400 50∽	230 460	*9,646 8,6/10	*1,797	110	2,491	*
19	**Brighton Corporation**	J. Christie	Engineering works, breweries, sawmills, laundries, foundry, &c.	...	230, 460	2,492 13,8/10	464	100	..	...
20	**Bristol Corporation**	H. Faraday Proctor	Tobacco, cocoa, printing, leather, confectionery, cloth and brewing	105 & 210 93∽ S.P.; & 360 50∽ 3-phase	250 500	11,158 20/7/10	1,250	120	2,529	None
21	**Burnley Corporation**	Jas. E. Starkie	Cotton weaving, foundries, &c.	...	220, 440	7103 31/3/10	241	30	529	None
22	**Burton-on-Trent Corporation**	P. J. Pringle	Breweries, timber mills, engineering works	200, 100	500 (tramways only)	940·7 21/5/10	151	45	500*	...
23	**Bury Corporation**	S. J. Watson	Textile, engineering, paper, &c.	...	220, 440	2,642 31/8/10	306	80	...	...
24	**Carn Brea, R.S.O. (Urban Electric Supply Co.)**	L. A. Hards	Mining and foundries	10,000, 440	240, 480 three-wire	1,943 31/8/10	141	30	924	None
25	**Canterbury Corporation**	C. A. Blascheck	Brewing and various	...	220, 440	395 6/6/10	96	50	411	...
26	**Cardiff Corporation**	Arthur Ellis	Ship-repairing yards, engineering works, foundries, laundries, printers, brewers, millers, cold storage, &c.	200 400	200, 400 three-wire	3,418 30/6/10	514	110	...	None
27	**Carlisle U.D.C.**	S. T. Allen	Cotton factories, tinplate printers, engineering works and railway shops (companies)	...	L. & P. 230 440, 3-wire, traction 550	785 31/7/10	259	57	L. & P. 555 traction 230	...
28	**Charing Cross, West End & City Electricity Co.**	H. W. Kingston J.M. Gatti (*Mn. D.*)	Printing	10,000	100, 200, 400, 1,000	Ex. bulk sup. 14,913, 31/7/10	...	250	...	...
29	**Chester Corporation**	S. E. Britton	Engineering, flour mills and printing	...	210, 420 three-wire	860 31/8/10	177	30	1,400	...
30	**Chesterfield Corporation**	R. L. Acland	Printing, brewery, furniture-making, foundries	...	240, 480 three-wire	716 31/12/08	150	30	...	...
31	**Clyde Valley Electrical Power Co.**	D. A. Starr	Steel works, rolling mills, collieries, paper mills, brickworks, foundries, shipyards, &c.	11,000 trans. to 400 for low. p.	...	30,853 27/7/10	...	500	6,500	Several
32	**Colne Corporation**	A. G. Cooper	Weaving, spinning, loom making, foundries, fell-mongering and electric crane making	...	240, 480 three-wire	417 31/8/10	158	20	...	...
33	**Cork Electric Tramways & Lighting Co.**	H. H. Nalder	Breweries, butter factories, laundries, bacon curing, feather purifiers, printing, tanneries, milling, refrigerating, &c.	...	460	2,497 11/8/10	353	40	...	None
34	**County of Northampton Electric Power & Traction Co.**	W. J. S. Jones	Boot factories, engineering works and joineries	...	230, 460 three-wire	174	26	20	175	...
35	**Coventry Corporation**	George Tough	Cycle and motor cars, toolmaking, weaving, watchmaking	200 two-phase	...	5,944 31/8/10	620	100	3,754	...
36	**Darlington Corporation**	J. R. P. Lunn	Engineering, yarn spinning and school furniture	...	230, 460	1,757 30/11/09	199	125	867	
37	**Derby Corporation**	T. P. Wilmshurst	General engineering, foundries, motor cars, silk mills	200	460, 230 three-wire	2,720	430	230	1,100	...
38	**Derbyshire & Nottinghamshire Electric Power Co.**	A. E. Loos	Iron works, collieries, lace and hosiery works, engineering works, brickworks, &c.	440	500 550	2,759 31/8/10	...	200	708	...
39	**Dewsbury Corporation**	R. H. Campion	Woollen manufacturers, rag grinding, printing, laundries, clothing manufacturers, wool shaking, iron cutting	...	220 440	693 1/8/10	146	30	...	...
40	**Dublin Corporation**	M. Ruddle	Saw mills, factories, elevators in stores, &c.	200 S.P. 3-phse. 346	...	1,620 1/4/09	364	20	...	...

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ELECTRIC POWER SUPPLY.

No.	Method of Driving: Group. H.P.	Method of Driving: Indiv. H.P.	Rates: Per unit.	Rates: Bulk supply.	Approx. H.P. of other power displaced by electric motors.	Isolated Plants at present Operating. g=Gas. sg=Suction Gas. s=Steam.	Remarks. (NOTE.—Inst. E.E. Wiring Rules for Motors generally app'y in all districts.)
						H.P.	
1	...	...	2½d. to ⅞d. accord. to cons.	...	...	...	Two 100 H.P. motors for harbour sheerlegs shortly to be coupled.
2	...	...	1⅜d. flat 2½d.&1d.M.D.	Under consid'n	..	150*g*, 220*sg*, 200*s*	Includes three electric pumps at Council's sewage works, auto. plant.
3	...	...	1½d. to 6d. sliding scale	On application	...	...	* All purposes except traction.
4	200	100	2d. to 1½d. Load factor basis	...	400	150*g*, 50*sg*, 200*s*	.....
5	48	410	1½d. with dis. to 33⅓ p.c.	On application	*	55*g*, 500*s*†	* Most of our consumers are new to the dis- † Includes plant at sewage works [trict.
6	...	...	1½d.-1d. motors, 3½d. flat, lighting 7d & 1½d. D.I.*	...	...	...	* Discount 5 per cent. off lighting accounts Sliding scale for motors. [only.
7	...	...	3d. and 1d. M.D. 2d.—1½d. F.R.	...	...	...	.....
8	...	...	1d. day rate 1⅜d. to 1d.	...	...	*	* Isolated plants using gas, suction gas and steam are in operation, of which there are no particulars.
9	...	...	Flat rate1d.‡	Terms by arrangem't	...	...	* Under 3 H.P. † 3 H.P. and above. ‡ Or £4 per kw. per annum and ½d. per unit.
10	...	...	1½d. & 1d. M.D., accord. to cons.	On application	..	...	* Lighting and power 4,000, traction 3,300.
11	...	...	1½d. for first 1,500 units†	...	...	...	* Motor load only. † Exceeding 1,500 units per quarter at 1d.
12	...	...	1·35d. to 1·10d.	1d. to 0·7d.	13,300	...	.. ..
13	...	...	...	F'm 1½d. to0·45d.*	...	...	Total B.H.P. does not include traction. * Sliding scale according to amount taken.
14	...	...	3d. and 1d. M.D.	...	...	...	.....
15	...	...	2d. 1st 1,000, 1d. after less 10°/.‡	...	...	...	* Single-phase. † Three-phase. ‡ Extra discounts to large consumers.
16	...	...	2d. to 500 per qtr., 1d. after	...	1,000	1,500*g*, 80*sg*, 4,510*s*	.....
17	...	...	2½d. flat.	On application	...	...	.....
18	...	...	2d. to 1d. 2d. to ¾d.	£3 per kw.†	...	...	*These figures include the following motors owned by a consumer taking a supply of current from 3 500 kw. motor-gens. used for converting our supply current at 6,600 volts, 3-phase, 50 periods, to d. cur. at 230 and 460 volts: number of motors, 140; horse-power, 2,116. †Plus ½d. per unit, less discount.
19	...	...	1d. restricted hours, 1½d. unrestricted	...	...	...	Special terms to large users.
20	...	...	1½d. & dis., 1½d. and ¾d. *M.D. with discount	On application	...	800*sg*	*To avoid as far as possible the use of max. demand indicators a flat rate is usually agreed upon. Special agreements based on a fixed charge of £7 3s. per annum per kw. plus ·2d. per unit.
21	2,640	..	Lighting3½d.flat Pwr. 1⅜d. 1st 30 hrs.per ½,1d. aftr	None	...	...	.....
22	211·0	729·7	3d. & 1d. MD also 2d.&1½d. 1d.-⅜d†	...	327	75*sg*	80 per cent. of total power is on restricted hour system. 80 per cent. of total power units sold on restricted hour system. * Includes lighting. † Restricted hour.
23	About 2,246½	About 395½	1⅜d., 1d. and ⅝d.	On application	1,280	About 40,000	.....
24	...	126	4d.& 1d. M.D. or 2½d. flat	On application	...	50*g*, 10*sg*	Power supply includes driving stamps, pumps and other mining machinery.
25	...	395	1½d. flat 5 p.c. dis. cash 28 days	...	..	...	Maximum demand to date (February 12, 1910), 411 kw. on feeders, includes light and power.
26	...	...	1½d. flat, 4d. & 1d. M.D.	Spl. rates to large consumers	...	...	Most of the engineering works on private property, from which Corporation are at present debarred from entry.
27	68	717	2d. flat. 1d. and 3½d. two-rate. Also Maximum Demand.	Special terms	66	...	Power supplied to tramway company, also to Council for sewage pumping.
28	...	...	3d. to ¾d.	On application	...	...	.....
29	460	400	1½d. 1st 200 units per qtr., 1d. after	Above 25,000 p.a 1d.flat rate	. .	...	....
30	...	...	1½d.—1d.	...	...	...	.....
31	...	...	On application	On application	...	...	.....
32	62	96	2½d. flat, 3d. and 1d. M.D.	On application	212	...	Several of ½ H.P. and less not included in return. Motors let out on hire.
33	1,697	800	2d,1½d.,1½d.,1d. sliding scale	None	500 steam 450 gas	500*g*, 200*sg*, 2,000*s*	Competing gas 2s. 8d. per 1,000 c.f. with 25% disc. when annual bill exceeds £50.
34	...	...	1½d. flat and spl.agreem'ts	...	100	...	.....
35	344 about	257 about	1½d. 2,500 units per quarter and 1d. after*	...	4,000	...	* Over 50,000 units per quarter flat rate of 1d.
36	...	...	½d.to¾d.: £4 kw M.D. and ½d.unit	...	...	...	.....
37	...	...	1d. for all day use	...	800	...	.....
38	...	...	1⅝d. to 0·4d.	...	...	...	... .
39	Both		2½d.(1)—1d.	Two Tramway Companies.	...	..	Maximum demand system or 1d. restricted hour.
40	Both		1½d.	...	2,200	...	Large additions in hand.

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SPECIALISTS IN SWITCHGEAR FOR CENTRAL STATIONS, AND INDUSTRIAL POWER . . . . . INSTALLATIONS.
H.T. OIL SWITCHES, CIRCUIT BREAKERS, INSTRUMENTS.
Waverley Works, ST. SIMON ST., MANCHESTER.

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For Car Trucks, &c., USE . . . "Driorol,"
Quickly dries over oily or greasy surfaces.
Sole Manufacturers—
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Makers of Insulating Varnishes. Damp proof Composition for Manholes, "Ferrodor" Paint for Standards, Enamels, Paints, Colours, Varnishes, &c.
MACKS ROAD, BERMONDSEY, LONDON, S.E.

SIEMENS WIRES and CABLES.

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No.	Supply Authority.	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit. H.P.	Max. demand Kw.	H.T. motors (if any).
41	Dundee Town Council	H. Richardson	Jute mills, shipbuilding, foundry	...	400	1,950	404	65	...	...
42	East Ham Corporation	W. C. Ullmann	Printers and wood yard for motors, otherwise district is purely residential.	...	240, 480	Pte.471, *Stn., 43½, July, '10	Prvte, 131 Station, 5	40	...	..
43	Edinburgh Corporation	F. A. Newington.	Printing, joiners, masons, engineers, brewers	...	230, 460	10,485 30/8/10	2,455	50	...	...
44	Fulham Borough Council	Arthur J. Fuller	Engineering works, woodworking machinery, laundries, paper mill	200 two-phase above 5 H.P.	...	1,321 31/3/10	183	80	540	...
45	Frome U.D. Council	F. H. Merritt	Cloth, silk and india-rubber mills, iron foundries, engineering and motor works, breweries, mill furnishing, dairies, bacon curing, printing, furniture & cabinet mkg.	...	240, 480 three-wire	845 31/8/10	205	35	210 approx	...
46	Glasgow Corporation	W. W. Lackie	Engineering, clothing, printers, butchers and bakers	6,500	250/500 three-wire	33,993 31/7/10	4,970	250	...	...
47	Govan Council	T. C. Parsons	Shipbuilding and engineering ...	...	500, 250	5,925 15/8/10	...	165	1,736	...
48	Grantham Urban Electric Supply Co.	J. E. Edmundson	Brickwork, foundries, timber merchants, engineering works, blouse factory, malting	..	240, 480 three-wire	342 31/8/10	105	13½	...	...
49	GreenockCorporation	J. A. Robertson	Shipbuilding, engineering, sugar refining	380	500	5,831 31/7/10	458	545	1,500 Appx.	...
50	Grimsby Corporation	W. A. Vignoles	Docks, timber yards, foundries and engineering works	...	230, 460 three-wire	1,118 21/7/10	170	90	1,496	...
51	Guernsey Electric Light & Power Co.	C. Lakin-Smith	Laundries, stoneworks and quarries, joinery works, foundry	...	210, 420	2,200 31/8/10	215	80	845	..
52	Hammersmith Borough Council	G. G. Bell	Engineering works, electric lamp works, small laundries, &c.	110, 220, 440 2,300 H.T.	...	4,772 16/8/10	402	500	...	3 200 2 120 2 500
53	Hanley Corporation	C. H. Yeaman	Brickworks, potteries, iron works, collieries, earthenware and china manufactories	Single-phase 100 ~, 100-200, 400	50*	1,101½ 31/3/10	144	60	1,251	1 60
54	Heckmondwike Council	G. H. Carter	Woollen manufacturers, rag grinders, foundry, boot and shoe, factory, coachbuilders, &c.	...	230, 460 three-wire	1,210 31/8/10	...	150	...	...
55	Hereford Corporation	W. T. Kerr	Cider making, breweries, mills (flour), farm work, joinery, refrigerating	...	220, 440	525 31/8/10	110	50	410	...
56	High Wycombe Electric Light & Power Co.	W. E. Brandreth	Chair and cabinet making, paper mills, engineering	...	420 210	570 31/8/10	153	30	...	...
57	Hove Electric Lighting Co.	C. B. Smith	Purely a residential district excepting shops	...	220	460 18/8/10	143	12	...	...
58	Huddersfield	A. B. Mountain	Cloth manufacturers ..	Three-phase One-phase	... ...	*2,644 *1,496	128 480	150 35	1,150 2,000	..
59	Hull Corporation Electricity Department	H. Bell	Oil mills, shipbuilding and engineering.	...	220, 440 three-wire	7,108 20/8/10	618 Consumers	75	4,780	...
60	Ilford Urban District Council	A. H. Shaw	Photographic apparatus, chemical works, paper mills	...	230, 460 three-wire	674 2/8/10	127	60	...	...
61	Islington Borough Council	Albert Gay	Bakers, brewers, builders, clothiers, coach and van builders, engineering works, confectioners, printers	Single-phase 50 ~ 100 200 and 400	...	2,537 31/7 10	517	50	3,863	...
62	Kettering Council	W. A. Walker	Boot and shoe and clothing factories	...	230, 460 three-wire	812½ 31/7/10	172	30	315	...
63	Kidderminster & District Electric Lighting & Traction Co.	A. Charlton	Carpet manufacture	...	460	1,010	...	26	520*	...
64	Kirkcaldy Corporation	O. F. Francis	Linoleum, engineering, furniture, malting works, linen, &c.	...	230 460	933 31/8/10	...	130	802	...
65	Lancaster Corporation	W. A. Tester	Timber yards, builders' yards, foundry, linoleum works	...	230, 460	460 16/8/10	121	50	200	...
66	Leeds City Council	H. Dickinson	Numerous	200 400	...	13,430 31/7/10	2,160	100	6,800	...
67	Leith Council	A. Peden Rutherford, M.I.E.E.	Engineering and general...	...	230, 460	3,432·24 30/6/10	437	100	723*	...
68	Liverpool	Alfred Clough	.....	...	230, 460	11,270 30/6/10	2,718	80	...	...
69	Lincoln Corporation	Stanley Clegg	Engineering works	...	230, 460 and 500	1,429½ 30/8/10	200	70	425	..
70	Loughborough Corporation	W. H. Allen	Hosiery and engineering	...	220, 440 three-wire	370 30/10/08	67	43	120, for pr. only	...
71	Luton Corporation	W. H. Cooke	Straw hat making, motor cars and lorries, hydraulic and general engineers, foundries, printing works	...	500	2,086½ 5/5/10	330	160	948	...
72	Maidstone Corporation	E. E. Hoadley	Building, brewing, paper making	...	230, 460	1,437 31/5/10	186	60	...	...
73	Mansfield Corporation	E. Holcombe Hewlett	Boots, hosiery, cotton doubling, founding, tin box, motor bodies, sand and stone quarries, coal mining	...	240, 480 500-600	284 16/8/10	88	12	About 50	...
74	Metropolitan Electric Supply Co.	J. S. Highfield	Ordinary shops	200	200	3,936 26/4/10	1,062	60	...	...
75	Middlesbrough Corporation	H. M. Taylor	Iron and steel works, shipyards, joiners shop	...	220, 440 three-wire	1,694	303	50	450	..
76	Motherwell	S. Williams	Engineering and steelworks	...	230, 460	About 3,500	60	3 of 120 1 of 200	1,040	...
77	Newcastle and District Electric Lighting Co.	W. D. Hunter	Engineering and shipbuilding, steel and lead works, &c.	100	240, 480 three-wire	10,000 16/8/10	...	150	4,500	...
78	Nelson Corporation	D. Helme	Cotton manufacturing	...	230, 460 three-wire	310 31/8/10	72 On hire	40	...	...
79	Newport Corporation	H. Collings Bishop	Coal, iron, clothing, nails, brickworks, millers, ship repairs, &c.	200 A few permitted	230, 460 three-wire	2,434 19/8/10	273	100	Cannot give	None

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ELECTRIC POWER SUPPLY.—*Continued.*

No.	Method of Driving. Group H.P.	Method of Driving. Indiv. H.P.	Rates. Per unit.	Rates. Bulk supply.	Approx. H.P. of other power displaced by electric motors.	Isolated Plants at present Operating. g=Gas. sg=Suction Gas. s=Steam. H.P.	Remarks. (Note.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
41	500 approx.	1,450 approx.	2½d. downwards	On application	...	...	.....
42	...	..	2d., 1¾d. & 1½d.	...	...	...	*Motors used in gen. stn. for cooling towers, artesian well, driving machinery, &c.
43	...	...	1⅛d. flat. ¾d. Stch. R., 1d. 5hr. M.D.	...	...	..	... .
44	...	...	1d. flat	...	...	...	Power and lighting on same mains, 540 kw. day-load motors only.
45	90 approx.	740 approx.	2½d. flat; 4d. and 1d. M.D.	On application	200, also 365 private electric plant	50g, 20sg, 850s, 10 water (approx.)	.....
46	...	...	1⅛d & ¾d. M.D. 1d. flat rate for restricted hours	¾d. & ½d. M.D.	...	...	.....
47	...	...	Sliding scale 2d.—¾d.	...	...	290s, 200s, 4,000s	.....
48	...	...	4d. and 1d. M.D.I. 2½d. flat.	Special rates	...	No record.	.....
49	...	...	2⅛d. to 1d.	1d. to 8d.	...	...	.....
50	..	...	2½d. to 1d. with dis., 1d. T.S.	...	...	...	Number and horse-power of motors does not include the docks or Admiralty supply.
51	...	...	2d. flat, special for large consumers	To substations	1,000	...	.....
52	...	...	1½d. with dis. to a max. of 33⅓ p.c.	...	...	...	.....
53	...	...	3d., 1d., ⅝d. and ½d.	On application	...	...	Power load rapidly growing and especially favoured with the many small and diverse trades subsidiary to staple industries of district. *Local for magnetting.
54	...	...	2d. to 1d. Sliding scale	Special terms	...	...	A large power demand still to connect.
55	100	285½	*3d. to 1d.	...	...	20g, 160g, 300s	* With discount on hours of running.
56	...	...	4d.—1d. M.D. system, 2½d. flat rate or on 2 rate meter	...	...	16g, 200sg	All motors are hired out by this company, and are maintained and inspected.
57	...	...	3d. one hr., 1½d. after	...	...	...	Radiators are at power rates but are not included in this return.
58	...	...	2d. and 1d. less discount	...	...	...	* July 31, 1910.
59	...	...	2d.—1d. per sliding scale*	On application	..	..	Hired motor system in operation. About 600 H.P. connected * Subject to 2½ per cent. dis., for payment within 14 days.
60	..	..	2d. & 1d. M.D. 2d. to 1d. sliding scale	...	..	...	1d. power rate for large consumers.
61	...	...	1d. flat	Nil	1,350	757g, sg, 742s, o	.....
62	760	52½	2d. to 1d.	On application	598	...	... .
63	...	...	1½d.	...	...	No information available	*This is a combined figure for lighting and power.
64	...	..	2½d. to ¾d. sliding scale	...	...	...	1 large engineering works, 1 large colliery, 1 large malting works received entire power supply from Corporation.
65	11	108	2½d. sliding scale to ½d.	By contract	440	200g 500s	.....
66	...	...	0·8d. to 1·75d. less 5 per cent.	...	...	...	.....
67	...	...	1½d. to 1d.	...	...	...	*For industrial purposes only.
68	...	...	*2d., 1½d., 1d.	...	..	...	* 2d. up to 3,000 per qr., 1½d. from 3,000 to 10,000 per qr. 1d. all units in excess of 10,000 per qr.
69	...	...	2½d., 2d. & 2d. & 1d. M.D	On application	...	...	.....
70	219	151	1d. flat	...	158	49g, 25sg, 492s	Two private plants, total 1,200 kw., running.
71	About 1,660	About 426	*2d., 1½d., 1d.	...	About 400	About 200g 100sg, 250s	*2d. first 1,000 per qr., 1½d. second 1,000 per qr., 1d. remainder.
72	Both		Various.....	...	650	15sg	.....
73	...	...	4d. & 1d. M.D. 1d. daylight	...	214	450s*	Town gas sold at 1/6 1,000 for power. Tramway supply 1,200 H.P. not included. * Not including collieries.
74	...	...	3d. and ¾d. M.D.	...	...	...	.....
75	...	...	2d. & 1d. M.D. Sp. on app'n.	...	1,500	...	Largest installation, shipyard, max. demand 400 kw.
76	...	...	1d. and ½d.	...	...	...	....
77	...	...	Max. 1½d.	According to load factor, &c	...	...	Largest consumer, Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick Works.
78	Both		*	...	...	...	* Motive power—2⅛d. for 1st hour per day, 1⅛d. every subsequent hour, less 5%.
79	About 833	1,601	2d. and 1d. acc. to quan.	On application	...	...	One dry dock being converted to electric from steam.

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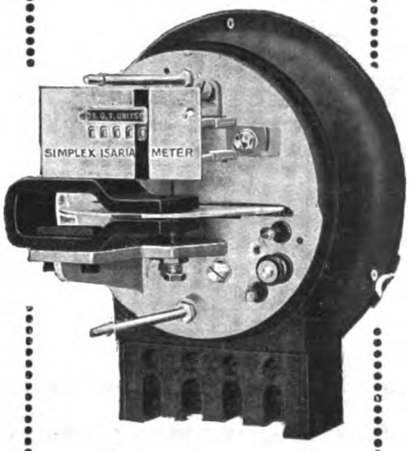

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"THE ELECTRICIAN" TABLES OF

No.	Supply Authority	Engineer and Manager.	Principal Local Trades.	Power Voltages. A.C.	Power Voltages. D.C.	Total B.H.P. connected at date indicated below.	Total number of Motors connected.	Largest Motor on Circuit.	Max. demand. Kw.	H.T. motors (if any).
80	Northampton Electric Light & Power Co.	G. H. Jackson ...	Boot and shoe factories, printers, motor car works and tanneries	...	210, 420 three-wire	1,593 31/7/10	...	40	...	...
81	North Wales Power and Traction Co.	G. K. Paton (Chief Elec. Eng.)	Slate quarries	500 3-phase	...	3,050 31/8/10	60	200	1,000	...
82	Norwich Corporation	F. M. Long	Boot and shoe, mustard, printing, breweries	...	220, 440	2,893 30/6/10	540	50	800 at station	...
83	Nottingham Corporation	H. Talbot	Lace, hosiery, tobacco, engineering, leather	...	200, 400 three-wire	4,379 17/8/10	1,094	60	...	...
84	Nuneaton Corporation	S. C. Gibson	Hat making, hosiery wool, cotton, elastic web, foundry, quarries and collieries	...	220, 440 three-wire	355½ 15/8/10	81	60	200	...
85	Partick Council	W. Sillery	Shipbuilding and engineering works	...	240, 480 three-wire	2,791 15/8/10	280	60	2,082	...
86	Peterborough Corporation	J. C. Gill.....	Engineering, brickworks, railway	...	200, 400	270 31/7/10	72	20	502	...
87	Reading Electric Supply Co.....	E. Rowley Hill ...	Printers, engineers and iron founders, saw-mills	200	200, 400	1,852 31/8/10	271	65	1,236	...
88	Redditch Urban District Council	Wm. J. Ferguson	Needle trade, fishing tackle, cycle factories	200	...	1,350 31/7/08	137	40	...	...
89	Rochdale Corporation	C. C. Atchison ...	Textile and engineering.....	3,000 220	220, 440, 500	1,622 31/7/10	266	50	...	84 H.P.
90	Rotherham Council.....	E. Cross	Iron, steel and brass works	...	230, 460 three-wire	1,082 1/8/10	121	106	350	...
91	Salford Corporation	H. J. Hawkins ...	Textile and engineering	200	220, 440 three-wire	10,978 31/7/10	1,020	300	...	...
92	Sheffield Corporation	S. E. Fedden	Steel and iron works, cutlery works, foundries, general engineering works	2,000, 400, 200	...	14,411 30/6/10	1,482	350 H.P.	6,870	One 350, 80, 120, 50 kw.
93	Shoreditch Borough Council.....	C. N. Russell	Printing, shoemaking, cabinet and furniture manufacture	...	240, 480 three-wire	4,690 31/8/10	960	...	3,510	...
94	Shrewsbury Corporation	C. M. Johnston ...	.....	...	210 420	198 31/3/10	85	20	381	...
95	Smithfield Markets Electric Supply Co.	Edgar Dowling ... (*Chief Engineer*)	Cold storage.....	...	100 200	482 31/8/10	31	130	400	...
96	South Shields Corporation	J. H. Cawthra ...	Shipyards, docks and marine engineering works	110, 220	550	2,617 16/8/10	...	160	...	...
97	Stalybridge, Hyde, Mossley and Dunkinfield Electricity Board	Robert Blackmore	Textile, paper mill boiler works, bleach works engineering works, iron works	400 230	460 230	7,500 31/8/10	250	375	4,600	...
98	Stamford (Urban Electric Supply Co.	J. E. Edmundson	Brickworks, laundry, foundry, engineering works, flour mills, printing works, timber yard	..	240, 480 three-wire	495 31/8/10	101	35	...	...
99	St. Helens Corporation	E. M. Hollingsworth	Chemical, glass and bottle works, steelworks, collieries	230, 400 3-phase	230, 460 three-wire	2,150 31/7/10	275	100	400	...
100	St. Marylebone Borough Council	A. Hugh Seabrook	Printing, building, small workshops (various trades)	None	240 480	2,960 31/8/10	782	110	8,688 whole supply	None
101	Stockton-on-Tees Council	J. J. Smith.....	Shipbuilding, engineering and ironworks	...	230, 460 three-wire	1,077 31/3/10	133	50	...	...
102	Stoke-upon-Trent Corporation (Stoke Station)	P. J. S. Tiddeman	Potteries, engineering works.....	None	240, 480 three-wire	1,089½ 16/8/10	...	80	545	...
103	Sunderland Corporation	A. S. Blackman...	Shipbuilding, marine engine and boiler makers, coal mining, flour mills	5,000 220	220	11,293¾ 31/7/10	734	275	4,425	...
104	Swansea Corporation.....	C. A. L. Prusmann	Metallurgical, coal exporting &c.	220, 440 three-wire	220, 440 three-wire	2,038 30/6/10	...	60	1,122	...
105	Uxbridge and District Electric Supply Co.	A. Randall Bell...	Flour mills, printing, engineering, brickmaking	200	...	633 31/8/10	67	60	466	...
106	Wakefield Corporation	H. A. Nevill	Engineering, woollens, coal, printing, laundries, wire mills	200	...	1,378 31/8/10	183	110	1,205	...
107	Walsall Corporation	A. S. Barnard ...	Saddlery, harness, leather, clothing, iron founding, tubes, brushes and rolling mills	...	105 210	790 31/1/10	161	35	...	...
108	Warrington Corporation	F. V. L. Mathias..	Wire mills, printers, saw mills, tanneries, engineers, corn mills, gas stove manufacturers, builders, min. water mfcrs &c	380 3-phse. 50 periods	460	5,500 31/8/10	...	215	...	...
109	West Bromwich Corporation .	W. A. Jackson ...	spring works, steel rolls, hollow ware foundries, edge tools, tubes, school furniture, corn mills, wire nails	...	230, 460 500	1,871 31/7/10	166	125	About 550*	...
110	West Ham	H. H. Couzens ...	Chemical, engineering, flour mills, ink mills	100, 200, 400	500	7,985 kw. 31/7/10	1,050	115	...	...
111	West Hartlepool County Boro'..	H. F. Friederichs	Blast furnaces, steel wks., ship yds., engine wks., paper mill, saw-mills and joinery wks	...	230, 460 three-wire	2,009 31/7/10	231	120	550	...
112	Whitby (Yorks) District Council	L. H. King	Fishing	...	460	175	32	18	400	...
113	Whitehaven Corporation	B. Sankey	Tannery, flour mill, printing and machinery works, &c.	...	420, 210 three-wire	176¾ 31/5/10	39	20	240	...
114	Wigan Corporation	Jas. Slevin	Coal mining, cotton mills, engineering works	...	230, 460 three-wire	1,680 31/8/10	233	50	921	...
115	Windsor Electrical Installation Co.	A. E. Farrow.....	Brewing	220	220	208	78	13	75	6
116	Wolverhampton Corporation ...	C. E. C. Shawfield	Ironworks, edge tool works, corn mills, paint works, cycle and motor works, saw-mills, &c.	6,000, 400	440, 220 three-wire	5,338 31/8/10	419	100	4,180	...
117	Worcester Corporation	C. M. Shaw	Porcelain, glove, leather, flour, engineering, various, buttons, confectionery, printing, horse-hair cloth, &c., works	100, 200	230, 460 500	948 31/8/10	175	2 40's	910	...
118	York Corporation	J. W. Hame	Confectionery, printing, railway works, flour mills, brickworks	...	230, 460 three-wire	1,245¾ 31/7/10	267	35	1,035	...
119	Yorkshire Electric Power Co.	W. B. Woodhouse	Textile mills, iron works, collieries, calcium carbide factory	2,000, 400	500	13,000 14/2/10	350	140	3,400	1 100 H.P.

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ELECTRIC POWER SUPPLY.—*Continued.*

No.	Method of Driving. Group. H.P.	Method of Driving. Indiv. H.P.	Rates. Per unit.	Rates. Bulk supply.	Approx. H.P. of other power displaced by electric motors	Isolated Plants at present Operating. g=Gas. sg=Suction Gas s=Steam. H.P.	Remarks. (Note.—Inst. E.E. Wiring Rules for Motors generally apply in all districts.)
80	About 1,300*	About 293	2d. to 1d. sliding scale	On application	About 1,250	...	.....
81	575	2,475	1½d.—⅝d. and under sliding scale	...	3,050	...	Slate quarry load mostly winding, pumping, air compressor and mills. Transmission at 10,000 volts three-phase, all overhead, bare wire and 20,000 volt.
82	...	...	2d. to ¾d.	...	...	...	A 150 B.H.P. motor-driving sewage pump will shortly be installed.
83	...	...	1¼d.	...	...	...	.....
84	...	220	2½d. to ¾d. on sliding scale	On application	...	50*sg*, 100*s*, 20 *oil*	A temporary supply of motors aggregating 305 H.P. is at present being given to a large spinning mill. This is not included in the figures given.
85	...	...	1d. flat rate	...	...	...	.....
86	...	...	1½d. flat.	...	...	...	.....
87	About 1,400	300	£4 and ¾d. or £1 per unit according to demand	...	400	50*g*, 125*sg*	.....
88	...	...	2d. to 1d. sliding scale.	...	...	350*sg*	.....
89	Practically all group driven.	...	2d. to 1d sliding scale*	On application	Steam 804 Gas 187	365*g*, 20*sg*, 310*s*	Isolated plants on present route of mains (approximate only). *Special terms for special conditions.
90	Both		1½d. and 1d.*	On application	About 1,000	...	Several large firms about to adopt electric drive. *Sliding scale down to 0·6d. for large users.
91	...	...	*	...	...	...	* Flat rate.—1½d. first 1,600 units per qr., 1d. all in excess. Fixed charge system £1 per qr. per E.H.P. demanded and ½d. per unit consumed.
92	...	...	Lht 4d., Heat 1d., Power 2d. to $\frac{5}{16}$d.	...	6,000	...	Great expansion of use of power supply in rolling mills and cutlery works.
93	...	...	¾d. up to 75,000 p.a., ½d. after*	...	...	..	* Plus £3 per E.H.P. demanded.
94	...	...	*3d., 2d. and 1½d.	...	...	...	* Discounts: 5 per cent. over 600 units, 10 per cent. over 1,000 units.
95	...	...	1½d. and 1d.	...	...	...	.....
96	Both		1½d. 1st 5,000 per qr. 1d. after. less discount 2½%	...	...	...	Also traction supply.
97	...	...	2½d.—·45d.	On application	2,000	300*g*, 1,700*s*.	... .
98	...	...	2½d. flat, 4d. and 1d. M.D.	On application	..	...	.. ..
99	...	...	2d. and 1d. with disc'nts	...	1,000	100*sg*	.....
100	...	...	£2 per H.P. per annum and 1d. per unit	...	220 since Aug., 1905	703*g*, 10*sg*, 1,109*s* 160 *oil*	* Or 40s per H.P. per annum, and 1d. per unit: also restricted hour 1d. flat rate.
101	...	...	Sliding scale 2d. down to 1½d.	On application	...	...	One works take about 250,000 units per annum, and the total amount sold per annum for power purposes amounted to 421,692 units.
102	Both		1½d. to 0·8d.	...	...	...	The potteries all require steam for heating, and this is generally the drawback to electric driving.
103	..	...	2½d. (dis. to ½d.) ¾d. & 1½d. M.D.	On application	...	...	.. ..
104	...	...	2d. (1st hr.) & 1½d. M.D.*	...	...	...	Motor hiring scheme in operation. * 200,000 per annum and over special rates.
105	58	568	2½ to 1½ flat*	...	...	50*g*, 1,200*sg*, 500*s*	Large power users by contract at prices based on load factor. * £4 per H.P. demanded per an. and ½d. per unit.
106	...	...	2d. to 1d.	...	746½	...	.....
107	594	196	(*See* remarks)	On application	...	...	2d. up to 100, 1½d. up to 200, 1½d. up to 500, 1¼d. over 500; 10 per cent. discount for over 10,000 per annum, 12½ per cent. discount for over 15,000 per annum.
108	...	...	0·6d. to 2d. according to conditions	...	4,500	...	.....
109	About 1,092	About 779	1½d. to ¾d. Less 2½ % dis.	...	About 750	...	72 motors on hire = 487 H.P. Applications in hand for 150 H.P. * Motors only.
110	Partly both		1d. max.	On application	5,209 kw.	...	.....
111	100	1,755	2d.—1½d. flat with disc.	1d.—¾d.	1,650	510*g*, 230*sg*, 5,369*s*	Flat rate for less than 50,000 per annum, 2d.-1½d.; over 50,000, under 500,000, 1½d.-1d.; from 500,000 to 600,000 and over, 1d.-¾d.
112	115	60	£5 per kw. per an. at 1d. unit	...	...	...	.....
113	...	...	1½d and 1¼d. or 2 rate, 2d. for small motors	...	67	35*g*, 20*sg*, 12*s*	.....
114	580	About 1,100	Up to 1,000 units per annum 2d., over 1,000 1d.	...	300	...	.....
115	...	...	£3 per H.P. installed per ann. and 1d. per unit	None	108	15*g*, 90*sg*, 40*s*	.....
116	...	...	1d.	Various	...	...	.....
117	683	266	2½d. & 1d. M.D. ¾d. sewerage P. 1d. & 1¾d. restricted hour	...	Over 1,000	200*g*, 450*sg* 1,860*s*	.....
118	...	...	1½ downwards	On application	...	...	... .
119	...	...	Sliding scale	...	...	...	.....

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Development of Flame Arc Lighting. . . .

THE accompanying illustration of a railway yard lighted with Siemens "Caxton" flame arc lamps is particularly interesting inasmuch as it deals with a class of arc lighting which is quite distinct from either shop window or what we might term "lighting for advertisement purposes."

The sale of flame lamps has unquestionably suffered in the past on account of electrical firms not studying sufficiently the exact conditions under which lamps are required to burn and the nature of the ground to be illuminated.

Siemens "Caxton" Flame Lamps.

Maximum and mean hemispherical candle-powers, however carefully calculated, count for little beside the effectiveness of the illumination, and a lamp which is most suitable for shop lighting is not necessarily the best lamp to put forward for the lighting of large areas of ground such as railway and shipping yards, streets, large factories, &c.

The introduction of "inclined" carbon flame lamps, which give their maximum candle-power at an angle of about 70 deg. from the horizontal, has met the requirements of those wishing to light shop fronts, &c., where it is desired to illuminate, as brilliantly as possible, the window directly beneath the lamp, and it is considered an advantage rather than otherwise if the next door neighbour's window is left in comparative darkness. That this class of lamp can also be most suitable for the lighting of large areas of ground, where the even distribution of light is desired rather than brilliant points of light, seems unreasonable, and in many instances electricity has been replaced by gas because the gas companies have been more alive to this vital distinction between two entirely different classes of lighting.

The "Caxton" lamp, which Messrs. Siemens have recently placed on the market, is essentially a lamp suitable for the lighting of large areas of ground, on account of the excellent distribution of the light. The lamp is of the vertical carbon type and burns carbons of special construction and chemical composition which are manufactured under the Blondel patents. These carbons have a very large core containing chemical salts, and, as is the case with most flame lamps, the greatest volume of light is derived from the arc itself and not from the crater of the carbons. As this is the case, it has been found an advantage with continuous-current lamps to place the positive carbon below the negative, which tends to cause the arc to burn more steadily on account of fewer particles of carbon passing through the arc from the positive to the negative electrode during combustion. The arc itself burns in a fire-clay economiser, which intensifies the light and projects it downwards in such a manner as to illuminate larger areas than has previously been possible with flame lamps of the same current. The maximum candle-power is obtained at an angle of about 30 deg. from the horizontal, and throughout the whole radius of illumination the light is evenly distributed.

In addition to the question of the distribution of the light, this class of lamp also has the distinct advantage of being of extremely simple design, the mechanism is, in fact, only a slight modification of their standard open-type lamp. Generally speaking, where large areas are to be lighted, such as railway and shipping yards, large factories, &c., it is not desired to have a lamp with intricate mechanism, and the simpler the better. The feeding device is most reliable in its action and is entirely unaffected by violent vibration or atmospheric conditions. The case containing the mechanism is constructed in such a manner that it is impossible for the fumes from the arc to enter, and the lamp is also fitted with a deposit preventer which prevents the globe from becoming fogged.

The carbons used in these lamps are, as stated above, of large diameter, and in consequence the risk of breakage is practically nil, whereas with thin carbons as used in "inclined" flame lamps this is an item which has to be taken into consideration.

For export work it is interesting to note that, in the event of not being able to obtain flame carbons, ordinary quality open-type carbons may be used in these lamps without any adjustment to the mechanism.

Flame Lamps for Sign Illumination.

THE accompanying sketch, which we take from the "Electrical World," shows an arrangement of a flame arc lamp sign, suggested by Mr. C. M. Axford, of Chicago, in which a pair of lamps are used to illuminate the letters, and at the same time to light the sidewalk and store front where the sign is installed. The proposed construction is made clear by the sketch. The two flame arc lamps are connected in series across a 110-volt circuit, and together consume about 1 kw. The signs should consist of black letters on a frosted background, or *vice versa*, and the sign surfaces should be inclined about 10 deg. to the vertical so as to be most effectively read

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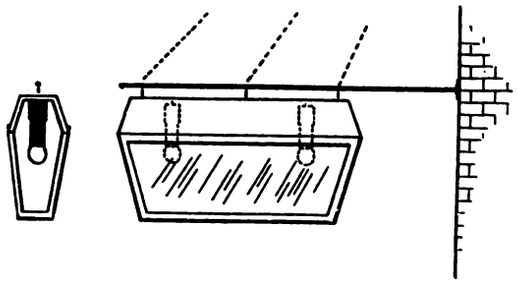
along the street. Above the sign spaces are hinged doors, through which access can be obtained to the lamps. These doors should be provided with gutters discharging at the curb line. The street end of the box should be closed, or may consist of a small sign, while the end toward the building should be left open and preferably cut away as shown, to allow light from the lamps to reach the windows and store front. For this purpose, the sign, which should be about 10 ft. in length, extending to the curb, should be mounted at least 4 ft. away from the building line, being suspended from a chain and bracket or other construction. Opal globes on the flame arc lamps will tend to improve the diffusion of the light within the sign, and to minimise the "spotting" of the letters. The use of an illuminated sign of this kind is suggested in positions where it has been the custom to hang a pair of naked flaming arc lamps in front of a store, depending on them to light the front and windows and the owner's sign. Under such conditions the extreme intensity of the lamps defeats the latter purpose, causing passers-by rather instinctively to shield their eyes from the glare. The sign proposed would, on the other hand, show the proprietor's legend to advantage along the entire street, besides lighting his sidewalk and windows at a minimum of electrical expenditure.



A Flame Lamp Sign.

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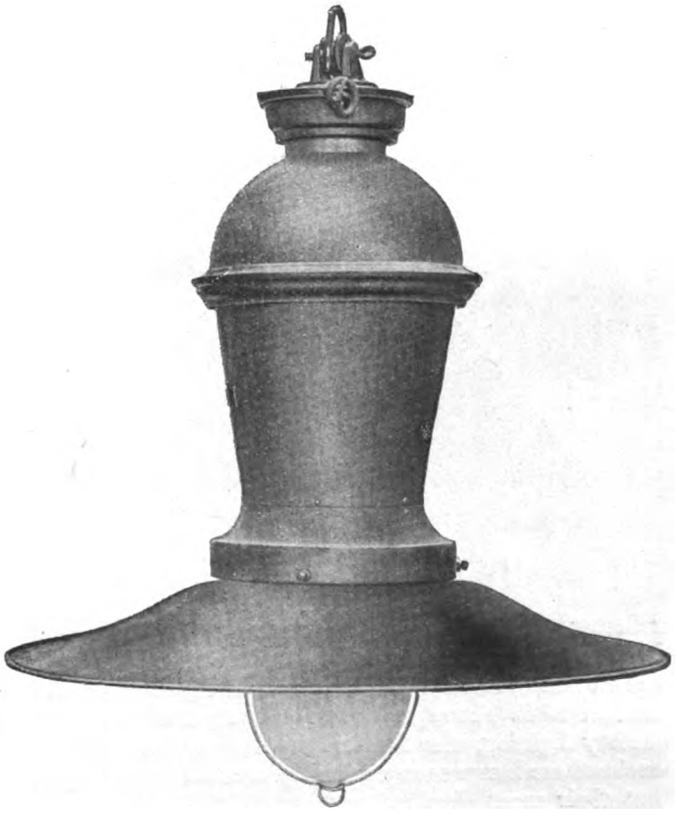
B.T.H. Intensified Arc Lamps.

THE B.T.H. intensified arc lamp, which has just been placed on the market, is the result of a continued research towards improving the efficiency of enclosed arc lamps. It embodies, it is claimed, novel features, and marks a distinct advance in arc lamp design. Carbons of small diameter are used, the result being that when an arc is formed the whole of the carbon tips, as well as the crater, become a source of light. In order to maintain a reasonably long life, the ends of two small positive carbons about 0·25 in. in diameter are brought into contact, and the arc is thereby maintained at a predetermined position in relation to the reflector. This arrangement obviates the necessity of regulating the mechanism for the upper carbon. Under normal conditions and with high-grade carbons these lamps will burn 50 to 60 hours with one set of carbons.

The lower negative carbon is actuated by the lamp mechanism which regulates the arc. An entirely new mechanism has, in fact, been designed which permits the use of these small carbons. The design embodies the following desirable features: A white light suitable for selecting and matching colours, a focusing arc (which is maintained throughout the life of carbons), steady operation, artistic appearance and high efficiencies. These lamps are designed to operate singly on circuits of 100 to 125 volts pressure, two in series on 200 to 250 volts, or five in series on 500 volts continuous current only.

The superior colour value of the enclosed carbon arc, when compared with other artificial illuminants, is a well-established fact. These intensified arc lamps when equipped with single enclosing globes and metal reflectors, and when operating at 5 amperes on 110-volt circuits, have an efficiency of approximately 1·5 watts per mean hemispherical candle-power and 1·04 watts per maximum candle-power. The maximum candle-power is at 60 deg. to 70 deg. below the horizontal. The figures of watts per candle-power include the loss in the line resistance. Apart from the high efficiency and uniform distribution obtained, the intensified arc is practically devoid of such variation in candle-power as heretofore experienced with lamps designed for use with larger carbons. Our illustration shows one type of this new lamp.



The B.T.H. Intensified Arc Lamp.

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E.O.A. Arc Lamps.

A NUMBER of interesting arc lamps which are suitable for use for a number of different purposes are those manufactured by the Electric & Ordnance Accessories Co., of Birmingham. Among these are the ship's lamp, which is illustrated in Fig. 1. This shows the Victor enclosed arc lamp, which in this case is fitted with special reflector, so that when unloading at night the light from the lamp is concentrated exactly where required. The lamp shown will illuminate a circle 40 ft. in diameter when suspended 25 ft. above the deck. As regards workshop or factory lighting, the Electric & Ordnance Co. find that enclosed arc lamps are very largely used for factory lighting, but their great disadvantage is that the globes are very easily broken, and, therefore, the cost of upkeep is no small item. To reduce this as far as possible the Electric & Ordnance Accessories Co. have introduced the lamp illustrated in Fig. 2. It will be observed that the lantern is hexagonal, and, as the glass is only held in position by small copper clips, the cost of replacing a pane in the event of an accident is very small. No special globes need be kept in stock, so that a saving in storage room is thereby effected.

The above lamps are complete as illustrated. The resistance is included in the case, thus making the installation of the lamp a very simple operation. The resistance is very effectively cooled by means of the open joints in the split case. Both terminals are thoroughly insulated with mica or porcelain, and there are no live parts on the outside of the lamp.

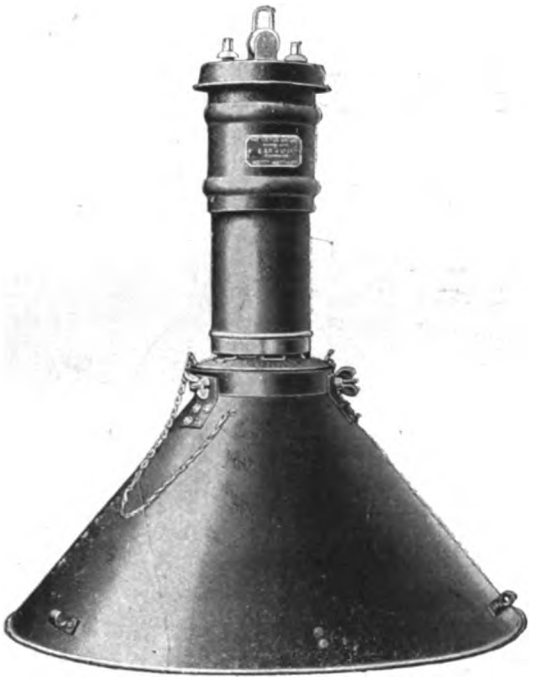
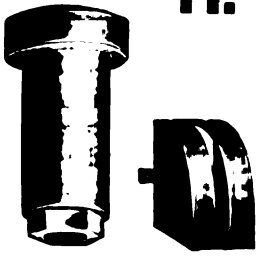


Fig. 1.—"Victor" Ship's Arc Lamp

Fig. 2.—"Victor" Lamp with Hexagonal Lantern.

In connection with the above factory lamp, we understand that the Electric & Ordnance Accessories Co. are prepared to supply a stout wire guard for use where there is little head room to suspend the lamp, or where machines are placed close together. This guard is attached by means of spring clips to the outside rim of the metal reflector, and, while not obstructing the light in any way, very effectively protects, it is claimed, the globe against breakage by ladders, poles, &c., being carelessly moved about.



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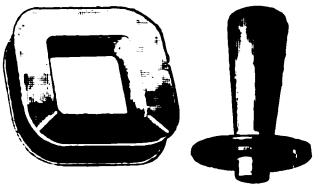

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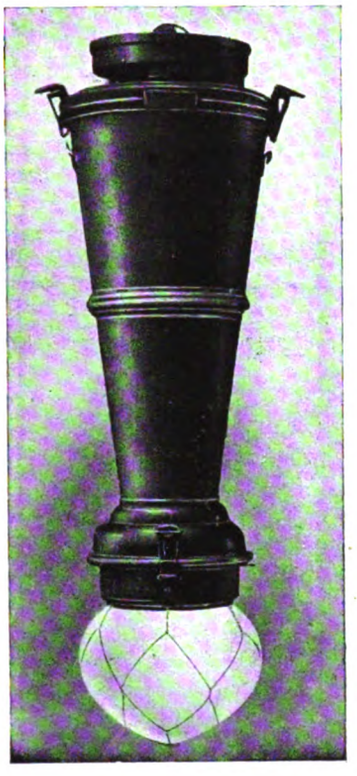
DAVY SUNRÆ FLAME ARC LAMPS



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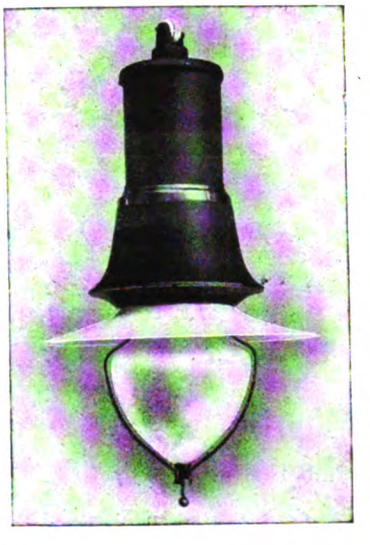

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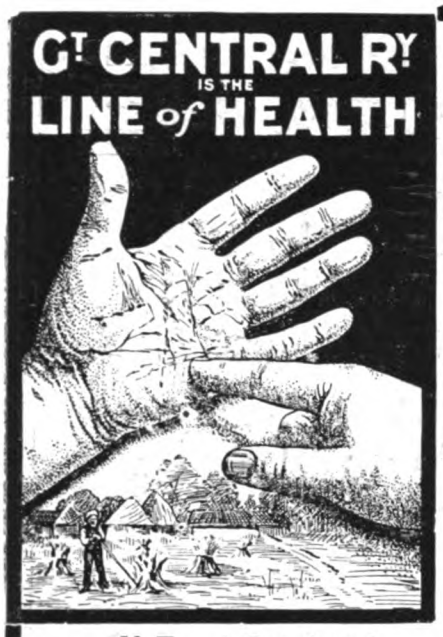

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Davy Sunrae Arc Lamps.

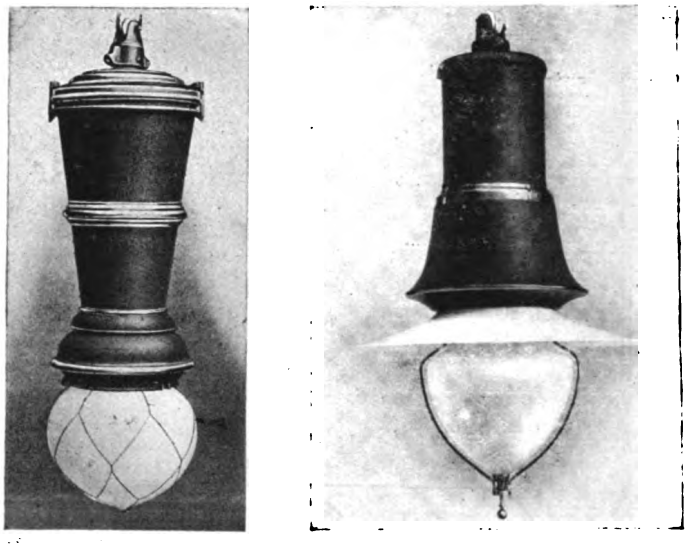
DAVY Sunræ flame arc lamps having been on the market for several years, during which time they have achieved considerable commercial success, cannot claim to be of new introduction, but rather to have established an excellent reputation over a length of time, which alone proves the merits of any kind of apparatus.

In the early days of the manufacture of flame arc lamps in this country, numerous endeavours were made by inventors and manufacturers to simplify and to get away from the complicated and clockwork mechanism of the foreign-made arc lamp, and at the same time to produce a lamp which would give longer burning hours. The four converging carbon principle upon which the Sunræ flame lamp is constructed offered one of the best and simplest solutions of this problem, as it at once possesses the advantage of a very simple form of mechanism, while securing reasonably long burning hours, equal practically to a magazine form of lamp, without the disadvantage of the complication inseparable from a lamp of the latter type.

In the Sunræ flame lamp the four carbons are held in V frames, two in the positive and two in the negative frame, and pass through a metal nozzle at the lower end of the frame until they meet and rest against each other, being fed downwards by a gravity weight, at the same time making firm electrical contact against the nozzle; thus the metallic strip through the carbon as used in some other flame lamps is rendered quite unnecessary. In the Sunræ flame lamp, too, shunt coils are entirely dispensed with, the carbon feed being quite independent of the electrical regulation of the lamp.

Another feature of the Sunræ flame lamp is a special patent form of ventilating corona, by means of which the carbon fumes are prevented from being deposited on the globe. No inner globe is used, as is common in other flame lamps, and which in practice is frequently found to become obscured and permanently discoloured, requiring renewal at frequent intervals. We give illustrations of two different types of this lamp, the longer burning pattern being built principally for street, railway, factory and similar general lighting, and the shorter pattern for purposes where long burning life is not of first importance.

We are informed that during past years large numbers of these lamps have been supplied to the Admiralty and also to some of the largest shipyards in this country, where battleships of the "Dreadnought" type are being built, which in itself is speaking testimony to their excellence.



Two Types of Davy Lamps.

Of Davy enclosed lamps it is unnecessary to make much mention as the number of years these lamps have competed successfully in the market proves their merit and good qualities where a thoroughly reliable and well-manufactured article is required. We learn that the manufacturers have recently supplied close upon 400 lamps of this type to the London & South-Western Railway for the lighting of their new works at Eastleigh.

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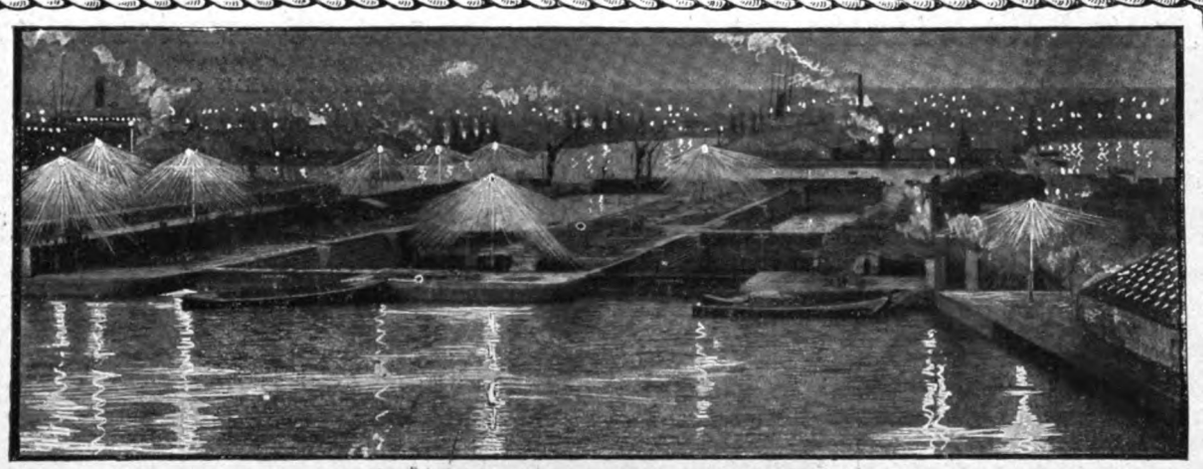

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ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,689. [No. 25. Vol. LXV.] **FRIDAY, SEPTEMBER 30, 1910.** PRICE SIXPENCE (by post. 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Street Illumination.

ON another page we give an abstract of a Paper by Mr. A. J. SWEET in which he deals with street illumination as affected by glare. Although we do not care to accept without further proof the author's view as to the effect of glare upon the eyes and the reason why it causes discomfort, the conclusions at which he arrives are of considerable interest. He remarks that if a given relative illumination (as regards maximum and minimum) is to be obtained, the ratio of the distance between adjacent light units to the height of the light unit above the street must be a constant quantity, which he designates M. He finds that in America the value of M ranges from 5 up to 31, and that the value of M=15 can probably be taken as the most representative one in American practice. The great importance of this ratio does not seem to be appreciated as it should be. As the intensity of light units is increased to meet the popular demand for greater illumination it should be borne in mind that the same result is obtained with the more intense units when placed at a further distance apart, provided they are fixed at a greater height above the ground. Mr. SWEET comes to the conclusion that the best value for M is 4. This certainly seems to give an ideal illumination, but it is one that will not be reached except in large towns where the lamps are placed at a considerable height and relatively close together. Fortunately, with this value of M, it is quite possible to obtain lamps with polar curves giving only a low ratio of maximum to minimum illumination.

IN discussing the effect of glare the author has made a number of measurements, the basis of which is not entirely clear. Assuming this basis to be satisfactory, the results obtained are valuable. Thus, at an ordinary distance the presence of a light source, even of very low candle-power, in the centre of the field of vision causes a tremendous drop in visual efficiency, while a considerable increase in distance between the eye and the object produces only a small decrease in the glare. The author finds, however, that at a certain angle depending on the candle-power (the angle varying approximately between 22 deg. and 26 deg. from the line of vision) the glare effect reaches zero, although the light source is still within the field of vision. So far as we are aware this result is not in accordance with those of certain other observers. Mr. SWEET concludes that the effect of glare on the retina is local and does not cause a disturbance when the spot affected is sufficiently separated from the retinal image of the object under inspection. Based on these observations, Mr. SWEET concludes that the light instrumental in causing glare comes entirely from those rays whose polar angles are above 60 deg. with the nadir. Consequently, the light between the angles of 60 deg. and 80 deg. should be partially or wholly suppressed. There is a good deal of truth in the statement that if the glare limit is exceeded at all it will almost of necessity be exceeded excessively, and we fear that in many cases glare must remain with our present systems of illumination, for the simple reason that the local authorities concerned would not be able to afford its elimination. There is also much truth in the statement that the ordinary citizen of to-day uses, in his ignorance, the very defect itself—namely, the glaring character of street illumination—as a measure of its excellence. Possibly this is why our gas friends place horizontal reflecting surfaces above their mantles.

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Tramway Comparisons.

MUNICIPAL tramway committees have frequently been criticised for handing over to the rates considerable sums of money from the profits of their tramway undertakings, sometimes without having made adequate provision for depreciation. The desirability of paying over large amounts for the relief of the rates, even where this is amply justified by the financial position of the undertaking, is open to question. No two opinions, however, can be held as to the necessity for a reserve fund sufficient to meet future renewals of track and plant, although opinions may differ as to what allowance can be considered adequate for this purpose. In this connection comparisons between the allowance made in the case of municipal undertakings and that in company-owned tramways can scarcely be regarded as in any way convincing. In his Presidential Address last week to the Municipal Tramways Association, Mr. C. J. SPENCER mentioned that whereas in the case of municipal tramway undertakings a total sum equivalent to 3½ per cent. of the whole capital outlay was paid last year into the sinking funds and reserve and renewals funds, tramway companies only put aside for depreciation, obsolescence, &c., an amount equal to 1·05 per cent. of their capital. On these figures Mr. SPENCER considered that municipal tramways were, as a whole, commercially sound.

WE think, however, that, apart from the fact that a sinking fund should not be compared with a provision for depreciation, such comparisons by no means justify the policy of many municipal authorities in regard to depreciation and reserve funds. Municipal trading should be as little speculative as possible; and it is therefore desirable that municipalities should err on the side of an ample provision for reserve and depreciation in the case of their electricity and tramway undertakings. Unfortunately, however, this is not often the case. From our analysis of the Bradford Corporation tramway accounts elsewhere in this issue, it will be seen that whereas a sum of £20,000 has been handed over for the relief of the rates, the contribution to the reserve and renewals fund amounts to £12,365. This latter sum only represents a little over 0·5d. per car-mile, and can scarcely be regarded as in any way an adequate provision for depreciation, especially as many other undertakings are now finding it desirable to provide for possible future requirements on a much higher scale than this figure. In support of the adequacy of the present contribution, Mr. SPENCER, in his annual report, compares the provision of £12,365 for reserve and renewals with the sum of £8,708 set aside last year in the case of a company-owned undertaking of similar size and working under similar conditions to those at Bradford. This, however, cannot be regarded as justification of the policy adopted, and we think that the Committee would be well advised in future to build up the reserve and renewals fund, which at present only amounts to £44,006, the capital expenditure totalling £930,114, even if this policy involves a certain amount of unpopularity, due to the ratepayers not benefiting to so large an extent from the tramway "profits." With the above exception, the annual report of Mr. SPENCER is very satisfactory, and shows that good progress is being made by the Bradford tramways, the success of "through-running" between Bradford and Leeds being particularly noteworthy.

Town Planning and Tramways.

THAT a municipality should not, as a general principle indulge in speculative transactions will, we think, be universally admitted, and we fear that if the suggestions put forward by Mr. A. BAKER, in his Paper read last week before the Municipal Tramways Association, were extensively adopted, they might lead to unfortunate results for the ratepayers in the case of a too enterprising local authority. The suggestion to which most exception is likely to be taken is that in regard to speculation in land outside the municipal boundary; but the question as to whether a tramway should be laid down when the prospective traffic is insufficient to make the undertaking a financial success, at any rate in its early days, will also certainly arouse much discussion. There is no doubt that the housing problem has been rendered easier of solution by the provision of cheap tramway facilities, and the tendency for suburban districts to develop in proximity to electric tramway routes is very marked at the present time; but proposals for the extension of tramways into practically undeveloped localities would require most careful consideration, and we think that in such cases a railless traction scheme should undoubtedly be preferred. If future developments warranted the laying down of a tramway track the railless vehicles could then be transferred to other routes. In regard, however, to the benefits likely to result from a well-planned scheme of thoroughfares with a minimum width of 91 ft., there can be little diversity of opinion, and the location of the tramways in the centre of such a road would undoubtedly facilitate the maintenance of a much higher average speed. In this connection, the suggestion of one speaker during the discussion on Mr. BAKER'S Paper, that in the ideal scheme the tramways should run up and down the sides of the main road, will not, we think, meet with much support, for even with cars running at the usual speeds a tramway track close to the footpath is dangerous, to say nothing of the inconvenience caused to vehicles standing at the side of the road. It is certainly important, however, that tramway requirements should be taken into account in the laying out of future roads, for the capital expenditure which has been incurred in widening streets and altering curves has often proved a considerable burden to both municipal and company tramways, more especially to the latter.

Submarine Cable Concession.—H.M. Consul at San José (Mr. F. N. Cox) states that a contract has been made between the Foreign Minister and a *British subject* for the establishment and working of a submarine telegraph cable between Colon and Limon. The concessionaire has the exclusive right for 15 years of working a cable office in the Republic, and during that period may import duty free all materials, instruments and supplies required for use in his enterprise. He is also granted the right to establish one wireless telegraph station in connection with the cable station. Work must be begun within nine months from date of approval of the contract, and be completed within 18 months. The "Board of Trade Journal" states that the name of the concessionaire may be obtained by British firms on application at 73, Basinghall-street, London, E.C.

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Wireless Telegraphy and Kites.—We understand that Mr. Marconi, who is at present on his way to Buenos Ayres, has during his voyage been conducting some interesting experiments on the use of kites in wireless telegraph work. From a message that has been received at the offices of the Marconi Wireless Telegraph Co. in London, it appears that, using a kite to support the antenna, Mr. Marconi has been able to transmit and receive "strong" signals over a distance of 3,500 miles. With the apparatus installed on the "Principessa Mafalda," of the Italian Lloyd line, the ship on which Mr. Marconi is travelling, the maximum range during daylight would be, using the mast to support the antenna, about 1,500 miles. It will thus be seen that a distinct increase in range can be obtained, even taking into account the fact that a special valve receiver was being used (this would probably increase the range about 10 per cent.), and that Mr. Marconi's well-known skill as an operator was applied. We understand that the experiments will be continued, though they were temporarily suspended owing to a high wind making it difficult to keep the kites up. The possibility of thus using kites seems to point to an easy way of increasing temporarily the range of the ship's instruments in case of need.

Trunk Line Electrification in Austria-Hungary.—In a Paper read at the Berne International Railway Congress, an abstract of which appears in the "Electric Railway Journal," A. Hruschker, of the Government Railway Engineering Department, presented statistics on electric traction developments in Austria-Hungary. These show that the following electric trunk line railways were in operation at the end of 1909 :—

Line.	System and voltage.	Length Opened in miles.	in
Tabor-Bechyn	Three-wire c.c. 700 volts	14·50	1903
Innsbruck-Fulpmes	Single-phase, 2,500 volts	11·35	1904
Bludenz-Schruns	Continuous, 500 volts	8·06	1905
Vienna-Baden	Single-phase & 550 volts c.c.	17·95	1907
Bruneck-Sand	Continuous, 500 volts	9·52	1908
Neumarkt-Waizenkirchen	„ „ „	10·06	1908
Trient-Malé	„ 800 „	37·25	1909
Total		103·69	

In addition there are some 16 extended electric tramways and mountain railways, aggregating about 94 miles in length. Two additional trunk lines are under construction for electrical working, aggregating 87·6 miles, viz., Vácz-Rákospalota, 31 miles, being equipped with 15 cycles single-phase at 10,000 volts, and St. Pölten-Mariazell-Gusswerk, 50 miles, 2 ft. 6 in. gauge, being equipped with 25 cycles single-phase at 6,000 volts. In 1906 a branch of the Austrian Government State Railways was formed to study the subject of the electrical equipment of the different lines. An examination of the available water powers was made and 11 schemes, with an aggregate capacity of 140,000 H.P., were worked out. Calculations were also made of the application of this power to 2,722 miles of track. An official report on the results will appear shortly. Those lines to which especial attention has been given are in the neighbourhood of Trieste and Innsbruck. While no official decision has been reached in the selection of a system the speaker favoured the single-phase. In this connection he stated that the only other system worth serious consideration was the three-phase, whose principal advantage was the smaller weight of car for the same output. Plans have already been prepared by the Austrian Government engineers for the equipment of certain of its railway lines with the single-phase system at 15 to $16\frac{2}{3}$ cycles and 10,000 volts. The Hungarian Government has also considered electrification. It has plans prepared for the equipment of one line with three-phase equipment and has decided to use single-phase on another, but has not definitely settled upon any standard system.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910
Tourane—Amoy	Sept. 25, 1910

The Late Harry W. Cox.—A grant of £150 has been made by the Prime Minister to Mrs. Cox, widow of the late Mr. Harry W. Cox, whose death resulted from his pioneer work on X-rays.

Trans-Atlantic Cables.—Two notices appeared in Tuesday's "Gazette" to the effect that application has been received by the Board of Trade from the American Telegraph & Cable Co. and the Western Union Telegraph Co. for the renewal of their licence to maintain and use upon the foreshore and bed of the sea at Sennen Cove, Cornwall, two telegraph cables from America; and that an application had been received by the Board from the Western Union Telegraph Co. for a licence to lay down and maintain upon the foreshore and bed of the sea at Sennen Cove, Cornwall, two additional telegraph cables from America. All persons interested are to take notice that 28 days after September 24th the Board will proceed to consider the applications, and in the meantime they will receive any objections which may be made thereto.

Magnetic Alloys Formed from Non-Magnetic Materials.—At the meeting of the Institute of Metals at Glasgow last week a Paper dealing with investigations carried out chiefly on ternary alloys consisting of copper, manganese and one of the elements aluminium, tin, bismuth and antimony, was read by Mr. A. D. Ross. Details were given as to the method of preparing, analysing and testing the materials. All the groups showed fair magnetic quality, but the most interesting were the ternary alloys containing aluminium and tin respectively. Some of the former were, under small magnetising forces, much more magnetic than cobalt, and had little coercive force. The tin alloys were less permeable, but exhibited greater hysteresis. Most of the alloys improved in magnetic quality when they were annealed for a short time at a moderate temperature—150°C. to 200°C. Prolonged annealing invariably had an adverse effect, the hysteresis loss increasing rapidly with time. The behaviour of the alloys on cooling to the temperature of liquid air was peculiar and characteristic. For low and moderate fields the process resulted in general in a decided increase in susceptibility, whereas almost all other magnetic materials were rendered less susceptible. Quenching the alloys at a red heat diminished the permeability. The point of greatest interest was that it also resulted in greatly reducing the hysteresis loss. In fact, nothing was known which approached closer than a quenched copper-manganese-aluminium alloy to the ideal magnetic material which should be strongly magnetic and without hysteresis. The quenched alloys were in a somewhat unstable condition, their permeability gradually increasing towards its former value, but with little or no augmentation of the coercive force. These alloys, while of great theoretical interest, have not yet found practical application. They are hard and brittle, very sensitive to thermal changes, somewhat unstable and apt to segregate. The magnetism of the copper-manganese-aluminium alloys is apparently due to the formation of solid solutions of the compound Cu_2Al with Mn_2Al, or possibly with manganese. Similar solid solutions probably occur in the other ternary magnetic alloys.

Electric Railway for Ore Transportation in Brazil.—According to the "Electric Railway Journal," construction work was recently begun on the first of two 25,000 kw. hydro-electric generating stations on the tributaries to the Doce River, in Brazil, which will furnish energy for an electric railway, 400 miles in length, between Victoria and Itabira, in the State of Minas Geras. The region penetrated by the new electric railway is a mining country producing large quantities of iron ore, the transportation of which to the coast will be the principal business of the new line. In building the line, about 250 miles of existing narrow-gauge steam roadbed will be utilised, the track being converted to standard gauge. Our contemporary states that the railway is being constructed by a British company which owns the iron ore workings, and that the electrical equipment will be of English manufacture.

The Operation of Electrical Commercial Vehicles.—On August 12th 69 motor trucks of all sizes, powers and types participated in the "North American's" commercial motor

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vehicle run from Philadelphia to Atlantic City, *via* Camden, and return. The "Electrical World" mentions that nine of the vehicles were electrically driven, and these, although competing out of their class, and taken from active service without special preparation, made several good records. The distance between Camden and Atlantic City is 60 miles, and the return run was made on August 13th. According to the rules governing the contest, each truck was weighed-in, both empty and full, and in order to facilitate matters three weighing-in stations were established. The schedules of speeds established were as follows: Class A, 1½ tons and less, 12 miles per hour; class B, 3,001 lb. to 5,999 lb., 10 miles per hour; class C, 3 tons and over, 8 miles per hour. In reckoning the results a penalty of one point was imposed for every half minute a car departed from the schedule, and the awards were based on the ability of cars to keep to the time schedule and on the smallest consumption of energy. The actual load carried by the vehicle over and above its own weight formed the basis of the computations. The energy consumed was charged at a rate of 2d. per kw.-hour. The results were as follows:—

CLASS A.

Type.	Weight empty, lb.	Load carried, lb.	Penalties.	Kw-hrs. used.	Cost per ton-mile.
Commercial truck	5,350	2,000	6	41·830	0·65d.
Commercial truck	5,050	2,000	14	38·399	0·60d.
Commercial truck	3,650	1,500	0	30·268	0·65d.
*General vehicle	4,980	2,000	8	30·824	0·51d.

CLASS B.

*General vehicle	6,700	4,000	15	42·336	0·35d.
Commercial truck	6,540	4,000	93	57·935	0·45d.
Commercial truck	7,200	4,000	144	†	†

CLASS C.

*Commercial truck	10,250	7,000	0	83·190	0·35d.
General vehicle	9,562	7,000	30	79·776	0·40d.

* Winner. † Meter defective.

The nine vehicles came within 100 per cent. of each other on the cost per ton-mile, while those of a single manufacturer came within 43 per cent. on the cost per ton-mile. The gasoline vehicles showed a difference of 867 per cent. Gasoline vehicles of the same manufacture showed a difference of 143 per cent. The lowest cost per ton-mile for the gasoline vehicles was 0·35d. and the highest 3·4d. Every electric vehicle finished the run, whilst 11 per cent. of the gasoline vehicles and seven trucks failed to finish.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Messrs. W. H. Eccles and A. J. Makower contribute an article on "The Efficiency of Short-Spark Methods of Generating Electrical Oscillations."

We give abstracts of the remaining Papers read at the Annual Conference of the Municipal Tramways Association, at Bradford, last week—viz., "The Comparative Durability of Brake Shoes and Tyres," by J. W. Dawson; "Tramways in Relation to Town Planning," by A. Baker; and a report on "The Lubrication of Car Bearings," the last being the work of a sub-committee of the Association.

We give an abstract of a report on "The Use of Meters on Tramcars," by Mr. Battes, of the Frankfort tramways, read at the recent meeting of the Union Internationale de Tramways et de Chemins de fer d'Intérêt local.

A new system of car lighting has been introduced by Messrs. C. A. Vandervell & Co.

We give an analysis of the accounts of the Bradford Corporation tramways for the year ended March 31st last.

Acton Council have referred back a recommendation for the transfer of their electricity undertaking to the Metropolitan Electric Supply Co. Particulars of the proposed transfer are given in another column.

The Electricity Committee of Leicester Corporation have finally decided not to appeal against the recent injunction restraining them from carrying on their electric wiring and fittings department.

Rotherham Corporation have decided to promote a bill to authorise them to equip railless trolley omnibuses, and for additional powers for electricity supply, &c.

A 50-years' concession for the supply of electricity in Constantinople has been awarded to a group composed of Hungarian and French syndicates.

At the meeting of Dick, Kerr & Co. yesterday (Thursday) the chairman, Mr. John Kerr, said the past year's trade had been disappointing, but a period seemed at hand when there would be great expansion in electrical work at home and abroad. The Company have arranged to manufacture steam turbines under the Bergmann patents.

INSTITUTIONS AND SOCIETIES.

Municipal Tramways Association.—At the annual general meeting held at Bradford on Friday last, Mr. J. Dalrymple, general manager of the Glasgow Corporation tramways, was elected president, and Mr. H. E. Blain, of West Ham, vice-president. Next year's meeting will, therefore, take place at Glasgow.

Victorian Institute of Electrical Engineers.—The first annual dinner of the Victorian Institute of Electrical Engineers took place on August 19. Among the visitors were Dr. Alex. Graham Bell and the Australian Postmaster-General, and their health was proposed by the president, Mr. A. H. Jackson.

Dr. BELL, in replying, gave some interesting reminiscences of the history of the telephone, and said the first telephone was erected by him at Brantford (Ont., Canada) in 1876. The wire was tacked along a wooden fence from his father's house to the corner of Mount Pleasant-road and there connected with a telegraph wire leading into the town. A remarkable occurrence took place in 1877 when the first commercial telephone was being put up. Some friends of his at Rhode Island put up a telephone from one house to another as an experiment, and persons who listened at one end of the line heard a concert which was afterwards found to have taken place in New York City, 200 miles away.

The POSTMASTER-GENERAL (Mr. Thomas), in proposing "The Electrical Profession," said he had the pleasure lately of fixing matters so that if the Government were in power for the next two years it would be found to have spent more money on telephones than had been spent in Australia during any previous two years. He hoped a great deal of telephone material would be produced in Australia before long. He was determined to make their telephone service the best that could be got.

The Association of Mining Electrical Engineers.—A special meeting of engineers interested in the application of electricity to mining will be held at the Royal Hotel, Dunfermline, to-morrow (Saturday) at 6 p.m. The object of this meeting is to consider the inauguration of a branch of the above Association in the East of Scotland, and to appoint a local president, a committee and other officers, in order to further the objects of the Association in that district. A representative of the council from one of the other established branches will attend the meeting to give any information or particulars as to the work of the Association.

Smithsonian Institution.—The general appendix to the annual report for the year ended June 30, 1908, of which we have recently received a copy, contains a selection of miscellaneous memoirs of interest to the collaborators and correspondents of the institution, teachers, &c. Among the many Papers and lectures reprinted we notice the following of electrical interest: "Wireless Telephony," by Prof. R. A. Fesseaden (a Paper read two years ago before the American Institute of Electrical Engineers); "Phototelegraphy," by H. Armagnat (translated from the "Revue Scientifique"); "On the Light thrown by Recent Investigations on Electricity on the Relation between Matter and Ether," by Sir J. J. Thomson (the Adamson lecture delivered at Victoria University, Manchester, in November, 1907); "The Life and Work of Lord Kelvin," by Prof. S. P. Thompson, (the first Kelvin lecture, delivered before the Institution of Electrical Engineers); and "The Work of H. Becquerel," by A. Broca (translated from the "Revue Générale des Sciences Pures et Appliquées").

ARRANGEMENTS FOR THE WEEK.

MONDAY, Octo er 3rd

SOCIETY OF ENGINEERS.

7:30 p.m. Meeting at Caxton Hall, Westminster. Paper on "Current Professional Topics," by Mr. H. C. Adams.

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BRADFORD CORPORATION TRAMWAY ACCOUNTS.

The tramways undertaking of the Bradford Corporation, although not one of the largest, is certainly one of the most interesting in this country. This partly arises from the fact that the undertaking has always been to the fore in adopting innovations, both as regards apparatus and methods of working. Thus, it will be remembered that the problem of adapting a car to operate on two different rail gauges was first successfully solved in connection with the "through service" between Bradford and Leeds. Again, the Corporation have applied for powers to adopt the trackless trolley system on a route from Laisterdyke to Dudley Hill, as a result of the favourable report of the deputation of the Tramways Committee that paid a visit to the Continent last December to inspect the various systems of railless traction. The advantages of car meters for checking the energy consumption, of a parcels department, and of electrically operated point controllers were also early appreciated by the management; whilst the practice of carrying blind persons free of charge is a striking innovation.

The annual report for the year ended March 31, 1910, of Mr. C. J. Spencer, general manager of the undertaking, records greatly improved results compared with those of a year ago. This will partly be evident from the fact that 50,518,813 passengers were carried, compared with 47,660,011 in 1908-9, an increase of 6 per cent. The total revenue amounted to £259,696, or £15,462 more than in the previous 12 months; whilst, as the car-mileage only increased by 1·1 per cent. a much higher revenue per car-mile was obtained. The total number of car-miles was 5,436,529, the number of miles of route being 54·8.

The traffic mentioned above represented 149 journeys per annum per head of population, the average fare paid per passenger being 1·167d., and the average revenue per car-mile amounting to 10·977d., as against 10·456d. a year ago. A feature of the traffic records is the large number of "through tickets" between Bradford and Leeds. "Through running" only commenced on June 7, 1909, but 105,569 6d. "through tickets," and 5,054 children's 3d. tickets were issued by the Bradford tramways department, and 107,463 by the Leeds tramway department. The service has proved of great public convenience, and has worked very smoothly. As 8d., 10d., and 1s. tickets are also issued over the Yorkshire Woollen District Tramways, it is perhaps surprising that the average fare per passenger is not greater than 1·167d. The 1d. fare, however, is the controlling factor, about 80 per cent. of the total traffic coming under that heading. The average distance covered by this fare is 1·61 miles in the case of ordinary passengers, and 4·03 miles on all cars before 8 a.m. An interesting feature of the statistics is that 43,852 blind passengers were carried free of charge.

In regard to power consumption, 10,076,417 units were used, representing 1·85 units per car-mile, compared with 1·88 units in the previous year. The cost of the power worked out at 2·073d. per car-mile. The average number of cars in use for a 15-hour day was 136, the total number of cars in stock being 239.

Turning now to the accounts it is seen that the total expenditure amounted to £170,699, compared with £170,196 in 1908-9. Against this, however, must be placed an increase of £15,462 in the receipts, so that a net profit of £32,365 is shown for the year's working, as compared with £15,318 a year ago. The contribution of £20,000 to the relief of the rates, however, may seem open to criticism. From the point of view of whether a sufficient sum is being set aside for depreciation, Mr. Spencer includes in his report an extract from the last published Board of Trade returns the figures relating to a large successful tramway company in the South of England working under similar conditions to those at Bradford and of similar size. The figures are set out herewith.

Mr. Spencer says it will be noted that with receipts approximately the same and with very similar expenditure, the gross profit of each undertaking is fairly comparable. In the case of the Company Tramway, £76,639 of the gross profit of £85,347 is disbursed in dividend, the balance of £8,708 being passed forward to the reserve fund for depreciation purposes. In the case of Bradford, after the gross profit of £91,613 is arrived at, £22,407 is paid for interest, which in some senses represents dividend, £12,365 is passed forward for depreciation, and in addition thereto £30,454 is paid to the Sinking Fund and a sum of £20,000 is paid over in relief of rates. Mr. Spencer remarks: "It is obviously fair to assume that if the large Company concern mentioned, with a similar capital and similar conditions, is adequately meeting depreciation with £8,708, then Bradford must be exceedingly generous when it puts by for the same purpose £42,819." Comparisons of this nature, however, we consider are not very convincing.

	Bradford figures.		Company's figures.
Revenue	£262,311	..	£263,689
*Expenditure	170,699	..	178,342
Gross profit (and interest on net revenue)	91,613	..	85,347
Interest	22,407		Dividend 76,639
Repayment of debt, or sinking fund	30,454	..	nil.
Rent of leased lines, &c.	4,137	..	nil.
Reserve, including Depreciation and Renewals fund.	12,365	..	8,708
Other matters, including income tax, balance carried forward, &c.	22,250	..	nil.

The total working expenses per car-mile work out at 7·149d. as against 7·221d. last year, and are the lowest on record for the undertaking; whilst the figure of 10·977d. for traffic and sundry revenue is the highest. This condition of affairs is certainly most gratifying. In regard to details of the expenses, it will be noted that only one item in the traffic expenses shows an increase, namely, the cost of cleaning, salting and sanding track. The small increase is wholly accounted for by the severity of the winter and the heavy expense incurred in keeping the track open for traffic during the snowstorms. Mr. Spencer points out that this is a great convenience to the public generally, as the tramways open up the main routes for vehicular traffic.

In regard to the parcels department, this has earned £8,169 as against £7,350 in the previous year, the net profit being £1,741 and £1,028 respectively. The number of parcels handled was 675,719, an increase of 70,406 over that of 1908-9.

We give below an analysis of the accounts for the year ended March 31st last, together with the cost per car-mile, the latter figure also being tabulated for the previous year to facilitate comparisons:—

		Cost per car-mile. 1909-10.	1908-9.
Traffic Expenses.			
Superintendence	£331	0·01d.	0·01d.
Wages of drivers and conductors	44,384	1·96d.	1·97d.
Wages of other traffic employés	2,425	0·11d.	0·11d.
Cleaning and oiling cars	6,154	0·27d.	0·28d.
Cleaning track	2,225	0·10d.	0·09d.
Fuel, light and water for depôts	2,032	0·09d.	0·10d.
Ticket check	2,927	0·13d.	0·13d.
Uniforms	1,980	0·09d.	0·09d.
Miscellaneous	1,542	0·07d.	0·07d.
Total Traffic Expenses	£64,000	2·83d.	2·85d.
General Expenses.			
Salaries	£2,779	0·12d.	0·12d.
Administration and establishment charges	750	0·03d.	0·03d.
Store expenses	366	0·02d.	0·02d.
Rents	758	0·04d.	0·04d.
Rates and taxes	8,840	0·39d.	0·44d.
Printing and stationery	550	0·02d.	0·02d.
Fuel, light and water for offices	242	0·01d.	0·01d.
Compensation	1,740	0·08d.	0·09d.
Insurance	257	0·01d.	0·01d.
Miscellaneous	2,278	0·10d.	0·08d.
Total General Expenses	£18,560	0·82d.	0·86d.

* The expenditure for Bradford does not include renewal cost of permanent way. The Board of Trade figures do not show whether the Company's return does or not.

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		Cost per car-mile. 1909-10.	1908-9.
Repairs and Maintenance.			
Permanent way	£7,295	0·32d.	0·30d.
Electrical equipment of line	4,514	0·20d.	0·19d.
Buildings and fixtures	655	0·03d.	0·03d.
Tools and sundry plant	334	0·02d.	0·02d.
Cars	19,544	0·86d.	0·85d.
Other rolling stock	84	0·00d.	0·00d.
Total Repairs and Maintenance	£32,426	1·43d.	1·39d.
Power Expenses (1¼d. and 1⅞d. per unit)	£46,965	2·07d.	2·12d.
TOTAL WORKING EXPENSES (*ex.* capital charges, &c.)	£161,951	7·15d.	7·22d.
Parcels department	£6,330	0·28d.	0·28d.
Miscellaneous (motor garage, &c.)	£2,418	0·11d.	0·10d.
Capital Charges, &c.			
Interest	£22,407	0·99d.	1·06d.
Sinking fund	30,454	1·34d.	1·35d.
Income tax	2,250	0·10d.	0·12d.
Rent of leased lines	4,137	0·18d.	0·19d.
Total Capital Charges, &c.	£59,248	2·61d.	2·72d.
TOTAL EXPENSES (*inc.* capital charges)	£229,947	10·15d.	10·32d.
Revenue.			
Traffic	£245,682	10·85d.	10·33d.
Advertising on cars	2,493	0·11d.	0·11d.
Parcels	8,169	0·36d.	0·33d.
Miscellaneous	3,367	0·14d.	0·13d.
Bank interest	2,601	0·12d.	0·10d.
TOTAL REVENUE	£262,312	11·58d.	11·10d.
Balance (surplus)	£32,365	1·43d.	0·68d.

Of the balance of £32,365, £12,365 is appropriated for the reserve and renewals fund, whilst £20,000 is handed over for the relief of the City rate. A year ago, the whole balance of £15,319 was appropriated for reserve and renewals.

The capital expenditure during the year amounted to £6,599, the total expenditure to March 31, 1910, being £930,114. The various items comprising the total are as follows :—

Permanent way	£583,718
Electrical equipment of line	66,623
Land	14,358
Buildings and fixtures	65,604
Workshop tools and sundry plant	7,504
Cars	153,203
Other rolling stock	3,056
Miscellaneous equipment	955
Office furniture, &c.	750
Parliamentary expenses	5,511
Suspense accounts—cables, &c.	28,832
	£930,114

THE COMPARATIVE DURABILITY OF BRAKE SHOES AND TYRES.*

BY J. W. DAWSON.

(Assistant Engineer, Bradford Corporation Tramways.)

Summary.—The author gives particulars of tests on brake shoes, to ascertain the durability of the various types and their wearing effect upon steel tyres.

Many opinions have been put forth respecting the wearing effect upon steel tramway tyres by brake shoes. Until quite recently no systematic tests appear to have been carried out to demonstrate the relation between the material of the shoe and its effect upon the tyre, and to indicate which type of shoe should prove most economical in use. The amount appearing in car repair and maintenance costs for the upkeep of brakes and wheels is quite sufficient to warrant a very close consideration of the inter-relation of these two indispensable parts of the equipment.

The investigations recorded in this Paper were undertaken with the object of ascertaining the comparative durability of the various grades of brake shoes used on tramcars in this country, together with their wearing effect upon steel tyres, recording at the same time any observed features or properties of the shoes under test which appeared to have a bearing upon the durability of the shoes and tyres. Twenty different grades of shoes have been tested (particulars of each are given in the Paper) and were chosen to cover the range of shoes in actual use in this country.

* Abstract of a Paper read last week at the Conference of the Municipal Tramways Association.

Service Tests.—Comparison of the life of brake shoes and tyres on one tramway with those obtained on other tramway systems is of very little value, so many factors operating which entirely vitiate the results, such as difference in gradients, nature of the road grit, track brakes, speed, average number of stops per mile, use of rheostatic or magnetic brakes for service stops, &c.; but comparison of various grades of shoes can with advantage be carried out on the cars of any one system. The results will not, of course, be of quantative accuracy, but will give an indication of the difference between, say, a standard brand of shoe and other types used at the same time. For purpose of comparing results obtained with shoes on tramcars under service conditions with those obtained in the works laboratory under uniform conditions, tests have been made by this method. In service tests one particular make of shoe was adopted as the standard for comparison. One standard shoe and one with which it is to be compared were fitted to the wheels at one end of the car, and similar shoes fitted at the other end, the same grade shoe being at diagonal positions on the truck, one of each grade of shoe thus acting upon each axle and making the retarding effort per axle equal, the shoes being accurately weighed before fitting. The car is then run until some of the shoes are worn out; they are then taken off and again weighed. The amount of metal worn from the test shoes to that worn from the standard shoes will be in inverse proportion to their durability when run with equal pressures upon each shoe; but it must be particularly noted that the shoes with the highest coefficient of friction will have done the most work, so this method of testing is decidedly favourable to shoes having the lowest coefficient of friction. If the circumferences of the tyres are measured before and after the test, it will be ascertained which shoes have caused the greatest tyre wear. The average of measurements from several cars should be taken. Results obtained by this method are shown in the table herewith.

Service Tests of Shoe and Tyre Wear.

	Wheels. Miles per ⅛th radial wear.			Shoes. Miles per lb.		
	Test shoe.	Standard.	Ratio.	Test shoe.	Standard.	Ratio.
Cast white iron	6,060	10,954	0·55	966	447	2·16
Cast iron with white iron inserts	12,665	9,900	1·30	296·7	722	0·41
Cast soft grey (hardness 41)	14,307	5,830	2·45	214	834	0·26
Cast soft grey (hardness 46)	14,630	8,955	1·63	181	5,332	2·94

Comparison of these tests with those obtained with the test apparatus under laboratory conditions proves that the results obtained on the latter correctly indicate the comparative wearing properties of shoes and tyres when run under ordinary service conditions, with the exception of the first, of which the characteristics of the metal appeared to produce seizing readily. Examination of the table shows very clearly that by this method of comparison the life of the standard shoe varies with the coefficient of friction of the shoe with which it is run. Differences of tyre wear by various grade shoes are very noticeable. The author is of opinion that one cause of the differences in wheel diameters, so prevalent on tramcars, may be the use of brake shoes of uneven grades.

Another method is to fit up a number of cars with test shoes, keeping record of their mileage and loss in weight, also records of standard shoes on similar cars running concurrently on the same route and schedule if possible. This test, to be of value, should extend over a long period, in order that running conditions may reach an average.

Adjustable Leverage.—To obtain accurate comparative results of shoe wear and differences of tyre wear, it is absolutely necessary that each shoe should give the same retarding effort. To do this the pressure applied to each shoe must be in inverse proportion to its coefficient of friction. This has been secured by means of the brake gear designed by the author and illustrated on p. 1011. In use, shoes of equal grade are fitted on each pair of wheels. The leverage ratio of the brake gear is adjusted by means of the links between the supplementary brake beams, in proportion to the respective coefficient of friction of the shoes, thus obtaining from each pair of shoes the same retarding effort.

To form an accurate estimate of the value of a shoe from results of road tests is practically impossible. To obtain standard and comparable results it becomes necessary, therefore, to carry out the tests with a true wheel revolving at a constant rate of speed with steady braking load, and a uniformly clean surface. While these conditions are far removed from those existing on the road, the author submits that the results are quite in accordance with those

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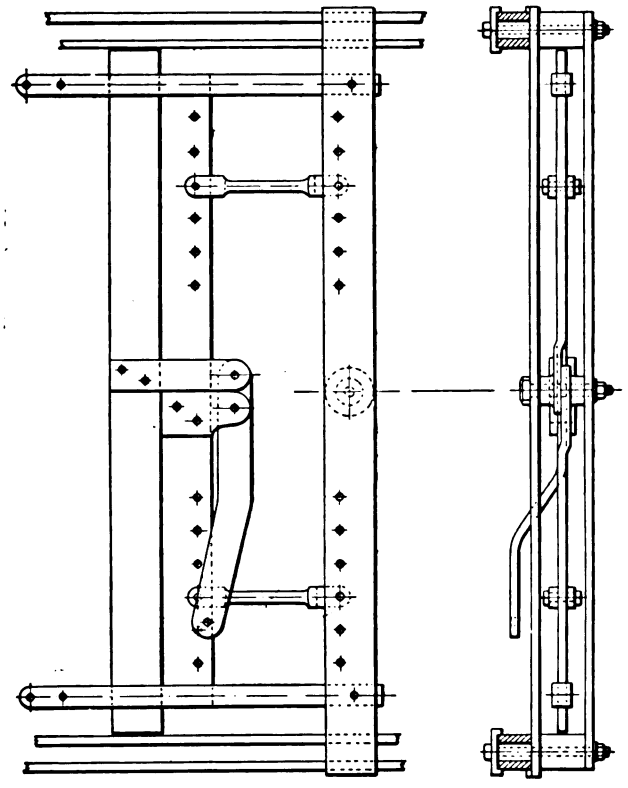
obtained on service cars, and have the great advantage that shoes may be tested at any period of their life—their characteristics and subsequent value determined in a few hours.

Laboratory Tests.—For the purpose of carrying out tests under known conditions, a 30 H.P. tramways motor has been installed, driving through the usual single reduction gear an axle upon which is mounted a wheel-centre with steel tyre. The shoe is pressed upon the wheel by means of a lever carrying at one end a pan, which can be loaded with weights, and at the other an adjustable radius rod and a dynamometer for registering the pull upon the shoe. A pulley running upon the tread of the wheel drives a speed and mileage indicator. (The apparatus is similar to that used in connection with the brake shoe tests for the Municipal Tramways Association Brakes Sub-Committee, and illustrated in their report.)

For measuring tyre wear an apparatus designed by the author is used. It consists of a means for determining the difference of volume reduction over a pre-determined area of the tyre surface, this by calculation giving the total amount of tyre removed. The apparatus comprises a die with means for forcing its inner face to a fixed radial distance from the centre of the wheel, the distance being determined by the outer faces of the die being in contact with two side faces of the tyre. In operation a piece of ductile metal (lead) is placed under the die which is then forced on to a turned face on each



ADJUSTABLE LEVERAGE-RATIO BRAKE GEAR.

side of the wheel, the inner face of the die will thus be a fixed distance from these faces, and the thickness of the lead will be equal to the distance between the inner face of the die and the surface of the tyre, the lead following exactly the conformation of the wheel face. In the die are two small recesses, which form projections on the backs of the test pieces. These projections enter into holes in the block of the cutting die, ensuring accurate cutting of the test pieces. After being removed from the die, the test pieces are cut to 0·5 in. wide, a test piece being taken at the beginning and close of each run. These cut pieces are weighed on a chemical balance, the difference in weight of the two pieces equals the weight in lead of the volume of tyre removed per 0·5 in. of the tyre circumference, and can be calculated into equivalent weight of steel worn off the tyre. The tread portions of the shoes only are used, the flanges being removed in order to prevent uneven readings due to side pressure or wedging of the wheel flange in the groove of the shoe, the wearing face of the wheel being flat, the shoe bearing upon the centre portion only.

The particulars of the test apparatus are as follows:—Wheel tyre 33 in. diameter by 3⅛ in. wide, made from Siemen's open hearth acid steel, test piece from a tyre of the same cast giving 56 tons maximum stress, 14 per cent. elongation in 2 in. 30 H.P. series traction motor, equivalent speeds during tests, 10 miles per hour. The adjustment in the "wet" tests was such as to give a pull on the shoe equal to one-fourth of the retarding force required to balance the acceleration due to gravity of a four-wheel 10-ton car descending a 1 in 9 gradient at a speed of 10 miles per hour. If applied to the car on the level, this would be equal to a retardation at the rate of 3·6 ft. per second per second, and would stop the car from 10 miles per hour in 4·09 seconds in a distance of 30 ft., neglecting any retardation due to the friction of the car or other forces. In the "dry" tests the weight on the shoe was one-half of that used in the "wet" test. The "wet" tests lasted 4 to 5 hours, and the "dry" tests 2 hours.

Mr. J. A. Panton has recently stated in his Paper on "Brake Shoe Standardisation," that "it is cheaper to wear out brake shoes than wheels, which are more costly." The present author finds the cost of shoes and tyres to be about equal, as follows:—

Shoes.

Four shoes, 112 lb., at £8. 10s. per ton*	£0	8	6
Scrap, 56 lb., at £2. 10s. per ton	0	1	3
	0	7	3
Labour, 13 hours at 6d.	0	6	6
Total cost 56 lb. useful metal =	£0	13	9
= Cost per lb. useful metal = 2·94d.			

Tyre.

Weight rolled blank	290 lb.	Cost	£1	12 4
Removed by boring	10 lb.			
Profile turning	5 lb.			
Half life re-turning	20 lb.			
Scrap weight	87 lb.			
Total scrap weight	122 lb. at £3 per ton =		0	3 3·21
Net useful metal	168 lb.		£1	9 0·79
Labour.—(Boring 2¾ hours, turning 2¼ hours, re-turning half life 2¼ hours, shrinking ¼ hour, removing from centre ¼ hour) 7¾ hours at 34s. for 53 hours. =			£0	4 11·64
Gas for heating			0	0 1·5

Standing Charges.

Boring mill or lathe, £250 at 15 years	£16	13	4
Average interest at 4 per cent.	5	0	0
Tools and repairs at 2 per cent	5	0	0
	£26	13	4

Taking 50 weeks at 53 hours, *i.e.*, 2,650 hours. This equals 2·41d. per hour. For 7·25 hours =	£0	1	5·47
Power, five units per hour at 1·125d =	0	3	4·78
	£1	19	0·18

The cost per lb. of useful metal is therefore 2·78d.

Taking cost on the above basis, the value of *shoes and tyres is approximately equal*, and it may be considered immaterial which suffers the greater wear. In works where, by the use of improved machinery, the cost of labour on tyres is very low, it is possible that tyres will be cheaper than shoes, while conversely, where attention has been paid to obtaining the greatest possible wear from brake shoes, and scrap cut to a minimum, they would stand at a lower cost per pound of useful metal than tyres. On the assumption that the cost of shoes and tyres per useful lb. of metal is approximately equal, the combined wear of the various shoes and tyres tested is set out in a table in the Paper.

One of the most striking features is the greater wear with "dry" runs, this being contrary to that obtaining on service cars, and may be accounted for by the test wheel being absolutely clean and free from any material which would prevent the tyre and shoe coming into perfect contact, such as exists on tyres when running on the track, the brake shoe and wheel consequently seize, and, according to their characteristics, one or both suffers increased wear. Although there is this peculiar variation between the "wet" and "dry" conditions of tests, yet an approximation is quite apparent between the two. Considering the impossibility of having "dry" runs on the road track with perfectly clean surfaces, the writer is of opinion that the "wet" test, with its slight yet uniform lubrication by water, offers reliable and uniform means of comparison, and is quite adequate for the purpose of ascertaining the relative values of different grades of shoes.

The tests also show that shoes of the same grade, but from different founders, do not have the same frictional coefficient, durability, or wearing effect upon the tyre. In investigating this difference one naturally considers first their respective hardness, especially in view of the statement of so high an authority as the Brakes committee of the Master Car Builders' Association of America, who state in their official report, 1907: "The frictional effect and wearing qualities of each particular shoe depend entirely upon the proportion and texture of hard and soft material in its make-up." Also the statement of Mr. J. H. Panton in his Paper previously mentioned: "No matter what make of brake shoe is considered, if the proportion of hard and soft metal remains the same, the wearing properties will be

* Average; the figures vary from £5 to £10.

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equal with correspondingly equal wear and friction." To determine the effect of this property the shoes have been tested for hardness by means of a "shore scleroscope." Examination of this property of the shoes demonstrates conclusively that shoes of equal hardness are not necessarily equal in durability, frictional coefficient or effect on the tyre.

Hardness having failed as a criterion of the durability of brake shoes, chemical analysis of the tested shoes, which had given extremes under test of durability and wearing effect on the tyre, was made. Definite conclusions, however, cannot be drawn from chemical analysis only, as it is well known that metals which have the same chemical contents do not necessarily have the same properties.

—	Silicon. per cent.	Sulphur. per cent.	Phosphorus. per cent.	Manganese per cent.
Shoe with minimum wear.....	1·23	0·31	0·67	0·52
Shoe wearing tyre least.....	0·79	0·24	0·02	0·54
Shoe with maximum wear.....	1·92	0·18	0·77	0·74
Shoe wearing tyre most.....	0·18	0·45	0·45	0·15
Shoe giving minimum combined wear	0·67	0·14	0·34	0·65
Shoe giving most combined wear	1·92	0·18	0·77	0·74
Shoe taken as standard for service tests	1·33	0·33	0·63	0·49
	1·14	0·06	0·65	1·73

The author is of opinion that if, in addition to chemical analysis and physical tests, a microscopical research was made of the structure of shoes which have been submitted to service and laboratory tests, the combinations of their constituent parts would be revealed, which would indicate the particular structures producing the different characteristics of the shoes, and probably enable a standard specification to be drawn covering the essentials required for the most economical and efficient grade of brake shoes.

Conclusions.—The conclusions arrived at by the author from the investigations described in this Paper may be briefly summarised as follows:—

The durability and efficiency of a cast-iron brake shoe is (1) a question of chemical composition, (2) the combination of its constituents and methods of founding.

From the cost point of view it matters little which suffers most wear—shoe or tyre. If financial economy is the only consideration, the shoe that gives the least combined wear, per unit of cost, will be the one to adopt.

When it is desirable to economise energy for brake application and to reduce mechanical stresses on brake gear to a minimum, it is obviously best to use a shoe with a high coefficient of friction.

Given correct designs of brake gear with ample stress margin and suitable method of power application, or its equivalent, financial economy can be made consistent with operative needs.

The Paper contains photographs of the apparatus employed, shoe fractures, and the surface of tyres in ordinary service.

DISCUSSION.

Mr. J. M. M'Elroy (Manchester) opened the discussion and drew attention to the principles underlying the matter of car braking. One of the limiting factors in the retardation of a car was the adhesion between wheel and rail; also there was the question of the best method of applying the brakes. He regarded the economic aspect of the problem as subservient to the more important item of efficiency. He wanted to advocate strongly standard specifications for brakes, tyres and rails. Then a uniform basis on which to build up some valuable data would be provided. He wished to include in his remarks some correspondence* which had passed between Mr. Mozley (Burnley) and himself. He also asked for information as to the rise of temperature between block and wheel. He thought that the question of brakes and wheels should be considered quite independently of the Corrugation Committee.

Mr. A. L. C. Fell (L.C.C.) asked for figures which could be used as a standard. He thought that the cost of removing wheels and axles should have been included in the author's figures. The cost of replacing a tyre was higher than that of renewing blocks; the latter could be done at night in the sheds and the car was not put out of commission. He thought that the effects of wear could have been as well obtained by weighing rather than by measurement. Again, tests in actual service were more valuable than laboratory tests. Chilled blocks should, in his opinion, be chilled right through; otherwise a surface chill would wear down in time and the block have to be renewed. As to the varying effects of wear, he asked for information as to the difference in wear of brake blocks over roads paved with wood and granite respectively. With the latter the grit from the setts tended to increase wear.

Mr. H. E. Yerbury (Sheffield) questioned the value of the micro-study of the metal in tyres and brake blocks, mainly on the ground that the factors entering into the problem varied so enormously. The human element also played an important part in the process of chilling. He asked for details as to the best depth of chill to adopt.

Mr. H. Mozley (Burnley) said that in some experiments made with hard brake blocks there had been an undue wear of the tyres.

Mr. G. R. Blackburn (Manchester) thought that wet tests were not altogether reliable, and further, he considered that the microstructure of the metals employed in blocks and tyres could be studied with advantage.

Mr. Dawson (in reply) said there were great difficulties in arriving at a standard shoe. In the matter of brake operation he thought that the leverage was not sufficient. In Bradford the leverage had been increased by 2 to 1 with relief to the drivers. There was no falling off of the coefficient of friction with rise of temperature. Wheels were only removed for re-turning, and in Bradford this was done every two years and in another two years re-tyring was done. He thought that the chief advantage of the microstudies of steel and iron was that the hand of the founder could be forced and he would take greater care in his deliveries. He recommended tramway men to find out what shoe gave them the best results, and when they had found it they should stick to it.

* In this Mr. Mozley calculated the various leverages required to produce the brake block pressures for the various coefficients of adhesion.

REPORT ON LUBRICATION OF CAR BEARINGS.*

A list of questions was compiled and issued by the sub-committee for the purpose of obtaining as much information as possible on the subject of lubrication of car bearings, the object of the sub-committee in compiling these questions being the eliciting of as full information as possible on the following points, viz.:—Class of lubricant used in every case and how applied, first cost and life of medium for conveying lubricant to bearings, cost of lubricant, intervals of inspection and cost thereof, horse power of motors, description of bearings and of what composed, amount of wear in bearings, cost of renewals of bearings, and particulars of cost and life of pinions and gear wheels.

Class of Lubricant.—It is interesting to note that the use of oil appears to be finding more favour, for out of a list of 56 tramway undertakings there are 16 towns using oil throughout, while 33 towns are using oil partially, and only seven towns are adhering solely to grease.

Application.—The method most favoured for application where oil is used is the usual spring pad for the lubrication of armature and suspension bearings. In other cases syphons are used, and in several instances steel and wool waste, moelline, elastic packing and splash system find favour relatively in the order in which they are placed. With regard to axle bearings, pads are used to a very great extent, while Armstrong oilers figure largely, and in some cases wool, hair, and steel and wool packing is used.

Cost of Lubricant.—The price per gallon paid for oil varies from 5½d. to 2s. There are quite a number of undertakings who use oil at a price varying from 8d. to 9d. per gallon, and there is also a fair number who pay 1s., 1s. 2d. to 1s. 6d. and 1s. 9d. per gallon. The highest price paid for grease appears to be 18s. 6d. per cwt., but the usual price appears to be about 12s. 6d. per cwt.

Inspection and Replenishing.—There seems to be a considerable advantage in the use of oil so far as the amount of labour required for inspection and replenishing is concerned. Where grease only is used, the necessary period of inspection appears to vary from once each 24 hours to twice per week. Where oil is used the intervals between examination vary from twice a week to once a week, every four weeks, and in one instance six weeks.

Cost of Inspection and Replenishing.—The replies vary greatly, the lowest cost experienced being 2·29d. per thousand miles, and the highest 2s. 10d.

Bearings.—White metal lined bearings find most favour, but there seems to be a considerable variety in the character of the alloys; only seven undertakings use solid bronze bearings unlined.

Wear.—The information given under this head is considered to be of the utmost importance, and it is interesting to note the number of miles which can be got out of bearings in different towns. As an instance, the following short table of half-a-dozen experiences helps to show the remarkably diverse character of the results obtained:—

A.	Miles per ½ in. wear,	armature,	5,300,	suspension,	—
B.	,,	,,	,,	5,000,	,,	6,000
C.	,,	,,	,,	3,000,	,,	—
D.	,,	,,	,,	51,000,	,,	16,670
E.	,,	,,	,,	38,500,	,,	45,000
F.	,,	,,	,,	38,000,	,,	114,000

* Abstract of the report of a sub-committee presented last week at the Conference of the Municipal Tramways Association. The sub-committee consists of Messrs. E. Cross (Rotherham), R. L. Acland (Chesterfield), P. J. Pringle (Burton-on-Trent) and T. R. Smith (Leicester).

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The life for armature bearings varies from 84,000 to 5,000 miles but the average life appears to be between 10,000 and 12,000 miles.

Gear Lubricant.—There are eight towns who are using oil for the purpose of lubricating gears; the remainder use grease at about from 14s. to 16s. per cwt.

Life of Gear Wheels.—The life of gear wheels varies considerably in different towns, although the conditions are similar, and the class of gear wheels used are identical, with few exceptions. The highest mileage obtained is 10 to 11 million miles, although there is a reply which states, "None worn out yet." Another answer states, "None worn out after 5½ years use," the lowest mileage obtained being 52,506. Lives of 250,000, 200,000 and 160,000 seem to be fairly common, but many undertakings have had to be satisfied with mileages well under 100,000.

Life of Pinion Wheels.—Here again there is a great difference in the results, and it is interesting to note that in one case mileages of 2½ to 2½ millions have been obtained, and in another case from 150,000 to 200,000 miles. The lowest mileage obtained is 5,000, but there are instances where a mileage of 165,000 to 155,000 has been experienced. The bulk have had to be satisfied with from 70,000 to 40,000, while there are many well under the lower figure. It is interesting to find that specially hardened pinions have not found a place in the higher mileages, the best result attained being 112,000 miles, but this figure stands quite by itself, other results being much lower.

General.—The sub-committee have been struck with the remarkably short life of bearings in connection with traction work, and even the best instances recorded are short compared with those of stationary motors working under equally disadvantageous conditions with respect to heavy intermittent working. In comparing these types against each other there is one adverse circumstance under which the traction motor has to run, as compared with the stationary motor, and it seems that it is in this respect that the comparatively short life of the traction motor bearing is brought about. Take, for example, a motor driving a heavy crane in an engineering shop where the atmosphere is fairly loaded with dirt, and still under these circumstances bearings have been known to last for a great many years. In the case of the traction motor, when the car is running, there is a large amount of grit and dirt of the hardest kind, made up largely of fine particles of granite dust surrounding the motors, and unlike the engineer's shop, these particles are not floating about and allowed to fall by their own gravity, but they are driven by a pressure varying as the speed of the car into any interstices that may present themselves. Consequently, as the present oil or grease chamber is by no means rendered airtight, the grit finds its way into the oil or grease as the case may be.

The sub-committee are of opinion that a system of ring lubrication or its equivalent should be insisted upon in all new motors, and their tangible reason for this recommendation is the already excellent experience of those few undertakings who already have had these motors installed for sufficient time to give a decided opinion. Moreover, the evident advantages of such a system is shown by the fact that as the oil ring is to be relied upon to feed with an ample and generous supply, it does not become necessary to inspect or replenish so frequently, and an allowance of six weeks between inspections is not considered to be too daring. With the "ring" system the wasteage of oil is practically nil, and consequently a higher grade of oil can be used without affecting the cost materially, therefore, with the reduced number of inspections—which, by the way, would be carried on in the daylight under proper supervision—it would then be well worth while properly to joint all inspection doors in such a manner as to seal hermetically the oil well and bearing.

Given conditions similar to the foregoing, the sub-committee are of opinion that even the best results now obtained should be far surpassed in the future, and should bring the cost per running car-mile down in an agreeable manner by favourably affecting a number of items under that head. It may be of interest to know that two members of the sub-committee (Messrs. Cross and Pringle) had been previously experimenting, quite independently and unknown to each other, with a system of chain lubrication adapted to the older type of DK motor, so as to improve the lubrication of these motor bearings and to obtain the advantages of the "ring" system as far as possible under the conditions. Mr. Acland is also carrying out experiments with his Westinghouse (46 M type) motors in a similar direction. Some degree of success has already been attained, and the sub-committee have reason to believe that the experiments will end satisfactorily.

Replies to the queries have been of a most diverse character, and it would seem that some form of standardisation would be an advantage in the methods adopted in connection with lubrication of car bearings. Take, for instance, the cost of lubricant, the L.C.C. pay 5½d. per gallon for oil, while Glasgow pay 2s., The sub-committee lay particular stress on the inadvisability of using grease, or a combination of grease and oil, the latter being particularly objectionable on account of the liability of the grease to mix with the oil and so render the pads or other conveying medium inoperative.

There is a divergence of opinion as to the most suitable metal to be used for lining bearings, and consequently there is a great difference in the cost per thousand miles in the results under practically similar running conditions. It will prove to be most valuable information for all members to know the reason why Bury can obtain from 10 to 11 million miles out of their gear wheels, and how Glasgow and Keighley have been able to run their cars without renewals of gear wheels from the commencement.

It appears to the sub-committee that if co-operation between all undertakings was established with regard to the subject of this report, it might be that an undertaking, although having an excellent experience on the one hand, but unfortunate in other respects, would receive benefit by an interchange of ideas, and thus hope to arrive at the good results obtained by undertakings in other directions.

DISCUSSION.

Mr. C. W. Hill (Bournemouth) opened the discussion and said that a saving of £300 per annum had been effected at Bournemouth by paying attention to the oil used. They were largely in the hands of the oil makers, but he could not understand why Glasgow should pay 2s. and London 5½d. for their oil; he did not approve of cheap oils. The best oil for the purpose should be discovered and then adhered to. Dust was, he thought, the controlling factor in wear of car bearings. A dust-proof motor was badly wanted. At present oil boxes were little better than refuse bins. In seaside places the sand which penetrated to the bearings naturally occasioned excessive wear. He had not found that case-hardened pinions gave good results.

After some other members had taken part in the discussion Mr. Cross briefly replied to the effect that the matter would be further investigated.

TRAMWAYS IN RELATION TO TOWN PLANNING.*

BY A. BAKER.
(General Manager, Birmingham Corporation Tramways.)

After discussing some of the principal features of the Housing and Town Planning Act, 1909, the author lays down the dictum that "Means of communication is the first essential to successful town planning." Under the Act it is possible to restrict the number of houses to 12, or even less, to the acre. This means that the population must be spread over a greater area, and consequently further away from their work. It is obvious that it is cheaper to transport a number of persons congregated at a given point than to collect the same number of persons from several different points spread over a large area. It therefore seems that town planning will tend to make operating costs heavier.

It is certain that the cost of tramway operation cannot generally be reduced. There may be individual towns where little economies may be effected, but these would not materially affect the matter. How, then, can the situation be met? I think a lesson may here be learned from the Continent. In connection with town planning on the Continent, special provision in many of the new wide thoroughfares has been made for tramways. In some cases avenues in the centre of the streets have been specially constructed for tramway lines, other vehicular traffic not being able to use this part of the thoroughfare. In other cases the carriageway is divided into two portions, each of considerable width, by an avenue of trees. Where this has been done the tramway tracks have been laid close to the footpath on either side of the avenue, leaving ample room for other vehicular traffic. By these means a much higher average tramway speed can be attained. Again, where new thoroughfares have been made in sparsely populated districts and traffic is light, a cheaper method of tramway construction has been adopted. This is particularly noticeable in Berlin. In this city macadam paving has been largely employed, and as the ordinary wheeled traffic does not pass over it, it appears to be quite satisfactory as a tramway paving. In other cases no paving of any kind except at crossings has been used, but the rails are laid on sleepers and the space between the rails filled in with green turf. This not only cheapens the cost of construction and maintenance very considerably, but the effect of well-kept grass in the tramway areas is most pleasing.

The advantage to tramway traffic and to the ordinary vehicular traffic by having a portion of the road set apart exclusively for tramways is enormous. Besides obtaining a better average speed

* Abstract of a Paper read before the Municipal Tramways Association.

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collisions with other vehicles are obviated, and general repairs to permanent way, by its only being used for tramway purposes, considerably reduced. The width required for a double line of standard gauge tramway is 17 ft. If the carriageways of all the new main thoroughfares were made 91 ft. in width minimum there would be plenty of room for a special tram "way." A thoroughfare of these dimensions would provide for two footpaths each 10 ft. wide, two roads for vehicles each 24 ft. wide, and a way for trams 23 ft. wide. This 23 ft. would give two footpaths each 3 ft. wide for passengers leaving the cars, thus permitting them to alight in safety, instead of having to step straight on to the carriage way. If at the same time trees were planted on each side of the tramway, thus forming a tramway avenue, much of the objection to trams in suburban districts would be overcome, and a charming effect produced.

As to cost, we all know that paving forms a very considerable portion of tramway construction. The paving of one mile of double track costs approximately £3,000. By adopting this method of construction, which is really only possible in new districts, and through the agency of town planning, a very large saving can be made in the capital expenditure on tramways. There is no doubt that in many cases the landowners would be willing to give up the extra width required to make the wide thoroughfare here described, knowing that they would be benefited enormously by having such a main road adjoining their property. But, even where this could not be arranged, the price of agricultural land even near a large town could not be more than £100 to £200 per acre. Presuming the tramway authority was called upon to add 6 yds. to the width of the road, this would only mean an additional cost of not more than £400 per mile. In such a case a reduction of capital expenditure of upwards of £3,500 per mile of double track could be immediately made, allowing for extra strip of land, besides the very considerable saving that would be effected annually in repairs and maintenance. Such a cheap form of construction would enable tramway extensions to be made into districts of light traffic, which under present conditions cannot be contemplated.

In this connection I venture the opinion that such a cheap form of tramway construction is far more likely to assist town planning than any other form of traction, not even excepting the railless trolley system as we know it. Doubtless the latter system has a useful purpose to fill, in giving travelling facilities between sparsely populated districts where it would not be convenient to lay down tramways, or where they could not be constructed with any prospect of success; but there is no doubt that in districts which are capable of showing any signs of development it would be much better policy to lay down a tramway, and face a loss for a year or two, with the prospect of the tramway becoming remunerative at a later date. Trackless trolley cars can never deal with large masses of people like tramways, and in my opinion it would be the height of folly to instal such a system in a district which might in two or three years grow to such an extent as would render the system unequal to giving adequate facilities.

There is another lesson I think we may well learn from the Continent. In the new part of the old town of Ulm a great deal of land development is taking place. The municipality, after the old fortifications had become obsolete and partially removed, purchased large tracts of land which they have town planned. Certain portions of this land have been set apart for high class residences, other portions for middle class residences, and other portions again for workmen's dwellings. One district has been set aside for industrial purposes. Here factories, mills, warehouses, &c., are allowed to be erected. In selecting the industrial quarter regard has been had to the facilities afforded by railways and canals, and also as to the prevailing winds. The trams in Ulm also belong to the municipality, and communication has been provided between each district. Frequent services are run to enable workmen and others to get from one district to another. These tramways do not at present pay their way—indeed, there is a considerable annual loss on working. The municipality, however, is not at all concerned about this, because whatever the loss on the tramways amounts to is made up several times over by the profit on the sale of the land, and in the advantages accruing by having the town laid out on well-defined principles, to say nothing of the benefit accruing to the town by reason of the low death rate which inevitably follows the making of open spaces instead of congested areas. In Vienna, Frankfort-on-Main, and the great industrial city of Mannheim, the same policy obtains, although perhaps not to such a great extent as in Ulm, viz., that wherever new developments in land are taking place communication by tramways must be established, even though there is not much prospect of profit immediately accruing from the tramways.

In these towns it seems to be the settled principle that means of communication must precede population. This is certainly contrary to English practice. The first question asked when a new tramway has been proposed is, will it pay its way? Indeed, Parliament has hitherto been careful to inquire into the financial possibilities of all tramway proposals, and not a few have been rejected because the promoters have failed to satisfy Parliament that the proposed lines would yield an immediate return on the capital invested. This being so, the very important question is raised as to whether, in view of the new Town Planning Act, Parliament might not modify its view that tramways should not be constructed unless they can be shown to have an immediate prospect of yielding a profit.

I think it is of the utmost importance that tramway committees and their officers should keep in close touch with those charged with the conduct of housing and town planning affairs. This is recognised in Birmingham, where a town plan is in course of preparation. This provides for arterial roads varying from 80 ft. to 120 ft. in width.

DISCUSSION.

Ald. E. PRIESTLEY, in opening the discussion, said that what Mr. Baker had foreshadowed would take 100 years to accomplish. His figures were ideal on paper, but experience proved that the value of land was always put up by property owners when it was known that the municipal authority wanted to purchase for road construction.

Councillor BARROW (Birmingham) said they were not waiting 100 years in Birmingham, but would soon have a scheme, on the lines outlined in the Paper, in actual operation. The four main townships outside Birmingham had grown in population from 88,000 in 1891 to 230,000 in 1908 and that was a striking proof of the value of tramway operation. He commended the managers to study the Town Planning Act.

Mr. C. W. HILL (Bournemouth) thought that in Mr. Baker's ideal tramway the cars should run up and down the sides of the main road and not in the centre. This up and down traffic would facilitate the entry and exit of passengers. He also advocated circular routes. For one thing if a passenger was careful and sat still he could make two circuits for the price of one. In Bournemouth they had found the landowners willing to co-operate in their town planning scheme.

Mr. P. FISHER (Dundee) did not approve of the running of the tramways at a loss in the initial stages. If the traffic would not perimt the laying of a track at first then the trackless trolley should be used to develop the new districts, and when the heavier traffic came along then rails could be laid and the same overhead equipment used.

Mr. J. B. HAMILTON (Leeds) said that Mr. Baker's ideas suggested speculation in land outside the boroughs, but this was too uncertain a matter to be discussed further at the moment. He approved of the trackless trolley for development purposes, but pointed out that on many of these suburban routes where private right of way could be got, the construction of the track made the tramway a good competitor of the trackless trolley. The cost of the land was recouped largely by the cheapening of the track construction.

Mr. BAKER (in reply) said that it was a fact that good agricultural land could be bought in the 5 miles radius of Birmingham for £100 to £200 an acre. The trackless trolley he thought to be both complicated and expensive, and when tramway extensions were wanted the whole equipment would have to be scrapped.

THE EFFICIENCY OF SHORT-SPARK METHODS OF GENERATING ELECTRICAL OSCILLATIONS.

BY W. H. ECCLES D.SC., AND A. J. MAKOWER, M.A.

In a recent Paper read before the Institution of Electrical Engineers we published some measurements of the efficiency of transference of oscillatory energy from the circuit containing the discharge gap to a circuit representing the aerial wires in a plant for wireless telegraphy. The method employed consisted in measuring calorimetrically the energy supplied to the discharge gap, the energy wasted there as heat, and the energy passed into the aerial circuit; the method is direct and involves no assumptions. Our principal result was that the efficiency reckoned from the terminals of the discharge gap was, in the best disposition of our apparatus, rather less than 50 per cent. This figure is much lower than that claimed by makers of wireless telegraph apparatus of the type discussed. The Telefunken Gesellschaft claim to reach in normal plant 75 per cent. efficiency, and the Lepel Wireless Synd. claim to get higher than 60 per cent. Our apparatus was not precisely the same as that of either of these firms, but was rather of an intermediate nature. Nevertheless, it was our opinion that the discrepancies stated above were due to differences in methods of measurement, and we welcomed an offer to witness experiments in the Telefunken laboratory. Their method of measurement is indirect, and rests upon one that is widely applied in the determination of the logarithmic decrements of vibratory circuits. In order to estimate efficiency,

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the supply of power to the discharge gap is directly measured by a wattmeter and the current in the circuit representing the aerial is read on a hot-wire ammeter; thus the power developed in the aerial circuit becomes known as soon as the high-frequency resistance of that circuit is determined. This resistance is determined by aid of a damping-factor method, which is as follows: A resonant circuit comprising an inductance, a variable condenser and a low-resistance thermal ammeter is loosely coupled to the aerial circuit under test, and adjusted to resonance—a state indicated by a maximum reading of the thermal instrument. It is now mistuned by variation of the condenser so that the power given to the instrument is halved; there are two values of the capacity that will effect this, one greater and one smaller than the capacity C_r that gives resonance. Call these C_1 and C_2. The approximate formula deduced by Bjerknes for the current induced in a resonator gives for the method described the formula

$$\delta_1 + \delta_2 = \frac{\pi}{2} \cdot \frac{C_1 - C_2}{C_r}, \quad \ldots\ldots (1)$$

where δ_1 is the logarithmic decrement of the aerial circuit and δ_2 that of the resonator, both decrements being reckoned per whole period, T, of the aerial oscillation. The decrement of the resonator can be calculated from the formula $\delta_2 = \frac{R_2 T}{2L_2}$, where R_2 and L_2 are the resistance and inductance of the resonator, and are known. Thus the decrement of the aerial circuit is given by

$$\delta_1 = \frac{\pi}{2} \cdot \frac{C_1 - C_2}{C_r} - \frac{R_2 T}{2L_2}. \quad \ldots\ldots (2)$$

The resistance of this circuit is given by $R_1 = \frac{2L_1\delta_1}{T}$, and the power consumption therein is C^2R_1, where C is the current recorded by the hot-wire ammeter in the circuit.

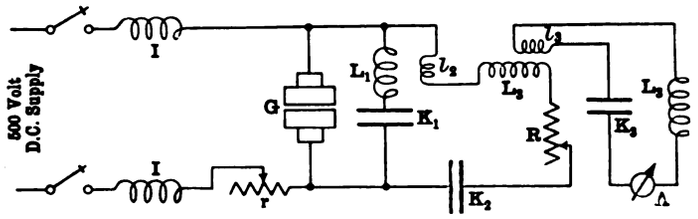

FIG. 1.

The method is, obviously, open to the criticism that it is based on a theory of the resonator which is admittedly not accurate for such great variations of capacity as are made in the use of the method. The limitations of the Bjerknes formula are well known, and have, in fact, been discussed mathematically; and the discussion might be carried forward into an examination of the theoretical limitations of the above method, and the deduction of formulæ of correction. We decided, however, to test the method by experiment rather than by theory. Accordingly, the method was applied to measure the effective resistance of an aerial circuit into which different known resistances were introduced in turn. In addition, each resistance was measured with four different resonators of widely differing electrical dimensions. Throughout the measurements the circumstances of the short-spark circuit in which the oscillations were generated were, of course, kept unchanged.

The diagram of the circuits employed by us is given in Fig. 1. The gap G, which is formed by two copper plates, water cooled and separated by a ring of paper, is connected to a 500-volt continuous-current supply through a regulating resistance, *r*, and choking coils I. The gap G, the large capacity K_1 and the small inductance L_1 form the oscillation generating circuit. The aerial conductor is represented by the capacity K_2, the inductance coils l_2 and L_2, and the resistance R. The resonator used in the experiments consists of a variable capacity, K_3, the inductances l_3 and L_3, and a sensitive short-period thermal instrument A.

The electrical dimensions of the apparatus were as follows: $K_1 = 300{,}000$ cm.; $K_2 = 1{,}680$ cm.; L_1, L_2 and l_2 were chosen so as to keep the period of the oscillations $4{\cdot}66 \times 10^{-6}$ seconds (wave-length 1,400 metres) in each branch throughout all the changes of the resistance R. This resistance was a frame of fine copper wires, and took values varying from 5 to 120 ohms in the course of the experiments. In the resonator, K_3 varied from 340 cm. to 5,200 cm., L_3 from about 1,430,000 cm. to 72,000 cm., and l_3, which was a movable "search coil," had the fixed inductance of 22,600 cm.

Experiments were made on eight different values of the resistance R. At each of these values, after the necessary retuning of the aerial branch by aid of L_2, the method described above was applied to determine the resistance. When R was large the coupling between the resonator and the aerial had to be larger than when R was small, but the coefficient of coupling never exceeded 0·05. Each determination of resistance by the method under criticism was carried out with four very differently dimensioned resonators in turn. A comparison of these indirect determinations with the known values of the various resistances is given below.

Table I. gives details leading to the calculation of the decrements of the resonator in its four different dispositions, (*a*), (*b*), (*c*), (*d*), which are needed as corrections in the next table.

Table I.—*Decrement of Resonator.*

	Capacity, K_3 cm.	Inductance, $(L_3 + l_3)$ cm.	Resistance,* R_3 ohms.	$\delta_2 = \frac{R_3 T}{2(L_3 + l_3)}$
(*a*)	340	$14{\cdot}53 \times 10^5$	5·7	$9{\cdot}1 \times 10^{-3}$
(*b*)	540	9·08	5·1	13·1
(*c*)	1,150	4·50	4·6	23·8
(*d*)	5,200	0·95	4·1	101·0

Table II. is practically the record of the measurements, and gives the sum of the decrements of aerial and resonator, as calculated from the half-power formula (1) above, for each of the four dispositions of the resonator.

Table II.

$\delta_1 + \delta_2$ from $\frac{\pi}{2} \times \frac{C_1 - C_2}{C_r}$.

Actual resistance, R.	(*a*)	(*b*)	(*c*)	(*d*)
4·7	0·116	0·105	0·180	0·306
7·1	0·102	0·152	0·181	0·310
12·7	0·149	0·222	0·220	0·410
21·3	0·269	0·245	0·310	0·400
35·0	0·359	0·326	0·335	0·503
55·0	0·468	0·432	0·503	0·575
87·0	0·620	0·557	0·540	0·640
123·0	0·663	0·712	0·702	0·810

These two tables lead to Table III., wherein appear the calculated effective resistances of the aerial circuit.

Table III.—*Calculated Values of Resistance R.*

Actual resistance, R.	(*a*)	(*b*)	(*c*)	(*d*)
4·7	13·5	11·6	19·6	26·1
7·1	11·8	17·6	19·9	26·6
12·7	17·7	26·4	24·8	39·1
21·3	32·8	29·3	36·1	37·9
35·0	44·1	39·4	39·2	50·8
55·0	57·4	52·4	59·9	59·4
87·0	76·0	67·7	64·2	67·2
123·0	80·7	86·2	83·7	87·6

Finally, Table IV. gives the ratio of the calculated resistances in Table III. to the actual resistances.

Table IV.—*Ratio of Calculated to Actual Resistance.*

Actual resistance, R.	(*a*)	(*b*)	(*c*)	(*d*)
4·7	2·87	2·47	4·17	6·05
7·1	1·66	2·48	2·81	3·75
12·7	1·40	2·08	1·95	3·08
21·3	1·54	1·38	1·70	1·78
35·0	1·26	1·126	1·12	1·45
55·0	1·04	0·954	1·09	1·08
87·0	0·875	0·778	0·738	0·773
123·0	0·656	0·701	0·680	0·712

* Including resistance of thermal instrument.

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The results of the experiments may be looked at in two principal ways. In the first place, if the numbers in a column of Table IV. be plotted with actual resistances as abscissæ, we can examine the half-power method as employed with a resonator of fixed electrical dimensions. For example, in Fig. 2 the numbers obtained with resonator (*d*) are plotted. If the method were trustworthy a horizontal straight line (shown dotted) would be obtained. Instead, a falling curve appears which displays great departures from the truth in the low resistances. In the second place, we may inquire into the working of the method when a certain aerial resistance is

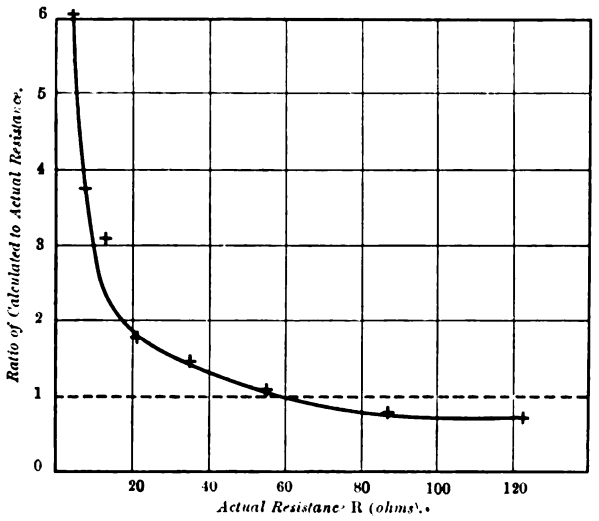

FIG. 2.—RESONATOR (*d*).

measured by means of different resonators in turn. This is done in Fig. 3. Each curve corresponds to a horizontal row of Table IV., the abscissæ being the inductances of the changing resonator. The departures from the correct horizontal straight line (shown dotted) are very great, especially when the aerial resistance is low. It appears that the estimated resistance of the oscillatory circuit may vary more than 100 per cent. when it is measured by different resonators, and the estimated resistance may be as much as six times the actual aerial resistance. The cause of the former kind of error lies probably in the fact that

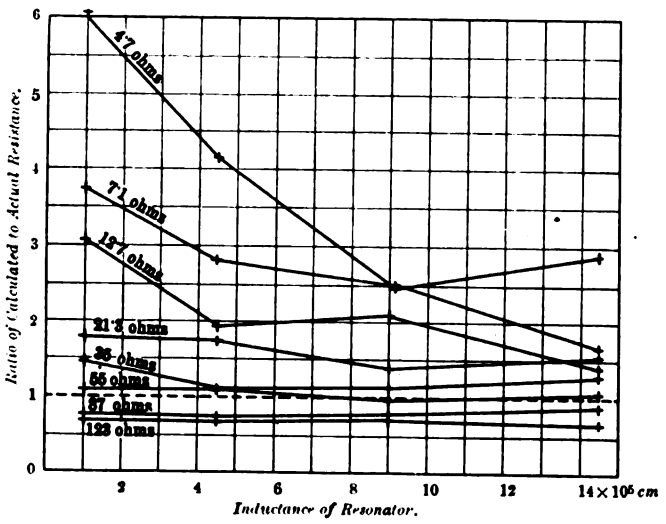

FIG. 3.

the formulæ of Bjerknes are not strictly applicable to the half-power method of measuring the decrement. The second kind of error probably arises in the discharge gap. It is to be expected that when the aerial resistance takes different values the physical conditions of the discharge may alter. The present experiments indicate that the proportional wastage in the gap increases as the aerial resistance decreases. In other words, the reaction of the aerial branch currents on the discharge is such as to add a fictitious part to the estimated resistance of the aerial branch.

It is plain, then, that if the efficiency of the whole plant is measured by this half-power method for decrement—the estimated resistance being multiplied by the square of the virtual amperes in the aerial branch in order to get the power delivered to the branch—a result is obtained which may be much too large when the resistance in the aerial branch is small. In the particular instance presented by our own apparatus, the efficiency would probably work out fairly correctly if the aerial resistance were about 60 ohms, but would be too large with smaller aerial resistances and too small with larger aerial resistances. In the extreme case shown in Fig. 2, since the estimated resistance has six times its actual value, the estimated efficiency would be six times too large.

ELECTRIC RAILWAY CATENARY TROLLEY CONSTRUCTION.*

BY W. N. SMITH.

(*Continued from page* 938.)

Summary.—The author describes recent practice in catenary construction, discussing the various features of the different forms in use. He believes that the roller type of trolley may possibly prove a distinct improvement over the present sliding bow for trunk line work.

Catenary Hangers.—For the plain type of construction there now seems to be a preference for a hanger that has an easy or flexible grip on the messenger wire and a powerful positive grip on the trolley wire, with a joint between clamp and rod, either at the top

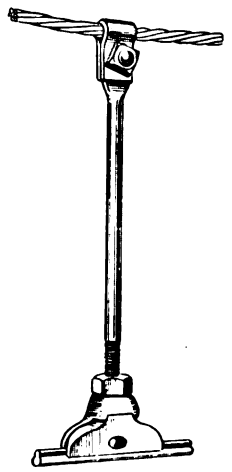

FIG. 5.

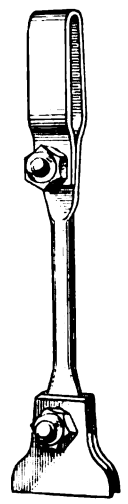

FIG. 6.

or bottom, or sometimes both, to increase the general flexibility. In the earlier work, four or five years ago, messenger and trolley clips were rigidly connected together and even in spite of the lack of experience in design and erection they operated very well in many cases, provided the trolley wire was pulled sufficiently tight. The Connecticut Co. recently constructed several miles of experimental catenary construction, and some of the designs of hangers† are reproduced in the present Paper.

It is safe to say that almost every engineer who has built a catenary line has tried his hand at devising a new catenary hanger that would combine simplicity, flexibility, certainty of grip, speed of application and adjustment, and cheapness. Fewness of parts is essential to cheapness and speed of adjustment. A hanger of five or six parts, including bolts and nuts, is preferable to one of 10 or 12 parts. The grip on the trolley wire should be powerful and easily applied. One nut only should be allowed, to tighten or loosen the trolley clamp. The hanger shown in Fig. 5 seems to answer most of these requirements. The writer's preference is for a nut screwing down on the lower end of the hanger rod as in Fig. 5, as it can then never work off. It is desirable to have at least one pivot joint in the rod, either at the messenger or at the trolley ear. The loop type of connection to the messenger wire where the top of the rod is practically looped over the messenger wire, or forms a slot for the entire hanger to work up and down on the wire as in Fig. 6, has only one

* Abstract of a Paper read before the American Institute of Electrical Engineers.

† A description of the experimental installation appeared in THE ELECTRICIAN of April 15th, 1910, p. 12.

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drawback and that is the possibility of wearing away the galvanising of the steel messenger cable. If the messenger be of copper the wear would probably injure the cable mechanically. This type has also the advantage of permitting the endways movement of the contact wire which will allow its tension to be well equalised on different sections of the line.

There is one feature of catenary design that always deserves careful attention, and that is the number of different lengths of hanger rods in a span. The average railway will have more or less curvature, and spans of different lengths on the same, in which the number of inches sag of the messenger will vary considerably, though the old spacing interval of the hanger rods is ordinarily uniform no matter what the distance between poles or bridges. On the Erie R.R. electrification there was little curvature and the number of different lengths of span was limited, and only six different lengths of hanger rod were needed, with 10 ft. spacing. On the Denver & Interurban there was considerable curvature; the spans varied from 120 ft. down to 60 ft. in length, spacing 10 ft., and yet there were only six lengths of hanger rod required.

It is noticeable that there is a tendency toward increasing the distance between hanger points in catenary spans. It originally started at about 10 ft. One company, during the early development, advocated three-point suspension on tangents for spans as

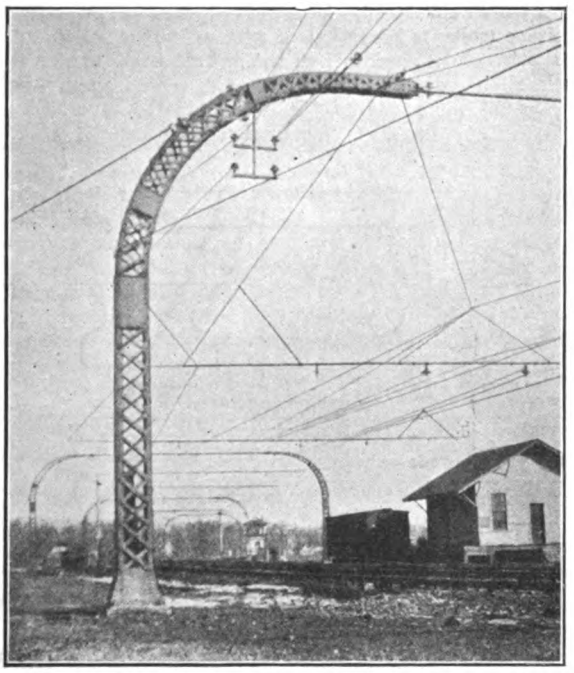

Fig. 7.—New Catenary Construction of New Haven Railroad.

long as 150 ft. At the present time, however, the three-point suspension is only recommended for wheel trolley operation and 11-point suspension is recommended for sliding bow operation. This brings the hangers approximately 14 ft. apart. Another company shows spans varying between 10 ft. and 13 ft. 7½ in., which is 12 points of suspension for 120 ft. span, and 11 points for 150 ft. span, as desired. A third company gives in its catalogue fittings designed for 10 ft. and 15 ft. spacing, on spans from 60 ft. to 150 ft.

The American Street & Interurban Ry. Association's Committee on Power Distribution prepared a report on catenary construction in 1908, and its conclusions were rather in favour of hanger spacing of 20 ft. to 30 ft. because the sag between hangers, though very slight, would still be sufficient to help take up the expansion of a copper trolley wire in warm weather. It was quite evident that the Committee hesitated to recommend the complication of the compound catenary type of construction if any means could be adopted that would accomplish reasonably smooth operation with plain catenary construction. It also reported very favourably on making spans 300 ft. in length; that the hangers should be as light and flexible as possible and that the messenger cable should be of steel, strung to a small sag.

Much is said from time to time about the necessity of staggering the trolley wire from side to side when constructing for sliding bow operation. The writer has noted enough successful operation without staggering to confirm his belief that it is not absolutely necessary under interurban conditions with average track and motor cars of the usual interurban type. With these conditions the car is generally so sure to sway from side to side as to equalise the wear fairly well on the sliding bow. It is only where there are very heavy locomotives and extremely solid track and roadbed that the writer would entertain seriously the necessity of staggering the wire; but though these conditions are present on the New Haven Road, the contact wires have not been staggered. Unless great pains are taken to prevent it a staggered wire always tends to pull straight and consequently to induce some sag that is not desired.

The new design of heavy catenary construction developed last year by the New Haven road is a remarkable advance in several respects, and is illustarted in Fig. 7. The chief points of interest are the following: (1) The supporting bents are much more sightly and more economical of material than the original bridges. (2) The main suspension cables of 1¼ in. stranded steel wire which carry the insulators and the messenger wires proper are uninsulated and earthed, which will facilitate maintenance, painting, &c., and will obviate much of the danger to men on the signal bridges. (3) Insulators, if broken, can be replaced by removing only three bolts, the two by which the insulator is suspended from the crossbent and the one which suspends the messenger wire from the insulator. (4) The feature of a steel working trolley wire below a copper conductor, using the elasticity of the upper wire to permit the contact wire to yield in an upward direction, is here repeated, showing it to be regarded as a successful means of securing smooth and reasonably flexible contact. (5) The necessity for steady strain insulators and pull-offs of the previously accepted types on curves is entirely done away with because the hanger rods are so dimensioned that by inclining them at such an angle that the trolley wire follows the alignment of the curve exactly, the tendency is for the lower wire to pull to a curve of shorter radius than the messenger wire. By adjusting the lengths of the hanger rods with some care the curve

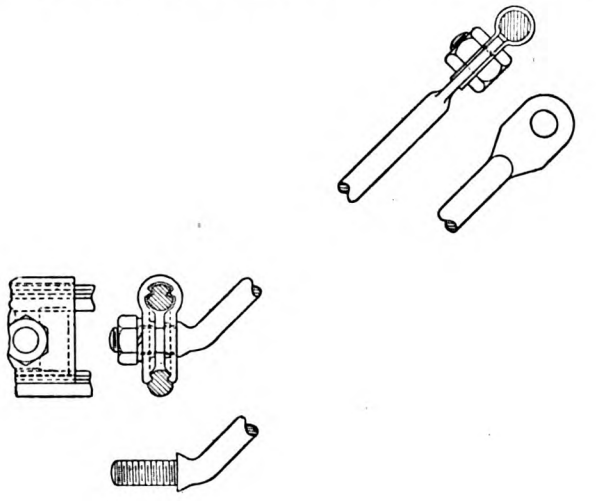

Fig. 8.—Bent Inclined Hanger Rods.

of the centre line of the track can be closely approximated by the lower ends of the hanger rods when thus inclined and rightly adjusted for length. By bending these inclined hanger rods so that their bottom ends are horizontal, then passing the horizontal end through the middle of the clip that fastens the contact wire to the secondary messenger, the two latter are held rigidly in a vertical position and the working trolley is maintained as exactly under the secondary messenger as though it were on a straight line. (*See* Fig. 8.) The criticism is sometimes made of steady-strain insulators for catenary curve construction that the tension under which they do their work makes the curve rigid and unyielding. In this case the heavy steady-strain insulators are dispensed with altogether, being replaced by the light iron hanger rods which for the time being are acting as steady-strain insulators. Their greater frequency must minimise the pull of each individual rod and tend to make the whole structure less rigid than where steady strain-insulators or pull-offs are applied at intervals of 30 ft. to 60 ft. (6) The adjustments for height in this construction are extremely simple, being accomplished by slipping the suspending members of the cross bents nearer to or further from each other along the bent, thus raising or lowering it.

Steady Strain Insulators.—Steady strain insulators usually consist of a stick of treated wood shaped like a long strain insulator, terminating at the outer end in a hook-shaped fitting that is attached to the trolley car, being pivoted at the inner end to an insulator on the bracket. When in this form they must be inclined upward away from the trolley wire so as to clear the sliding bow. While originally intended for curve construction only, it is often found

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desirable to instal them at intervals along tangents, say, from 5 to 10 poles apart, as their presence helps to prevent swaying of a suspended trolley wire in a very high wind.

The form of steady strain insulator used on the Denver & Interurban Ry. is shown in Fig. 9. This has the merit of employing the same kind of 11,000-volt insulator that is used on the standard straight line catenary support, the head of which is cemented into a socket on the end of a malleable iron bar bolted to the bracket. The brace proper is a short link of malleable iron loosely hooked into an eye-bolt projecting from the bottom of the insulator. It will thus swing through an arc permitting some longitudinal movement of the trolley wire. In case the insulator breaks it will fall to the ground from the outer end of the hook, and the hook is light enough so that the stiffness of the trolley wire will make it stand out straight after the insulator has fallen and it will not hang down and foul the sliding bow.

Between poles, various schemes for pull-offs are used, but the commonest method is to run a bridle from the upper and lower ends of the hanger spacing rods, joining the bridle wires at some distance away from the trolley and insulating the pull-off by a strain insulator. Sometimes a wooden strain insulator may be put into each of the bridle wires, but care must be taken not to weight them down so that they would be in danger of fouling a bow trolley. Probably the best way to insulate a pull-off for high voltages is to use the disc type of strain insulator.

Strain Insulators.—The writer's experience with catenary construction having been with high voltages, it has been necessary to be particular about strain insulators. After some unfortunate experiences with strain insulators built up of metal and moulded insulating material of one form or another, it was found that porcelain, if it could be kept in carefully equalised compression, was the most reliable insulation, and as in the case of the straight-line insulators, a single insulator (of the heavy porcelain spool type), properly mounted, can always be depended upon. The easiest way to mount such insulators is to cement them upon a piece of pipe large enough to carry a $\frac{7}{8}$ in. or 1 in. bolt. If a bore of the spool is fairly large it

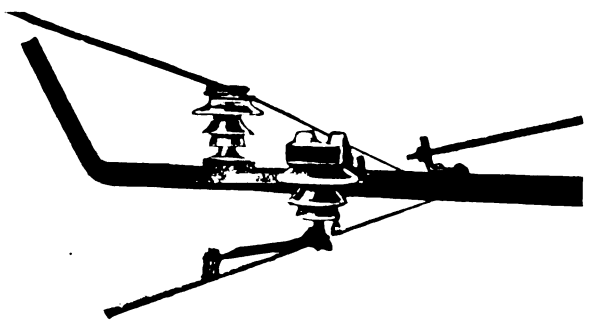

Fig. 9.—Steady Strain Insulator, Denver & Interurban Railway.

may be necessary to use $1\frac{1}{2}$ in. pipe. It is more necessary to have the pipe nearly as large as the insulator than it is to have the bolt nearly fit the pipe.

The disc type of insulator is very ingenious, light and attractive, but the body of the porcelain under compression is not sufficient to resist a crushing strain of more than 5,000 lb. or 6,000 lb., or it was not when certain tests were made under the writer's supervision between two and three years ago. The $6\frac{1}{2}$ in. diameter disc insulators are now advertised to carry a safe working load of 2,500 lb., and the 10 in. insulator 4,500 lb. With the trolley tension sometimes reaching 5,000 lb. at low temperature, a strain insulator for dead ending must have a working capacity of at least 7,500 lb. to 10,000 lb., and it ought to be as high as 12,000 lb. to 15,000 lb. This puts the disc type out of the running. The writer designed for the Denver & Interurban a double spool insulator comprising a porcelain spool cemented on $1\frac{1}{4}$ in. pipe with $1\frac{1}{2}$ in. by $\frac{1}{2}$ in. flat iron driven through the pipe and standing edgeways to the strain, there being a hole in each end of the flat iron for linking to the other porcelain similarly fitted. This insulator, under test, withstood 50,000 volts and 14,000 lb. mechanical stress simultaneously, without failure. It is shown in Fig. 10.

It is the writer's belief that, even more than in the case of direct suspension, strain insulators for catenary construction should be specified to be tested mechanically and electrically at the same time up to their maximum mechanical and electrical capacities. It is only in this way that actual conditions of service can be duplicated in a test. An excellent point about the disc type of insulator when used within its capacity is that there is a mechanical linkage of the guy cables on opposite sides of it which prevents their falling apart if the porcelain burns. This is not true of a wood strain insulator, which under high voltages is much more likely to get burned in two than at low tension, and for this reason the writer does not believe in using wood strain insulators for heavy strains where there is any possibility of a full voltage being applied to opposite ends of the insulator.

Deflectors and Frogs.—The deflector has sometimes been found necessary to prevent the horns of the pantograph bow trolley from getting tangled in the wrong wire where two trolley wires intersect on a switch or crossing. If the bow has no horns or if the horns are prolonged downwards there is no danger of a bow catching and no necessity for the deflector. In fact, deflectors are about the worst nuisance one has to contend with in maintaining a catenary line, and even where they have been carefully installed they are very apt to give trouble. It is very difficult to stretch the intermediate wires perfectly tight, and to keep them tight, even after they are adjusted.

Section Insulators.—With wheel trolleys, wood section insulators are a necessity, as in the case of direct suspension, but by far the best form of section insulator for bow trolley operation is the overlapping break without any wood or any other insulated under-run. They are also cheaper to instal than the wooden insulator, there is far less weight to support, and there is no danger of warping or of destruction by fire. Section insulators make good feeding-in points and should always be fitted with a jumper which includes a knife switch, usually kept closed. When it is desired to open a section of high-voltage trolley a hooked stick with an earthed chain attached above the handle is used to pull the switch, being kept hung permanently in the switch box, which should be well up on a pole out of reach of all but employés. It is desirable to have such switch boxes located at railroad stations or signal towers.

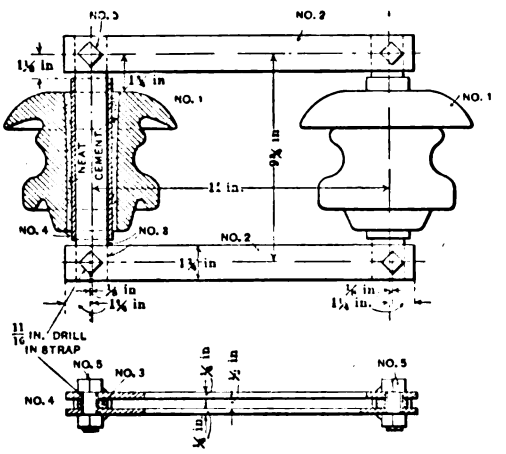

Fig. 10.—Double Spool Strain Insulator.

On two important installations of 11,000 volts, with multiple unit car operation, no feeder wire has been found necessary and section insulators have been introduced mainly for subdividing for the purpose of more readily locating trouble.

Lightning Protection.—It is absolutely necessary at high voltages to earth all the brackets and spans of a catenary line. This is most effectively done by steel or iron bars about $\frac{5}{16}$ in. or $\frac{3}{8}$ in. by $1\frac{1}{4}$ in., with the top end bolted to the butt end of the bracket and the bottom end run over to the track through the ground from the butt of the pole. The best kind of a connection to make with the track is through a cross bond, as this is more flexible than to connect a rod directly to one of the rails. The earthed rods, brackets and truss rods together form a pretty fair lightning protector for the trolley construction, but to make it more effective, on the Denver & Interurban Railway a $\frac{5}{16}$ in. steel earthed cable was run on the tops of all the poles and connected to every bracket, and at every fifth pole an earthed rod was run down the pole and attached to a cross bond and also to a pipe or a plate, the latter being used when there was any moist earth near at hand. This general scheme is the cheapest method of combining the earthing of brackets and lightning protection and it has an additional advantage of stiffening the pole line considerably. If circumstances make the use of line lightning arresters desirable, the swinging fuse type may be installed at intervals of $\frac{1}{2}$ mile. This arrester has given good service for three years on the Erie Railroad, at 11,000 volts.

Splices.—For a trolley wire at ordinary tension, the old forms of splicing sleeve did fairly well, but where the tension is great and the wire very stiff, as with phono-electric or steel wire, the old form of sleeve, with the necessity of curving the wire slightly in order to get it through, is inconvenient, especially for emergency work. A

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sleeve with both holes bored perfectly straight and inclined slightly upwards towards the centre will allow the trolley to enter and pass through without binding. To ensure sufficient strength this type of sleeve is made out of rolled bronze about 1 in. square with rounded edges, as shown in Fig. 11. Experiments showed that it was not safe to depend upon a mechanical splice that involved bending trolley wire beyond the elastic limit, although such a splice would be very quick and easy to make. For splicing messenger wire, use is made of cable splicing sockets shown in Fig. 12. To prevent the messenger wire from pulling out, the ends of the strands were doubled back on themselves, the cable end pulled back hard into the socket, and babbit poured in.

Moving Contact.—It is the writer's impression that the high-voltage catenary construction now in use is in nearly all cases operating under conditions favourable to the sliding bow. The conditions on the New Haven road are doubtless more severe than any other, as they involve high speeds, many low bridges, and the heaviest currents yet demanded in alternating-current railway work. On nearly every other single-phase alternating-current railway the traffic is in single-car trains, or with much lighter locomotives, and at lower speeds. More skill and judgment are needed to erect and maintain catenary than direct suspension, and experience shows that the fundamental difficulties preventing smooth operation arise primarily from the expansion and contraction due to changes in temperature, which must be overcome by following some of the methods herein suggested.

Barring the tendency of the old-fashioned trolley wheel to jump at high speed, even on fairly well aligned wire, it has proved a reliable contact maker up to the limit of its capacity, and has shown itself readily adaptable to all conditions of sag in long spans. The gradually increasing use of the catenary construction with the wheel trolley, a combination which seems to be well thought of by railway operators, encourages the writer to believe that in the heavy railway work of the future on trunk lines or over long distances, where high-voltage alternating current is the obvious solution, the rolling contact will tend to reassert its superiority over the sliding bow. The manufacturing companies, to whom engineers generally look for progress in such directions, cannot be said to have made much progress in this direction during the last few years. Although the writer has not been in a position to conduct any experiments

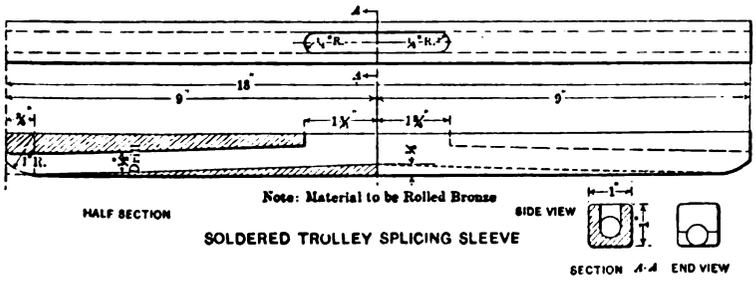

FIG. 11.

with the roller type of trolley, nevertheless, in the absence of convincing proof to the contrary, he is disposed to believe that it may yet be so developed as to constitute a distinct improvement over the present sliding bow, in the rough and ready service which the trunk line work of the future is likely to require.

As has been the case before in some practical electrical matters, progress in this respect has had its start on the Pacific Coast. On the interurban cars of the San Francisco, Oakland & San Jose Railroad there are now in use pantograph roller trolleys of the type shown in Fig. 13. The roller for these trolleys, which is held against the wire by a spring connected with the pantograph, is a brass cylinder 5 in. outside diameter and $\frac{1}{8}$ in. thick. The pantograph has a vertical movement suitable to accommodate the rise and fall of trolley wire 14 ft. to 22 ft. above rails. This type of trolley requires little attention, and the brass cylinders show an average life of about nine months on cars making 250 miles a day. These cars are working on 600-volt direct current and have four 125 H.P. motors, so that the roller trolley evidently carries quite a respectable current. It is to be hoped that the heavy alternating current locomotive work of the future as well as the multiple unit car operation can be made even more successful than now, and the wear and tear on trolleys and line construction diminished, if the development of the roller contact trolley can only be given the attention to which it seems entitled.

The life of 67,500 miles for pantograph roller trolleys, computed from the above quotation, seems incredible, and in the absence of detailed records may be somewhat discounted; but it is quite evident that the device is worthy of consideration. The life of pantograph shoes is variously reported as from 8,000 to 15,000 miles on single-car interurban lines, and very much lower than this on the New Haven road, where the conditions of high speed, heavy currents, more rigid trolley construction and low bridges, all combine to wear them out rapidly.

Double Trolley Construction.—The writer has paid no attention in this Paper to double trolley construction as distinct from standard types, because it is used so little in the United States, either in direct or alternating-current systems. Where used, it is generally erected with the same types of overhead material used in single trolley construction. Europeans have worked it out for three-phase alternating railway equipment with all the care and neatness that char-

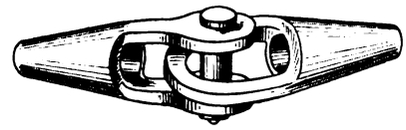

FIG. 12.—CABLE SPLICING SOCKET.

acterise their construction. They seem to be willing to put up with more complications in the accomplishment of results than does the average American engineer, and the principle of adherence to form rather than simplicity in attaining a result seems to prevail both in the personal side of railway administration and in the development of mechanical and electrical ideas. It is very doubtful whether any American railroad man will ever become reconciled to erecting two trolley wires of opposite polarity over any railroad track, if he can possibly get along with one. It is the writer's opinion that this one condition more than any other, will retard three-phase railway development in America.

In considering the development of heavy electric traction on

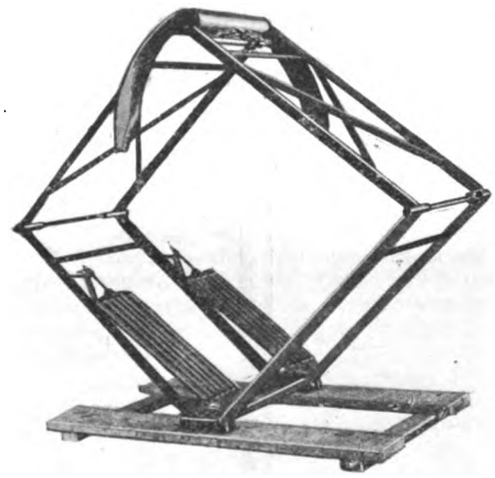

FIG. 13.—BROWN PANTOGRAPH ROLLER TROLLEY.

trunk line railways, therefore, we are brought back to our starting point by the controlling influence of the working conductor—namely, that it is the trolley system rather than the motor which is the characteristic feature of a railroad, and that that type or system of motors will ultimately prevail which can utilise the cheapest and most easily maintained working conductor.

[An account of the discussion on this paper will be given in our next issue.—ED. *E.*]

MAGNETIC BALANCE OF MM. P. CURIE AND C. CHENEVEAU.*

BY C. CHENEVEAU, WITH AN APPENDIX BY A. C. JOLLEY.

Summary.—The author first shows how the coefficient of specific magnetisation can be calculated from measurements with this balance, and then describes the apparatus. In an appendix particulars of tests on various materials carried out at the Northampton Institute are given.

This apparatus is intended for the measurement of the coefficient of specific magnetisation, of the susceptibility or permeability of feebly paramagnetic or diamagnetic bodies. The body whose magnetic properties are to be determined is suspended from one end of the arm of a torsion balance. By means of this balance the force

* Abstract of a Paper read before the Physical Society. A short account of the discussion in connection with this Paper appeared in THE ELECTRICIAN, May 20, 1910, p. 244.

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is measured, which is experienced by the body when placed in a non-uniform magnetic field, produced by a permanent magnet whose lines of force cross the space occupied by the body.

The author first indicates the method of calculating this force. If I is the intensity of specific magnetisation and Hy the intensity of field, the value of the force is $f = mI\frac{\partial H_y}{\partial x}$, $\frac{\partial H_y}{\partial x}$ representing the space variation of the field. As we are only concerned with feebly magnetic bodies, the demagnetising force arising from the magnetisation of the body is negligible, and we may assume that the intensity of magnetisation is proportional to the field. If we denote

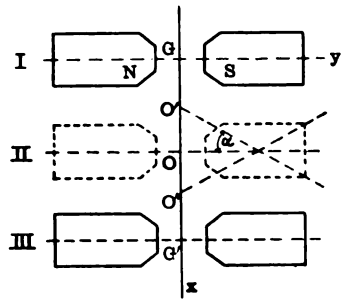

Fig. 1.

the constant ratio between the intensity and field, or coefficient of specific magnetisation, by K, we have $I = KH_y$, and therefore

$$f = KmH_y\frac{\partial H_y}{\partial x},$$

In bringing the magnet producing the field from a considerable distance the force, at first = 0, increases to a maximum at a certain point, O′ (Fig. 1), where the product of the field H_y, by its gradient $\partial H_y/\partial x$, is a maximum, and becomes zero again when the body O coincides with the centre of the magnet G (position II., Fig. 1). A minimum or negative maximum is reached by further rotation of

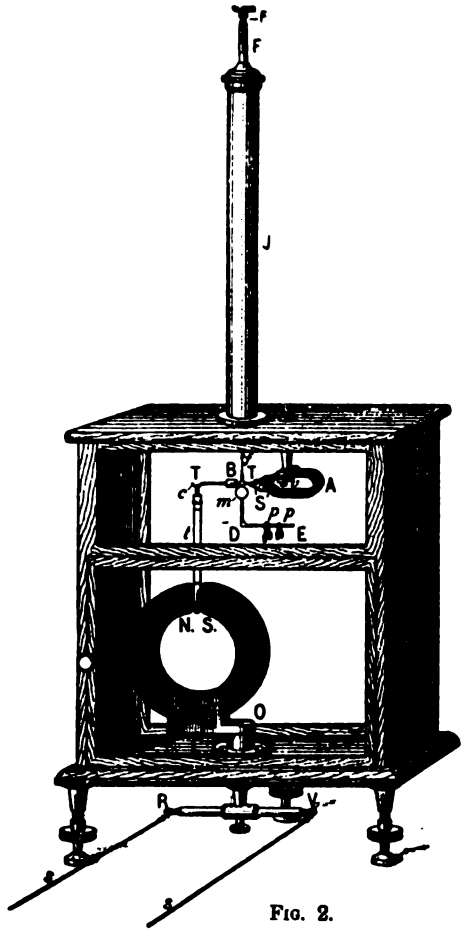

Fig. 2.

the magnet at a point, O″, symmetrical with O′, relatively to O, and becomes zero again after the magnet is withdrawn far from the body.

At every instant the action of the force is balanced by the torsion of the balance wire. If c is the moment of torsion per unit angle, and a the maximum deviation of the arm at O or O′ (Fig. 1), the equilibrium condition is $fl = ca$, l being the length of the balance arm. If the deviation is measured by lamp and scale, $a = D/2L$, D being the deflection of the spot upon the scale, and L the distance of the scale.

From the above equations

$$K = \frac{cD}{2mlLH_y\frac{\partial H_y}{\partial x}}.$$

This formula permits the absolute value of the coefficient K to be determined for a body if the other quantities are accurately determined. But the apparatus is especially adapted for relative measurements, and in this case it becomes extremely simple and practical, $Km/K'm'$ equalling D/D′, where m and m' are the respective masses. If the body is placed in a tube of glass or other substance, this tube being subjected like the body under test to the magnetic forces, an experiment must be made with the tube alone, and the effect due to the tube represented by a displacement of the spot D″ added or subtracted. This formula is not corrected for the effect due to the magnetisation of the air; the exact formula is obtained in the Paper.

If we take water as the standard body ($K' = -0{\cdot}79 \times 10^{-6}$), it enables us to obtain an absolute value of the coefficient of specific magnetisation of a body. It is convenient if the masses of the bodies compared correspond to the same volume; on this account the tube containing the substance is always filled to a given mark. When the substances tested are very strongly magnetic, a smaller length may be employed, but in that case it is absolutely necessary that the comparison substance should have the same length. The apparatus could be made still more sensitive with the aid of an electromagnet. On the other hand, with a torsion wire of larger diameter, the magnetic properties of iron or other ferro-magnetic metals and alloys could be determined. It would doubtless suffice to use an

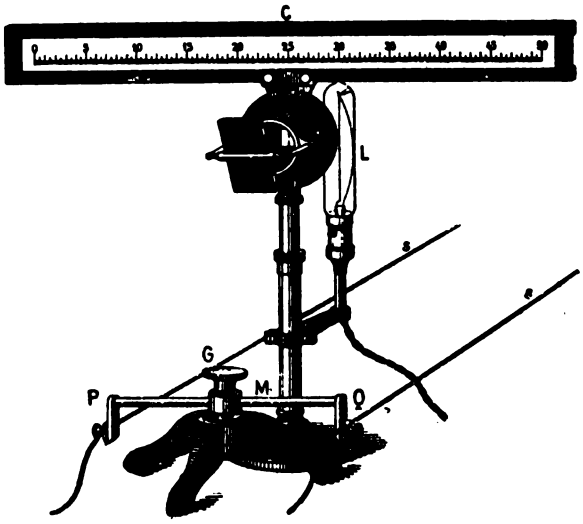

Fig. 3.

extremely fine wire of the metal, and to employ the method of experiment and the corrections already proposed by P. Curie in a work on the magnetic properties of bodies.*

Magnetically Damped Form of Instrument.—The arm of the torsion balance is formed by a rod, TT (Fig. 2), which carries from one of its two extremities a hook, c, from which the glass tube t, which contains the body, can be suspended. To this end the glass tube is closed by a cork carrying a metallic ring which hangs on the hook c. The tube t is therefore in a vertical position. On the other end of the arm TT is fixed a copper sector, S′, which moves between the poles of a fixed damping magnet, A. To vary the sensitiveness the torsion wire can be changed, and the damping varied by the position of the copper sector in the field. On the horizontal arm TT is fixed a vertical copper strip which carries a hook to which the torsion wire f ($\frac{1}{10}$ mm. platinum) is attached. Below, this strip is turned at right angles, as shown by the portion DE parallel to TT. Balance is obtained partly by the aid of a small copper cylinder, B, sliding on the rod TT, when the tube is empty, and partly by copper or aluminium riders, pp, to compensate for the weight of the solid or liquid material which fills the tube to the level marked.

The displacement of the magnet N.S. is obtained by a movement of rotation around an axis, O; this movement is smoother than the sliding motion of our earlier model. The movements of the torsion balance are followed by the observer upon a divided scale, C (Fig. 3). For this purpose a 2-metre radius concave mirror, m, is attached to the balance arm, and the image of a straight filament is employed. The displacement of the magnet is effected by a controller, M (Fig. 3), fixed in front of the scale, which consists of a horizontal rod, PQ

* Annales de Chimie et de Physique (1895).

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turning about a vertical axis in a heavy base, and furnished with a large milled head, G, which can be turned by the observer. This rod is provided with two clamps, P and Q, which are attached by two cords to two rings, R and V, on a similar rod attached to the axis of the magnet NS. If the cords are initially arranged so that the rods PQ and RV are parallel, the position of the magnet is at once determined by the direction of the rod PQ, and it can be turned either by the milled head G, or preferably by holding the two cords *ss* like reins.

The advantage of employing a rectilinear filament lamp is considerable in practice, as the spot is always visible on the scale even if the torsion arm is not perfectly balanced horizontally.

Appendix.

One of these balances has been set up and tested in the laboratories of the Northampton Institute. The instrument was of the magnetically damped type described above, and was used with a lamp and scale at some 2 metres distant from the mirror. No attempt was made to obtain absolute values of the coefficients of specific magnetisation; but relative determinations only were made, using as a standard substance distilled water, and assuming for it the value $K' = -0{\cdot}79 \times 10^{-6}$, found by M. Curie.

The results obtained, some of which are given below, are set out in the accompanying table, and show some interesting figures.

Of the chemically pure liquids tested all exhibit diamagnetic qualities. The samples of aluminium are all magnetic, and we have not been able to get a sample which is less magnetic than the first of these. Eleven samples of brass showed a great range of magnetic qualities. Of nine samples of copper tabulated one only is diamagnetic, again emphasising the difficulty of obtaining really non-magnetic conductors.

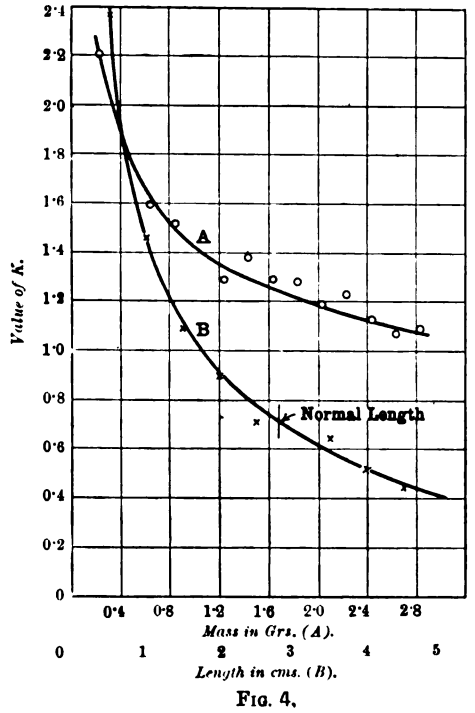

Fig. 4.

A point in connection with resistance alloys tested is the fact that every alloy is magnetic, but that those alloys containing relatively a large proportion of the magnetic metal nickel—*i.e.*, nickelines—are among the least so. The samples of platinoid fall into this group. The constantans come next in order. Eureka is a resistance material which is often classed as a constantan, but the balance easily disproves this, as it shows it to be so magnetic that observations would have had to be made with a stiffer suspension than we were using, and this, coupled with its positive temperature coefficient, rule it out of the group. The magnetic behaviour of manganin is remarkable. This is of particular interest in view of its almost universal adoption for the construction of accurate resistances, but it is not altogether unexpected when we remember that the remarkable Heusler alloys have a copper-aluminium manganese composition.

Another table in the Paper indicates the variation in the value of K with increase in mass of the specimen and increase in length. In the first case the sample, in the form of a bare wire 1 mm. in diameter, was cut up into standard length (approx. 2·8 cm.), and successive lengths of measured mass were introduced into the tube until it would hold no more; it will be observed that the value of K tends to diminish as the mass increases. (Curve A, Fig. 4.) The apparatus is, of course, very sensitive to the length of specimen, and an extreme range of length was taken in a wire of 1 mm. diameter, and the results are shown in curve B (copper).

Substance.	Density, Δ.	Coeff. of specific magnetisation, K.
Water	1·0	$-0{\cdot}79 \times 10^{-6}$
Alcohol	0·79	$-0{\cdot}78$
Benzene	0·85	$-0{\cdot}962$
Luxor oil	0·8	$-0{\cdot}594$
Aluminium (four samples)	2·67	$1{\cdot}19 \times 10^{-6}$ to $2{\cdot}99 \times 10^{-6}$
Brass (eleven samples)	8·1	$-0{\cdot}026 \times 10^{-6}$ to $+4{\cdot}05 \times 10^{-6}$
Copper (nine samples)	8·9	$-0{\cdot}097 \times 10^{-6}$ to $+1{\cdot}06 \times 10^{-6}$
Tin	7·3	$0{\cdot}151 \times 10^{-6}$
Zinc (three samples)	6·9	$0{\cdot}043 \times 10^{-6}$ to $0{\cdot}224 \times 10^{-6}$
Nickelin (four samples)	9·09 to 8·77	$2{\cdot}11 \times 10^{-6}$ to $5{\cdot}76 \times 10^{-6}$
Platinoid	8·83	$1{\cdot}75 \times 10^{-6}$
Constantan (four samples)	8·99	$9{\cdot}67 \times 10^{-6}$ to $12{\cdot}37 \times 10^{-6}$
German silver	9·06	$6{\cdot}77 \times 10^{-6}$
Manganin	8·61	$28{\cdot}05 \times 10^{-6}$

The difficulty of obtaining non-magnetic copper has already been referred to, and every instrument maker knows how difficult it is to wind a really non-magnetic D'Arsonval coil. In order to see how far this is dependent upon surface conditions, a sample of copper was taken and treated with concentrated hydrochloric acid and retested, and it was found that the value of K was reduced to nearly one-half, and that further treatment had but little effect.

From these results it will be seen that there is a considerable field of usefulness for the balance. Firstly, for examining the materials to be used in the construction of standard apparatus where the permeability becomes of first importance. Secondly, in grading and examining alloys whose properties are materially dependent upon minute traces of alloying constituents which are so difficult to estimate by chemical means, and which play such an important part in their electrical behaviour. Thirdly, it could well be used to maintain the standard of purity in the commercial production of such a metal as aluminium, whose chief impurity is iron, the last traces of which are so difficult to remove.

SOME PRACTICAL RESULTS OF THE USE OF CAR METERS.*

BY M. BATTES.

Summary.—After briefly summarising the progress that has been made in the use of car meters up to the present year, the reporter goes on to deal with the answers he has received to the *questionnaire*. It appears that great economies in money and energy consumption are derivable by the use of both clock and wattmeters, but the former class have the advantage of being cheaper in first cost and upkeep. The use of these instruments has allowed the average speed to be raised, but it is not known what effect they have on the number of accidents. The economies realisable are not set off by the greater cost of energy due to the higher speeds, nor are the motors adversely affected.

The subject of car meters was first dealt with by the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Local at the Milan congress four years ago, Mr. Wattmann, of Frankfort, being the reporter. He pointed out that by the use of these instruments very good control of the energy consumption could be obtained, a view that was supported both by Mr. Otto, of Berlin, and by the present author at the congress at Munich two years ago.

Mr. Otto summed up his report on the results obtained up to 1908 by showing that the control of the motorman, whether it be by a clock or current meter, is a certain means of discovering the skill of the individual and of obtaining economies in energy consumption. On the other hand, as the results obtained with the clock meter possess the same practical value from the point of view of control as do those of the current meter, while the first cost, upkeep and adminis-

* Abstract of a report by Mr. Battes, general manager of the Frankfort tramways, on the replies received by the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Local in response to the *questionnaire* sent out to the members, presented at the biennial meeting at Brussels (1910).

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trative charges, necessary for the evaluation of the results, are much less in the case of these instruments than with the current meter, and that, further, the accuracy of the clock meter is certainly not less than that of the current meter, preference must, therefore, be given to it.

The Munich report concluded as follows: On systems of minor importance, good inspection may take the place of control by means of meters; the control of energy consumption by means of meters placed on the cars is recommended on all systems of any importance; such control becomes increasingly necessary as the service becomes more complicated, for the conditions under which the service is carried on in large towns, in the middle of dense traffic and where frequent stops are necessary, due to the great use of the tramways made by the public, require that the motormen should continually pay close attention to their work; control can be effected by watt-hour meters, ampere-hour meters or clock meters; as such control does not require that the absolute consumption of energy should be known, clock meters should be sufficient and are preferable, since they are accurate, simple and cheap; the office work necessary to evaluate the results obtained by the meters can be organised very simply and cheaply; the presentation of prizes for economical working is not recommended. The opinion was also expressed that the introduction of a good system of energy control would lead to a reduction in the number of accidents, and those members who had adopted these ideas were asked to give this point their particular attention.

In the *questionnaire*, on which the present report is based, stress was laid on the comparative results obtained by the use of current and clock meters and on the influence which the use of these meters has on the upkeep of the motors, whence it appears that the tests made during 1909 and 1910 indicate the special advantages of the clock meter.

At AMSTERDAM 235 clock meters have been installed since July, 1908, while up to that time the control of energy consumption had been effected experimentally by means of 75 clock meters and 21 wattmeters. It is considered that the clock meter is the simplest, least costly and most certain in operation. Tests have shown that wattmeters do not give accurate results and, further, require frequent and heavy repairs. The cost of installation of a clock meter, including fitting, is £2. 4s., the cost of repair is practically nil and the expenses of administration work out at about 0·0026d. per car-mile. The saving realised in 1909, as compared with the expenditure in 1906, was 11·5 per cent., while the consumption of energy per car-mile decreased from 0·876 to 0·776 units. It should be remarked, however, that part of this economy is due to the introduction of a better system of cleaning the rails.

At BERLIN, the success of a system of energy control has been very remarkable. The whole of the motor cars—that is to say, 1,491—have been equipped with clock meters since 1908. Comparative tests on a large scale, which have been carried out between wattmeters and clock meters, have shown that from the point of view of accurate results the two systems are about equivalent. On the other hand, the greater simplicity of the clock meters, their less first cost and cost of upkeep, and, above all, the great ease with which their readings can be understood by the motormen, have led this company to consider them superior to wattmeters. The first cost, including fitting, of a clock meter is about £2 in Berlin. Up to the present no upkeep costs have been incurred, as the instruments are still working under guarantee. The administration costs work out at about 0·004d. per car-mile. The application of the results obtained from the meters is very simple, being similar to that employed on the Frankfort tramways, and described in THE ELECTRICIAN, Vol. LIX., p. 252. The reduction in energy consumption in 1909 compared with that in 1907 was 7·8 per cent., which works out at an economy of £21,344, in spite of the fact that the average speed has been increased by 10 per cent.

At BERNE, 10 motor cars were fitted with clock meters in 1908. This step has led to an economy in energy consumption of 10 per cent. Meanwhile clock meters have been installed on the whole of the 41 motor cars now in service.

The results obtained at COLOGNE by the use of clock meters have been just as favourable as those set out above. As an experiment, 75 cars were fitted with these instruments in June, 1907, and as a result of the tests then made it was decided, at the beginning of 1909, similarly to equip the remaining 335 cars. Up to the present this system has worked quite well. The total first cost is £2. 1s. per car, the upkeep costs being about 0·0004d. per car-mile, and the administrative expenses about 0·01d. per car-mile. Control is effected in the same way as in Berlin. This system of control during 1909 has led to an economy of 0·072 unit per car-mile as compared with the energy consumed in 1908—*i.e.*, about 8·6 per cent. of the total consumption—in spite of the fact that during the course of the year 60 motor cars 1½ tons heavier and 140 trailers weighing 2·5 tons more than those formerly used were placed in service. Taking into account these extra weights it is calculated that the actual reduction in consumption due to car meters amounted to about 0·1 unit per car-mile. The amount saved in energy cost per month from April to December was £3,750, energy being purchased at a price of 0·85d. per unit.

At DUSSELDORF, all motor cars are now equipped with clock meters, the sole inconvenience complained of in these instruments being that they do not allow the time during which the motors are working in parallel to be determined. The first cost is about 35s. per car, the cost of upkeep and administration being 0·004d. per car-mile. It would seem that a saving in energy consumption of from 5 to 7 per cent. can be obtained, while on some of the newer cars after clock meters had been fitted the economy in energy was as much as 15 per cent.

At BARMEN-ELBERFELD, all cars built since 1908 have been equipped with clock instead of wattmeters. The cost is £2 per car, while wattmeters cost £7. 10s. No new results have been obtained during 1909, owing to the abnormal conditions of working.

At HAGEN, clock meters have been installed on all the motor cars for some years, but they were not used for controlling the energy consumption until May, 1909. Very bad results were obtained with wattmeters. An economy of 6 per cent. has been effected, though the clock system has only been in operation for a few months. The financial result is a saving of £323, the equipment of each car costing £2. 6s.

Clock meters were adopted on the GLADBACH tramways in 1907, and in this case, it is surprising to note, the first cost reached the high figure of £3. 2s. per car. A 4·3 per cent. saving in energy consumption was, however, effected, with a reduction in the working expenses of £350.

At NEUENBOURG unfavourable results were obtained with wattmeters, and clock meters were installed at the end of 1908. The first cost was £2. 16s. per car, and the economy in energy consumption 11·3 per cent.

At NUREMBURG-FÜRTH, where clock meters are also used, a saving in energy consumption of 6·2 per cent. was obtained, while the working costs were reduced by £650 per annum.

Similar results were obtained at PLAUEN, while clock meters, which were adopted at UTRECHT after comparative tests had been made, showed that, though all classes of meter work equally well, the first and upkeep costs were much less in the case of clock meters.

At VIENNA, all motor cars have been fitted with car meters since January of this year. This step was taken after comparative tests had been made between clock and wattmeters. The apparatus has been in use too short a time for any practical results to be obtained. Similar replies have been received from WIESBADEN and ZURICH.

From these replies it appears that a large number of undertakings have obtained excellent results, and have even notably improved their previous results by controlling their energy consumption with clock meters. On the other hand, control by wattmeters has but little developed.

In 1908, 126 motor cars in DRESDEN were fitted with wattmeters. In the interval the whole 504 motor cars have been so fitted, with successful results. The cost of installation is £3. 15s. per car.

The 19 motor cars in use on the MULHAUSEN tramways are still fitted with wattmeters. In 1908 it was reported that these worked badly, and that the motormen had lost confidence in them. Since then the construction of the apparatus has been improved. The economy obtained has been 10 per cent., but the instruments require constant inspection.

At STOCKHOLM, where in 1908 only 10 motor cars were fitted with watt meters, the whole are now so provided. An economy of 5·75 per cent. in current consumption has been obtained and reduction in expenses of £1,925. The first cost is £6. 17s. per car.

Of the numerous systems of control in use the reporter points out that that by ampere-hour meters has developed the least.

The BORDEAUX tramway company chose this type of meter after comparative tests. The whole of their cars have been provided with them since June, 1909, and they have proved satisfactory. Their first cost is £4. 5s., their upkeep 12s. 6d. and the administration expenses 0·009d. per car-mile. The control of the energy consumption has resulted in an economy of 10 per cent., or £1,600.

At MARSEILLES, where there are 400 motor-cars, 15 are fitted with clock meters and 10 with ampere-hour meters, but it has not yet been decided which of the two systems shall be adopted. Greater exactitude in the control of the energy consumed can be obtained than by using clock meters, while ampere-hour meters are preferred to wattmeters on account of their accuracy and construction. It has not been possible for any results to be given on the economies obtainable, as the tests have been too short and on too small a scale.

On the EAST PARIS tramways the whole of the 287 motor-cars are now fitted with ampere-hour meters. Previously, comparative

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tests were made between wattmeters and clock meters. The first cost of the ampere-hour meters is £5. 13s. per car. On this system this class of meter has given excellent results, an economy of 7·27 per cent. in consumption having been obtained, corresponding to a saving of £2,419. The upkeep of these meters is 0·005d. per car-mile, and the administrative expenses are 0·009d. per car-mile.

From the results given above it appears that important systems cannot do without some sort of control over the energy consumed, while this control may be practically realised by means of some relatively simple apparatus. The different systems of control, whether by wattmeters, ampere-hour meters or clock meters, have given quite favourable results.

The majority of the companies who have answered the questions use clock meters, and these instruments have indubitably furnished results quite as good as either wattmeters or ampere-hour-meters. Besides, taking into account the importance of the financial results obtainable, the first cost and costs of upkeep, which are much higher for the last two types than for clock meters, can certainly be neglected, and each system may, therefore, be allowed the choice of determining what sort of instrument it should use.

The *questionnaire* inquired whether still further economies might be expected, taking into account the good results that had been generally obtained from the control of energy consumption. The majority of the members answered in the negative. It may be observed in this connection that on account of the growing increase in traffic, an increase in the energy consumption must also occur. This will inevitably reduce the percentage of economy obtained by the use of car meters. Some of the companies, however, hope to obtain still further economies than they have at present reached. In the opinion of the reporter there is a danger in laying too much stress on obtaining a great economy in energy consumption, for the motormen are thus incited to start contrary to reasonable orders that they have received.

As regards the question whether the use of car meters has led to a greater regularity of service, only a few of the companies have answered in the affirmative. No opinion is, therefore, expressed by the reporter on the point as to whether the control of energy consumption leads to a greater regularity in the service, either directly or indirectly. Directly, in the sense that motormen, observing the time the current is on or the energy consumption that has been fixed for certain sections of the route, are generally as regular as when they take into account the total operating time; indirectly, in the sense that the control of energy consumption allows the inspection of the motormen to be controlled in a closer manner.

In 1908 it was mentioned, in answer to a question by Mr. Hähner, of Strassburg, that the introduction of car meters permitted an increase in the commercial speed at Frankfort. Formerly, on account of the rule against increasing the maximum speed between consecutive stopping places, the motormen were led, in order to keep to the time-table, to prolong their waits at the termini. Control had, therefore, as a result, a decrease in the mean speed. It follows from this that the time allowed for travelling could be without inconvenience reduced by raising the former maxima speeds. The increase in rapidity of communication was very much appreciated by the public. General satisfaction has been caused by raising the mean speed from 7½ to 8¾ miles per hour and during the year 1908-09 a reduction in the running expenses of £13,000 from this cause alone has been obtained. Similar results have been obtained in Berlin.

These practical results and the accurate observations made in Frankfort on the increase of energy consumption owing to the increased commercial speed, contravert the false hypothesis formulated in Magdeburg, that the economies realisable in the running costs would be absorbed by the extra expense for energy.

Another question asked whether the employment of car meters exercised an unfavourable effect on the upkeep of the motors. This question was prompted by the fact that in certain places an assertion had been made that the economies realised in energy consumption were absorbed by repairing the motors, due to the new methods of working. It is interesting to notice from the answers given that only one company—and that of secondary magnitude—has stated that it is obliged to turn up the commutators more often than formerly. In general, no unfavourable influence on the upkeep of the motors has been noticed, while on certain large systems the use of car meters seems to have been favourable to their good operation.

The question, which was also asked, regarding how the number of accidents was affected by the use of car meters, is very difficult to answer. The number of accidents, in fact, depends on a series of circumstances, viz., the quality of the *personnel* and its professional education, the nature of the population in the different towns, the local circumstances of the track, the commercial speed, the braking arrangements, the operation of the brakes, the careful upkeep of the rolling stock and the general traffic conditions in the streets. It is, therefore, very hard to say whether a diminution in accidents is due to the use of car meters alone. Several answers state that the number of accidents has decreased since car meters were introduced, but they do not say in what proportion this diminution is due to the better methods of control. One single system alone states that the use of car meters has undoubtedly led to an important decrease in the number of accidents. Another member states that following on the use of clock meters the class of accidents which occurs to travellers at the moment they get on to the car will become more frequent. The reporter cannot subscribe to this opinion, which does not seem to be based on any fact.

As regards the improvements which it would be desirable to introduce into the various meters actually in use, attention may be called to one which is mentioned by most of the undertakings. It is that the current meters should register the energy consumption or the time during which the current is on separately for series and parallel working. Certain undertakings also think it would be useful to employ automatic apparatus to prevent the motormen from starting too quickly. However justified these desiderata may be under certain conditions, care should be taken not to interfere with personal control too much, or else the remedy will tend to become worse than the disease. In this connection it may be mentioned that the Hagen undertaking report that they have put into service a ratchet arrangement for working the controllers. It would be interesting to know later on how this behaves in practice. Brussels, too, employ with great success a system of so-called automatic starting resistances.

A special question which was introduced into the *questionnaire* at the request of Mr. Bouton, seems to have rather lost its purpose on account of the results described above. Even before the introduction of current control all the undertakings had dealt with motormen who started too rapidly. Passengers, too, exercise an excellent control in this respect, as they would not tolerate the continual disadvantages occasioned by starting too quickly. Before the adoption of current control the motormen were inclined to diminish the running time in order to increase the waits at the termini. In this respect, too, the use of wattmeters and ammeters have a disadvantage. When the motors are started too rapidly the resistances are cut out of circuit quickly. In consequence, the losses in the resistances are diminished, and an increase in the useful effect during the period of acceleration is obtained. Well-standardised wattmeters and ammeters, therefore, tend to render the motorman less conscientious in starting at an exaggerated speed than is the case with the clock meters. If it is considered that in the case of rapid starting the motor meter, on account of its armature, gives results which do not correspond to the absolute values because it cannot follow immediately the rapid increase in current or electrical work, one is led to the conclusion that this reproach, which has been made specially against clock meters, is not justified. Besides, the motorman who habitually starts too rapidly is soon discovered, from the fact that his figures for energy consumption are much less than the mean value. In the reporter's opinion this inconvenience is relatively easy to avoid, notably by giving instructions to the motormen that they must keep their consumption as far as possible in the neighbourhood of the mean value and by not inciting them by the inopportune inspection to try and obtain figures which are favourable in appearance. It may be admitted that in general after proper instruction motormen will do this conscientiously. Some motormen, of course, to whom all control is an annoyance, will be disposed to commit intentional faults in starting in the hope of lowering the good name of the system in the eyes of the public and in the hope of doing away also with this system of control.

From the answers received to the last question of the *questionnaire* it appears that most of the systems are content with simply watching more closely such motormen as consume energy in a spendthrift way and to give them further instruction. Many of the others obtain the same end by working on the self-respect of their men, and by bringing to the knowledge of the *personnel* at more or less regular intervals the names of the best and the worst motormen. Some systems reward their best motormen by making them teach new comers. The majority of the systems are not in favour of punishment, which they consider as inefficacious.

Electric Cooking on War Vessels.—According to the "Electrical World," after elaborate tests the United States Navy Department have installed electric ranges and electric bakers on the "Dixie," and is considering electric cooking upon practically all their battleships and cruisers. The tests of these cooking devices were made at the Navy bakery school, near Newport, R.I.

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ILLUMINATION REQUIREMENTS IN STREET LIGHTING.*

BY A. J. SWEET.

Summary.—The author first discusses the requirements of street illumination and the avoidance of glare, and then proceeds to investigate the distribution curve necessary for a source of light in order that a practically uniform horizontal illumination (within limits of 1:4) may result. Some interesting investigations on the relation between glare effect and distance, between glare effect and candle-power, and between glare effect and angular position of the light source are described.

There are two results to be achieved in adequate street illumination, both of such paramount importance that it is properly a matter for individual opinion as to which should be ranked first. These are the avoidance of glare effect and the obtaining of an approximately uniform degree of illumination at all points along the course of the street, with higher intensities at street corners. These two results can only be obtained, the one by the correct solution of the allied problems of intrinsic brilliancy, total light flux and shadow contrasts, the other by the correct solution of the problem of distribution. Let us consider each of the results sought and define it a little more exactly.

Glare effect results whenever, throughout any infinitesimal period of time, an amount of light continues to fall upon the actively visualising portion of the retina of the eye sufficient in quantity to cause chemical changes more rapidly than the regenerative functions of the eye can keep pace with. Thus, when an eye, which has been exposed for some time to conditions of dark with resultant pupillary expansion, is suddenly exposed to even a moderate light, glare effect results. An excessive amount of light reaches the retina through the expanded pupil, and the regenerative functions cannot keep pace with the chemical changes induced. Rapidly, however, the pupil contracts, the regenerative functions regain their normal control, and the glare effect passes away. If now the eye be exposed to a still greater intensity of light, beyond the very limited capacity of pupillary contraction to compensate for, or if an even moderately bright light source is introduced near the centre of the field of vision, glare effect is again experienced; and this glare effect, after a brief period, reaches a certain state of equilibrium characterised by a quite definite decrease in efficiency of vision, which decrease thereafter increases in magnitude only rather slowly. We may, therefore, for convenience designate a glare condition as casual when it results from the inability of the pupil to adjust itself instantly to a changed condition of light intensity, and as fundamental when it results from a light intensity exceeding the contractive power of the pupil to compensate for, or when it results from a light source near the centre of the field of vision. The presence of strong shadow contrasts tends to produce a casual condition of glare. The evil effect of the shadow contrast lies in the demand it introduces for instantaneous pupillary changes of considerable magnitude when the eye is turned from the shaded to the unshaded area, or vice versa. In street lighting, this casual condition of glare is much less objectionable to the slowly moving pedestrian than to the more rapidly moving automobilist or carriage driver. It is usually sufficient, therefore, to throw the shadows toward the sidewalk and to provide against too deep shadows. The avoidance of objectionably-located shadow contrasts can only be taken care of by the proper placement of the light sources, while the intensity of the shadow contrast can be decreased by using smaller light sources placed nearer together. The problem of shadow contrasts, while of considerable importance, is one that must be solved individually for each individual case.

Brilliant, high candle-power light sources in the field of vision, the usual practice in contemporary street lighting, produce a fundamental condition of glare, with resultant heavy decrease in efficiency of vision—with probably also, be it noted, a permanently injurious effect on the faculty of vision. This fundamental condition of glare arises from the intrinsic brilliancy and total light flux of the light units employed and can only be avoided by the proper limitation of these. The study of the relations existing between intrinsic brilliancy and total light flux on the one hand, and glare effect on the other, becomes, therefore, one of the two chief purposes of an analysis of the illumination requirements of street lighting. The end sought should be the elimination of glare effect, or at least its reduction to such a permissible minimum as will not seriously decrease the efficiency of vision nor be sufficient to produce eye discomfort.

The derivation of the polar curves of light distribution which will give the proper relative intensity of illumination for points along the course of the street is, as has already been noted, the second of the two chief purposes of an analysis of illumination requirements in street lighting. Here the end sought is the uniform illumination of all points along the course of the street. At street intersections and similar crossings a brighter illumination is needed, of course. This should be of from four to eight times the intensity of the illumination along the main course of the street. Such brighter illumination is properly provided for by employing from four to eight light units each having the same light distribution as the units used along the course of the street, or by one or two light units of similar light distribution and larger size. The street intersection, therefore, presents no complication to our problem, and its proper treatment becomes merely a matter for adequate consideration at the time of installation.

The statement is often heard that in street lighting absolute uniformity of illumination is not required, or is of any particular importance. Taken in a very strict sense, this statement contains much truth. A ratio of maximum to minimum intensity of 4 to 1 is permissible; but the ratio in present practice most frequently falls between 100 to 1 and 500 to 1.

Another much-mooted question concerns the way in which illumination should be measured, whether horizontally or perpendicular to the light ray. The latter method has been largely adopted in American practice chiefly through the influence of the commercial interests concerned, who desire to make the minimum value look as large as possible. The horizontal plane, which is the accepted reference plane in interior lighting, is the logical and most satisfactory basis for street illumination measurements.

The ideal to be aimed at, therefore, in street lighting, as far as intensity is concerned, is uniform horizontal illumination. On this basis we can proceed to derive the ideal curves of light distribution. These curves once derived, we may properly take into account the fact that absolute uniformity is not of importance; and we shall only ask that the actual light distribution sought for as a practical ideal shall show no greater variation from our theoretical ideal than 4 to 1 in ratio of maximum positive variation to maximum negative variation, as read in percentage values of the theoretical curve along the corresponding angles.

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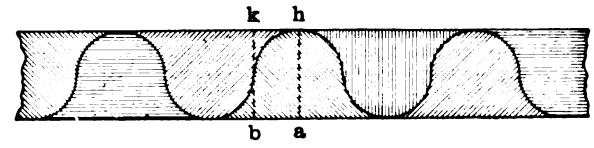

FIG. 1

The nature of a street makes most natural a placement of light units as a line of single units extending along the street, the units being hung over the centre of the roadway or located alternately on either side. For all practical purposes, these two cases can be treated as one, the separation of adjacent units being taken as the straight line distance between the units, and the distribution curve derived being the correct distribution in a vertical plane passing through the unit concerned and the adjacent unit. There are an infinite number of light distributions which will give uniform illumination from a line of light units along a line extending immediately under those units. Other considerations than the obtaining of uniformity must therefore serve to enable us to select the most desirable distribution curve.

Two such considerations are of especial importance and may therefore be applied with especial propriety. First, we should seek a distribution as will be best suited for actual, practical attainment. This consideration is of the more importance because, as we shall find, even when maximum weight is given to this consideration, our derived curve will present considerable, though by no means insurmountable, difficulties of practical realisation. Second, the illumination at any point should be derived from a source as near as possible in order to avoid both excessively long shadows and the glare effect which results from the high candle-power made necessary by illumination at great distances.

Various illumination curves are illustrated in the Paper. The author states that it can be shown mathematically that the curve which best meets the conditions is as shown in Fig. 1. This curve is formed by two circle quadrants. The corresponding distribution curve shows a low maximum which occurs at a slightly smaller angle than that subtended by half the separation of the units. It is also as well adaptable to practical realisation as any curve obtainable.

We have, therefore, obtained the ideal illumination curve from which the desired distribution curve can be easily derived.

* Abstract of a Paper read at a meeting of the Franklin Institute, Philadelphia.

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The relation between any desired illumination results and the distribution required to produce those results depends, in the type of problem under consideration, upon: (*a*) The distance between adjacent units; (*b*) the height of the light unit above the street. It is obvious that any given distribution curve will give the same proportionate illumination so long as the relation between the separation of units and the height above street is kept constant. We can combine, therefore, the factors (*a*) and (*b*), and say that the distribution required to produce any given illumination result depends upon the relation between (*a*) and (*b*). Let us call this relation $M = \frac{\text{distance between adjacent light units}}{\text{height of light unit above street}}$. For any value of M there is a given distribution curve which will produce the desired illumination result.

Present-day street lighting practice shows a wide variation in the value of M. In the large cities of America the values of M vary from M=5 to M=31. The smaller cities would probably show in general a higher value for M than the large cities. All

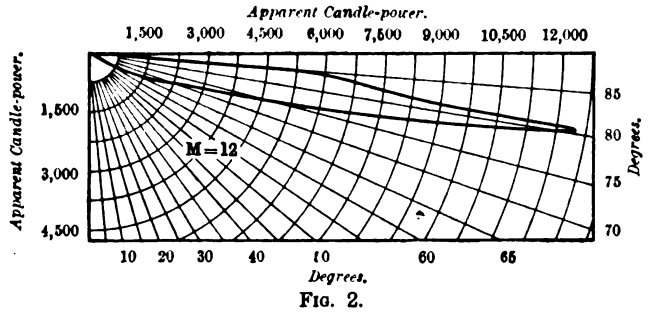

FIG. 2.

things considered, a value M=15 can probably be taken as the most representative value of present-day American practice, with a marked tendency towards smaller values in the more recent installations.

Fig. 2 shows the distribution curve required to produce uniform illumination when M=12. Such a curve, of course, is impractical for actual realisation, and would be extremely undesirable, even if it were practical to obtain it, on account of the excessive glare effect resulting from the very high candle-power maximum at a large angle. Fig. 2 serves one excellent purpose. It shows beyond argument that, with a value M=12 or greater, any attempt at adequate street lighting is absurd. If ignorance and a false economy compel an installation value of M=12 or greater, the pretence of obtaining "street illumination" should frankly be abandoned. Instead, the lights should be installed on the basis of a system of street markers, and located where they will best serve as markers. In such case, maximum usefulness as markers will be obtained when the candle-power values at the different angles are as close as pos-

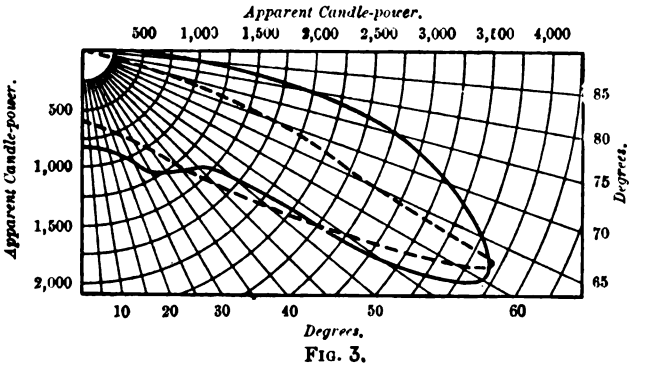

FIG. 3.

sible to, yet not exceeding, the limits imposed by the avoidance of glare effect. Be it noted that in sparsely settled districts, where the very slight use of the streets by night may not warrant adequate street illumination, such a system of markers has a very real field of usefulness.

The required distribution curves for M=8, M=6 and M=4 are given by the author. The latter two are quite practical. For instance, the full-line curve in Fig. 3 shows the actual distribution of one make of arc lamp to-day on the market, whilst the dotted curve is the ideal curve for M=4. It will be seen that the agreement of the two curves is admirable up to an angle of about 62 deg. The curves M=4 and M=6 would also be comparatively easy of attainment with the incandescent lamp or with the inverted gas mantle. This is of especial importance since, with these lower values of M, such smaller units give amply sufficient intensity of illumination except in those business centres where night traffic is considerable.

Smaller values for M than 4 would obviously fulfill all the conditions imposed by the requirements of good illumination. It is shown later in connection with glare that a value M=3 is necessary to obtain best results whenever, on account of shaded conditions of street or other considerations, it is desirable to mount the units at a height of 15 ft. or less above the street.

Thus far we have considered distribution only as referred to the vertical plane passing through the light unit and its adjacent unit. We will now consider the vertical plane perpendicular to the street line. In those rare instances where the width of the street from property line to property line is greater than the separation of adjacent units, the ideal distribution in this latter plane is similar, for the lesser angles, to the distribution required by the existing value of M. It continues, however, to a higher maximum, turning and receding rapidly to zero above the angle subtended by the distance from the light unit to the more distant property line. When the street width is not greater than the separation nor less than three-fourths of the separation, the distribution in the plane across the street should be approximately the same as in the plane

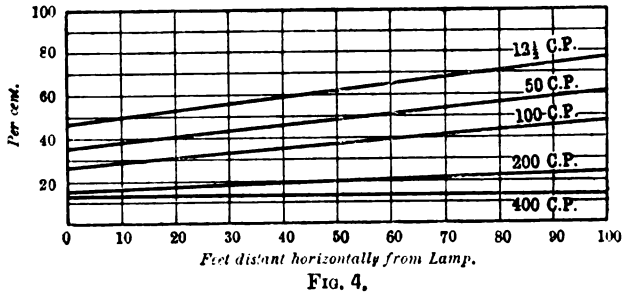

FIG. 4.

through the light units. When the street width is less than three-fourths of the separation, the distribution in the plane across the street is similar, for the lesser angles, to the distribution required by the existing value of M.

The second great division of our subject, the study of glare effect, has already been introduced in general terms in the earlier portion of this Paper. It now remains to analyse glare effect closely, to determine the laws of operation of the conditions that produce it, and to learn the limitations which it imposes on our problem. Avoidance of glare effect will operate by imposing a definite candle-power limit at each distribution angle, this limit varying only with the mounting height. In proportion as this candle-power limit is exceeded a greater or less glare effect will result.

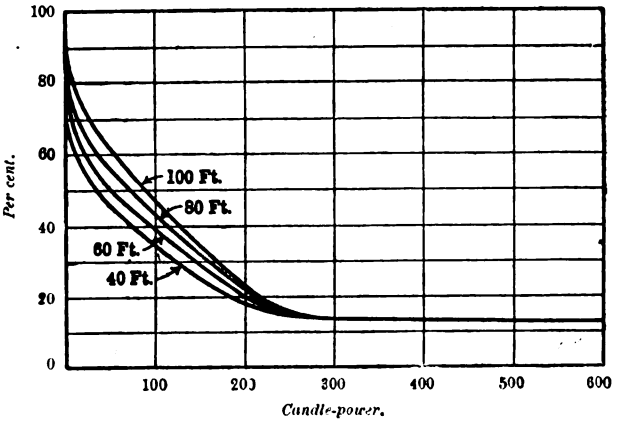

FIG. 5.

Subject to confirmation by research results, glare effect may be assumed to vary with the following factors: (*a*) Distance of the eye from the light source; (*b*) total light flux in the direction of the eye, this being measured in apparent candle-power at the distance of the eye; (*c*) intrinsic brilliancy of the light source; (*d*) angular position of the light source in the field of vision, the visualised object being assumed to occupy the centre of the field of vision; (*e*) distance of the light source from the eye relative to the distance of the visualised object upon which the eye is focussed.

In the present research the factor (*a*) was separately studied and determined with sufficient exactness to indicate reliably its character and approximate magnitude for distances up to 100 ft. Factors (*b*) and (*c*) were studied unseparated, as a single factor, the light flux varying directly as the intrinsic brilliancy. Factor (*d*) was separately studied and evaluated. Factor (*e*) was not investigated, the distance of the light source from the eye being in all cases taken

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as equal to the distance of the visualised object. This condition corresponds to the most usual condition of actual street vision.

Heretofore no satisfactory measure of glare effect has been proposed. Since we are dealing with a psychological phenomenon, the basis of measure must obviously be a psychological one. On the other hand, the measure must be expressible in definite numerical units. A basis of measure fulfilling these requirements was conceived of for this investigation and proved a very satisfactory one. Preliminary to a more detailed description, such a measure may be described as the ratio of the two minimum light intensities on the visualised object, of magnitude just sufficient to enable its discernment, when the eye was successively exposed to the two conditions under comparison. A careful preliminary investigation established the fact that, under widely varying daylight conditions, visual acuity was wholly independent of distance, within the limits investigated: that is to say, with any given type of visualised object, the minimum size of object which can be just barely distinguished as a separate unity is exactly proportional to the visual distance. Three different test-plates were employed. In these test-plates each object or unit gradation is 10 per cent. smaller than the one previous. After establishing the fact just stated, each observer was calibrated, the determination being made of the minimum unit gradation which could be individualised under daylight conditions at various standard test distances. The fourth larger gradation was then chosen as the test object at the corresponding distance in the glare tests. This made it certain that the test objects were, by a uniform amount, well within the limits of visual acuity under adequate conditions of illumination. Consequently the ability to visualise these objects was wholly determined by the visual efficiency of the eye and by the intensity of illumination on the object. Expressed mathematically, we are here dealing with a constant which is a function of two variables. One variable, therefore, the minimum intensity of illumination on the object

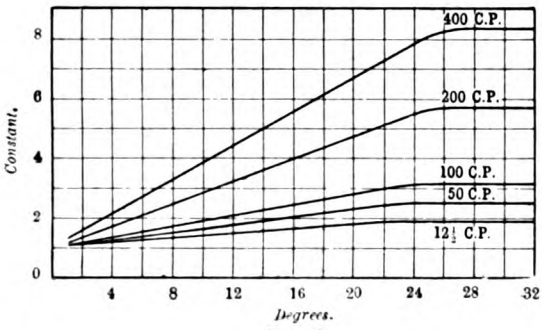

FIG. 6.

required to produce just-visibility, may be correctly employed as a measure of the other variable, the efficiency of the eye under any given condition. [The author believes that this basis of measurement is a very satisfactory one and has a wide field of usefulness in future investigations of this character.]

The basis of measurement being established, tests were first made to determine the relation between distance of the light source from the eye and the magnitude of the decrease in visual efficiency due to glare. These tests were made at five test stations, three independent sets of readings, one with each test plate, being taken at each station. Parallel tests were made with different observers. The complete series was then repeated with each observer, using various other candle-power intensities of the light source. The area of the light source throughout all these tests was kept constant, at about 50 sq. in., the intrinsic brilliancy thus varying directly with the candle-power, as has already been stated.

Fig. 4 expresses the relation between glare effect and distance, the light unit being situated beside the visualised object in the centre of the field of vision. The ordinates express visual efficiency in terms of the per cent. intensity of illumination on the visualised object which would be required for equal visual acuity were the light source entirely removed from the field of vision. It will be noted that at 12½ c.p. and an intrinsic brilliancy of 0·25, the glare effect drops off at a moderate rate with increase in distance. At higher candle-powers and higher intrinsic brilliancy, the glare effect decreases more slowly with increase in distance; until finally, at 400 c.p. and an intrinsic brilliancy of 8, there is no measurable decrease in glare effect with increase in distance within the limits investigated.

Fig. 5, derived from the same test data, expresses the relation between glare effect and candle-power (or, as it may be instead, between glare effect and intrinsic brilliancy). These curves are especially significant. It will be seen that, for all ordinary distances, the presence of a light source of even a very low candle-power in the centre of the field of vision causes a tremendous drop in visual efficiency. It will also be noted that at 300 c.p. the glare effect has nearly reached its maximum, and that beyond 300 c.p. a large increase in candle-power produces but a small decrease in visual efficiency. Finally, one should not fail to observe that at any given candle-power a considerable increase in distance produces only a small decrease in glare effect.

The relation between glare effect and the angular position of the light source in the field of vision was determined by a series of tests similar in general method to the tests already described. The amount of illumination required to see the test object when the light source was in the angular position was compared with the amount required when the light source was in the centre of the field of vision. The results obtained are shown in Fig. 6. The ordinates here express the intensity of illumination required with the light source in the centre of the field of vision as measured in terms of the

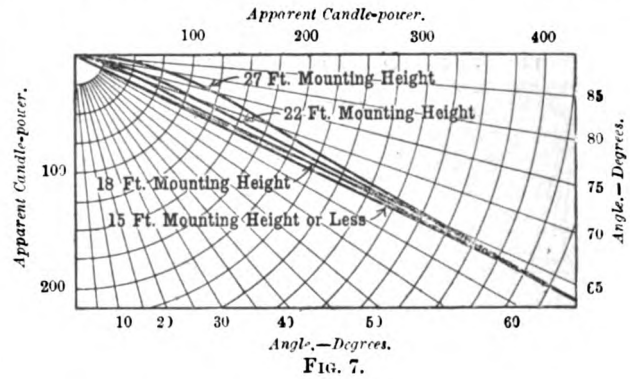

FIG. 7.

required intensity with the light source in the indicated angular position. The abscissæ in Fig. 6 represent the angles which the line from the light source to the eye makes with the line of vision.

The curves of Fig. 6 express a fact of the very highest importance in the study of glare, namely, that, at an angle varying, depending on the candle-power (intrinsic brilliancy ?), between approximately 22 deg. and approximately 26 deg. the glare effect reaches zero, although the light source is still well within the field of vision. This would seem to indicate that on its physiological side glare effect is a local retinal disturbance which, when sufficiently separated on the retina from the disturbance produced by the visualised object, does not extend to or affect the latter area of disturbance. This apparent fact seems to hold true even when a considerable time factor is introduced. Apparently pupillary contraction acts merely as a function protecting, within its very limited capacity, from a glare effect more or less suffused over the whole retina. The writer has

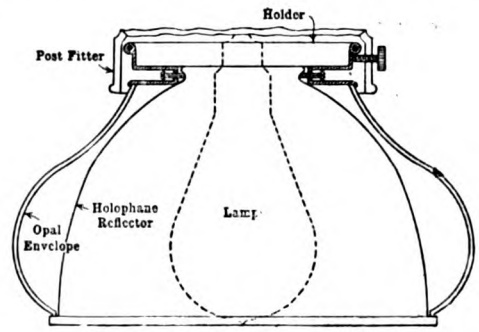

FIG. 8.

previously believed that pupillary contraction was in itself a cause of decreased visual efficiency in that, on account of pupillary contraction, a lesser amount of light would be admitted to the retina from the visualised object. He now believes that pupillary contraction should be regarded as a purely protective function and not, through its operation, in any sense itself a cause of decreased visual efficiency.

The practical importance attaching to these facts is of no less vital interest than the scientific. Fig. 6 means that the light instrumental in causing glare comes entirely from the polar angles above 60 deg. In the average actual case, glare is almost wholly caused by the light between the angles of 65 deg. and 80 deg. with the nadir. The light within these angles must be partially or wholly suppressed, as the further facts of the case will show to be required, if glare is to be avoided.

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We have already discussed the operation of the curve of zero glare effect in eliminating certain curves of distribution. We are now in a position to determine the true curves of zero glare effect, which, as will be remembered, will vary somewhat with the mounting height.

Fig. 7, derived from Figs. 4 and 6, gives the curves of zero glare effect for various mounting heights. Comparing these curves with the curve of ideal distribution when M=6, we see at once that this curve, together with curves of larger value of M, will be eliminated on account of the serious glare effect which would result from the application of such distributions to actual practice. The curve M=4, however, comes within the limitations imposed by the curve

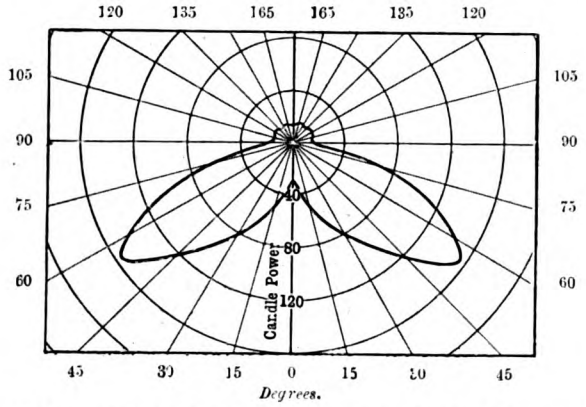

FIG. 9.—DISTRIBUTION GIVEN BY HOLOPHANE STREET LIGHTING UNIT WITH STANDARD 100 WATT 110 VOLT MULTIPLE LAMP.

of zero glare effect, providing the scale of the M=4 curve does not exceed that amount which would make the zero-degree candle-power equal to 100 c.p. The distribution curve corresponding to M=3 would come well within the limitiations imposed by zero glare.

Reference to Fig. 7 shows that for all practical purposes, 60 deg. is an absolute limit for maximum candle-power if serious glare effect is to be avoided. It will also be observed that an increase in mounting height, while it does not change the limiting angle for maximum candle-power, does considerably lighten the severity of the limitations at 65 deg. and above. Mounting heights of the larger values, when made possible by actual conditions, are also desirable as permitting wider separation of units with resultant decreased installation and maintenance cost. For mounting heights of 15 ft. or less, the curve M=4 will produce considerable glare, beyond,

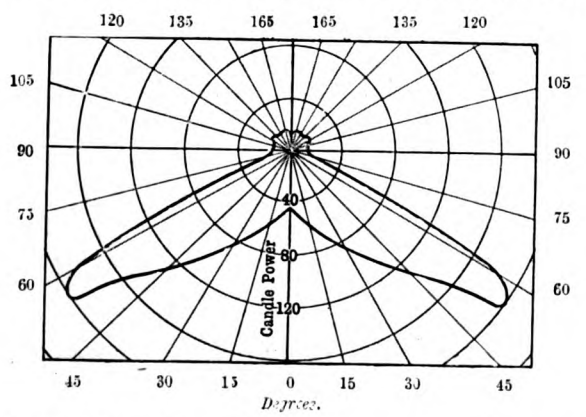

FIG. 10.—DISTRIBUTION GIVEN BY HOLOPHANE STREET LIGHTING UNIT WITH SPECIAL 100 WATT 5·5 AMP. SERIES LAMP.

indeed, what proper limitations can permit. For such lesser mounting heights, as has already been pointed out, a closer spacing of units and a distribution corresponding to the curve M=3 should be used.

In designing a light unit to give the desired distribution which has largest field of application, namely, the distribution from M=4, it will be preferable by far that the candle-power values at 60 deg. and above, be less than those made proper by the ideal curve, rather than that these ideal values be exceeded. With an ideal curve of such candle-power magnitude as would be most useful, the candle-power values at the angles under consideration come perilously near to the glare limit, or may even exceed the glare limit. A per cent. variation from the ideal curve of four to one is, as has been pointed out, permissible. Even a moderate condition of glare, on the other hand, is very undesirable. Practical considerations, therefore, will lead us, in the design of the actual unit, to deviate intentionally from the M=4 curve at angles of 60 deg. and above, this devitaion being in the direction of lesser candle-power values.

It is of the utmost importance to note that if the glare limit is exceeded at all, it will almost of necessity be exceeded excessively. The curve of zero glare-effect runs almost instantly back to zero near the angle of 65 deg. The glare-effect would therefore increase with great rapidity as an angle of 65 deg. was exceeded. The curves required for uniform illumination, on the other hand, increase with great rapidity in candle-power values to their point of turning. It is obvious that the curve of zero glare effect must be taken as a line of absolute prohibition. If it is to be exceeded at all, it may as well be entirely ignored. For an apparently small violation of the limit will produce a decrease in visual efficiency of approximately the same order of magnitude as the maximum possible effect.

It is also of great importance to note that the curve of ideal distribution for M=4 remains, though not an ideal, yet none the less the best possible curve when applied to actual conditions where M has a larger value than 4. The curve M=4 gives the best spot-lighting effect and the best marker-effect which are possible without engendering a condition of glare. This research has indicated that, for ordinary mounting heights, moderate glare is a mere name: the reality is always excessive glare. It is the opinion of the writer, therefore, that glare must be avoided, even if so important a consideration as proper distribution has to be sacrificed. And indeed, as has been shown, other conditions than glare make a proper distribution impractical or even impossible with the larger values of M. The curve M=4 is to be regarded, therefore, not merely as the ideal curve for a certain relatively close spacing of light units which the public is not as yet educated up to, but as the best possible distribution which can be applied to any of our present-day spacings. This Paper is not presented, therefore, as merely expressing an ideal to be approximated to in a comparatively remote future. Rather, it should serve as a guide of immediate usefulness and application to present-day practice. The ordinary citizen of to-day, however, uses in his ignorance the very defect itself, the glaring character of a street illuminant, as a measure of its excellence. Such ordinary citizen would consider himself defrauded were he called upon to pay through his taxes for a street illumination characterised by absence of glare, by light on the street itself and not in the eye.

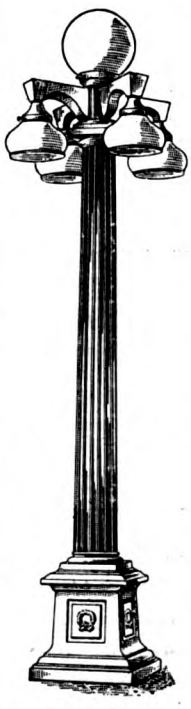

FIG. 11.

In the current issue of the "Illuminating Engineer," of New York, Mr. A. J. Sweet, after enumerating the requirements of street lighting, as set out above, describes a new combination diffusing and reflecting unit for use with a tungsten lamp. The construction of this unit is shown in Fig. 8 herewith. It consists essentially of a Holophane prismatic reflector surrounded by an outside opal envelope, the two being held together by a suitable metal holder. The primary function of the opal envelope is to protect the reflector prisms from dirt deposit which, in the presence of the mositure incident to out-of-door service, would cut down the reflecting efficiency of the prisms. A metal envelope might, of course, be used to accomplish the same purpose, but it is considered desirable that the unit be visible by night, both on account of artistic considerations and in order to afford a marked effect along the course of the street.

When used with the standard multiple lamp this unit, the author claims, gives a materially lower degree of glare than any other unit of equal illuminating power with which he is acquainted. The several large manufacturers of tungsten lamps are now seeking to develop a special series lamp, and when this has been satisfactorily worked out it is believed that a street lighting unit giving complete absence of glare will be produced.

The curves of distribution of the present unit are shown in Figs. 9 and 10. Its appearance in service in connection with a modern lamp-post is shown in Fig. 11.

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ENERGY CONSUMPTION ON TRAMWAYS.

An examination of the statistical records of electric tramways for the past year, together with the reports of the general managers of the undertakings, shows that in several cases economies have been found possible in the consumption of electrical energy, apart from any saving due to lower charges being made for current supplied by the electricity departments. A short time ago it was the general experience that the number of units used per car-mile had a tendency to increase—in many cases owing to the use of heavier cars with top covers and to the growth of traffic—but of recent years, owing to the disappointing financial returns shown by many undertakings, considerable attention has been paid to checking any such tendency and to reducing the working expenses generally of tramways. This has led to a careful scrutiny of all items of expense; and on that account efforts have frequently been concentrated on obtaining a lower charge for the electrical energy purchased. In some instances, undoubtedly, a lower charge is justified, and it would tend to harmonious working if it were possible to agree upon a uniform method of calculating the charge for energy. Though, if the true cost of generating the electrical energy is to form the sole basis of calculation, together with the respective capital charges, as has already been arranged by some electricity and tramway committees, this to some extent ignores the

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factor for the due observance of which Mr. E. W. COWAN is energetically pleading, namely, the character and intensity of the demand.

In the case of a large undertaking a small reduction in the price per unit at which current is purchased means a considerable sum when reckoned on the total number of units used; but it must not be forgotten that equally satisfactory results can be obtained by even small economies in the energy consumed per car. In this connection, encouraging results have been obtained in this country, as well as abroad, by instructing the motormen in the handling of their cars in a more careful manner and by installing meters so that a complete check can be obtained on the energy consumption of individual cars. To Mr. R. S. PILCHER, general manager of the Aberdeen Corporation Tramways, belongs the credit of being one of the first to appreciate the benefits likely to accrue from systematic instruction of the motormen. In a Paper read last year before the Municipal Tramways Association, Mr. PILCHER called attention to this subject, and further particulars of the results achieved at Aberdeen are contained in his annual report, for the year ended May 31st last, on the tramways of that city. A curve given in this report shows how the energy consumption on the Aberdeen tramways steadily increased from 1·05 units per car-mile in 1903 to a maximum of 1·328 units in 1906. At that date instruction of the motormen was introduced, and was followed by the installation of car-meters. The result is that the consumption has now decreased to 1·182 units per car-mile, notwithstanding that a large proportion of the cars have been fitted with top covers during this period. It is interesting to notice that Mr. PILCHER believes the minimum point of energy consumption has now been reached. It must also not be forgotten that a saving over and above that shown in energy consumption is obtained where meters have been installed, since there is considerably less wear and tear upon the gear and equipment of the cars, particularly as regards brake blocks. In fact, the full effects of more careful driving are likely to become apparent to a still greater extent in the future when the repairs and maintenance item is considered.

Further striking evidence of the saving in energy brought about by the employment of meters on tramcars is provided in the annual report of Mr. L. E. HARVEY on the working of the South Shields Corporation tramway undertaking. Up to the end of November last the energy used by the cars averaged 1·363 units per car-mile. Meters had been installed on all cars by that date, but owing to the necessity of the men having to be trained to economise energy, and also owing to the exceptional climatic conditions prevailing, the full effect of the meters did not become apparent for the next two months. In February of the present year, however, the energy consumption had decreased to 1·196 units per car-mile and in March to 1·188 units, a reduction of about 13 per cent. on the figure recorded before the installation of the meters. Although, of course, it is impossible to compare the energy consumption on two tramways without full consideration of all the particulars of their equipment and operation, it is interesting, nevertheless, to notice how these figures resemble those at Aberdeen, both as regards energy consumption and the saving obtained by the use of meters. In fact, the experience at Aberdeen and South Shields is typical of the results achieved elsewhere, and emphasises the importance of keeping records of this kind.

Although during the last year or two much greater interest has been taken in the advantages to be derived from recording the energy consumption of each car, as is shown to some extent by the number of meters in use (in this connection reference may be made to "The Electrician" Annual Tables of Electric Tramway Undertakings), it is rather curious to notice that many of the largest undertakings in this country appear to have done very little experimenting, or, at any rate, have few, if any, meters in use. The most striking instance, of course, is that of the London County Council tramways. The emergencies of London traffic to some extent prevent the motormen from exercising that care which would be possible under other conditions; nevertheless, there would certainly seem to be a need for recording the energy consumption, since it is noticeable that "coasting" is rarely practised by the motormen. On the other hand, if we turn to Continental tramways it will be found that extensive experience has been gained for some years on most of the important undertakings, and the subject has been carefully investigated by the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Local. At the Congress of this Society at Brussels during the present month two reports on car meters were submitted; the first by Mr. BATTES, general manager of the Frankfort-on-Main Corporation Tramways, and the other by Mr. BOUTON, of the East Paris Tramway Co. Elsewhere in the present issue we give an abstract of Mr. BATTES' report, and we hope to give an abstract of Mr. BOUTON'S report in a subsequent issue. Both of these reports should prove very valuable to English tramway managers. It will be remembered that at previous congresses reports have been presented by Messrs. OTTO and BATTES, and it was owing to the desirability of collecting further information and reaching, if possible, final conclusions that the present reports have been prepared. Mr. BATTES reports that watt-hour, ampere-hour and the clock type of meter appear to be giving satisfactory results, but the clock type is generally preferred. Mr. BOUTON is in favour of the ampere-hour type under the following conditions:—where a bonus system is under consideration, where it is difficult to supervise drivers, wherever stops are frequent, cars are heavy, curves are numerous, gradients steep and current is expensive. Under other circumstances the use of time meters is recommended, except in the case of small undertakings. It is worth noting that the subject is also being considered in America, and the abstract of a Paper by Mr. H. St. C. PUTNAM, which is given on another page, should prove of interest to engineers. In fact, a wealth of information is now available, and it is noteworthy that it practically all points to the importance of recording and checking the energy consumption of individual cars.

Reverting, in conclusion, to practice in this country, most tramway managers now appreciate the value of diagrams for conveying at a glance information which would otherwise be buried in a mass of statistics, and they frequently attach to their annual reports diagrams showing the traffic, receipts, etc., throughout the year.

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Some of the clearest and most interesting diagrams of this nature that we have seen are included by Mr. W. M. ROGERSON in his annual report on the progress of the Halifax Corporation Tramways; and we may mention, as one of the most interesting, the diagram illustrating the weekly consumption of electrical energy per car-mile. The variation of this item throughout the year, especially when the records for several years are included on the same diagram, is certainly most instructive. This variation is, of course, to some extent affected by the traffic peculiarities of each particular town. In the case of Halifax we notice that the curve for the past year lies considerably below those of the previous two years, the minimum consumption, viz., 1·74 units per car-mile, being recorded during three consecutive weeks in September, 1909, and the maximum of 2·05 units being reached early in April, 1909—the week preceding Easter. The average consumption throughout the twelve months was 1·87 units per car-mile, compared with 1·97 units in the previous year. In this connection, it must be remembered that the conditions at Halifax are unusual, owing to the hilly nature of the town. The publication of figures of this kind, however, cannot fail to be appreciated by other managers and by electrical engineers in particular.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 3s. Add 10 per cent. for abroad or for foreign books.)

Telephonology. By H. R. VAN DEVENTER. (London: McGraw-Hill Book Co.) Pp. xii. + 586. 17s. 6d. net.

This book is divided into 16 chapters, and contains 586 pages of closely printed matter and 682 illustrations. The matter is not very well arranged, descriptions of apparatus, systems, clearing of faults and instructions for makeshift apparatus being crowded into the same chapter. The illustrations are frequently too small and the diagrams involved. There is no description of the subject under the illustration (only a figure number), and this necessitates frequent reference to the text. There is a great mass of useful information, however, and many examples regarding what may be called general telephony; but the book does not deal fully with the later developments and does not deal with private branch exchanges, transmission or loaded lines. Chapter I. deals with theory. Then follows a chapter which is devoted to signalling equipment. This contains a good deal of really practical information. The author first deals with the action of polarised bells and magneto generators, explaining their theory very clearly. He then sets out the advantages of the bridging, as compared with the series, system when a number of instruments are joined on one line, and shows how the self-induction of the ringer coils, which in the latter system is a serious drawback, becomes an advantage in the bridging system. He also discusses the design of series and bridging ringer coils, and furnishes some excellent data in the form of graphic curves bearing on the winding of coils. The curves, are, however, all worked out to B. & S. gauge.

The author rightly criticises the usual method of rating generators—that is, in terms of the resistance through which they will ring a bell, without quoting also the resistance of the bell used. He then explains his own method, which also brings in a debateable point—for example, he states on p. 43 that a good bridging generator should ring a 1,600 bell when shunted with a resistance of 40 ohms through a resistance of 2,000 in series with the generator. This is hardly consistent with the author's previous statement, as he does not mention whether a commercial ring is intended or the faintest tinkle. The only really satisfactory method is to measure the current which will give a commercial ring on the particular bell used, and then adjust the shunt until the required current is given through the ringer. The figures given for the output of generators must be considerably in advance of English practice if correct, as the reviewer has yet to find a three-bar generator that will give an open circuit voltage of 65 to 90 and an output of 150 to 200 milliamperes at 750 revs. per min. The same remark applies to the four-bar; the figures given for the five-bar are rather nearer the mark.

A novel type of ringer is described on p. 37, termed the Schwarze bell, which should have many useful applications. On pp. 38 and 39 the author shows that a large number of magnets does not necessarily mean a more powerful generator; an instance is given to show that a four-magnet generator may be considerably more powerful than a five-magnet. Another point he emphasises is the importance of the air-gap between the pole-pieces and the armature being as small as possible. This statement should be qualified, as experience teaches that if the clearance is too fine, directly the slightest wear takes place in the bearings the armature knocks badly. Another point is that the closer the armature is to the pole-pieces the greater the demagnetising action upon the magnets, thus reducing the output of the generator.

Chapter III. is devoted to Talking Equipment—*i.e.*, receivers, transmitters and induction coils. On p. 50 the author negatives the idea that the receiver which will lift the heaviest weight is the best, an idea which dies very hard. Several illustrations of really well-designed receivers are given, together with a rough method of testing receivers. On pp. 57 and 58 is described a method of making a revolution counter from a cheap alarm clock, of which novelty is the sole recommendation. He then deals with transmitters, all save one being of the solid back variety, and gives excellent illustrations of some of the latest American productions.

On pp. 97, 98 and 99 (Chapter IV.) a description is given of the different types of lightning arresters and their action. Chapter V. is devoted to magneto switchboards, starting with a description of the origin of the simplest switchboard circuit, followed by different types of indicators both manually and automatically restored. Some of the types shown seem almost super-refined, but serve to illustrate the ingenuity which has been expended upon this type of apparatus. A novel type of combined jack and indicator is illustrated, which also automatically rings the wanted subscriber when the plug is pushed home. A new local bell circuit is shown on p. 118, and has many advantages.

Chapter VI. deals with selective and lock-out systems. This chapter is especially interesting because although most of the systems shown will never be used in England, it illustrates to what a high standard party line apparatus has attained in America, as exemplified by the descriptions of the Leich, Baird and Homer Roberts systems. Explicit instructions are given to overcome any troubles which would be likely to occur in installing the different systems.

Chapter VII. is devoted to batteries. An ingenious and practical method is described on p. 215 for testing the life of batteries under as nearly as possible actual working conditions. Some very practical hints are given on the connecting up and general care of batteries. The second portion of the chapter treats of accumulators.

Chapter VIII. describes the testing of telephone parts, and is most practical. On p. 250, in describing the action of the tuning fork vibrator, we note the following: "This rise of current in the working coil R1 causes a rise in voltage at its terminals. This charges the condenser C1 to flow out." This reasoning does not seem quite clear. The method described of testing receivers is not as good as others in use. A useful test for obtaining the external characteristic of a repeating coil is given, and the method mentioned of testing magneto generators is a practical one. A rather vague description is given of the secohmmeter, and a standard of self-induction as used for the measurement of self-induction. No reference is made to the latest methods of testing apparatus at telephonic frequencies.

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Fault localisation is the subject matter of Chapter IX. One noticeable feature is that the plug blocks in nearly all the American types of instruments are made from circular rod, a point which must enter very largely into the cost of such apparatus, and as there are no drawbacks attached to this method, except perhaps its appearance, it seems rather remarkable the practice has never been adopted in this country.

Chapter X. is devoted to measuring instruments and their uses, and is especially interesting as demonstrating the possibility of making any measurements in telephony (direct current) with the aid of an ammeter, voltmeter, milliammeter and a millivoltmeter. The latter part of this chapter may appeal to the amateur electrician, as full working instructions are given for making a galvanometer, ammeter and ohmmeter.

Chapter XI. includes some useful information on p. 350 in connection with the W.E. instrument circuit, and the coil used in connection therewith. There is also a good description of the theory of the W.E. circuit. But no reference is made in this chapter to the extended use which is being made of the electromagnetic receiver.

Harmonic party line systems are dealt with in Chapter XII. In the instructions great pains are taken to prevent any damage being done to their products by lack of skilled attention. Every risk down to the smallest detail is treated with the greatest respect, no knowledge at all being assumed on the part of the user. We note a typographical error on p. 438 under the heading, " How Worn Cells can be Detected," the word *west* being used instead of *wet*.

Chapter XIII. deals with line and cable construction, protection, &c. Some useful data in connection with cables are given on pp. 498 and 499, and the accuracy of Sir William Preece's K.R. law is reaffirmed. Chapter XIV. is devoted to the automatic telephone systems, and explains in a lucid manner the possibilities of the Automatic Electric Co.'s system. No mention is, however, made of the later developments with two wires without earth.

Chapter XV. deals with systems of simultaneous telegraphy and telephony. The information given is especially valuable from the fact that the matter of composite working is being taken up seriously in England by the various railway companies. One might suggest that a fuller explanation should be given of the operation of the phantom circuits. This chapter gives one the impression that the author is in a great hurry to get the book finished.

Chapter XVI. deals with wireless telephony, and is interesting as showing the probable lines along which the wireless telephone is likely to be developed, since it deals with a system which in 1909 had spoken a distance of 40 miles.

In conclusion, the work throughout is thoroughly practical, and should be welcomed as a valuable aid to telephone literature. One only regrets that private branch exchange boards are practically ignored. However, much valuable information is given which the reviewer has not seen in any previous text book.

W. A.

Theorie der Krafteplane. By H. E. Timerding. (Leipzig: B. G. Teubner.) Pp. vi. + 99. M.2·60.

Since Rankine published in the " Philosophical Magazine " for 1864 his Paper on the " Principle of the Equilibrium of Polyhedral Frames " considerable advances and improvements in graphical methods of solving difficult statical problems have been made. These methods are in everyday use in practical engineering, and so a working knowledge of them is indispensable to the student. Unfortunately, some of the treatises on the subject fail to give satisfactory proofs of the fundamental theorems. Sometimes even obscure statements made in the original Papers are slavishly reproduced, whilst difficult steps in the proof are omitted. This leads students either to take the theorems for granted or to expend an excessive amount of time trying to clear up the difficulties. To all who have experienced these difficulties we can recommend this book. Within a hundred pages Mr. Timerding gives a helpful introduction to the theory of graphical statics. He very properly supposes that the reader wants a logical exposition of the subject, and that he possesses a good working knowledge of analytical statics.

A. R.

Die Vektoranalysis und Ihre Anwendung in der Theoretischen Physik. By Dr. W. v. Ignatowsky. Part II. (Leipzig: B. G. Teubner.) Pp. iv. + 123. M.2·60.

In the second part of this book Dr. Ignatowsky applies the mathematical results obtained in the first part. He shows that they can be usefully employed in proving the fundamental theorems in rigid dynamics, elastic solids, hydrodynamics, electrostatics and electrodynamics. The proofs given will satisfy even the most exacting of physicists. Both the Maxwell-Hertzian and the Lorentz forms of the general equations of electrodynamics are obtained, and it is instructive to note the differences in the results obtained on the wave and electron theory. Dr. Ignatowsky is to be congratulated on the thoroughness with which he has done his work.

A. R.

POWER ECONOMY IN ELECTRIC RAILWAY OPERATION.*

BY H. ST. CLAIR PUTNAM.

Summary.—The author describes some tests made on the Manhattan Elevated Division of the Interborough Rapid Transit Co., New York, in which a clock was used to record the amount of coasting in the operation of trains, the object being to obtain from the motormen a better manipulation of the trains and a greater economy in power consumption.

The clock used in these tests on the Manhattan Railway consists of a clock mechanism manufactured for factory and office use for recording the time of employés. To the balance wheel escapement a braking device has been added, as shown in Fig. 1, which is lifted free from the balance wheel by an electromagnet that is energised

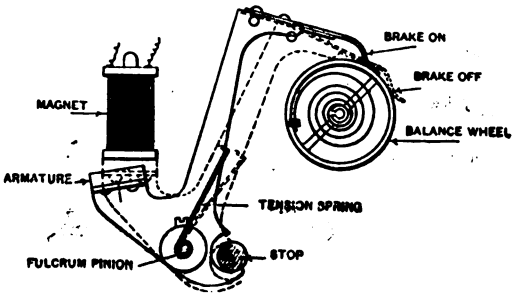

Fig. 1.—Details of Clock Mechanism.

only during the coasting of the train. This permits the clock to record the coasting time only. Each motorman is provided with an individual key which he inserts on taking charge of the train and again on leaving. The turning of this key records the motorman's number or initials and the time as shown by the clock mechanism; the difference in the time between the two records made by the key representing the total time of coasting during his run. The slip record is torn off by the motorman and handed to the proper official. This is checked up with his running time, and the motorman is rated according to the percentage that the coasting time is of the total time of his run, due allowance being made for variation from the schedule. His individual rating is based upon the average results of a week or month as may be selected. The electric circuits controlling the clock are interlocked with the master controller and the brake mechanism and arranged so that the coasting clock will start only after the two actions of turning the power on and then off. The connections used are shown in Fig. 2. The operation of the clock is stopped as soon as the air brakes are operated and the brake cylinder has started to move to the braking position. If, for any reason, after the brakes are applied, the air is released and additional coasting obtained before the train stops, this additional coasting is lost from the amount of coasting recorded unless power is again applied. This is not an important factor in normal operation as the actual amount of coasting of this character is small.

While the principles involved in the use of speed time curve calculations in electric operation are well understood, for the purpose of making clear the economies in power consumption that can be realised from the better operation of trains, which it is the object of this clock to encourage, the author discusses briefly the various factors entering into electric operation.

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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Acceleration.—The rapid acceleration of trains, providing the schedule speed is unchanged, results in an important saving of power for two reasons, first, the maximum speed reached is less with a high acceleration, and, consequently, the train resistance is somewhat less; second, and of much greater importance, is the fact that with a high rate of acceleration, the speed at the start of braking is less than with a lower rate, and, consequently, the energy absorbed and lost in braking is less.

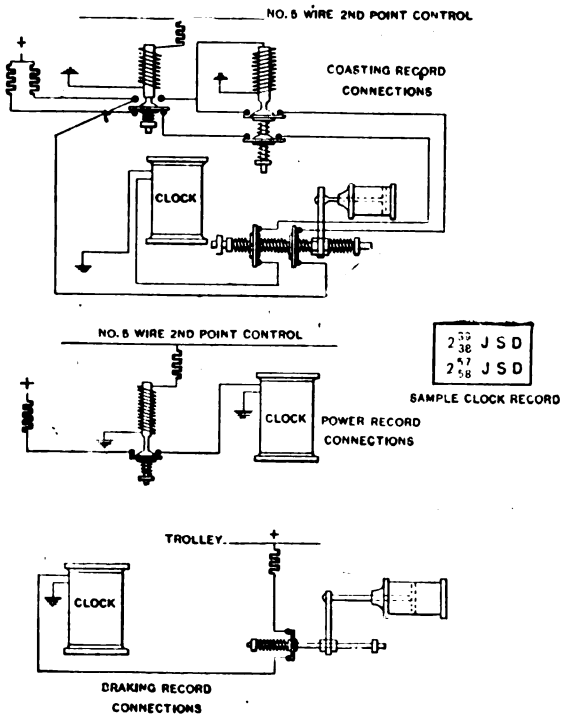

FIG. 2.—CLOCK CONNECTIONS.

The equipment provided naturally limits the permissible rate of acceleration, but within such limitations, a quick acceleration is one of the most feasible methods of saving power in such service as exists on the Manhattan Railway. In Fig. 3 is shown the percentage increase in coasting time resulting from the increase in the rate of acceleration from 0·9 mile per hour per second to 2 miles per hour per second, and the resulting decrease in power consumption, based upon an average run on the Second Avenue line. In the tests on the entire Manhattan system conducted on March 22, 1910, the acceleration of different motormen was found to vary from 0·9 miles per hour per second to 1·47 miles per hour per second. Providing other

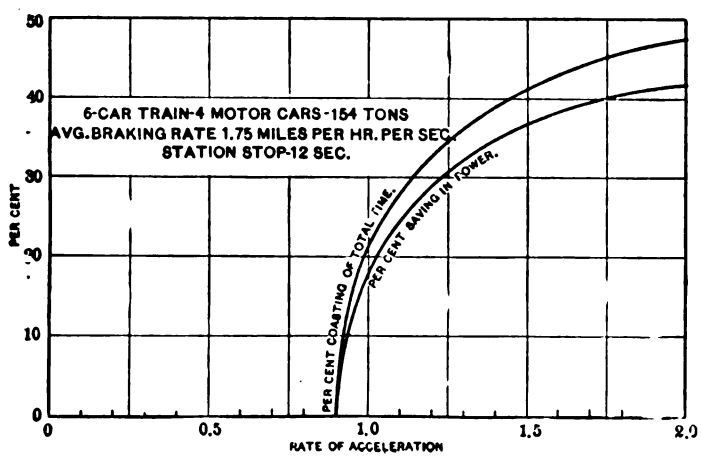

FIG. 3.—INFLUENCE OF ACCELERATION.

factors of train operation remain the same (that is, the braking, running time and time of stop) the increase in the rate of acceleration from 0·9 to 1·47 miles per hour per second will result in an increase in the coasting time of 40·5 per cent. of the total time, and a saving of 36 per cent. in energy consumption. A motorman on the Manhattan system on full runs will average about 600 car-miles per day, and the power used at the car with slower acceleration will approximate 2·82 kw.-hours per car-mile. As between these two motormen, therefore, providing the scheduled speed is maintained, the motorman who accelerated his train at an average rate of 0·9 mile per hour per second will waste during the day 610 kw.-hours at the car. With 80 per cent. efficiency to the power house, this becomes 762 kw.-hours. In practice the full saving of power resulting from better acceleration is not realised, owing usually to the better running time made by the good operator. This results frequently in his having to wait for the train ahead and by so doing, a large part of the saving in power which should follow his good operation is lost. The use of this clock should result, however, in a material increase in coasting time under such circumstances, with a resulting saving in power.

Series Running.—In Fig. 4, the effect of series running upon the percentage of coasting obtained and the resulting power consumption is shown. It will be noticed that an increase in the percentage of coasting obtained by reducing the amount of series running does not effect a corresponding saving in power. This is due to the fact that while the total time during which power is applied is increased and the time of coasting reduced by holding the controller in the full

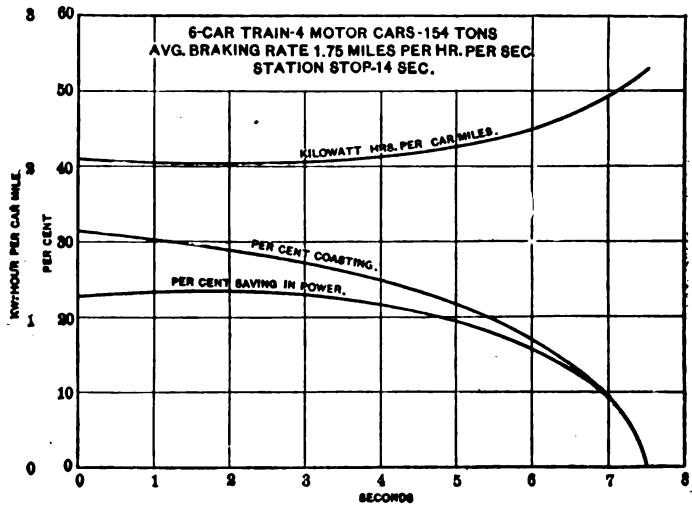

FIG. 4.—INFLUENCE OF SERIES RUNNING.

series position, say for four or five seconds, the actual power used remains practically the same because the additional power required on account of the longer time of power application is offset in large measure, if not entirely, by the saving in rheostat losses owing to the reduced time that the rheostat is in circuit in passing to full multiple. This is shown in Fig. 5, which has been used in calculating the results plotted in Fig. 4. A limited amount of series running, therefore, is not objectionable, and under certain conditions it is better to run in series for a short time than to pass to the multiple position,

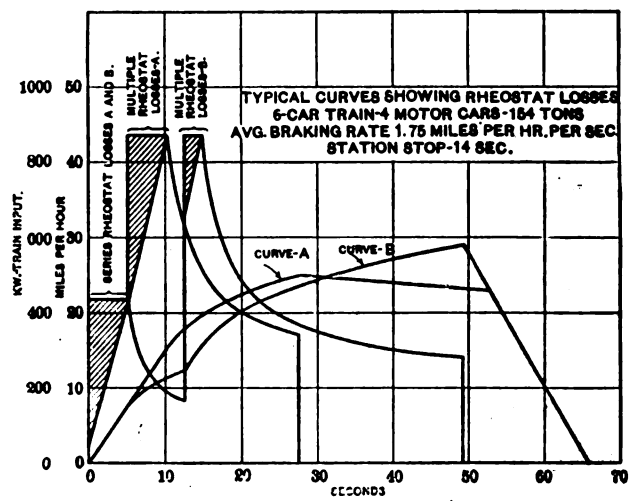

FIG. 5.—INFLUENCE OF SERIES RUNNING.

especially where power is cut off almost immediately after the multiple position is reached as under certain conditions in approaching a station. The decrease in coasting time resulting from a moderate amount of series running does not therefore necessarily represent an increase in power consumption, unless the series running has been excessive. In this respect the coasting clock will give misleading results; but as under normal conditions there is little occasion for running in series, except around curves, the error thus introduced into the record is not important.

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Braking.—A high rate of braking results in a reduction in power consumption for reasons similar to those existing as to the rate of acceleration. It permits the power to be cut off at an earlier point, a longer time of coasting introduced, power otherwise wasted in the brakes to be recovered and the train brought to a quick stop. Perfection in braking is much more difficult of attainment than acceleration, as the train must be stopped at the station within a space limited to a few feet. Many motormen, therefore, operate on the side of safety and feel their way into stations, with a resulting material increase in the power used if schedules are maintained.

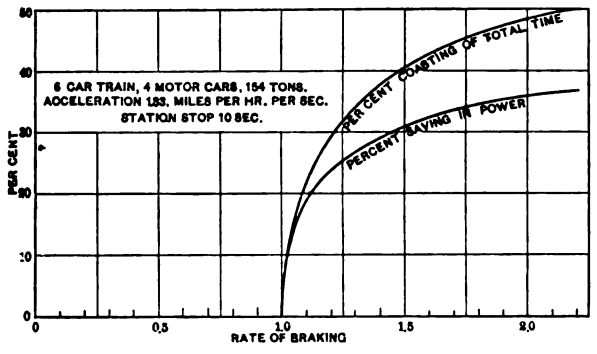

FIG. 6.—INFLUENCE OF BRAKING.

In Fig. 6 is shown the percentage of power saved on account of the increased percentage of coasting introduced by increasing the rate of braking from 1 mile to 2·25 miles per hour per second. These limits are frequently found in the operation of Manhattan trains.

Station Stops.—In Fig. 7 is shown the influence of the station stop. On the Second Avenue line, the average run is 0·335 mile and the maximum possible stop with the maintenance of the schedule, and with no coasting, is 16·2 seconds, assuming an average run as typical, which is substantially correct for the purposes of the present discussion.

Coasting.—The amount of coasting which a motorman can obtain and still maintain his schedule is obviously the result of the factors of operation above discussed. The ideal amount of coasting will result from the observance of all these factors. The theoretical coasting as shown on the typical curve is 27·5 per cent. of the total

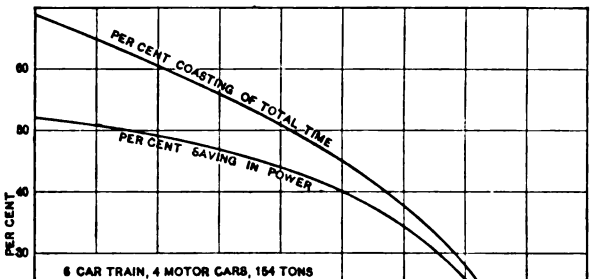

FIG. 7.—INFLUENCE OF STATION STOP.

time including stops. It has been shown in the above discussion that it is possible to obtain this amount of coasting and even to exceed it by changes in operation which are entirely within the range of practicability.

Power Consumption.—In Fig. 8 the calculated power required at the car, per car-mile, is plotted under different conditions as to acceleration, braking and station stops as above discussed, these factors being plotted in terms of the resulting percentage of coasting obtained.

Test Results.—The results of the tests of the coasting clock which have been conducted on the Second Avenue line are plotted in Fig. 9. All trains on the Second Avenue line were equipped with coasting clocks, and the power supplied to the section between 127th-street and Canal-street was metered by direct-current integrating watt-meters on the sub-station feeders. Corrections have been made for heaters and light, and the wattmeter readings corrected in accordance with frequent calibrations. On account of the corrections that have to be made for heaters, light, control and auxiliaries, the results obtained are necessarily approximate. Under these circumstances, therefore, the records are remarkably consistent and show graphically the material improvement in coasting which has resulted from the use of the coasting clock, and also the reduction in the power required for the operation of the cars.

These test results are plotted in further diagrams in the Paper, and are shown to agree very closely with the calculated curves given

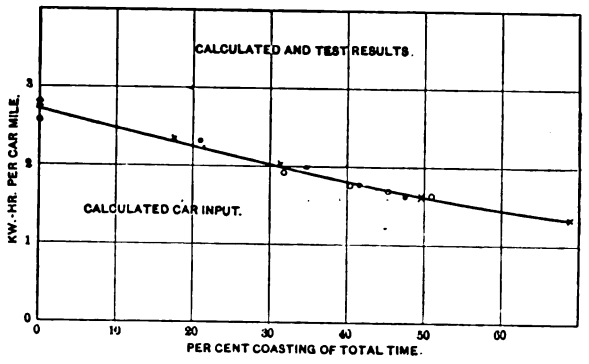

FIG. 8.—POWER REQUIRED PER CAR-MILE.

above. The important feature is that on the Second Avenue line the increase in the time of coasting from 10 per cent., as it was prior to the installation of the clocks, to 38 per cent. following such installation resulted in a saving of 25 per cent. in the power required for traction.

The author gives statistics and "running charts" of a large number of tests carried out on various lines of the Company. These tests bring out strongly that any system of rewards based upon coasting time should include a penalty for overrunning the scheduled time.

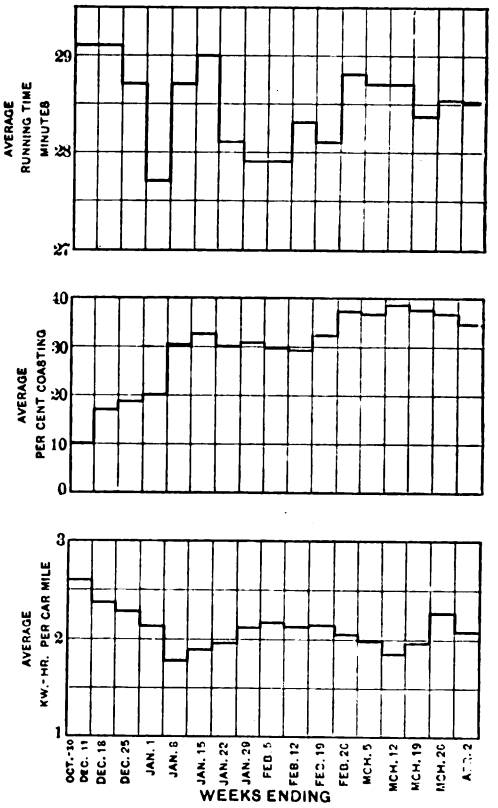

FIG. 9.—COASTING CLOCK TESTS ON SECOND AVENUE LINE, 127TH STREET TO CANAL-STREET, OCTOBER 30 TO DECEMBER 11, BEFORE CLOCK INSTALLATION; DECEMBER 18 TO APRIL 2, AFTER CLOCK INSTALLATION.

The various factors that enter into the operation of the train have been analysed with a view to determine which is the preferable element to measure. The choice practically narrows down to the measurement of either the power input by wattmeter or time of application by means of a clock arrangement, or the measurement

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of the time of coasting. The author thinks it has been made clear that whatever good results are obtained from the better operation of the train by the motormen can only result in the saving in power through the increase in the coasting time. Coasting is the recovery of power already used, and hence is the key to the problem. The coasting clock, therefore, gives a direct measure of the power recovered by the motormen, and as this recovery can also only be made by cutting off the power application sooner, it is believed that it is the most effective element in train operation to measure. At the same time it concentrates the motorman's attention on that element of operation which is the direct reason for the saving in power which results from changes in the methods employed as to the other factors of operation.

THE TEMPERATURE COEFFICIENT OF RESISTANCE OF COPPER.*

BY J. H. DELLINGER.

The values in common use for the temperature coefficient of copper vary from $a_0 = 0{\cdot}00398$ to 0·00445, or $a_{20} = 0{\cdot}00369$ to 0·00409 (a_0 and a_{20} are defined respectively by the equations: $R_t = R_0 (1 + a_0 t)$, and $R_t = R_{20} (1 + a_{20} [t-20])$, in which t = any temperature Centigrade, and R_0, R_{20}, R_t = resistance respectively at 0°C., at 20°C. and at t°C.). The differences in these various values assumed as standard may be considered to be due either to errors of the measurements made in establishing them or to differences in the temperature coefficients of different samples of copper. In either case, accurate results cannot be expected when one of these values is taken as fixed and used for all samples. That this fact is not recognised is shown by the common practice of assuming that the temperature coefficient is the same for different samples of copper, while the conductivity is usually measured. It was accordingly considered of importance to determine whether the temperature coefficient of different samples does vary, and also to find whether there is any simple relation between the conductivity and the temperature coefficient.

This investigation has shown that there are variations of the temperature coefficient, and that to a fair accuracy the relation of conductivity to temperature coefficient is a simple proportionality. Thus, annealing is known to increase the conductivity of hard-drawn wire; it was found that annealing increases the temperature coefficient by an exactly proportionate amount. Samples varying in the amount of chemical impurities are known to vary in conductivity; it was found that the temperature coefficient was substantially proportional to the conductivity.

Samples were investigated from 14 of the most important copper refiners and wire manufacturers in the U.S.A., Germany, France and Austria. The range of conductivity of the samples covered thoroughly the range of the copper furnished to the electrical industry. The experimental work was carried out with wires, most of which were No. 12 B. & S. gauge about 120 cm. long. The resistivity and percentage conductivity were computed from measurements of the length, mass and resistance. The resistivity is given in "ohms per metre-gramme" by multiplying the resistance per metre by the mass per metre. The "per cent. conductivity" is calculated on the assumption that 100 per cent. conductivity corresponds to the arbitrary standard resistivity of 0·153022 ohm per metre-gramme at 20°C. The resistance measurements were made in a specially designed apparatus, by the Thomson bridge method. Temperatures were measured with a mercury-in-glass thermometer. The accuracy of the resulting conductivity values is estimated as within 0·03 per cent., and of the temperature coefficient values within 0·000004, or 0·1 per cent. To an accuracy of 0·2 per cent., the temperature coefficient was found to be linear between 10°C. and 100°C. The results of the measurements on the separate samples are given in a table in the Paper, the mean value of C for 37 samples being 0·003938, the greatest deviation from the mean being 0·000018.

The effect of bending and winding of wires was also investigated. Any distortion of an annealed wire is known to produce local hardening and increase of resistance. It was found that much the greater part of this increase was due to local changes of cross-section and not to the change of resistivity. This was shown by the fact that while the apparent conductivity decreased, the temperature coefficient changed practically not at all. This having been established for cases of bending and distortion more severe than those arising in ordinary practice, it may accordingly be assumed without serious error that the temperature coefficient of a copper wire is the same after winding on a machine or instrument as it was before. Accordingly, if a measurement has been made of either the conductivity or the temperature coefficient of the wire before winding, the temperature coefficient may safely be assumed to be known after winding, and may be used in the calculation of temperature rise.

The main result of this investigation may be expressed in the form of the following practical rule: The 20°C. temperature coefficient of a sample of copper is given by multiplying the number expressing the per cent. conductivity decimally by 0·00394. The rule can be put in a remarkably convenient form for reducing the results of conductivity measurements to a standard temperature, viz., the change of the resistivity per degree C. of a sample of copper is 0·000598 ohm per metre-gramme, or 0·00681 microhm per centimetre cube. The last two constants are independent both of the temperature of reference and of observation, and also independent of the sample of copper.

The foregoing results indicate that the measurement of conductivity may often be replaced by a measurement of the temperature coefficient. Four particular cases suggest themselves in which the measurement of temperature coefficient has considerable advantage over a conductivity measurement: (1) Odd shapes. Unless a uniform sample can be prepared, the determination of conductivity directly is hopeless. (2) Short samples, for which the difficulty of measurement of the dimensions and the possible uncertainty of the current distribution limit the applicability of conductivity measurement. (3) Wires that have been distorted or bent. As shown above, the apparent conductivity of a distorted wire is incorrect, while the temperature coefficient is not materially changed. (4) The estimation of chemical purity, of which the conductivity is a familiar criterion. Evidently the temperature coefficient is fully as reliable a criterion as the conductivity, and is more generally applicable, and is often an easier test to apply than either the conductivity or chemical determinations.

* Abstract, from the "Journal" of the Franklin Institute, of a Paper in the Bulletin of the Bureau of Standards.

CORRESPONDENCE.

THEORY OF THE QUADRANT ELECTROMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Recent correspondence in your columns has made it clear that the idea of electrostatic control, as an essential factor in the theory of the quadrant electrometer, by no means meets with the general acceptance which its utility undoubtedly merits. In view of this, I should be glad to have the opportunity of explaining, in the briefest possible manner, how the very elementary and, within its limits, quite legitimate device of resolving the total electrostatic couple acting on an electrometer needle into (1) a deflecting component independent of the deflection θ, and (2) a controlling component proportional to θ, enables a general electrometer formula to be written down, if not directly, at any rate with the utmost ease.

Let V_1 denote the potential difference between the needle and one pair of quadrants, V_2 the potential difference between the needle and the other pair of quadrants, and V_3 the potential difference between the two pairs of quadrants. Then the behaviour of an electrometer whose needle is totally enclosed by the quadrants, or effectively shielded by them, is determined solely by these quantities, or rather, since $V_3 = V_1 - V_2$, by any two of them, say, V_1 and V_2. Moreover, both the deflecting and the controlling components of the electrostatic couple must be homogeneous quadratic functions of these variables.

If the electrometer is unsymmetrical, little of importance beyond these bare facts can be deduced, either on the present theory or on any other, except by invoking the aid of experiment to discover exactly what terms should enter into the various expressions concerned. But if the electrometer is symmetrical, and is so adjusted as always to give equal deflections in opposite directions when V_1 and V_2 are interchanged, then it is possible to lay down the following two further conditions which must be complied with by the deflecting and controlling couples respectively, these conditions being a direct consequence of the fact that an electrometer, adjusted as described, possesses double symmetry in the sense that it is symmetrical with respect to both the deflecting and the controlling forces.

In the first place, the deflecting couple must obviously remain unaltered in magnitude, but must reverse its sign, when

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V_1 and V_2 are interchanged. This couple must, therefore, be represented by $aV_3(V_1+V_2)$, where a is an instrumental constant.

Secondly, the coefficient of the total controlling couple—that is to say, the factor by which θ has to be multiplied in order to obtain the total controlling couple—must remain unaltered, both in magnitude and in sign, when V_1 and V_2 are interchanged. Now the coefficient of the total controlling couple is made up of two parts. One of these, k, relates to the mechanical control and is necessarily independent of V_1 and V_2. The other relates to the electrostatic control, and, being a function of V_1 and V_2, must fulfil the above-stated conditions; it must therefore be represented by the expression $bV_3^2+cV_1V_2$, where b and c are instrumental constants. The total controlling couple is thus $(k+bV_3^2+cV_1V_2)\theta$, and by equating this to the deflecting couple, as just determined, we get

$$\theta=\frac{aV_3(V_1+V_2)}{k+bV_3^2+cV_1V_2}.$$

This is the shape which the formula for a symmetrical electrometer with an efficiently shielded needle, and adjusted as already described, is bound in general to take. By making use of the relation $V_3=V_1-V_2$ we can, of course, transform it in various ways to suit individual tastes; we can, for example, show that, as a particular case, it includes the formula given in my letter of August 26th. As it stands, however, it is the working formula of the symmetrical electrometer in its most general form; and to anyone who cares to acquire even a slight familiarity with the point of view here advocated, the result can hardly fail to be almost obvious. There is no difficulty in devising methods of determining the several constants which enter into this formula; but anyone specially interested in the matter will naturally consult the published accounts of work done at the Reichsanstalt on this subject during the past few years.—I am, &c.,

Manchester University, Sept. 19. ROBERT BEATTIE.

TARIFFS AND METAL FILAMENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With regard to your note in to-day's issue of THE ELECTRICIAN, I see that you incline to the view that if the "Telephone" form of tariff is to be modified, it would be better to omit the fixed annual charge, and merely to charge a predetermined number of units per quarter at a higher price, say 6d. per unit, all units in excess being at 1d.

The difficulty in this case would be, as we found in the maximum demand system of 8d. and 1d., that the consumer does not know when he is getting off the 6d. units and on to the 1d. ones. Practically no consumers ever read their meters, although we endeavour to get them to do so. When the consumer has paid his annual or quarterly charge under the "Telephone" system, he then knows that the whole of his units supplied are at 1d. each.

You are perfectly correct in saying that the fixed number of units can be easily determined, but the question of tariff must be looked at from the consumer's point of view, and the fact remains that *he* does not know whether he is using at a given time 6d. or 1d. units.—I am, &c.,

St. Marylebone, Sept. 23. A. HUGH SEABROOK.

[Undoubtedly these questions must be looked at from the consumer's point of view, and probably neglect of this precaution falsified the hopes of those who originally favoured the maximum demand system. We do not think, however, that the consumer would have any difficulty in appreciating a tariff in which a predetermined number of units were charged at a higher price. If, for example, the first 30 units in a quarter were charged at 6d., the consumer would know that he would have to pay 15s. before getting on to the penny rate. It might, of course, be a stipulation that the consumer would have to pay for this number of units in any case as a minimum, though we doubt if this would be the wisest course to adopt. It will be seen that the payment of a predetermined number of units in this way is much the same as the "telephone tariff," only that the consumer pays when he has had the units, instead of paying to a large extent in advance.—ED. *E.*]

MOTOR CAR LIGHTING.

Where a supply of electricity can be obtained the adoption of electric lighting offers so many advantages over the use of other illuminants that it is not surprising that efforts have been made to bring these advantages within the reach of all vehicles. In the case of automobiles, several systems have been introduced in which a dynamo is employed; the most recent, and certainly one of the most interesting, is that of Messrs. C. A. Vandervell & Co., of Acton, London, W. Where a dynamo is used the difficulty, of course, is

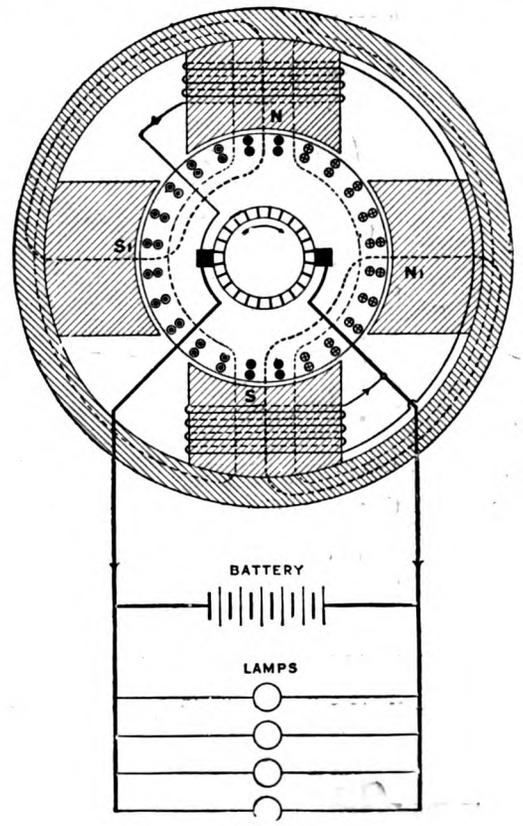

FIG. 1.

to obtain an approximately constant output at varying speeds, and resistances and cut-outs have usually largely figured in previous attempts at a solution of the problem.

The feature of the "C.A.V." dynamo car-lighting system of Messrs. Vandervell is undoubtedly its simplicity, the output of the generator being maintained constant by the magnetic reaction of the armature and field magnets. Two shunt-wound poles N, S, and two unwound poles N_1, S_1 are provided, as shown in Fig. 1. Commutation takes place under N, S, as indicated by the black dots for the conductors (the brushes being in a position at right angles to the conductors). The effect of this is to cause the armature to have a demagnetising

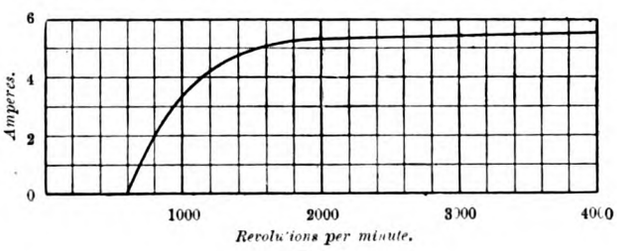

FIG. 2.

reaction on N, S, and thus the current does not rise above a certain value, and a constant current can be maintained at different speeds. At first sight it is difficult to see how satisfactory commutation can take place, but we gather that this is rendered possible by the redistribution of the flux between the wound and unwound poles as this demagnetisation comes into play. A typical output curve of one of these generators, showing the exceptional steadiness of the current over a very wide range of speed, is shown in Fig. 2.

Any standard winding can be adopted for the armature, but Messrs. Vandervell are using a patent winding in which the coils

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cover an arc of 120 deg., instead of the usual 180 deg. in a two-pole machine.

Accumulators form an essential element in any car-lighting system, and thus the use of a dynamo of this kind means that a steady charging current is obtained over a wide range of speed. This, of course, favours the obtaining of better results, since a smaller battery can be carried and the plates have a more satisfactory life. It is also particularly interesting to notice that the principle of the "free wheel" has been adopted by Messrs. Vandervell for the armature (Fig. 3). This had made possible the elimination of cut-outs. Thus, when the driving engine slows down an excessive current is not taken from the accumulators (which would otherwise be the case if no cut-out were used), but the battery supplies about 1½ amperes to

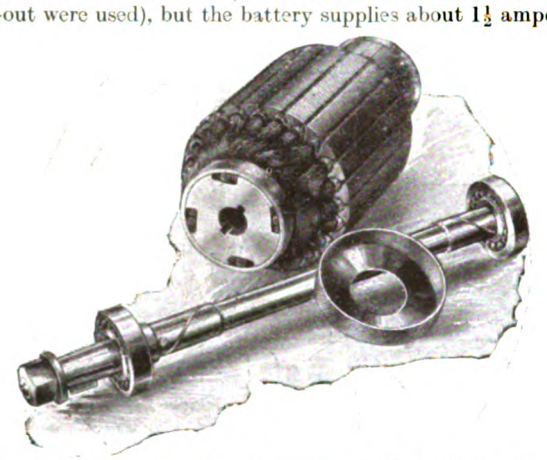

FIG. 3.—ARMATURE AND SPINDLE, SHOWING FREE WHEEL CLUTCH.

the dynamo, which then runs idly as a motor. It may also be mentioned that the capacity of the dynamo is less than that of the lamps, so that overcharging of the accumulators is unlikely. During the daytime when the dynamo is not supplying the car lights, its voltage rises as the battery becomes charged, the current at the same time decreasing. When desirable, current from the dynamo is cut off by the switch seen at the extreme left hand end of the row of switches in Fig. 4. The remaining switches control the car lights, for which metal filament lamps have been adopted of Edison & Swan manufacture.

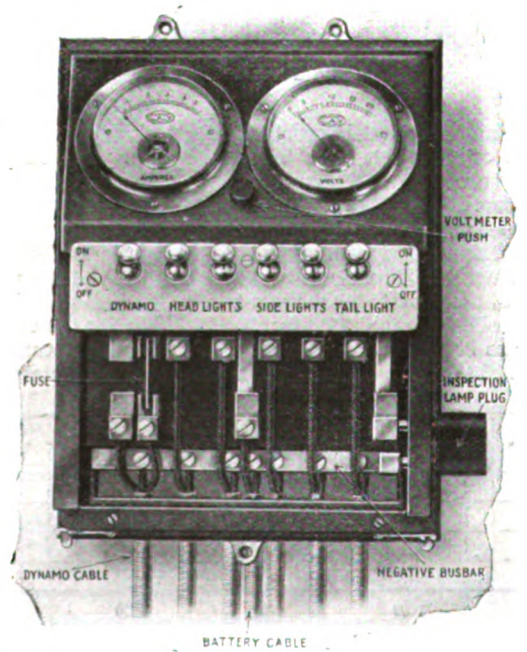

FIG. 4.—SWITCHBOARD, WITH FRONT OPEN SHOWING CONNECTIONS.

The dynamos are made to give a pressure of 6 or 12 volts, and a fixed output of 5 amperes, the generators of smaller output being intended for taxi-cabs. The output curve of such a dynamo is shown in Fig. 2 above, and it will be noticed that the generator begins to charge the battery at a speed of 600 revs. per min., and at all speeds above 1,800 revs. per min. it gives a practically constant output. This machine is intended to be geared so as to run at about 1½ to double the speed of the engine. Fig. 5 illustrates one of the dynamos ready for installation on a car.

In most cases it is proposed to fix the dynamo under the bonnet and to support it on a small bracket, in which case the dynamo may be belt or chain-driven from some revolving part of the engine, or it may be gear-driven or coupled direct.

The wiring of the car is by no means an unimportant detail, and particular attention has been paid to this by Messrs. Vandervell. In the "C.A.V." patent flexible armoured cable, the conductors, which are specially insulated, are protected by a spiral armouring, the latter

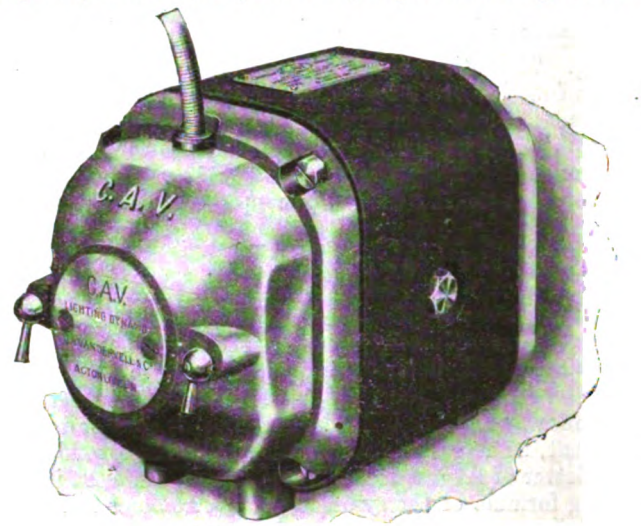

FIG. 5.—C.A.V. DYNAMO.

having no tendency to unwind even if cut. Special lamp-holders and lamps have also been designed, and, in fact, no detail likely to add to the efficient operation of the lighting equipment has been overlooked.

As the C.A.V. system of car-lighting appears to be well adapted for train lighting, it is not surprising to learn that developments in this connection are to be expected.

CONTROLLERS FOR ELECTRIC TRACTION.

As the use of any particular piece of apparatus is extended, so its design develops. This is particularly true of Messrs. Dick, Kerr & Co.'s tramway controllers, which have been in use since the very earliest days of electric traction, and have equally been receiving over that period improvements tending to make them more efficient than they were at first.

For instance, some years ago a metallic shield blow-out controller was introduced, while the use of higher speed, top covers and magnetic brakes have all caused the adoption of modifications in the general design of this equipment. The metallic shield blow-out is still retained in the latest form of Dick-Kerr controller, which we illustrate herewith, while further improvements that have been effected are set out in the following paragraphs.

The main frame of the controller is, as usual, of cast iron of ample strength lined with suitable insulating material. The cover is of the enamelled sheet-iron type, but has been simplified by entirely dispensing with hinges and screws, while a simple but effective spring catch holds the cover firmly in position. The cover is lined with thick asbestos throughout, while mica sheets are provided at places opposite where arcs are broken.

The latest standard practice is followed as regards the construction of the cylinders, segments, fingers, as will be seen from the illustration. The contact fingers are provided with renewable copper tips, the adjusting screw of the contact fingers being automatically locked by a spring, thus obviating, it is claimed, the necessity of locking the screw by a lock nut or other device. The segments are made of the best hard drawn copper tubing, and all segment tips subject to burning are provided with short renewable tips. Wood has been entirely eliminated from the construction of the main power barrel, the shaft being of square section steel throughout, with mica insulation baked thereon. Round this insulation the segment castings are firmly clamped. The reversing cylinder is also strongly constructed, having a round steel shaft with a mica sleeve insulation, round which is fitted the wooden drum carrying the reversing contact plates.

The notching gear is, it is claimed, made as clear and as positive as is possible, consistent with absolute freedom of motion. There are 15 notches in all on the braking controllers, four for series work, four for parallel and seven on the brake side. The novel

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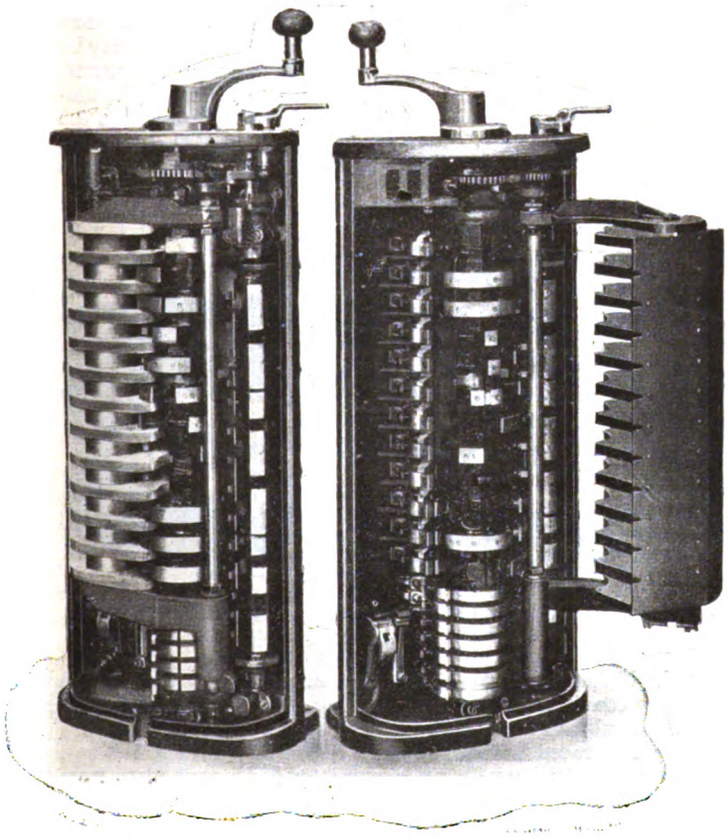
feature of the braking type of controller is the combination of the brake and power cylinders on the same shaft. This eliminates the mechanical device which was previously necessary for throwing over a special brake cylinder when passing from the off position on to the brake notches; where magnetic braking is utilised to any great extent, this is, it is pointed out, a notable improvement, for it ensures the braking action being reliable and positive. A separate reversing cylinder is provided. This is operated in the usual manner by the reversing handle, and the arrangement employed by Messrs. Dick, Kerr of interlocking the reversing and power handles is also embodied in this design. By this means it is impossible to switch on the power until the reversing handle has been removed to the ahead or reverse position, while the reversing handles cannot be removed until the power handle is brought back to the off position. The reversing handle is only removable from the controller in the off position. An important modification has been introduced in regard to the power handle which is now non-removable from the controller. This is a practical point which Messrs. Dick, Kerr feel will be much appreciated by those responsible for controller maintenance, as it reduces maintenance cost, prevents the power handle from getting damaged or lost, while better and more positive operation of the controller is assured, and, consequently, there is a lower maintenance cost for the fingers and contacts generally.



STANDARD DICK-KERR TWO-MOTOR CONTROLLER ARRANGED FOR ELECTRIC BRAKING.

A point of practical utility is the arrangement of the motor cut-out switch. This consists of a knob projecting through the back of the controller at the top, which can only be operated by the reversing handle. Turning the knob either upward or downward through a quarter of a revolution cuts out either motor, or, in the four-motor controller, a pair of motors, the intermediate position leaving both or all motors connected. Thus a motorman can, in a few seconds, by means of his reversing handle, throw any motor or pair of motors in or out if he desires to test them; this saves any block in traffic, and also obviates the necessity of the motorman meddling with the controller in any other way. The cut-out switch is also interlocked with the reversing cylinder in such a way that it is impossible to cut out a motor except when the reversing switch is in the off position, and it is impossible to move the reversing switch except when the cut-out switch is in an operating position. It is impossible therefore for the motorman to make a mistake. In cutting out either motor a locking lever is raised, which prevents the power barrel from being moved beyond the last series position. Each motor, when running single, will therefore start up as usual on the first series notch of the controller.

NEW ELECTRICAL SHOWROOM IN HACKNEY.

It was a happy idea of the electrical powers at Hackney to open their new showroom at 306, Mare-street, on a Thursday afternoon. Thursday afternoon happens to be early closing day in Hackney, so that the attention of many of the matrons of the district, which would doubtless otherwise have been fixed on the goods in the drapers' windows, was concentrated on the electrical apparatus on view in Mare-street. So great was the crowd that gathered to see a

FIG. 1.—EXTERIOR VIEW OF THE NEW SHOWROOM OF THE HACKNEY ELECTRICITY SUPPLY DEPARTMENT AT 306, MARE-STREET.

laundress at work with an electric iron in one window, and two lady lampmakers testing Tantalum lamps for vacuum, voltage and mechanical defects in the other, that a sergeant and two members of the police force, not to mention a commissionaire, had to be retained to keep a way clear for those who wished to obtain further information about the electrical appliances from the attendants inside the showroom.

Some enterprise of this kind is undoubtedly needed in Hackney, for on our way down we noticed a sign which informed all travellers on the Great Eastern Railway that "Gas is Cheaper than Electricity for all Purposes." It is this sort of general inexactitude that Mr.

FIG. 2.—INTERIOR VIEW OF THE ELECTRICAL SHOWROOM AT HACKNEY.

Robinson has to fight against in Hackney, as electrical engineers have to elsewhere, and the opening of a showroom should be an excellent way of carrying on the campaign. We are pleased to see that great stress is being laid on the domesticity of electrical apparatus. Radiators and ovens of all types are on view, while on the occasion of our visit samples of food which had been cooked by electrical means were handed round for inspection. Seeing is believing in such cases, and many of the visitors were able to recognise through several

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of their senses the benefits obtainable by the use of electrical cooking apparatus. There was no burning or smell.

The showroom is provided with a good stock of fittings and is well lighted. The general offices of the undertaking are now on the premises, which is a distinct step forward, for the benefits which can be derived by the removal of the directing staff from the generating station in a remote part of the borough to a situation in the main street are not small.

Hackney have powers to sell electrical fittings and to do wiring, but we understand Mr. Robinson proposes to allow this work as far as possible to pass through the hands of contractors, which is as it should be, in our opinion.

The accompanying illustrations, which have been kindly lent us by Messrs. Siemens Dynamo Works, give exterior and interior views of the new showroom.

TROTTER'S ACCELEROMETER AND GRADIENT MEASURER.

The problem of how best to measure under working conditions the acceleration of a moving vehicle has lately become of extreme importance, and many attempts have been made to solve it. Some of the instruments designed for the purpose have not erred on the side of simplicity, while others have been bulky or insensitive. An

FIG. 1.

apparatus which, however, it is claimed, overcomes all these difficulties has been designed by Mr. A. P. Trotter, and is now made by Messrs. Everett, Edgcumbe & Co. This instrument works on the "spirit level" principle. It possesses great sensitiveness, and is at the same time simple and compact enough to be carried in the pocket, while it does not easily get out of order.

The general appearance of the instrument is shown in the accompanying illustrations. The instrument, which can be calibrated to any convenient scale, though the most usual is feet per second per second, consists of an accurately shaped glass tube completely filled with a special liquid except for a small air bubble, bearing a definite relationship to the diameter of the tube. The bubble acts as an index and the instrument has only to be placed so that it is at zero when the carriage is at rest, and points in the direction in which it is desired to measure the acceleration. It will then indicate the true acceleration in this direction and take no account of that in any other. The instrument acts on the pendulum principle, the bubble being "left behind" as the vehicle starts, the amount it is "left behind"

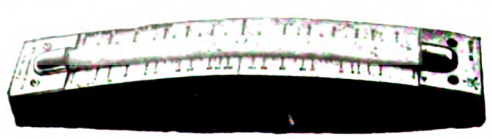

FIG. 2.

depending, of course, on the acceleration which is thus measured on the scale. The instrument is so constructed (*see* Fig. 2) that it can conveniently be placed on the window ledge of a tramcar, railway carriage, or motor car, and another pattern is made having a hinged bracket, which is particularly suitable for fixing to the dash board of a motor car, and is so arranged that when not required it can be swung out of the way (Fig. 1).

Should it ever be found that the acceleration or retardation to be measured exceeds the limits of the scale, the instrument may be set out of level to any required extent, so that, for example, when travelling along the flat the bubble stands at 4 ft. per second per second; this amount has then to be added to the actual reading when measuring accelerations, thereby increasing the available range to that extent. The instrument can also be successfully used for testing the retardation, while the stopping distance when testing brakes can easily be determined by a simple calculation.

PAUL'S DIRECT READING THERMO-ELECTRIC PYROMETERS.

In these days of scientific manufacture it is necessary that temperatures and pressures, volts and amperes, times and seasons should be known with great accuracy. Certainly not the least important of these data is temperature, and among the best instruments for the determination of high temperatures may certainly be included thermo-electric pyrometers.

Mr. R. W. Paul, of New Southgate, has recently designed a fresh series of these instruments which we describe below.

Such an instrument falls naturally into two parts, the indicator and the couple. The indicator in Paul's instruments is a low reading moving-coil voltmeter, the circular coil of which is pivoted at the centre of a spherical iron core, and carefully balanced so that its position is affected as little as possible by vibration or want of exact levelling. The pivot works in a finely polished jewel, from which it is completely lifted on depressing a plunger projecting through the top of the instrument, thus rendering the apparatus proof against rough handling in transit. The sensitivity attained allows the use of a moving coil of low resistance, in conjunction with a large resistance of negligible temperature co-efficient included in the instrument. Any error due to change of temperature of the indicator is thus reduced to a minimum, being less than 1 per cent. for a change of 20°C. The movement of the coil is controlled by a spring, and the index may be set to zero, should this be necessary, without opening the instrument, an external adjustment being provided for this purpose. The unipivot principle due to Mr. Paul is specially suitable for use when the small forces generated by thermo-couples have to be easily and accurately measured under workshop conditions, and it entirely, it is

FIG. 1.—VIEW OF PAUL'S WALL TYPE DIRECT READING THERMO-ELECTRIC PYROMETER.

claimed, eliminates the delicate suspensions previously used, which frequently caused trouble by accidental breakage, this necessitating the entire readjustment of the apparatus.

The indicators are made in two styles; the wall type (Fig. 1) is best suited for industrial work. It is supported by a wall plate from which it is readily removable. Notwithstanding its large scale it occupies but little space, which is a convenience when several instruments have to be placed side by side. The case is of cast iron and acts as a screen against external magnetic fields; it is of handsome design, stove enamelled, and relieved with brass fittings, and is perfectly dust-proof. The scale is marked in degrees Centigrade or Fahrenheit, and a second scale marked in millivolts renders it possible for an electrician to check the accuracy of the indicator separately. A magnifying device, with a movable index, may be fitted to this pattern, in combination with a swivel bracket (Fig. 2) which allows the operator to set the instrument to face in any desired direction and also enables him to see, from a distance of 30 ft. or 40 ft., whether the requisite temperature is being maintained.

The portable type is for use where occasional tests of temperature have to be made in various situations. It has a horizontal scale, the working parts being mounted below an ebonite plate. The whole is entirely enclosed in a strong teak case and is fitted with detachable lid and strap handle. Each of the standard type indicators has an internal resistance of 100 ohms, 90 ohms of which consists of "swamping" resistance.

Great care has, Mr. Paul informs us, been taken in the selection of suitable materials for the thermo-couples and in the design of efficient protecting tubes, in order to ensure maximum durability and constant readings. For the measurement of temperatures between 600°C. and 1,200°C. pure platinum is used in conjunction with a platinum-iridium alloy. The electrical properties of the actual

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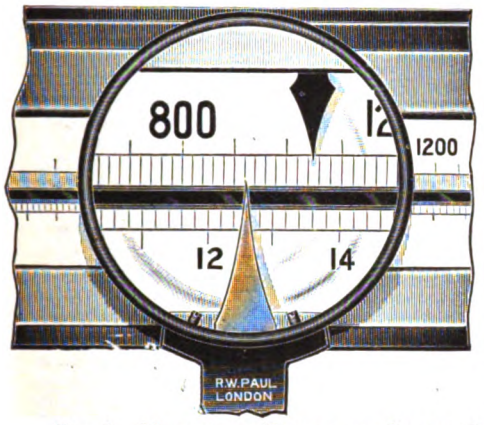
materials employed have been investigated by the National Physical Laboratory, and large batches have been made up in order to secure exact reproduction of the results. The junctions are welded electrically, and a supply of spare wire is coiled on bobbins in the cold junction boxes, so that the welded junctions may be readily renewed in case of deterioration or damage.

Protection of the couple is afforded by a renewable steel sheath attached to an iron collar on the cold junction box by means of set screws, so as to be readily removable; while a quartz tube protects the thermo-couple from the furnace gases. A wrapping of asbestos twine separates the quartz from the steel tube, and protects it from accidental shocks. A small inner tube insulates the two wires. The platinum and platinum-iridium wires are 0·02 in. diameter, and the internal resistance of all mounted thermo-couples is brought to a total of 5 ohms, which, in conjunction with the care taken to secure uniformity of material, renders them, it is claimed, electrically interchangeable. In all mountings the external steel sheath, which is easily removed even by an unskilled man, is employed as a safeguard against accidental blows.



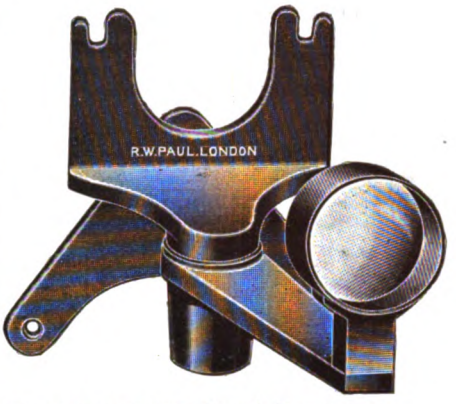


FIG. 2.—MAGNIFYING DEVICE AND SWIVEL BRACKET FOR USE WITH PAUL'S PYROMETER.

Since the readings of the indicator depend on the difference in temperature between the hot and cold junctions, it is obvious that the latter should not be exposed to high temperatures, either by radiation from the furnace or otherwise. The length of the couple, therefore, must be so chosen that the cold junction box may be at a proper distance, say, 18 in., from the wall of the furnace. Since the apparatus is standardised on the assumption that the temperature of the cold junction will be 20°C., it is necessary, when the greatest possible accuracy is required, to add the cold junction temperature, minus 20, to the reading on the scale. A thermometer may be used to ascertain this temperature, or a supplementary water-cooled junction may be adopted when it is not possible to cut down the temperature of the cold junction box within reasonable limits.

The standard form of cold junction box is provided with two holes into which corresponding plugs fixed to the supplementary water-cooled junction may be inserted. By using this attachment, a secondary couple is placed in series with, and in opposition to, the thermo-couple proper. This junction is immersed in water at a known temperature, preferably 20°C., contained in the body of the attachment, and this water may be easily renewed from time to time as it becomes heated. The further ends of the secondary couple reach the points in the cold junction box at which the main couple is connected. The attachment can also be provided with tubes for connecting to the water supply in order that a constant stream of water may be maintained.

ELECTRIC MOTOR SYRENS.

In some parts of the country, where factories abound, the steam hooter has long been in use for signalling the times of starting and stopping work, meal-hours, fire alarms, and for other similar uses. It also provides a convenient means by which the inhabitants of the district may set their clocks.

As the steam drive is more or less quickly vacating our factories in favour of the electric motor, so we may expect the place of the steam hooter to be occupied by the electric syren—an apparatus quite as capable of doing the work. Messrs. Siemens Bros. & Co. have supplied this want, and in the accompanying illustrations are shown the apparatus they have designed for the purpose.

Fig. 1 shows a small motor syren for signalling purposes. It may be used whenever it is necessary to give a specially loud and penetrating signal, or where a characteristic sound is desired. It may also be fitted with a device for giving sharply defined signals. This device consists essentially of an electromagnet with a protecting case mounted on the top of the syren; the armature of the electromagnet is connected with a disc which, in its normal position, closes the air inlet of the syren. Since the driving motor of the syren is connected in series with this electromagnet the armature becomes attracted immediately the motor is switched on, causing the disc to be withdrawn from the air inlet of the syren. As soon as the motor is cut off the disc is restored to its normal position by a spring, whereupon the syren immediately ceases to sound. By switching in the syren for longer or shorter periods, sounds of any desired length may be produced.

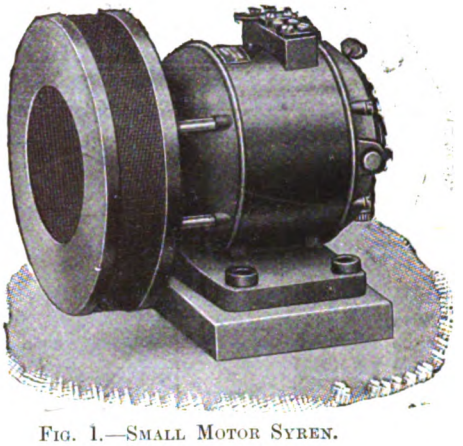


FIG. 1.—SMALL MOTOR SYREN.

Fig. 2 shows a larger type of syren, which is mounted on a round cast-iron base. This is fitted with a strong galvanised iron weather-proof case (Fig. 3) which allows the apparatus to be fitted out-of-doors. Another type of signalling device can be used in connection with this instrument. Behind the bearing covers of the syren are situated discs with radial slots, which, by being opened and closed, cause or prevent, respectively, a suction of air through the syren wheel. The discs are coupled with the armature of an electromagnet by means of a lever, the electromagnet being connected either in series or in parallel with the motor. When switching in the driving motor, the magnet is immediately excited and the air inlet opened by a movement of the discs. When the motor is cut off, current ceases to flow through the magnet and a spring moves the discs into their original position which causes the sound of the syren to cease instantaneously. This device permits of an intermittent signal of any desired length and avoids continuously running the motor and the consequent waste of energy.

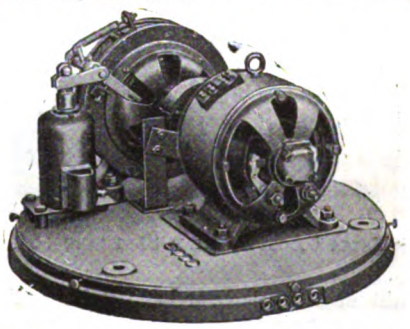


FIG. 2.—LARGE MOTOR SYREN WITH COVER REMOVED.

FIG. 3.—COVER FOR LARGE MOTOR SYREN.

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THE "UNICA" ACCUMULATOR SEDIMENT PUMP.

One of the disadvantages attendant on the use of accumulators is the sediment that gathers at the bottom of the cells. Often the only efficient way to get rid of this is to take out the plates and strain the acid. To overcome this difficulty the "Unica" sediment pump, which we illustrate herewith, is now being supplied by Mr. S. Heilpern, of Manchester.

The "Unica" pump, which is sold at very moderate prices, will soon, it is claimed, pay for itself, as it allows the accumulator owner to keep his battery constantly clear of sediment, and therefore saves him the great inconvenience and heavy cost of washing out the cells. The pump is made in two sizes and is of guaranteed acid-proof materials. It is of simple and compact design, light in weight, easily portable and has no stuffing boxes or packings subject to wear and

"Unica" Accumulator Sediment Pump.

tear. Size I. will lift 5·28 gallons and size II. 2·64 gallons per minute of lead sediment, &c., from the bottom of the cells without requiring the plant to be shut down or the plates to be taken out of their receptacles.

The "Unica" pump may also be used for filling up the cells with acid or distilled water, while by its means acid can be pumped up to a great height, the pump being suitable for suction and delivery up to 32 ft.

THE PROPOSED ACTON TRANSFER.

At the meeting of the Council last week a report was received from the deputation appointed in June last to meet the directors of the Metropolitan Electric Supply Co., with a view of arranging the best terms possible for taking over the electricity undertaking. The deputation recommended the Council to accept certain terms, and that the common seal of the Council be affixed thereto, for the purpose of submitting the same to the company. The heads of the proposed agreement were:—

Upon Parliamentary powers being obtained (at the expense of the company) the Council to transfer to the company the Acton electrical undertaking for 42 years upon the terms of the Company's Act of 1906, of the Electric Lighting Acts of 1882 and 1888, and of the heads of the agreement. On the execution of the agreement the company to deposit £2,500, which sum, when the bill receives Royal assent, to be paid to the Council as part consideration for the transfer of the undertaking, but if the bill fails to receive Royal assent, to be forthwith repaid to the company.

The consideration for the transfer by the Council to the company (in addition to that in par. 2) shall be:—

(*a*) A covenant by the company to pay to the Council from time to time such sums as will be necessary to enable the Council to pay the annual interest and sinking fund charges on the loans contracted for their electrical undertaking, subject to the provisions with regard to street lighting.

(*b*) A covenant by the company, in addition to paying to the Council £2,500, that in the event of the net receipts of the undertaking amounting in any year to a sum exceeding 10 per cent. of the total capital expenditure at the end of that year, the company to make a further payment to the Council of one-half of such excess until the total further payments so made shall reach £2,500. The term "net receipts" to be gross receipts, less the cost of energy at the rate of £5 per kilowatt of maximum load and ¼d. per unit, together with all local expenses incurred in carrying on the said undertaking.

(*c*) A covenant that the company will not charge consumers more than the present charges for an equivalent candle-power and for the same hours of using as charged by the Council during the six months preceding the date of the transfer, or (in the alternative) that the profits of the undertaking to be divided among the company shall not exceed 10 per cent. upon the paid-up capital of the undertaking, unless a larger dividend be at any time necessary to make up the deficiency of any previous dividend, which shall have fallen short of the said yearly rate.

(*d*) And if the clear profits of the undertaking in any year amount to a larger sum than is sufficient to pay 10 per cent. dividend, after making up the dividend of any previous year, the excess to be applied towards reduction of rates of district.-

With regard to capital expenditure incurred by the Council on street lighting, the company to pay the interest and sinking fund charges thereon only if and while the Council contract with the company to continue to use electricity for street lighting to at least the same extent as at present.

The transfer to provide that if the Council decides to exercise its power of repurchase it shall give to the company five years' notice in writing, and during the currency of any such notice if any additional capital is required for properly carrying on the undertaking such additional capital, if desired by the company, to be provided by the Council, the company repaying to the Council the interest and depreciation charges on same.

The company to continue to supply energy in bulk to the Council from Jan. 1, 1911, to June 30, 1911, or such further time as may be necessary for passing the bill, at present rates.

On the motion to accept the suggested terms an amendment was moved in favour of asking the deputation to endeavour to secure better terms, and after discussion this amendment was carried by 11 votes to 10. Four members were then added to the deputation, bringing the number up to 11.

LEGAL INTELLIGENCE.

Workmen's Compensation.

At the Birmingham County Court on Friday Judge Amphlett, K.C., resumed the hearing of the application by the British Thomson-Houston Co. for the review of a memorandum of agreement (filed November, 1909) for the payment of £1 a week to George Mackenzie, an electrician, of Handsworth. Further evidence was given to the effect that Mackenzie was unable to undertake any work which would cause him to be on his legs for any length of time. It would be surgically impossible for him to do the same work now as he did before the accident.

Judgment reserved.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Governing Body of the Northampton Polytechnic Institute invite applications for the post of laboratory demonstrator in the electrical engineering and applied physics department. Applicants should be qualified to take charge of heat, photometric and electrical engineering laboratories. Commencing salary £100 per annum. Particulars and forms of application (which should be returned by Oct. 10) from the principal, Dr. R. Mullineux Walmsley. See an advertisement.

The Committee of Visitors of the County Asylum, Rainhill, Lancs., require an electrical engineer to take charge, under the medical superintendent and the clerk of works, of the generating plant and wiring at the asylum. Salary £120 per annum, rising to £150, together with house, coal and light. Applications to the Medical Superintendent, County Asylum, Rainhill, near Liverpool. See an advertisement.

An assistant is wanted in the electrical test-room by the Cambridge Scientific Instrument Co. Ltd., Cambridge. See an advertisement.

An experienced draughtsman is required for c.c. dynamo and motor work. Applications to the Manager, Electric Construction Co., Bushbury Works, Wolverhampton. See an advertisement.

Cleveland & Durham Electric Power (Ltd.), Hinton's-buildings, Middlesbrough, require junior electrical engineers with technical

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training. Commencing salary 10s. a week. Applications to Secretary. See advertisement.

Test-room assistants are required, used to calibrating m.c. and e.m. instruments. See an advertisement.

The following appointments on the staff of the Northampton Polytechnic Institute (Clerkenwell, London) have recently been made:—

Assistant lecturer and demonstrator in the mechanical engineering department, Mr. A. B. Morice, B.Sc. (Eng.). Mr. Morice was trained at Merchant Venturers' Technical College (now Bristol University), and served his apprenticeship with Ferranti Limited, Hollinwood, Lancs. Mr. J. S. Norton has been appointed drawing office assistant and assistant lecturer in the same department. Mr. Norton spent four years in Messrs. Vickers, Sons & Maxim's works as apprentice, and acted as assistant instructor to apprentices' drawing class. The senior assistant at the new generating station is Mr. Angus MacKenzie, who has had considerable experience at home and abroad with electrical and gas engine plants. And Mr. W. H. Bird, who has been appointed junior assistant, has been apprenticed with engineers' fitter, and has had central station experience. The second lecture assistant in the electrical engineering department is Mr. F. D. Edwards.

Mr. Arthur Hale has been appointed second demonstrator in chemistry at the Finsbury Technical College.

Mr. W. S. Templeton, M.A., B.Sc., A.M.I.E.E., has been appointed Principal of the Devonport Technical School, in succession to Dr. W. M. Varley, who was recently appointed to Swansea.

Mr. D. P. Roberts, chief electrical engineer, of London, Ontario, has been appointed provincial inspector of electrical energy in British Columbia.

Mr. George Nelson, B.Sc. (London, first class honours), A.R.C.S., late demonstrator in advanced physics in the Royal College of Science, has been appointed assistant lecturer and demonstrator in physics at the Technical College, Sunderland.

Mr. J. G. Potts, of the Bury (Lancs.) municipal electricity works staff, has been appointed electrical clerk of works at the new power station.

EDUCATIONAL NOTICES.

University of Edinburgh.—The next session opens on Oct. 4. In the engineering department of the University complete courses of instruction are provided in civil, mechanical and electrical engineering, qualifying for the degree of B.Sc. in Engineering, and extending over a period of three years. Particulars of entrance examination scholarships, fees, &c., can be obtained from the Matriculation Office of the University.

University of London, University College.—A course of lectures on the "Design of Continuous Current and Alternating Current Machines" will be delivered by Mr. H. M. Hobart on Mondays at 5 p.m., beginning Oct. 10.

Armstrong College, Newcastle-on-Tyne.—The session commenced on Sept. 26. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

Finsbury Technical College.—The next session for evening classes (lectures and laboratory work in mechanical and electrical engineering, industrial and technical chemistry, &c.), begins on Monday, Oct. 3 at 6 p.m. A special course of six lectures on India Rubber will be given by Dr. P. Schidrowitz, F.C.S., on Wednesday evenings, from 7:30 to 8:30, commencing Oct. 12. The programme may be obtained at the College, Leonard-street, Finsbury, or at the head office of the City and Guilds of London Institute, Gresham-street, E.C.

Battersea Polytechnic (London, S.W.).—The day courses at this Polytechnic prepare for the B.Sc. degree (in engineering) of the University of London, and for the Polytechnic diploma in mechanical, electrical, civil and constructional engineering. The day courses commenced on 22nd inst. and the evening courses on 26th inst. Prospectuses from the Secretary.

Borough Polytechnic Institute.—The new session began on 26th inst. There is a four years' course of instruction in electrical engineering, and in electric wiring there is a three years' course. There are day and evening classes. Further particulars and detailed syllabus are given in the prospectus, which can be obtained from the Principal, Mr. C. T. Millis.

The prospectus gives particulars of the work carried on in the Institute. Amongst the alterations are the re-arrangement of the electric wiring courses, and there are some new classes in mechanical engineering. There has been an extension and development of the work in nearly all departments. Copies may be obtained from the Principal.

Northampton Polytechnic Institute (London).—Full day courses in the theory and practice of mechanical and electrical engineering and electro-chemistry will commence on Monday, Oct. 3.

The courses in mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include specialisation in radio-telegraphy. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in engineering at the University of London. There are full and part time courses in all branches of technical optics. Particulars as to fees, &c., can be obtained at the Institute, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

South-Western Polytechnic Institute (London, S.W.).—At this Institute a complete three years' course in electrical engineering is held during the day, and a four years' course in the evening. Courses of lectures and practical work are given in a number of subjects, including elementary, intermediate and advanced electrical engineering, electrical design, instruments and lamps, alternating and polyphase currents, wiring and fitting, and the calculus for engineers.

The evening classes commenced on 26th inst. and the day college opens on Oct. 3. The institute is provided with well-equipped electrical, mechanical and physical, chemical and metallurgical laboratories, and wood and metal workshops, &c. Particulars from the Secretary, Manresa-road, Chelsea, S.W.

Sir John Cass Technical Institute.—A course of evening lectures and practical work on "Fuel" will be given at this institute during the session 1910-11, including one on "Liquid, Gaseous and Solid Fuel," by Mr. J. S. Brame, on Monday evenings, 7-8 p.m., commencing Oct. 17; one on "Fuel Analysis" (and course of laboratory work), by Mr. C. O. Bannister, during the summer term on Monday evenings, 7-10 p.m., commencing April 24; and a course of laboratory work on "Gas Analysis" in the summer term, by Mr. Chas. A. Keane, D.Sc., Ph.D., F.I.C., on Wednesday evenings, 7-10 p.m., commencing April 26. The courses of instruction are arranged to meet the requirements of those engaged in chemical and engineering works, or who are concerned with the use of fuel for motive power. Detailed syllabuses of the courses may be obtained at the offices of the institute, Jewry-street, Aldgate, London, E.C., or by letter to the Principal.

Faraday House Special Lectures.—Mr. H. M. Hobart, B.Sc., M.I.C.E., has begun a special course of lectures on "Electric Railway Engineering" to the third year students at Faraday House. Mr. J. Rennie, M.I.E.E., of the Board of Trade Laboratory, is lecturing on "Electrical Measuring Instruments."

BRITISH NOTES.

Aldershot.—The mains are to be extended to Queen's-road.

Association of Chambers of Commerce.—At the autumnal conference last week it was resolved:—

That sec. 175 of the Companies Consolidation Act, 1908, should be so amended as to provide that when a winding-up order had been made the court should have power to direct a public examination of the directors or other officers of a company, or of any person who had taken any part in the promotion or formation of the company or had been a director or officer of the company.

A proposal for the establishment of tribunals of commerce was rejected.

A resolution was also adopted that the Factory and Workshops Act, 1901, should be amended so as to provide that in the case of orders given by factory inspectors to fence machinery or to provide exhaust or other ventilation there should, in case of difference of opinion between an inspector and an occupier, be an appeal to a tribunal composed of magistrates, assisted by expert assessors.

Barking.—The engineer and manager of the electricity department (Mr. Henley L. Howard) recently reported on the proposed extensions of the generating plant. Mr. Howard recommended the installation of a 600 H.P. Diesel engine coupled to a compound-wound direct-current generator with traction battery, three-phase motor generator and necessary switchboards, &c., and also the construction of a new engine room at the side of the existing engine room to house the new plant. The whole of the recommendations have been adopted by the Council.

Belfast Electrical Exhibition.—A sub-committee of the Tramways and Electricity committee, in conjunction with Mr. T. W. Bloxam, A.M.I.E.E., city electrical engineer, is making arrangements for holding an electrical exhibition in the Ulster Hall between Jan. 9 and 31, 1911.

Carlisle.—The Rural Council has consented to the proposed application of the Corporation for a provisional order to extend the area of supply.

Church Lighting.—Dr. Chalmers' Territorial Church, West Port, Edinburgh, which has recently been renovated, has been provided with an electric lighting installation. The wiring work, &c., was carried out by Messrs. Platt Bros., and the historic church is now brilliantly illuminated by metal filament lamps.

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East Ham.—Barking Council has asked East Ham for suggestions as to a scheme of inter-running between the tramway systems of West Ham, East Ham and Barking.

The engineer and manager (Mr. W. C. Ullmann) is to bring up a report at the next meeting of the Electric Light and Tramway committee upon the question of providing additional condensing plant at the generating station.

Fifeshire.—The Road committee of the Kirkcaldy District committee have been informed by the Fife Electric Power Co. that they intend to erect an electric power cable from Lochgelly to Newton of Wemyss.

The Road Surveyor pointed out that the proposal of the company was to construct overhead lines of bare copper wire on wooden poles. The wires would pass over six highways within the district, and it was resolved to recommend the District Committee that the cables where they cross or pass alongside roads should be placed underground.

Fire.—A small fire occurred at the works of Messrs. Johnsan & Phillips, Charlton, on 26th inst., but only 6 tons of jute and a portion of a shed were destroyed. The prompt action of the firm's firemen prevented further damage.

Hereford.—The extensions to the Corn Exchange are to be wired.

Leicester.—The Electricity committee announce that they have decided not to appeal against the injunction granted against the Corporation in the proceedings instituted by the Attorney-General, at the instance of Mr. C. J. Utley, for an injunction to restrain them from carrying on the electric wiring and fittings department.

Leigh-on-Sea.—Southend Council have applied to the Board of Trade for an order to authorise them to supply current to the Leigh Cinematograph Hall. Leigh Council agree to the supply being given.

Llanelly.—Callender's Cable & Construction Co. has commenced the work of laying electric supply cables in this district.

Listowel (Ireland).—The Council is negotiating with electrical firms as to electricity supply.

L.C.C. Tramways.—Chelsea Council resolved on Wednesday to refuse its consent to the proposal of the London County Council to construct tramways in the borough to link up Kensington and Battersea.

Manchester.—A special meeting of the Corporation will be held on Wednesday to consider a bill to extend the time for completing certain authorised tramway lines, &c.

Manchester and Salford Amalgamation.—The subject of the amalgamation of the boroughs of Manchester and Salford is again being raised, and a petition, which has already been signed by a number of influential ratepayers (including Sir Wm. Mather, I. Frankenburg & Sons, the Broughton Copper Co., the Peel-Conner Telephone Works, &c.), is to be presented to Salford Corporation in favour of the proposal.

Mexborough.—An animated discussion arose at last week's meeting of the Council on a recommendation of the Highways committee to allow the Mexborough & Swinton Tramways Co. to run a motor char-a-banc service on the Wath and Denaby roads.

Mr. J. Rowan thought the application should be considered with the question of trackless trolley trams, in connection with which the Council had received a communication. The trackless trolley system would give an outlet for power from their own electricity undertaking.

Ultimately the recommendation was rejected by 5 votes to 4.

Municipal Wiring.—The following notifications of intention to support the bill of the Municipal Electrical Association to authorise municipal wiring, &c., have been received :—

Blackburn Corporation will consider the matter further when the bill is drafted; Hounslow Council will give moral support and reconsider the question of giving financial aid when the bill is drafted; and Manchester Corporation will give moral support and the question of giving financial aid has been deferred for the present.

National Electrical Manufacturers' Association.—The half-yearly general meeting of the Association will be held at the Midland Hotel, Manchester, at 2:30 p.m. Oct. 11. A committee meeting will be held at the same place on the same day at 11.30 a.m.

Obituary.—We regret to record the death of Mr. George Alexander Mason, which took place at Bahia Blanca (Argentina) on Sept. 23 from typhoid. Deceased, who was only 32 years of age, was in the employ of the Buenos Aires & Pacific Railway Co., having gone out to Bahia Blanca in January, 1909. His apprenticeship was served with Messrs. Crompton & Co., of Chelmsford, and he had also been with the B.T.-H. Co. (Rugby), the Brush Co. (Loughborough), and the Corporation electricity works, Grimsby. He served for 15 months with the Corps of Electrical Engineers in the South African war.

We also regret to record the death of Mr. Edward P. Martin, vice-chairman of Messrs. Guest, Keen & Nettlefolds, and a director of the South Wales Electrical Power Distribution Co. and other undertakings.

Newcastle-on-Tyne.—In consequence of the increasing demand for electrical energy for power at the works of Messrs. Hawthorn, Leslie & Co., at St. Peter's, some additions have recently been made to the plant in the local sub-station of the Newcastle-on-Tyne Electric Supply Co. from which these works are supplied.

The sub-station buildings have been extended, and now consist of three transformer chambers (29 ft. by 21 ft. by 14 ft. high). The sub-station is used for reducing the pressure from 5,500 volts, at which it is received from the generating station, to a pressure of 440 volts. The total capacity of the sub-station is now 2,000 H.P., there being three 700 H.P. transformers, oil cooled. The h.t. switchgear is of the Brown-Boveri "Grid" type, supplied by Messrs. Richardsons, Westgarth & Co. and consists of two feeder panels, each of 2,500 kw. rated capacity at 5,500 volts, and three transformer panels, each of 1,000 kw. rated capacity, while one extension panel is allowed for. The l.t. switchgear is of the Reyrolle ironclad type with three transformer panels, each of 1,000 kw. at a voltage of 440.

Olympia Engineering Exhibition.—After the close of this exhibition on Monday evening the exhibitors presented the organiser (Mr. F. W. Bridges) with a gold card case.

The chairman of the Council (Capt. H. Riall Sankey) made the presentation and Mr. Bridges acknowledged the gift in suitable terms.

At a meeting of the exhibitors on the same day a resolution was passed expressing entire satisfaction at the manner in which the whole of the arrangements have been carried out by Mr. F. W. Bridges, and at the successful result of the exhibition. It was agreed to support a similar exhibition, if held, in 1913.

Overhead Telephone Wires.—As Croydon Corporation failed in the recent arbitration proceedings in the dispute with the Postmaster-General in regard to overhead telephone wires in the borough, the Council have decided to pay the extra cost of placing the wires underground in certain cases where unsightly poles would be likely to depreciate property.

Personal.—Mr. A. S. E. Ackermann, B.Sc., A.M.I.C.E., has returned to London after an absence of 10 weeks in the United States, where he has been to test and report upon a new engine and to visit some of the latest engineering works.

Presentations.—Hanley Electricity staff have presented a case of Loewe pipes and a copy of Dr. J. W. Mellor's "Higher Mathematics" to Mr. C. H. Yeaman, on his appointment as chief electrical engineer of the new County Borough of Stoke-on-Trent.

Bournemouth Tramways staff have presented a cheque to Mr. A. H. Bowles on his marriage.

Rotherham.—On Tuesday the Council decided to promote a bill giving power to provide and run rail-less cars in a number of districts; to run motor omnibuses in the borough, and to extend the Wellgate tramways, and also additional powers relating to electricity supply, &c.

Scarborough.—The local tramways company notify that they will cease to run the trams during the winter months, commencing Oct. 15.

Surbiton.—The Board of Trade have appointed Dr. Alex. Russell, M.A., M.I.E.E., principal of the Electrical, Standardizing, Testing and Training Institution, Faraday House, to be an electric inspector under the Surbiton Electric Lighting Order.

Village Lighting.—The public electric lighting of the streets of Ainsworth (Lancs.) was inaugurated on Monday, when Mr. Hy. Whitehead, chairman of the Parish Council, formally switched on the current. The sub-station is located at the Ainsworth Cotton Co.'s mill.

Watford.—A discussion took place at the last meeting of the Council upon a proposal to oppose the Herts County Council's bill for powers to instal the rail-less traction system through Watford. Ultimately it was decided to proceed to next business. The Metropolitan Electric Tramways (Ltd.) are bearing the whole of the expense of sending a deputation from the Council to Berlin and Vienna to see the rail-less system working in those cities.

West Ham.—12 additional cars of the bogie type are to be purchased by tender, and application is to be made to the Board of Trade for sanction to a loan of £11,000.

Application was made during the vacation to the L.G. Board for a loan of £7,946 for motors and £6,027 for a turbo-alternator, and sanction has been received for the raising of these amounts.

The Electricity committee report that, in connection with the accounts of the undertaking to March, 1910, they have decided to write down the value of certain stores by £2,800, and have agreed to the appropriation of part of the reserve fund to meet the deficiency. The committee also report that on a communication from the Borough Treasurer they have resolved to ask the Fianace committee to include £18,000 in the next half-year's estimate, being the estimated deficiency on the electricity undertaking at March 31, 1911.

The borough electrical engineer (Mr. H. H. Couzens) has reported that with regard to the contract for the new turbo-alternator, the contractors (the British Westinghouse Co.) had agreed to replace the existing 3,000 kw. turbine with one of the Rateau type, the guarantees being the same as for the new set provisionally ordered. After investigation, Mr. Couzens

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ELECTRICITY SUPPLY TABLES AND DATA.

This Valuable Set of Tables and Engineering Data relating to Electricity Supply and to Electric Traction on Railways and Tramways in the United Kingdom, the Colonies, and some important places abroad, is now ready, and can be obtained complete in handy book form, price 6s. 6d. post free, or on very hard paper for rough or constant use, price 8s. 6d. post free. A complete Index is included.

was not satisfied that the contractors could adhere to the original delivery given for December, and as some of the new supply contracts would not commence until after the winter's load, the machine would not be required until about July of next year. He, therefore, recommended that the existing turbine be replaced with the Rateau machine as soon as possible, a course which the committee agreed to.

Wigan.—Sanction has been received by the Council to a loan of £30,083 for extensions of the electricity undertaking.

Wireless Telegraph Notes.—An announcement has been made that the Marconi Co. have received a message from Mr. Marconi on board the ss. "Prinsipessa Mafalda," that he has successfully obtained wireless messages from Clifden (Ireland) and Glace Bay (Canada) on board the ship for distances up to 3,500 miles in broad daylight. A kite was employed to support the aerial wire on board the ship. The distance compares with the highest former record of 1,750 miles.

The London correspondent of the Sheffield "Daily Telegraph" discussed in the issue for Sept. 23 the subject of wireless steering of war ships.

Out of 98 days passed at sea by the "Otranto" (Orient line), the vessel was 81 days in wireless communication either with shore stations or with other vessels. The "Otranto" is fitted with the Marconi apparatus, and during a journey out from London was in continuous contact with Poldhu for a distance of 1,600 miles.

The ss. "Nonsuch," of what is known as the tramp class of steamer, is fitted with wireless telegraphic apparatus on the British Radio-telegraph Co.'s system, and reports that she was in communication with the North Foreland up to 15 miles south of Cape de Gata, the south-east point of Spain, and 940 miles distant from the Foreland.

The chief point of interest in wireless telegraph work at the present time is the establishment of effective communication with submarine vessels, both from the shore and from more or less adjacent war ships. Important experiments (following those in Torbay) are being conducted at Portsmouth and Devonport. It is reported that continued success follows these experiments.

Mr. Robert Loraine, besides being one of our leading actors, has acquired renown as an aviator, and when he is not crossing the Irish Channel, or making other records, he is engaged in wireless telegraph experiments which are likely to add to the sum of our knowledge as to what is required to secure success in this branch between the air and terra firma and the air and ships at sea. Mr. T. Thorne Baker, on the staff of the London "Daily Mail," has designed some special apparatus for this purpose, and the British & Colonial Aeroplane Co., of Bristol, have designed and manufactured a Farman biplane to enable the experiments to be made under the most favourable conditions. Wireless communication is said to have been maintained up to a quarter of a mile in the air, and valuable data was collected.

The importance of isolating wireless telegraph stations—*i.e.*, protecting them from the curious and the inquisitive—is dawning upon the authorities, and a number of the more important stations are being protected from "outside influences."

The first telegram originating in the air was a message received at the Eiffel Tower, Paris, from some special apparatus devised by a French engineer. This apparatus was taken up in the Clément-Bayard airship, and 50 miles from the tower a message was sent by M. Sabatier, the engineer-in-chief on board, to his family informing them of his imminent arrival.

Wolverhampton.—An inquiry was recently made into the Council's application for sanction to borrow £6,740 for extensions to the refuse destructor and power plant at Crown-street.

The Town Clerk explained that the proposal was to instal four extra cells, two boilers and another forced draught fan. With these additions they would be able to dispose of the town refuse as collected, and they would be able also to supply steam more regularly to the electricity department at a time when it was most required. That would warrant the electricity department in putting down a proper condensing plant, and when that was in operation it would effect a saving of about £300 a year. The output of the works would be increased about 50 per cent.

Workhouse Lighting.—The L.G. Board have sanctioned a loan of £1,160 for the electric lighting of Haslingden workhouse, repayable within 10 years.

West Ham Guardians are inviting tenders for wiring the new receiving homes at Wanstead.

York.—The city electrical engineer (Mr. J. W. Hame) has been authorised to prepare specifications of the additional plant required at the electricity works.

COLONIAL AND FOREIGN NOTES.

Argentina.—The "Review of the River Plate" states that Buenos Aires Corporation have been reminded by one of their officials that on taking over the undertaking at the end of 60 years from the signing of the contract with the Cia Alemaña Transatlantica de Electricidad (two years ago) the Corporation may have to pay about $100,000,000 for improvements.

It is expected that the contract with Agar, Cross & Co. (representatives of the British Westinghouse Co.) for the electrification of the *Mar del Plata* tramways will shortly be signed.

The electricity supply works at *Salta*, formerly owned by Señor B. Garcia, have been acquired by a new local company, with Mr. M. Henlitzka (ex-manager of the Cia Alemaña Transatlantica de Electricidad) as chairman.

At the Avenida (Buenos Aires) exchange of the United River Plate Telephone Co. a central battery switchboard was recently substituted for a multiple magneto board. The exchange has 4,000 subscribers.

Balearic Islands.—It is stated that Don Mariano Gual (Count of Ayamans) and Don Alfonso Chopitea have applied for a concession for the construction and working of an electric tramway from Cás Catalá to Palma station.

Constantinople.—As reported in our last issue, a convention for the supply of electricity in this city has been signed between the Minister of Public Works and representatives of a group composed of Hungarian (including Messrs. Ganz & Co.) and French syndicates, whose tenders were accepted. The concession is for 50 years.

Ecuador.—The report of Consul Cartwright on the trade of Ecuador for 1909 says the capital and objects of the electric light and car company at Guayaquil have been considerably extended during the past year.

The capital is now 1,500,000 sucres (£150,000), all locally subscribed, with power to increase the capital or to issue debentures. At present the electricity is generated by means of steam-driven plant, and the fuel principally employed is crude petroleum from the canton of Santa Elena. Arrangements are being made to obtain power by hydraulic turbines erected where there is water-power available near Bucay, on the Guayaquil and Quito Railway. The turbines are to be of 3,000 to 4,000 H.P. Electrical energy will be conveyed by a cable running about 54 miles along the side of the railway, from Bucay to Duran, and thence by cable under the river. It is understood that the contract has been given to a French firm and that work will shortly be commenced. The company supplies electricity to several industrial enterprises in the city, and will eventually be able to do a considerable business in this direction.

Italy.—The "Sole" (Milan) announces that the Ministry of Public Works have granted a concession for the construction and working of an electric railway from Argegno to Lanzo d'Intelvi, and have reported favourably on an application lodged by the Società Edison for the construction of an extension of the Milan-Affori electric tramway, from Affori to Varedo.

Mexico.—Two contracts have been entered into between the Government and the Cia de Tranvias de Mexico for the construction of electric tramways from Ixtapalapa to Puebla (about 100 miles) and from Santa Fé to Toluca (about 32 miles), forming extensions of the present electric system of Mexico City. The company is of Canadian origin, and the address is Indianilla, Mexico, D.F.

South Africa.—The Uitenhage (Cape Colony) electricity supply was formerly inaugurated on Aug. 25.

Cradock Municipality have decided to adopt electric lighting.

The message rate system of charging for telephone facilities in the Transvaal is said to have been a success, and has enabled a reduction of rates to be made.

It is stated that the Transvaal Government recently obtained a report by an expert in regard to a suggestion for the electrification of the Central South African railways.

Spain.—Senor D. José Riestra López (Marqués de Riestra) has been granted permission to utilise public lands in Freixa, Caramiñal, as a site for an electric power station.

Toronto (Canada).—The Toronto Electric Co. are applying for an injunction to prevent the completion of the municipal plant for the distribution of electric power brought from Niagara Falls over the Ontario Government transmission line, on the ground that the poles and wires in the streets will interfere with the company's system.

Water Power Development in Japan.—In a recent communication to "The Times" a correspondent (a member of the Japanese Board of Commerce and Agriculture) states that the development of the great water-power resources of Japan is a matter of national importance, and offers a sound and remunerative field for the investment of native and foreign capital.

About four years ago a concession was granted to a British syndicate (the Kobe Synd., Ltd.), jointly with a Japanese syndicate under the presidency of Mr. Sonoda, chairman of the Nobles Bank, and this syndicate comprised some of the leading bankers, financiers, and business men in our country. The propositions for power development were most

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favourably reported on by a number of leading British and American hydraulic and electrical engineers. The project was highly approved of by the Government and warmly supported by Marquis Inouye, Viscount Hayashi, and your ambassador, Sir Claud MacDonald. It was decided to form a company with a capital of £1,280,000 for the development of 205,000 H.P. Half this amount was guaranteed by the Japanese, and it was understood that the other half would be found in England. About £500,000 was immediately subscribed by the leading men in Japan, including princes, noblemen, and all the first bankers and business firms. Such a thoroughly representative list was never before seen in connection with any company in Japan. But the British share of the capital was not forthcoming. Various reasons were given for this, and many alterations of terms, &c., were asked for, to all of which the Japanese side acceded. Extensions of the concessions were asked for and granted, but still no British capital appeared. After being held for many months the Japanese subscriptions were returned. The concessions are still held, and the Japanese ready to subscribe again. Great German and American firms were willing to finance and construct, but were refused. If the directors of the Kobe Synd., who belong, I understand, to contracting firms and members of the London Exchange, cannot finance the project after all these years are there not others to be found in London who can, to whom they might resign their seats? We Japanese would much prefer to do business with our allies than to be forced to do it with others.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Bournemouth.—The accounts of the Corporation tramways department for the year ended March last show capital expenditure £422,799 (increase £2,787). The amount of sinking fund applied in reduction of debt is £67,112, and the reserve or renewal fund shows an unappropriated surplus of £8,127.

Revenue was £85,540, working expenses £55,622, interest required £11,201 and sinking fund instalment £13,134, the net deficit being £2,263. 13,940,588 passengers were carried, 1,789,437 car miles run and 2,887,178 units used. Average speed per hour was 7·10 miles, total revenue per car mile was 11·47d. and working expenses, exclusive of power cost, 5·61d. and including power costs 7·45d. The average fare per passenger was 1·47d.

Dartford.—The capital expended on the electricity department to March 31 was £43,292, an increase of £2,192.

Receipts from the sale of current by meter were £7,602 net, from public lighting £1,207, meter rental, &c., bringing the total to £9,078. Total expenses were £5,405, leaving gross profit £4,033. Interest on loans required £1,245, instalments of loans repaid £1,905, income tax £55, and payments to tramways department as rent of light railway generating plant £221. The cost of condenser shed was £32, and after transferring £686 to reserve £1,405 was carried forward. The net profit on the year's working, after making a special provision of £489 for accrued loan instalments, amounted to £629, against £58 last year, when no such special provision was made. 1,046,615 units were sold (against 904,999), including 518,855 to private consumers for light and power, 405,185 units for traction and 122,575 for public lighting. There are 266 public lamps (against 264) and the total maximum supply demanded was 598 kw. (against 529 kw.)

In the report of the electrical engineer and manager (Mr. J. D. Pember) it is stated that during the past year 29 new services were laid and the equivalent of 868·8 c.p. lamps was connected. There were also nine motors (of 136 H.P.) connected, bringing the total to 588 H.P. The total works costs were 1·15d. per unit sold (against 1·43d.), and the total costs 1·94d. (against 2·16d.). The average price received per unit was 1·93d. (against 2·01d.), but the average price for private lighting was 3·58d. (against 3·58d.)

Ebbw Vale.—The annual report of the electrical engineer (Mr. Wm. Horsfall) states that the total capital expended on the electricity department at March 31 was £15,852, an increase of £213 during the past year.

£1,000 has been paid off, leaving the net expenditure of £14,852, but as the Council are authorised to borrow only £9,654, excess expenditure is £5,197. 17s. 10d. The sinking fund provided for the repayment of the loan of £9,654, stands at £1,274. 8s. 4d., and in addition £696. 11s. 8d. has been set aside for repayment of £5,197 17s. 10d. overspent, bringing the net amount overspent to £4,501. 6s. 2d. The number of consumers is 321, an increase of 84, and the number of lamps connected to the mains is equivalent to 7,162 8 c.p., an increase of 1,920. The number of units sold to private consumers amounted to 85,462, an increase of 11,563. Revenue from private consumers was £1,551. 2s. 1d., compared with £1,360. 8s. 3d. (for 73,899 units) in 1908-9. The gross profit for the year was £1,173, out of which £354 was paid as interest, and £160 paid to the Council's general accounts as interest on the amount overspent, and £608 as sinking fund, leaving a net profit on the year's working of £51, against a net loss of £58. £1,432 has been expended on free wiring installations, leaving £398 unexpended.

Leicester.—The accounts of the electricity department for the half-year ended June 30 show a net profit, after paying expenses and interest on capital and £3,343. 16s. 10d. on account of sinking fund, of £635. 3s. 6d.

Poplar (London).—The accounts of the electricity undertaking for the year ended March 31 last show net income of £42,251 from sale of current, an increase of £4,441.

Working expenses were £21,835, increase £2,368; gross profit £20,415, against £18,342. Net profit was £4,425 against £3,381. The total available surplus was £6,293, and it is proposed to pay various sums out of this of a capital nature which will reduce the balance to £5,336. The increase in units sold over the previous year was 2,035,116, and the net cost of coal £924 more, the extra units thus being produced at a cost of 0·109d. The cost per unit sold was reduced by 0·663d., equivalent to a reduction of £2,068 on the full output. The percentage of gross profit on capital was 8¼, increase 1 per cent. The average depreciation set aside by the metropolitan companies is slightly over 1¾ per cent., so that the comparable result with company dividends is claimed to be nearly 7 per cent. Loans redeemed during the year were £7,020, and £956 was paid out of revenue for work of a capital nature. Negotiations are in progress with regard to bulk supply. In the year prior to the change-over from carbon to metal filament lamps in street lighting, the cost for current was £1,625, and last year £1,170, a saving of £454. The cost of lamp renewals was in the first instance £162, and in the second instance £320, an increase of £158, showing a net saving of £296, without taking into account the number of lamps converted from gas in the interval. By the change the borough has gained in efficiency of street lighting from an initial 24 c.p. per post, and a steady diminution during use, to 50 and 100 c.p. per post, without any material reduction during life of lamps. The provision for depreciation (3¼ per cent.) is not unduly low, and the proposals for augmentation agreed with the L.C.C., will considerably increase this percentage in future. The net result, after providing for depreciation, is 5 per cent. profit on capital.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is READY, price 15s., post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

Tenders are invited by WEST HAM Guardians for installing the electric light at the receiving homes in course of erection at Wanstead. Specification, &c., from the architect, Mr. Wm. Jacques, A.R.I.B.A., 2, Fen-court, London, E.C. Tenders to the office of the Clerk to the Guardians (Mr. Thos. Smith), Union-road, Leytonstone, London, N.E., by 10 a.m. Oct. 13. See also an advertisement.

Tenders are invited (till 2:30 p.m., Wednesday, Nov. 2) for supply to the Postmaster-General's department, New South Wales, of 1,000 25 c.p. metal filament lamps, with bayonet cap fittings, for 110 volts d.c. Tender forms, &c., at the Commonwealth offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited by Nov. 23 for supply of cable ironwork, c.i. pipes, earthenware conduits, switchboards, telegraph and telephone instruments, &c., to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to Nov. 2, 1910, for the supply of insulators, wire (covered phosphor-bronze and g.i. stranded) to the Postmaster-General's Department in QUEENSLAND. Tender form and specification from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited by EDINBURGH Corporation for three steam turbines and d.c. generators, each of 1,200 kw., and condensing plant and interior parts of cooling towers, for their Dewar-place electricity

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station. Copies of specification, forms of tender, &c., from the engineer, Mr. F. A. Newington, Dewar-place, Edinburgh, and specifications, conditions and drawings may be seen at, but not obtained from, the offices of the consulting engineer, Sir Alexander Kennedy, 17, Victoria-street, London, S.W. Tenders must be delivered at the office of the town clerk, Mr. Thomas Hunter, W.S., City-chambers, Edinburgh, by Oct. 10.

Tenders are wanted for electric lighting and power installations at the Scottish Exhibition of National History, Art and Industry at GLASGOW in 1911. Forms of tender from Mr. A. C. Freeman, 499, Sauchiehall-street, Charing Cross, Glasgow, to whom tenders by 10:30 a.m. Oct. 3.

The Directors of the METROPOLITAN RAILWAY Co. are prepared to receive tenders for the supply of general stores during 12 months ending Oct. 31, 1911. Forms of tender (No. 13, electric wires and cables; No. 14, electric lamps, carbons, switches, fuses, telephones, coils, &c.; and No. 15, insulating materials) from the Secretary, 32, Westbourne-terrace, London, W., to whom tenders by 10 a.m. Oct. 3.

HALIFAX Tramways and Electricity committee want tenders (by noon Oct. 17) for supply of a 1,500 kw. turbo-alternator, with condenser, two 750 kw. rotary converters, with transformers, switchboard, &c. Forms of tender from Borough Electrical Engineer.

LONDON County Council require tenders by 11 a.m. Oct. 11, for the road work and platelaying required for the reconstruction of the Highgate-road tramways for the conduit system, and for paving works of street widenings. Specifications from the Chief Engineer.

LONDON County Council also want tenders by 11 a.m. Oct. 5 for electrical installation work at the Poplar Coroner's Court and Hoxton House Schools, Shoreditch. Specifications, &c., from the Chief Engineer.

LONDON County Council want tenders by 11 a.m. Oct. 12 for wiring and fitting Sherington-road school, Greenwich, for electric light. Specifications from the Chief Engineer, Spring Gardens, S.W.

YORK Electricity committee want tenders by Oct. 7 for 12 months' supply of carbons, carbon brushes, carbon filament lamps, meters and time switches, motors, &c. Forms of tender, &c., from the City Electrical Engineer.

HACKNEY (London) Council require tenders by 7 p.m. Oct. 13 for supply of 90,000 pairs of white open-type arc lamp carbons. Specifications, &c., from the Town Clerk.

ISLINGTON (London) Guardians want tenders (by 4 p.m. Oct. 6) for supply and fixing of bells, fire alarms and telephones at the Workhouse, Upper Holloway, N. Specification from the Master of the Workhouse.

MANCHESTER Libraries committee want tenders by 9 a.m., Oct. 3, for electric wiring. Specification, &c., from the City Architect.

DERBY Corporation want tenders for steel and c.i. piping. Forms, &c., from the Borough Electrical Engineer.

Tenders are invited up to noon Oct. 17 for the supply of telegraph and telephone instruments and material (as per schedules 1 to 9) to the Postmaster-General's Department in TASMANIA. Tender forms and specifications at the office of the High Commissioner.

The Deputy Postmaster-General, MELBOURNE, will receive tenders until 3 p.m. Oct. 18 for supply of 23 miles of telephone cable (specification 284) and 500 composition insulators (specification 374) and until 3 p.m. Oct. 25 for 10,000 Cordeau insulators (schedule 373). Specifications, &c., from 72, Victoria-street, London, S.W. Local representation is necessary.

The Deputy Postmaster-General, MELBOURNE, wants tenders by 3 p.m. Oct. 25 for supply of electric lighting material (schedule No. 311). Specification, &c., from the High Commissioner.

ADELAIDE (S. Australia) Municipal Tramways Trust want tenders by Oct. 11 for supply of 1,750 tons of tramrails, 150,000 dogspikes and 1,200 tiebars and by Oct. 18 for bonding material.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

The Ministry of Public Works, CAIRO, require tenders for electrical installations and refrigerating plant for the lunatic asylum in course of construction at Khanka. Specifications from the Chief of the Administrative Service, Ministry of Public Works, Cairo. Stamped paper for tenders is obtainable from Mr. A. L. Webb, Westminster, S.W. Tenders by noon Oct. 20. Legal domicile at Cairo is necessary in the case of this contract, and to obtain temporary domicile British firms must, before electing such domicile, formally advise the Consulate at Cairo of intention to do so, formally authorise the Consulate on their behalf and inform the Consulate of the address to which documents should be forwarded.

Tenders will be received at the Ministere des Colonies, rue Oudinot, 27, Paris, until Oct. 14 for the supply and laying of a submarine cable between LIBREVILLE and LOANGO (French Congo). Deposit of £2,000 required with all tenders, to be increased to £4,000 with successful tender.

Tenders are wanted by noon Oct. 31 for supply and erection of machinery, &c., for electricity supply and water supply systems for the town of BENI-SOUEF (Egypt). Particulars may be obtained from Mr. A. L. Webb, C.M.G., Queen Anne's-chambers, London, S.W. Local representation is necessary.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

The "North China Herald" states that SHANGHAI electricity department require tenders by noon Oct. 10 for supply of electric heating and cooking appliances, and by noon Oct. 20 for 10,700 carbon and 15,000 metal filament lamps. Specifications from the Electricity Works, 31, Fearon-road, Shanghai.

TENDERS RECEIVED AND ACCEPTED.

Westminster Council has accepted the tender of Speedy, Eynon & Co. (at £47. 10s.) for wiring for additional lights of the large Caxton Hall, and for re-wiring consequent upon certain alterations. The tender of the same firm (at £45) was also accepted for altering the positions of the wires, switches, &c., adjoining the entrance to the large hall. The firm's tender at £20 for 100 metal filament lamps has also been accepted.

Coventry Corporation have placed an order with Ed. Bennis & Co. for supply of four sets of Bennis-Miller-Bennett chain-grate stokers for B. & W. boilers; and Kettering Council have placed an order with the firm for three independent coal elevators for feeding the hoppers of Bennis stokers on three Lancashire boilers. The Coventry order is a repeat.

West Ham Council have accepted the following tenders (lowest received):—

New Conveyor Co., ash elevator, £315; Aiton & Co., c.i. piping and valves, £163; Bruce Peebles & Co., motor, £125, and motor-generator, £152. 10s.; W. H. Allen, Son & Co., centrifugal pump, £121.

Barking Council has accepted the following tenders (the lowest received):—

Union Cable Co., 110 yds. 0·125 single cable, £9. 17s. 6d., and 440 yds. 0·008 twin cable, £23. 19s. 6d.; Western Electric Co., 880 yds. 0·05 three-core cable, £123, and 110 yds. 0·025 h.t. cable, £31.

Chelmsford Education committee have accepted the tender of the Banbury Electricity & Motor Co. for wiring Trinity-road schools and supplying fittings at £175.

Knottingley Education committee have accepted the tender of J. Richardson for installing electric bells at Rope Walk schools at £16. 4s.

Heckmondwike Council have accepted the tender of the Council's Electrical Engineer for wiring the cemetery lodge.

Venner & Co. recently supplied nine electric meters to the Bengal-Nagpur Railway electrical department.

Mansfield Council have accepted the tender of B. Meggitt for maintaining the electric fire-alarms.

Radcliffe Council have accepted the tender of W. Brierley for wiring the new Council offices.

Chippenham School governors have accepted the tender of Edwards & Armstrong for wiring the chemical laboratory and gymnasium.

Dudley Education committee have accepted the tender of Whittaker Bros. for wiring the new schools at Holly Hill.

Swansea Harbour Trust have accepted the tenders of Crompton and the British Westinghouse Co. for electrical plant at the docks.

Battersea (London) Council have accepted the tender of Pooley & Austin for switchboard, &c., at £120.

The tender of the Urban Electric Supply Co. has been accepted by the Grantham Guardians for electric pumping plant.

The South Indian Railway Co. recently placed orders with J. Stone & Co. for 26 dynamos and 26 switches for train lighting, and also 875 storage cells; Siemens Bros.' Dynamo Works for electric lighting cables, and the Wardle Engineering Co. for electric lighting materials.

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We are informed that the Trenton Power Co. (Canada) have placed an order with Jens Orten-Böving & Co. for four turbines of 1,500 H.P. under 20 ft. head, complete with governors; and the Chicoutimi Pulp Co. (Canada) an order for two turbines of 4,500 H.P. under 75 ft. head.

BUSINESS NOTICES.

The Glasgow office of the Western Union Telegraph Co. has been removed from 49, Gordon-street to 113, Hope-street.

W. V. Waite & Co. (Ltd.), 31, Queen-street, Cardiff, have been appointed South Wales district agents for Bruce Peebles & Co.

Mr. J. M. M. Munro has severed his connection with Messrs. Anderson & Munro, and will devote himself entirely to consulting work at 108, Douglas-street, Glasgow. Mr. Munro has had extensive experience in country house lighting, power installations, street lighting, &c.

Messrs. T. & E. Wannbacher, engineers, merchants, &c., have removed their London office to 5, Appold-street, Finsbury, E.C. Telephone No. (6448 Central) and telegraphic address ("Wannbacher London") remain as at present.

Mr. F. Peake Sexton, A.R.C.S., A.M.I.E.E., has opened offices at Clarence-chambers, London-road, Kingston-on-Thames, where he will carry on business as consulting electrical engineer and dealer in electric lamps, fittings, &c.

The Ruberoid Co. have recently completed an extensive factory at Brimsdown, Middlesex, for the manufacture of the well-known Ruberoid roofing, damp course, flooring, sarking felt, insulating papers, insulating varnishes, and the well-known P. & B. tapes.

The materials manufactured by this company are well known throughout the electrical industry, particularly the P. & B. insulating varnishes and tapes. The company have recently brought out an interesting catalogue of preservative paints, which with full sets of samples of all materials manufactured and catalogues, will be sent to bone fide inquirers.

Patent Development.—The proprietor of patent No. 21,181/1905, for "Improvements relating to electrical measuring instruments," desires to enter into arrangements, by licence or otherwise, for exploiting same in this country. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

Onewatt Lamps.—Messrs. Siemens Brothers incandescent lamp and fittings department (Tyssen-st., Dalston, N.E.) inform us that they are placing on the market a range of 50-volt "Onewatt" lamps, 10 c.p. and 16 c.p., in bell-shaped and spherical bulbs. They are now listing battery lamps, 13 to 16 volts, 100 c.p. lamps, 200 to 250 volts, and 10 c.p. and 16 c.p. lamps, 20 to 50 volts, all of the "Onewatt" type with drawn tungsten filaments. The prices of the new 50-volt lamps are, we are informed, low, and Messrs. Siemens Brothers are prepared to supply quantities of literature regarding same, upon receipt of application accompanied by trade card. It seems probable that during the coming lighting season other types of "Onewatt" lamps will be placed on the market.

"Wood Craft."—We have received a copy of the first number of a new monthly journal entitled "Wood Craft," which is intended to be a technical journal for the woodworking and timber trades. The journal has hitherto only been published in the United States, but as there has been no paper exclusively devoted to the technical side of woodworking in this country it was thought "Wood Craft" would fill this gap. Judging from the character of the articles, which are well illustrated, and the variety of the topics dealt with in the present issue, the new journal should prove a useful addition to the ranks of technical papers. It is published monthly at 22, Henrietta-street, London, W.C., and the annual subscription is 8s.

CATALOGUES, &c.

SUNBEAM LAMPS.—We have received from the Sunbeam Lamp Co. an advance copy of the lamp section of their catalogue, which gives full details of their well-known manufactures, comprising both metal and carbon filament lamps. Both of these are British made. The catalogue also contains details of Sunbeam new carbon and metal filament battery lamps, which are specially adapted for motor-car work.

LEUCONIUM LAMPS.—The Stearn Electric Lamp Co., 47, Victoria-street, S.W., have sent us a catalogue in which are illustrated and described their well-known Leuconium lamps. These are suitable for voltages up to 250, and are made in a number of shapes and sizes. Details are also given of this firm's well-known "Nevaout" lamps.

"SPOOKIE" NIGHT WATCH LANTERNS.—Simplex Conduits (Ltd.) have sent us a card illustrating a new design of lantern on the well known "Spookie" principle. Many improvements have been introduced into the new fitting. No glue is used in fixing the roof piece which prevents the shade from coming apart owing to the heat of the lamp. The frame of the lanterns is made up of specially thick card, which we are informed closely resembles wrought iron.

ELECTRIC BELLS AND ACCESSORIES.—Messrs. Siemens Bros. & Co. have sent us a catalogue dealing with this subject. It contains illustrations and details of a large variety of domestic bells of all patterns. A number of special lines of indicators have also been introduced and especial attention may be drawn to water-tight bells, with a diaphragm device for both out-door and mining purposes.

ELECTRIC CRANES AND HOISTS.—The Witton-Kramer Electric Tool and Hoist Co. have sent us a well illustrated catalogue in which is shown a variety of electric hoists and transporting appliances manufactured by them.

ALLGEMEINE APPARATUS.—The Allgemeine Elektricitäts Gesellschaft (Berlin) have sent us three pamphlets dealing respectively with Automatic Voltage Regulation on the Tirril System, the Application of various types of Motors, and with Totally Enclosed Switch Boxes. A large amount of useful technical information is contained in all of these.

BANKRUPTCIES, LIQUIDATIONS, &c.

An application for the discharge of Frank Sheppard, electrician, 4, Haslett-road, Kensington, London, W., will be heard Oct. 18 at Bankruptcy-buildings, London, W.C.

The Telewriter Synd. (Ltd.), having sold the telewriter and other assets to the National Telewriter Co. (Ltd.), and having gone into voluntary liquidation, creditors are required to send particulars of their claims to Mr. J. Craggs, 3, London-wall Buildings, London, E.C., by Nov. 10.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

*NOTE.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

July 21, 1910.

17,312 CHADBURN'S (SHIP) TELEGRAPH CO. & GRANT. Ships' and analogous telegraphic apparatus.
17,322 KESSELS. Printing telegraph instruments.
17,330 HALL. Electric generators.
17,336 HANNEMANN. Batteries.*
17,340 & 17,341 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Motor controller circuits.*
17,344 ELECTRIC & ORDNANCE ACCESSORIES CO. & GARNER. Electric circuits, closers or starters for use in connection with electromotors and the like.*
17,349 ELECTRIC AND ORDNANCE ACCESSORIES CO., GARNER & MUELLER. Controllers for use in connection with electric-motors.
17,369 BLECKLY. Arc lamps.
17,380 ENGEL. Trolley guard attachment for electric tramcars.*

July 22, 1910.

17,399 ATKINSON. Construction of continuous-current electric generators and motors.
17,405 WHITELEY & MOSS. Means for resetting tramcar and like lifeguards.
17,415 CHAMBERLAIN & HOOKHAM & SPRAGUE. Prepayment electricity meters. (Addition to No. 3,250/10.)*
17,425 INCLEDON & INCLEDON. Connecting electrical conduits to their fittings.
17,447 BROWNE. Portable apparatus for the softening and purification of water by means of electricity.
17,469 EISNER. Manufacture of filaments for incandescing electric lamps.*
17,477 MAYOR. Electric conductors.
17,482 TUCKER. Current collectors for overhead electrical railways.

July 23, 1910.

17,498 CLAPHAM. Method and means for changing the trolly connection upon electric tramcars and the like.
17,523 JUDD & HARDIE. Telegraph relays.*
17,532 MCCLEAN. Time and destination indicators for tramways, railways, and like systems.

July 25, 1910.

17,597 CROSS. (Franz Krizik, Austria.) Electrically-actuated brakes.*
17,624 DUNOYER. Instruments for measuring the intensity and variations in the intensity of magnetic fields. (Date applied for, 18/8/09.)*†
17,641 KARAVODINE. Secondary batteries or storage cells.
17,650 HELFENSTEIN. Electric furnace with a receptacle for the charge arranged on the enlarged furnace chamber. (Date applied for, 27/7/09.)*†
17,658 VENNER & GRIESBACH. Switches.

July 26, 1910.

17,684 VENNER. Resistances for electric heating apparatus.
17,685 RICHMOND. Galvanic batteries.
17,694 MALSON. Electrical fuses.
17,731 SIEMENS BROS. DYNAMO WORK. (Siemens-Schuckertwerke G.m.b.H., Germany.) Arrangements for controlling the speed of induction electric motors.*
17,782 MYERS. X-Ray screen or shield.*

July 27, 1910.

17,818 HOPE. Fusible cut-outs for controling electric circuits.
17,819 GOLDSTONE & LIGHTFOOT. Electrical cord grips.
17,873 UPTON. Means and appliances for removing and replacing electric light or like bulbs in their sockets
17,874 MUNRO & RAILLESS ELECTRIC TRACTION CO. Electric traction systems.

July 28, 1910.

17,904 SCHOLEFIELD. Electric switches of the quick-make and quick-break type.
17,915 TAYLOR. Operating the switches or points in tramways and the like.
17,917 ALLOTT & CHEERS. Making copies of tracings and the like by means of electric light
17,991 SIMPSON. Generation of electric energy and apparatus therefor.
17,994 SIEMENS BROS. & CO. (Siemens & Halske Akt.-Ges., Germany.) Automatic telephone exchange circuits.*
17,995 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke G.m.b.H., Germany. Control devices for electric cars on routes in which two different voltages are supplied.*

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July 29, 1910.

18,054 KRAMER. Inductive wireless telephone installations.
18,073 ROGERS. System of cutting out or electrically interlocking sockets and plugs in electric circuits.
18,095 BOSCH. Magneto-electric machines. (Date applied for, 15/10/09.)*†
18,098 SEWELL. Device for use in connection with a telephone to facilitate the recording of calls and messages.
18,115 BERRY. Electrical heating apparatus.

July 30, 1910.

18,136 VERITYS & PIPKIN. Electrical heaters or stoves of the radiator kind.
18,151 HAEFELY. Winding apparatus for coils or the like for electrical or other apparatus.*
18,180 BURNEY & BELL. Inter-communication telephone systems.
18,190 & 18,191 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Controllers for electric motors.*
18,195 BROWN, BOVERI & CO. (Akt.-Ges. Brown, Boveri et Cie., Switzerland. Dynamo) electric machinery. *
18,197 LEITNER. Dynamo-electric machines. (Addition to No. 8,219/10.)*

August 2, 1910.

18,217 STEVENSON & WILLIAMS. Disconnecting a fitting, mounted perpendicularly over a supporting column or ledge.
18,236 SUGDEN. Telephone instrument whereby the transmitter may be cut out of the telephonic circuit.
18,241 WARDLE, jun. Lamps or lanterns for incandescent electric lamps.
18,253 KESSLER & KESSLER. Magnetic separators.*
18,295 ANDERSON. Manufacturing spark plugs.*
18,302 BLOXAM. (Société Debauge et Cie., France.) Machine for squirting tubes or wires of lead, or for sheathing cables with lead.
18,306 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Means for controlling dynamo-electric machines.*
18,307 WARBURTON. Combined reciprocating enignes and turbo-electric generator and motors*

August 3, 1910.

18,333 KRAMER. Inductive wireless telephone installations.
18,344 FAIRWEATHER. (Hart Mfg. Co., U.S.) Switches.*
18,359 DICKSON. Switches and signs.

August 4, 1910.

18,443 ADAMS MFG. CO. (Cutler Hammer Mfg. Co., U.S.) Electro-mechanically operated switch.*
18,449 HODGSON. Applying recording apparatus to telephone systems.
18,459 HODGKINSON. Rotary motors. (Date applied for, 1/9/09.)*†
18,470 JOHNSON & BILLINGTON. Electricity meters.

August 5, 1910.

18,528 SIEMENS SCHUCKERTWERKE G.M.B.H. Electrical fuses. (Date applied for, 11/8/09.)*†
18,545 DYMOND. (Gesellschaft für Drahtlose Telegraphie m.b.H., Germany.) Producing but slightly damped electrical oscillations by the shock excitation method.*

August 6, 1910.

18,577 AITKEN & BRITISH INSULATED & HELSBY CABLES. Telephone switchboards.
18,591 A. P. LUNDBERG, G. C. LUNDBERG & P. A. LUNDBERG. Switches.*
18,608 DARWIN & CAMBRIDGE SCIENTIFIC INSTRUMENT CO. Electric controlling apparatus.

August 8, 1910.

18,622 BRAMPTON & THORNEYCROFT. Manufacture of conduit fittings for electrical and like purposes.
18,631 LANCHESTER. Propulsion of vehicles by combination of prime mover and electrical storage.
18,656 RENTON. Flexible cord attachment for electric lamp-holders.
18,658 JUDD, SCHAEFER & HARDIE. Screening of cables.
18,678 VIETTE. System of control and apparatus for indicating electric calls. (Date applied for, 19/10/09.)*†

August 9, 1910.

18,733 WILKINSON & FEARNLEY. Current collectors for electrically-propelled vehicles.
18,738 WEISSMANN. Holder for electric incandescent lamps. (Date applied for, 10/8/09.)*†
18,742 GILLIATT & EXCESS INDICATOR CO. Overload indicators.*
18,786 TOBIAS. Measuring and indicating the ratio of electrical forces and turning moments.*

August 10, 1910.

18,801 WHEELWRIGHT & MOXON. Lampholder attachment for the protection of flexible cable against fire and lamp filaments against vibratory motion.
18,821 GILL. Sheath for electric lamps.
18,837 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke G.m.b.H., Germany.) Stator windings for single-phase electric induction motors.*
18,848 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke G.m.b.H., Germany.) Starting arrangements for single-phase alternating-current series motors.*
18,867 B.T.-H. CO. (A.E.G., Germany.) Devices for securing wires or conductors in place.
18,868 B.T.-H. CO. (G.E. Co., U.S.) Signalling systems.
18,869 PRICE. Switches for working in connection with dynamo, motors, accumulators, and the like.

August 11, 1910.

18,916 MIDGLEY & VANDERVELL. Fittings for use in connection with electric incandescent lamps.*
18,935 BROWN. Electric telegraphy.
18,948 NORTH & WARD. Electric signalling.

August 12, 1910.

18,972 BARRY. Method of and appliances for greater safely in distribution for electric light and power circuits.
18,999 PATTISON. Holders for shades for electric incandescent lamps.
19,030 ARSEM. Filaments and the like for electric incandescent lamps. (Date applied for, 18/8/09.)*†
19,031 B.T.-H. CO. (G.E. Co., U.S.) Signalling systems. (Addition to No. 18,868/10.)
19,033 BEIGE. Incandescent electric lamps or like holders. (Date applied for, 12/8/09.)*†

August 13, 1910.

19,071 DAVIES, KENT & DAVIES, KENT & STEWART. Switches.*
19,075 JOHNSON & BILLINGTON. Recording mechanism of integrating electricity meters and other instruments.
19,077 SIEMENS & HALSKE AKT. GES. Manufacture of metallic filament incandescent lamps. (Date applied for, 9/6/10.)*†
19,093 HARDINGHAM. (Hartmann & Braun Akt.-Ges., Germany.) Electrical measuring instruments.*
19,095 A.E.G. UNION ELEKTRICITATS-GES. Manufacture of tungsten filaments. (Date applied for, 14/8/09.)*†

SPECIFICATIONS PUBLISHED.

1909 SPECIFICATIONS.

9,066 GARDE & ADAMS. Electrodes of secondary batteries.
10,665 ALLGEMEINE ELEKTRICITATS GES. Alternating electric current commutator machines having two working and two exciter windings. (Date applied for, 6/5/08.)
12,452 FISHER. Electric plugs.
14,212 TAYLOR. Charging and discharging electric accumulators or secondary batteries. (Cognate Application, 16,522/09.)
15,681 THOMAS & THOMAS. Switches.
16,621 RENNIE. Electric measuring instrument.
16,645 DALZIEL'S CONSTANT VOLTAGE PATENTS & DALZIEL. Electric distribution systems.
17,031 B.T.-H. CO. & WEDMORE. Protective devices for electrical transmission and distribution systems.
17,043 BOULT. (Deutsche Elektro Sparlicht Ges.) Small electric transformers.
17,215 EISENSTEIN. Mast or post for wireless telegraphy or other purposes.
17,230 WARDLE ENGINEERING CO. & WARDLE. Electric incandescent lamp fittings and the like.
17,274 SCHULTZ. Switches.
17,490 STEINERT & STEIN. Electromagnetic separator with rotating magnet drum. (Date applied for, 27/7/08.)
17,520 HOLMES. Induction motors.
17,739 TAYLOR & SCOTSON. Regulation of dynamo-electric machines.
17,774 BROWN, JUDD & HARDIE. Electric telegraphy.
17,888 WEBBER, WEBBER & WEBBER. Electric driving mechanism for clockwork.
17,895 JUKES-BROWNE. Switches. (Cognate application, 1276/10.)
17,904 SIEMENS BROS. & CO. & BRADLEY. Twin projectors or searchlights.
17,998 KENNY. Safe indicator and control for electric lifts.
17,999 KENNY. Metal moulding for encasing electric wires.
18,036 JEVONS & GREEN. Circuit-breakers for electric welders.
18,118 SAUVAGEON. Electric furnaces.
18,221 FIELD & FERRANTI LIMITED. Contacts for electric switches.
18,310 CLEMENTS. Electric advertising signs.
18,405 HOPE-JONES. Electric time-indicators.
18,420 HUTCHINSON. Magnetic separators.
18,436 COLIN & JEANCE. Wireless telephony. (Date applied for, 17/4/09.)
18,469 LEWIS. Electrodes for arc lamps.
18,471 TUCKER. Switches.
18,499 PINK. Electric traction systems.
18,524 MARCONI & MARCONI'S WIRELESS TELEGRAPH CO. Transmitting apparatus for wireless telegraphy.
18,590 MARINO. Preserving or protecting the lead supports of the positive electrodes of secondary or storage batteries from per-oxidation.
18,687 RORKE & RORKE. Switch for controlling electrical circuits.
18,691 HAMILTON & FERRANTI, Ltd. Counting trains for electricity or other meters.
18,922 MARCONI & MARCONI'S WIRELESS TELEGRAPH CO. Receiving apparatus for wireless telegraphy.
20,229 MARCONI & MARCONI'S WIRELESS TELEGRAPH CO. Transmitting apparatus for wireless telegraphy.
21,185 BERRY & MARKHAM. Switches and switch fuses.
21,249 KOHLER. Alternating current motor controllers.
23,225 B.T.-H. CO. (G.E. Co., U.S.) Insulating compounds and processes of making the same.

COMPANIES' MEETINGS AND REPORTS.

BRITISH THOMSON-HOUSTON CO. (LTD.)—Mr. J. F. Nauheim, who presided at the meeting on Wednesday, said the accounts showed a distinct improvement on those of last year, but did not, in the opinion of the directors, warrant the payment of a dividend. The company had to meet severe competition, both at home and abroad, and it was only by the strictest economy that they were able to cope with the difficulties of the position. The factory had been enlarged, and he hoped the shareholders would reap the benefit of that next year. The company now owed the General Electric Co. (of New York) £174,000, against £161,000, which was the corresponding figure in the previous year's balance-sheet, while sundry creditors had decreased from £122,000 to £120,000. Apparatus, meters, supplies, &c., stood in the books at £298,000, having increased from £255,000 the year previous, as a result of increased trade. Sundry debtors had decreased from £244,000 to £234,000.

DICK, KERR & CO. (LTD.)—At the ordinary general meeting yesterday (Thursday) the Chairman, Mr. John Kerr, said, in moving the adoption of the directors' report (abstracted in our last issue), he wished, before proceeding with the business, to make a brief reference to the great loss the company had sustained in the tragic death of Mr. George Flett, their managing director. Mr. Flett was associated with the company for nearly 30 years, and ever since the formation of the company as a limited liability company he had acted as a managing director. His early demise, in the fullest business vigour, left the Board with nothing but one great regret. Mr. Rutherford who had for a number of years acted so ably as assistant managing director, had been appointed managing director. Regarding the past year he was sorry to say the views he expressed at the last meeting, and he might also include the year before, as to the extreme competition in the electrical trade had proved only too true. With a demand none too brisk prices were likely to rule low, but in many cases figures were quoted by some firms below the cost of production. In times of depression all industrial concerns had to face restricted profits, but there was a point where discretion should cry a halt. Foreign competition also helped to aggravate matters. After three years of dull times, a period seemed at hand when there would in many directions be a great expansion of electrification in this country and abroad. The year now being dealt with must be equally a disappointment to the shareholders and the directors, but the directors, without holding too optimistic views, were of opinion that the work at present on hand and in prospect, made the outlook distinctly encouraging. In matters of depreciation and other provisions everything had been dealt with in the most careful and conservative manner, as in the past, the policy of keeping in reserve a goodly sum in times of prosperity had been fully warranted. The directors felt justified in trenching on the carry forward on this occasion, but it was their earnest hope that it would be the last. The financial position was one of comfort. They had in bills £22,565. 16s., cash £69,949. 18s. 10d., and investments £139,227. 18s. 8d., or together £231,743. 13s. 6d. Regarding the investments, at the price at which they stood in the books the return was a little over 6 per cent. per annum. After due consideration, the Board decided to take up the manufacture of steam turbines, and arrangements had been concluded to make turbines under the Bergmann patents. It was hoped that that departure would be the means of increasing their business in large alternators, for which they had a good reputation. The works had been maintained in a high state of efficiency and everything was being done to cheapen the cost of production while maintaining the highest standard of workmanship. It would be to the ultimate advantage of financiers as well as the advantage of their industrial concerns if they could use their

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influence to see that as far as possible the money provided by the British investor was expended as regards material in providing employment for their own people. German and French financial methods were an object lesson in that respect. He concluded by expressing the directors' thanks to the staff for their zeal in promoting the interests of the company.

In reply to a shareholder, who asked why there had been this sudden outburst of competition during the past two or three years and remarked that, apart from the Board of Trade returns, he did not think individual companies had found the last two or three years particularly favourable, the chairman said there was not work to go all round. Some very large works were put down with the idea that there would be a very large quantity of work at once, but that had not been realised. He thought it was only Mr. Lloyd George who had seen the great boom in trade. None of them (the manufacturers) seemed to have realised it.

The report and accounts were adopted.

DIRECT WEST INDIA CABLE CO. (LTD.)—At the meeting last week Mr. T. Skinner presided and moved the adoption of the directors' report for the year ended June 30. The net result of the year's working was an available balance of £4,530. 15s. 3d., compared with £5,189. 11s. 1d. for the previous year. An interim dividend of 3 per cent. (tax free) had already been paid, and it was proposed to make a further equal payment (tax free), leaving £2,730. 15s. 3d. to be carried forward. The balance to credit of revenue was last year £33,965. 3s. 7d., and this had been debited with £900 applied to dividend and with £4,069. 18s. 5d. expended in renewals and repairs during the year, and credited with £2,730. 15s. 3d. surplus revenue of the past year, bringing the amount to £31,726. 0s. 5d. In November last the Turk's Island–Jamaica section of cable was damaged by floods in Bull Bay, Jamaica, the repair of which involved the large expenditure above recorded. During the year debentures have been paid off to the amount of £7,500, leaving £36,000 outstanding. The report and accounts were adopted.

DUNDEE, BROUGHTY FERRY & DISTRICT TRAMWAY CO. (LTD.)—At the meeting on Tuesday the chairman (ex-provost Brownlee) said that notwithstanding a falling off in receipts of £117, almost wholly attributable to the weather in the last week of the financial year, there was a saving in working expenses of £422, which enabled them to record a dividend of 2 per cent. to be paid on the ordinary shares. They had a very steady business with drawings that could always be depended on, and they expected to be able to keep down the expenses to the level of last year. The line was being kept up out of revenue in good repair.

HALIFAX & BERMUDAS CABLE CO. (LTD.)—Mr. T. Skinner, who presided at the meeting last week, said that the net result of the year's working to June 30, was an available balance of £5,737. 11s. compared with £3,312. 13s. for the previous year. An interim dividend of 2½ per cent. (tax free) had already been paid, and it was proposed to make a further equal payment (tax free), leaving £3,237. 11s. to be carried forward. The balance to credit of revenue account, which was last year £18,439. 5s. 2d., had been debited with £1,250 applied to dividend, and credited with £3,237. 11s. surplus revenue of the past year, and now stands at £20,426. 16s. 2d. The company's cable has worked efficiently. During the year £10,000 debentures have been paid off and the debenture debt is now extinguished.

HOBART ELECTRIC TRAMWAY CO. (LTD.)—The directors' report states that the traffic and general receipts show a substantial increase as compared with any previous year. Owing principally to the fact that a less sum was required to be expended on repairs, maintenance of permanent way, &c., the total working expenses show a reduction, and the net profit (after providing for interest, &c.) was £8,281. A dividend on the shares at the rate of 5 per cent. per annum (or 1s. per share), tax free, leaves £1,997 to be carried forward.

WESTERN UNION TELEGRAPH CO.—The report of the Western Union Telegraph Co. for the quarter ending Sept. 30 states that as a balance-sheet showing the financial condition of the company as at June 30, 1910 (at which date the fiscal year closed) is in preparation the usual quarterly statement is omitted pending submission of the balance-sheet. The net revenues of the quarter ending Sept. 30 inst., based upon nearly completed returns for July, partial returns for August, and estimating the business for September, will be about $2,000,000. Interest on bonded debt requires $433,062.50, and a dividend of ¾ per cent. about $747,770, leaving a surplus for the quarter of $819,167.50. These figures (as usual) do not allow for depreciation or reconstruction beyond current expenditures. The amount necessary to provide for depreciation and reconstruction has not yet been determined.

WILLANS & ROBINSON (LTD.)—The directors' report for the half-year to June 30 states that, after writing off £4,422. 1s. 4d. as depreciation, paying £4,216. 18s. 1d. debenture interest and £593. 6s. 5d. cost of upkeep of Queen's Ferry Works, the result of the half-year's trading shows a loss of £8,001. 14s. 3d. Added to £7,267. 2s. 6d. brought forward, this brings up the total debit standing against profit and loss to £15,268. 16s. 9d. Debentures representing £6,104 have been redeemed during the half-year out of the fund set aside for that purpose, and having been purchased at a discount the profit of the transaction has been transferred to reserve. The unsatisfactory result for the half-year is due to low prices prevailing and scarcity of orders obtainable during the whole of the year 1909. There has, however, been a steady improvement in the volume of orders booked during the present year, but although the amount of work in hand is now fairly satisfactory and orders are continuing to come in at an increasing rate, yet the prices obtainable are on even a lower scale than for the year 1909, and until there is a material improvement in this respect it will not be possible to show a profit. Every effort is being made to reduce costs so as to leave a margin on selling prices.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

ALLMANNA SVENSKA ELECTRIC CO. (LTD.) (111,849.)—Reg. Sept. 23, capital £5,000 in £1 shares, to carry on the business of manufacturers of and dealers in electric, mechanical and other machines, appliances and apparatus, &c. Private company. First directors, J. S. Edstrom, J. L. Fuller, K. Hedin and S. H. Busch.

CARLTON ENGINEERING CO. (LTD.) (111,787.)—Reg. Sept. 19 capital £6,000 in £1 shares, to carry on the business of mechanical, electrical and general engineers, electricians, machinists, boiler makers, &c., and to adopt an agreement with A. A. Rupprecht & Co. Private company. First directors, A. A. Rupprecht, E. L. Grant and H. S. Sutherland. Reg. office, Carlton House, Regent-street, London, S.W.

COLONIAL AND FOREIGN TRADERS) (LTD.) (111,932.)—Reg. Sept. 22, capital £1,100 in £1 shares (100 founders') to carry on mercantile, transport, trading and financial business, and to acquire and turn to account any electric, hydraulic or other motor power, water and other rights, &c. Private company. First directors, F. M. B. Carter and H. M. King. Reg. office, 32, Great St. Helens, London, E.C.

WHIPPLE & CO. (LTD.) (111,883.)—Reg. Sept. 24, capital £2,500 in £1 shares, to take over the business of manufacturing electricians, electrical engineers and contractors carried on as "Whipple & Co." Private company. C. R. Whipple is first managing director. Reg. office, 9, Cook-street, Liverpool.

STATUTORY RETURN.

CONSOLIDATED ELECTRIC WORKS & APPLIANCES (LTD.)—In return dated March 10, 1910 capital is given as £5,000 in £1 shares. 3,002 shares taken up. £1 per share called up on 2. £2 paid. £3,000 considered as paid on 3,000 shares. Mortgages and charges, £3,840.

MORTGAGES AND CHARGES.

KIRLEW BROS. (LTD.)—Particulars of £1,500 debentures, created by resolutions of June 6, 1902, April 6, 1903 and May 3, 1907, have been filed, amount of present issue being £500. Property charged: Company's property, present and future, including uncalled capital. No trustees.

THOMAS L. SCOTT & CO. (LTD.)—Issue on Sept. 7 of £400 debentures, part of a series of which particulars have already been filed.

"Z" ELECTRIC LAMP MFG. CO. (LTD.)—Issue on Sept. 9 of £3,300 debentures, part of a series of which particulars have already been filed.

CITY NOTES.

MEMORANDA (Sept. 29).—Bank rate 4 per cent. (Sept. 29, 1910) Price of silver, 24⅛d. per oz. Consols 80—80⅛ for money and for account. Consols Pay Day, Oct. 5; Stock and Shares Continuation Days, Oct. 12 and 26; Ticket Days, Oct. 13 and 27; Pay Days, Oct. 14 and 28; Mining Shares Carry Over Days, Oct. 11 and 25.

PRICES OF METALS (London).—*Copper*, cash, 55½; three months, 55⅝. *Lead*, English, 13—13¼; foreign, 12¾—12⅞. *Spelter*, 23½—23¾. *Tin*, English, 157½—158½; foreign cash, 159; three months, 158½. *Iron*, Cleveland, cash, 48/10, three months, 49/8.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—The directors have declared an interim dividend of 3s. 6d. per share (less tax), being at rate of 7 per cent., on the ordinary shares for the half-year ended June 30.

BABCOCK & WILCOX (LTD.)—The directors announce an interim dividend of 10 per cent., compared with 8 per cent. a year ago.

BRISBANE ELECTRIC TRAMWAYS INVESTMENT CO (LTD)—The directors have decided to pay an interim dividend of 4s. per share (at rate of 8 per cent. per annum) on the ordinary shares, compared with 2s. 6d. per share last year.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the four weeks ended July 29 were 794,120, compared with 728,069 units in the corresponding four weeks of 1909. The figures for the four weeks ended Aug. 26 were 824,917 in 1910, compared with 735,625.

CITY OF SANTOS IMPROVEMENTS CO. (LTD.)—An interim dividend of 2½ per cent. on the ordinary shares has been declared, tax free.

EASTERN TELEGRAPH CO. (LTD.)—This company announce payment on 15th prox., of a dividend at the rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending Sept. 30, and the second quarterly interim dividend of 1¼ per cent. on the Ordinary stock (tax free) in respect of profits for the year ending Dec. 31, 1910. The transfer books of the ordinary stock will be closed from Oct. 7 to 14 inclusive.

REUTER'S TELEGRAM CO. (LTD.)—The directors have declared an interim dividend of 4s. per share (at the rate of 5 per cent.), tax free, for the half-year ended June 30.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted quotations to a further issue of £200,000 4½ per cent. perpetual consolidated debenture stock of the *Winnipeg Electric Railway Co* and £250,000 5 per cent. first mortgage debentures (in lieu of the scrip) of *Vera Cruz Electric Light, Power & Traction (Ltd.)*. The committee have been asked to appoint a special settling day in and grant a quotation to £256,800 5 per cent. 30-year first mortgage gold bonds of the *Calgary Power Co. (Ltd.)*

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 21	1,475	+ 128	16	24,953	− 51
Airdrie	„ 16	239	+ 17	37	8,089	+ 60
Anglo-Argentine	„ 23	46,272	+ 6,047	38	1,679 392	+ 196,849
Ayr Corporation	„ 24	284	− 1	19	8,135	+ 304
Barnsley	„ 16	163	− 4	37	6,402	+ 161
Barrow	„ 16	281	+ 8	37	10,133	+ 1,456
Bath Electric Trams, Ltd...	„ 21	926	+ 59	38	31,649	+ 1,720
Birmingham Corporation ..	„ 24	6,746	+ 63	25	169,965	+ 2,338
Birmingham & Midland....	„ 16	907	+ 53	37	31,675	+ 553
Blackburn Corporation	„ 21	1,042	− 137	‡26	28,266	− 1,133
Blackpool and Fleetwood ..	„ 24	1,015	+ 139	..	..	..
Bolton Corporation.....	„ 25	2,299	− 123	26	61,562	− 23
Bombay	Aug. 26	2,699	+ 209	34	91,520	+ 6,381
Bournemouth Corporation.	Sept. 21	1,965	+ 65	25	50,798	+ 4,419
Bradford Corporation.....	„ 17	5,001	+ 112	25	126,511	+ 4,146
Brighton Corporation.....	„ 25	1,075	+ 23	§25	27,828	+ 72
Bristol Trams & Carriage ..	„ 23	6,237	+ 376	12	77,862	+ 4,834
Burnley Corporation	„ 24	1,180	− 108	12	15,532	− 96
Burton Corporation	„ 25	251	− 8	25	6,939	− 14
Bury Corporation	„ 24	1,228	+ 1	§25	30,601	− 413
Calcutta Tramways Co....	„ 24	₹54,860	+ ₹6,840	12	₹645,212	+ ₹48 859
Camborne-Redruth	„ 24	125	..	38	4,680	− 115
Cardiff Corporation.....	„ 17	2,302	− 4	25	56,691	+ 406
Cavehill.....	„ 16	105	− 2	37	3,508	+ 167
Central London Railway .	„ 24	5,688	+ 433	12	63,293	+ 3,832
Chatham & Dist. Lt. Rys. .	„ 22	970	+ 68	38	32,544	+ 1,115
City & South London Rly..	„ 25	3,173	− 43	12	36,981	+ 193
City of Birmingham	„ 16	2,912	+ 89	37	105,694	+ 2,505
Colchester Corporation ...	..	..	..	..	..	..
Cork Electric Trams Co....	„ 22	502	− 49	38	18,747	+ 1,700
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams .	„ 16	511	+ 119	37	15,868	+ 2,193
Dover Corporation	„ 24	236	+ 11	25	6,131	+ 165
Dublin & Lucan Railway .	„ 23	169	+ 6	12	2,137	+ 121
Dublin United	„ 23	5,454	− 109	12	73,561	+ 1,393
Dudley-Stourbridge	„ 16	884	+ 38	37	22,768	− 650
Dundee Corporation	„ 21	1,215	+ 3	§18	22,767	+ 351
East Ham Council	„ 24	1,116	+ 110	¶25	26,754	+ 812
Exeter Corporation.....	„ 23	330	− 24	25	8,561	− 710
Gateshead & Dist. Trams .	„ 16	1,002	+ 26	37	36,545	− 131
Glasgow Corporation	„ 24	18,429	+ 1,138	17	295,367	+ 15,833
Glossop Trams.....	„ 24	119	− 19	38	4,463	− 291
Gloucester Corpn.....	„ 21	289	− 6	..	..	..
Gravesend-Northfleet.....	„ 16	216	− 20	37	7,766	− 69
Great Northern & City Rly.	„ 24	1,352	+ 54	12	15,635	+ 551
Greenock & Port Glasgow .	„ 16	700	+ 14	37	23,627	+ 3,016
Hartlepool Tramways	„ 16	270	+ 12	37	9,396	+ 621
Hastings Elec. Trams Co. ..	„ 22	1,259	− 42	12	17,035	− 4
Hong Kong	„ 24	$8,515	+ $307	12	$105,057	+ $5 067
Huddersfield Corpn.	„ 24	1,677	− 49	25	44,818	+ 2,107
Hull Corporation.....	„ 24	2,618	+ 45	25	68,328	+ 3,460
Ilford District Council.....	„ 24	549	+ 56	25	13,734	+ 831
Ilkeston District Council ..	„ 21	144	+ 2	25	3,297	− 185
Ipswich Corporation	„ 24	461	+ 23	25	11,690	+ 612
Isle of Thanet Co.	„ 24	921	+ 152	¶51	33,903	+ 2,343
Jarrow	„ 16	116	− 2	37	4,643	+ 254
Keighley Corporation.....	..	..	..	..	..	..
Kidderminster & District ..	„ 16	120	+ 9	37	4,240	+ 124
Kilmarnock Corporation ..	„ 24	143	+ 4	19	3,001	+ 87
Lanarkshire Trams Co.	„ 22	1,522	+ 58	38	53 004	+ 3,863
Lancashire United	„ 21	1,357	− 62	38	50,127	− 553
*Leamington	„ 16	213	− 29	37	6,313	− 297
Leeds Corporation	„ 24	6,963	+ 83	25	181,051	+ 5,537
Leicester Corporation.....	„ 24	2,375	+ 132	..	..	..
Leith Corporation	„ 24	617	..	19	12,296	+ 46
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	„ 17	11,182	+ 423	37	413.157	+ 14,981
Liverpool Overhead Rly. ..	„ 25	1,393	+ 4	13	19,131	+ 162
Llandudno&ColwynBayRy.	„ 23	429	+ 87	§42	13,127	+ 336
*London County Council	„ 14	41,727	+ 4,033	§24	1,004,737	+ 130,537
London Elec. Ry. Co.....	„ 24	12,270	+ 185	12	138,350	+ 810
London United	„ 24	6,854	+ 290	39	245,542	+ 9,920
Lowestoft	..	..	..	..	..	..
Maidstone Corporation	..	..	..	..	..	..
Manchester Corporation....	„ 24	14,996	− 412	25	392,563	+ 6,647
Mersey Railway	„ 24	2,010	+ 9	12	23,421	+ 327
Merthyr	„ 16	235	+ 26	37	7,737	− 209
Metropolitan Dist. Railway..	„ 24	10,480	+ 651	12	120.748	+ 7,542
Metropolitan Elec. Trams ..	„ 16	8,060	+ 1,234	37	277,564	+ 47,672
Middleton	„ 16	343	+ 3	37	11.892	− 730
Nelson Corporation.....	„ 24	151	− 7	§25	3,799	+ 136
Newcastle-on-Tyne Corp. ..	„ 24	3,825	− 74	¶25	100,546	+ 1,042
Newport (Mon.)	„ 24	674	+ 7	26	18,095	+ 728
Northampton Corporation..	„ 24	498	− 51	§25	12,815	− 21
Oldham, Ashton & Hyde ..	„ 16	577	+ 14	37	20,630	− 117
Oldham Corporation	„ 25	1,798	− 60	26	48,989	− 975
Perth (N.B.) Corporation ..	„ 21	181	+ 15	§18	3,387	+ 251
Perth (W.A.) Elec. Trams ..	„ 23	1,261	− 147	38	47,063	− 6,066
Peterborough	„ 16	116	− 3	37	4,326	− 73
Portsmouth Corporation ..	„ 24	2,171	+ 39	25	57,210	− 1,473
Potteries	„ 16	1,915	− 34	37	64,755	− 812
Preston Corporation	„ 21	722	− 16	25	18,672	− 312
Rotherham Corporation....	„ 22	628	+ 41	25	15,742	+ 722
Rothesay	„ 19	327	− 5	37	9,057	+ 53
Salford Corporation	„ 25	4,636	+ 40	‡26	120,874	+ 1,795
Sheerness	„ 16	59	..	37	1,923	− 8
Sheffield Corporation	„ 25	5,963	+ 319	¶26	157,120	+ 9,222
Singapore Trams.....	„ 24	$9,935	+ $1,096	12	$109,864	+ $9,062
South Metropolitan.....	„ 16	887	+ 5	37	30,953	+ 1,140
South Staffs.....	„ 16	904	+ 70	37	31,192	+ 196
Southend Corporation	..	..	..	..	..	..
Southport Tramways	„ 16	341	+ 20	37	11,259	+ 187
Stalyb'dge,Hyde,&c., Jt.Bd.	„ 24	697	− 87	¶25	18,685	− 1,431
Sunderland Corporation....	„ 25	1,048	+ 20	26	30,345	− 88
Sunderland District	„ 21	430	− 19	47	20,260	− 1,385
Swansea Trams	„ 16	1,125	+ 123	37	40,386	+ 4,574
Swindon Corporation	„ 21	155	− 14	25	3,641	+ 140
Taunton	„ 16	45	− 4	37	1,590	+ 76
Tynemouth and District....	„ 16	307	+ 36	37	10,190	+ 519
Tyneside Trams Co.	„ 21	404	− 17	12	5,869	+ 332
Wallasey District Council ..	„ 24	940	+ 4	¶25	25,117	+ 235
Walsall Corporation	„ 24	534	+ 15	38	20,370	+ 871
Warrington Corporation....	„ 22	374	+ 10	25	9,824	+ 240
West Ham Corporation	„ 15	2,490	+ 132	24	60,101	+ 2,527
Weston-super-Mare	„ 16	263	+ 41	37	6,364	− 18
Wolverhampton Co.	„ 16	424	− 40	37	15,812	+ 290
Wolverhampton Corpn.	„ 21	895	+ 15	..	..	..
*Worcester	„ 16	315	+ 18	37	10.654	+ 205
Wrexham	„ 16	112	− 2	37	3,621	− 45
Yorkshire W.R. Trams	„ 25	1,308	− 54	39	48,619	..
Yorkshire Woollen District.	„ 16	1,015	− 4	37	36.561	+ 2,824

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	NAME.	Price Wed., Sept. 28	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 28. High-est.	Business Week to Sept. 28. Low-est.
		Electricity Supply.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	8¾—9¼	5 16 0	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9 —9⅛	4 12 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 13 0	Feb, Aug	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	102	..
5	4/6	Brompton & Kensington Elec. Sup. Ord. ..	6⅞—7⅛	6 9 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.....	6⅞—7⅛	4 15 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅜—3⅝	6 5 6	Feb, Aug	3⅛	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 14 0	Feb., Aug	4⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 0	..	102½	102
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3½—4½	5 9 6	Jan, July	..	..
5	2/0	†Chelsea Electric Supply Ord.....	3⅜—4	5 12 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	City of London Electric Lighting Ord.	11⅛—11⅜	6 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11½—12½	4 18 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 —124	4 0 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99½—102½	4 7 6	Jan, July	..	..
5	..	County of Durham Elec. P. D. Ord.....	1½—2	..	April, Oct	..	..
5	5%	†Do. 5 per Cent. non Cum. Pref.	2⅜—3½	8 0 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7⅜—7⅞	6 7 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅞—11½	5 6 6	Mar, Sept	11⅛	..
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104½—107½	4 3 6	Jan, July	101½	..
5	4½%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	..	..
5	2/0	†Folkestone Electricity Supply Co. Ord.	4¼—4⅝	5 19 0	April, Oct	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	4⅞—5⅛	4 13 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	99 —102	4 8 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.....	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.....	6⅞—7⅛	5 6 9	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5⅛—6⅛	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	97 —100	4 0 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1⅜—2	4 10 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	4⅞—5⅛	5 18 0	Mar, Sept	4⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	91	..
5	2/0	Metropolitan Electric Sup. Ord.	3½—3⅝	6 13 3	April, Oct	3⅞	..
St.	2/3	Do. 4½ per Cent. Cum. Pref.....	4⅛—4⅜	4 17 0	Jan, July	4¼	4¼
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	96 —98	4 12 0	June, Dec	..	..
1	1/6	Newcastle Elec. Supply Ord.....	3⅞—4⅛	4 11 0	Feb, Aug	4¼	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4½	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	100 —102	4 8 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	..	..
5	3/0	†Oxford Electric Ord.	6¼—6½	5 4 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7¼—8¼	6 2 3	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.....	6¾—7¼	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1⅛—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2⅜—3	6 4 6	April	..	..
St.	5%	Do 5 % 1st Mort. Stock (red.).....	99 —102	4 19 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅞—1	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	⅞—1 ⅛	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red.).....	98 —101	4 9 0	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	½—1	..	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 —2½	..	April, Oct	..	..
S .	4½%	Do. 4½ per Cent. 1st Mort. Deb.	79 —81	5 11 0	April, Oc	80½	80
5	5/0	Westminster Elec. Sup. Ord.....	8 —8½	5 17 9	Mar, Sep	8⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5⅛	4 2 0	Jan, July	5⅛	..
		Electric Railways and Tramways.					
..	..	Bath Elec. Trams Pref. Ord.....	⅛—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—½	6 13 6	Jan, July	..	..
1	4½%	Do. 4½ 1st Mort. Deb. Stock (red.)½.....	82 —86	5 5 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	79 —82	5 18 10	Jan, July	80¾	..
St.	6%	Bristol Tramways & Carriage Ord.	5½—6½	9 4 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7⅛—7⅝	5 8 6	..	..	..
10	4%	Do. 4 per Cent. Debs.	100 —101	3 19 0	Feb, Aug	⅜	..
St.	..	British Electric Traction Ord.	⅞—1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅞—3	..	Feb, Aug	2⅝	2⅛
10	5%	Do. 5 per Cent. Perpetual Debs.....	89 —93	5 6 6	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	70 —75	6 0 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock	63 —65	4 12 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Pref. Stock	84 —86	4 14 6	Feb, Aug	..	..
St.	2%	Do. Deferred Stock	45 —47	4 5 0	Feb.	..	..
St.	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	..	..
100	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4½—5⅛	4 15 0	April, Oct	..	..
5	4%	Do 4 per Cent. 1st Mort. Debs.	98 —102	3 18 0	April, Oct	..	..
100	11%	City & South London Rly. Con. Ord. ..	27½—28½	5 3 0	Feb, Aug	27⅞	27½
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —105	4 15 6	Feb, Aug	104⅝	..
St.	5%	Do. (1901)	99 —102	4 18 0	Feb, Aug	..	..
St.	5%	Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.....	99 —101	3 19 0	May, Nov	..	..
St.	6/0	Dublin United Trams. 6 per Cent. Pref....	12½—13½	4 9 0	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾—1	..	Feb, Aug	..	..
10	..	Hastings & District Elec. Trams, 6% C. P.	¾ —1¼	..	Mar. Sept	..	..
5	4½%	Do. 4½ Deb. Stock	72 —77	5 1 6	April, Oct	..	..
St.	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3½—4	7 10 0	Mar, Sept	..	..
10	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
St.	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1⅛—1⅜	3 12 9	Mar, Sept.	..	..
5	4%	Do. 4 per Cent. Deb. Stock	70 —75	5 16 0	Jan, July	..	..
St.	5/6	Lanarkshire Tramways	9⅞—10⅛	4 19 0	Feb, Aug	..	..
10	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —85	5 16 0	Jan. July	..	..
St.	..	London Electric 4% Deb. St.	94½—96½	..	..	95½	95
St.	..	Do. 4% Pref.	84 —86	..	..	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2½	..	jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	67 —71	5 12 6	Jan, July	68½	..
St.	..	Mersey Con. Ord. Stock	2⅝—3⅛	..	Feb, Aug	⅛	..
1	1/0	Metropolitan Elec. Tramways Ord.....	⅝—⅞	..	..	..	..
1	..	Do. Deferred	⅝—⅞	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅛—⅛	5 6 8	Feb, Aug	27	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	96 —99	4 11 0	Jan, July	93	..
St.	..	Do. 5 per Cent. Db. Stk	97 —99	5 1 0	..	98½	98
St.	1½%	Metropolitan Railway Consolidated.....	37½—38½	2 19 0	Feb, Aug	38½	37½
St.	2½%	Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	66½	65½
St.	3½%	Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	88	87½
St.	3½%	Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	85¼	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	85	84½
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	92½	91½

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name	Price Wed. Sept. 28.	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 28. Highest.	Lowest.
		Electric Railways and Tramways— *Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	90 —92	3 15 6	Jan, July	..	..
St.	..	Metropolitan District Railway Ord.....	21⅛—21¼	..	Feb, Aug	21⅛	21¼
St.	3%	Do. 4½% First Pref.....	79 —81	3 14 0	Feb, Aug	80½	79½
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	72 —74	4 14 6	Feb, Aug	73	72½
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	4 0 0	Jan, July	..	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	140 —142	4 4 6	Jan, July	..	..
St.	4%	Do. 4 per Cent. Ditto.....	95 —97	4 2 6	Jan, July	..	..
1	4½d.	Potteries Electric Traction Ord.	¼—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	7/16—½	7 4 0	Feb, Aug	⅜	..
St.	4½%	Do. 4½ per Cent, Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	¼—¼	..	..	⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoupt	38 —40	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds.....	103 —104	4 16 0	..	..	..
..	4½%	Do. 4½% Bonds with coup. 6	92 —94	4 15 9	..	93⅛	92½
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	98 —100	4 0 0	..	99½	99½
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	¼—¼	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1⅛—2⅛	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
St.	4½%	Anchor Cable Co. 4½ % Deb. Stock	101 —103	4 7 6	..	102½	..
1	..	Aron Electricity Meter Ord.....	7/16—½	..	..	..	..
1	1/9	Do. 6% Cum. Pf.	5/16—⅜	6 16 0	April, Oct	..	..
1	3/2	Babcock & Wilcox Ord.....	5⅛—5½	4 5 6	April, Oct	5⅛	5⅛
1	0/7½	Do Pref.....	1⅛—1⅜	3 17 0	..	..	..
5	4/0	†British Insulated & Helsby Cables Ord...	6⅞—7⅛	6 18 0	July, Feb	6½	..
5	3/0	Do. 6 per Cent. Pref.....	6 —6½	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	101 —104	4 6 6	Jan, July	103½	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	98 —101	4 12 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref.....	7/16—⅛	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	101 —103	5 17 0	..	102½	102
St.	4%	Do. 4 per Cent. Mort. Deb. Stock.....	61 —63	3 3 6	Jan, July	..	..
St.	4½%	BrushE. Eng. Co. 4½% Perp. 1st Deb. Stock	37 —42	10 14 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	22 —26	17 6 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9⅛—9½	7 12 6	Jan, July	9⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.....	4⅛—5⅛	4 15 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)..	103 —105	4 5 9	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.....	3⅛—3⅜	4 7 1	May, Nov	3⅜	3⅜
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	105 —108	4 5 6	Feb, Aug	105½	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	5 19 0	March ..	..	..
1	0/8½	Consolidated Electrical Co.....	5/16—⅜	5 18 9	August ..	..	..
1	0/6	Consolidated Signal Co.....	⅛—¼	5 12 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.....	⅝—¾	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	¼—⅜	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.)..	83 —86	5 16 0	Jan, July	..	..
1	0/7½	Davis & Timmins	⅛—¼	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	⅛—1	6 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	½—1⅛	6 0 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	7/16—½	..	Feb, Aug	..	..
..	..	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St	5%	Do. 5 per Cent. 2nd Deb. Stock.....	79 —82	6 2 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	7/16—⅜	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛—2	..	May, Nov	..	..
St.	4½%	Do 4½ per Cent. 1st Mort. Deb. (red.)..	75 —78	5 15 6	Jan, July	76	75½
2	..	Electric Construction Co.....	⅛—¼	..	Jan, July	⅛	..
2	2/9	Do. 7 per Cent. Cum. Pref.....	1⅛—1¼	4 13 6	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	59 —61	6 5 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7⅛—8	6 5 0	June, Dec	..	..
St.	4%	Do 4 per Cent. 1st Mort. Debs.....	82 —86	4 13 0	Mar, Sept	..	..
5	5/0	Henley's Telegraph Works Ord.....	12⅛—13	5 15 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.....	5 —5⅛	4 5 9	Feb, Aug	5⅛	5⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107 —109	4 2 6	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works....	14⅛—15⅛	6 18 0	Feb, Aug	14⅛	14⅛
10	5/0	Do 5 per Cent. Cum. Pref.	10⅛—11	4 14 0	..	..	..
100	4%	†Do. 4 per Cent. Debs. (red.)	98 —100	4 0 0	April, Oct	99	..
1	..	National Elec. Construction Co.....	⅛—¼	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—¼	..	Nov	..	..
1	..	Do. 6 per Cent. Cum. Pref.....	7/16—½	..	May, Nov	⅜	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5⅛	..	..	..	..
12	12/0	Telegraph Construction & Maintenance..	35½—37½	5 12 0	Mar, July	36 7/16	36
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2 —2⅛	4 11 0	..	2⅛	2
1	0/6	Do 5 per Cent. non-Cum. Preference..	1⅛—1⅜	4 1 0	..	1⅜	..
St	5%	Do. 5 per Cent. non-Cum. Preferred ..	107 —110	4 12 0	..	107⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	104	103½
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	104½	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	105 —107	4 13 6	..	106	105½
10	10%	J. G. White & Co. 6% Cum. Pref.	12½—13½	7 8 0	..	..	..
1	..	Willans & Robinson Ord.....	⅛—¼	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1⅛—1½	10 13 6	Apr, Oct	1½	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3⅛—4⅛	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan, July	95	..
St.	19/0	Am. In-American	67 —69	5 8 9	F, My, Ag, N	67½	..
St.	30/0	Do. Preferred	109 —111	5 8 0	F, My, Ag, N	110½	109
St.	20/0	Do. Deferred	26½—27	4 12 6	F, My, Ag, N	27⅛	26½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk..	85½—87½	4 11 6	Jn, Ap, Jy, O	86½	86½
10	6/0	Cuba Submarine Ord.	8⅛—9⅛	6 6 0	Feb, Aug	9⅛	..
10	10/0	Do. Preference 10 per Cent.	16⅛—17⅛	5 13 9	Feb, Aug	17⅛	..
5	2/0	Direct Spanish Ord.	3⅛—3½	5 3 0	April, Oct	3½	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	8⅛—9⅛	5 10 9	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	101 —103	4 17 6	Jan, July	..	..
20	6/0	Direct United States Cable.....	16⅛—17	5 6 0	Ja, Ap, Jy, O	16⅛	16⅛
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.).	101 —102	4 8 0	June, Dec	..	..
St.	2/0	Eastern Ordinary	133 —136	5 4 6	Ja, My, Jy, O	135	133½
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	84 —86	4 1 6	Ja, My, Jy, O	85½	85
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	102½—104½	3 17 9	May, Nov	102⅛	..
St.	2/6	Eastern Extension	12⅛—13½	5 6 0	Ja, Ap, Jy, O	13	12⅛
100	4%	Do. 4 per Cent. Deb. Stock	100 —102	3 18 6	Feb, Aug	100½	100
25	4%	Eastern and S. Af., 4% Mauritius Sub. Debs	100 —102	3 18 0	May, Nov	..	..
10	5/0	E. N. (of Copenhagen), with Coupon 80 ..	30½—31½	5 14 3	Jan, July	..	..
25	5/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	†Mackay Companies Common	94 —97	5 3 0	Ja, Ap, Jy, O	..	..
100	4%	†Do. Preference	75 —80	5 0 0	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛—¼	..	April	2⅛	2
100	4%	Marine & Europ'n Tel. 4% Guar. Dbs. (red.)	98 —100	4 0 0	June, Dec	..	..
1	1/3	West Coast of America	1⅛—1⅜	4 7 0	May	..	..
100	4%	Do. 4 per Cent. Debs.....	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	1⅛—1⅜	..	May, Nov	1⅜	1
10	6/0	Do. 6 per Cent. 1st Pref.	9⅛—9½	6 2 6	May, Nov	9⅛	..
10	6/0	Do. 6% 2nd Pref.	9⅛—9½	6 2 6	May, Nov	..	..
100	5%	Do. 5 per Cent. Debs.....	101½—103¼	4 16 6	Jan, July	..	..
10	3/0	Western Telegraph.....	13⅛—14⅛	4 16 9	Mr, Jn, O, D	14	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 —102	3 19 0	June, Dec	101⅛	..
—	4%	Western Union Telegraph, $1,000 4% Bds	103 —106	3 15 3	—	..	..
..	4½	Do. $1,000 4½% Rdg. & Rl. Est. Gd. Bnds	99 —102	..	..	..	..

Share	Last Dividend	Name	Price Wed., Sept. 28.	Rate per cent. Yielded.	Dividend Due.	Business Week to Sept. 28. Highest.	Lowest.
		Telephones.		£ s. d.			
100	2$	Amer. Telephn. & Telegh. Cap. St.	139 —142	5 12 0	..	..	..
..	4%	Do. Coll. Trust $1,000 4 per Cent. Bds	93 —95	4 7 3	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	104 —106	3 15 3	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101½—103½	4 15 6	Mar, Sept	..	..
5	5/0	Chili Telephone	9½—10	4 0 0	August ..	9⅝	..
1	0/7½	Monte Video Telephone Ord.....	3/16—⅜	6 0 0	Nov	⅜	⅜
1	0/6	Do. 5 per Cent. Pref.	3/16—⅜	5 12 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	104½—105½	5 15 0	Feb, Aug	104½	104½
St.	6%	Do. Def. Stock	122 —124	4 17 3	Feb, Aug	123½	123½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 8 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 8 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.....	5⅜—5⅝	4 8 0	Feb, Aug	5⅜	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.)....	98 —100	3 10 0	June, Dec	99½	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	99 —101	3 19 0	Jan, July	..	..
..	4½%	New York Telephone Co. 30 yr. Bnds.....	99½—100½	4 9 6	..	100⅝	99⅜
1	1/0	Oriental	1 1/16—1 1/8	4 19 6	April, Oct	..	..
..	..	Do 6 per Cent. Cum. Pref.	1⅛—1⅛	4 11 0	April, Oct	..	..
..	4%	Do. 4 per Cent. Red. Deb. Stock.....	87 —89	4 10 0	Jan, July	88	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	99 —101	4 9 0	Jan, July	..	..
5	5/0	United River Plate Ord. ex rights	7⅛—7⅜	5 8 6	July	7⅛	7⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜—5½	4 9 0	June, Dec	5⅜	..
St.	4½%	Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan, July	104½	104½
		Financial, Investment, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref...	2⅜—3⅜	9 4 6	Jan, July	..	..
10	5/9	Globe Telegraph & Trust	10½—11	5 7 6	Sp, DcMr Ju	10⅛	10⅛
10	3/0	Do. 6 per Cent. Pref.	13⅛—13½	4 7 0	Sp, DcMr Ju	13⅛	13⅛
10	6%	Submarine Cables Trust (Cert.)	133 —136	4 8 3	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
St.	4%	Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅜	5 4 0	April, Oct	4⅛	4⅛
St.	4%	Do. 5% Cum. 2nd Pref.....	4⅛—4½	5 11 0	Jan, July	..	..
St.	4%	Do. 4% Deb. Stock	92½—94	4 5 0	June, Dec	93½	92½
St.	4%	Do. 4½% Deb. Stock	95 —97	4 12 6	..	96⅛	96
St.	4½%	Auckland Elec. Trams. 5% Deb. (red.)....	103 —105	4 15 3	Jan, July	104	..
St.	5%	Brisbane Electric Trams. Invest. Ord	6 —6½	6 3 0	May	6⅛	6⅛
St.	4%	Do. 5 per Cent. Cum. Pref.	4⅛—5⅛	4 15 0	May, Nov	5⅛	..
St.	£3	Do. 4½ per Cent. Db. Prov. Certs.....	99 —102	4 8 6	Jan, July	..	..
St.	8%	British Columbia El.. Rly. Df. Ord.	143 —147	5 9 0	Mar, Sept	145⅛	143½
St.	5%	Do. Pref. Ord. Stock 2d & bonus	124 —128	4 13 9	May, Nov	126⅛	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock.....	110 —113	4 8 6	Jan, July	111⅛	110½
St.	4%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
40	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
100	4½%	†Do. 4½% Perp. Con. Deb. St.	103 —105	4 5 0	..	104½	103½
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db	98 —100	5 0 0	Mar, Sept	98⅛	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	97 —100	6 0 0	Feb, Aug	98⅛	98⅛
5	2/6	Calcutta Tramways (1 to 137,610).....	4½—5	4 10 0	Mar, Sept	4⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅛—5⅛	4 17 6	Jan, July	..	..
100	2/6	Do. 4½% 1st Deb. Stock (red).....	96 —99	4 11 0	Jan, July	..	..
1	4½%	Cape Electric Tram Shares	7/16—¼	..	..	..	..
St.	..	City of Buenos Ayres Trams Co. (1904) Sh.	5⅛—5⅜	4 5 6	F, My, A, N	5⅜	5⅛
St.	4%	Do 4 per Cent. Deb. Stock.....	99 —102	3 18 0	June, Dec	..	..
5	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	97 —100	5 0 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	80½	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	99 —101	5 4 0	Feb, Aug	..	..
5	..	Kalgoorlie Elec. Trams Sh.	3/16—¼	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock.....	92 —95	5 5 0	Jan, July	..	..
5	4/9	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	Lisbon Elec. Trams. Ord.	1⅜—1⅝	4 15 6	July	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16—1⅛	4 10 0	Jan, July	..	..
100	5%	Do. 5 per Cent. Reg. Mort. Debs.	98 —102	4 18 0	Jan, July	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	..	..
100	5%	Manaos Trams and Lt. Co. 5% Debs	87½—89½	5 12 6	..	89⅛	..
100	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	97 —99	5 1 0	Feb, Aug	96	95⅛
100	$1	Mexico Trams Co. Com. St.	129 —131	5 19 0	..	129½	129
100	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	98 —99	5 1 0	..	98⅛	97⅞
St.	6%	Do. 6% 50 yr. Mort. Bds.	100½—101½	5 18 6	..	101⅛	100⅛
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 0	Feb, Aug	..	..
..	..	Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	..	..
1	..	Perth Elec. Trams Ord.	⅛—1⅛	2 4 6	May	⅛	⅛
100	£3	Do. 1st Mt. Db. Stock	100 —103	4 17 6	Jan, July	..	..
100	5%	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5⅛—5⅜	5 3 9	..	5⅜	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	97 —102	4 18 0	..	..	..
100	$1	Rio Janeiro Tram, Lt. & P. Co.....	106½—107½	3 17 6	..	107⅛	102½
100	5%	Do. 30 yr. Gold Bnds.	99 —100	5 0 0	..	99⅛	99⅛
100	5%	Do. 50 yr. Mt. Bnds	94½—95½	5 5 0	..	95⅛	94⅛
100	$2½	Sao Paulo Tramway, Light & Power Co. $100 Stock	154 —156	6 8 0	..	156	154
100	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102⅛	102
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5⅛—5⅜	5 4 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.	10⅞—11⅛	5 6 6	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red).....	94 —96	4 13 6	Jan, July	95⅛	..
5	5%	Do. 5 per Cent. 2nd Mort. Deb. Stock..	97 —99	5 1 0	..	..	..
5	4/9	Calcutta Elec. Supply Ord.	6⅛—6⅜	5 15 0	April, Oct	6⅜	..
100	$3½	†Canadian Gen. Elec. Co. Com. St.....	108 —112	6 5 0	..	112	111½
100	5%	†Do. 7% Cm. Pf. Stock	118 —121	5 15 6	..	118½	118½
100	5%	Castner Electrolytic Alkali Co. (of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
500	5%	Elect Development Co. of Ontario.....	82½—85½	5 17 0	..	84½	83⅛
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	85 —89	5 14 0	Jan, July	..	..
..	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	..	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	7/16—½	8 2 6	April, Oct	⅜	..
100	5%	Kaministiquia Power Co. 5% Gold Bnds...	100½—102½	5 0 6	..	..	..
5	..	Madras E. S. Corp. Ord.	2⅛—3	..	..	..	..
..	..	Melbourne E. S. Co. 6% Cum. Pref.	33 —38	..	..	..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock	90½—92½	5 9 0	..	..	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	91 —92	5 8 6	..	91⅛	91
St.	$1	Mexican Lt. & Power Co. Com. St.	89 —90	4 9 0	..	89⅛	88½
St.	$3½	Do. 7% Cum. Pref. St.	108½—109½	6 8 0	..	110⅛	109½
500	5%	Do. 5% 1st Mort. Gold Bnds.	94 —95	5 5 6	..	95⅛	93⅛
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	153 —153	4 8 6	F, My, A, N	152⅛	152
St.	£3	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	216	..
St.	6%	Do. 6 per Cent. non-Cum. Pref. Stk. ..	105 —115	5 5 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	..	..
5	3/0	Rosario Elec. Co. Ord.	8⅛—9	..	..	..	..
5	3/0	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	..
5	3/0	Do 2nd Pref.	8⅛—8½	6 14 6	..	..	..
100	$1	Shawinigan Water & Power Co. Ca ex rights	109 —111	3 12 0	..	111⅛	109½
5	5%	Do. 5 per Cent. Bds.	108 —110	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ Per Con. Mt. Db. St.	102 —104	4 6 0	..	103⅛	..
St.	6d.	Toronto Power Co. 4½% Db. St.	100 —102	4 8 0	..	..	..
..	..	Victoria Falls Power Co. Pref. (1 to 808,000)	⅛—¼	5 6 6	Jan, July	..	..
..	..	Do. (803,081 to 1,700,000)	⅛—¼	..	..	—	—

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,690. [No. 26. Vol. LXV.] FRIDAY, OCTOBER 7, 1910. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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NOTES.

Rival Departments at Manchester.

MOST of the more important towns have both a Gas Department and an Electricity Department, and where such is the case there must be great difficulty in maintaining true competition. Such competition is really only possible where the rival concerns are run by private enterprise and are entirely separate. Where the control of two such competing departments is in the hands of a single Council, as it must be in municipal working, it is almost a case of a house divided against itself. Such a position, however, must be accepted in many cases, and Manchester is an instance of this kind. Presumably there has been a little ill-feeling on the subject, for recently a conference was held between the two departments at Manchester, and a report has been issued, in which it is stated that no useful purpose can be served by one department criticising the other, and the conclusion is reached that the prices of each department are fixed on recognised principles. Further, it is stated that nothing valid can be urged against the methods of working without prolonged special study of the problems facing each department. This savours of a truce; but the really important part of the report, of which an account will be found in another column, appears to be that dealing with the question of sums paid in aid of rates. Apparently, the City Council exacts from each department an annual sum for this purpose. It appears to us that any such exaction must be extremely undesirable. There is little objection to small contributions for such a purpose when the undertaking is fully meeting its responsibilities in regard to depreciation, and indeed this may be the simplest method of disposing of a surplus, since dividends are not available for this purpose in municipal undertakings. It seems, however, more rational when there is a substantial surplus that the price of the commodity should be reduced. Parliament has recently shown itself averse to the wholesale use of profits for the relief of rates, and it has been laid down in the case of certain gas bills that a maximum of only 1 per cent. on the outstanding mortgage debts of the undertaking should be so paid. This basis has been accepted by the two departments, with the result that the Gas Department ought to contribute £12,127, whereas the Electricity Department should contribute £19,701. It is certainly a defect of this basis that it introduces an anomaly, for the Electricity Department, with a somewhat lower capital expenditure, is looked to for the larger contribution to the rates. Also, the more free the capital from debt, which generally means the older the undertaking, the less is the relative contribution to the rates. In some respects this may be reasonable, because an undertaking is then dependent less on the credit of the rates, but nevertheless a department must obviously be able to afford such contributions less readily when it has to meet heavy capital charges than when its capital has been somewhat relieved. There is little doubt that these contributions in aid of rates can only act in a way to retard progress.

IN many ways it would be better for the Manchester Electricity Department if the gas supply were in the hands of a company. The electricity undertaking would then be able to gird up its loins and carry the war into the enemy's camp. In the present state of affairs something in the nature of an armed truce appears to have been entered upon. From the point of view of organisation the Electricity Department and the electrical contractors in the district

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are fighting gas on the most aggressive lines possible. The contractors have good showrooms, and appear to be keen in giving publicity to the various uses of electrical energy. The supply undertaking, however, suffers considerably from the fact that the Gas Department is the street lighting authority, not only for the city area, but for Greater Manchester. It is the experience of most large towns in which electricity is used for street lighting that that particular form of illumination constitutes a valuable advertisement. Manchester has denied this useful class of publicity to its Electricity Department. The latter Department has laid mains specially for street lighting, and is in a position to give the inhabitants of Cottonopolis a cheaper and better form of lighting for their streets than they have at present, but the Gas Department holds the magic wand of authority and practically nothing can be done. In what was once the township of Gorton the Electricity Department erected a number of enclosed arc lamps for the lighting of the principal streets, and the experiment proved so satisfactory that the Council arranged for the conversion of all the gas lamps. Before the work could be commenced, however, the township was taken into the City area, in which, of course, the Manchester Gas Department alone had authority to supply the street lighting. The electric lamps meantime remain in the streets of Gorton as witnesses to an extremely unsatisfactory state of affairs, for gas lighting alone is possible in the streets under the new conditions. It will be interesting to follow the future policy of both departments, and we look forward to the time when the electricity undertaking will be able to carry on a vigorous campaign without let or hindrance from the members of the Gas Committee. The march of progress will probably bring about some such development, because, considering the matter of street lighting particularly, Manchester will be constrained to follow the example of many other commercial and industrial centres in which electricity will have superseded gas.

Car Meters.

THE diversity of opinion which exists in regard to the relative advantages of watt-hour meters, ampere-hour meters and clock meters for indicating the skill of individual motormen is perhaps accounted for by the conflicting experience of various managers. This is especially brought out in the report of Mr. BOUTON to the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Local, which is abstracted elsewhere in this issue. Thus, whereas several undertakings have found that the use of clock meters leads to increased wear and tear of armatures, commutators and brushes, due to the motormen starting their cars too rapidly, others have not experienced this disadvantage; in fact, two undertakings are in favour of this procedure on the part of their motormen. As Mr. BOUTON points out, however, this is largely a question of capacity of the motors relative to the work they have to do; and we certainly think too rapid acceleration is to be avoided if the life of the equipment is not to be unduly short. That the use of clock meters encourages the motormen to reach the parallel running position as quickly as possible, regardless of the current taken in the process, cannot be gainsaid, and for this reason ampere-hour meters are, we think, to be recommended; watt-hour meters seem to be an unnecessary complication, since pressure variations may usually be neglected. It has often been stated that a clock meter effects the same result as if the energy consumption were measured. That this is by no means so is evident by the tests recorded in Mr. BOUTON's report. These show that a classification according to the period of coasting by no means agrees with the classification in which the energy consumption is the basis of comparison. Thus, where 36 motormen were under observation, the motorman who showed the best result with a clock meter was placed eighteenth on the list when the men were classified on the ampere-hour basis. Similarly, the motorman who occupied the thirty-third position in the clock meter list had the third lowest ampere-hour consumption. The other figures also showed unmistakably that reliance cannot be placed on the clock meter method of controlling the motormen if the economical operation of the cars is the object, although, naturally, supervision of any kind is bound to lead to improved results.

Gas Mishaps.

"SEVERAL fires occurred in London through window curtains being blown against gas jets." The above short sentence, culled from the reports in the daily Press of last Sunday's gale, was probably passed over without thought by the majority of its readers. Such a sentence is, however, very significant at the present time, when fires of unknown origin are of only too frequent occurrence. When one considers the multitude of gas jets which are in close proximity to inflammable materials and that a draught may be sufficient to bring such materials into a position where they are liable to catch fire, one can only marvel that serious conflagrations are not more numerous. That the danger is accepted as to some extent inseparable from gas lighting is evident from the fact that such calamities are passed over almost without comment by the public and the Press; while the latter usually honours electrical mishaps of much less consequence with all the importance of a startling headline. In this connection the efforts of the "Journal of Gas Lighting" to attach the blame for the recent fires at Brixton to electrical apparatus, in spite of evidence that the fires were in no way due to the latter, does not savour of good taste. But perhaps it is a form of humour.

Personal.—We learn that Mr. Walter Clark, for many years works superintendent of the Electrical Power Storage Co. has resigned.

Interference with Street Lamps.—At the meeting of the Islington Borough Council this evening, the following report from the Lighting Committee (dated September 28th, 1910) will appear upon the agenda:—

"We have had under consideration a report from the Electrical Engineer calling attention to interference with one of the Council's electric lamps by officials of the Gas Light & Coke Co. The Company's attention has been directed to the matter and they have tendered a written apology, but we think it desirable that the Council should be made acquainted with the circumstances, as it will be necessary to recommend that legal action be taken against the Company if such interference is continued.

Our readers will remember that we commented recently on the incident of which the above is the sequel.

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Northampton Polytechnic Institute.—The new generating station of the Institute, which has been installed at a cost of about £6,000, will be formally opened by the Chairman of the London County Council on Wednesday next.

Lighting of Side Streets in Boston (U.S.A.).—A recent article in the "Electrical World" on this subject is of interest, showing, as it does, that similar problems have to be overcome in America with regard to street lighting as over here. It appears that, after many weeks of investigation, the superintendent of streets, Mr. L. K. Rourke, has decided to advertise for minor street lighting on the basis of five year and ten year contracts, instead of placing the contract on a two year basis, as originally announced. Twelve thousand lamps are involved, and either gas or electricity may be used. The existing conditions as regards the gas lighting of minor thoroughfares are entirely unsatisfactory. The work is handled by a company which has held the field for about 22 years, and the gas is purchased for use by the city only after a considerable profit has been paid to the lamp company for its part in handling the gas, which in the first instance is supplied by the Boston Consolidated Gas Co. If electricity is used in place of gas all these middlemen's profits will be obviated, and the city will secure light with the minimum of trouble. Automatic lamp-lighting equipment is being investigated by the Street Department, but thus far without any results tending to show that these devices have reached a stage of development when they can be considered genuinely reliable. In some of the outer suburbs the Edison Electric Illuminating Co. of Boston has installed tungsten lamps with decided economy to the city as compared with gas lamps. The city authorities are trying to avoid any system which would involve a large investment in lamps and mantles, or any extended maintenance organisation. It is probable that there will be vigorous competition between electricity and gas for the contract which is about to be let.

A Master Patent for Electric Traction.—It seems rather extraordinary at this stage in the development of electric traction that discussions on fundamental patent questions should still be going on; but this is apparently the case, at least in the United States, for according to "Engineering News" the Schlesinger electric railway patent, which was applied for in 1885 when electric railways were in their infancy, and which is said to affect nearly all the electric railways in that country, has been in litigation for several years both as to its validity and its ownership. A decision given by Judge Bradford in the U.S. Circuit Court (Pennsylvania) on July 28, 1910, covers the following points: (1) Wm. M. Schlesinger was the original inventor, (2) the Allis-Chalmers Co. are the owners of the patent, (3) the General Electric Co. and the Hestonville, Mantua & Fairmount Passenger Rly. Co. have infringed upon the first claim of the patent, and (4) that profits derived by the infringing companies since December 15, 1896, may be recovered by the owning company. The application for this patent was filed on November 24, 1885, and the patent (No. 546,059) was issued September 10, 1895. The first claim, which was the basis of the suit, covers an electric railway system in which the working conductor (trolley wire or third rail) is divided into insulated or disconnected sections, each section being connected to the generator or 'bus bar at the power station through a separate feeder provided with an automatic circuit-breaker or other protective device. The ownership of the patent by the Allis-Chalmers Co. has been upheld by a previous decision of the U.S. Circuit Court of Appeals. In the present suit, an injunction has been issued against the use of, manufacture, or sale of the infringing apparatus by the defendant companies, and our contemporary is informed that, after hearing arguments, the Court refused to suspend this injunction pending appeal.

Cable Interruptions.	Date of Interruption.
Assab—Perim	July 8, 1909
Malta—Tripoli	April 20, 1910
Reunion—Mauritius	May 20, 1910
Latakia—Palura	May 26, 1910
Obock—Djibouti	June 24, 1910
Tourane - Amoy	Sept 25, 1910
Paramaribo—Cayenne	Oct. 1, 1910

Tests with a New Brake Shoe at Philadelphia.—A recent issue of the "Electric Railway Journal" mentions that the Philadelphia Rapid Transit Co. has been obtaining some remarkable results with a new type of brake shoe with regard to long shoe life, minimum wheel wear and high friction coefficients in braking. The first operating installation was made in May, 1910, and since that time about 1,000 shoes have been placed on both single and double-truck cars with hand or air brakes. These shoes are of the inset type, the body being made of a fine grade of iron, with a tread containing six cylindrical pockets 1½ in. deep and filled with cement. It has been found that these insets are a strong factor in eliminating the screeching common to many brake shoes. The inset composition is not affected by moisture, as was shown by its behaviour during six weeks of heavy rain, when the first shoes were placed in service. The pattern in use up to the present time has a groove or throat to receive the wheel flange for the full length of the shoe. However, in accordance with a suggestion that has been made, the new design will have a tread 2¼ in. wide and heel and toe guides only for the flange of the wheel. This change will bring all the braking on to the treads, and prevent the pinching or breaking of the wheel flanges. The older shoes have been scrapped at an average weight of 6½ lb., but the new pattern shoe, weighing 20 lb. originally, will not have to be discarded until it reaches 4 lb. Not one of the shoes has been removed from the hand-brake cars, and the railway company expects them to give at least a year's service before scrapping. The average life of 115 shoes taken off the air-brake cars was 10,173 miles. The rest of the air-brake shoes, constituting about 70 per cent. of the total, are still in service, so that the net average life should be several thousand miles more than the figure given. The drawback of the ordinary long-life shoe is its excessive abrasion of the wheel. This is particularly true of shoes made of such material as chilled or soft gray iron. However, the tests made with the new inset shoe by the Philadelphia Rapid Transit Co. show that it wears the wheels far less than cast iron steel-back brake shoes. The exact figures obtained or the action of both shoes on steel wheels were as follows: Inset shoe used 67 days, or 8,445 miles, wore off $\frac{3}{32}$ in.; inset shoe used 69 days, or 8,645 miles, wore off $\frac{1}{8}$ in.; cast-iron shoe used seven days, or 940 miles, wore off $\frac{1}{8}$ in.; cast-iron shoe used five days, or 740 miles, wore off $\frac{3}{32}$ in. On September 13, 1909, before the extended installation of the inset shoe, the railway company tested it for its frictional coefficient value in comparison with common cast-iron brake shoes. The test runs were made on a 3 per cent. down gradient 690 ft. long. The air brakes were applied when the cars were running at top speed. The results showed that with 50 lb. pressure the inset shoe equipment was stopped in an average length of 204 ft., or 59 ft. less than the cast-iron shoe equipment. Similarly, with 75 lb. pressure, the inset shoes enabled the car to be stopped in 158 ft., or 22 ft. less than the cast-iron shoe equipment.

The Hygienic Aspects of Illumination.—In a Paper on this subject read before the second Congrès International des Maladies Professionelles at Brussels last month, Mr. Leon Gaster pointed out how much, not only the workman, but also the employer, benefited by the maintenance of good lighting conditions. The question had recently been receiving much attention, both on the Continent and in America, while the Home Office were now making a special study of the question of the conditions of illumination in factories, and were providing for the collection of data bearing thereon. Good results in illumination could only be obtained by the joint efforts of the engineer, the oculist and the architect. The whole question of illumination depended upon the behaviour and well-being of the eye, and the medical profession were, therefore, intimately concerned. At the same time, new developments were constantly taking place, and newer and brighter sources, with the technical details of which the engineer was chiefly familiar, were replacing the old lights of the past. In one respect these new sources were notably different from the lamps they were superseding. The "intrinsic brilliancy," or "candle-power per square inch," was much greater, and the lights were there-

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fore apt, if misused, to be dazzling to the eye. For this reason it was most essential to arrange the sources wisely, so as to avoid any tendency to glare, and especially in the case of workshops and factories where people were exposed to artificial light for long periods of time. Lights should therefore be placed outside the direct range of vision, and advantage should be taken of appropriate shades and reflectors to direct the light where it was wanted and to screen it in directions in which its brilliancy would be inconvenient. Again, there were many industrial processes, such as those in lamp factories, glass and iron works, welding operations, &c., where workers might be exposed to the rays of these bright illuminants, and proper methods of protection were most important. But it had been suggested that it was not only the intrinsic brilliancy that was harmful. Dr. Stockhausen and others had laid stress on the effect on the eyes of the ultra-violet invisible rays, and attributed the severe inflammation following incautious exposure to powerful lights to this cause: this question required further examination before definite recommendations could be made. It had also been suggested that the prevalence of cataract among glassworkers was due to the peculiar radiation given out by the molten material, and an inquiry was now being conducted into the matter. Yet another aspect of the subject which deserved to be emphasised was the tendency of bad conditions of illumination to lead to accidents. Naturally, mishaps were more apt to occur when the machinery could not be clearly seen. The Fidelity and Casualty Co., of New York, in a recent report placed defective lighting first in the list of causes of accidents.

British Standard Specification for Bayonet Socket Lamp Holders and Caps.—The latest report of the Engineering Standards Committee deals with this subject, and all will be agreed that it appears at an exceedingly opportune moment, for the advent of the metal filament lamp has brought with it a difficulty in regard to the fitting of any lamp cap into any holder in general use. This difficulty has, the Committee find, been very noticeable of late, and whether it is due to hasty manufacture or, on the other hand, to faulty gauging, the result is annoyance to the user and the possible loss of custom to the maker. Lamp makers would therefore do well to adopt the suggestions of the Committee as outlined in their specification, especially in regard to the question of the verification of their shop gauges. It should not be a difficult task to do away entirely with any tendency to non-interchangeability between lamp caps and lamp holders of different makes. The Committee, in a preface written by Dr. R. T. Glazebrook, point out that although they have kept in view the great desirability of interchangeability, they have been most careful not to interfere in any way with invention and progress. They also express their appreciation of the courteous assistance rendered by the makers. The present specification deals with holders for lighting purposes only, but we understand that the effect of heat on the ordinary lamp holder is being investigated experimentally at the National Physical Laboratory, and an addendum to the present report, dealing with lamp holders for use with radiators, may shortly be expected. The price of the present report is 5s. 2d., post free, and it may be obtained from any bookseller or direct from the offices of the Committee, 28, Victoria-street, Westminster. It is published for the Committee by Messrs. Crosby Lockwood & Son.

Current Topics.

Subjects of current interest dealt with in this issue include the following:—

Mr. J. Rezelman contributes an article on "Leakage Reactance."

A description is given of the wireless telephone apparatus devised by Mr. E. F. Huth, of Berlin.

At the meeting of the Iron and Steel Institute last week a Paper was read by Mr. D. F. Campbell on "Electric Steel Refining."

We give an abstract of the Paper "On Hysteresis Loops and Lissajous' Figures, and on the Energy Wasted in a Hysteresis Loop," read by Prof. S. P. Thompson before the Physical Society. This is also referred to in a Leading Article.

The report of Mr. Bouton on car meters, presented at the recent meeting of the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Local, is abstracted in another column.

As a result of a conference between the Gas Department and the Electricity Department of the Manchester Corporation, a report has been presented as to the methods of working of the two departments and as to their respective contributions for the relief of the rates.

The accounts of the Manchester Corporation Electricity Department for the year ended March 31st last are analysed elsewhere in this issue.

Acton Council have agreed to transfer their electricity supply undertaking to the Metropolitan Electric Supply Co.

West Hartlepool Corporation have made an arrangement with the Seaton Carew Iron Co. for the utilisation of the waste heat of blast furnaces at the ironworks for generating electricity.

Another Telephone Subscribers' Protection Association has been formed, this time at Edinburgh.

An electric power scheme of considerable magnitude is briefly mentioned in a note headed "India." A company has been registered in Bombay with a capital of £1,134,000 in connection with this project, in which the Lahmeyer Co. is interested.

Loans for Electricity Supply.—An inquiry was held last week into the application of *Walsall* Corporation to borrow £23,225 for extensions of the electricity undertaking.—The Local Government Board have sanctioned a loan of £20,000 for an electricity supply scheme for *Dundalk*.—*St. Helens* Corporation have received sanction to a loan of £11,206 for extensions of the municipal electricity works.—*Stepney* (London) Council have applied to the L.C.C. for a loan of £7,150 for additional plant, &c., for the Limehouse generating station.—*Aston* Council have received sanction to loans amounting to £2,575 for electricity supply.—*Wigan* Corporation have received sanction to a loan of £36,000 for the electricity undertaking.—*Heston and Isleworth* Council are to borrow £3,048 for extensions of the electricity undertaking. An inquiry was held on Wednesday into the application of *South Shields* Corporation for permission to borrow £9,400 for their electricity undertaking.

Arbitrations.—Mr. Robert Hammond has been appointed arbitrator to determine the price to be paid for electrical energy for the next seven years by Paisley District Tramways Co. to Paisley Corporation. The proceedings will commence to-day (Friday).

Mr. Archibald Read has been appointed arbitrator in regard to the price to be paid by Winchester Corporation for the Winchester electricity works.

Mr. Archibald Read has given his award in the Torquay tramway arbitration to the effect that the consent of the Corporation to the use of the overhead system on Torbay-road has been unreasonably withheld.

Legal.—An interesting legal case, in which Mr. Justus Eck was successful in an action brought against the Union-Castle Mail Steamship Co., is reported. The result is of something more than personal interest—electric fan makers please note.

INSTITUTIONS AND SOCIETIES.

Institution of Civil Engineers.—The Council of this Institution have made the following awards in respect of Papers published in Section II. of the Proceedings for the Session 1909-1910:—A Telford Gold Medal to Major W. W. Harts, U.S. Army; a Watt Gold Medal to Mr. A. Trewby; a Crampton Prize to Prof. A. H. Gibson and Mr. A. Ryan; and Telford Premiums to Messrs. W. R. Baldwin-Wiseman, O. W. Griffith, W. E. Lilley, W. Corin, J. A. Saner and F. O. Blackwell. They have also awarded the Indian Premium for 1910 to Mr. C. W. Lloyd-Jones.

ARRANGEMENTS FOR THE WEEK.

MONDAY, October 10th.

JUNIOR INSTITUTION OF ENGINEERS.

7:30 p.m. Meeting at Caxton Hall, Westminster. Lecture on "The Law Relating to Engineering," by Mr. L. W. J. Costello.

GRADUATES' ASSOCIATION OF THE INSTITUTION OF MECHANICAL ENGINEERS.

8 p.m. Meeting at Storey's Gate. Paper on "Recent Improvements in Wood Working Machinery," by Mr. A. E. Harris.

WEDNESDAY, October 12th.

ASSOCIATION OF ENGINEERS-IN-CHARGE.

8 p.m. Meeting at St. Bride's Institute, Bride-lane, Fleet-street. Presidential Address on "The Ordnance Survey and the Design and Use of Machinery for Printing Maps," by Capt. H. R all Sankey, R.E.

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MANCHESTER CORPORATION ELECTRICITY SUPPLY ACCOUNTS.

Whatever may be said as to the general development of electricity supply in this country, there is no doubt that Manchester is well to the fore in things electrical. From the early days of electricity supply the Manchester undertaking has been a centre of interest to electrical engineers, and during the last year or two the rapid progress made, particularly as regards power supply, has attracted more than usual attention. The total number of units sold by the electricity department during the year ended March 31st last was no less than 71,557,387, or over 90 units per head of population. This is, we believe, one of the highest figures recorded in this country. Of this total, about two-fifths is accounted for by electric traction, viz., 28,526,468 units, whilst private consumers required 42,886,223 units, public lighting being only responsible for the small amount of 144,696 units. Compared with the previous year's figures there is an increase of 5,736,201 units in the quantity sold to private consumers, an increase of 45,103 units, or 45 per cent., in the energy used for public lighting, and a decrease of 1,148,781 units in the amount of electrical energy supplied to the tramways.

As the maximum load increased from 31,118 kw. to 33,785 kw., the latter figure comprising a demand of 24,193 kw. for lighting and power and 9,592 kw. for traction, it will be seen that the load-factor is 24·2 per cent., compared with 24·6 per cent. a year ago, and 25·4 per cent. in 1907-8. This decline in the load factor is rather surprising in view of the extensive power supply developments in recent years. If the figures are analysed, it will be found that the traction load factor has increased from 33·3 per cent. in 1908-9 to 33·9 per cent. in 1909-10, whilst the load factor recorded for lighting and power during the last 12 months was 20·3 per cent., the same as a year ago. The total capacity of generating plant at March 31st was 45,300 kw.

In regard to the energy lost in distribution, or otherwise unaccounted for, this has reached the high figure of 17,175,300 units, or approximately 18 per cent. of the total quantity generated, which latter amounted to 95,542,254 units. The above figure of 18 per cent. is about 1 per cent. higher than in the previous year. This is due to a greater output to the high-pressure alternating-current network, the energy absorbed in the latter being necessarily higher than in the low-pressure continuous-current area.

Turning now to the financial statistics of the undertaking, the sales of current for lighting and power were £247,420, as against £231,648 a year ago, whilst the revenue obtained from the sale of current to the tramways department has decreased from £128,613 to £119,348. The net result is that the total income of £374,878 shows an increase of £7,031. As the total costs (including capital charges) amounted to £338,873, compared with £333,949 last year—a very satisfactory result considering the increased output—the balance shown is £36,005.

It will be seen, from our analysis of the expenditure below, that considerable economies have been introduced, and the total costs (excluding capital charges) now stand at 0·61d., compared with 0·66d. last year. There is little doubt, however, that a much lower figure will be reached as greater use is made of the new plant in Stuart-street station.

The following is an analysis of the expenditure during the past financial year, together with the cost of working per unit sold, the latter figure also being given for the previous year.

		Cost per unit sold. 1909-10.	1908-9.
Generating Costs.			
Coal, &c.	£63,239	0·21d.	0·24d.
Oil, waste, water, &c.	6,046	0·02d.	0·03d.
Salaries and wages at station	18,359	0·06d.	0·07d.
Repairs and maintenance	13,438	0·05d.	0·05d.
Total Generating Costs	£101,082	0·34d.	0·39d.
Distribution Costs.			
Salaries and wages	£15,373	0·05d.	0·06d.
Repairs and maintenance of sub-station machinery, meters, fuses, &c.	14,760	0·05d.	0·04d.
Miscellaneous	2,352	0·01d.	0·01d.
Total Distribution Costs	£32,486	0·11d.	0·11d.
Management Costs.			
Salaries and wages	£8,569	0·03d.	0·03d.
Printing, stationery, &c.	950	0·00d.	0·00d.
General establishment charges	1,552	0·01d.	0·01d.
Law and Parliamentary charges	536	0·00d.	0·00d.
Special charges	1,339	0·00d.	0·01d.
Total Management Costs	£12,946	0·04d.	0·05d.
Rents, rates and taxes	£34,684	0·12d.	0·11d.
TOTAL COSTS (ex. capital charges)	£181,197	0·61d.	0·66d.
Capital Charges.			
Interest	£69,311	0·23d.	0·24d.
Sinking fund and repayments	88,365	0·30d.	0·29d.
Total Capital Charges	£157,676	0·53d.	0·53d.
TOTAL COSTS (inc. capital charges)	**£338,873**	**1·14d.**	**1·20d.**
Revenue			
Sales of current	£367,702	1·23d.	1·29d.
Rental of meters	431	0·00d.	0·00d.
Rental of motors	4,791	0·02d.	0·02d.
Miscellaneous (less bad debts)	1,954	0·01d.	0·01d.
TOTAL REVENUE	**£374,878**	**1·26d.**	**1·32d.**
Balance (surplus)	£36,005	0·12d.	0·12d.

Of this balance, £23,822 is paid into the Renewals Suspense Account and £183 to the Reserve Fund Account, whilst the remaining sum of £12,000 is handed over to the city fund in aid of the rates. This last-mentioned contribution is a similar amount to that paid over to the rates a year ago. The Renewals Suspense Account showed on March 31st last a balance of £141,451, compared with £135,252 a year ago, the expenditure on plant discarded, &c., during the 12 months having been £20,553.

The generating costs given above are the combined costs for Dickinson-street, Bloom-street and Stuart-street power stations. The individual figures per unit generated are as follows :—

Stuart-street.		
Number of units generated	68,505,025	
Cost of fuel	£41,080	or 0·144d. per unit generated.
„ oil, &c.	3,968	or 0·014d. „ „ „
Salaries and wages	8,913	or 0·031d. „ „ „
Repairs and maintenance	7,266	or 0·025d. „ „ „
Total cost at Stuart-street	0·214d.	„ „ „
Dickinson-street and Bloom-street.		
Number of units generated	27,037,229	
Cost of fuel	£22,159	or 0·197d. per unit generated.
„ oil, &c.	2,078	or 0·018d. „ „ „
Salaries and wages	9,446	or 0·084d. „ „ „
Repairs and maintenance	6,172	or 0·055d. „ „ „
Total cost at Dickinson-street and Bloom-street	0·354d.	„ „ „

In comparing these figures with the combined figures given in the analysis above, it should be remembered that the latter are calculated per unit sold. Moreover, in comparisons between the results of the different stations, it must not be forgotten, as mentioned above, that the distribution losses are greater in connection with the high-tension transmission.

In connection with the extensions to the power plant during the year, the most interesting feature was the large Tudor battery installed. This is now in successful operation. The large extensions of steam plant and accessories at the Stuart-street station have also been brought to a satisfactory conclusion, and substantial improvements have been effected in the high-tension switchgear. As to extensions of mains, a net addition of 16¾ miles has to be recorded.

During the year the capital expenditure amounted to £111,924, mains accounting for £30,714 of this total, buildings and plant at Stuart-street station for £39,439, and plant and buildings at Dickinson-street for £21,688. The total capital expenditure to March 31, 1910, was £2,678,630, the various

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items comprised in this total, together with the respective cost per kilowatt of plant installed, being as follows :—

		Per kw. installed.
Land and buildings (Dickinson-street)...	£101,174	
„ „ (Bloom-street)	72,961	
„ „ (Stuart-street)	214,720	
Total	£388,855	...£ 8·6
Machinery and plant (Dickinson-street)	£194,019	...(20·2)
„ „ (Bloom-street).....	127,301	...(17·7)
„ „ (Stuart-street).....	396,537	...(13·9)
Total	£717,857	... 15·8
Stuart-street railway	£81,380	... 1·8
„ water supply.....	4,896	... 0·1
Distributing stations	356,934	... 7·9
Mains	949,239	... 20·9
Meters	60,989	... 1·3
Motors	33,554	... 0·7
Electrical instruments.....	2,713	... 0·1
Cable stores and workshop.....	30,520	... 0·6
Cottage property.....	3,993	... 0·1
Warehouse property	47,122	... 1·1
Street lighting	578	... 0·0
Total capital expenditure	£2,678,630	...£59·0

ELECTRIC STEEL REFINING.*

BY D. F. CAMPBELL.

Summary.—The author discusses the general aspects of the use of electricity for the refining of steel, and describes the usual procedure with an electric furnace. Probable future developments in this country are also outlined.

The electric furnace is at present used in various works for the refining of steel from the Bessemer converter in the manufacture of rails and all classes of railway material and castings, and more commonly in connection with the basic open-hearth process for the manufacture of various products of intermediate quality, castings and tool steel of all kinds. These are the purposes for which it has been most widely adopted, notably in America, Germany and France, though it is also used for melting and refining charges of cold scrap of cheap quality for the manufacture of tool steel and small castings, and its high efficiency is now generally acknowledged. The refining of steel that had been previously melted was the first use to which the electric furnace was applied commercially; but now that single furnaces have been producing over 200 tons a day for more than 16 months, it is obvious that the field for the process has widened, and already many furnaces are in construction or operation in this country.

The author is of opinion that the electric furnace is especially suitable, and will be widely adopted, for any class of work in which raw materials of a high degree of purity are now used. A wider application for rails and sections may occur when working in connection with the Talbot furnace, for the charge can be taken to the electric furnace as soon as the carbon is down, and the necessity of removing the sulphur and getting a teeming heat is avoided, as this is done in the electric furnace both economically and completely. Thus the capacity of the Talbot furnace is substantially increased, and this covers the greater cost of electric refining. Again, in the case of a basic open-hearth plant, using 60 per cent. of molten pig iron and 40 per cent. of scrap, a 40-ton furnace might have 15 tons removed to the electric furnace for refining, and a similar charge put in every two hours. Thus the capacity would be increased, the quality improved, and, in addition, a reduction in the cost of raw materials can also be made in some cases, as a low quality of pig iron can be used.

Similar conditions occur when working in conjunction with an open-hearth plant for making castings, and a thoroughly dead melt and extreme fluidity can be obtained, while the commonest raw materials can be used, and refined completely. This gives economy both in the amount of gits and runners, and also in the reduction of wasters. Even in the case of foundries engaged in ordinary open-hearth casting work, in which the margin of profit is now exceedingly small, the electric furnace is considered necessary for an improvement in quality, while in a small foundry making light and intricate castings from crucible steel, an economy of several pounds per ton may be expected to result from the adoption of the electric furnace, judging from the reduction of the costs in works in Germany where crucible furnaces were replaced by this process. There is little doubt that crucible steel, Swedish billets, and products of intermediate quality, such as are used for the Sheffield trade and by tube-makers of Staffordshire and South Wales, can be economically replaced by steel refined by electricity, and made in Middlesbrough, Cumberland, or the larger steel works in the Sheffield and Rotherham districts.

The use of the electric furnace is not likely to become general for rail steel manufacture at the present time, except in cases where the conditions are exceptional. In certain cases, such as at South Chicago, it has been adopted for that purpose owing to the economic conditions, notably the scarcity of good Bessemer ores and the demand for better rails. The electric furnace in such cases may save Bessemer plants from the scrap heap, or, at any rate, prolong the life of present installations, and at the same time make it possible to produce rails of a quality better than the best open-hearth steel, thus avoiding heavy capital expenditure.

In the electric furnace, almost any degree of refining can be economically effected, and the removal of sulphur, phosphorus and oxygen is especially easy. This is probably due to at least three causes: (1) The intense heating of the slag, which is the place at which refining takes place. Owing to this high temperature and the extreme fluidity of the slag, the rate of the refining reaction is very great, because the velocity of reaction rises very quickly for high temperatures, and not in direct proportion to the temperature. (2) The extremely basic slag that can be kept in a very fluid state, and the calcium carbide formed by the action of the arc on the calcareous slag, are especially advantageous for desulphurisation. (3) The violent motion of the steel, which results from the convection currents produced in the bath due to the two intensely hot areas caused by the arcs below the electrodes, increases the volume of steel exposed to the hot and fluid slag area, and hence the rate of refining.

The usual procedure for the use of the electric furnace in connection with the Bessemer converter is to charge the steel, holding back all slag in the ladle, after putting on the bottom of the furnace, lime and mill scale or iron ore. This produces an oxidising or dephosphorising slag, which may be carefully skimmed or poured off. On the bath of steel, carbon is thrown to carburise to any required degree, and then a second highly basic and desulphurising slag is added. The arc acting on the calcareous slag produces calcium carbide, which may combine with sulphur to form calcium sulphide. As neither gases nor air enter the furnace, and the conditions are almost completely reducing, no sulphates are formed, a dead melt is easily obtained, and when the slag is molten and the requisite heat obtained, the steel is teemed. In the open-hearth or any oxidising furnace these reactions cannot take place so completely and efficiently.

With steel from the basic open-hearth furnace, the procedure is similar, but when the quantity of phosphorus to be removed is small, it is only necessary to use one refining slag for the elimination of sulphur and any small amount of phosphorus remaining. The usual practice is to put the carbon necessary for carburising in the bottom of the furnace and then add the steel and the basic slag materials. As soon as the teeming heat is obtained, the necessary ferro-alloys are added and the steel will be completely refined.

Another point of interest is the rarity of blow-holes in electric steel when properly made, and this leads to the question of the cause of these troubles. It is well known that any ingot of steel when placed in a vacuum evolves nitrogen, and this is about equally true whether it be made in the crucible, the Bessemer converter, or the electric furnace. Blow-holes contain nitrogen, but this is probably not the cause. It is far more probable that they are due to the combination of oxides with the carbon in the process of cooling, and that the carbon monoxide so formed at a high temperature causes blow-holes in the cooling steel, and owing to the diminution of volume of the carbon monoxide on cooling, a partial vacuum is formed, and nitrogen is sucked into the blow-holes. In electric steel, oxides do not occur in any quantity, and consequently the prime cause of blow-holes is reduced. Again, the quality of electrically refined steel is better than a material of similar chemical composition made in any oxidising furnace. This is probably due to the reducing conditions under which it is finished.

It must not be forgotten in discussing these special qualities of electrically refined steel, that some inferior material has been made by incompetent melters or in ineffective furnaces, and that the electric, just as much as any other furnace, requires trained men, and most careful designing by metallurgists who have made a special study and had practical experience in this subject.

The question of the cost of applying this process, which must be considered before all others, is more difficult to discuss generally, owing to the great variety of conditions. The following are the chief points, all of which must be carefully considered in each particular case: (1) The possibility of saving in cost of raw materials, since the best qualities of steel can be made from impure raw materials. (2)

* Paper (somewhat abbreviated) read before the Iron and Steel Institute, at Buxton.

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Possibility of increasing the output of present furnaces by the addition of electric furnaces with improvement of product. (3) The cost of power and possibility of using blast-furnace or coke-oven gas, exhaust steam, &c., will be the determining factor in regard to deciding whether, in the manufacture of steel, electric refining can be economically adopted. In the case of cheap power or valuable products, scrap may be economically melted and refined in the electric furnace at a current consumption of 700 to 800 kw.-hours per ton, or if the price of power be high, the steel may be merely desulphurised and deoxidised, after melting and dephosphorising in a basic furnace, with a power consumption of 100 to 150 kw.-hours per ton. (4) The possible reduction of capital expenditure at certain works where the present products are not sufficiently good for modern specifications.

The figures given apply chiefly to Héroult furnaces, as this type has been far more widely adopted, and is used in larger units than any other. This furnace is similar to a basic open-hearth furnace, and seems to present more simplicity and to embody more of the desirable features of electric furnace design than any other. These features, in the author's opinion, are: (1) The best basic open-hearth design should be followed as closely as possible. A bottom homogeneous and solid and banks free from embedded electrodes is important, and above all simplicity of design. (2) All electric mechanism, in the form of generators, transformers, &c., should be entirely separate from the furnace, and should be of standard design. (3) A high-power factor must be maintained. (4) To avoid excessive cost of refractory materials, the roof should be protected from the direct radiation of the arcs by the electrodes themselves, and the intensely heated area of slag should be as large as possible, to increase the surface of refining action. (5) The heat should be applied to the slag as in the basic open-hearth furnace, and the temperature of the slag should be maintained above that of the steel, which allows of extreme basicity and fluidity being obtained and gives an intensely active refining action. The conditions in the furnace should be oxidising, neutral or reducing, at will.

The adoption of electric refining will cause some readjustment in the steel trade. As soon as the Sheffield steel melter has become acquainted with the process, and accustomed to the working of electric furnaces, electrically refined steel will largely replace ordinary crucible steel. This has already occurred in Germany and America. Large crucible plants and small open-hearth furnaces engaged in the manufacture of small and intricate castings, such as motor car parts, &c., may be replaced by electric furnaces, because the high degree of fluidity and dead melt obtained are especially advantageous. In many cases manufacturers of axles, guns and tubes will abandon the use of Swedish raw materials, and refine steel made from low-grade ores, thus reducing the value of high-grade ore deposits and the quantity imported; for, by the use of electricity, Cleveland stone will produce a steel equal to the best hæmatite ores. The capacity of many Talbot and basic open-hearth plants will be increased and the quality of the product improved, while much of the power that is now going to waste will be utilised for steel refining.

From the electrical engineer's point of view, the electric furnace is an attractive load, as it is more or less in continuous operation. In the case of the Héroult furnace the power factor is 0·88 to 0·90, though much less with large induction furnaces. Single, two or three phase current of any frequency from 20 to 60 has been used without any difficulty, though it is preferable in the case of a two-phase system to transform to three-phase current, which can be done without additional difficulty or expense. The load factor will be most favourable, the usual practice when refining, for example, in a 15-ton furnace, being to use 2,000 kw. for 20 minutes after charging, while the steel is being heated. The current is then reduced to about 1,500 kw. for 45 to 75 minutes until the steel is ready for teeming. There is then an interval of 10 to 15 minutes during which the furnace is teemed, fettled and charged, which allows the transformers or generators time to cool before the period of overload commences. Current fluctuations occur for a few minutes, while there is an evolution of gas from the steel which makes the bath boil up and touch the electrodes. This, however, is not sufficient to be objectionable, provided that the electrical machinery is properly designed for the purpose, and the extent of these variations is not so great as in the case of many rolling-mills, the fluctuations in voltage being only about 3 per cent. in the South Chicago works, where a 2,000 kw. furnace has been working steadily since May, 1909.

DISCUSSION.

Mr. E. H. Saniter (Rotherham) said he believed in the future of the electric furnace in certain directions, but he thought its future would be damaged by the furnace being recommended for the making of comparatively cheap qualities of steel, because people would find that the steel was not sufficiently improved to pay for the extra cost. He agreed that rails were not likely to be generally manufactured from the electric furnace at present. Even under the special circumstances at South Chicago, he was inclined to doubt whether the process would be continued. He believed they turned out something like 2,000 tons of rails in 24 hours. It was time members had some more definite information on the subject of costs.

Mr. E. C. Ibbotson (Sheffield) said many of the points mentioned by the author applied equally to the induction furnace. It was a question whether the arc furnaces, with their intensely hot areas, would not seriously affect the high-carbon steels such as were produced in Sheffield. The question of scorching ingots, and of the control of heat, was very important for these classes of steel.

Mr. J. H. Heap (London) said they could not give a simple answer to the question of whether steel could be made better or cheaper in the electric furnace. The general answer was, probably, that the more coke or coal was used, as fuel only, the better did electric smelting compete with the other processes. In fine crucible steel they had an expenditure on coke, as fuel, of 60s. to 70s. per ton of steel produced. If they took the consumption of electricity as 800 kw.-hours per ton, it would cost them, at ½d. per unit, 33s. 4d., so that they had a great margin, which was only slightly reduced by the cost of electrodes, &c. At the other end of the scale, for pig-iron they had a consumption of 2,000 kw.-hours per ton, costing nearly 84s., and this only represented a part of the coke, because they must still use the latter as a reducing agent. Between these two extremes there were intermediate stages at which the electric furnace could be economically introduced. In considering its application in place of crucibles, they must remember that they were limiting it to the conditions of the crucibles, and assuming that it would be working with the same pure materials; whereas, when they came to review the question all round, they recognised that it could start with cheaper material. An obvious application for the furnace was that of refining common Bessemer steel. In view of the importance of the subject of the electric furnace, he suggested that it should be officially considered by the Institute.

Mr. T. Rowlands (Sheffield) said it would be more correct to state that the South Chicago works were experimenting with the Héroult furnace than that they had adopted it. He wished for information as to the cost of electrodes for the large-sized furnaces. He understood that there had been considerable trouble with the carbon electrodes, and that graphite electrodes, costing 7½d. or 8d. a pound were being used.

Mr. F. W. Harbord (London) said that, from an economical point of view, the electric furnace could easily compete with the crucible. The next question was whether the quality of the product was equal, and he thought it must now be admitted that for practical purposes it was so. There might be some very special classes of steel which could only be produced from very carefully selected materials melted in a crucible, but for 90 per cent. of the purposes for which tool steel was required, electric steel, made by any of the well-known furnaces, met all the conditions. In the making of axles and tyres, too, there was a great opening for the electric furnace. It was useful in the making of moderately high-priced materials, very low in sulphur and phosphorus, but he did not think that, generally speaking, it could be applied to rail steel.

Mr. Campbell, in reply, said the making of rail steel at South Chicago might certainly be regarded as experimental. The work started in May, 1909, and several thousand tons of rails were made for the New York, Central Railroad, but until they had had a year's test it could not be decided whether the electric furnace should be used on a very large scale or not. In the meantime, it was being used chiefly for axles, tyres and castings with very satisfactory results. As to whether the electric furnace would displace the crucible furnace entirely, he said "No." He quite agreed that there were special cases where crucible steel would always hold its own, but there was a lot of steel made in Sheffield that could advantageously be made in the electric furnace.

THREE-PHASE ARC LAMP WITH FOUR CARBONS.*

BY ALDO RIGHI.

Before describing his particular design the author makes reference to the simple type proposed by the Edison Co. of Milan, in which three carbons—one connected to each phase—are arranged vertically with the arc underneath. The arc is maintained in this position due to the electro-dynamic action of the current. Experiments have also been carried out by R. Flemming, of Swampscott (Mass.), on lamps with six vertical carbons, the three top ones being each connected to a phase and the bottom three to the middle point of a star-wound transformer.

Mr. Mercanton, of Geneva, has constructed a lamp in which the carbons formed the edges of a regular trihedron, and moved in channels cut in a cone of refractory material. The circuits were Δ connected, and the regulation was effected by means of a differential three-phase motor.

Mr. Mercanton has closely investigated the efficiency of a lamp of this kind, using hand feeding for convenience, although a suitable mechanical regulator was devised by Bentivoglio & Siciliani, of Milan on the principle of two rotating fields in opposite directions.

With yellow flame carbons, 8 mm. diameter, and a current of

* Abstract of a Paper in the *Proc.* Assoc. Elettro. Italiana.

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20 amperes per phase at 38 volts and 38·5 ∞, the efficiency was found to be 0·16 watt per Hefner candle vertically and 0·217 horizontally. With plain carbons and a current of 15·17 amperes at 51 volts and 51 ∞, the corresponding figures are 0·192 and 0·58, whereas the ordinary monophase lamp has an average value of only 0·8 watt per Hefner candle-power.

Although the efficiency is relatively so high these lamps have scarcely come into practical use, probably because, as pointed out by Blondel at the Marseilles Congress in 1908, their candle-power is too high if they are to be stable, and also because it frequently happens that one of the arcs remains extinguished for a whole alternation. Due to this, the character of the light fluctuates more than would be expected, considering that at any instant there are always two arcs alight.

The new arrangement of carbons proposed by the author is the following. The three bottom carbons, of 8 mm. diameter, connected to each phase and adapted for fixing in the ordinary holder of a monophase lamp, are set vertically, so that they form the edges of a triangular prism, whose side measures 14 mm. to 15 mm. The fourth carbon, about 25 mm. diameter, is set above them co-axially with the prism, and is suspended in such a manner that it can deviate slightly from the vertical, so as to enable it to make simultaneous contact with the three bottom carbons.

In this way three star-connected arcs are formed with the production of six craters, which, as is well-known, are the main sources of luminosity in an arc lamp. Owing to the position of the three top craters the light is in great part thrown downwards without the necessity for using reflectors such as monophase lamps require.

The supply pressure can be adjusted either by impedances, or by transformers, mesh or star wound. In the latter case the fourth carbon can be connected to the centre point of the star. In the regulating mechanism the series coil carries the current of one phase, while the shunt coil may be connected between the fourth carbon and any one phase or between two phases. For the following experiments hand regulation was employed.

When the arcs are started between the three carbons, the fourth carbon, which at first is supported quite clear of them, is gradually lowered until it forms part of the path of the arcs and three craters are then developed in it.

During the movement there is not much change in the value of the current or the light emitted, but when the craters are once formed there is a marked diminution of the current, and the light, which to begin with, was fluctuating and badly distributed, undergoes a substantial increase, and gives a distribution which is well suited for illuminating purposes.

The author is unable to say *a priori* whether his arrangement should give a higher luminous efficiency than that of other three-phase lamps. He is content to emphasize the point that the increase in the number of craters (as was indeed to be anticipated) improves the efficiency.

He mentions another fact, which he is still investigating, and that is the very small consumption of the top carbon. In certain special conditions, instead of the craters, highly luminous prominences are formed extending towards the lower carbons.

The minimum frequency with which these lamps will work is an important point. In Mercanton's lamp as low a figure as 17 ∞ is possible, which can be explained by the close proximity of the three craters and the fact that at a given instant at least two of the arcs are alight, both causes preventing the cooling of the carbon points. In the author's arrangement it is hoped that lower working frequencies will be attainable on account of the great concentration of heat with the six craters.

The practical interest in this subject will be recognised, at least for conditions in Italy, on account of the numerous three-phase traction installations which run at 15 ∞ in that country. Arc lamps are at present debarred, as the monophase type will not work below 25 ∞.

The author hopes to return to the subject at a later date, more especially to determine the minimum possible frequency, and to give comparative figures for the luminous efficiency.

An Electrically-worked Passenger Counter.—According to the "Electric Railway Journal" a new mechanical device for registering the number of passengers as they pass into the McAdoo Hudson River tunnels is being installed for trial at the Hoboken, N.J., station. By interrupting a stream of compressed air, which holds an electric circuit open in an instrument across the passageway, each person completes the circuit and is registered. If this instrument continues to work successfully it may do away with the ticket checker.

HYSTERESIS LOOPS AND LISSAJOUS' FIGURES, AND THE ENERGY WASTED IN A HYSTERESIS LOOP.*

BY PROF. SILVANUS P. THOMPSON, D.SC., F.R.S.

Summary.—The author shows that any hysteresis loop can be analysed into a harmonic series of closed curves corresponding to the various terms in the analysis of the current wave. These constituents are examined in the Paper. Details are given of the analysis of various loops; the effect of eddy currents on the size and form of the loops is discussed, and an account is given of the effect of the higher sine and cosine constituents of the current wave.

Probably many physicists have attempted to find an explanation of the forms of the looped curves which express the hysteresis exhibited by iron and steel when subjected to cycles of magnetisation. Physical explanations to account for their general shape have indeed been given by Ewing and by Hopkinson. Neither of these pioneers, however, offered any mathematical equations to express their forms; nor, so far as appears, has any other person yet found any, though M. Pierre Weiss has put forward an electronic theory to account for the principal features. According to Ewing's molecular hypothesis of magnetism, the act of magnetisation consists in the orientation into a common direction of the axes of the elementary magnets constituted by the iron molecules which, when the mass of iron is in the unmagnetised state, are miscellaneous in their directions, the molecules being then arranged in groups within which the individuals are so oriented as to satisfy amongst themselves their various polarities in a more or less stable equilibrium. To deduce from this hypothesis an expression for the ascending curve of magnetisation, it might be possible to apply the statistical method, under the assumption that the number and variety of the groupings is enormously great. The ratio $d\mathfrak{B}/d\mathfrak{H}$ would represent at each stage the differential permeability of the specimen, or the rate (per unit of magnetising force) at which the magnetisation was proceeding; and this would at every stage be proportional to the probable number of groups that were coming into alignment, and to the magnitude of the aligning force. The expression would thus assume the form

$$\frac{d\mathfrak{B}}{d\mathfrak{H}} = a \cdot \epsilon^{-(\mathfrak{H}-b)^2},$$

where a and b are constants, the one denoting the maximum value of $d\mathfrak{B}/d\mathfrak{H}$, the other the particular value of $\mathfrak{H}$ at which that maximum is reached. The difficulty of integrating this expression is not the only objection to it; for it would at best give only the ascending curve of magnetisation, and additional assumptions would need to be made before it could be adapted to express the descending branch.

Hysteresis loops, as found by experiment, can, however, be considered from a wholly different standpoint. Whatever the law connecting $\mathfrak{B}$ and $\mathfrak{H}$, the area enclosed by the loop measures the amount of energy lost in the iron in the cycle of magnetic operations, the value, in ergs per cubic centimetre, being $\frac{1}{4\pi}\int \mathfrak{B} \cdot d\mathfrak{H}$.

Let it be assumed that the variations of $\mathfrak{H}$ are such that $\mathfrak{B}$ passes from the value $+\mathfrak{B}_1$ to $-\mathfrak{B}_1$ and back, through a regular cycle of values according to the expression $\mathfrak{B} = \mathfrak{B}_1 \cos\theta$; then, in general, the variations of $\mathfrak{H}$, though they go through a cycle, will not be capable of being expressed by any such simple form, otherwise the shape of the hysteresis loop would be simply an ellipse or, in the limiting case, a straight line. The fact that the magnetising current (and therefore the magnetising force) in choking coils and transformers does not follow a simple sine or cosine function is well known to all electrical engineers. In these instruments, if worked from a source of alternating E.M.F. in which the wave form of the supply is a pure sine curve, the wave form of the flux in the core, and therefore of the flux density $\mathfrak{B}$ in the core, will also be a pure sine curve having a lag of exactly 90 deg. with respect to the impressed voltage curve. Or if the impressed voltage is expressed by the equation $V = V_0 \sin\theta$, the flux density will be given by the equation $\mathfrak{B} = -\mathfrak{B}_0 \cos\theta$. But the current will not be capable of being expressed in any such simple fashion.† It has also long been known how these curves of magnetising current are related to the hysteresis loop. If the form of the hysteresis loop is known, then the form of the magnetising current can be deduced graphically. An example will be found in Kapp's "Transformers" (1908), Fig. 56, p. 106. Assuming that the flux density follows the equation given above, let

* Abstract of a Paper read before the Physical Society. A short account of the discussion on this Paper appeared in THE ELECTRICIAN, August 12, 1910, p. 735.

† These irregular current curves seem to have been first observed by Ryan, see "Transactions" of the American Institute of Electrical Engineers, Vol. III., January 10, 1890. *See also* THE ELECTRICIAN, Vol. XXIV., p. 239 and p. 263, January, 1890, and Vol. XXV., p. 312, July 25, 1890.

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it be plotted as a curve, with maximum ordinate equal to that of the hysteresis loop. Consider any point on this curve, or the point on the loop having the same ordinate; then the ordinate at the same instant on the current curve will be (on some scale) proportionate to the abscissa of the same point of the hysteresis loop; whence it follows that the current curve can be constructed, point by point, through the entire cycle. This process is followed here, save that for convenience the hysteresis loop is turned over through a right angle, so that the values of B are taken as abscissæ, and those of H as ordinates.

In Fig. 1 the hysteresis loop ABCDEF selected has been taken from Ewing's classical memoir of 1885. Assuming a closed magnetic circuit, and an impressed voltage of a pure sine form, marked V, the flux density curve is a sine curve lagging 90 deg. behind the voltage curve. Then the current curve is derived by taking any point P on the hysteresis loop, projecting it by first turning its abscissa through a quadrant about the centre O, then tracing along horizontally to the point Q on the flux density curve, where a vertical line, QM, is dropped. Then a horizontal line projected from P cuts QM in R, giving thus the corresponding point on the current curve, the peak of which, corresponding to the cusp of the loop, occurs at the time when the flux density curve is a maximum, and when the voltage curve is at its zero. It will be seen that the wave form of the current curve reflects, in a certain way, the form of the hysteresis loop. If the loop is sharply cusped, the wave curve will have corresponding sharp peaks. In fact, the loop consists of the two halves of the wave curve, folded back one upon another, but with the ordinates differently spaced, exactly as if the wave curve had been wrapped around a cylinder* and projected upon a plane cutting the cylinder diametrically through the two peaks of the curve.

Now this current curve can be subjected to harmonic analysis, and its harmonic constituents discovered. Each constituent will be a pure sine curve or cosine curve. If each such constituent be drawn, and then be projected back by reversal of the process by which the wave curve was obtained, the several constituents will

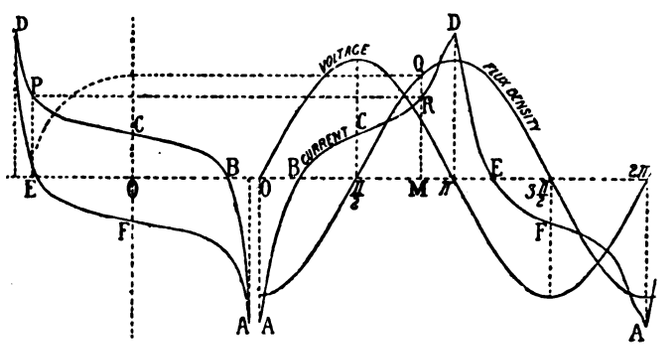


FIG. 1.—RELATION OF CURRENT CURVE TO HYSTERESIS.

reappear as separate closed curves; and by the summation of these the original hysteresis loop can be reconstituted. It thus appears that *any hysteresis loop can be analysed into an harmonic series of closed curves corresponding to the various terms in the analysis of the current wave.* An examination of these constituents of the hysteresis loop is the principal object of this communication.

In this graphic process, which is equivalent to wrapping the periodic curve around a cylinder, the area of the projected curve is equal to the integral, over the whole period, of products obtained by multiplying each ordinate by the sine of the angle at which it stands in the wave curve, abscissæ in that curve being reckoned as values of angles. (The origin of the cycle is taken where the curve has its negative peak.) In symbols this is equivalent to $\int_0^{2\pi} \sin\theta \,.\, \psi(\theta) \,.\, d\theta$. Now $\psi(\theta)$, the function which represents the current curve, may by Fourier's theorem be expanded into the series

$$A_1 \sin\theta + A_3 \sin 3\theta + A_5 \sin 5\theta + \ldots A_n \sin n\theta + B_1 \cos\theta + B_3 \cos 3\theta + B_5 \cos 5\theta + \ldots B_n \cos n\theta.$$

Odd terms only are present, as in all alternating current work; and there is no constant term, because the mean ordinate is already zero. The constituent terms in the area of the hysteresis loop correspond therefore to the integrated products of $\sin\theta$ into the successive terms of the above series.

To investigate the form of the constituent elements of the loop, let us consider a simple harmonic motion $x = X \sin\theta$, where θ stands for $2\pi ft$, f being the fundamental frequency and X the amplitude.

* As in the graphic method of harmonic analysis of Clifford described by Perry in "Proc." Phys. Soc., Vol. XIII.

This motion is to be compounded, at right angles, with another simple harmonic motion $y = Y_n \sin(n\theta + \phi_n)$, where Y_n is the amplitude, ϕ_n a possible angle of phase-difference, and n any (odd) integer giving the order of the harmonic. We have then to find an expression for the curve of which x and y are the co-ordinates. For simplicity we deduce the expressions where $n=1$, $n=3$, and $n=5$, that is for the first, third and fifth terms of the constituent elements.

First Term (Fundamental); $n=1$. We have

$$x/X = \sin\theta. \quad \ldots \quad (1)$$
$$y/Y_1 = \sin(\theta + \phi_1). \quad \ldots \quad (2)$$

Multiplying both sides of (1) by $\cos\phi_1$, we have

$x/X \cos\phi_1 = \sin\theta \,.\, \cos\phi_1$; also $y/Y_1 = \sin\theta \,.\, \cos\phi_1 + \cos\theta \,.\, \sin\phi_1$.

Subtracting this equation from the preceding, we have

$$x/X \cos\phi_1 - y/Y = -\cos\theta \,.\, \sin\phi_1. \quad \ldots \quad (3)$$

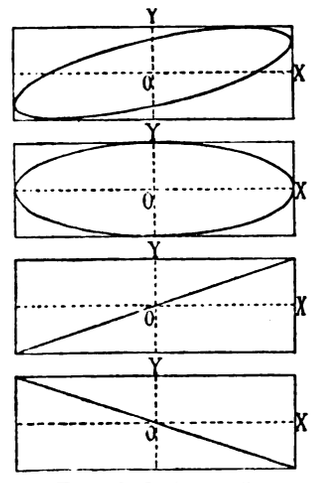
Multiplying (1) by $\sin\phi_1$, we get

$$x/X \sin\phi_1 = \sin\theta \,.\, \sin\phi_1. \quad \ldots \quad (4)$$

Squaring (3) and (4) and adding them gives us

$$\left(\frac{x}{X}\right)^2 + \left(\frac{y}{Y_1}\right)^2 - 2\frac{xy}{XY_1}\cos\phi_1 = \sin^2\phi_1. \quad \ldots \quad (5)$$

This is the equation to an ellipse, such as is represented by Fig. 2. According to the values given to ϕ_1 there arise three principal cases: (i.) If $\phi_1 = \frac{\pi}{2}$ or $3\frac{\pi}{2}$, the equation becomes $\frac{x^2}{X^2} + \frac{y^2}{Y_1^2} = 1$, an ellipse set orthogonally with respect to the co-ordinate axes (Fig. 3). (ii.) If $\phi_1 = 0$ the equation becomes $\frac{x^2}{X^2} + \frac{y^2}{Y_1^2} - 2\frac{xy}{XY_1} = 0$, whence $y = +\frac{Y_1}{X}x$, and the ellipse shrinks into a straight line as in Fig. 4. But its



FIGS. 2, 3, 4 AND 5.

length is limited by the prior expressions, since x and y cannot exceed X and Y_1 respectively. (iii.) If $\phi_1 = \pi$, the equation becomes $\frac{x^2}{X^2} + \frac{y^2}{Y_1^2} + 2\frac{xy}{XY_1} = 0$, or $y = -\frac{Y_1}{X}x$, which is a straight line sloping the reverse way as in Fig. 5.

For all other values of ϕ the ellipse takes some intermediate form. The sine-component of the first term in the harmonic analysis of the current curve corresponds to the orthogonal ellipse; the cosine-component to the oblique line form. All the intermediate forms of the ellipse could be obtained by wrapping a sine-curve of period T around a cylinder of diameter T/π and projecting in appropriate directions upon planes parallel to the axis of the cylinder the apparent outline of the sine-curve.

Third Term (Third Harmonic); $n=3$. Here the two equations are $x/X = \sin\theta$ and $y/Y_3 = \sin(3\theta + \phi_3)$. From these the author obtains the equation

$$\left(\frac{3x}{X} - \frac{4x^3}{X^3}\right)^2 + \left(\frac{y}{Y_3}\right)^2 - 2\left(\frac{3x}{X} - \frac{4x^3}{X^3}\right)\frac{y}{Y_3}\cos\phi_3 = \sin^2\phi_3,$$

which is the equation to a figure having the general form of Fig. 6, the well-known Lissajous' figure, compounded of two vibrations the frequencies of which are as 1 : 3. It could be obtained by taking three complete sine-waves, each of period T/3, and wrapping them around a cylinder of diameter T/π. Again there arise three cases:— (i.) $\phi_3 = \frac{1}{2}\pi$ or $\frac{3}{2}\pi$. (ii.) $\phi_3 = 0$ and $\phi_3 = \pi$. The corresponding curves are shown in Figs. 7, 8 and 9.

Fifth Term (Fifth Harmonic); $n=5$. The two equations now are $x/X = \sin\theta$ and $x/Y_5 = \sin(5\theta + \phi_5)$. From these the author obtains

$$\left(\frac{5x}{X} - \frac{20x^3}{X^3} + \frac{16x^5}{X^5}\right)^2 + \left(\frac{y}{Y_5}\right)^2 - 2\left(\frac{5x}{X} - \frac{20x^3}{X^3} + \frac{16x^5}{X^5}\right)\frac{y}{Y_5}\cos\phi_5 = \sin^2\phi_5.$$

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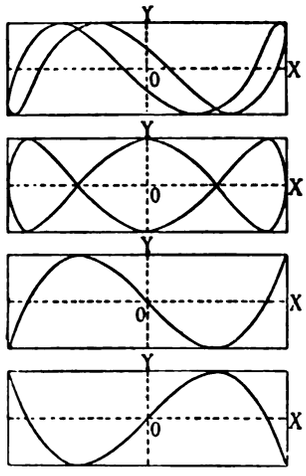
This is the equation of the general Lissajous' figure of the fifth order, representing the result of compounding two vibrations having relative frequencies of 1 : 5, and a general form like Fig. 10. As before, three cases arise: (i.) $\phi_5 = \frac{1}{2}\pi$ or $\frac{3}{2}\pi$. (ii.) $\phi_5 = 0$. (iii.) $\phi_5 = \pi$. The corresponding curves are shown in Figs. 11, 12 and 13.



FIGS. 6, 7, 8 AND 9.

The Higher Terms (generalised expression for the Lissajous' Curve of the nth term).—The expression for any higher term has the general form

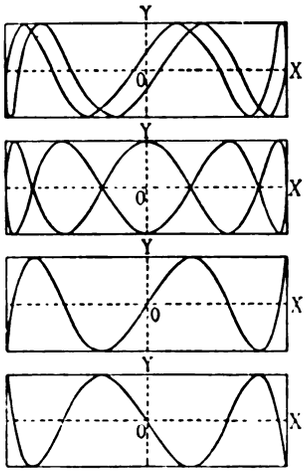
$$G_n^2 + \left(\frac{y}{Y_n}\right)^2 - 2G_n\frac{y}{Y_n} \cdot \cos\phi^n = \sin^2\phi_n,$$

which reduces in the case of symmetry to $G_n^2 + \left(\frac{y}{Y_n}\right)^2 = 1$, and, in cases where $\phi_n = 0$, to $G_n \pm \frac{y}{Y_n} = 0$, in which expressions G_n is written for the series

$$G_n = n\frac{x}{X} - C_3\frac{x^3}{X_3} + C_5\frac{x^5}{X^5} - C_7\frac{x^7}{X^7} + \ldots + C_n(-1)^{\frac{n-1}{2}} \cdot \frac{x^n}{X^n},$$

where $C_r = \frac{n(n^2-1^2)(n^2-3^2)\ldots\ldots(n^2-r-2^2)}{\lfloor r}$, where r is an odd number greater than unity.

It is now possible to re-state the proposition italicised earlier in the Paper in the following way. *Any hysteresis loop can be analysed into an harmonic series of Lissajous' figures* of the kind just considered.



FIGS. 10, 11, 12 AND 13.

A number of examples of hysteresis loops were chosen, and subjected to harmonic analysis, to ascertain what constituents were present. The loops chosen relate to various kinds of iron and steel, hard and soft, solid and laminated, taken by various methods; a wide selection being made in order to ascertain the physical significance of the several constituent terms. In carrying out the analysis the author used the simple approximate method described by him to the Physical Society, December 9, 1904. It was found that for the present purpose it sufficed to ascertain the harmonic sine and cosine terms up to the eleventh, and therefore to employ 12 equidistant ordinates in the half-period. At first the values of the 12 ordinates required for the analysis were taken from the current curve plotted, as explained above, from the hysteresis loop. But it was seen that it was unnecessary to draw the current curve, and that the values of the ordinates might be taken direct from the hysteresis curve, by taking them not equidistant, but at places corresponding to equidistant points in the axis of abscissæ of the wave curve, which points, when the curve is wrapped round a cylinder, will no longer appear equidistant.

Fig. 14 shows one of the several results given by the author. The example is Ewing's loop for annealed iron wire, being Fig. 5 of Plate LVIII. of "Phil. Trans." 1885. The analysis gives:—

Sine terms.	Cosine terms.
$A_1 = 3{\cdot}98$	$B_1 = -7{\cdot}38$
$A_3 = 2{\cdot}14$	$B_3 = -4{\cdot}74$
$A_5 = 1{\cdot}36$	$B_5 = -2{\cdot}04$
$A_7 = 0{\cdot}88$	$B_7 = -3{\cdot}78$
$A_9 = 0{\cdot}16$	$B_9 = -2{\cdot}14$
$A_{11} = 0{\cdot}14$	$B_{11} = -1{\cdot}90$

The ellipse and the straight line, corresponding respectively to A_1 and B_1, have been added in dotted lines in the figure.

Work done in the Cycle.—It was early pointed out by Warburg and by Ewing that the work spent in carrying the iron through a cycle of magnetising operations was represented by the area of the hysteresis loop. We now consider this from another point of view. Whatever work is spent in magnetising the iron is derived from the electric energy which is imparted by the circuit, and this, at any

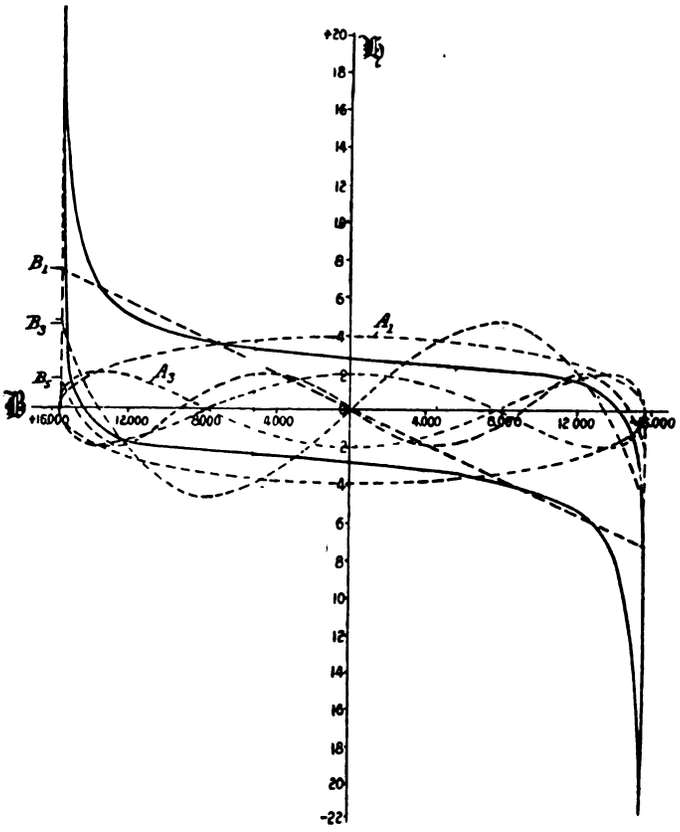


FIG. 14.

instant, is proportional to the product of the current and potential at that instant. If the voltage is represented by the expression $V = V_0 \sin pt$, where p stands for $2\pi f$, and if the current, being some periodic function of the time, is represented as $C = \psi(pt)$, then the element of work imparted to the circuit during time dt being $CV dt$, the work given to the iron (if the copper resistance is negligible) during one cycle will be

$$V_0 \int_0^T \sin pt \cdot \psi(pt) \cdot dt.$$

But $\psi(pt)$ consists (see above) of a series of harmonic sine and cosine terms. The quantities which will be formed by multiplying the members of that series by $\sin pt$, and integrating each product over a whole period, will fall under three kinds, the values of which are known, viz.:—

(i.) $\int_0^T \sin pt \cdot A_n \sin npt \cdot dt = 0$ (except when $n = 1$);

(ii.) $\int_0^T \sin pt \cdot B_n \cos npt \cdot dt = 0$ (in all cases);

(iii.) $\int_0^T A_1 \cdot \sin^2 pt \cdot dt = A_1 \cdot \frac{T}{2}$.

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That is, *the only work done in the cycle* is that done by that constituent of the current which is in phase with the voltage, namely, its fundamental sine term. *All other constituents are wattless.* And since the area of the loop represents the work done, it follows that the area of the hysteresis loop is equal to the area of the orthogonal ellipse which is its fundamental constituent of the sine series. *The true and fundamental form of every hysteresis loop is therefore an orthogonally placed ellipse.* All departures from that form are wattless—are mere distortions which involve no expenditure of energy. The area of the hysteresis loop is proportional to the maximum value of $\mathfrak{B}$ and to the amplitude of the first sine term into which the values of $\mathfrak{H}$ (corresponding to the values of the current) can be analysed. If the value of the amplitude of that sine-term be denoted by $\mathfrak{H}_1$, then the area of the loop is accurately given by the expression $\frac{\pi}{4} \times \mathfrak{B}_{max.} \times \mathfrak{H}_1$, being the area of the fundamental elliptical constituent.

Presence of Eddy Currents.—If the hysteresis loop has been produced by some slow process, absence of eddy currents may be assumed. But this is by no means the case when alternating currents of ordinary frequencies are used, even if the iron be finely laminated. It therefore remains to be seen how the presence of eddy currents will affect the size and form of the hysteresis loop. The eddy current, being a secondary current, will be of pure sinusoidal form only if the inducing E.M.F. be of a pure sinusoidal form, and if the resistance and permeability be constant also. But it is not necessarily in phase with the impressed E.M.F., but may lag by magnetic reaction, and indeed, as is already known, lags by different amounts at different depths below the surface of the iron. Assuming equal permeability and resistance in the different layers, the effect of the eddy current will be represented with sufficient accuracy by a sine-curve lagging by an amount that will depend on conditions into which there is no need here to enter. For

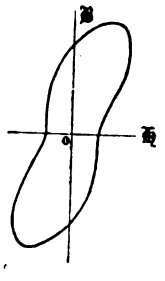

Fig. 15.

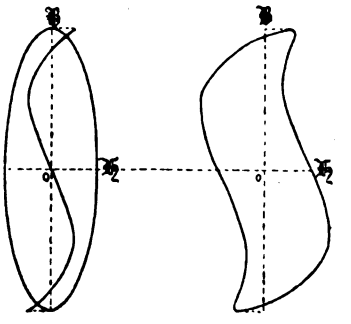

Fig. 16.

here, again, the only effective component—effective, that is, in the sense of involving expenditure of energy—is the sine-component in phase with the voltage, and the element which the sine-component contributes to the loop is an orthogonal ellipse. So far as it lags it possesses a cosine-component, and this contributes to the loop only an oblique line, shearing the loop over; but this constituent is wattless. Harmonic analysis cannot of itself distinguish as to how much of the fundamental elliptical constituent of the loop, or of the fundamental sine-component of the magnetising current, is due to eddy currents and how much to hysteresis. It is, indeed, already known* that the effect of eddy-currents is to widen out the loop elliptically.

Effect of the Higher Sine-Constituents.—The third harmonic has been noted above. Indeed, it is usually present. A fine example is afforded by the curve, Fig. 15, taken from Fleming's "Alternate Current Transformer." It is obvious that the effect of superposing a third-term sine-constituent upon the fundamental ellipse will be to narrow it at the middle. It will widen it towards the ends, the widening beginning at a distance of 0·134 of the semi-major axis from the ends. If sine-constituents were present, of all orders, in the following proportions, $A_1=1$, $A_3=\frac{1}{3}$, $A_5=\frac{1}{5}$ ..... $A_n=\frac{1}{n}$, the form of the loop would become a pure rectangle.

The half-width of any static hysteresis loop, which is commonly taken (following Hopkinson) as a measure of the coercive force, is independent of all the cosine terms, and is in all cases equal to $A_1-A_3+A_5-A_7+A_9-$, &c. For loops of equal height (that is, equal maxima of flux density) the coercive force is not proportional to the work spent in the cycle; for the work spent in the cycle is represented by the area of the loop, and, as shown above, this is invariably proportional to A_1, while the coercive force is represented by the sum of the series named in the previous sentence. Since in static hysteresis loops the fifth and higher terms are practically absent, the coercive force is proportional to A_1-A_3.

Effect of the Cosine-Constituents.—As already seen, the fundamental cosine-constituent is an oblique line. It is in reality a double line, traversed upwards during half the cycle, and downwards during the other half. The effect of superposing this constituent upon the fundamental ellipse is to shear it over. Cosine-components are always negative, corresponding to lagging constituents of the wave-curve. They shear the $\mathfrak{B}$-$\mathfrak{H}$ curve over toward the right, on the ascending side. If a mass of iron undergoing magnetisation is traversed by an air-gap, or is constituted as a non-closed magnetic

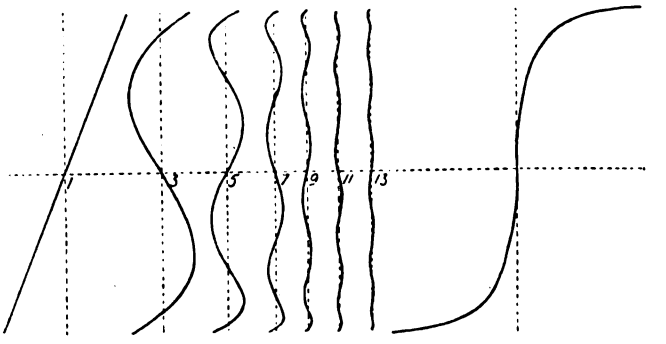

Fig. 17.

circuit, the reaction of the air-gap brings a lagging constituent into the magnetising current, imposing a negative cosine-constituent upon the loop, and shearing it over.

The presence of negative cosine constituents in hysteresis loops is specially marked in those beaked forms which are obtained when the magnetisation has been pushed to high degrees of saturation: the diminished permeability of the material resulting in a diminished reactance, and therefore in a disproportionate increase in the magnetising current. Fig. 16 shows the result of superposing a negative third cosine constituent upon the ellipse. But this particular figure, resembling a capital S, could not result from any experiment, as neither the ascending nor the descending half is single valued. Such a curve would be unstable; and the ascending branch could, at most, ascend parallel to the $\mathfrak{B}$ axis before turning

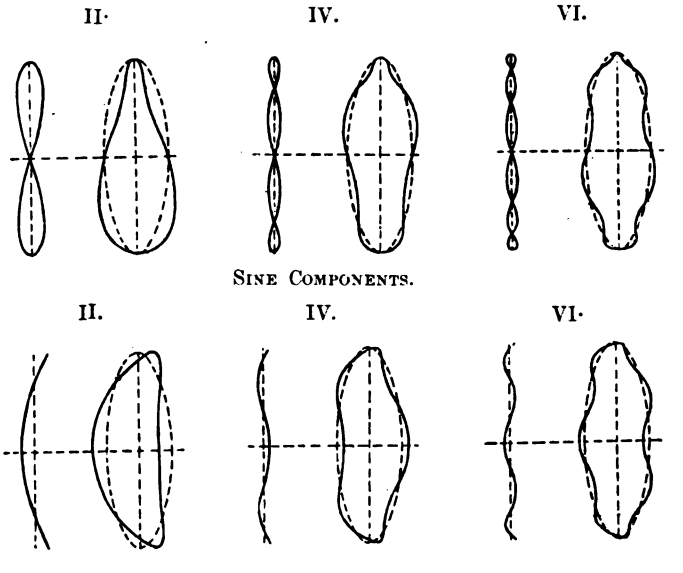

Fig. 18.

to the cusp. Is it too remote to speculate that the vertical portions of the loops experimentally found for soft iron really do represent instabilities, and mask the true forms of the loops?

It is noticed that in the analyses of some of the loops the amplitudes of the negative cosine terms appear in a descending set of values. If these amplitudes are of relative magnitudes as $1:\frac{1}{2}:\frac{1}{4}:\frac{1}{8}$, &c., the resultant curve will have its middle portion truly vertical. Fig. 17 gives a set of such curves up to the thirteenth order, together with their resultant. If this resultant is then superposed on a fundamental ellipse, the result is a characteristic two-beaked loop. The horizontal

* *See* Angström, *op. citat.*; and Heinke, "Die Electrophysik" (1904), p. 500.

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length from the cusp to the vertical axis (*i.e.*, the amplitude of ϕ at its maximum) is in all cases equal to $B_1 + B_3 + B_5 + B_7$, &c.

Effect of Harmonic Constituents of Even Orders.—If constituents of even orders could exist, they would produce distortions of the loop, such as are shown in Fig. 18. No such distortions have ever been observed.

Hysteresis is commonly regarded as an irreversible process, and as such involving a degradation of energy into heat. But in view of the present analysis of the hysteresis loop it is necessary to revise this opinion. In the first place, no energy is wasted in producing any cosine component of the loop. In the case of the first cosine term—the oblique line—the distortion is a mere shear. True energy is spent in half the cycle in producing the magnetic flux, but that energy is returned to the magnetising circuit during the other half of the cycle, exactly as it is in the case of the production of a magnetic flux in a solenoid devoid of iron. The like is true of the higher cosine components. Also the sine components higher than the first represent reversible processes. The only component which represents an irreversible process is the fundamental sine component, the ellipse, itself due to that component of current which is in phase with the voltage. This irreversible part is due in detail to an energy waste which at every instant is proportional to the square of the magnetising current, and is in phase with it. True hysteresis waste accompanies the current, and does not either lag behind it or precede it. True hysteresis does not cause any lag in the current, being necessarily simultaneous with it. True, the curve of the flux density always lags 90 deg. behind the voltage curve, and therefore 90 deg. behind the effective component of the current curve. Of the reversible components, it is the first cosine term which is concerned in the lag of the current, and the lagging component of current is wattless. The higher cosine components conjointly produce additional lags, and are also wattless. The higher sine components, also wattless, do not cause any lag of the current as a whole. The name "hysteresis" was originally given* to the phenomenon to connote an effect which lagged behind its cause. The term is now usually restricted to the phenomenon of energy waste. But the energy waste does not involve or produce any phenomenon of lag. On the contrary, as it is a simultaneous phenomenon, its presence actually produces an advance in the phase of an otherwise lagging current. The greater the reluctance of the magnetic circuit, the greater the angle of lag. The less the permeability which enters into that reluctance the greater is the angle of lag. The lagging components, that is the cosine components of the loop, so far as they are not due to eddy currents, depend solely upon the reduction of the permeability of the iron during the process of the cycle of magnetisation. The lag is in fact due to components other than the fundamental component which represents the true hysteresis.

ELECTRIC RAILWAY CATENARY TROLLEY CONSTRUCTION.†

DISCUSSION.

Mr. P. H. Thomas asked as to the practicability of obtaining sparkless action in pantagraph trolleys by having a relatively light piece on the top of the pantagraph which would have the least possible inertia. The heavy arms would then not be required to follow every slight movement of the sliding contact.

Mr. C. J. Hixson said the vertical flexibility of the trolley wire seemed the keynote to the successful collection of the current. The general conditions of stability and of sidewise anchorage limited the vertical flexibility to a few inches, and it was necessary to assist this flexibility by frequent supports or hangers. The height of the wave in the trolley wire as the collector passed along should be such as to take up all the sag between hangers and still raise the hanger a couple of inches as it passed under it. The lifting of the hanger to a floating position eliminated the blow that would be delivered to a rigid support. Catenary hangers rigidly connected became increasingly hard as the bracket-arm was approached. With a flexible hanger the increased and ever present flexibility at the point of contact compensated in a measure for the inherent sluggishness of the roller pantagraph. For very heavy currents with two trolley wires side by side vertical flexibility was of great assistance in keeping the necessary contact pressure down to a modest figure and yet maintaining continuous contact with both wires at all times. In order to have vertical flexibility the strain in the trolley wire should be moderate, say, from 1,200 lb. to 1,500 lb. With this tension, with hangers 13 ft. apart and with a No. 4/0 trolley wire, a vertical flexibility of an inch or so could be attained with an upward pressure of about 7 lb. This low tension in the trolley reduced the strain upon pull-offs, anchorages, strain insulators, and the line in general, thereby decreasing the original cost and the cost of maintenance. The trolley wire was held best on curves by frequent pull-offs. This gave maximum flexibility with low stresses and moderately strong strain insulators. On earlier installations steady braces were used, but they had now been superseded either by flexible pull-offs or line steadiers. In conclusion, he mentioned thata single messenger flexible catenary had been in successful operation for the past two years upon the Saratoga division of the Schenectady Railway. There had been no sign of wearing the galvanising on the messenger wire due to the movement of the loop, as the sides of the same seldom if ever more than just touched the messenger wire.

Mr. R. D. Coombs considered that since the track on which the equipment ran was not a plane, but a series of vertical curves, it was entirely unnecessary to attempt to keep the trolley wire perfectly horizontal. The question of flexibility was as yet very uncertain. The Germans had used a secondary catenary, and according to their statement it was entirely successful, but their speeds and trainloads were less than in America. The experiments made by the Pennsylvania Tunnel & Terminal Railroad seemed to indicate that a single catenary with a very light hanger, composed of a flat section, 1⅛ in. by ¼ in., looped over the messenger, and with the ordinary type of ear, was about as successful during the limited range of those experiments, as the German type with the auxiliary catenary. He believed that a light hanger, particularly in conjunction with a trolley wire having considerable stiffness and strength, possibly a steel trolley wire, as used on part of the New Haven installation, with either a copper messenger or copper feed wire to provide the necessary conductivity, would be a combination worth very carefu investigation, and perhaps some experimentation. The little hanger which looped over the secondary wire and attached to the trolley wire permitted vertical movement, but seemed to have a tendency to roll. On a portion of the experimental line, in putting up the trolley wire it was found that the trolley wire had a twist or roll in it, and that the little hanger above the car rolled laterally and became, to a certain extent, bound, particularly at a pull-off. He doubted whether it was necessary to pull the trolley wire to an excessive tension; and he believed it to be a subject which required more investigation. The pantagraph had always seemed to him to be a suitable field for experiments, and he noted that the secondary flapper, according to the statements of the German engineers, had given entire satisfaction abroad. He had been told that their auxiliary arrangement on top of the pantagraph gave entire satisfaction and that it did not spark. Their speeds were less than in America, and their train-loads were also less; but if these pantagraphs had given the satisfaction abroad which it was claimed, it would certainly seem that the pantagraph was a field for further experimentation and improvement.

Mr. R. C. Thurston said that during a high wind and from the rolling of the car, unless the wires were in ideal condition, there was a good deal of slack wire, which would cause the trolley or the pantagraph to go on one side and dip, and while over, allow the ends of the shoe to hit the cross-arm. If the wire was perfectly tight this would not happen. When their road was first installed they had no such trouble, but after the heat of summer and the cold of winter had expanded and contracted the wire there was slack. But owing to the expense and the lack of time between trains, it was not always advisable to pull a slack wire tight. The spacing rods were clamped tight to the messenger wires. He believed there should be a loop at the top of the spacing rod to allow the spacing rod to slide along the messenger wire, as the slack in the trolley wire would not then form the kinks in the trolley wire that it did now. They had had several bad cases of breaks in the copper wire and the break was not sudden, but was found to be an old fracture, probably caused by the pounding of the shoe. As these breaks did not occur in cold weather, it showed they were not from contraction of the wire through cold. The break was always formed after the car had passed.

Mr. C. R. Harte thought it was too often forgotten that the overhead construction of an electric railroad served in two capacities: As a conductor its function was simple and well understood; that it was also the track upon which the collector travelled at high speed was too frequently ignored, although it was in this latter capacity that practically all of the serious problems and difficulties arose. Up to the present time developments had indicated that the flexible line was easier of attainment than the rigid type; the writer believed, however, that the possibilities of the rigid construction had been by no means exhausted, and he hoped to see further experiment in that direction. The unfavourable condition was that in which whatever the cause, the trolley wire tended to bend on a short radius. A truly straight trolley wire was by no means a necessity. It was not the amount of the intersection angle at directional changes, but rather the shortness of radius of the enclosed curve that caused injury. With a long radius bend, and a type of support which would either gradually damp out the displacement wave or would transmit it without material interference, a heavily sagged trolley ought to give excellent service under severest conditions. Such a type of suspension, employing spans of 240 ft. with a sag of 30 in., the wire being carried in a curved ear of special design, and some 44 in. long, had been proposed by Mr. J. Mayer, but so far as the writer was aware had never been actually tried out. The author, in describing double catenary construction, had said, "The excessive rigidity of this type has been found undesirable in practical operation." As an unconditional statement this was open to question. It was quite true that the first installation of this type to receive a thorough try-out was not entirely satisfactory, but the difficulty arose from the fact that while the hangers were very rigid, the line between yielded. At the critical speed the resultant chatter of the collector became synchronous with its period of vibration, and the line received severe punishment from the heavy blows of the pantagraph, in addition to the tendency to crystallisation from bend reversals. The difficulty was most successfully overcome by duplexing the trolley, attaching the lower wire to the old trolley only at the centres of the

* Ewing. Phil. Trans. 1885, Pt. II., p. 524.

† Discussion on a Paper read before the American Institute of Electrical Engineers. An abstract of this Paper was given in our issues of September 16th and 30th.

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secondary spans, but it was at least open to question if equally good results would not have been obtained had the line been made uniformly rigid by the use of a tee or similar stiff section attached to the hangers. As pointed out by the author, the question of the side clearances of poles was very important on electrifications, and particularly so on railroads with block signals. 8 ft. from centre of track to face of pole brought the latter practically in line with the signal mast in its usual position, and the engineer or motorman was hedged by an apparently solid wall of poles, behind which except as it was very near, nothing could be seen. Certain types of signal employed a centrally pivoted blade, half being in front of the mast, to obviate this difficulty of sighting, but even for this 10 ft. clearance from track centre to face of pole was little enough. The author's conclusion that the trolley wire should very closely follow the centre line of the track would have the endorsement of practically all operating men, particularly if qualified by the further proposition that for wheel work the centre of the track was to be considered projected through the centre line of the car, in order to meet the offsetting of the wheel by the super elevation of the rail. This same offsetting affected the lengths of brackets on curves particularly if the poles were on the outside, in which case the bracket bar would often have to be materially longer than the standard. Operating men generally would further agree with the author that the irregular and unavoidable cross motion of the shoe, due to various car movements and sways, entirely obviated the necessity—and most undesirable complication—of staggering the trolley wire to prevent localised wear on the collector. To secure the desired alignment on curves, the preference of the writer was with the method by bridle between poles from which were taken equidistant pull-offs. The matter of proper tension in the wire was complicated by the fact that conditions preventing excessive sag at high temperature resulted in very high stresses at low temperatures. How closely these stresses might approach the actual breaking strength of the wire was not always realised. Grooved 4/0 copper trolley was usually credited by the handbooks with a breaking strength of from 8,000 lb. to 8,400 lb. A series of tests made by the writer, however, on commercial stock samples gave a maximum of barely 7,100 lb. on the unbrazed portion, with an average at brazes of 5,600 lb., two samples failing below 5,000 lb. While there were some differences as to detail, commercial trolley wire was in general made from a "wire bar" of rectangular section, which was first rolled down to a round rod and then finished by drawing. Brazing was usually done just before drawing, and in the samples tested it was evident that the latter treatment was not sufficient to overcome the local annealing at the surfaces of the braze. It was generally believed by users that trolley wire could with advantage receive further treatment than was at present usual, for the market material of to-day certainly had decidedly less resistance to wear than the earlier output. The writer was watching a working test of especially rolled wire which gave to 4/0 grooved copper an average breaking strength of practically 9,000 lb. But it was after all an illogical proceeding to impose the duty of resisting the abrasive action of the collector upon that member of the overhead which by nature was least adapted to resist wear, and functionally was most affected by loss of section, as was the case when the trolley wire was of copper. The author would doubtless be interested to know that his suggestion of a steel trolley and copper messenger had actually been in service for over a year. The trolley wire was identical in section with 4/0 grooved copper; the messenger was 19 strand bare copper wire cable sagged 24 in. for standard spans of 150 ft. This was on the experimental catenary section of the Connecticut Company's Hartford–Middletown line. At night the wheel had a bright tail of light, but the actual wear in over a year's service was inappreciable, and this was also true of the messenger where it was feared the loops of the sliding hangers might cut the copper. This latter would indicate less danger to galvanising on a steel messenger from sliding hangers than had been anticipated by some. The Connecticut Company's experimental catenary had not had long enough service for final deductions as to the most desirable type of hangers, but indications seemed to point to the old mechanical screw clamp ear with light hanger rod rigidly fastened to the ear and looped over the messenger. The screws should be long enough to head up after the trolley was gripped; if this was properly done the type was at least as efficient as the more elaborate forms and was far simpler. In this connection the author expressed a preference for "a nut screwing down on the lower end of the hanger rod." In the writer's experience, while the nut could not escape, it had been found necessary for such types of hangers to be fitted with a lock-nut, as otherwise the main nut backed up to the rod enough to loosen the clamp and permit serious wear. Rigid hangers required high trolley tension, and in case of relative movement of trolley and messenger were apt to come to grief; hinged types, if jointed top and bottom and rigidly gripped to messenger, allowed relative movement and gave a little flexibility that hardly seemed commensurate with the complication. Bottom slide hangers seemed unduly subject to wear, but had the marked advantage that the parts lifted were all of equal weight. The foreign sliding hanger lines had a secondary messenger of very slight sag and the loop hangers were all of equal length and weight; that satisfactory results were not obtained on certain American lines where hangers varied in length from 4 in. to 20 in. was hardly surprising. Long loop-hangers hinged at the ear had a tendency to tip when lifted, and sliding down the messenger lost their characteristic feature: and as a result of the shortened effective length, picked up the trolley. Hangers with jaws closing symmetrically with reference to the rod would, within the limits of their capacity, take various wire sizes equally well; hangers in which the jaws did not so move, however, while they had a small range, did not work well on sizes other than the one for which they were designed. For shoe work the contour of the jaws was of less importance; for wheel work it was essential that the jaws gave good clearance lines, or, particularly on curves, they would be badly pounded. The matter of hanger spacing was one on which was needed much practical information. It was the general impression that for shoe work the secondary spans should be very short; the writer knew of no installation on which long secondaries had actually been tried out, but it would seem that the manifest economy, if the number of hangers could be materially reduced without impairing the efficiency, warranted careful investigation. The author's hope that further investigations would be made in regard to roller types of collar would be shared by all who had investigated the subject, and it was by no means impossible that a modification of the present form of trolley wheel might be of much value. The writer had for some time had in mind a shoe design in which the main pantagraph movement ranging through several feet should be effected by some positive mechanical device, probably a pneumatic cylinder, the air supply to be controlled by a sensitive contactor mounted on the main pantagraph. This contactor, having little inertia and therefore able to follow the wire almost instantly, would take care of variations within its range of about 1 ft. each side of the middle point.

Mr. O. S. Lyford, jun., considered the ideal conductor for the distribution of electric power for heavy railway operation was one that was either absolutely flexible or absolutely rigid, and parallel to the running rails. For low voltage work, which in heavy service involved the collection of large currents, the tendency was towards the rigid conductor, as characterised by the third rail. For high voltage work and consequent low current the tendency was towards absolute flexibility of structure, and catenary trolley construction had been the best development thus far. Improvements in third rail construction had been in the direction of greater rigidity and improvements in catenary construction towards greater flexibility. For intermediate voltages, it remained to be seen what construction would prevail and neither of these two, as now developed, was entirely suitable. There was still room for the development of a light form of pole to take the place of wood. One of the principal criticisms which maintenance-of-way officials made to electrification with the overhead trolley system was the danger to persons and property in the case of a derailment or collision which might result in overthrowing the overhead structure. It had been found that with wooden poles supporting a strong catenary structure, a derailment would result in cutting away the pole without bringing down the conductors. Heavy bridge work or heavy steel pole structures would not act as satisfactorily in such accidents. Referring to the various forms of catenary hanger illustrated, one point which should be looked out for was that the hangers should not damage the galvanising of the messenger cable. This cable was an expensive item of the catenary structure and one hard to replace without delay to the traffic. A form of hanger which had a flat loop over the messenger wire was, therefore, safer than a sister hook construction or any other form in which the cable might be more or less cramped. As Mr. Thurston had pointed out, the design of the loop over the messenger should be such that the hanger could be moved along the messenger easily. The author mentioned an excellent point about the disc type of insulator—that there was mechanical linkage of the guy cables on the opposite sides of it, which prevented their falling apart if the porcelain broke. This feature should be incorporated in all strain insulator construction. It could not, however, be incorporated in such wood strain insulators as were now employed, and this was one of the principal objections to the use of wood, as either burning or breaking of the wood would throw the overhead structure out of alignment and possibly cause it to drop.

Mr. W. H. Kempton raised a point in regard to the length of the brackets for a spacing of 8 ft. between the centre of the track and the centre of the pole. He found it was necessary to use a longer bracket on curves than on tangent, when the poles were placed on the outside of the curve. This was due to the rake of the pole in one direction, and the elevation of the track in the other. With these conditions it was necessary to use extra long brackets on curves, or longer ones everywhere. The author spoke of lining up trolley wires on the curves when pantagraph trolleys were used. The speaker thought it was unwise to allow as much deviation from the centre line on curves as was the practice at the beginning. There were four considerations to be borne in mind in this connection. One was the rake of the pole, (2) the elevation of the outer rail, (3) the speed, (4) the play of the bolsters on the car. At standstill or at slow speed on curves the pantagraph trolley tended to swing toward the inside of the curve; but when running round the curve at 40 miles an hour the momentum of the car threw it over on the bolsters towards the outside of the curve so that there was a difference of from 10 in. to 12 in. in the position of the trolley with respect to the wire. In one case, the line had been constructed very carefully, but in spite of that the pantagraph trolley would swing out free from the trolley wire and pull down some of the line or pull the trolley from the wire. It looked impossible from measurements on the line until it was discovered that the construction of the car allowed it to swing over on the bolsters when going around the curve at high speed, sufficient to throw the pantagraph clear of the trolley wire. The remedy in that case was to re-line-up the trolley wire and add more poles or pull-offs where necessary to reduce the offset of the trolley wire, and then fix up the car to avoid such excessive swaying. This was one of the personal experiences the speaker had had emphasising the care that must be exercised in the erecting of a trolley line on which pantagraph trolleys were to be used.

Mr. W. N. Smith, in reply, thought that Mr. Coombs had answered Mr. Thomas's question in respect to the secondary arm or tip which had sometimes been employed at the top of the main pantagraph. This device had been used on the Simplon tunnel locomotives with sliding shoe on the tip. The Simplon locomotives travelled with a maximum speed of 45 miles per hour and the contact shoes were of the sliding type.

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Even with the lessened inertia of this device, the shoes only lasted about 1,700 miles. The fact that the old pole and wheel trolley operated so well with trolley wires having considerable sag, illustrated the importance of recognising wave action, which was so much in evidence with the wheel type trolley, and this confirmed his belief that the natural and desirable wave action in the trolley wire would be very much helped by the roller pantagraph, and with less wear and tear than with the sliding pantagraph. This point of view was based upon the probability that the heavy work of the future would be at high tensions—*i.e.*, at 11,000 volts or higher—and that the trolley pole and the narrow grooved wheel accompanying it would not be regarded as thoroughly reliable for high-speed operation under steam railroad conditions, so that it would be necessary to have a transverse rolling or sliding contact which would not leave the wire under any circumstances. With respect to the possible twisting in the compound catenary construction, where the wires were strung to a fairly even tension, and the hangers of the proper length, and all parts securely and tightly drawn up, there would not be any tendency to roll when the line was properly adjusted. Mr. Harte had emphasised the interesting fact that successful operation depended upon uniformity of resistance at the contact surface—*i.e.*, hard spots should be kept out of a yielding line, or soft spots out of a hard line—or, in other words, the line should be either uniformly hard or uniformly yielding. The successful operation of the Denver & Interurban catenary line had been due to the fact that it was uniformly hard and smooth. The experimental lines constructed with flexible hangers mentioned by Mr. Hixson and Mr. Harte would doubtless have considerable effect in determining the development of catenary details, but it now appeared that both the Schenectady and Connecticut lines were operating with wheel trolleys and not with sliding bows. It seemed that the contact-making conditions which must ultimately be fulfilled by equipment for heavy traction were not being met in these installations, and to that extent they would be somewhat inconclusive. If they should be tried out with pantagraph trolleys of the sliding or roller type, then there would be something definite upon which to base conclusions for the heavy and high speed work of the future. The question of clearance was, of course, one that pertained to conditions on each particular job; 8 ft. was mentioned as a minimum. He believed, however, that 8½ ft. was better, as used on the Denver & Interurban line. The roller type of trolley contact had been in use in Europe for some years; the Valtellina installation in Italy being perhaps the best known instance of its application there. He referred to its use on the Pacific coast as the first and only application of its use in America. Since writing the Paper he had ascertained that on the Valtellina line, where the overhead construction was not very tight (and not of the catenary type) the rollers had an average life of 15,500 miles and frequently carried more than 200 amperes per roller, and that in the opinion of Mr. Von Kando, of the Italian Westinghouse Company, the excellent life of the contact roller was due partly to the difference between rolling and sliding friction and partly to the fact that each element of the roller was heated by the passing current only at the instant of contact, and did not remain in contact long enough to get melted; while with the sliding contact the wear was excessive when the current was more than 50 amperes. It seemed to be agreed that the vertical flexible working conductor was very desirable, and the best reports of smooth operation with it emanated from installations where the rolling and not the sliding contact was used. It was his belief that trolley pole and wheel were not suitable for heavy railroad operation at high tensions and speeds, and that the horizontal transverse form of contact device was indispensable under such conditions, and he suggested that the next step forward should be in the development of the roller type of contact against the yielding or floating trolley wire, in which the elements of wire tension, contact pressure and pantagraph inertia would be compromised to produce the desired effect.

RESULTS OBTAINED BY THE USE OF CAR METERS ON TRAMWAYS.*

BY G. BOUTON.

From the answers to the *questionnaire* it appears that 37 undertakings have definitely adopted the method of controlling their motormen by means of meters. Twelve others are carrying on tests towards this end, while three, on the contrary, have definitely renounced the use of these instruments. It is interesting to note that in 1906 only 10 undertakings, and in 1908 26 undertakings, were using this apparatus, and thus it is evident a distinct step forward has been made.

The question which has to be solved to-day is not so much whether it is advantageous or not to control the work of the motormen by means of meters, but to choose between the different methods of applying this principle, between the apparatus and the method of using the results which are obtained. The two points of view from which the question can be considered, although very different in appearance, are in reality quite closely connected. With Mr. Wattman, the present reporter is of opinion that the solution of the problem differs from undertaking to undertaking, and that before making a choice each undertaking must weigh all the elements of success. These elements are fairly numerous. Perhaps the undertaking is one of those exceptional cases, where control by meters is of little use. It may, perhaps, happen that the undertaking is of little importance and that the motormen can be supervised easily and efficiently. If the price at which the energy is bought is extremely low, the consumption of light cars on level lines will be low, too. If, on the other hand, the system is composed of very hilly routes with frequent stops, &c., the consumption will be high.

If it is not considered that the undertaking is one of these exceptional cases, a choice must be made of one instrument or another, and, to begin with, all types whose regular operation does not seem to him to be assured should be placed on one side, for irregularity in the value of the readings obtained has one inevitable consequence, a loss of confidence both on the part of those who are controlled and of those who control them. There are at the present time no longer two but three types of car meters, each of which has its advantages and disadvantages; but these advantages and disadvantages are of different kinds, so that each system may best be accommodated with one particular type of meter.

After briefly describing the three types of meter in use and the disadvantages of each, the reporter goes on to point out that clock meters, although very simple, do not measure what one is trying to obtain, *i.e.*, the energy consumption of the car. Partisans of clock meters recognise in principle that this reproach is well founded, but they consider that in practice the indications which are obtained are just as good as those obtained from wattmeters in allowing an efficient control over the motormen. They further state that the question is more complex than simply determining the energy consumption; that what the manager requires to know is the greater or less skill of each motorman in expending only the minimum of energy possible in producing a certain amount of useful work. This work produced, which appears under the very simple form of a certain service effected, is in reality so complex that it is not possible rigorously to measure it. Allowing that its intrinsic value depends on a certain number of factors, some of which are of an essentially variable nature, such as the efficiency of the gearing, the atmospheric conditions, the number of passengers, the traffic on the routes, and the knowledge of the motorman, they consider that whatever type of meter is employed there must exist the same and rigorous proportion between each of the readings and the skill of each of the motormen whose work is judged by these readings.

The reporter is not impressed with this argument, considering the happy results that have been obtained on a large number of systems, but considers that the nature of the indications furnished by the clock meters constitute an inherent vice; while he thinks this type of meter contains a grave fault which in a number of cases should prevent its use. In 1906 Mr. Wattman suggested that comparative tests should be carried out between the two types of meter, and a question relating to this subject was placed in the present *questionnaire*; but of the 38 undertakings which have answered nine only say that they have made comparative tests between clock meters and watt or ampere-hour meters placed in series. Of these nine, four (Berlin, Nuremburg-Fürth, Wiesbaden and Zurich) say that they have obtained concordant results. One (Vienna) has noticed that on level runs there is generally agreement, but that this agreement does not continue on sloping lines. Four (Bordeaux, Marseilles, Munich and East Paris) have noticed a very considerable difference between the results given by clock meters and those given by watt meters or ampere-hour meters. In the presence of these contradictory declarations it would not be without interest to have a detailed account of the operations made by each undertaking in order to compare them. Only one undertaking (Bordeaux) has backed up its statement by figures, which show a complete absence of proportion between the indications furnished by the two classes of meter; in fact, the results obtained on three days for the same service with different motormen are as follows:—

Car No.	Time meter readings.	Consumption per car-mile. Kw.-hr.
104	6·53	1·10
	4·1	1·17
	6·19	1·20
128	5·27	1·12
	5·20	0·91
	5·50	1·01
82	5·35	1·12
	5·32	1·28
	5·20	1·15

The tests which the reporter personally made do not give any better results. During 1906 and 1907 two cars were fitted up with a

* Abstract of a report by Mr. Bouton, general manager of the East Paris Tramway Co., on the replies received by the Union Internationale de Tramways et de Chemins de Fer d'Intérêt Local, in response to the *questionnaire* sent out to the members, presented at the bi-ennial meeting at Brussels (1910).

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clock meter, a wattmeter and an ampere-hour meter. Several tests were taken, but the results all showed very great discord between the readings given by the clock meters and those furnished by the other meters. In 1909, when the installation of ampere-hour meters had just been finished on all the cars, and the periodic classification of the motormen was being organised, it was desired again to discover whether it was really possible to obtain with clock meters the end desired. For this reason two clock meters were placed on two of the cars on the same line, and at the end of several days the motormen who had worked the cars were classified. They were 36 in number, and were divided into two lists, one arranged in the order of the results given by the clock meters and the other in the order given by the ampere-hour meters. The results of these tests are given in the accompanying table :—

Motormen.	Time per car-mile.	Consumption per car-mile.	Classification according to clock meter.	Classification according to ampere-hour meter.
A	2·16	1·637	1	18
B	2·86	1·595	3	11
C	2·90	1·427	4	1
D	3·04	1·648	6	19
E	3·09	1·522	8	2
F	3·23	1·851	10	35
G	3·33	1·722	14	29
H	3·33	1·528	15	4
I	3·58	1·731	21	31
J	3·68	1·610	24	12
K	3·71	1·557	25	6
L	4·11	1·528	33	3

A third list of motormen was also prepared according to the mean energy consumption per minute that the car was under current. This mean consumption varied between as little as 300 watt hours and as much as 600 watt hours; while, further, nine of the motormen who were classed amongst the 10 first, according to the clock-meter readings, were found amongst the 10 motormen whose consumption per minute under current was the highest, which tends to show that they obtained their classification, not by a real economy of energy, but by an abusive employment of parallel working. The results of these tests further indicate that with the clock meter the skill of the motorman is measured by means of a unit (*i.e.*, the time the car is under current) whose value, compared with the quantity of energy consumed, is susceptible of very great variation according to the way the car is operated. In consequence, the readings of the clock meter are not sufficient by themselves to determine the skill of the motorman. These indications can only be of real use when a very close control causes the motorman to work in a uniform manner according to the rules which have been laid down. This is only realised with difficulty, especially on lines in traffic, or else under the condition which is very seldom fulfilled (if the answers to the 14th question of the *questionnaire* are to be believed) of possessing a *personnel* which is sufficiently conscientious to follow the instructions, that are given without any inspector being necessary.

Certain supporters of clock meters argue that motormen who depart from these instructions can be recognised by the fact that the time which is measured on their meters is lower than that laid down for the standard journey. This might be true if the motorman were to work without discrimination, but it is easy for him to falsify the results which concern him, as shown by the case of motormen F and G in the table above. It is admitted by most of the members that clock meters do not permit a classification of motormen or the application of a system of prizes for economy. Clock meters have, on the other hand, indisputable advantages which up to the present time have made them more used than wattmeters on the majority of lines. They are both simple and robust in construction, and they scarcely ever get out of order; their first cost is low, while their upkeep is insignificant. Certain undertakings remark that the indications such instruments give are more easily understood by their *personnel* than those furnished by current meters, the notion being that time is more easily intelligible to the motormen than energy consumption. Further, the readings can be made easily at the end of each journey. On the contrary, it is stated that the use of clock meters causes the motormen to exaggerate the speed in starting. This appears to be confirmed by the answers on the subject which have been made to questions 3 and 14 of the *questionnaire*. Some members have remarked that starting, which is obtained by cutting the resistances out very quickly, has the effect of decreasing the resistance losses, and thus increasing the useful effect during the period of acceleration. In consequence, the wattmeter, which registers the energy absorbed by the resistances, should incite (as does the clock meter) the motormen to start rapidly. This fact is in itself true, but it must be added that if from the point of view of starting the two types of meter exercise their influence in the same sense, they exercise them in a different degree, for if the wattmeter gives the motormen exactly the benefit realised by starting quickly, that benefit is of the order of 5 per cent., while the clock meter registers favourably to the motorman a fictitious benefit which is much greater than the real benefit. Starting quickly leads, in fact, as we have shown above, to the motormen using the most efficient means of changing the value of the unit or the quantity of the ener y consumed; in fact, the error in the case of the clock meter is of the order of 10 or 12 per cent., as compared with 5 per cent. The ampere-hour meter differs from the wattmeter in the fact that the motorman when starting quickly produces a rush of current, so that the line voltage is diminished, and this is not registered on the ampere-hour meter. This, therefore, makes but a small advance which tends to counterbalance the economy realised by the starting quickly.

Several undertakings where clock meters are used stated at the Munich Congress, and repeat the statement now, that the effect of starting too rapidly operates unfavourably on the upkeep of their motors, particularly on the armatures, the commutators and the brushes. Certain others have, however, noted no aggravation of this kind. Two of them, in fact—viz., Barmen and Frankfort—see nothing but an advantage in the fact that their motormen are incited to start too rapidly, for their motors do not appear to be worn out in any way. It is certain that the influence which rapid starting must have on the motors should vary from one system to another in accordance with the power of the motors compared with the work they have to do. There is no doubt that the system which does not possess very generously designed motors should make every effort to avoid a rapid starting. As we have seen above, the meters afford to various systems which use them advantages which differ according to type and design. It may, however, be remarked that they all have one common advantage in the fact that the motormen know they are being submitted to continual control.

The types of meters at present employed are three in number—viz., the wattmeter, the ampere-hour meter and the clock meter. The first of these is most complete, as it makes a true comparison, in which each motorman in each car possesses a certain rank in accordance with the energy consumption. It is more complex, however, and more costly than the second, which consists simply of the classification on the "dossier" of each motorman, and on the way bills, of the readings given by the meters, and the average time during which a car is under current for the service it has undertaken. The first allows a proper classification of the motormen to be obtained, while the second simply points out those who are working in a reprehensible manner.

We have just seen that in determining the method to be adopted the question of cost comes in. The first cost and upkeep varies very considerably with the type of meter employed. As, however, there exists a close relation between the type of meter and the method of using it, we have brought together these considerations of expense in order to examine them.

It appears from the answers to the *questionnaire* that the first cost and cost of installation varies for wattmeters between £3. 14s. and £9, the average price being £5. 8s., which, supposing that the life of one of these instruments is 187,500 car-miles, works out at 0·007d. per car-mile. For ampere-hour meters the price is between £4. 5s. and £5. 12s., the average being £4. 16s., or 0·006d. per car-mile. For clock meters the price is between £1. 14s. and £5. 4s., the average being £2, or 0·003d. per car-mile. The running expenses vary per car-mile between 0·002d. and 0·005d. for wattmeters, the average being 0·003d.; for ampere-hour meters between 0·002d. and 0·005d., the average being 0·003d.; for clock meters between 0d. and 0·001d., the average being 0·0005d. The administrative expenses vary per car-mile between 0·004d. and 0·05d. for wattmeters and ampere-hour meters, the average being 0·01d., and between 0·0002d. and 0·0009d. for clock meters, the average being 0·0004d. The total expenses per car-mile are, therefore, for wattmeters 0·02d., for ampere-hour meters 0·016d., and for clock meters 0·004d. In order further to determine the advantages which the low cost of the clock meter should bring to the system, it is necessary to take into account the value of the energy which each meter measures, a value which varies according as the price of the energy is high or low, as the weight of the cars is small or great, as the system is flat or hilly, between 0·4d. and 1·33d. per car-mile. Bringing these figures into the calculation, it appears that in the lower limit the advantage of the clock meter, from the point of view of expense and compared with watt and ampere-hour meters, is from 2·3 to 2·5 per cent. of the value of the energy it controls, while in the upper limit this advantage is only from 0·75 to 0·69 of 1 per cent. The advantage of the clock meter in requiring lower costs to operate it should only exercise on the choice of the meter an influence as variable as the conditions under which each system works.

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The last question which has to be examined is that regarding the methods employed by those systems using car meters to obtain from their motormen a judicious employment of the energy which is placed at their disposal. An analysis of the answers to the *questionnaire* shows that 17 members stimulate the zeal of their motormen by means of prizes or gratuities, combined with repressive measures. On the other hand, 18 members work upon their staff simply by repressive measures, reprimands and instruction courses, or, by means of these measures combined with rewards for the best of the men, or by publishing the results obtained periodically. Some of these 18 members express themselves strongly against any system of prizes.

It is undeniable that a system which consists in the distribution of money prizes among the *personnel* carries with it difficulties which it is not easy to overcome. Its application requires great circumspection on the part of the management. The answers to the *questionnaire* show that there exists at the present time certain undertakings which at first were partisans of a prize system, but have now abandoned it, while others have adopted it. The reason for this is, as before, that the choice varies with the peculiarities of the methods of working.

At the Milan Congress Mr. Wattmann said: "Mr. Koehler, of Berlin, thinks that on important systems the allocation of prizes to motormen cannot be avoided, but immediately afterwards he shows the dangers which such an arrangement causes, especially on important systems. For my part I share in the fears of Mr. Koehler, and I have expressed myself very circumspectly on this subject in my report. The allocation of prizes has already given rise to difficulties in certain undertakings, the evil can only advance with the progress of the socialist movements. On wide-spread systems especially the principle of equality is placed in the forefront. No one, it is said, should receive preferential treatment. The movement which is being made with regard to the equality of salaries would also be applied to prizes."

It seems, in fact, to be very difficult, if not impossible, to impose a system of prizes on a *personnel* which does not want it. Recourse in such a case must, therefore, be had to other means. Without knowing exactly the number of undertakings which meet with such hostility, and which have, therefore, replied to the *questionnaire* unfavourably, we are right in saying that the 17 undertakings which give money prizes represent the great majority of those which are allowed a freedom of choice by their *personnel*. We may incidentally remark that although this spirit of opposition is shown in Germany, especially among the *personnel* on the railways and in certain industrial centres, it is by no means general up to the present. The socialistic spirit has not advanced in the same way in all countries. In Belgium, as well as in France, the principle of individual prizes continues to be acceptable to the industrial world, and especially to the railway and tramway *personnel*. There are numerous undertakings which either are already using meters or are proposing to do so in the future, and who find the bestowal of prizes is favourably considered by their *personnel*.

The answers to the *questionnaire* show the primordial interest which is taken by certain undertakings in the bestowal of prizes. For instance, at Hamburg a system of prizes based on the economy in energy consumption realised year by year compared with that consumed in 1902 was instituted. At a certain period the value of these prizes decreased, owing to the fact that the traffic had considerably increased and that the results obtained in 1902 became, therefore, inapplicable. Far from doing away with the prize system, its superiority was so far recognised that a new basis of calculation, more favourable to the *personnel* was adopted.

It should not, however, be forgotten that the principle of prize giving is a delicate one. When its adoption has been decided upon, a judicious choice should be made between the arrangements used, while the basis on which the prizes are to be given should be determined with prudence and care. Whatever methods are adopted, they will require the periodical calssification of the motormen, and in consequence, there must be a choice between watt meters and ampere-hour meters, to the exclusion of the clock meters, so that the decision is closely connected with the choice of the type of meter, and is governed by the same considerations as is the latter.

It should, however, be noted that the employment of clock meters is only compatible with a peculiar system of prizes, which consists in giving a certain gratuity monthly to all motormen who are above a certain standard. This amount is fixed by the mean consumption per car-mile during the month. This method of operation, though there is little to commend it, is adopted by several undertakings.

It appears that Amsterdam combines the results obtained by means of clock meters with a verification of the passing times at certain points on each route. This is effected by control clocks, and is said to give satisfactory results. At Brussels "automatic" starting resistances are used. These possess the peculiarity that their resistance decreases when the current passes through them, so that an acceleration of the car is progressively produced without the jumps that occur when passing over controller notches. From Hanover there is a suggestion that apparatus for indicating when too rapid starting takes place should be used

An analytical study of the various results set out in the above reports leads to the following conclusions:—

1. In a general way it is recommended that the work of motormen as regards energy consumption should be controlled by means of meters. This control is only truly efficient when each car is fitted with a meter.

2. The application of this control can be effected in two ways: In the first, with a view to ensuring that the individual motorman consumes the lowest amount of energy compatible with the necessities of the service, an influence is exerted on the *personnel* by distributing among the most skilful pecuniary prizes whose value is proportionate to the results obtained, while at the same time disciplinary measures are taken against those whose work leaves something to be desired. This method requires the periodical classification of the *personnel* by determining, as exactly as possible, the relation between the energy consumed by each motorman to the standard energy consumption for the work done. This method also predicates, as a logical conclusion, the employment of either a watt or ampere-hour meter.

In the second way an attempt is made to get the different motormen to do their work in as uniform manner as possible. They are no longer classed according to the energy they consume, but by the way they differ from a standard line of operation. In this case a clock meter may be employed, the results which it gives being sufficient, always allowing that its work is supplemented by personal supervision, which must increase as the *personnel* becomes less conscientious.

3. If a system is operated by a *personnel* who are favourable to the idea of rewards, while the system itself is of such a nature that supervision of the motormen is difficult, while the amount of traffic leads to frequent stoppages, the gradient profile is irregular, the cars are heavy, the motors closely designed, the price of energy is high, &c., all conditions tending to increase the influence of the motormen on the operating expenses, the solution given first above is to be recommended.

If the conditions under which the system operates are quite the reverse of these, the second solution is preferable.

In an intermediate case it must be decided which of the conditions set out above have the most influence, in order to determine the final result and to be able to make a choice.

If the system is of little importance, making the supervision of the motormen easy and efficient, the price of energy low, the energy consumption of little importance owing to the infrequent stops, the cars light, the lines level, &c., it might even be preferable not to control motormen by means of meters at all.

4. There are at the present time on the market meters capable of satisfying both the first and second solutions. With regard to the first, watt meters, though giving satisfaction on certain important systems, have been the object of disparaging remarks. It would, therefore, rather savour of temerity to recommend their employment, especially as their manufacture has not been subject to any recent improvements. But ampere-hour meters have now been proved, and their employment may therefore be recommended.

When the second solution is adopted the use of the clock meter is particularly recommended.

EXPERIMENTAL APPARATUS FOR WIRELESS TELEPHONY.

The interest concentrated upon wireless telegraphy owing to its application to the transmission of news has been materially increased by the possibility of wireless telephony. In order to demonstrate this branch and to facilitate the study of the subject, the apparatus described below has been constructed by E. F. Huth, of Berlin. By its aid it is possible, with a mast of 5 ft., to transmit music as well as the human voice over a distance of about 50 metres. By the use of a longer and higher aerial line this distance can be considerably increased.

The apparatus is made of two different types. The simple form consists of two stations, one of which can transmit, the other, receive; between these stations, therefore, speech in one direction only is possible. The more complete equipment allows of speech in both directions. It consists, therefore, of two stations, each of which is arranged for transmitting as well as for receiving.

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Figs. 1 and 2 show a station for speech in one direction only. The transmitting set (Fig. 1) is mounted on a case of polished ash about 37 cm. by 50 cm. and 10 cm. high. It consists of a generator for continuous electric oscillations, transmitter coil and microphone. The case, which is fixed on an iron frame with castors for wheeling it from place to place, contains the Leyden jars and the choking coils. The receiving set (Fig. 2) is mounted on a small board, and consists of a receiving coil, detector and double head-piece telephone receiver.

The appearance of the set for working in both directions with antenna opened is shown in Fig. 3. The transmitter and receiver

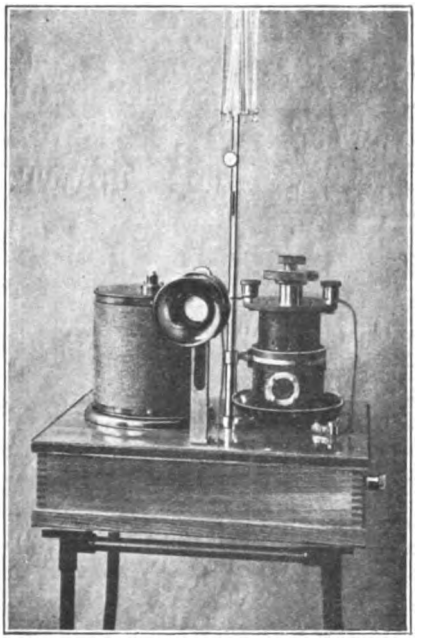

FIG. 1.—WIRELESS TELEPHONE STATION FOR SPEECH IN ONE DIRECTION ONLY.

are both mounted on a small case (Fig. 4). Inside the case are fixed the Leyden jars, choking coils and the automatic main switch. The lid of the case can be opened, thus making it possible to get at every part and to trace the connections (Fig. 5).

The case carrying the apparatus is mounted in the same way as in the set for working in one direction, viz., on an iron frame, about 90 cm. high with castors. It is, therefore, very easy to wheel the set about together with the antenna wherever it may be wanted.

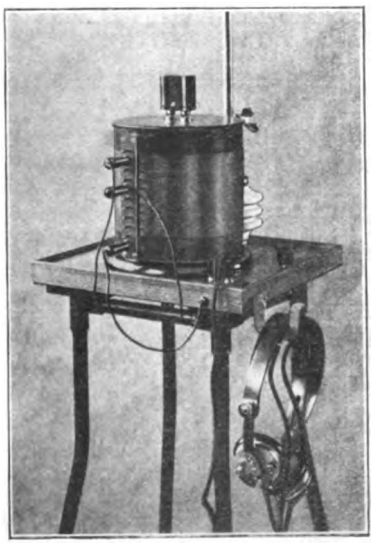

FIG. 2.—RECEIVING STATION.

In both of these sets the cases are attached to the frames by screws and can easily be removed. The main parts of the set, viz., generator, microphone, antenna, &c., can also be taken off and used separately; different experiments can, therefore, be made with a single apparatus. It is simple to demonstrate the principles of wireless news transmission, as also Tesla's and any other experiments depending upon the use of electrical oscillations of high frequency.

If required, the apparatus can be arranged for wireless telegraphy and in connection with a Morse telegraph instrument written messages can be obtained.

Connections.—The diagram in Fig. 7 shows the connections used in the sets for working in one direction only or in both directions. The connections in the set for working in both directions are shown in Fig. 6. By closing the plug connection continuous current at 220 volts flows through a choking coil to the arc generator, in parallel to which is an oscillation circuit consisting of self-induction (transmitter coil) and a capacity (Leyden jars). From the transmitter coil, which is connected at the upper part with the antenna, a branch connection is made through a Leyden jar and a microphone to earth; the coupling between the generator circuit and the antenna is therefore direct. By reversing a switch (automatic), which in Fig. 7 is shown turned to "transmitting," the receiving circuit is put in. It consists of the receiving coil, the thermo-detector (cell) and a double-head telephone. All three instruments are connected in series. Part of the receiving coil is connected to the antenna; the coupling in this case is also direct.

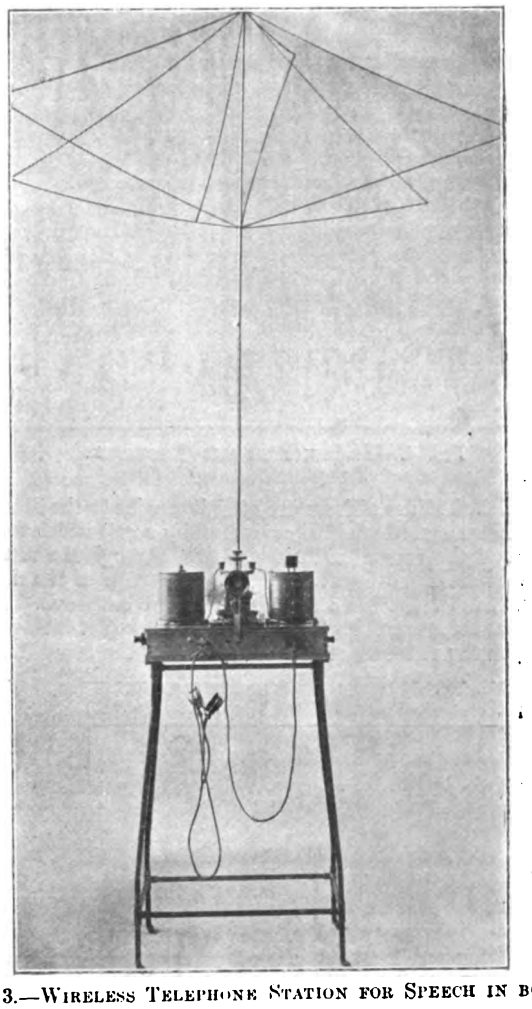

FIG. 3.—WIRELESS TELEPHONE STATION FOR SPEECH IN BOTH DIRECTIONS.

APPARATUS.

The instruments are the same both for working in one or in both directions; the latter only, therefore, will be described.

Transmitter.—The transmitter consists of the following parts: The choking coils are wound with enamelled wire. They are fixed inside the case, on which the separate instruments are mounted (Fig. 5). The generator (British patent 15,891/09) is constructed on a new method for producing continuous electric oscillations. The generator, as shown in Fig. 8, is worked by an arc between two carbon electrodes of a special form.

In Figs. 9 and 10 different forms of electrodes are depicted. In both cases the electrodes consist of tubes the ends of which are conical. In Fig. 9 the upper electrode projects into the lower. The arc is started at the place where the electrodes are nearest to each other, and is driven outwards by the heated air. It is then lengthened, owing to the conical form of the electrodes, and finally broken.

The advantage of this system is, that undamped electric oscillations of great constancy can be obtained without using special blow-

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out arrangements or magnetic blow-outs. By using methylated spirit or any other quickly evaporating liquid, which surrounds the lower electrode and increases the blowing out of the arc by its evaporation, the intensity of oscillations can be increased.

In order to secure an even consumption of the electrodes, which is very important for a constant generation of oscillations, the arc rotates electromagnetically. For this purpose the arc is in a magnetic

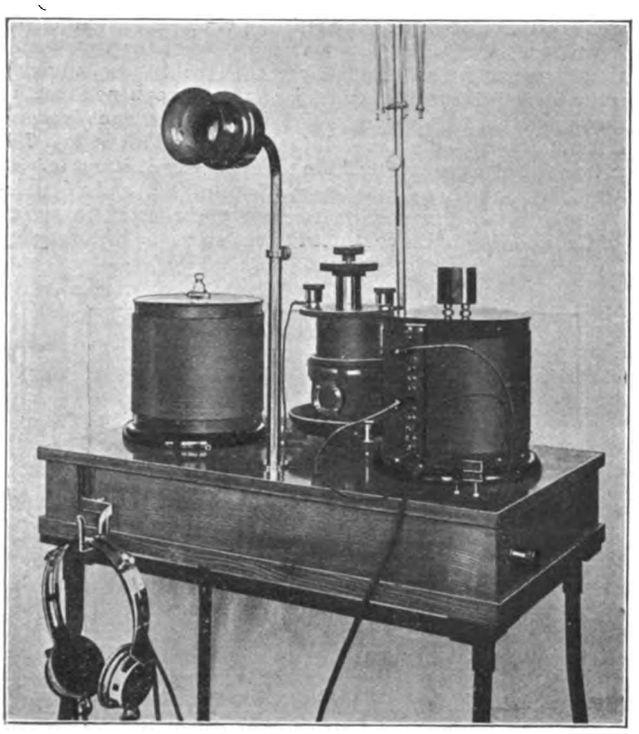

FIG. 4.—TRANSMITTER AND RECEIVER.

field, of which the lines of force are at right angles to the direction of the arc. The magnetic field is generated by a coil which forms the upper part of the generator. Besides this, through the rotation of the arc, the breaking influence caused by the shape of the electrodes is increased, as the arc has a tendency to curve outwards.

The generator is started automatically. The coil, which generates the field for the rotation of the arc serves, at the same time, as a striking coil. It is connected in series with the arc electrodes. When

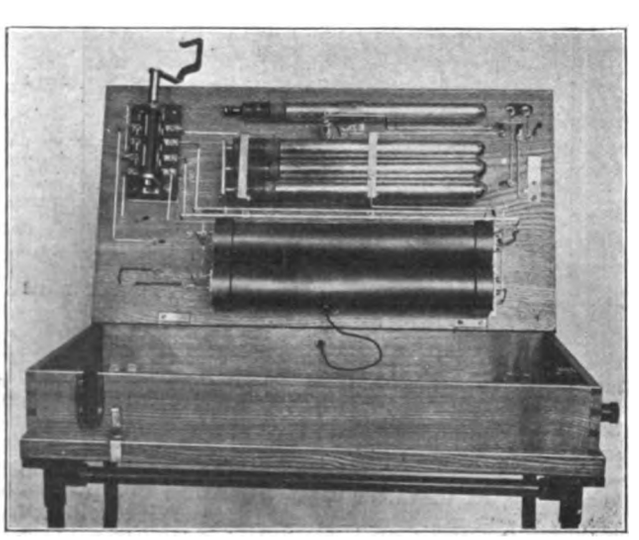

FIG. 5.—INTERIOR OF CASE.

no current is passing through the generator the electrodes are in contact; when current is applied, the upper electrode, which is composed mostly of magnetic material, is drawn into the coil and the arc is produced. By turning the knob at the top of the electrode any length of arc required can be obtained.

By the striking arrangement the operation of the generator is greatly facilitated. If the arc be extinguished, which may happen when too much energy is taken off, or when the power of the primary current is too small, it is indicated by a "knocking" of the ignition electrode. The electrode drops down, the circuit is again completed, the electrode is drawn into the coil again, and so on. The generator thus automatically indicates a mistake in its working.

A knob which is fixed to the upper part of the electrode makes it possible to start the generator by hand. The upper part, consisting of striking coil and electrode, is fixed to the lower part by a bayonet joint. By turning the upper part through 120 deg. it can be lifted from the lower part in the simplest way in order to adjust the inner parts of the generator, to put in new electrodes and to fill up with methylated spirit. The lower part consists of a cast-iron basin, which carries the other electrode in its centre. A mica window in

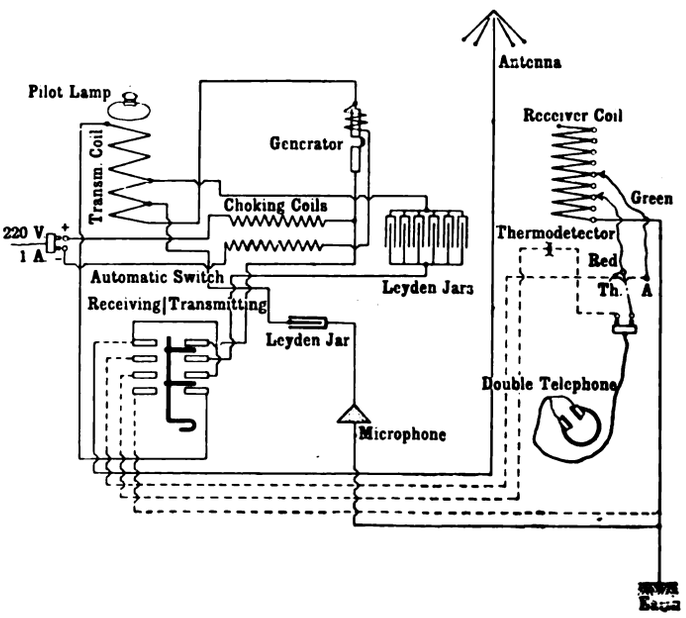

FIG. 6.—RUN OF LEADS.

the front makes it possible to control the arc with the generator closed. Opposite the window is a valve serving to regulate the pressure. The weight of the complete generator is about 3·5 kilos.

The self-induction exciting coil consists of stranded copper wire, the single wires of which are carefully insulated from each other. It is wound on a presspahn cylinder and afterwards soaked with a non-hygroscopic varnish. A few turns of copper wire which are in series with a glow lamp are coupled inductively with the transmitter coil. As soon as oscillations are generated, which also flow through the transmitter coil, the lamp begins to glow. This serves not only as a detector of the oscillations, but also as an indicator of their intensity.

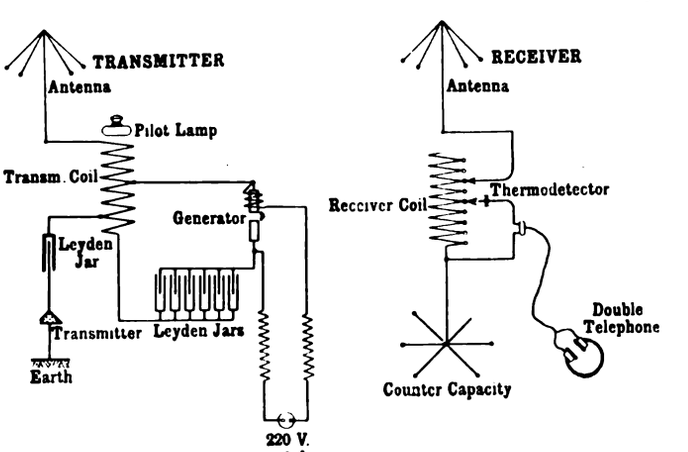

FIG. 7.—HOOK-UP.

The Leyden jars (Fig. 5) have a collective capacity of 3,000 cm., and are six in number. The microphone is of the strong current type. It can be moved vertically and easily be changed.

Receiver.—The receiving coil consists of wire strand which is finely subdivided and wound on a presspahn cylinder. At every 10 turns a connection is taken out and led to a plug, of which there are 13. By means of two plug sockets the necessary tunings can be effected. The leads to these sockets are placed side by side in ebonite inlet

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tubes. The wire covered with green, connects the coil with the antenna, the red covered wire, with the thermo-detector and the double-head telephone.

The thermo-detector, which is mounted on the receiving coil, is constructed in the form of a two-polar plug. It is adjustable and can be interchanged. It is not sensitive to shaking and practically independent of changes in temperature. The telephones are of high resistance. The diaphragm and the connecting clip are adjustable.

Antenna.—The antenna consists of an umbrella-shaped nickel-plated frame, which can easily be closed and opened. When closed it is 133 cm. high, when opened it is 240 cm. high, with a diameter of

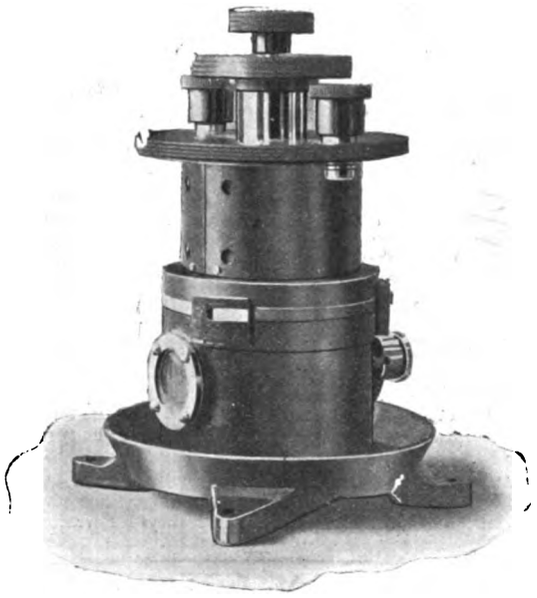

FIG. 8.—GENERATOR.

165 cm. The antenna is insulated from the iron frame of the station by a porcelain grooved insulator.

When speaking with the sets for working in both directions, the main switch, which at the same time carries the telephone, must be pulled down. This is effected by leaving the telephone on the holder, and later on, when the apparatus is adjusted, by pressing it down by hand. The earth terminal can simply be connected to a gas or water pipe. In order to start the generation of oscillations the plug is put in and the generator filled with methylated spirit up to the upper rim of the brass holder carrying the lower electrode. This done, the current is regulated at a pressure of 220 volts to about 1·0 ampere, and the arc started as small as possible, increasing it by degrees till the pilot lamp glows with a moderate light. The arc should then begin to rotate about twice a minute.

When oscillations are generated, and the microphone spoken loudly into, the

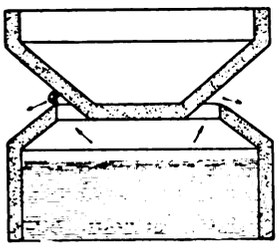

FIG. 9.

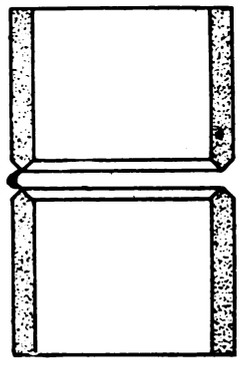

FIG. 10.

lamp will burn duller or brighter, according to the change of resistance caused by the microphone.

Wireless telephony, quite contrary to wireless telegraphy, came into practical use very slowly. It remained in the laboratory, and at present, four years after the invention of Poulsen, we note the first beginnings of commercial use. It appears that the importance of wireless telephony has been very much underestimated, all the trials in this quarter being considered as laboratory experiments.

The apparatus described above for demonstrating wireless telephony has been constructed to prove the contrary. It shows that neither complicated apparatus nor difficult instructions are necessary, and it is suited to convince anybody of the possibilities of wireless telephony for practical appliance.

The manufacturing company, Dr. E. F. Huth (Ltd.), of Berlin, has also constructed complete stations for wireless telephony for distances up to 50 miles. The company has a special type of a telephone station with a range of 5 miles, using masts 40 ft. in height. This station is made particularly for use with spark stations on board ship with a view to facilitate conversation between ship and ship in harbour or while under sail.

THE THOMAS YOUNG ORATION.

On Thursday evening of last week Prof. R. W. Wood, of Johns Hopkins University, gave, as the annual Thomas Young oration before the Optical Society, a very interesting account of some of his work in the domain of optics. He first described the making of what he terms "Echelette" gratings. As is well known the efficiency of a prism in spectroscopic work is in one respect greater than that of a grating, because all the light goes to one spectrum, whereas several spectra are produced from a beam of light falling on a grating. Nevertheless, it has been found that by suitably ruling the light from a grating may be concentrated mostly into a single spectrum, but so far it has been found impossible to determine what shape of groove in the ruling produces this effect, as the lines are so extremely close together. In order to investigate this question, Prof. Wood ruled gratings with very much larger lines and worked with heat waves instead of light waves. In order to obtain regular ruling it was necessary to get a very definite form of groove. As a material for gratings alloys were found to be useless, because they were not sufficiently homogeneous; pure metal was found to be necessary, and a film of gold deposited upon copper was finally used. There was some difficulty in getting optically flat copper, but the plates used for producing half-tones were found to be fairly satisfactory. Having deposited a film of gold upon such a plate the ruling was effected by means of a crystal of carborundum mounted in solder. The crystal was used in its natural state, and produced grooves whose sides made an angle with each other of 120 deg. In this way gratings were ruled with lines varying from 7,000 down to 1,000 or 2,000 per inch. It was found that no metal was actually removed in the process, the crystal merely making an impression, though sometimes some metal was broken away rendering the grating useless. The angle of the sides of the groove to the normal was varied by changing the setting of the prism. As such ruling did not necessarily give curves having the angle of the crystal, owing to the fact that any groove might be modified by the ruling of the next subsequent groove, it was necessary to measure the angles obtained. Owing to the breadth of the ruling this was possible by means of a spectrometer. It was necessary to obtain grooves without any plain metal between them, and this quality was checked by observing that the gratings did not give normal reflection from normal incidence. The finer gratings could be tested by means of light waves, and they showed a number of spectra each side of the normal, as is usually the case with a grating, but in addition to these spectra it was noticeable that, after a large interval, a strong band of reflected light occurred, on each side of which there were spectra of a high order, such as the 33rd to 35th. This was found to be due to the fact that the grooves were of such a size as to have a difference between their faces of 34 wave lengths in the reflected light, and consequently the grating in addition to acting as an ordinary grating acted like an Echelon grating. It was found that with suitable conditions heat waves were practically all concentrated into one spectrum.

In the concluding part of his discourse Prof. Wood gave an account of the "mercury telescope" which he has been using. In this telescope the reflector consists of an iron dish containing mercury set in rotation, the weight of the mercury being 50 lb. and the dish being 20 in. in diameter. When the dish is set in rotation the mercury assumes the shape of a paraboloid, the length of the focus depending on the speed of rotation. The difficulty is that if mercury is subjected to any vibration it becomes useless as a mirror. In order to avoid vibration the iron dish is drawn round by a spider through the medium of elastic threads, and the spider, which is motor driven, is entirely clear from the supports of the rotating dish. A plane reflector surmounts the telescope. As to the sensibility of the arrangement, Prof. Wood found that he was able to detect very small craters in the moon, such as are only just noticeable in photographs taken by the large telescope in the Lick Observatory. Consequently, there is some advantage in the system owing to its cheapness, though there is some difficulty in obtaining perfect definition.

In conclusion, Prof. Wood showed some exceedingly interesting landscape photographs taken by means of heat waves beyond the limits of vision. In these it was noticeable that the sky was practically black, whereas a great deal of the foliage appeared to be bathed in bright sunshine, or even covered with snow.

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The present number of "THE ELECTRICIAN" completes Vol. LXV. The Index to the Volume will be issued (Gratis) on October 21st.

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HYSTERESIS LOOPS AND HARMONIC ANALYSIS.

THE magnetic hysteresis loop, with its graceful symmetry, was bound sooner or later to fall a victim to the inquiring mathematician armed with FOURIER'S theorem. In fact, ever since Dr. J. BUCHANAN wrote to the "Philosophical Magazine" in March and November, 1901, it has been reduced to the ranks of "the harmonically analysed"; and now most teachers of electrical engineering, who possess oscillographs, exercise their students in finding the components of the no-load current in transformers, a process essentially equivalent to analysing the hysteresis loop. It has been reserved for Prof. S. P. THOMPSON, however, whose recent Physical Society Paper we reproduce in abstract on another page, to deal with this matter in the most comprehensive and illuminative manner. Of necessity his method of analysis is fundamentally that suggested and carried out by Dr. BUCHANAN; only, by employing an adaptation of RUNGE'S well-known method of harmonic analysis, he is enabled to obtain his components with greater facility. It is, however, in the very elegant way in which the components, once obtained, are combined and presented graphically in the form of a series of LISSAJOUS' figures, and in the deductions which he draws, that the chief value and novelty of his Paper consists.

One's only fear is that, with the simplification of methods of harmonic analysis, every analysable function

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will be resolved into its sine and cosine components whether there is any real justification for it or not. Certainly to many it will appear one thing to analyse by a dynamical and, in a sense, natural process, say, a compound ray of light into its simple vibrations by means of a prism or grating, and quite another to analyse a hysteresis loop into harmonic components by a method purely trigonometrical and more or less artificial. In the one case each simple vibration has a traceable physical cause, the presence or absence of a particular vibration revealing something definite about the physical condition of the body emitting the light; whereas it is by no means always obvious what a given harmonic component of a hysteresis loop actually means, or to what it owes its existence.

To some, even, it may not be at all clear that much useful information is in reality gained as to the magnetic processes at work by stating that the power conveyed to the iron core of a transformer, with a fixed sinusoidal E.M.F. across its primary, is proportional to the co-phasal component of the fundamental harmonic in the magnetising current; any more than a knowledge of the character of an arc, burning under a fixed sinusoidal E.M.F., is gained by saying that the power absorbed by it is proportional to the co-phasal component of the fundamental harmonic in the current.

Such objectors will very probably point to the remarks of Dr. L. A. BAUER, contained in an address on the "Meaning and Method of Scientific Research," delivered before the Philosophical Society of Washington on December 5th, 1908 ("Nature," February 18th, 1909, p. 473), as voicing their scruples in this matter. Dr. BAUER, in his remarks—which have special reference to geo-physics but are equally applicable to other branches of physics—maintains, with some show of justice, that harmonic analysis is very often applied regardless of its suitability or necessity, and his question, "Does the resolution into Fourier terms of a phenomenon of the kind given really prove their existence in Nature?" sufficiently reveals an attitude which is doubtless shared by many. However, with proper reservations, and always bearing in mind that a thing is not necessarily physically existent simply because it is mathematically derivable, we may willingly admit that the process of harmonic analysis has its own fit and proper place in physical work, as has the corresponding process of resolving forces into their components, with which it may indeed be compared, and with which it ranks as of at least equal importance and utility. But it must be remembered that, like the resolution of forces, it is more often a means than an end, and care must invariably be taken not to put upon the results to which it leads any construction that they were never intended to bear, and, in particular, not to imagine that we have succeeded in arriving at the true nature of some special periodic effect merely by resolving it into its harmonic constituents.

Prof. THOMPSON is, of course, far too experienced not to avoid such pitfalls, and although the practical man who has to build and work transformers, and who is unversed in the arts of analytical geometry, may very probably regard his treatment as far-fetched and uninstructive, yet to many his methods will appeal as especially elegant and his conclusions as highly suggestive. The fact that his results are in their very nature empirical in no way detracts from their value; for in our present state of ignorance regarding the precise molecular laws upon which the phenomenon of hysteresis depends, the establishment of an empirical formula is all that anyone can hope to achieve.

REVIEWS.

(Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.)

Die Fernsprechtechnic der Gegenwart. By C. HERSEN and R. HARTZ. (Brunswick: F. Vieweg & Sohn.) Pp. 128. M.2·50.

The title of this work is somewhat too comprehensive for the ground covered, for the authors deal only with what is known as the "inside plant," namely, the exchange and subscribers' equipments. The authors do not make any attempt to deal with the subjects of transmission and traffic which form perhaps the two most important branches of telephone engineering of the present day. The authors explain in the preface that they have so limited themselves, but we think a clearer indication of the restricted scope of the work might have been made in the title.

The book forms, however, a valuable record of Continental practice and ideas in the design of exchange equipments and apparatus, and also of the various types of instruments used in subscribers' offices. In addition to the apparatus of Continental design a considerable amount of space has been devoted to descriptions of American types.

We are glad to note that the authors have attempted to treat the subject in the only way which is of the slightest use in a science which is developing so rapidly as that of telephony—namely, by dealing very clearly with the fundamental principles underlying the design of the various circuits and apparatus. The diagrams of connections especially are simplified to show the working of the circuits, so that the reader is not confused with details of connections and wiring necessary only to the wireman.

The illustrations are very numerous, and no use has been made of half-tone blocks, with the result that the figures are all refreshingly clear and distinct.

The authors commence with a detailed description of the essential parts comprising a subscriber's instrument and their connection, and pass on to consider the terminal and protective apparatus for the line. The details of the exchange apparatus are then fully dealt with, and connection diagrams are given for all the most important systems of central battery working. The attempts to reduce the extent of multiple required by such devices as group working, divided multiple and transfer working are then dealt with. Trunk line working and simultaneous telegraphy and telephony are explained. The treatment of extension working is not very full and leads one to believe that this has not reached a very high state of development on the Continent. Private branch exchange systems, however, receive due consideration, while miscellaneous auxiliary appliances and circuits such as for registering calls, service observation, &c., are also included. The last chapter deals with the lay-out of exchange buildings; this part of the subject might well have been given fuller treatment.

The work under review does not select any particular system for specially full treatment, but deals with many as if they were practically of equal importance. This leads one to the conclusion that telephony in Germany is in a condition rather similar to that existing in England some years ago, when several different systems were under trial, except that in Germany the various systems are more modern and individually better.

English practice is barely mentioned, and the book will, therefore, prove interesting and useful to English readers as a book of reference rather than as a text book. The impartial treatment which each system receives increases its value in this respect.

In addition, there are explanations of many details of design and manufacture of apparatus not to be found in English works, which deal with the subject more from an operating than from a manufacturing point of view.

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Electric Power Conductors. By Wm. A. Del Mar. (London: Crosby, Lockwood & Son.) 9s. net.

In the present work the author gives a very comprehensive and concise account of the facts concerning the use, properties and sizes of electric power conductors. It is replete with reliable and useful data which will be welcomed by all engaged in the calculation of underground and overhead mains and cables. The author has been at considerable pains to give an enormous amount of information, based on his own large experience in transmission work in America and culled from the writings of the best-known authorities, to whom reference is always made, in a form directly applicable by the practical man. An excellent book has, however, been somewhat spoilt by the very apparent carelessness with which the proofs have been read, and by its somewhat slovenly composition in parts. A little more care on the part of those responsible for its publication in this country would have greatly enhanced its value, and would have rendered its study much easier and much more agreeable. Surely both the author and the publisher know that in this country we use the word aluminium instead of aluminum, which occurs throughout the book! On page 4 we find 4×6^6 instead of 4×10^6; on page 5 "teaches" instead of "reaches"; the abbreviation of circular mils denoted by cm. (the usual abbreviated form of centimetres), also by c.m. and at other times by cir. mils; "tables" for "cables" (p. 79), and so on. Apart from these blemishes it is a useful, practical work.

There are 12 chapters, and in seven appendixes are given the theoretical explanations of the formulæ, &c., used in the book. In the first three chapters the materials, gauges, mechanical and electrical properties of conductors, insulation, insulated cables and insulators are dealt with. The skin effect of conductors carrying an alternating current is very well explained, and some interesting notes on the conductivity of the atmosphere at high voltages are included in Chapter III.

Chapter IV. is on the determination of the size of conductors. In Chapter V. the method of calculating the size for a given stress in the span of an overhead conductor is explained. Specifications for overhead and insulated cables are contained in Chapter VI., and in the following chapter the method of testing wires and cables—copper resistance, capacity, insulation, localisation of faults—are briefly stated. The installation of underground and overhead cables is considered in Chapter VIII., which also includes useful notes on jointing. Chapters IX. to XI. inclusive deal with depreciation and deterioration, third-rail circuits and rail-bonding; and the final chapter is on inductance, reactance and capacity, and, in common with the other portions of the book, contains several very complete tables. Not only are the formulæ given for the calculation of the various quantities connected with conductors, but several numerical examples are also included. The appendixes at the end of the book explain the basis of the American, or Brown and Sharpe, wire gauge, the formulæ for skin effect and capacity, the thickness of rubber insulation on cables, the formulæ for direct and alternating current transmission lines, those for stresses in spans of aerial lines, the specifications in Chapter VI. and the tables giving the self-induction of parallel wires.

H. G. S.

Matriculation Magnetism and Electricity. By R. H. Jude and J. Satterly (London: University Tutorial Press.) Pp. vii. + 415. 4s. 6d.

The object of this work, as stated by its authors in the preface, is "to provide a sound course of elementary magnetism and electricity suitable for use in schools and colleges, containing a lucid account of the theory illustrated by a large collection of simple and instructive experiments." It must be stated that the authors appear to have succeeded to a great extent in attaining this ideal. Throughout, the experiments described are most suitable for school purposes, the apparatus is generally simple and inexpensive, and the exercises are quite equal to the attainments and requirements of the pupils for whom they are designed.

The book is divided into three parts, of which Part I. (pp. 1–90) deals with Magnetism. Part II. (pp. 91–225) Electrostatics, and Part III. (pp. 226–387) Electrodynamics. In all, 159 experiments are suggested; in some cases the theory is developed from the experiments, and in others the theory is stated and illustrated by experiments. Each chapter, of which there are 16, is followed by a summary and by exercises on the subject matter considered, and answers and suggestions as to the correct solutions of the exercises are given at the end of the book. Numerous fully worked problems are interspersed with the text, and a good appendix (pp. 388–395) deals with units, mechanical considerations, &c.

In Part I. the treatment of the magnetic field and of tubes of force deserves special mention, and the diagrams will be found of great assistance to the student. In Part II. the subject of potential—most difficult to elementary students—is very carefully and successfully treated. In most cases the potential of the conductor, as well as its charge, is considered, and thus confusion on these points is guarded against. The electric field is well described, and here again the diagrams given should be very valuable.

In Part III. Ohm's law is applied to the internal as well as to the external circuit; and the theory of the tangent galvanometer is developed. Although the authors give potential curves in connection with the seat of the E.M.F. of the cell, which do not seem to be in agreement with those of some other authorities, the subject is nevertheless well explained.

In Chapter XIII. an account of the chemical effects of the current is given, including a good description of secondary cells. Electromagnetism, telegraphic and telephonic instruments, suspended coil galvanometers and the heating effects of the current are considered in the last chapters.

Altogether the book is a distinct advance on many other similar publications, and it can be thoroughly recommended for matriculation students and others of a similar standard.

LEAKAGE REACTANCE.

BY J. REZELMAN.

Summary.—From the test results on various machines, the author deduces a method for estimating the mutual induction between the overhang coils of the different phases of a stator winding. Following this he proceeds to estimate the negative mutual induction between the overhang coils of the stator and rotor of an asynchronous motor.

Determination of the Mutual Induction between the Overhang Coils.

Experiments carried out on the rotor of a 1,250 KVA turbo-alternator have shown that the formula for the permeance:

$$\lambda_s = 0{\cdot}46 q_s \left(\log \frac{2l_s}{U_s} + A \right)$$

is applicable between fairly wide limits, in order that an approximation to the mutual induction between coils can be obtained by calculation.

This table of experimental results also shows that the coil (a), excited separately, induces the same voltage in a neighbouring coil (b), as (b) produces in (a) when traversed by the same current:

line (a) $e_a = 6{\cdot}4$ ..... $e_b = 4$
,, (b) $e_b = 5{\cdot}6$ ..... $e_a = 4$.

The coil (a) induces in the neighbouring coils
line (a) $e_a = 6{\cdot}4$; $e_b = 4$; $e_c = 2{\cdot}6$; and $e_d = 1{\cdot}6$.

The E.M.F. induced diminishes with increase of distance, *i.e.*, of the periphery U_s.

$e_b = 0{\cdot}626\, e_a$; $e_c = 0{\cdot}407\, e_a$; and $e_d = 0{\cdot}25\, e_a$.

To determine the mutual induction, we take:

line (a) $e_a = 6{\cdot}4$ ..... line (b) $e_b = 5{\cdot}6$ ..... line ($a+b$) $e_{a+b} = 19{\cdot}65$,

then the ratio $m_{a,b} = \dfrac{e_{a+b}}{e_a + e_b} = \dfrac{19{\cdot}65}{6{\cdot}4 + 5{\cdot}6} = 1{\cdot}64$,

represents the *augmentation* of the reactance of (a) and (b) produced by mutual induction.

In the same way:

$m_{b,c} = 1{\cdot}65$ and $m_{c,d} = 1{\cdot}64$;
$m_{a,c} = 1{\cdot}43$ and $m_{b,d} = 1{\cdot}43$; $m_{a,d} = 1{\cdot}34$.

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It follows then that for the same U_s:

(1) $m_{a,b} = m_{b,c} = m_{c,d}$; and (2) $m_{a,c} = m_{b,d}$.

In order to determine the mutual induction between the overhang coils of the different phases, it is therefore sufficient to calculate:

(1) The reactance $x_{s\,I}$ of the end connections of phase I.
(2) " $x_{s\,II}$ " " II.
(3) " $x_{s\,I,II}$ " phases I. and II. connected in series; then the coefficient

$$m_{I,II} = \frac{x_{s\,I,II}}{x_{s\,I} + x_{s\,II}}.$$

For the permeance λ_s of one phase we have considered the three parts:

(a) λ_{sa} along a length l_{sa} and a periphery U_{sa}
(b) λ_{sb} " l_{sb} " U_{sb}
(c) λ_{sc} " l_{sc} " U_{sc}

l_s = the length of one end connection, being split up into l_{sa}, l_{sc}, and l_{sb}, l_{sc}. The permeance of the two phases in series can be determined by the same procedure; for this case the value of l_s is the same as for one phase only. The peripheries U_{sa2}, U_{sl2} and U_{sc2} are larger than for one phase owing to the number of adjacent turns being doubled.

As can be seen from Fig. 1, we can consider that l_{sc} still has the same value as for one phase only, but for the connections

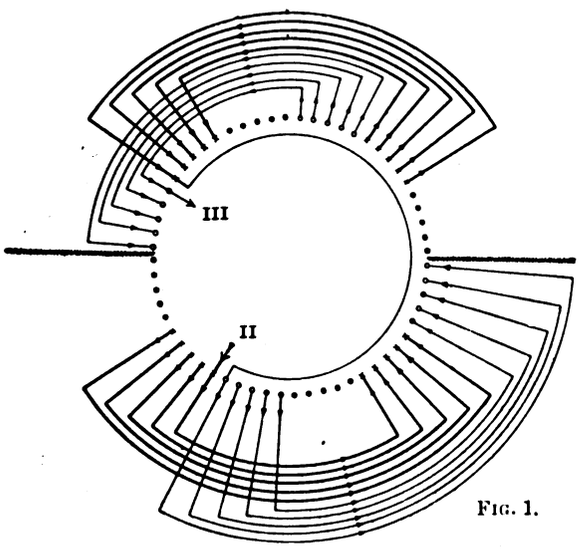

FIG. 1.

l_{sa} and l_{sb} mutual induction is only produced along a part, $C \times l_{sa}$ and $C \times l_{sb}$.

The reactance of the overhang coils in *single phase* per phase being:

$$x_{s1} + x_{sb} + x_{sc} = \frac{12{\cdot}5 \times c \times w_a^2}{p \times q_a \times 10^8} \times l_{sa} \times 0{\cdot}46 q_a \left(\log \frac{2l_s}{U_{sa}} + A\right) + \frac{12{\cdot}5 \times c \times w_b^2}{p \times q_b \times 10^8} \times l_{sb} \times 0{\cdot}46 q_b \left(\log \frac{2l_s}{U_{sb}} + A\right) + \frac{12{\cdot}5 \times c \times w_c^2}{p \times q_c \times 10^8} \times l_{sc} \times 0{\cdot}46 q_c \left(\log \frac{2l_s}{U_{sc}} + A\right)$$

$$= \frac{5{\cdot}75c}{p \times 10^8} \left\{ w_a^2 \times l_{sa} \left(\log \frac{2l_s}{U_{sa}} + A\right) + w_b^2 \times l_{sb} \left(\log \frac{2l_s}{U_{sb}} + A\right) + w_c^2 \times l_{sc} \left(\log \frac{2l_s}{U_{sc}} + A\right) \right\}.$$

That for *two phases in series* becomes:

$$x_{sa_2} + x_{sb_2} + x_{sc_2} = \frac{5{\cdot}75 \times c}{p \times 10^8} \left\{ (2w_a)^2 \times C \times l_{sa} \left(\log \frac{2l_s}{U_{sa_2}} + A\right) + (2w_b^2) \times C \times l_{sb} \left(\log \frac{2l_s}{U_{sb_2}} + A\right) + (2w_c^2) \times C \times l_{sc} \left(\log \frac{2l_s}{U_{sc_2}} + A\right) \right\}$$

$$= 4 \times \frac{5{\cdot}75 \times c}{p \times 10^8} \left\{ w_a^2 \times C \times l_{sa} \left(\log \frac{2l}{U_{sa2}} + A\right) + w_b^2 \times C \times l_{sb} \left(\log \frac{2l_s}{U_{sb_2}} + A\right) + w_c^2 \times C \times l_{sc} \left(\log \frac{2l_s}{U_{sc_2}} + A\right) \right\}.$$

The value of A is the same for the two cases; we will determine the value of C from experiments on the machines already described.

Stator of a Three-Phase Turbo-Alternator.

4,000 KVA; 4 poles – 50 ∼ – 6,600 volts between phases, 60 slots each containing 5 conductors, hence 50 turns per phase.

l_s = 1,860 mm.
l_{sa} = 1,060 mm. ..... U_{sa_2} = 620 mm. (Fig. 2)
l_{sc} = 800 mm. ..... U_{sc_2} = 1,200 mm. (Fig. 3)

The machine is wound with consequent poles, but the end connections of phase II are bent in opposite directions; the reactance of the overhang coils of phases II. and III. in series (Fig. 4) has been measured:

$$x_{sa_2} + x_{sc_2} = 1{\cdot}80w.$$

Calculation gives:

$$x_{sa_2} + x_{sc_2} = 4 \times \frac{5{\cdot}75 \times 51}{2 \times 10^8} \left\{ 50^2 \times C \times 106 \left(\log \frac{2 \times 1860}{620} + 0{\cdot}05\right) + 50^2 \times 80 \left(\log \frac{2 \times 1860}{1200} + 0{\cdot}05\right) \right\}$$

$$= 1{\cdot}29C + 0{\cdot}635; \quad A = 0{\cdot}05 \text{ from experiments,}$$

then $1{\cdot}29C + 0{\cdot}635 = 1{\cdot}8$ and $C = 0{\cdot}905$.

For this machine, the mutual induction of the end coils is high since the end connections are carried parallel with a relatively small clearance (Fig. 2); the ratio $m = 1{\cdot}55$.

B. *Stator of a Three-Phase Alternator.*

270 KVA; 14 poles – 50 ∼ – 3,000 volts between phases. 84 slots, 266 turns per phase.

The machine has a winding "per pole."

$w_a = w_b = 133$ and $w_c = 266$.

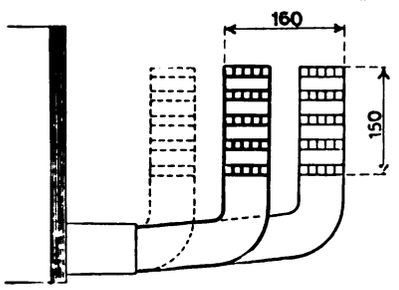

FIG. 2.

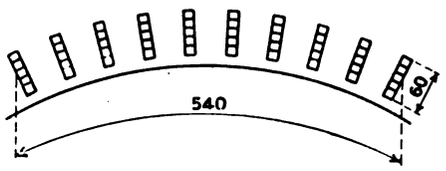

FIG. 3.

1. *Phases I. and II. in Series.*

l_s = 560 mm.
$l_{sa} = l_{sb}$ = 200 mm. ..... $U_{sa_2} = U_{sb_2}$ = 255 mm. (Fig. 4)
l_{sc} = 360 mm. ..... U_{sc_2} = 380 mm. (Fig. 5)

From experiments $A = 0{\cdot}25$ and $x_{sa_2} + x_{sb_2} + x_{sc_2} = 3{\cdot}76w$.

Calculation gives

$$x_{sa_2} + x_{sb_2} + x_{sc_2} = 4 \times \frac{5{\cdot}75 \times 50}{7 \times 10^8} \left\{ 133^2 \times C \times 20 \times \left(\log \frac{2 \times 560}{255} + 0{\cdot}25\right) \times 2 + 266^2 \times 36 \left(\log \frac{2 \times 560}{380} + 0{\cdot}25\right) \right\}$$

$$= 1{\cdot}04C + 3{\cdot}0 = 3{\cdot}76,$$

whence $C = 0{\cdot}73$ and $m = 1{\cdot}31$.

2. *Phases I. and III. in Series.*

l_s = 560 mm.
$l_{sa} = l_{sb}$ = 200 mm. ..... $U_{sa_2} = U_{sb_2}$ = 380 mm. (Fig. 4)
l_{sc} = 360 mm. ..... U_{sc_2} = 380 mm. (Fig. 5)

From experiments $x_{sa_2} + x_{sb_2} + x_{sc_2} = 3{\cdot}66w$.

In a similar manner we find $C = 0{\cdot}76$ and $m = 1{\cdot}26$.

3. *Phases II. and III. in Series.*

l_s = 560 mm.
$l_{sa} = l_{sb}$ = 200 mm. ..... $U_{sa_2} = U_{sb_2}$ = 255 mm. (Fig. 4)
l_{sc} = 360 mm. ..... U_{sc_2} = 380 mm. (Fig. 5)

From experiments $x_{sa_2} + x_{sb_2} + x_{sc_2} = 3{\cdot}96w$.

whence $C = 0{\cdot}86$ and $m = 1{\cdot}37$.

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C. *Stator of a 220 h.p. Three-Phase Motor.*

2 poles; 50 ∼; 6,300 volts between phases; 30 slots with 60 conductors per slot, hence 300 turns per phase. The machine has a winding "per pole."

$w_a = 180$; $w_b = 120$; and $w_c = 300$.

1. *Phases I. and II. in Series.*

$l_s = 1{,}050$ mm.
$l_{sa} =$ 580 mm. ..... $U_{sa_2} = 500$ mm. (Fig. 6)
$l_{sb} =$ 580 mm. ..... $U_{sb_2} = 420$ mm.
$l_{sc} =$ 470 mm. ..... $U_{sc_2} = 940$ mm.

From experiments A = 0·35, and $x_{sa_2} + x_{sb_2} + x_{sc_2} = 58{\cdot}8w$.
Calculation gives:

$$x_{sa_2} + x_{sb_2} + x_{sc_2} = 4 \times \frac{5{\cdot}75 \times 50}{1 \times 10^8} \left\{ 180^2 \times C \times 58 \left(\log \frac{2 \times 1050}{500} + 0{\cdot}35 \right) + 120^2 \times C \times 58 \left(\log \frac{2 \times 1050}{420} + 0{\cdot}35 \right) + 300^2 \times 47 \left(\log \frac{2 \times 1050}{940} + 0{\cdot}35 \right) \right\}$$

$$= 30{\cdot}1C + 34{\cdot}1 = 58{\cdot}8w.$$

Whence $C = 0{\cdot}82$ and $m = 1{\cdot}31$.

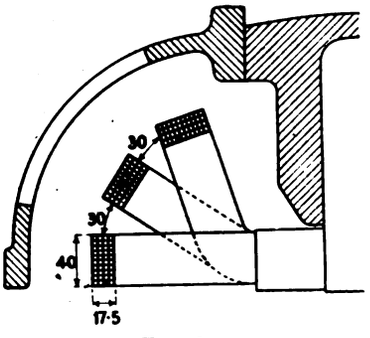

FIG. 4.

2. *Phases II. and III. in Series.*

$l_s = 1090$ mm.
$l_{sa} =$ 620 mm. ..... $U_{sa_2} = 720$ mm.
$l_{sb} =$ 620 mm. ..... $U_{sb_2} = 620$ mm.
$l_{sc} =$ 470 mm. ..... $U_{sc_2} = 940$ mm.

From experiments $x_{sa_2} + x_{sb_2} + x_{sc_2} = 61w$.

In the same way we find $C = 0{\cdot}90$ and $m = 1{\cdot}23$.
The greater distance between the coils thus diminishes the coefficient m from *1·31* to *1·23*.

3. *Phases II. and III. in Series.*

$l_s = 1{,}220$ mm.
$l_{sa} =$ 750 mm. ..... $U_{sa_2} = 500$ mm.
$l_{sb} =$ 750 mm. ..... $U_{sb_2} = 420$ mm.
$l_{sc} =$ 470 mm. ..... $U_{sc_2} = 940$ mm.

From experiments $x'_{sa_2} + x_{sb_2} + x_{sc_2} = 69{\cdot}5w$.

Whence $C = 0{\cdot}76$ and $m = 1{\cdot}26$.

These investigations have been continued on the rotor of a 175 H.P. motor, 3,000 volts, 50 ∽, 750 revs. per min., with a 2 bars per slot winding. The value of C was found to be *0·93* and m was *1·52*. For such a winding the mutual induction of the end connections is high, since the connections are carried parallel and at a small distance from each other.

To sum up

C	m	C	m
0·905	1·55	0·82	1·31
0·73	1·31	0·90	1·23
0·76	1·25	0·76	1·26
0·86	1·37	0·93	1·52

Conclusion.—With the ratio m varying from *1·25* to *1·55*, the coefficient C varies from *0·75* to *0·90*; this variation in C appears large, but when it is considered that it belongs to a term which is only a small part of the total reactance, and therefore a small error in the measurements involves a considerable change in the value of C, it is rather surprising that the variation is not greater.

It follows then, that by taking the value of C as *0·85*, we can determine with a very close approximation the coefficient of the *mutual induction* between the *overhang coils* of various phases.

Now let us see how to apply the formula in order to determine the negative mutual induction between the overhang coils of the *stator* and of the *rotor* of an asynchronous motor.

When the rotor is placed in the stator, there is a compensation of the lines of force; we will let m again represent its magnitude.

There are *three* cases to be considered:—

1. Stator *and* rotor with windings per consequent poles.
2. Stator *and* rotor with windings per pole.
3. Stator with winding per consequent poles and rotor with winding per pole, or conversely.

In the first case, the end connections are normally arranged in *two* planes, *each* phase having as many coils in *the one* plane as in *the other*. In the second case, the end coils are arranged in *three* planes, *one* plane for *each* phase.

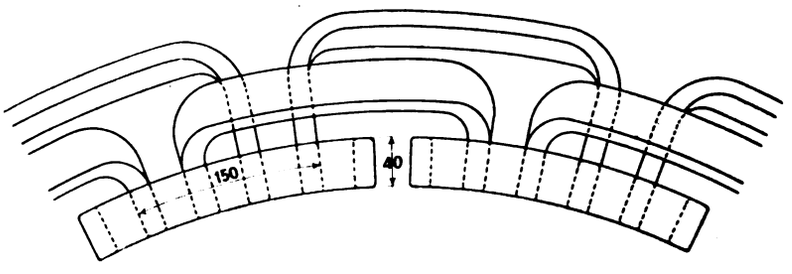

FIG. 5.

For the first case the compensation is therefore the same for *each* phase, whilst for the second it will depend on the position of the plane; it will be sufficient to consider the case of the middle plane.

The combined permeance is determined by the mean value of l_s for the end coils of the stator and the rotor, with the corresponding mean periphery U_s.

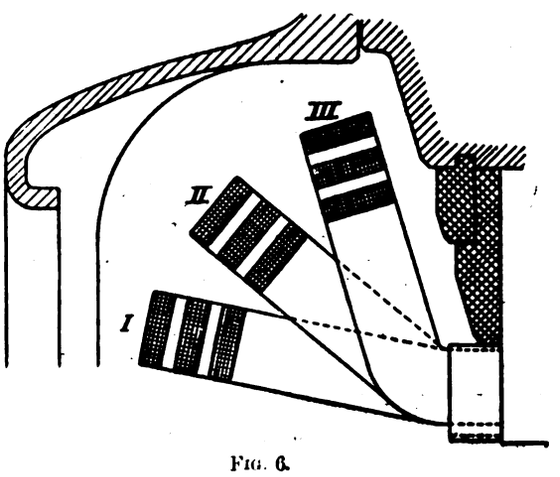

FIG. 6.

In cases 1 and 2 by calling

x_{sI} = reactance of the end coils of the stator.
x_{sII} = reactance of the end coils of the rotor reduced to the stator reactance.
$x_{sI,II}$ = reactance of the end coils of the stator and rotor, supposed connected in series and in the same sense.

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Then the ratio $m = 2 - \frac{x_{s\,I,\,II}}{x_{sI} + x_{sII}}$, represents the *diminution* due to the mutual negative induction and the resulting reactance has the known value

$$2(x_{sI} + x_{sII}) - x_{s\,I,\,II} = x_{sr}.$$

In order to determine the importance of the compensation, let us consider the case of the three-phase 175 H.P. motor,

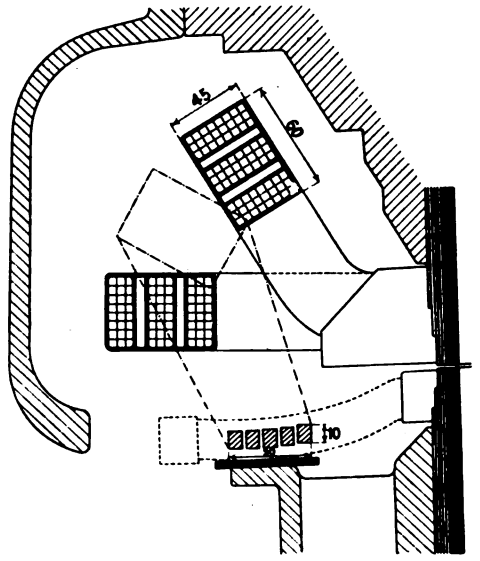

FIG. 7.

8 poles, 50 periods, 3,000 volts between phases, belonging to the third category. The stator has 72 slots each containing 23 conductors—hence 276 turns per phase—and a winding per *consequent* poles.

$l_s = 680$ mm.
$l_{sa} = 360$ mm. ..... $U_{sa} = 210$ mm. ..... $x_{sa} = 1{\cdot}865w.$
$l_{sc} = 320$ mm. ..... $U_{sc} = 250$ mm. ..... $x_{sc} = 1{\cdot}520w.$

$$x_{sI} = 3{\cdot}385w.$$

$A = +0{\cdot}06$, by experiment.

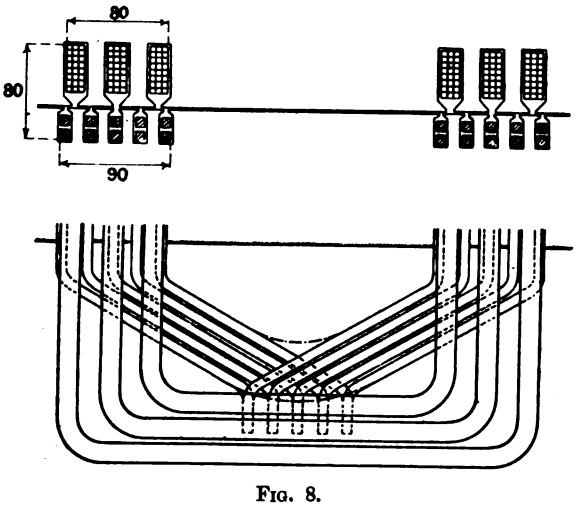

FIG. 8.

The rotor has 120 slots and two bars per slot, therefore 40 turns per phase, and a winding *per pole*.

$l_s = 420$ mm.
$l_{sa} = l_{sb} = 300$ mm.... $U_{sa} = U_{sb} = 100$ mm.... $x_{sa} + x_{sb} = 0\,0239w.$
$l_{sc} = 120$ mm.... $U_{sc} = 200$ mm.... $x_{sc} = 0{\cdot}0148w.$

$$x_{sa} + x_{sb} + x_{sc} = 0{\cdot}0387w.$$

$A = +0{\cdot}42$ from experiment.

The reactance of the end coils of one phase of the rotor, reduced in terms of the stator, thus becomes

$$x_{sII} = 0{\cdot}0387 \times \left(\frac{276}{40}\right)^2 = 1{\cdot}84w;$$

the part b does not take part in the mutual induction, reduced to the stator

$$x'_{sb} = 0{\cdot}01195\left(\frac{276}{40}\right)^2 = 0{\cdot}57w.$$

Consider now that one of the rotor phases is placed opposite to a stator phase, and also that the number of rotor turns per phase is the same as for the stator, $w_a = 276$. The winding of the stator being per consequent poles, and that of the rotor, per pole, we have

$$\begin{aligned} x_{s\,I,\,II} = {} & \frac{12{\cdot}5 \times c \times 1{\cdot}5 \times w_a^2}{p \times 10^8} \times l_{sa} \times 0{\cdot}46\left(\log \frac{2l_s}{U_{sa}} + A_I\right) \\ & + \frac{12{\cdot}5 \times c \times 3 \times \left(\frac{w_a}{2}\right)^2}{p \times 10^8} \times l_{sb} \times 0{\cdot}46\left(\log \frac{2l_s}{U_{sa}} + A_{II}\right) \\ & + \frac{12{\cdot}5 \times c \times 2 \times (w_a)^2}{p \times 10^8} \times l_{sc} \times 0{\cdot}46\left(\log \frac{2l_s}{U_{sc}} + A_I\right) \\ & + \frac{12{\cdot}5 \times c \times 2 \times w_a^2}{p \times 10^8} \times l_{sc} \times 0{\cdot}46\left(\log \frac{2l_s}{U_{sc}} + A_{II}\right) + x'_{sb} \\ = {} & \frac{5{\cdot}75 \times c \times w_a^2}{p \times 10^8}\left\{1{\cdot}5l_{sa}\left(\log \frac{2l_s}{U_{sa}} + A_I\right) + 0{\cdot}75l_{sa}\left(\log \frac{2l_s}{U_{sa}} + A_{II}\right)\right. \\ & \left. + 2l_{sc}\left(\log \frac{2l_s}{U_{sc}} + A_I\right) + 2l_{sc}\left(\log \frac{2l_s}{U_{sc}} + A_{II}\right)\right\} + x'_{sb}. \end{aligned}$$

For our motor the mean dimensions are as follows:—

$l_s = 550$ mm.
$l_{sa} = 330$ mm.; $U_{sa} = 550$ mm. (Fig. 7.)
$l_{sc} = 220$ mm.; $U_{sc} = 330$ mm. (Fig. 8.)

The estimation of the periphery U_{sa} for this motor is approximate, since the stator coils are rectangular and of wires, and the rotor winding is a bar, wave winding; however, a small mistake in this term does not have a great effect, since it acts on a logarithmic term.

We find then

$$\begin{aligned} x_{s\,I,\,II} = {} & \frac{5{\cdot}75 \times 51{\cdot}5 \times 276^2}{4 \times 10^8}\left\{1{\cdot}5 \times 33\left(\log \frac{2 \times 550}{550} + 0{\cdot}06\right)\right. \\ & + 0{\cdot}75 \times 33\left(\log \frac{2 \times 550}{550} + 0{\cdot}42\right) + 2{\cdot}22\left(\log \frac{2 \times 550}{330} + 0{\cdot}06\right) \\ & \left. + 2{\cdot}22\left(\log \frac{2 \times 550}{330} + 0{\cdot}42\right)\right\} + 0{\cdot}57 = 6{\cdot}39w. \end{aligned}$$

It follows that

$$x_{sr} = 2(x_{sI} + x_{sII}) - x_{s\,I,\,II} = 10{\cdot}45 - 6{\cdot}39 = 4{\cdot}06w.$$

and the ratio $\frac{x_{sr}}{x_{sI} + x_{sII}} = \frac{4{\cdot}06}{3{\cdot}385 + 1{\cdot}84} = 0{\cdot}775.$

For the part subjected to mutual induction the coefficient

$$m = 2 - \frac{x_{s\,I,\,II} - x'_{sb}}{x_{sI} + x_{sII} - x'_{sb}} = 2 - \frac{6{\cdot}39 - 0{\cdot}57}{5{\cdot}225 - 0{\cdot}57} = 0{\cdot}75.$$

In the cases (1) and (2) where the end connections are similar, we have:

1. $$x_{s\,I,\,II} = \frac{5{\cdot}75 \times c \times w_a^2}{p \times 10^8}\left\{4l_{sa}\left(\log \frac{2l_s}{U_{sa}} + A\right) + 4l_{sc}\left(\log \frac{2l_s}{U_{sc}} + A\right)\right\}$$

where $w_a = w_c$;

2. $$x_{s\,I,\,II} = \frac{5{\cdot}75 \times c \times w_a^2}{p \times 10^8}\left\{2l_{sa}\left(\log \frac{2l_s}{U_{sa}} + A\right) + 4l_{sc}\left(\log \frac{2l_s}{U_{sc}} + A\right)\right\}$$

where $w_a = w_b$ and $w_c = 2w_a$.

For A, the mean value for the stator and the rotor can be taken. If the rotor of the 175 H.P. motor had a winding per consequent poles, like the stator, with $A = 0{\cdot}06$ we would have

$l_s = 420$ mm.
$l_{sa} = 300$ mm.; $U_{sa} = 120$ mm.; $x_{sa} = 0\,0322w.$
$l_{sc} = 120$ mm.; $U_{sc} = 200$ mm.; $x = 0{\cdot}0097w.$

$$x_{sa} + x = 0{\cdot}0419w.$$

and reduced in terms of the stator $x_{sII} = 1{\cdot}99w.$

For the determination of $x_{s\,I,\,II}$, the dimensions would be

$l_s = 550$ mm.
$l_{sa} = 330$ mm.; $U_{sa} = 550$ mm.;
$l_{sc} = 220$ mm.; $U_{sc} = 330$ mm.; which gives

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$$x_{s1,\,11}=\frac{5\cdot75\times51\cdot5\times276^2}{4\times10^8}\left\{4\times38\left(\log\frac{2\times550}{550}+0\cdot06\right)+4\times22\left(\log\frac{2\times550}{330}+0\cdot06\right)\right\}$$

$=5\cdot56w$ and $x_{sr}=2(3\cdot385+1\cdot99)-5\cdot56=5\cdot19w$.

Here the ratio $\frac{x_{sr}}{x_{s1}+x_{s11}}=m=\frac{5\cdot19}{5\cdot375}=0\cdot965$.

Suppose now the stator and the rotor to be wound per pole with A=0·42, we would have

$l_s=680$ mm.
$l_{sa}=300$ mm.; $U_{sa}=135$ mm.; $x_{sa}+x_{sb}=1\cdot20w$.
$l_{sc}=380$ mm.; $U_{sc}=250$ mm.; $x_{sc}=2\cdot48w$.

$x_{s1}=3\ 68w$.
and $x_{s11}=1\cdot84w$.

For the determination of $x_{s1,\,11}$ the dimensions would be

$l_s=550$ mm.;
$l_{sa}=300$ mm.; $U_{sa}=520$ mm.,
$l_{sc}=250$ mm.; $U_{sc}=330$ mm., which gives

$$x_{s1,\,11}=\frac{5\cdot75\times51\cdot5\times276^2}{4\times10^8}\left\{2\times30\left(\log\frac{2\times550}{520}+0\cdot42\right)+4\times25\left(\log\frac{2\times550}{330}+0\cdot42\right)\right\}$$

$=7\cdot8w$, and $x_{sr}=2(3\cdot68+1\cdot84)-7\cdot8=3\cdot24w$.

The ratio $\frac{x_{sr}}{x_{s1}+x_{s11}}=m=\frac{3\cdot24}{3\cdot52}=0\cdot59$.

Let us check finally the case of the stator wound per pole A = 0·42 with rotor wound per consequent poles and A=0·06;

$x_{s1}=3\cdot68w$
$x_{s11}=1\cdot99w$
$x_{s1}+x_{s11}=5\cdot67w$

$l_s=550$ mm.
$l_{sa}=300$ mm. ..... $U_{sa}=520$ mm.
$l_{sc}=250$ mm. ..... $U_{sc}=300$ mm.,

then
$$x_{s1,\,11}=\frac{5\cdot75\times51\cdot5\times276^2}{4\times10^8}\left\{1\cdot5\times30\left(\log\frac{2\times550}{520}+0\cdot06\right)+0\cdot75\times30\left(\log\frac{2\times550}{520}+0\cdot42\right)+2\times25\left(\log\frac{2\times550}{330}+0\cdot06\right)+2\times25\left(\log\frac{2\times550}{330}+0\cdot42\right)\right\}+0\cdot6.$$

$=6\cdot2+0\cdot6=6\cdot8_w$,

whence $x_{sr}=2\times5\cdot67-6\ 8=4\cdot54w$, and $\frac{x_{sr}}{x_{s1}+x_{s11}}=\frac{4\cdot54}{5\cdot67}=0\cdot80$.

To sum up

	$x_{s1}+x_{s11}$	x_{sr}	$\frac{x_{sr}}{x_{s1}+x_{s11}}$
1. Stator per consequent poles ($A_I=0\cdot06$) Rotor per pole ($A_{II}=0\cdot42$)	5·225	4·06	0·775
2. Stator per consequent poles ($A_I=0\cdot06$) Rotor per consequent poles ($A_{II}=0\cdot06$)	5·375	5·19	0·965
3 Stator per pole ($A_I=0\cdot42$) Rotor per pole ($A_{II}=0\cdot42$)	5·52	3·24	0·59
4. Stator per pole ($A_I=0\cdot42$) Rotor per consequent poles ($A_{II}=0\cdot06$)	5·67	4·54	0 80

The table shows that the compensation is almost negligible when stator and rotor are wound per consequent poles (where $A\simeq0$), whilst it is very important when they are both wound per pole. The compensation has an intermediate value for a mixed winding.

By calculating the value of $x_{s1}+x_{s11}$ for $A_I=A_{II}=0$ in the four cases considered it is found

1. $x_{s1}+x_{s11}=4\cdot18w$.
2. $x_{s1}+x_{s11}=4\cdot83w$.
3. $x_{s1}+x_{s11}=3\cdot635w$.
4. $x_{s1}+x_{s11}=4\ 83w$.

We can conclude from this, that with a motor of normal construction and dimensions, which we are considering, the relationship is such, that the *sum* of the reactances of the stator and the rotor and (x_{s1} and x_{s11}), calculated with $A_I=A_{II}=0$, is very nearly equal to the *resultant reactance* x_{sr}.

It follows then that the compensation by negative mutual induction is sensibly equivalent to the suppression of the induction factor A.

In addition, the positive mutual induction between phases of a winding per pole in the case of two phases in series, three-phase, will diminish, since owing to their length these common lines of force will come under the influence of the end connections of the other winding.

ELECTRICITY AND GAS IN MANCHESTER.

At the suggestion of the chairman of the Electricity Committee of the Manchester Corporation, the chief officials of the electricity and gas departments met some months ago to consider carefully the relationship existing between the two departments. Their report has now been issued, and we give below certain extracts from it.

The prices charged by each of the respective committees were considered at some length, with specific reference to the allegation that supplies were sometimes furnished below cost. We came to the conclusion that no arbitrary ruling could be laid down, as so much depended upon the conditions of supply and upon the different factors entering into each individual case. Further, we were convinced that all the prices of each department were fixed on recognised principles.

We are unanimously of the opinion that no useful purpose can be served by one department criticising the other; and that if further criticism were desirable, nothing valid could be urged as to methods of working without a prolonged special study of the problems facing each department. As the situation presents itself to us, it is simply that the City Council has entrusted to the two committees certain amounts of capital outlay, and that the City Council exacts from each committee annual sums in aid of rates. Such being the case, the question arises, on what common basis can a fair comparison be made?

The outlay on permanent works (disregarding floating stocks) should form the first line of comparison. Allowance has then to be made for the difference in the economic status of the departments. Owing to the gas department having been established many years longer than the electricity department, it has had time and opportunity to free a much larger proportion of its assets from debt than is the case with the latter department.

From a comparison of the capital expenditure of the two departments it appears that that of the gas department is £2,851,184 and of the electricity department £2,678,629. During the year the former department has contributed £46,500 and the latter £15,000 in aid of rates, *i.e.*, the percentage of rate aid to capital in the two cases is 0·67 and 0·56 of the per cent. respectively. Allowing for the probability of future gas contributions to rate aid being £50,000 (the normal figure for some years past), the gas percentage would be raised from 0·67 to 0·79, or £22,700, an excess over the electricity figure of £7,700, or 0·23 per cent. On the electricity capital this difference of percentage represents £6,160. This deficiency is explained in a supplementary report signed by the electricity officials alone.

It may be permissible to call attention to the attitude of Parliament in regard to rate aid. In dealing with certain gas bills, Parliamentary committees have laid down the condition that a maximum of only 1 per cent. on the outstanding mortgage debt should be paid over in aid of rates. In the case of the Glasgow Gas Consolidation Bill before a House of Commons commitee this year, the gas undertaking was precluded from carrying any balance of profit to the credit of the Corporation for general purposes; in fact, the committee specifically said that Glasgow ought to balance income and expenditure, and so supply at cost. It is quite clear, then, that if Manchester were now establishing its gas and electricity undertakings no option would be given by Parliament as to the extent to which profits could be devoted to rate aid. Equally clear is it that Parliament considers the benefit, if any, to accrue to the ratepayers must be calculated on the outstanding mortgage debt as being the only true measure of the ratepayers' risk.

Applying the principle laid down by Parliament to the Manchester gas and electricity undertakings, the position in regard to rate aid would be as follows:—

	Mortgage debt as at March 31, 1910.	Amount of rate aid.
Gas	£1,212,685	£12,127
Electricity	1,970,112	19,701

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Leaving altogether the questions of rate aid and financial comparisons, we have considered how best to deal in the future with gas and electricity supplies for new colonies or estates where both supplies are demanded, such as has been the case at Burnage, Chorltonville, &c. As the ratepayers have a right to demand either or both supplies, provided an adequate return is assured to the Corporation on the necessary capital, it is held that the electricity department should continue exercising its powers of requiring an annual gross revenue of 20 per cent. on capital outlay on mains, and that the gas department should also demand a corresponding return. In the event of no adequate return being forthcoming for both departments from supplies to such estates, and failing a satisfactory arrangement between the departments themselves, it is suggested that such cases should be referred to a standing joint committee composed of representatives of each committee and, say, of the Finance Committee. The joint committee would not deal with all supply applications, but only with those of the nature before mentioned. A committee so constituted would necessarily consider the interests of the Corporation as a whole rather than those of either department.

In conclusion, we desire to say that we are unanimously in agreement with Parliamentary practice as to the mortgage debt being taken as the basis upon which rate aid should be computed, and the adoption of that basis by the two departments would remove all grounds for criticism in the future.

Supplementary Report by Electricity Officials.—The electricity contribution in aid of rates, after allowing for "free" capital, apparently still falls short of the gas contribution. Taking the year 1910-11, the shortage is £2,946; had the gas contribution been at the normal figure of £50,000, the deficiency would have been £6,160. As the gas contribution, judging from the experience of recent years, will probably remain at £50,000, and as the electricity contribution will at some time in the near future probably increase, the apparent shortage is in a fair way to disappear. But without waiting for that time there is already ample justification for the difference in the contribution. This will be evident when it is remembered that a sum of approximately £1,000,000 has been sunk by the Electricity Committee in meeting traction requirements, and that by arrangement between the Tramways and Electricity Committees approved by the City Council, a price of 1d. per unit is charged, representing cost only, thus precluding the earning of profit on that capital for handing over to the rates. Obviously, if the price to the Tramways Committee were increased, that committee would have its revenue reduced, and would be in a worse position for contributing to the rates. Moreover, such a step would be totally contrary to the spirit in which the Tramways and Electricity Committees and the City Council regarded the question of supply at the outset, which was that one committee should not make a profit out of the other. The validity of this has up to the present time been unquestioned.

THE PREVENTION OF ACCIDENTS IN MINES (THE FISHER SYSTEM).

As a precautionary measure against accidental shock it is usual to earth the metallic casings of motors, switches and cables in mining, colliery and industrial installations. Unless the system of earth connections is carefully made a break may occur in the earthing circuit. This, of course, has no immediate effect on the working of the plant, and a feeling of false security is engendered, whilst it may become possible for men to receive shocks, with disastrous results. The Fisher system has been introduced by Messrs. W. T. Glover & Co. with the object of removing this undoubted disadvantage from earthed systems of distribution. The Company has recently issued details of the system, and the following description applies to apparatus for three-phase circuits; modifications can, however, be introduced for direct-current working.

In connection with this system there are provided a gate end box comprising a solenoid-operated three-pole oil switch having automatic no-voltage release and overload release with variable time limit; an overload earth-circuit relay switch in series with the solenoid holding in the main switch is also included. In addition there are provided a signal lamp and shutter device to indicate whether the pressure is (1) "off" the main supply cable, (2) "on" as far as the gate end box, (3) "on" the trailing cable and right through to the motor. All these parts are enclosed in a specially cased iron box (*see* Fig. 2), which has suitable glands with armour clamp for the entry of the main three-core cable, and also a specially designed socket for the entry and inter-locking of the trailing cable plug. The trailing cable comprises a three-core rubber-insulated bitumen-sheathed cable, which can be enclosed with metallic, leather or cord protection, according to the working conditions. Beside the three main conductors there are two other conductors forming part of the subsidiary circuit, which will be referred to later. These additional conductors are laid up with the main cable, so that any damage or breakdown of the latter will interrupt the subsidiary circuit. Leakage from an incipient fault on the cable cores, if picked up by one of the subsidiary conductors, will increase the earth current in the latter, and thereby open the relay switch. Interruption of the subsidiary circuit follows, and immediately the main switch is also opened.

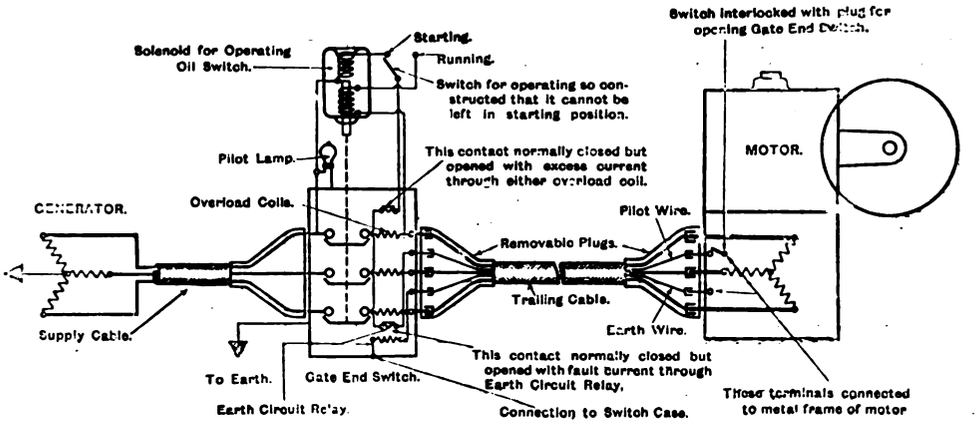

FIG. 1.—DIAGRAM OF FISHER SYSTEM APPLIED TO THREE-PHASE DISTRIBUTION.

The equipment is completed by suitable plugs for connecting the trailing cable into the gate end box and motor respectively. The gate end box plug is interlocked with the operating handle of the gate end switch, so that the plug can only be withdrawn when the switch is in the off position. Similarly, the motor plug is interlocked with the socket on the motor and the subsidiary circuit switch. This latter is used for the remote control of the gate end switch by the men at the working end of the trailing cable. The diagram Fig. 1 shows the connections between the earth wire, pilot wire and the solenoid operating the gate end switch. All these are in electrical series, and form a subsidiary circuit for the purpose of opening the gate end switch immediately upon any interruption of supply from the passage of excessive current due to faulty conditions. The scheme of connections prevents the supply being renewed until the continuity of the earthing circuit has been remade.

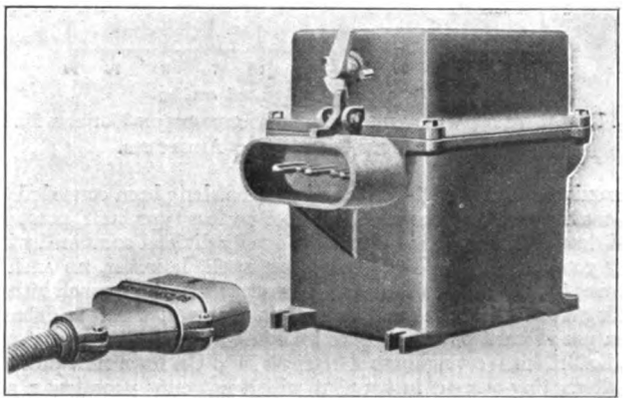

FIG. 2.—GENERAL VIEW OF FISHER APPARATUS AND CABLE PLUG.

Before current can pass from the gate end switch to the motor, both plugs, which are, of course, interlocked with the gate end switch of the remote control switch on the motor, must be inserted. When this has been done the operating handle of the gate end switch can be moved into the on position, and the subsidiary circuit is completed through the solenoid, which closes the switch in the main supply circuit. It should be noted that the operating switch is constructed on the free handle principle, so that the main circuit cannot be kept closed under fault conditions. The remote control

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switch is closed by the insertion of the plug in the socket on the motor. The scheme of connections affords complete protection, in that the gate end switch is automatically tripped when any one of the following contingencies arise: (1) Accidental or intentional removal of either plug, or breakage of earth or pilot wires in the subsidiary circuit; (2) breakdown of insulation resulting in earthing or short-circuiting the main cores of the trailing cable, motor windings or other live parts in connection with them; (3) accident to the coal cutter or other apparatus, necessitating immediate interruption of the circuit; (4) constant overload, which is guarded against by the variable time limit (this admits passage of heavy starting currents, but protects the circuit against persistent overloading); (5) interruption of supply from the power house, which causes the solenoid to act as a no-volt coil; (6) leakage from an incipient fault of the subsidiary circuit operating the earth circuit relay switch.

The Fisher apparatus has the initial advantage of being portable. It also appears to meet the possible objection of colliery managers to the use of automatic apparatus in the workings. It will be gathered from the foregoing description that the whole of the protection apparatus is enclosed in a cast-iron case, and, consequently, is beyond the reach of inquisitive or vindictive workmen. The construction also provides adequately for efficient insulation, so that the apparatus is comparable with the standard appearance of the oil-insulated switchgear as now regularly used in mines.

SCALES OF ELECTRICAL INSTRUMENTS.

It is well recognised that the utility of a direct-reading instrument is closely connected with the character of the scale, crowded divisions at one end and an open scale at the other being often far from

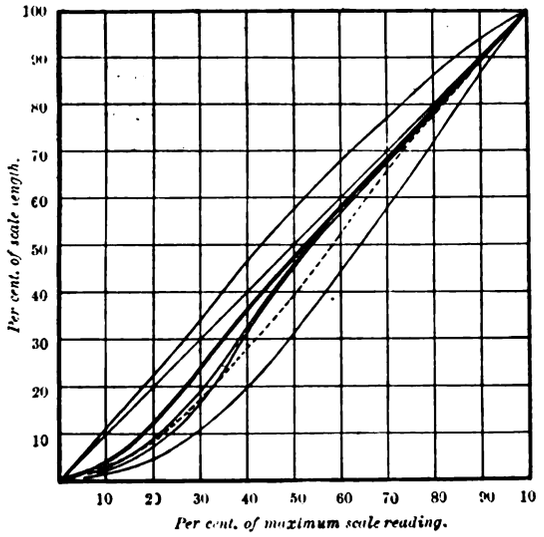

FIG. 1.—CURVE SHOWING THE SCALE DISTRIBUTION ON MODERN MOVING IRON GRAVITY CONTROLLED AMMETERS.

convenient. For direct-current work it has long been conceded that the moving coil instrument is the most perfect type built, possessing as it does a scale which is absolutely evenly divided combined with a very good accuracy. For alternating work, however, no such instrument has been available, the nearest practical approach hitherto having been the induction type of instrument, which is debarred from use in most cases owing to its comparatively heavy cost.

The British Westinghouse Electric & Mfg. Co. have now produced an alternating-current instrument which not only possesses a scale almost identical with a moving coil instrument, but which is at the same time as cheap as any instrument on the market. The type "SB," as this instrument is called, is of the well-known moving iron pattern, differing but slightly in construction from the many instruments of this class. The exceptional scale is obtained by means of a specially shaped armature, which, we understand, is the result of exhaustive experiments lasting over several months.

To illustrate clearly the improvement introduced by this scale, the makers have sent us curves showing the relation between scale length and scale reading for this and other instruments, as reproduced in Fig. 1. Obviously a perfectly evenly divided scale will have a straight line curve, and the further the curve departs from this line the more important is the division of the scale. The curve for the "SB" instrument is shown as a heavy line, and is seen to depart from the straight line much less than the other curves obtained from the scales of moving iron instruments, made by the leading makers both in England and on the Continent. Moreover, it should be observed that the Westinghouse curve is practically a straight line above 10 per cent. scale marking. A further and most interesting comparison is afforded by the dotted curve, which is that of a modern high-class induction ammeter.

When it is remembered that the instrument under consideration is suitable alike for alternating current or direct current (and this without special calibration), the cheaper cost of the moving iron instrument should cause it to be a formidable rival of the moving coil instrument. We understand that the instrument has an

WESTINGHOUSE A.C. AMMETER.

unusually light movement and a very high moving force, which, combined with first-class workmanship, should give a close accuracy and permanency of calibration. Fig. 2 illustrates one of these ammeters.

HAMPSTEAD ELECTRICAL EXHIBITION.

An interesting exhibition of domestic electrical appliances, which has been organised by the Electricity Department of the Hampstead Corporation, was opened on Tuesday last by the Mayor (Mr. Ernest Todd). This exhibition is being held at the Public Baths, Finchley-road, N.W., and will remain open until to-morrow. The exhibitors include several local contractors; for instance, Mr. E. Rivers-Smith, who is showing Ediswan and Bastian cooking and heating apparatus; the Premier Electrical Co., who are showing heating and cooking apparatus, Venetian glass shades, electrical fittings and Premelco metal filament lamps; Mr. E. G. Kellond, who is showing heating and cooking apparatus and wooden electric light fittings; Messrs. Troy & Co. who are showing Horvath "Mascot" "Metaflect" and "Solar" shop window reflector lamps; and Messrs. Roper & Co., who have a special display of the "Archer" heating and cooking apparatus. Other exhibitors, whose sphere of action is rather more than purely local, include Messrs. Siemens Bros. & Co. and Siemens Bros. Dynamo Works who are showing examples of the O.S. wiring system, as well as "Tantalum" and "Onewatt" lamps, fittings, heating and cooking apparatus and "Zed" fuses; Messrs. Purcell & Nobbs, on whose stand are fresh air electric heaters, "Electroyl" heaters, hot plates, irons and curlers; Messrs. Rashleigh Phipps, who have a special display and demonstration of heating and cooking apparatus; and the Berry Construction Co., who are showing "Tricity" cookers and cooking ranges. The Hampstead Corporation Electricity Department have an exhibition of joint boxes showing the various methods of connecting houses to the supply mains, while there is also a bureau at which full information regarding electricity supply in the district may be obtained.

Electricity Supply at Bergen.—According to "The Times Engineering Supplement," the generating station at Bergen, Norway, which contains steam-driven sets, is being replaced by a new station. This station is designed to accommodate machinery capable of developing 35,000 H.P., which is to be obtained from water-power. The work involves the blasting of a water tunnel which will exceed 2 miles in length, and which, it is expected, will take 2½ years to complete. The new station is being erected at Samnanger, to the east of Bergen, and will generate current at 7,500 volts, which will be transformed to 40,000 volts for transmission to Bergen. It is anticipated that the undertaking will be finished during 1912, and that the cost will be about £200,000.

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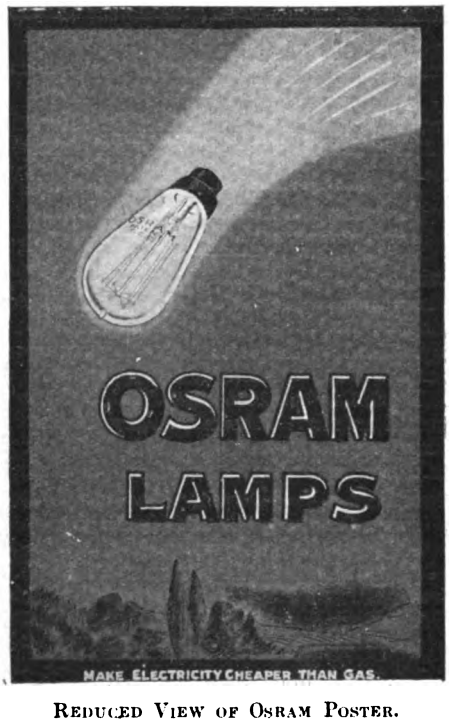
COMMERCIAL AND INDUSTRIAL NOTES.

OSRAM PUBLICITY.

The publication department of the General Electric Co. has embarked upon a vigorous campaign for assisting electrical contractors and central station engineers in making the Osram lamp even more popular than it is already. We have received a budget of Osram literature from the General Electric Co., which indicates that the advertising department has gone very carefully into the problem, and has practically covered the entire ground from the direct appeal to the public eye by large posters to the more personal solicitation of the picture postcard. Accompanying the coloured literature is a tastefully prepared booklet which generally points out the chief technical features of the Osram lamp, and also illustrates a few of the important buildings in which it is used. This particular item is worthy of acceptance by any householder, and if judiciously distributed by the electrical contractor should not fail to excite interest. At the same time, the contractor and central station engineer can affix to his letter paper tiny coloured labels which emphasise the economical properties of the Osram lamp and help to keep its merits well to the front. To that class of the public which is more technically inclined the company offers a squared paper diagram upon which a 50 c.p. Osram lamp is compared with a 65 c.p. Block Light mantle over a period of 500 hours. The cost of the two luminants is compared, and also the respective candle-powers. This is an interesting piece of literature and clearly shows how the candle-power of the Osram lamp is maintained throughout its life.



Reduced View of Osram Poster.

The Osram poster will already be familiar to our readers, as it has been displayed for some time now on the public hoardings in London and the larger provincial centres. It is an attractive multi-coloured production and should impress the name of the lamp upon the mind of the general public. A reproduction of this poster is given herewith.

A LARGE ELECTRIC CLOCK.

The Royal Liver Insurance Co. has erected enormous new offices on the Mersey side at Liverpool. The building rivals in dimensions and height the largest New York sky-scrapers, and reduces the neighbouring structures to insignificant proportions. Surmounting the building is a tower, into the four sides of which is being fitted what is claimed to be the largest electric clock in the world. Each dial measures 25 ft. in diameter, and the minute hands are 14 ft. long and 3 ft. across at the widest part. This nearly approaches the figures of the hands of Big Ben, the latter being some 16 ft. in length. Each hand is of copper with 9 in. gunmetal ribs, specially dimensioned to withstand the varying wind pressures of such an exposed position.

The dials are cast in several pieces, to facilitate manufacture, transmission and erection, and the white groundwork will be a special translucent glass only $\frac{1}{8}$ in. thick; this glass has satisfactorily stood a pressure test of 600 lb. per square inch without breaking. The hours are indicated by 12 distinctive marks instead of the usual Roman characters, and each measures 3 ft. by 1 ft. 6 in. Each of the minute marks is separated by a distance of 1 ft. 2 in. so that the actual circumference of the clock face at the minute line is 70 ft.

The clock is electrically operated on the waiting train movement system introduced by Messrs. Gent & Co., of Leicester, some years ago. The movement is such that the hands do not jump forward in half-minute impulses, but have a practically continuous motion. The waiting train movement is a reciprocating slow-speed motor

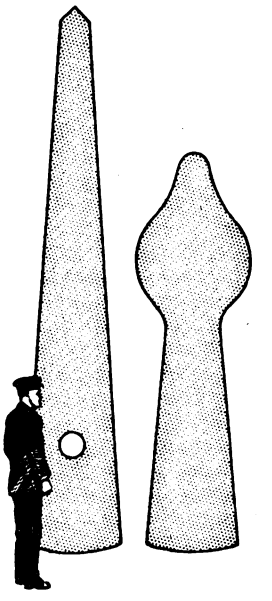
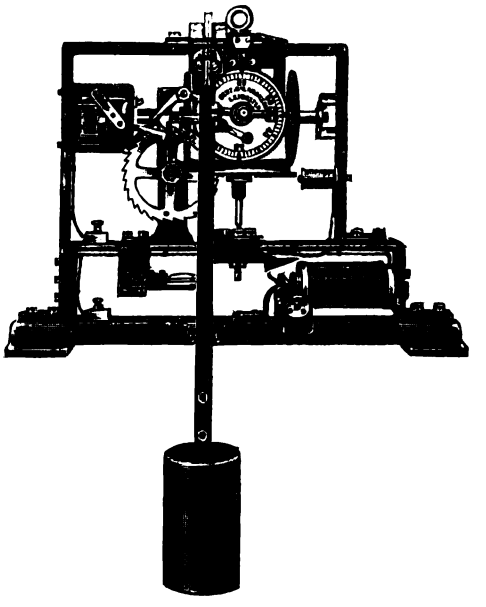


Illustration showing Comparative Size of Hands and a Man.



Mechanism of Electric Clock.

which rotates the hands only. The time keeping is effected by a time transmitter, which brings the waiting train movement under control every half-minute. The makers claim as a special advantage of this system that the time-keeping element of the clock is entirely independent of the hand-driving element. One of the principal features of this arrangement is that the effect of the weather cannot react on the time-keeping. The time transmitter will be connected through the G.P.O. wires to Greenwich, and will therefore automatically indicate Greenwich mean time.

The dials of this clock will be electrically illuminated, and the lamps will be lighted and extinguished by an automatically adjustable time switch. This apparatus alters the times of lighting and extinguishing to suit the seasons, and it also makes an adjustment of the error due to leap year. The accompanying illustrations give some idea of the size of the clock and also the construction of the waiting train movement.

The whole of this important work has been carried out by Messrs. Gent & Co.

O.S. WIRING.

We have referred from time to time to the O.S. wiring system and the advantages which it possesses over ordinary conduit and casing, particularly for surface work in private houses, ships, &c. We understand from Messrs. Siemens Brothers & Co. that the demand for Stannos wires, which form a portion of the O.S. wiring system, has exceeded their anticipations during the past year, and further that this demand is continuing to increase. The company is very anxious to give as wide publicity as possible to Stannos wiring, and has recently revised its catalogue and prepared a quantity of useful publicity literature. We are asked to specially call attention to the fact that the prices for Stannos wires have been considerably reduced, while the high quality of insulation and finished appearance of the covering is maintained. Stannos wires are now available in seven sizes from 1/18 to 7/16, either with ordinary or heavy sheathing. The former is employed for sizes up to 7/20, and the latter for all other sizes. The introduction of the larger sizes of Stannos makes its use possible for wiring to motors and the feeders of lighting

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installations. It is now possible to carry out an "all-Stannos" job instead of a mixture of Stannos and tubing as was formerly necessary on large installations.

It will be remembered that Stannos wire, by reason of its tinned copper sheathing, can be used for concentric wiring. To facilitate this class of work a special line of continuity fixtures and other accessories, including double-wound transformers and low-voltage 1-watt lamps, have been introduced. Attention has also been paid by Messrs. Siemens to the question of cheapening the cost of house services, and for this purpose they have introduced a Stannos house service box by means of which a row of contiguous houses can be supplied. The box will take a low-tension concentric service cable up to 0·05 sq. in. and outgoing Stannos mains up to 7/16. The latter can be run along the front of the houses and branch off to smaller Stannos wires by special watertight tee-joint boxes. Included in the O.S. wiring catalogue are details of a line of Stannos fuse boards fitted with Siemens Zed fuses.

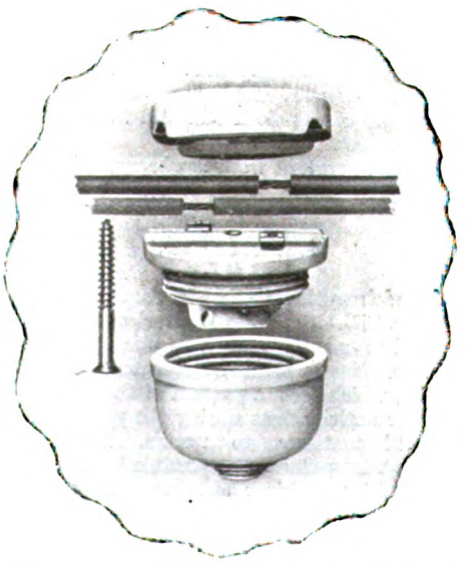
REDUCED ILLUSTRATION OF O.S. WIRING SHOW-CARD.

The catalogue has been written in a style which is readily understandable by the ordinary wiring contractor, and should assist him in introducing Stannos, more particularly to the householder.

With the idea of further exciting interest in the O.S. wiring system, Messrs. Siemens have issued a lithographed showcard, which every wiring contractor should immediately apply for and put up in a prominent position in his showroom. A reduced reproduction of this card is given herewith, and it will serve to illustrate its general suitability to the subject.

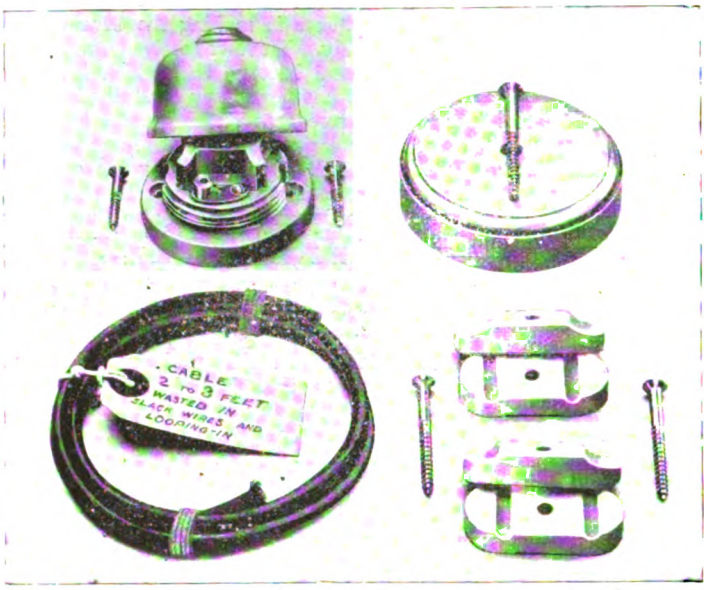
V.B. CLEAT CEILING ROSES.

Messrs. Loxley & Co., electrical engineers, Leeds, introduced about 12 months ago a type of ceiling rose which dispenses with a quantity



V.B. CEILING ROSE, ILLUSTRATING MINIMUM OF PARTS.

of the material usually employed in fixing this particular accessory for surface wiring. The ceiling rose dispenses with the necessity for the usual wood block, it does away with jointing, looping in, and straining cleats. There is no necessity to cut the wires, and the ceiling rose is held securely in position by only one screw. Similarly, there is a saving of the loops of cable which it is necessary to turn in and out of the usual ceiling rose. Not the least important item is the economy in time and labour. The difference between the V.B.



PARTS REQUIRED FOR ORDINARY CEILING ROSE, FOR SURFACE WIRING.

ceiling rose and the old pattern can best be shown by means of comparative illustrations. These are reproduced herewith and speak for themselves.

NEW TRADE LITERATURE.

House Service Cut-Outs.—A leaflet recently issued by the Edison & Swan Co. deals with an improved form of service cut-out. The base is of vitreous porcelain fixed in an asbestos lined cast-iron case. The cover is provided with a small inspection window, and all live metal parts are carefully shielded to reduce the risk of arcing to a minimum. Insulating bushes are provided, and the case can be sealed in the usual manner. A complete range of standard fuses for motor and house service work is now made in this type with 3 in., 4 in., and 6 in. break, according to the amount of current carried.

Dowsing Radiators.—The Dowsing Radiant Heat Co. directs special attention in the issue of its 1910-11 list to a considerable reduction in the price of luminous radiators. The standard of excellence in design and construction appears to be well maintained, and the revised prices should tend to materially increase the sale of these well-known radiators. Included in the list is a special description of the "solarium" or electric sun bath, which may be obtained in sizes for domestic use and also for medical institutes, hospitals, sanatoriums, hydropathic establishments, &c.

Crompton D.C. Motors.—The latest list, D.26, of Crompton enclosed d.c. motors and dynamos contains a complete specification of the machines manufactured by the company, which range in output from 2 to 125 B.H.P. The list is uniform with the company's other publications. It has been carefully compiled and the matter classified in a useful and convenient manner. The list also contains full range of prices of motors, pulleys, flywheels, foundation rig, starters and regulators.

The A.E.G., Berlin, have just issued four catalogues which respectively describe their products in the way of ironclad switchgear for medium voltages, the Tirrill system of automatic voltage regulation, a special charging switchboard for electric automobiles, and the applications of various types of meters.

Pulley-Blocks.—Messrs. Herbert Morris & Bastert (Ltd.), Loughborough, are issuing a booklet which describes fully their H.M.B. worm gear pulley-block. This is made in stock sizes to lift loads from $\frac{1}{8}$ ton to 60 tons. The block is chain-driven, and from the illustrations depicting its practical application appears to be very a useful and handy device. The booklet will be sent to interested engineers immediately on request.

Instruments.—The Walsall Electrical Co. is now issuing a list which describes and prices a line of d.c. and a.c. instruments for switchboard, testing and portable use. A noticeable item in the catalogue

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is an inexpensive form of portable voltmeter and ammeter. Both of these instruments are of the moving coil type, and the latter is a central zero instrument.

Cryselco Lamps.—The story of the manufacture of the Cryselco carbon and metal lamps is well told by a hypothetical personage "Chris Elco" in a booklet entitled "Light Notes on a Light Subject." This is being issued by Cryselco Limited, Kempston Works, Bedford.

CRYSELCO WORKS. THE CONTROL ROOM.

The reading matter of the booklet is couched in terms readily understandable by the average layman, and constitutes an interesting account of electric lamp manufacture. The illustrations are accompanied by line diagrams which clearly explain the processes of

CRYSELCO WORKS. THE PUMP ROOM.

manufacture. In addition to the story of the Cryselco lamp there are numerous illustrations of the standard patterns of both metal and carbon lamps. The booklet is a creditable production and should materially assist Cryselco sales.

Protection against Short-Circuit Dangers on High-Tension Networks.—In a recent issue of the "Atti" della Associazione Elettrotecnica Italiana, Mr. Fano described the arrangement used for this purpose by the Neapolitan Supply Co., whose network includes 25 miles of cable and 37½ miles of overhead work, the supply being three phase at a pressure of 5,000 volts, and a frequency of 42. It was recognised that the most efficacious means of protection against short circuits was to connect continuously all the insulating apparatus in the station and all the insulators on the line. The neutral points of all the transformer secondaries as well as the lead covering of the cables are also connected up in the same way. When a current flows through this circuit a signal is given at the generating station or sub-station, and is immediately followed by the cutting out of the damaged section. The operation of this arrangement is based on the difference in strength between the normal and short circuit currents in the return circuit.

LEGAL INTELLIGENCE.

Eck v. Union-Castle Mail Steamship Co. (Ltd.)

An interesting case came before Judge Rentoul in the City of London Court on Thursday last week, when Mr. H. Justus Eck (of the Union Electric Co.) sought to recover £4. 12s. 2d. from the Union-Castle Mail Steamship Co., who charged him that sum for extra accommodation on their intermediate liner the "Avondale Castle."

Mr. Eck, with his wife and daughter, went to Capetown in August last year in a Union-Castle boat, travelling first class. They returned in December, paying £56 for accommodation.

The evidence was to the effect that when they had been at sea some days Mrs. and Miss Eck could not occupy their cabin any longer because of the complete absence of ventilation. Counsel for plaintiff said that the company, in one of their booklets, stated that "a complete system of ventilation had been adopted, and that electricity was brought to bear on the cabins, saloons, &c., by the adoption of a large number of electric fans." There was (counsel said) no fan in Mrs. Eck's cabin, and Mr. Eck had to pay £4. 12s. 2d. to enable her to occupy a cabin where she could have the accommodation she needed. He contended that the company had been guilty of a breach of contract and misrepresentation. The cabin without a fan was quite intolerable. The porthole of the cabin could not be kept open because of the Trade winds.

On behalf of the company it was urged that they did not guarantee that every cabin would have an electric fan in it. The case was of the greatest importance to all steamship companies, as actions might be brought against them broadcast.

Judge RENTOUL said he thought anybody reading the booklet would think the cabins had electric fans in them, and Mrs. Eck's cabin had not. If there had been a fan in her cabin, no matter how badly ventilated it was, the company would not have been liable. If fans had been provided and they had gone wrong there would have been no case. He must, in the circumstances, find for Mr. Eck, with costs.

Leave to appeal was refused.

Torquay Tramways Arbitration.

Mr Archibald Read has now given his award in the arbitration between Torquay Corporation and the Torquay Tramways Co. to decide whether the Corporation have unreasonably withheld their consent to the adoption by the company of the overhead system of traction on the Torbay-road, in lieu of the present surface contact system, and whether the Corporation have an absolute veto in the matter.

In the award (which is in the form of a special case for the opinion of the Court, owing to the contention of the Corporation that he had no jurisdiction), the arbitrator states that he disagrees with the statement of the Corporation's counsel that the Corporation's right of option as to the system to be used on the Torbay-road was given as a consideration for the Corporation's waiving its claim for a financial guarantee. The provision in sec. 61 that the consent of any local authority to the exercise of any powers shall not be unreasonably withheld appeared to apply to every case throughout the Act, and therefore to the provision in sec. 58 that the Torbay-road tramway should not, except with the consent of the Corporation, be constructed on the overhead system. The Corporation, on June 21, themselves resolved, if negotiations then proceeding proved abortive, to refer the matter to arbitration. At a preliminary meeting with the arbitrator the Corporation raised no objection as to jurisdiction. He asked the Court to state whether, if he had not jurisdiction, the Corporation had not waived their objection and were therefore now debarred from raising it. From the first the Dolter system was most unsatisfactory and expensive to work. On May 2 the Board of Trade gave notice that they would not renew their license after Oct. 31 and it therefore became necessary to adopt some other system. He found that, as a fact, if the committee's terms had been accepted they would have advised the Council to give their consent. The noise of the tramways was increased by the contact of the skates with the studs. He had come to the conclusion that there was no reasonable ground for supposing that the amenities of Torbay-road would be appreciably affected by the overhead system. The electric light would be carried on the tram poles of about the same height as the present standards. They would not obstruct the view of the bay as they would be on the land side of the road, except opposite King's-road gardens, and from the gardens the wire could not be seen by persons sitting down as they would look right over it, and the number of standards would not be greatly increased. The æsthetic objection was based more on conservative tradition and a natural initial prejuidce than on solid fact. He thought the majority of the Corporation were prepared to consent if they could get their price. He found that the "G.B." system had proved on the whole a failure and that the Lorain system would, under the prevailing conditions at Torquay, be a doubtful and costly experiment and not likely to gain the approval of the Board of Trade. Owing to the discredit attaching to all surface contact systems it would be impossible for the company to finance those systems, with the result that it must abandon its undertaking. The alternative of constructing tramways 4 and 4A on the overhead system had never, in fact, been offered to the company, and if it had it was impracticable, unreasonable and impossible, having regard to the character of the route and the fact that the capital spent on the Torbay-road would be sacrificed. There was a statutory duty to maintain the Torbay-road route. He had come to his decision without

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taking into consideration the fact that the company would by a contrary decision lose £140,000 capital, although he was of opinion that some weight might properly be attached to that. He awarded that the Corporation's consent had been unreasonably withheld and that the Corporation pay the company the costs of the arbitration.

Cruse & Others v. Willans & Robinson.

At the Manchester Assize Courts on Wednesday Mr. E. Pollock, Official Referee, commenced the hearing of this action by Mr. H. Cruse (trading as the Cruse Controllable Superheater Co.) and Messrs. E. Grether & Co. against Messrs. Willans & Robinson, of Rugby, for the recovery of a sum of £10,000 for alleged breach of contract. Mr. E. M. Pollock, K.C., M.P., and Dr. Atkinson appeared for plaintiffs, and defendants were represented by Mr. J. Sankey, K.C., and Mr. Stewart.

For plaintiffs, it was stated that defendants contracted to manufacture for plaintiffs certain superheaters to the plans and specifications of plaintiffs. The plaintiffs alleged that some of the machines were not in accordance with the terms of the contract, and that in consequence they had incurred loss in replacing the superheaters. They also alleged that they had lost the benefit of other contracts.

Defendants denied that any breach of contract had been committed, and affirmed that the machines were made according to the terms of the agreement between the parties.

Mr. H. CRUSE gave evidence in support of the claim, and was under examination the whole of the day. He said he rejected the machines upon a report made to him by experts in January, 1909. As to a counter-claim in respect of undelivered superheaters, he could not possibly have erected them because he had a report that it would be dangerous to do so.

The case was adjourned.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Littleborough Urban District Council invite applications from competent men prepared to act as clerk of works, under the direction of their consulting engineers, during the laying of h.t. and l.t. electric cables and the installation of h.t. switchgear. Salary 3 guineas per week. Applications to the clerk of the council, Mr. Geo. H. Wild, Council Offices, Littleborough, near Manchester, by Monday, Oct. 7. See an advertisement.

The Governing Body of the Northampton Polytechnic Institute invite applications for the post of laboratory demonstrator in the electrical engineering and applied physics department. Applicants should be qualified to take charge of heat, photometric and electrical engineering laboratories. Commencing salary £100 per annum. A junior demonstrator is also required. Commencing salary £80 per annum. Particulars and forms of application (which should be returned by Oct. 10) from the principal, Dr. R. Mullineux Walmsley. See an advertisement.

An assistant is wanted in the electrical test-room by the Cambridge Scientific Instrument Co. Ltd., Cambridge. See an advertisement.

A draughtsman is required, accustomed to the design of c.c. motors, dynamos and switchgear.

A mechanical engineer is required to take charge of steam plant at Shoreditch Council's electric power station, Whiston-street, London, N.E. Salary, £3 per week, rising to £4, with house, &c. Applications to Borough Electrical Engineer by noon, Oct. 12.

Mr. W. A. Turnbull, chief assistant electrical engineer at York, has been appointed resident engineer at the Stoke-upon-Trent electricity works, under Mr. C. H. Yeaman, the chief electrical engineer of the county borough of Stoke-upon-Trent, which includes the works at Burslem, Hanley, Longotn and Stoke.

Mr. L. Romero has been promoted by Salford Electricity committee to the position of mains engineer at a salary of £180 per year, rising by £10 every two years to £230.

Mr. H. F. Barnes, of Eccles, has been appointed an assistant engineer at Rawtenstall electricity works.

Mr. O. B. Richardson has resigned his appointment as engineer-in-charge at Shoreditch (London) Council's Whiston-street station, to take up the position of baths superintendent under the same Council.

Mr. T. M. Nelson, assistant engineer of Launceston (Tasmania) tramways department, has been appointed electrical engineer to Christchurch (N.Z.) Tramway Trust. Mr. Oswald Claudsley (London) succeeds Mr. Nelson at Launceston.

Mr. A. Fraser (Melbourne) has been appointed engineer of the Korumburra municipal electricity works.

Mr. Chas. A. King, A.R.C.S., of Sunderland, has been appointed assistant professor of mechanical engineering at the Heriot Watt College, Edinburgh.

Mr. H. W. Mansfield, works foreman at Woolwich electricity works, who has been on probation for six months, has had his appointment confirmed and his salary fixed at £170, with annual increments.

EDUCATIONAL NOTICES.

Armstrong College, Newcastle-on-Tyne.—The session commenced on Sept. 26. There are full courses of instruction in mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and letters. Particulars from the secretary, Mr. F. H. Pruen, M.A., Armstrong College, Newcastle-on-Tyne.

At the meeting of the governors on Monday Dr. R. Spence Watson was elected first president under the new constitution, and Sir Hugh Bell was elected chairman of the Council.

Finsbury Technical College.—Attention may be called to the forthcoming course of lectures on Indiarubber by Dr. P. Schidrowitz at the above college. The first of a series of six lectures will be delivered on Oct. 12 at 7:30 p.m. From the programme submitted it is clear the subject will be treated in a distinctly practical way and that the field covered is sufficiently wide to be of use to all engaged in any of the numerous industries in which indiarubber is employed.

BRITISH NOTES.

Aberdeen.—By a majority the Electricity committee have decided against the adoption of the suggestion of the city electrical engineer (Mr. J. Alex. Bell) to introduce a system of giving bonuses to employés at the electricity works in order to encourage them to practise economy in keeping down the works costs.

Acton.—By 11 votes to 9 the Council have decided to transfer their electricity undertaking to the Metropolitan Electric Supply Co. for 42 years, in consideration of the company paying off all the loan charges and paying the Council £5,000, £2,500 of which is due when a net profit of 6½ per cent. is made. Further particulars of the terms of the transfer were given in our last issue, p. 1040.

Aston.—The L.G. Board have sanctioned a loan of £12,515 for additional plant at the electricity generating station and the Alma-street sub-station, £450 for site for sub-station in Alma-street, £2,250 building and equipment at that station, £4,500 excess expenditure on mains, services, &c., up to March 31 last, and £6,000 to defray expenditure on mains from April 1 last.

Barnstaple.—The Council are endeavouring to popularise the use of electricity for lighting, power and domestic purposes, and among other steps to be taken it has been decided

To appoint a firm, or firms (not exceeding two), who will energetically undertake canvassing business, such firm to have exclusive right of supplying incandescent lamps to the Council at a rate to be agreed and to receive a rebate for current supplied to them in consideration of an effective display of electric light fittings being made. A special committee has been empowered to draw up a scale of charges and (subject to the approval of the Electric Light committee) to make such terms and arrangements as the latter committee shall approve and direct. The official appointment of a suitable firm (or firms) has been left to the Electric Light committee on the recommendation of the special committee, and any firm (or firms) so appointed to be permitted to style themselves official electrical repairers and contractors to Barnstaple Corporation.

Beaconsfield.—The Uxbridge & District Electric Supply Co. and Callender's Cable & Construction Co. have intimated to the Council that they will apply for a provisional electric lighting order.

Bermondsey (London).—The Council have entered into agreements with a number of companies and firms for the supply of electrical energy for power, including Abbot's and Yardley's wharves, Crypto Electrical Co., &c.

Bispham.—A sub-committee has been appointed to superintend the erection of the electricity generating station in Red Bank-road.

Brighton.—The Tramways committee recommend the Council to appoint a joint sub-committee (of the Tramways, Lighting and General Purposes committees) to consider the question of the price to be charged for electricity for traction, with power to determine the price to be paid by the Tramways to the lighting department during the current financial year.

The tramways track in Queen's Park-road, from Elm-grove to the Pepper Box, is to be repaired at a cost of £1,540.

Brumby and Frodingham.—At a recent meeting of ratepayers it was decided by a large majority to adopt electricity for street lighting.

Burnley.—Major Pringle inspected the new branch tramway line in Briercliffe-road last week.

Caerphilly.—The Council have accepted the offer of the South Wales Electrical Power Distribution Co. for lighting the side streets at Aber, Senghenydd and Llanbradach.

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Canal Lighting.—The series of locks on the Caledonian Canal at Banavie, known as Neptune's Staircase, is now lighted electrically. Current is supplied by the Fort William Electric Light Co.

Cardiff.—Negotiations are proceeding between the Corporation and Llandaff and Dinas Powis Council as to supply of electricity by the corporation to a number of houses just outside the borough boundary in Whitchurch-road.

Central London Railway.—A start has been made with the work of extending the Central London Railway from the Bank to Liverpool-street, a distance of about 500 yards, but the loop at the Liverpool-street end will necessitate about 300 yards additional permanent way, making the total extension about half a mile.

The vertical shaft at Liverpool-street has been sunk at the West Suburban booking office, and the main operations will be conducted from that point and will proceed westward towards the Bank. From the new station near Broad-street station access will be given to the G.E. and Metropolitan Railways and (by means of lifts) to the high level platform of the L. & N.W. and North London Railways.

Dundalk.—The L.G. Board have sanctioned a loan of £20,000 for municipal electricity works. At the local inquiry strenuous opposition was offered by the local gas company.

Electric Arc Lamps and Fire Scares.—There appeared in the Halifax "Evening Courier," on the 27th ult., an instructive paragraph on the subject of

False Alarms of Fire.—The inhabitants of Greetland and Elland were last night alarmed about 10 o'clock by the fire buzzer in West Vale sounding its long and dread note of alarm. Many people hurried from home, anxiously inquiring where the fire was. This morning it was clear that there had been a false alarm, and people are now wondering whether something can be done to prevent alarms.

The Alarm heard in Halifax.— Many people in Halifax also rushed from their houses, for the ominous sounding whistle could be plainly heard all over the town. Quite a large crowd hurried from the Booth Town district. One report circulated was that a big mill at the bottom of Haley-hill was on fire.

The glare in the sky, later found to be from the new electric arc lamps that have been erected along North Bridge and up New Bank, gave credence to the story.

All this excitement was due to the new electric lamps of the Jandus regenerative flame lamp type lately erected on the bridge. The Jandus Company, perfectly naturally, we think, are amused, and write: "In case our gas friends should put this forward as another fire of electrical origin we hasten to publish the correct version. Possibly, however, the gas journals will find comfort in the thought that the sickly green of their high-pressure gas can never be mistaken for anything but gas."

Electricity in Collieries.—The Harton Coal Co. are putting down electric power and lighting plant at their Harton, Bent House, Boldon St. Hilda and Whitburn collieries, all of which are close to South Shields. The whole of the steam plant at the Harton Colliery has been superseded, and all the machinery and appliances are entirely worked by electricity. A new electrical winding engine, designed to deal with an output of 240 tons of coal per hour, has been put down.

Exhibition.—It is announced that there will be a Coronation Exhibition at Shepherd's Bush, London, next year which will be representative of the various parts of the British Empire. The exhibition authorities will devote a proportion of the receipts to the Mansion House Fund for a National Memorial to King Edward VII., and a minimum donation of £5,000 will, it is stated, be guaranteed.

Grimsby.—At a recent meeting of the Public Lighting committee the electrical engineer (Mr. W. A. Vignoles) reported that the street lamps were being converted from gas to electric lighting at the rate of 25 to 30 per week, the first 36 of the new lamps being used for the first time on Sept. 9. About 200 posts had been erected and the fittings delivered.

Hanwell.—In reference to the Metropolitan Electric Supply Co.'s contract for lighting Uxbridge-road the company suggest that instead of fixing 12 flame arc lamps (combined with small incandescent lamps) a new type of high candle-power metal filament lamp should be used which would give an improved light.

The revised proposal is to place 30 high candle-power lamps on either side of the main road, spaced on alternate tramway pillars, half the lamps to be extinguished at midnight. The company, in order to show the effect of the new lamps, are arranging to fix some experimentally.

Haslingden.—Both Haslingden and Accrington Corporations have sent deputations to the Board of Trade with reference to an objection lodged by the Lancashire Electric Power Co. to Accrington's application for powers to supply Haslingden with electricity in bulk, in accordance with an agreement arrived at between the two Corporations. The company had power to supply Haslingden, but it appears that they declined to bring a main to Haslingden alone when Rawtenstall and other neighbouring authorities decided not to take current from them.

Heston and Isleworth.—£3,048 is to be borrowed for an extension of the electricity undertaking, and application is to be made for sanction to borrow £1,200 and £800 for mains and house services respectively.

As an alternative to the existing rates for current, consumers using power continuously for not more than 12 hours daily are to be supplied at a fixed annual charge of £10 per kilowatt, payable quarterly, to be based on the maximum number of kilowatts demanded at any one time. The charge for current for cooking apparatus is 1½d. per unit.

Hornsey.—Application is to be made to the L.G. Board for sanction to borrow £2,000 for mains and £4,000 for house services.

The borough surveyor (Mr. E. J. Lovegrove) is to report on the subject of lighting the business parts of the borough.

There were 1,858 consumers of electricity on Aug. 31, an increase of 56 in two months, and the equivalent of 96,500 30-watt lamps is connected to the mains.

Application has been made to the L.G. Board for sanction to a further loan of £6,000—£2,000 for extensions and £4,000 for house services.

Hydro-Electric Works in Canada.—Work has been started on the Edmonton municipal scheme for the erection of hydro-electric works at Fort Saskatchewan. Current will be supplied for lighting and power.

Irlam.—In view of the proposal to erect new iron and steel works on the banks of the Manchester Ship Canal at Irlam, the Council are considering the question of electricity supply, and also of extending the Salford tramway system to the district.

King's Norton and Northfield.—There was a surplus of £590. 19s. 7d. on the working of the Moseley and King's Heath tramways for the year ended March 31, and of £25. 9s. 3d. on the Pershore-road tramways. The whole has been carried to the relief of the rates.

Kingsbury.—Private consumers will shortly be supplied with electric energy.

Leeds.—The Tramways and Electricity committee have decided to commence the work of equipping the City-square and Farnley route on the railless trolley system.

Lydney.—The Rural Council have modified the conditions upon which the Chepstow Electric Light & Power Co. is to supply electricity in the district. The maximum price to be charged is 6d. per unit and the company is to have 12 months' notice of the termination of the arrangement.

Municipal Wiring.—Tynemouth Corporation and Barking Urban Council have intimated that they will give financial assistance to the scheme of the Municipal Electrical Association for promoting a bill to authorise all municipal electricity undertakers to wire consumers' premises, &c. Stepney (London) Council will give their moral support and the question of financial assistance will be considered when the bill is drafted.

Mutford and Lothingland.—The District Council have decided to oppose a proposed application for a provisional electric lighting order.

Naval Electricians.—It is officially announced, in regard to the advancement of electricians in the navy to chief electricians second class, that a roster of electricians who have passed for chief electricians is to be established at each port, and candidates are to be placed on it in order of passing.

Electricians who desire to pass for chief are to be examined before requalifying in the schools. 70 per cent. of the marks in any one subject, or 75 per cent. in the aggregate, are required in order to pass. Candidates who fail to obtain the requisite percentage may, on the recommendation of the torpedo school, be allowed to present themselves for re-examination in three or six months, a second rejection being final.

Newport (Mon.).—The local ratepayers' association are threatening the Corporation with proceedings to restrain them from alleged illegal practices in connection with the electricity supply and tramways undertakings.

Northampton.—The Corporation propose to apply for powers to extend their tramway system, to employ the railless trolley system of traction, to run motor omnibuses, &c.

Oldham.—Owing to the increasing demand for electrical energy for lighting and power the borough electrical engineer (Mr. S. Wilmott Newington) has reported to the Electricity committee that further extensions of plant will have to be considered without delay.

Oswaldtwistle.—Accrington Electricity committee have agreed to supply electricity in bulk to Oswaldtwistle on terms similar to those contained in the agreement with the Haslingden Corporation.

The minimum payment is to be £200 for the first year, rising by £50 per year for seven years. The Corporation offer to promote and transfer

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a provisional order for supplying and distributing electricity in Oswaldtwistle.

Otley.—Another scheme has been brought forward for supplying electrical energy in Wharfedale.

The intention is to erect a generating station at Otley with radiating mains throughout the town, and also as far as Burley and Menston, each of which is 2½ miles distant. Otley Council will be asked to give its approval of the application by a company which is about to be formed for a provisional order to enable it to supply the district with electricity.

Ottery St. Mary.—At a recent public meeting, presided over by Lord Coleridge, it was unanimously decided to form a local company for establishing electricity works in the district. Mr. L. Steele is acting as consulting engineer.

Paisley.—An arbitration, under the Paisley District Tramways Order Confirmation Act, 1901, to settle the price to be paid for the electrical energy for the next seven years to Paisley Corporation by the Paisley District Tramways Co., commences to-day (Friday), at Westminster Palace Hotel, London. The arbitrator is Mr. Robert Hammond, M.Inst.C.E., and the engineers engaged in the case are Messrs. Mordey & Dawbarn for the Corporation and Mr. H. F. Parshall for the company.

Perth.—The Council have referred back a recommendation of the Gas committee to adopt electric stoking machinery for charging the retorts at the gas works at a cost of £4,000.

Presentations.—The Chelmsford staff of Messrs. Crompton & Co. have presented a case of cutlery to Mr. H. J. Harrop on his marriage.

The staff of the North-road electricity works, Brighton, have presented a case of cutlery to Mr. Stanley Gravett on his marriage.

Public Tendering.—On the subject of public tendering and its results we have received from the Davis Electrical Co. (Ltd) a letter as follows:—

TO THE EDITOR.

SIR: We think the following facts deserve publicity. Last year we quoted the Isle of Thanet Electric Tramways & Lighting Co., of St. Peter's, Kent, for their annual supplies of general stores. By reason of the wording of the specification samples had to be inspected at the stores, St. Peter's, which necessitated a special journey there for the purpose, occupying practically a day. We were in due course notified that our tender for certain supplies had been accepted; but from that day to this we have not been favoured with a single order for the accepted portion of the tender. In response to a letter to the engineer and manager we have received no acknowledgment. As the company are inviting tenders for next year's supplies we consider the time opportune to bring this matter before the trade.—Yours, &c.,

THE DAVIS ELECTRICAL CO.

17, Moor-street, London, W., Sept. 27.

St. Helens.—Sanction has been received by the Council to a loan of £10,206 for extensions to the electricity generating plant, &c.

Salford.—An agreement has been entered into with Manchester Corporation for a temporary supply of electrical energy from Sherbourne-street sub-station during the ensuing winter months. The agreement is determinable on three months' notice from either side

South Shields.—An inquiry was held on Wednesday into the application of the Corporation for sanction to borrow £9,410 for extensions of the electricity undertaking.

Mr. PRITCHARD, who appeared for the Corporation, said the application was for sanction to borrow money for extending the generating plant in order to meet the demand for power. That demand had grown in a satisfactory and rapid manner. The undertaking had made a profit every year, with the exception of the first four and last year, when there was a loss of £206.

Opposition was offered by the North Eastern Railway Co. and Smith's Dock Co., represented by Mr. Vesey Knox, K.C., who suggested an adjournment to enable the Corporation to consider the question of taking a supply of electricity in bulk.

Mr. Pritchard offered no objection, and the inspector (Mr. E. A. Sandford Fawcett), in adjourning the inquiry *sine die*, suggested that the engineers for the respective parties might make a joint report on the matter.

Southampton.—A loop tramway line is to be laid between Northam and St. Mary's roads, and plans are being prepared for another loop.

The cost of laying the tramways to the pier will be £2,000, and if the line is extended to the West Station the additional cost will be £5,250. The general manager (Mr. H. F. Street) recommends the extension of the track to the boundary, the cost being £3,150. The committee have recommended that powers be obtained for the construction of various tramways.

Southgate.—The North Metropolitan Electric Supply Co. intend laying a trunk main from Enfield to Wood Green, passing through Southgate.

Stepney (London).—Application is to be made to L.C.C. for sanction to borrow £7,150 to cover cost of plant at Limehouse generating station.

From March 31 to Sept. 17 the number of units purchased in bulk were 3,742,129 against 3,375,490 in the corresponding period last year. The maximum load during the two periods was 122,305 equivalent 30-watt lamps in 1910 and 108,274 in 1909, the net available plant being equivalent to 74,000.

The Works committee have again considered the proposals of L.C.C. for electrification of the tramways in Burdett and Grove roads and the Council have decided not to consent to the use of overhead traction.

Stoke-on Trent.—The borough electrical engineer (Mr. C. H. Yeaman) has reported to the Electricity Supply committee as to the urgent necessity of providing additional plant at the several electricity works in the borough.

Mr. Yeaman has been instructed to prepare and obtain information as to the financial position of the electricity undertakings and report at the earliest date as to the amounts to be included in a loan for over-expenditure and prospective expenditure. He was further instructed to report as to the best means of supplying electricity in Fenton.

Teignmouth.—The surveyor and gas manager have been asked to report upon a proposal by the Electric Supply Corpn. to supply electricity in bulk to Teignmouth area, provided the Council lay the mains and distribute the electricity in their area, as the Board of Trade are threatening to revoke the order.

Tonbridge.—An inquiry was held yesterday (Thursday) into the application of the Council for sanction to borrow £1,441 for extensions of the electricity undertaking.

Village Lighting.—Mr. E. Lewis, who is supplying electricity at Glais, Llansamlet and Ystradgynlais, has offered to give a supply in Ystalyfera, Swansea.

Walsall.—An inquiry was held here last week into the application of the Council for sanction to borrow £23,225 for extensions of the electricity undertaking. Originally the Council applied for sanction to a loan of £35,000, but after inquiry the L.G. Board withheld their consent, and asked the Corporation to consider suggestions which were made by the inspector.

The TOWN CLERK stated that there was no opposition to the loan, and although some communication had been received from the Shropshire, Worcestershire & Staffordshire Electric Power Co., the latter were not represented at the inquiry. Their desire had been, if possible, to come to some arrangement with the corporation who, however, could hold out no hope that they were likely to take a supply in bulk from the company.

The inspector (Mr. Ross HOOPER) intimated that, having on a previous occasion discussed the corporation's existing system of generation and distribution of current, he was in a position to state that the department fully appreciated the difficulty the corporation were in with regard to affording a cheap supply of current for manufacturing purposes, particularly in view of the proximity of the town to Birmingham and Wolverhampton. To meet that difficulty the corporation proposed to introduce a more modern system, and although the scheme had been held over for reconsideration on certain material points, he was prepared to take it that the general principle was accepted, and that the department recognised that the corporation's present system did not afford them the elasticity of supply which they desired.

The TOWN CLERK said the Corporation had appreciated the value of the criticism which the inspector had offered at the previous inquiry. There were three points to which the L.G. Board had drawn attention. They were that, instead of building a new generating station, the existing building should be enlarged; that further consideration should be given to the question of taking a supply in bulk from a power company; and also to the wisdom of extending the area of supply to Bloxwich. The Corporation had now decided to give effect to the first suggestion, and by the removal of certain old plant they would obviate the erection of a new building. An offer had been obtained from the Shropshire Power Co. to supply current in bulk at 0·75d. per unit, subject to the corporation taking a minimum supply of 2,500,000 units per annum; but the borough electrical engineer (Mr. A. S. Barnard) had satisfied the committee that he could, with the new plant, generate current at 0·52d. per unit, and his estimate was supported by the fact that during the past six months he had kept the cost down to 0·62d. per unit. The company had in a letter addressed to the L.G. Board made a comparison with what the Corporation had done in the past, but the Corporation asked that they should be judged by what they were prepared to do in the future. Under all the circumstances, the corporation felt it to be in the interests of the whole town that they should continue to generate the current they required, particularly as a great loss would be entailed if they had to scrap their existing plant. With regard to the Bloxwich extension, the committee had the opportunity of supplying current to Messrs. Lambert Bros.' new works at the Birchills, while they hoped to gain other new customers.

Replying to the inspector, Mr. A. S. BARNARD said he was not prepared to say that the loan would meet the requirements of the undertaking for the next five years. Up to the present, however, the corporation had not been able to offer terms which would induce manufacturers to use electricity for power.

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Walthamstow.—The salary of the electrical engineer (Mr. G. R. Spurr) has been increased by £50 per annum, and that of the assistant (Mr. W. H. Taylor) by £25 a year.

Additional plant is to be put down at the electricity works at a cost of £9,500

Walton.— Fifteen additional electric lamps for street lighting are to be erected by the Council at a cost of £56. Current will be supplied by the Urban Electric Supply Co., which already maintains 45 street lamps.

Warrington.—The borough electrical engineer (Mr. F. V. L. Mathias) is to report upon the provision of an automatic fire recorder at the generating station.

Wednesbury.—It was announced at the last meeting of the Council that the L.G. Board had given their sanction to loans amounting to £4,000 for extension of buildings and plant at the electricity works without the usual inquiry. The electricity undertaking had made considerable progress, and was now in a very healthy condition.

West Bromwich.—The borough electrical engineer (Mr. W. A. Jackson) has reported upon the comments made by the L.G. Board inspector (Mr. H. Ross Hooper) at the recent inquiry into the application for sanction to borrow £11,386 for a 1,000 kw. direct-current turbo-generator.

Mr. Jackson states that he has carefully considered the question of adopting alternating-current plant as suggested by the Inspector, and the results have more than justified his own support of the direct-current system. He estimated that the costs (interest, sinking fund and running charges) would be increased by nearly 50 per cent. per annum by the installation of an alternating-current turbo-generator. The direct-current supply had effectively met the demand for power in the borough up to the present, and he saw no reason to spend an additional £2,000 in putting down alternating-current plant.

West Hartlepool.—The Corporation have decided to enter into an agreement with the Seaton Carew Iron Co. by which the Corporation will be allowed to utilise the waste heat from the furnaces for the generation of electricity. A new generating station will be erected near the Seaton Carew Ironworks, and the present station will be used as a reserve. In return for the permission to use the waste heat from the furnaces, the Corporation are to enter into a special arrangement with regard to the supplying of electricity to the ironworks. The capital expenditure involved is between £17,000 and £20,000.

West Saltney.—The Parish Council are considering the question of adopting electric lighting at Queen's Ferry.

Wigan.—The L.G. Board have sanctioned the borrowing of £36,000 for the electricity undertaking, including £21,228 in respect of plant, and £8,855 in respect of mains.

The Electrical Engineer and the Waterworks Manager have been instructed to prepare plans and specifications for installing two electrically-driven centrifugal pumps at the pumping station. The electrical engineer (Mr. James Slevin) reported to the Waterworks committee that the cost of two Rees Roturbo centrifugal pumps (including motors and starters) would be £282, and two three-throw Worthington pumps (including motors and starters) £1,224. The efficiency of a three-throw pump was 8 per cent. higher than the centrifugal, and from his knowledge of the centrifugal pump combined with the difference in capital cost, he had no hesitation in recommending centrifugal pumps. With regard to annual cost, he (Mr. Slevin) was prepared to recommend his committee to supply the current necessary at an annual cost of £500.

The Tramways committee have approved an estimate of £2,700 for providing additional tramway loops.

Wimbledon.—The Watch committee are considering the adoption of a new system of fire alarms, and favour the Gamewell system, which is estimated to cost £193. 10s.

Winchester.—Mr. Archibald Read has been appointed Board of Trade arbitrator to ascertain the price to be paid by the City Council to the Winchester Electric Light & Power Co. for their electricity undertaking. The date and place of the arbitration are not yet fixed.

Wireless Telegraph Notes.—The tests that have been made for effecting reliable telegraphic communication between vessels in the air and terra firma, and vice versa, have made considerable progress during the past week. Experiments have taken place on the War Office grounds on Salisbury Plain which are reported to have proved more successful than was anticipated. Little further has to be done to bring the system into perfect working order. Mr. Barron, of the Marconi Co., is working with Mr. Thorne Baker in completing apparatus to overcome the few remaining difficulties.

On the coast of Korea a number of wireless telegraph stations are to be established, and also on the near islands of Sochong and Hangmun.

Particular care has been observed in selecting the site of a wireless station at Ceylon, and it is understood the choice has fallen upon Galle as the most eligible spot.

It is announced that Mr. Marconi, who has recently landed in Argentina, has notified Marconi's Wireless Telegraph Co., of London, that he has successfully accomplished wireless communication between Clifden (Ireland) and Buenos Aires, a distance of 6,000 miles.

Wireless on Channel Steamers.—We were last week a passenger on the "Onward," one of the South Eastern & Chatham Railway Co.'s turbine Channel steamers, which has now added to the comfort of its passengers the means of sending messages, both business and social, to either shore. This is one of the first of the S.E. & C. Co.'s boats to be furnished with these facilities. The compact station on the upper deck was the object of much attention and curiosity from the passengers, who are able to watch the work and take an interest in what is going on. In connection with these messages the railway company are acting as agents for the Post Office. The charges are as follows:—From the ship to England 3d. per word (half for the ship and half for the Post Office), minimum charge 2s. 6d.; to France, Belgium and Germany, 4½d. per word; to Switzerland, Italy and Austria, 5d. per word; to Denmark, Sweden and Norway, 5½d. per word. In all these latter cases the minimum is 3s. The wireless service promises to be very popular, and will, moreover, help to make the crossing of more interest to those who are not good sailors, or who think they are not.

Workhouse Lighting.—Canterbury Guardians have postponed for three months the question of the electric lighting of the workhouse.

Birmingham and District Electric Club.—The opening meeting of the session will be held at the Colonnade Hotel, New-street, Birmingham, on Saturday evening, Oct. 8, Mr. G. O. Donovan, M.I.E.E., in the chair. A smoking concert will follow.

COLONIAL AND FOREIGN NOTES.

American Submarine Cable Project.—It is announced in the "Review of the River Plate" that an American syndicate will shortly apply to the Uruguayan Government for a concession for a cable between Montevideo and New York.

Argentina.—The "Review of the River Plate" says the Soc. anon. Luz Electrica de Alavarria has been granted legal status, and that the Soc. anon. Alumbrado Electrico de San Antonio de Areco and the Soc. Co-operativa Luz Electrica de General Belgrano are being formed.

The electricity supply station at San Francisco (Cordoba) was recently opened.

The Cia. de Electricidad de la Provincia de Buenos Aires recently purchased the electricity works in Mar del Plata. A movement has been started in favour of the formation of a co-operative electric light company in the same town.

Mr. E. Volpatti has applied to Buenos Aires municipality on behalf of French and English capitalists for a 50 years' concession for electricity supply.

Australasia.—The "Australian Mining Standard" states that (*Gawler* (S. Australia) Council are in favour of the expenditure of £260 on plans and specifications for electricity works.

A recent meeting of ratepayers decided to adjourn consideration of the question for three months. The mayor stated at the meeting that the capital cost of the scheme would not exceed £6,600, and the annual income (at 8d. per unit) was estimated at £1,600. The present price charged for gas by the local company is 11s. per thousand.

A recent report of the directors of the *Balmain* (N.S.W.) Electric Light & Power Supply Corpn. states that an agreement has been entered into for the supply of electricity in Newtown for 57 years from January next, and the directors have decided to issue debentures for £25,000 to pay for this extension, and also to hire out motors.

The report on the *Sydney* municipal electricity undertaking for the year ended June last states that the output of the Ultimo power house was 56,462,781 units (42,529,719 a.c. and 13,933,062 c.c.), an increase of 19·63 per cent. over the previous year. The erection of the second of the two 5,000 kw. turbo-alternators ordered from England in May, 1907, has been completed, and the 12 additional boilers were almost ready. The new city sub-station has been equipped with three 1,500 kw. rotary converters, and a 1,000 ampere-hour battery booster and a 1,000 ampere-hour battery has also been installed at Dowling-street car shed. A contract was placed in June for an additional 5,000 kw. turbo-alternator, to be supplied early next year.

Mr. F. A. Hermann is preparing to submit (on behalf of the Foos Electric Supply Co., of America) a scheme for electricity supply in *Kapunda* (S. Australia).

The *Kilmore* (Victoria) Electric Supply Co.'s accounts show a debit balance of £403, but numerous additional applications for current are in hand.

Mansfield (Victoria) Progress Association recently decided to obtain expert advice as to electricity supply.

Australian Postal Telegraph Service.—The Royal Commission on the Australian Postal Telegraph services have issued their report, and among other recommendations are the appointment of a board

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of management to administer the department and the nationalisation of the cable services connected with the Commonwealth.

Austria-Hungary.—It is stated that the communal authorities of Podgorze (near Cracow) have earmarked (amongst other sums) £8,300 for extensions of the City electricity works.

Brazil.—The Government have approved plans for the electrification of the Victoria-Diamantina railway to Itabira do Matto Dentro.

The Ministry of Communications have been authorised to spend £25,500 on the construction of a telegraph line between the States of Matto Grosso and Amagonas.

Acting Consul-General Hambloch (Rio de Janeiro) writes that attention was called in his report for 1908 to the fact that Germany had increased her percentage of machinery, &c. import trade every year, while imports from the U.K. were declining. In 1909 the share of the U.K. in the imports of machinery, &c., increased by 2½ per cent., the value of her trade in 1909 showing an increase of more than 12 per cent. over that of 1908, chiefly due to increased imports of locomotives and electrical apparatus. Germany's share in the trade in machinery, &c., was lower in 1909 than in any year since 1903.

British Columbia.—The extensions of the British Columbia Electric Railway system were opened on Monday by the provincial Premier, the Hon. R. McBride. The company has now over 80 miles of track open for traffic.

China.—In the "National Review" of China, Mr. Stafford Ransome states that the engineering imports into China in 1908 were valued at £7,192,000.

The approximate proportions of the principal countries concerned were: British Empire, 43 per cent.; United States, 22; Japan, 13; Germany and Belgium, each 8, but, according to Mr. Ransome, the British share ought to be at least 70 per cent. The increase of Japanese business with China, as far as engineering items are concerned, has been mainly at the expense of Germany. Japan is now supplying to China a great many of the cheaper products that were formerly supplied by Germany, such as electrical accessories, telegraph plant, scientific instruments, hardware, &c.; although China's total imports dropped heavily in 1908, the engineering items increased by 5 per cent. Of the imports of metals the British share was 54 per cent., United States 22, Japan 10, Belgium 7 and Germany 5. In machinery, the British share was just over 50 per cent., that of Germany 19, United States and Belgium each 10 and Japan 5. In electrical plant the British share was 44 per cent., Germany 18, Japan 17, Belgium 12 and United States 6. In railway plant, the British share was 18 per cent., United States 45, Japan 18, Belgium 12 and Germany 6. In hardware, the British share was 33 per cent., Japan 30, Germany and United States each 10 and Belgium 2. In telegraph material, the British imports were 16 per cent., Japan 33, Germany 5, United States 2½ and Belgium 1.

Exhibition.—An International Exhibition of Novelties and Patents of the Iron and Engineering Industry will be held at Budapest in May and June next. Applications for space will be received at the Ausstellungsbureau, Gyar-Uteza, 38, Budapest, until Nov. 30.

Fochabers.—The Duke of Richmond some time back established hydro-electric works for the supply of electricity for lighting and power at Gordon Castle and also for public lighting in the village of Fochabers. Owing to interference with the water supply in winter by ice, &c., it has been decided to put down a steam-driven set as stand-by plant.

The contract has again been placed with Messrs. Drake & Gorham, who were the engineers for the original installation. The plant will include a 120 H.P. engine and 75 kw. shunt-wound dynamo. Steam will be provided by a locomotive type multi-tubular boiler suitable for a working pressure of 140 lb., and fed by a duplex steam pump. A switchboard will be fixed in the new engine room, cables being carried from that point to the existing switchboard and balancers in the turbine house. The work will be completed by the end of next month.

India.—"Indian Engineering" says the Government have authorised the telegraph department to carry out the installation and repair of electrical plant in the premises occupied by the department, thereby relaxing the rule that all works in connection with electrical installations in Government buildings shall be carried out by the Public Works Department.

It is understood that the remainder of the passenger coaches of the Bengal & N.W. Railway are to be fitted for electric lighting. At December last about 800 vehicles on this railway were fitted with the Stone system of electric lighting, leaving 465 not fitted. No carriages on this line are fitted with gas.

The Rohilkund & Kumaon Railway had, up to December last, 136 out of 217 vehicles fitted with the Stone system.

The "Indian and Eastern Engineer" states that, in regard to the first section of the scheme (of which Tata & Co. are the promoters) for the generation of electrical energy by water-power on the Ghats below Lonauli, and its transmission to Bombay, an Indian company is to be registered in Bombay with a capital of 170 lakhs (about £1,134,000) to finance the scheme, and the Lahmeyer Electrical Co. have entered into a contract to supply the first portion of the plant, which is to have a capacity of 40,000 H.P..

Italy.—The Soc. Anon. delle Tramvie e Ferrovie Elettriche di Roma have obtained a concession for construction and working an electric tramway from Rome to Albano, via delle Cave, 12 miles in length.

The Soc. pei Tramways di Livorno has purchased the steam tramway from Pisa to Marina. The line is to be converted to electric traction and extended from Marina to Leghorn.

Japan.—Consul-General R. de B. Layard, in his report for 1909 of the Kobe district, says imports of machinery decreased by 46 per cent., or over £670,000 (from £1,469,004 in 1908 to £796,682 in 1909.)

In the imports of electrical machinery the proportion of British to German and American goods has increased greatly. British electrical machinery is much esteemed by the Japanese, but cheapness is likely to outweigh quality. In machinery of other kinds there has been a great diminution of imports, due principally to the general depression in business throughout the country. Many new electric light and tramway companies were started during 1909, to which cause the increase in the imports of electrical machinery is to be attributed, but the boom came to an end with the close of the year. Cheap machine tools are now being turned out in ever increasing quantities by Japanese engineers which presumably satisfy requirements, although the foreign importer is of the opinion that they are unsatisfactory. There are now many small cable manufacturing concerns working in Japan; only one of these concerns, however, competes in quality with the imported goods, and this one is equipped with British machinery and has the services of a British expert.

The British Vice-Consul at Osaka says that the manufacture of machinery of all kinds is extensively carried on in Osaka. There is a growing demand for motors of various kinds owing to the great increase in the use of power in the smaller factories. With the exception of the spinning and weaving industries, by far the greater part of the machinery used in the Osaka factories is of Japanese manufacture, the designs having been taken from foreign models. In this connection, the importance of taking out patents in Japan for any new machinery imported into the country cannot be too strongly impressed upon British manufacturers. Since the commencement of the year numerous schemes have been brought forward for electric tramways to various places in the neighbourhood of Osaka, including one to Nara (a town of about 45,000 inhabitants situated 25 miles east of Osaka), another to Kyoto on the opposite side of the Government railway to the line just completed, a line for an express tramway service between Osaka and Kobe, and many others. The only one, however, for which a charter has been obtained is a line to Sakai, 6 miles to the south of Osaka. This will run parallel to the Nankai railway to Wakayama, which has already been electrified as far as Hamadera (4 miles beyond Sakai), and is shortly to be electrified for the rest of its whole length of 40 miles. The other tramway schemes, however, are hardly likely to mature for several years.

ELECTRICITY SUPPLY TABLES AND DATA.

This Valuable Set of Tables and Engineering Data relating to Electricity Supply and to Electric Traction on Railways and Tramways in the United Kingdom, the Colonies, and some important places abroad, is now ready, and can be obtained complete in handy book form, price 6s. 6d. post free, or on very hard paper for rough or constant use, price 8s. 6d. post free. A complete Index is included.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Edinburgh.—The accounts of the electric lighting department for the year ended May 15 states that capital expenditure is £1,031,833 (increase £22,669).

Capital borrowed is £1,029,278, of which £343,520 has been repaid. Revenue was £127,103, working and general expenses were £58,502, the surplus carried to net revenue account being £68,601. After adding £806 proceeds of reserve fund above prescribed limit, and providing for interest £19,611, contribution towards liquidation of debt £40,404 and income tax £1,995, the surplus for the year is £7,397. Units generated were 17,848,940 (compared with 17,636,385 in previous year), and 1,833,222 (1,806,946) were supplied to street arc lamps, 30,725 (25,691) to street incandescent and stair lamps, 9,580,909 (9,833,301) for public lighting, and 3,864,637 (3,589,527) for motive power.

Glasgow.—The Corporation tramways earned "record" traffic receipts last week, the amount being £19,874. 9s. 11d., compared with £17,902. 0s. 11d. in the corresponding week last year. The miles of double track open are 97¾, compared with 94½. The best week previously (ending Oct. 5, 1907) was £19,689.

A Citizens' committee has been formed to oppose the principle of rate relief from the tramway surplus.

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Marylebone (London).—The general manager of the electricity undertaking (Mr. A. H. Seabrook) reports that the gross income for the June quarter shows an advance of £160 over the corresponding three months of 1909. Eliminating the adjustment item (which applies to accounts prior to June) the real increase is £419.

The increase in units sold to private consumers number 113,447 or 6·2 per cent., compared with 8 per cent. estimated for the whole year. The total increase in units sold (including public lighting) is 260,577, or 14 per cent. The average price during the quarter, including meter rents, was 3·103d. per unit, and in June, 1909, 3·240d., a drop of 4·2 per cent. In the previous June the decrease was 11·5., and the estimate for this year was 9 per cent. Generation expenses were £4,173, against £4,888 and £4,930 in 1909 and 1908 respectively. The total expenditure during the three periods was £10,578, £10,048 and £11,785. There was an increase in each of the headings except generation. As to management and distribution expenses (£2,017 and £2,220, against £1,717 and £2,081), the increase was mainly due to the larger establishment necessary to cope with the increased activities of the department and the additional consumers on the books. They had added double the number of new consumers compared with the preceding year (600 against 300), and although the value of revenue per consumer was smaller, the establishment charges were nearly as heavy. The cost of production was 1·20d. per unit, against 1·29d. in 1909, and 1·54d. in 1908.

With regard to the sales department the income included £2,360 sundry sales, which, less prime cost (£1,805), left a balance of £555. The rental of motors on hire amounted to £100, maintenance of consumers installations £101, and payments under hire purchase agreements £98, total £856. Expenditure was £1,365, leaving net debit balance £509. Various orders in hand were incomplete, but taking credit for these on a conservative basis the net debit on the sales department was £368. After taking all things into consideration the probable actual cost of this department for the quarter did not exceed £273, which was the ascertained cost of the old publicity department during June quarter, 1909. The net result of the quarter's trading was a credit balance of £15,485 compared with £15,188 in the previous June quarter.

Melbourne (Australia).—The accounts of the municipal electricity department for the year ended Feb. 28 show capital expenditure £575,291 (increase £19,043).

Revenue was £113,579 (compared with £102,636 in the previous year). Working and general expenses were £54,662 (£52,458), leaving £58,917 (£52,458) gross profit. Capital charges were £42,188 (including £19,612 for depreciation and renewals), leaving a balance of £16,808, out of which £2,922 was applied to recouping the capital account for cost of changing over installations, £4,000 allocated as a special appropriation for depreciation and renewals, and £7,000 contributed to general town fund. Motors connected increased from 1,218 to 1,441 (4,684 H.P.), increase 1,115 H.P. There are 3,212 consumers (increase 359), of whom 1,178 take supplies for power and heating. 9,790,435 units were generated (compared with 8,642,154 in previous year), 3,654,063 (3,380,162) supplied to private consumers for lighting and 2,560,991 (1,911,355) for power and heating, 1,694,370 (1,574,137) for street lighting and 250,539 (226,613) for municipal buildings. There are 972 arc and 4,163 incandescent lamps in use in streets and Corporation buildings, and 79,717 yds. of feeders, distributors, street lighting cables and pilot wires laid for c.c. supply and 39,930 yds. of 4,000-volt feeders and public arc lamp cable on the a.c. system. Coal cost per unit was 0·484d. (0·532d.), total works costs were 1·003d. (1·036d.), total supply costs (including establishment and special charges) 1·003d. (1·036d.) and total costs (with attendance, renewal, &c., of public and private lamps) 1·607d. (1·698d.). Sinking fund and depreciation required 0·718d. (0·809d.) and interest 0·502d. (0·553d.)

The report of the Electric Supply committee states that a contract has been entered into for the supply of a 1,500 kw. generating set (by W. H. Allen, Son & Co.) at £9,881. A d.c. feeder to the corner of Russell and Collins-streets has been supplied by W. T. Henley's Co., at £3,695, and a feeder to supply current to the Victoria Rolling Mills, &c., by British Insulated & Helsby Cables, at £697.

Shoreditch (London).—The accounts of the electricity supply and refuse destructor undertaking for the year to March last show capital expenditure £365,656 (increase £3,477). The amount borrowed is £362,767, and £45,757 has been repaid.

Revenue for the year was £49,065, and working and general expenses were £25,189, gross profit being £23,876. Interest and provision for repayment of loans required £17,444, leaving £6,432 to carry to appropriation account. Of this amount, £4,000 was placed to reserve, £1,487 to change of pressure account and £617 carried forward, 6,900,031 units were generated (compared with 6,080,248 in previous year), 770,839 (775,997) were supplied to public lamps, 136,197 (181,983) by contract and 4,649,156 (3,915,431) by meter. There are 322 (322) public lamps. The total maximum supply demanded was 3,510 kw. (2,874 kw.). Receipts of the refuse destructor department were £9,943, including £1,336 for electricity generated, £1,181 for steam for Hoxton baths and public library, £1,318 for destruction of trade refuse and Bethnal Green and Islington refuse and £5,997 borne by general rate (£4,601 for destruction of 29,449 tons of refuse and £1,396 loan charges).

The accounts have been adopted by the Council, subject to audit.

Scuthwark (London).—Gross profit on the electricity undertaking for the year ended March 31 was £6,198. 11s. 5d., and after paying interest and sinking fund, &c., the net profit was £790.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1910 Edition of the Big Blue Book is READY, price 15s., **post free in the United Kingdom, 15s. 9d. The volume brings a great mass of very valuable statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified up to February 16th.**

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters receive every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been completely revised. The Big Blue Book contains more names of live electrical firms and persons than any other Directory published, and this notwithstanding that all mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as unreliable and of little value for Manufacturers' and Dealers' purposes. The full set of valuable Statistical and Engineering Tables, &c., have been very carefully revised and extended, and are now issued in a handy form. These are included in the 1910 Big Blue Book, making it the most complete work of the kind ever published.

TENDERS INVITED.

The Directors of the GT. WESTERN RAILWAY CO. invite tenders for one year's supply of various stores, including electrical wires and cables, telegraph ironwork and tools, telegraph drysalteries, telegraph apparatus (insulators, &c.), electric light carbons, india-rubber goods, glass, acids, alkalies, &c., oils and turpentine, zinc, antimony, brass, copper rivets, &c., wire, fishplates, bolts and nuts for permanent way, &c. Samples and patterns may be seen at the general stores, Swindon, from Oct. 10 to 15. Specification, with forms of tender, from the Stores Superintendent at Swindon. Tenders, addressed to the secretary, Mr. A. E. Bolter, Paddington Station, London, W., by Tuesday, Oct. 18. See also an advertisement.

Tenders are invited (until Nov. 22) for supply of telephone cable (schedule No. 337) and (until Nov. 29) for testing instruments (schedule No. 338) to the Postmaster-General's Department in VICTORIA. Tenders, forms, &c., from the Commonwealth Office, 72, Victoria-street, London, E.C. See also an advertisement.

Tenders are invited by Nov. 23 for supply of cable ironwork, c.i. pipes, earthenware conduits, switchboards, telegraph and telephone instruments, &c., to the Postmaster-General's Department in QUEENSLAND. Tender forms and specifications from the Commonwealth Offices, 72, Victoria-street, London, S.W. See also an advertisement.

Tenders are invited up to Nov. 2, for supply of insulators, wire (covered, phosphor-bronze and g.i. stranded) to the Postmaster-General's Department in QUEENSLAND. Tender form and specification from the Commonwealth Offices, London, S.W.

Tenders are invited by EDINBURGH Corporation for three steam turbines and d.c. generators, each of 1,200 kw., and condensing plant and interior parts of cooling towers, for their Dewar-place electricity station. Forms of tender, &c., from Mr. F. A. Newington, Dewar-place, Edinburgh. Tenders to the Town Clerk by Oct. 10.

HALIFAX Tramways and Electricity committee want tenders (by noon Oct. 17) for supply of a 1,500 kw. turbo-alternator, with condenser, two 750 kw. rotary converters, with transformers, switchboard, &c. Forms of tender from Borough Electrical Engineer.

LONDON County Council require tenders by 11 a.m. Oct. 11, for the road work and platelaying required for the reconstruction of the Highgate-road tramways for the conduit system, and for paving works of street widenings. Specifications from the Chief Engineer.

LONDON County Council want tenders by 11 a.m. Oct. 12 for wiring and fitting Sherington-road school, Greenwich, for electric light. Specifications from the Chief Engineer.

YORK Electricity committee want tenders by Oct. 7 for 12 months' supply of carbons, carbon brushes, carbon filament lamps, meters and time switches, motors, &c. Forms of tender, &c., from the City Electrical Engineer.

CHESTER-LE-STREET Rural Council invite tenders for an electric lighting and power installation at their infectious diseases hospital

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and for the erection of about 600 yds. of overhead single-phase transmission line. Tenders to clerk by Oct. 19.

HACKNEY (London) Council require tenders by 7 p.m. Oct. 13 for supply of 90,000 pairs of white open-type arc lamp carbons. Specifications, &c., from the Town Clerk.

WEST HAM Guardians want tenders by 10 a.m. Oct. 13. for electric lighting at the receiving homes, Wanstead. Specification, &c., from Mr. Wm. Jacques, A.R.I.B.A., 2, Fen-court, London, E.C.

EPSOM Council want tenders by noon Oct. 15 for supply of 1,000 tons of coal (Nixon's Navigation) to the electricity department.

Tenders are invited (till 2:30 p.m., Wednesday, Nov. 2) for supply to the Postmaster-General's department, New South Wales, of 1,000 25 c.p. metal filament lamps, with bayonet cap fittings, for 110 volts d.c. Tender forms, &c., at the Commonwealth offices, London, S.W.

The Deputy Postmaster-General, MELBOURNE, will receive tenders until 3 p.m. Oct. 18 for supply of 23 miles of telephone cable (specification 284) and 500 composition insulators (specification 374) and until 3 p.m. Oct. 25 for 10,000 Cordeau insulators (schedule 373). Specifications, &c., from 72, Victoria-street, London, S.W. Local representation is necessary.

The Deputy Postmaster-General, MELBOURNE, wants tenders by 3 p.m. Oct. 25 for supply of electric lighting material (schedule No. 311). Specification, &c., from the High Commissioner.

Tenders will be received at the office of the Deputy Postmaster-General, MELBOURNE, until 3 p.m. Nov. 8 for 500,000 jointing sleeves.

Tenders will be received by the Minister of Telegraphs, G.P.O., WELLINGTON, N.Z., up to noon Dec. 15, 1910, for supply and erection of installations of wireless telegraphy at or near Doubtless Bay, Gisborne, Cape Farewell, Sumner (near Christchurch) and Bluff. Specification, conditions, &c., at the office of the Superintendent of Electric Lines, G.P.O., Wellington, and the office of the High Commissioner, 13, Victoria-street, London, S.W. Tenders must state the name of the country in which the apparatus, &c., will be manufactured.

JOHANNESBURG Council require tenders by noon Nov. 4 for supply of five electric tramcars. Specification, &c., may be seen at 73, Basinghall-street, London, E.C.

Tenders will be received at the Ministere des Colonies, rue Oudinot, 27, Paris, until Oct. 14 for the supply and laying of a submarine cable between LIBREVILLE and LOANGO (French Congo). Deposit of £2,000 required with all tenders, to be increased to £4,000 with successful tender.

Tenders are wanted by noon Oct. 31 for supply and erection of machinery, &c., for electricity supply and water supply systems for the town of BENI-SOUEF (Egypt). Particulars may be obtained from Mr. A. L. Webb, C.M.G., Queen Anne's-chambers, London, S.W. Local representation is necessary.

The Turkish Ministry of Commerce and Public Works want tenders by Oct. 28 (Nov. 10) for a concession for the construction and working of electric tramways in CONSTANTINOPLE and suburbs. A deposit of £13,500 (sterling) is required with each tender. Local representation is essential. Copy of specification (in French) may be seen at 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Grimsby Public Lighting committee have placed a contract with Cryselco (Ltd.) for lamps for street lighting (with guaranteed life of 1,000 hours) at £15 per gross. The tender of Accumulator Industries (Ltd.) was originally accepted, but was, we understand, withdrawn.

Woolwich (London) Council have accepted the tender of Wilkin & Son (at £19. 17s. 6d.) for alterations to wiring, &c., at the new Plumstead vapour baths, and that of Willans & Robinson for six sets of valve lines for two engines at £41. 2s. net.

London County Council have accepted the tender of Pinchin, Johnson & Co. for supply of insulating varnishes for the tramways department.

Marylebone Council have placed an order with S. Williams & Co. (at £85) for a coal-grab for the generating station.

It is stated that a tender submitted by Wisby & Co. for the construction of electric tramways at Santa Fé (Argentina) will probably be accepted.

Bermondsey (London) Council have accepted the tender (at £20. 18s.) of the A.E.G. Electric Co. for a 5 B.H.P. motor for driving a lathe.

Chelmsford Council have accepted the tender of the Electric Supply Corporation for public lighting in the north and south ward (with arc and incandescent lamps) at £1,396. 10s. per annum.

Salford Council have accepted the tender at £145. 10s. of J. P. Hall & Sons for a compound vertical steam feed pump.

Derby Council have accepted the tender of the Union Electric Co. for 50,000 carbons at 45 per cent. discount off list price.

An order has been placed by Eccles Council with Browett, Lindley & Co. for spare parts for the 150 kw. traction set at £40. 17s. 6d.

Whitehaven Education committee have accepted the tender of D. Burns for wiring Irish-street schools.

Margate Education committee have accepted the tender of Coles Bros. for wiring the New Cross schools at £32.

Dublin Corporation have accepted the tender of the Greenmount Oil Co. for machinery oil for the electricity department.

Belfast Harbour Commissioners have accepted the tender of Siemens Bros. Dynamo Works for supply of 22 flame arc lamps.

Blackpool Council have accepted the tender of the Brush Electrical Engineering Co. for a new 40 H.P. motor for the refuse destructor.

Octavius Steel & Iron Co. are wiring and fitting the new Canning College, Lucknow, for the U.P. Government, and outside illumination and other work at the Allahabad Exhibition buildings. Osram lamps are being used for the Lucknow College.

Sydney (N.S.W.) City Council have now accepted the tenders of W. T. Henley's Co. for 36,000 zinc cable suspenders, at £216; Noyes Bros., 15 miles of 11,000-volt cable, £5,317. 8s. 3d. (delivery within 13 weeks); Ferranti Limited, section A switchgear and transformers (10,000-volt), £2,592. 16s. 11d.; and Australian General Electric Co., section B switchgear and transformers, £232.

Commonwealth Tenders.—The following tenders have been accepted by the Australian Commonwealth Postmaster-General's Department:—

Victoria: W. T. Henley's Co., lead-covered paper-insulated telegraph cable; Western Electric Co., twisted pair outside distributing wire; British Insulated & Helsby Cables, multiple magneto switchboard; Lawrence & Hanson, Leclanché porous pots; Davies, Shephard & Co., brass fittings and clips for cables and copper washers for cable boxes; Victoria Iron Rolling Co., w.i. clamps for attaching base plates to railway and tramway rails, ironwork for poles, &c.; and A. Challingworth, stayrods.

W. Australia: Leslie & Co., zincs for gravity cells.

Queensland: British Insulated & Helsby Cables, twin jumper wire; International Electric Co., triple jumper wire; Western Electric Co., lead-covered silk and cotton-insulated cable, six sections of common battery switchboard, &c.; Standard Cable Mfg. Co. and Geo. Cradock & Co., tinned copper wire, v.i.r. insulated, taped and braided.

BUSINESS NOTICES.

We are informed that the Brockie-Pell Arc Lamp Co., and Foster Arc Lamp Co. are amalgamating, and will henceforth be known as the Foster Engineering Co. (Ltd.) All existing contracts will be duly completed.

The Adnil Electric Co. have appointed Messrs. Scattergood & Johnson, of Leeds, their representatives for the sale (in the Yorkshire district) of Bergmann dynamos and motors. Mr. J. B. Chambers, who has represented the Adnil Co. in Yorkshire, having resigned, to take up an appointment in Eastern Europe.

The Lahmeyer Electrical Co. are opening offices at 2, New China Bazaar-street, Calcutta, with Mr. H. R. Speyer as their chief engineer in India.

Owing to the great increase in their business the Sloan Eletrical Co. have found it necessary to secure more commodious premises at Conradty House, 12, Golden-lane, E.C., whence they will remove shortly.

Horatio Stead and Wm. Hy. Illingworth, dealers in electrical fittings, &c., Haugh Shaw Works, Halifax, have dissolved partnership. Debts by Mr. Stead.

Hal Williams and Walter Bridges, consulting engineers, 3, Salter's Hall-court, London, E.C., have dissolved partnership.

John Norton Griffiths and Thos. Bruce Marriott (trading as Norton Griffiths, Bruce Marriott & Co.), consulting engineers, 59A, London-wall, London, E.C., have dissolved partnership.

Joseph Hodgson Woodhead and Harry Woodhead (trading as Woodhead Partners), electrical engineers and contractors, Cascoigne-street, Leeds, have dissolved partnership.

Sales by Auction.—Messrs. Marler & Marler will sell by auction at Messrs. Crisps' premises, Seven Sister's-road, London, N., on Wednesday, Oct. 19 at noon, in lots, the complete installation of electric generating plant comprising a Marshall 30 H.P. engine and boiler with steam feed heater and Allen, Weston and Paterson and Cooper dynamos, belts and shafting, arc and other lamps, &c. Catalogues of the auctioneers, 176, Sloane-street, Belgravia, London, S.W. See also an advertisement.

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Messrs. Horne & Co., 35, Old Queen-street, Westminster, S.W., will sell by public auction at the Royal Arsenal, Woolwich, on Thursday, 20th inst., at 11 a.m., unserviceable and obsolete stores, including quantities of iron and steel, brass, copper, gunmetal, lead and antimony alloy, zinc, lead, aluminium, &c., tools and lifting jacks, telegraph and electric light fittings and instruments, 650 electric lamps, 43,450 electric lamp bases, &c. The lots may be viewed at the Royal Arsenal, Woolwich, on Monday, Tuesday, and Wednesday, previous to and on morning of sale. Catalogues from the War Office, Whitehall; the Ordnance Office, Tower; and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Patents Development.—The proprietor of patent No. 21,181/1905, for "Improvements relating to electrical measuring instruments," desires to enter into arrangements, by licence or otherwise, for exploiting same in this country. Applications to Messrs. Haseltine, Lake & Co., 7 and 8, Southampton-buildings, Chancery-lane, London, W.C.

The owners of patents No. 23,501/1899, relating to "Improvements in vacuum table lighting," and No. 12,582/1902, relating to an "Improved system of electric lighting," desire to negotiate with electrical engineers with the view of granting licences. Information from Messrs. Lloyd Wise & Co., 46, Lincoln's Inn Fields, London, W.C.

BANKRUPTCIES, LIQUIDATIONS, &c.

A receiving order has been made against W. H. Hunter, electrician, &c., High-street, Towyn, Merionethshire.

A first and final dividend of 1s. is payable at 24, Friar-lane, Leicester, to creditors of Alan McAlpin (trading as McAlpin & Co.), electrical engineer, 44, Cauk-street, Leicester, and Cumbergate, Peterborough.

A first and final dividend of 4½d. will be payable at the O.R.'s City-chambers, Lowgate, Hull, to creditors of Harold Bristow, electrician, &c., 368, Hessle-road, Hull.

The Cascade (1906) Power Co. (Ltd.) is being wound up voluntarily. Claims by Nov. 1 to Mr. A. G. Bartholomew, 695, Salisbury-House, London, E.C., where a meeting of creditors will be held on Oct. 14.

In the report of the official receiver in regard to the liquidation of the Mid-Oxfordshire Gas Light & Coke Co. (Ltd.) it is stated that On June 24, 1909, the company purchased the Chipping Norton & District Electric Lighting undertaking for £10,500, which was satisfied by the issue of £7,000 special debentures carrying a first charge on the undertaking and ranking with the debenture stock in regard to any deficiency, and by the issue of fully-paid preference shares for the balance (£3,500). No agreement has been filed with the registrar of joint stock companies in respect to these fully-paid shares. The electric lighting works were purchased in order to obviate competition. The company's engineer (Mr. A. F. Painter) recommended the purchase at £10,500. In May last the court, on the application of special debenture holders, appointed W. A. Slade, 9, Old Jewry Chambers, E.C., receiver and manager of the Chipping Norton Gas Works, and on May 12, 1910, he was also appointed by the court receiver and manager of the Chipping Norton electric lighting works and of the Bicester gas works. The trustees for the special debenture holders had also entered into possession of the Woodstock works. On May 19 the company resolved to wind up voluntarily, and appointed H. A. Stevens, 6, Dowgate-hill, E.C., liquidator. The failure of the company is attributed by the directors to the inability to obtain statutory powers and shortness of working capital. In the opinion of the official receiver it is also due to over-capitalisation. Mr. R. W. Thornton, C.A., Oxford, has been appointed liquidator.

Deed of Assignment.—A dividend is to be paid under a deed of assignment executed on March 18, 1910, by Ellen Derbyshire (trading as P. Derbyshire), electrical engineer, &c., 6, Duke-street, St. Helens. Claims by Oct. 10 to Mr. P. S. Booth, 35, Exchange-chambers, 2, Bixteth-street, Liverpool, or Mr. R. Else, Victoria Works, St. Helen's.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

*Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application, an asterisk is affixed.*

August 15, 1910.

19,119 Karavodine. Secondary batteries or storage cells.
19,125 Scott. Electric switches.
19,164 Siemens Bros. Dynamo Works & Kieffer. Ventilation of dynamo-electric machines.*

August 16, 1910.

19,182 Collins. Switches.

August 17, 1910.

19,282 Herbeck & Holz. Electric signalling apparatus.*
19,291 Walmsley. Fittings for overhead wires.
19,359 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current motors.

August 19, 1910.

19,466 Hawkes. Electric heating and/or cooking stoves.*

August 20, 1910.

19,517 Conner. Telephone receivers.
19,525 Brooks & Alston. Contact breakers.
19,539 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke G.m.b.H., Germany.) Commutators for dynamo-electric machines.*
19,557 Krizik. Electromagnetic alternating-current apparatus. (Date applied for, 27/5/10. Comprised in Application No. 651, dated 10/1/10)*†

August 22, 1910.

19,583 Lancashire Dynamo & Motor Co., Wood & McLeod. Synchronous motors.*
19,593 Gibbs. Making wire electrolytically. (Date applied for, 4/9/09.)*†
19,600 Societe des Etablissements Sage Bine et Cie. Multitubular positive for electric batteries. (Date applied for, 25/6/10.)*†
19,619 Battaille. Electric tramways.*

August 23, 1910.

19,659 Aitken & British Insulated & Helsby Cables. Portable electrical firing instrument.*
19,701 Quertier. Electrically transmitting orders or signals and for indicating their nature and the points of transmission.*
19,703 Quertier. Electrical transmitting printing indicating and recording apparatus.*

August 24, 1910.

19,729 John & Berry. Secondary batteries.
19,772 Ruthenberg. Electrolytic production of antimony.
19,783 Williams-Ellis & Dutton. Calculator for electrical quantities.
19,786 Miram & Seidel. Electromagnetic clutches. (Date applied for, 14/2/10.)*†
19,795 City of London Electric Lighting Co. & Peard. Supporting and raising and lowering lamps.
19,804 Reid. Electric furnaces.*
19,805 Reid. Regulating electrodes in electric furnaces.*

August 25, 1910.

19,826 Copland. Electric incandescent lamp-holders.
19,851 Reyrolle & A. Reyrolle & Co. Electrical cut-outs.
19,863 Stirk. Shunt regulators for variable-speed motors.
19,866 Gebruder Siemens & Co. Manufacture of fireproof electrically conductive materials. (Date applied for, 4/10/09.)*†

August 26, 1910.

19,910 Brown. Automatic circuit-breakers.
19,914 Straussler. Metal filament lamp.
19,930 Druseidt. Combined fuse box and switch for electric circuits.*
19,932 Wheelwright & Moxon. Flexible protector and grip for use with cables conducting electricity.
19,952 Miram & Seidel. Electromagnetic clutches. (Addition to No. 19,786/10. Date applied for, 25/7/10.)*†
19,955 Balsillie & British Radio-Telegraph & Telephone Co. Transmitters for use in wireless telegraphy.
19,970 Siemens Bros. & Co. & Ferreira. Electrically detecting railway points.*
19,971 Siemens Bros. & Co (Siemens & Halske Akt.-Ges., Germany.) Electromagnets with removable cores.*

August 27, 1910.

19,989 McLean. Electric lamp-holders.
19,993 Kallmann. Electric resistance. (Date applied for, 31/8/09.)*†
20,004 Ashdown. Sparking or ignition plug.
20,040 Societe dite Etablissements Paz & Silva. Sockets for fixing electric bulbs. Date applied for, 28/6/10.)*†

SPECIFICATIONS PUBLISHED.

1909 Specifications.

13,728 Schuer. Arc lamps. (Post-dated 13/12/09.)
15,380 Simms. & Simms Magneto Co. High-tension magneto-electric machines. (Post-dated 3/1/10.)
16,332 Johnson & Billington. Electricity meters.
18,675 Medway & Scott. Switchgear for the remote control of electric motors.
18,756 Turquand & Turquand. Electric battery lamps.
19,090 Murphy. Rectifying electric currents.
19,387 Mount & Beck Flame Lamp. Arc lamps.
19,660 Farrand. Coin-freed apparatus for supplying or measuring a current of electricity.
21,179 Barbour. Homopolar generators and motors and other electrical machines having a large number of collector rings.
21,343 Kirwan & Quaney. Switches for breaking electrical circuits.
23,226 B.T.-H. Co. (G.E. Co., U.S.) Fluid meters.
23,227, 23,228 & 23,229 Murray. Electric cut-outs. (Dates applied for, 17/10/08 9/11/08, 30/11/08.)
23,291 Siemens Bros. Dynamo Works. (Siemens Schuckerwerke Ges.) Prevention of brush sparking in rotary electric frequency transformers having commutators.
23,328 Lake (Electric Press Bulletin Co.) Telegraph transmitting and receiving apparatus.
23,351 B.T.-H. Co. (G.E. Co., U.S.) Refractory insulating materials.
23,455 Dessauer. Taking photographs with Rontgen rays.
23,747 Graham. Electric signalling means.
23,802 Rogers. Audible electric signalling devices and the like.
24,017 B.T.-H. Co. (G.E. Co., U.S.) Signal systems for railways and the like.
24,109 Carrigan. Switches.
24,269 Siemens Bros. Dynamo Works, Ltd. (Siemens-Schuckertwerke Ges.) Driving and operation of electric frequency transformers having commutators.
24,302 Evans-Jackson. (Hiorth.) Electric induction furnaces.
25,383 Redfern (Compagnie Generale d'Electricite.) Soldering the filaments of incandescence lamps.
25,536 Siemens Bros. & Co. & Dieselhorst. Insulator for high-tension electric circuits.
25,719 Hosgood. Electric plug and socket couplings or connectors.
26,088 Kirwan & Quaney. Switching devices. (Post-dated 11/5/10.)
26,250 Siemens Bros. & Co. & Dieselhorst. Inductance coils for submarine and other electric cables.
26,259 Siemens & Halske Akt.-Ges. Telephone exchanges. (Date applied for 14/11/08.)
26,779 Leon & Lewis. Telephone transmitters.
27,208 Benjamin. Supporting devices for electric incandescent lamps.
27,458 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Automatic telephone exchanges.
27,674 Peterson. Method of charging electric resistance furnaces. (Date applied for, 7/1/09.)
27,976 De Laminiere & Soc. Anon. des Accumulateurs de Laminiere. Accumulator plates. (Date applied for, 8/12/08.)
28,429 Wynne. Switch with lever motion and instantaneous make and break.
28,555 McBride. Arc lamp.
29,068 Hirst & Angold. Arc lamps.
29,090 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke Ges.) Working of single-phase commutator dynamo-electric machines.
29,240 Hubbell. Storage batteries.
30,208 Fynn. Alternate-current motors.
30,331 Stevens (Ltd.), Stevens & Lambert. Brush-holders employed in electrical apparatus.

1910 Specifications.

672 Mulacek & Hatlanek. Electrical induction smelting furnaces. (Date applied for, 1/3/09.)
349 Krause. Metal filament lamps having filament carriers arranged elastically. (Date applied for, 5/7/09. Originally included in 22,458/09.)
439 Down & Down. Electric light bracket.
467 Siemens Bros. & Co. & Riber. Telephone apparatus.

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827 Soc. d'Electricite "Nilmelior" & Colas. Electrically-operated indicating, registering and controlling devices. (Date applied for, 13.1.09.)
1,206 Elektriska Aktiebolaget A.E.G. Systems for electrically operated submarine mines. (Date applied for, 18.1.09.)
1,461. & 1,462 Hartman. Purifying liquids by electricity.
2,032 Crocker. Electrolytic cells.
2,349 Kitsee. Telegraphic relays.
2,432 Felten & Guilleaume Lahmeyerwerke Akt. Ges. Checking the use of electric lighting apparatus. (Date applied for, 1.2.09.)
2,894 Martin. Current motors.
3,250 Sprague & Chamberlain & Hookham. Prepayment electricity meters.
3,314 Stachow. Magnetic ore separators. (Date applied for, 19/2/09.)
3,977 Dicker. (Benjamin Electric Mfg. Co.) Portable holders for electric incandescent lamps.
3,981 B.T.-H. Co. (G.E. Co., U.S.) Treatment of metals of the chromium group.
4,697 White & Carichoff. Control of electrically-operated switches. (Date applied for, 27.2.09.)
5,376 Fairburn-Hart (Electric Renovator Mfg. Co.) Centrifugal fans. (Date applied for 28.10.09.)
5,835 Neudorffer. Insulating wall-boxes for electric apparatus.
5,571 Midgley & Vandervell. Electric switches.
5,801 Adams Mfg. Co. (Cutler Hammer Mfg. Co.) Electro-magnetically actuated electric switches.
5,985 Smith, Green & Glover. Alternating-current induction motors.
6,160 and 6,363 Adams Mfg. Co. (Cutler Hammer Mfg. Co.) Switches.
6,667 B.T.-H. Co. & D'Arcy. Electric energy meters. (Date applied for, 20.9.09. Request under S.c. 19 of the Act not granted.)
6,658 Salzer. Supports for the filaments of incandescent electric lamps. (Date applied for, 19.3.09.)
6,668 B.T.-H Co. & Wedmore. Protective devices for electrical transmission and distribution systems. (Date applied for, 18.10.09.)
6,867 Adams Mfg. Co. (Cutler Hammer Mfg. Co.) Electric motor-controllers.
6,964 Siemens & Halske Akt.-Ges. Connections for semi-automatic telephone exchanges. (Date applied for, 20.3.09.)
7,154 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Electrical signalling apparatus.
7,266 Siemens Bros. Dynamo Works & Lydall. (Siemens Schuckertwerke Ges.) Single-phase commutator motors. (Addition to 2,303 08.)
7,292 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke Ges.) Electric frequency converters.
7,322 Reineking. Short-circuit detectors.
7,821 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke Ges.) Arc lamps.
7,822 Siemens Bros. Dynamo Works (Siemens Schuckertwerke Ges.) Starting of polyphase electric asynchronous motors.
8,024 Graham. Telephonic transmitters.
8,141 Kathura. Duplex systems of electric telegraphy. (Date applied for, 6.4.09.)
8,409 Siemens Bros. Dynamo Works & Parker. Ventilation of continuous-current dynamo-electric machines.
8,411 Siemens-Schuckertwerke Ges. Electric searchlights. (Date applied for, 8.4.09. Addition to 12,556 08.)
8,831 Jellinek & De Tovaros. Suspension of electric trolley wires. (Date applied for, 19.7.09.)
9,045 Siemens Bros. Dynamo Works (Siemens Schuckert-Werke Ges.) Polyphase electric compensated series motors.
9,094 Politz. Protecting tubes and vessels from galvanic or electric currents. (Date applied for, 22.4.09.)
9,176 Newlands & Parkinson. Making electrolyte for primary batteries. (Application for patent of addition to 11,926 09.)
10,312 Laurent. Indicating or alarm governors for motors. (Date applied for, 11.2.10. Addition to 16,802 09.)
10,423 Lundberg, Lundberg & Lundberg. Switches.
10,577 Graham. Telephone systems.
10,705 Brown, Gatenby, Gourlay & Gourlay. Electric conduit threaders.
10,771 Adams Mfg. Co. (Cutler Hammer Mfg. Co.) Electric circuit-breakers.
10,817 & 11,155 Fessenden. Wireless signalling. (Dates applied for, 19.7.09 and 29.1.10.)
10,820 Zahringer. Operating magneto-electric ignition machines.
10,843 Morse. Power transmission mechanism. (Date applied for, 15.12.08. Originally included in 28,923 09.)
10,961 Partington. Multiple fusible cut-out for electrical circuits.
11,251 Siemens Bros. & Co. (Siemens & Halske Akt.-Ges.) Telephone exchange circuits.
11,333 Howard & Coad. Telephone mouth-pieces.
11,903 Fessenden. Variable electric transformers. (Date applied for, 18.5.09.)
12,425 Gebrueder Siemens & Co. Protective coating for bodies consisting of carbon. (Date applied for, 24.5.09.)
13,502 Akt.-Ges. Brown, Boveri & Cie. Driving of dynamo-electric machinery. (Date applied for, 22.5.09.)
13,828 Lange. Portable electric lamps. (Date applied for, 28.2.10.)
14,153 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke Ges.) Preventing permanent magnetism in dynamo-electric machines.
14,315 Attis. (Noyes.) Magneto-generators.
14,353 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke Ges.) Obtaining a braking action in polyphase commutator electric motors.
15,977 Lewis. Electrodes for arc lamps. (Date applied for, 10.3.09.)

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price, adding 3d. for books published under 2s., and 5 per cent. for books published nett. Add 10 per cent. for abroad or for foreign books.)

"Diagram for the Easy Calculation of Shaft or Beam Deflections." By R. Livingstone. (London: "The Electrician" Printing & Publishing Co.) 2s. 6d. net; in tube 2s. 10d. post free.

"The Encyclopædia of Municipal and Sanitary Engineering." Edited by W. H. Maxwell and J. T. Brown. (London: Constable & Co.) 42s. net.

"Elementary Treatise on Physics." Translated from Ganot's "Eléments de Physique," by E. Atkinson. 18th edition. Edited by A. W. Reinold. (London: Longmans, Green & Co.) 15s.

"A Text-Book of Physics." By H. E. Hurst and R. T. Lattey. (London: Constable & Co.) 8s. 6d. net.

"Solenoids, Electromagnets and Electromagnetic Windings." By Charles R. Underhill. (London: Constable & Co.) 8s. net.

"Applied Mechanics." By John Graham. (London: Edward Arnold.) 5s. net.

"Notes on Applied Mechanics." By R. H. Whapham and G. Preece. (London: Edward Arnold.) 4s. 6d. net.

"Electric Lighting for Motor Cars." By Marks and Clerk. (London: The Technical Publishing Co.) 3s. 6d. net.

"Electric Circuit Problems in Mines and Factories." By Ellis H. Crapper. (London: The Chichester Press.) 3s. 6d. net.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

ALLIANCE ELECTRICAL STORES (LTD.) (111,884.)—Reg. Sept. 26, capital £25,000 in 47,500 preferred ordinary shares of 10s. each and 1,250 deferred ordinary shares of £1 each, to take over the business of electricians, electrical engineers, &c., carried on by the Alliance Electrical Co. (Ltd.) (in liquidation). First directors, T. Ions (chairman), J. E. Coles and W. R. N. Grimley.

LLANGEFNI ELECTRIC LIGHT & POWER CO. (LTD.) (111,909.)—Reg. Sept. 27, capital £3,000 in £1 shares (2,750 5 per cent. cumulative preference and 250 ordinary), to carry on business indicated by title. First directors, Major L. Williams, J. Jones, W. Owen, E. J. Owen and L. Milne. Reg. office, 66, Victoria-street, London, S.W.

LYNESS SYND. (LTD.) (111,896.)—Reg. Sept. 26, capital £3,500 in £1 shares (2,000 deferred), to acquire, develop and turn to account the Lyness patent electric control finger and tip, &c. Private company. R. C. Lyness is first permanent director.

PROGRESSIVE ENGINEERING CO. (LTD.) (111,880.)—Reg. Sept. 24, capital £500 in £1 shares, to carry on the business of electrical, mechanical, motor, aerial, civil and general engineers, &c. Private company. First directors, W. Smith and A. H. Jelly.

TELEPHONE SUBSCRIBERS' PROTECTION ASSOC. (LTD.) (7,660)—Reg. in Edinburgh, Sept. 26, to combine telephone users and to protect their interests. Reg. office, 144, St. Vincent-street, Glasgow.

UNITED SHERARDIZING (LTD.) (111,901.)—Reg. Sept. 26, capital £60,000 in £1 shares (14,000 5 per cent. preferred ordinary), to carry on the business of galvanisers, zinc workers, steel and iron workers, smelters, manufacturers and blenders of alloys, metal workers, &c., to acquire the right to use the process known as "Sherardizing" or any process for covering iron, steel or other metals with a coating of zinc or other metallic substances, to acquire certain patents and to adopt an agreement with T. H. Nelson. First directors, R. F. Hanbury, T. H. Nelson, P. Dawson, Major M. F. MacTaggart and H. M. Delacour.

MORTGAGES AND CHARGES.

ELECTRO-MECHANICAL BRAKE CO. (LTD.)—A memorandum of satisfaction in full on Aug. 13, 1910, of charge dated April 27, 1909, securing £250, has been filed.

MAWDSLEY'S (LTD.)—Issue on Sept. 12 of £100 debentures, part of a series created April 26, 1909, to secure £2,000, charged on the company's property, present and future, including uncalled capital. Holder, J. H. St. Hill Mawdsley. Previously issued of same series, £1,200.

CITY NOTES.

MEMORANDA (Sept. 29).—**Bank rate 4 per cent.** (Sept. 29, 1910) **Price of silver,** 24⅛d. per oz. Consols 79¾—80¼ for money; 80¼—80⅜ **account. Consols Pay Day, Nov. 4; Stock and Shares Continuation Days,** Oct. 12 and 26; **Ticket Days,** Oct. 13 and 27; **Pay Days,** Oct. 14 and 28; **Mining Shares Carry Over Days,** Oct. 11 and 25.

Prices of Metals (London).—*Copper*, **cash,** 56¼; **three months,** 57⅛. *Lead*, **English,** 13½—13¾; **foreign,** 12¾—13. *Spelter*, 23⅝—23¾. *Tin*, **English,** 158—160; **foreign cash,** 162; **three months,** 159¼. *Iron*, **Cleveland, cash,** 49/3¼, **three months,** 49/10½.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The directors have resolved, after placing £5,000 to renewal fund, to declare an interim dividend for the quarter ended Sept. 30 of 15s. per cent. on the ordinary stock, and £1. 10s. per cent. on the preferred stock (less tax) payable Nov. 1.

CALCUTTA TRAMWAYS CO. (LTD.)—The directors have declared an interim dividend of 2s. 6d. per share.

CLEVELAND & DURHAM COUNTY ELECTRIC POWER CO. (LTD.)—The directors' report for the year ended June 30 states that capital expenditure on new works during the year was £8,811. The continuous trade depression had retarded the amount of new business secured. The gross profit was £12,942, against £2,098 for the previous year. After providing for interest there was a net profit of £2,906, which deducted from debit balance brought forward, leaves a debit of £751 to be carried forward.

EASTERN TELEGRAPH CO. (LTD.)—This company announce the payment by warrants on Nov. 1 of interest for the half-year ending Oct. 31 on their 4 per cent. mortgage debenture stock. The transfer books of the debenture stock will be closed from 27th to 31st inst. inclusive.

EASTERN & SOUTH AFRICAN TELEGRAPH CO. (LTD.)—This company announce the payment by warrants on Nov. 1 of interest for the half-year ending 31st inst. on their 4 per cent. Mauritius subsidy debentures. The transfer books will be closed from 27th to 31st inst. inclusive.

RIO DE JANEIRO TRAMWAY, LIGHT & POWER CO. (LTD.)—The directors have declared a quarterly dividend of 1¼ per cent.

SUBMARINE CABLES TRUST.—The coupon due on the 15th inst. will be paid by Messrs. Glyn, Mills & Co., 67, Lombard-street, E.C.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

LINE.	Week ended.	Amount	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 28	1,487	— 18	17	26,440	— 69
Airdrie	„ 23	227	+ 3	38	8,316	+ 59
Anglo-Argentine	„ 30	45,894	+ 6,823	39	1,725,286	+ 203,672
Ayr Corporation	Oct. 1	301	+ 25	20	8,436	+ 330
Barnsley	Sept. 23	170	+ 3	38	6,572	+ 164
Barrow	„ 23	268	+ 20	38	10,401	+ 1,476
Bath Electric Trams, Ltd...	„ 28	923	+ 79	39	32,569	+ 1,799
Birmingham Corporation ..	Oct. 1	7,384	+ 308	26	177,350	+ 2,647
Birmingham & Midland....	Sept. 23	854	— 8	38	32,529	+ 554
Blackburn Corporation	„ 28	1,053	— 22	‡27	29,320	— 1,164
Blackpool and Fleetwood ..	Oct. 1	848	+ 50	..	..	..
Bolton Corporation.....	„ 2	2,427	+ 117	27	63,989	+ 93
Bombay	Sept. 2	2,734	+ 115	35	94,254	+ 6,496
Bournemouth Corporation..	„ 28	1,875	+ 182	26	52,673	+ 4,601
Bradford Corporation.....	Oct. 1	5,671	+ 635	27	137,340	+ 4,896
Brighton Corporation.....	„ 2	1,063	+ 104	§26	28,892	+ 177
Bristol Trams & Carriage ..	Sept. 30	6,320	+ 407	13	84,182	+ 5,241
Burnley Corporation	Oct. 1	1,404	+ 36	13	16,936	— 60
Burton Corporation	„ 3	440	+ 169	26	7,379	+ 155
Bury Corporation	„ 2	1,288	+ 117	§26	31,890	— 296
Calcutta Tramways Co.....	„ 1	₹55,890	+ ₹4,564	13	₹701,102	+ ₹53 423
Camborne-Redruth	„ 1	129	..	39	4,809	— 114
Cardiff Corporation.....	..	..	..	..	..	..
Cavehill.....	Sept. 23	101	— 5	38	3,609	+ 162
Central London Railway ..	Oct. 1	5,437	+ 95	13	68,730	+ 3,927
Chatham & Dist. Lt. Rys. ..	Sept. 29	980	+ 105	39	33,524	+ 1,219
City & South London Rly...	Oct. 2	3,020	— 28	13	40,001	+ 165
City of Birmingham	Sept. 23	2,921	+ 47	38	108,615	+ 2,542
Colchester Corporation	„ 28	204	— 2	..	..	..
Cork Electric Trams Co.....	„ 29	501	— 22	39	19,249	+ 1,678
Croydon Corporation	..	..	..	..	..	..
Devonport & Dist. Trams ..	„ 23	444	+ 87	38	16,312	+ 2,280
Dover Corporation	Oct. 1	255	+ 42	26	6,386	+ 207
Dublin & Lucan Railway ..	Sept. 30	166	+ 5	13	2,303	+ 126
Dublin United	„ 30	5,869	+ 201	13	79,430	+ 1,653
Dudley-Stourbridge	„ 23	807	— 36	38	30,576	— 687
Dundee Corporation	„ 28	1,276	+ 82	§19	24,044	+ 433
East Ham Council	Oct. 1	1,108	+ 121	¶26	27,862	+ 939
Exeter Corporation.....	Sept. 30	346	+ 8	26	8,908	— 701
Gateshead & Dist. Trams ..	„ 23	994	— 14	38	37,539	— 145
Glasgow Corporation	Oct. 1	19,874	+ 1,972	18	315,214	+ 17,988
Glossop Trams.....	„ 1	118	— 9	39	4,581	— 300
Gloucester Corpn.....	Sept. 28	401	+ 42	..	..	..
Gravesend-Northfleet.....	„ 23	211	— 28	38	7,979	— 86
Great Northern & City Rly..	Oct. 1	1,385	+ 40	13	17,020	+ 591
Greenock & Port Glasgow ..	Sept. 23	608	— 13	38	24,235	+ 3,004
Hartlepool Tramways	„ 23	263	+ 11	38	9,659	+ 632
Hastings Elec. Trams Co. ..	„ 29	1,188	+ 81	13	18,223	+ 77
Hong Kong	Oct 1	$9,123	— $216	13	$114,180	+ $4 851
Huddersfield Corpn.	„ 1	2,120	+ 147	27	46,938	+ 2,254
Hull Corporation.....	„ 1	2,754	+ 175	26	71,082	+ 3,635
Ilford District Council.....	„ 1	537	+ 62	26	14,271	+ 892
Ilkeston District Council ..	Sept. 23	135	..	26	3,432	— 186
Ipswich Corporation	Oct. 1	466	+ 43	26	12,155	+ 651
Isle of Thanet Co.	Sept. 30	643	+ 222	¶52	34,546	+ 2,565
Jarrow	„ 23	114	— 1	38	4,758	+ 253
Keighley Corporation.....	..	..	..	..	..	..
Kidderminster & District ..	„ 23	117	— 10	38	4,357	+ 114
Kilmarnock Corporation ..	Oct. 1	159	+ 13	20	3,159	+ 100
Lanarkshire Trams Co.	Sept. 29	1,592	+ 130	39	54,595	+ 3,992
Lancashire United	„ 28	1,328	— 10	39	51,455	— 582
*Leamington	„ 23	224	+ 46	38	6,537	— 250
Leeds Corporation	Oct. 1	7,401	+ 360	26	183,453	+ 6,006
Leicester Corporation.....	„ 1	2,433	+ 139	..	..	..
Leith Corporation	„ 1	627	+ 26	20	12,924	+ 74
Lincoln Corporation	..	..	..	..	..	..
Liverpool Corporation	Sept. 24	11,018	+ 36	38	424,175	+ 15,017
Liverpool Overhead Rly. ..	Oct. 2	1,423	+ 160	14	20,554	+ 322
Llandudno&ColwynBayRy.	Sept. 30	287	+ 24	§43	13,414	+ 360
*London County Council	„ 21	42,349	+ 3,477	¶25	1,047,086	+ 134,014
London Elec. Ry. Co.....	Oct. 1	12,120	— 155	13	159,470	+ 655
London United	„ 1	6,755	+ 758	40	252,297	+ 10,678
Lowestoft	..	..	..	..	..	..
Maidstone Corporation	..	..	..	..	..	..
Manchester Corporation....	„ 1	16,455	+ 656	26	409,018	+ 7,673
Mersey Railway	„ 1	2,051	— 14	13	25,472	+ 313
Merthyr	Sept. 23	208	— 4	38	7,946	— 214
Metropolitan Dist. Railway..	Oct. 1	10,567	+ 547	13	131,315	+ 8,089
Metropolitan Elec. Trams ..	Sept. 23	8,236	+ 1,247	38	285,800	+ 48,919
Middleton	„ 23	319	— 44	38	12,211	— 774
Nelson Corporation.....	Oct. 1	148	+ 6	§26	3,948	+ 141
Newcastle-on-Tyne Corp. ..	„ 1	3,884	+ 29	¶26	104,723	+ 1,147
Newport (Mon.)	„ 1	696	+ 19	27	18,792	+ 747
Northampton Corporation..	Sept. 30	511	— 27	§26	13,027	— 49
Oldham, Ashton & Hyde ..	„ 23	557	— 20	38	21,237	— 137
Oldham Corporation	Oct. 2	1,875	+ 55	27	50,864	— 921
Perth (N.B.) Corporation ..	Sept. 28	196	+ 23	§19	3,584	+ 274
Perth (W.A.) Elec. Trams ..	„ 30	1,272	— 70	39	48,335	— 6,137
Peterborough	„ 23	119	— 4	38	4,445	— 77
Portsmouth Corporation ..	Oct. 1	2,151	+ 2	26	59,361	— 1,471
Potteries	Sept. 23	1,851	— 8	38	66,606	— 820
Preston Corporation	„ 28	695	— 65	26	19,367	— 376
Rotherham Corporation....	„ 29	644	+ 65	26	16,386	+ 850
Rothesay	„ 23	218	+ 4	38	9,276	+ 57
Salford Corporation	Oct. 3	4,917	+ 339	‡27	125,791	+ 2,132
Sheerness	Sept. 23	54	+ 1	38	1,977	— 7
Sheffield Corporation	Oct. 2	6,212	+ 470	¶27	163,332	+ 9,693
Singapore Trams.....	„ 1	$9,749	+ $284	13	$119,613	+ $9,346
South Metropolitan.....	Sept. 23	871	— 36	38	31,823	+ 1,103
South Staffs.....	„ 23	852	— 45	38	32,045	+ 151
Southend Corporation	„ 28	671	+ 158	26	18,044	+ 1,989
Southport Tramways	„ 23	301	— 9	38	11,560	+ 178
Stalyb'dge,Hyde,&c., Jt.Bd.	Oct. 1	738	— 14	¶26	19,423	— 1,445
Sunderland Corporation....	„ 2	1,192	+ 74	27	31,537	— 14
Sunderland District	Sept. 28	439	— 18	48	20,699	— 1,404
Swansea Trams	„ 23	1,129	+ 77	38	41,515	+ 4,651
Swindon Corporation	„ 28	154	+ 9	26	3,795	+ 149
Taunton	„ 23	43	— 7	38	1,632	+ 69
Tynemouth and District....	„ 23	273	+ 22	38	10,463	+ 541
Tyneside Trams Co.	„ 28	405	— 5	13	6,273	+ 326
Wallasey District Council ..	Oct. 1	959	+ 1	¶26	26,076	+ 236
Walsall Corporation	„ 1	563	+ 30	39	20,933	+ 901
Warrington Corporation....	..	..	..	..	..	..
West Ham Corporation	Sept. 22	2,537	+ 145	25	62,639	+ 2,669
Weston-super-Mare	„ 23	198	+ 6	38	6,562	— 12
Wolverhampton Co.	„ 23	452	+ 30	38	16,264	+ 320
Wolverhampton Corpn.	„ 28	964	+ 3	..	..	..
*Worcester	„ 23	327	+ 12	38	10,981	+ 217
Wrexham	„ 23	94	— 35	38	3,714	— 80
Yorkshire W.R. Trams	Oct. 2	1,274	+ 99	40	49,893	..
Yorkshire Woollen District	Sept. 23	1,125	+ 121	38	37,686	+ 2,945

(a) These comparisons are with the corresponding period last year. * Partly electrical.
† Minus 3 days. ‡ Minus 2 days. § Plus 3 days. ¶ Plus 2 days.

ELECTRICAL COMPANIES' SHARE LIST.

Share	Last Dividend	Name.	Price Wed., Oct. 5.	Rate per cent. Yielded.	Dividend Due.	Business Week to Oct. 5. High-est.	Business Week to Oct. 5. Low-est.
		Electricity Supply.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord.	8¾—9¼	5 16 0	Mar, Sep	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.....	9 —9⅛	4 12 6	Feb, Aug	9⅛	..
10	6/0	Do. 6 per Cent. Cum. Second Pref.	10 —10½	5 13 0	Feb, Aug	10⅝	10½
St.	4½%	Do 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 6	Jan, July	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord. ..	6¾—7⅜	6 9 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.....	6¾—7⅛	4 15 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Deb. Stock	100 —103	3 17 0	June, Dec	101½	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾—3⅞	6 5 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4¼—4½	4 14 0	Feb., Aug	4⅜	4⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 —99	4 1 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	101 —103	4 7 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cum. Pref.	3¾—4⅛	5 9 6	Jan, July	..	..
5	2/0	Chelsea Electric Supply Ord.....	3¼—4	5 12 6	March	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.)	99 —101	4 9 0	June, Dec	..	..
10	6/0	City of London Electric Lighting Ord.	11¼—11⅝	6 9 0	Feb, Aug	11⅝	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11½—12¼	4 18 0	Jan, July	11¼	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 —124	4 0 6	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.) ..	99½—102½	4 7 6	Jan, July	102	101½
5	..	County of Durham Elec. P. D. Ord.....	1½—2	..	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	2¾—3½	8 0 0	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.	7⅜—7⅝	6 7 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10¾—11¼	5 6 6	Mar, Sept	11⅛	11¼
St.	4½%	Do. 4½ per Cent. Deb Stock (red.)	104½—107½	4 3 6	Jan, July	106	..
St.	4½%	Do. Second Deb. Stock	100 —103	4 7 6	May, Nov	..	..
5	2/0	Folkestone Electricity Supply Co. Ord.	4¼—4⅝	5 19 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5¼	4 13 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red)	99 —102	4 8 6	Feb, Aug	..	..
5	4/6	Hove Electric Lighting Ord.....	7 —7½	5 9 0	April, Oct	..	..
5	4/0	Kensington & Knightsbridge Ord.....	6¾—7⅛	5 6 9	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref	5¼—6½	4 18 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 —95	4 4 0	..	..	..
St.	4%	Kensington & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.) ..	95 —98	4 2 0	April, Oct	..	..
St.	4½%	Kent Elec. Power Co. Irred Deb. Stk.....	81 —85	5 6 0	Jan, July	..	..
3	1/2½	London Electric Supply Ord.	1¼—1⅞	3 4 6	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	4⅜—5¼	5 18 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb	90 —92	4 7 0	Jan, July	..	..
5	2/0	Metropolitan Electric Sup. Ord.	3¼—3⅜	6 13 3	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	4¼—4⅜	4 17 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort....	102 —105	4 5 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mort. Deb. Stock (red.)	82 —85	4 2 6	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Deb.	96 —98	4 12 0	June, Dec	..	..
5	1/6	Newcastle Elec. Supply Ord.....	3¼—4⅜	4 11 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4½	5 2 6	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. 1st Mort. Deb.	100 —102	4 8 0	Jan, July	..	..
100	5%	North Metro. Elec. Power Sup. 5 Morts.....	100 —102	4 18 0	..	..	..
10	6/0	Notting Hill Electric Ord.....	12 —13	6 0 0	March	..	..
5	3/0	Oxford Electric Ord.	6¼—6⅞	5 4 0	March	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7¼—8⅛	6 2 3	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.....	6¾—7⅛	4 16 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	84 —86	4 1 6	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord.....	1¼—2	..	Feb.	..	..
5	4/0	South London Electric Supply Ord.....	2⅜—3	6 4 6	April	2⅜	..
St.	5%	Do 5 % 1st Mort. Stock (red.).....	99 —102	4 18 0	..	..	..
1	..	South Metrop'n Elec. Lt. & Power Ord.	⅞—1	..	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	⅞—1⅛	6 13 0	Feb, Aug	..	..
St.	4½%	†Do. 4½ 1st Deb. Stock (red.).....	96 —99	4 11 0	April, Oct	..	..
5	2/6	†Urban Electric Supply Ord.	¾—1	..	April, Oct	..	..
5	2/6	†Do. 5 per Cent. Cum. Pref.	2 —2¼	..	April, Oct	..	..
St.	4½%	†Do. 4½ per Cent. 1st Mort. Deb.	77 —79	5 14 0	April, Oc	..	..
5	5/0	Westminster Elec. Sup. Ord.....	8 —8¼	5 17 9	Mar, Sep	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.....	5 —5¼	4 2 0	Jan, July	5⅛	..
		Electric Railways and Tramways.					
1	..	Bath Elec. Trams Pref. Ord.....	⅜—⅝	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—½	6 13 6	Jan, July	..	..
St.	4½%	†Do. 4½ 1st Mort. Deb. Stock (red.).....	80 —84	5 7 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Deb. Stock.	79 —82	5 18 10	June, Dec	82	..
10	6%	Bristol Tramways & Carriage Ord.	5 —5¼	10 18 0	Feb, Aug	..	..
10	4%	Do Cum. Pref. (fully paid)	7 —7¼	5 4 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 —101	3 19 9	Feb, Aug	..	..
10	..	British Electric Traction Ord.	⅜—1	..	June, Dec	..	..
10	..	Do. 6 per Cent. Cum. Pref.	2⅛—3	..	Feb, Aug	2⅛	2⅛
St.	5%	†Do. 5 per Cent. Perpetual Debs	87 —91	5 10 0	April, Oct	89⅛	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock.....	70 —75	6 0 0	May, Nov	73½	..
St.	3%	Central London Ordinary Stock	63 —65	4 12 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Pref. Stock	84 —86	4 14 6	Feb, Aug	85½	..
St.	2%	Do. Deferred Stock	44 —46	4 7 0	Feb.	..	..
100	4%	Do. 4 per Cent. Debs.....	100 —102	3 18 6	Jan, July	101½	..
5	2/6	City of Birmingham Trams, 5 % Cum. Pref.	4¼—5¼	4 15 0	April, Oct	..	..
100	4%	Do 4 per Cent. 1st Mort. Debs.	98 —102	3 18 0	April, Oct	..	..
St.	1½%	City & South London Rly. Con. Ord.	27½—28½	5 3 0	Feb, Aug	28½	27½
St.	5%	Do. 5 per cent. Perp. Pref. (1891)	105 —107	4 13 6	Feb, Aug	..	..
St.	5%	Do. (1896)	103 —105	4 15 6	Feb, Aug	..	..
St.	5%	Do. (1901)	99 —102	4 18 0	Feb, Aug	..	..
St.	5%	Do. (1903)	98 —101	4 19 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.....	100 —102	3 18 3	May, Nov	101½	101
10	6/0	Dublin United Trams. 6 per Cent. Pref.....	12½—13½	4 9 0	Feb, Aug	..	..
10	12/0	Gateshead and District Trams Ord.....	8 —8½	7 1 0	..	..	..
10	..	Gt. Northern & City Rly. Pref. Ord. (4%)..	¾—1	..	Feb, Aug	..	..
5	..	Hastings & District Elec. Trams, 6% C. P.	¾—1½	..	Mar. Sept	..	..
St.	4½%	†Do. 4½ Deb. Stock	70 —75	6 0 0	April, Oct	..	..
10	6%	Imperial Tramways Ord.	3 —4	7 10 0	Mar, Sept	..	..
10	6%	‡Do. 6 per Cent. Pref.....	3½—4	7 10 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	66 —70	6 8 6	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref. ..	1⅞—1⅞	3 12 9	Mar, Sept.	1⅞	..
St.	4%	Do. 4 per Cent. Deb. Stock	70 —75	5 16 0	Jan, July	..	..
10	5/6	Lanarkshire Tramways	9⅞—10⅛	4 19 0	Feb, Aug	..	..
St.	5%	Lancs. Utd. Trams, 5% Prior Lien Deb. Stk.	84 —86	5 16 0	Jan. July	..	..
St.	..	London Electric 4% Deb. St.	94½—95½	..	..	95⅛	..
St.	..	Do. 4% Pref.	84 —85	..	..	..	..
10	..	London United Trams, 5% Cum. Pref.	2 —2⅛	..	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock....	66 —70	5 14 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2½—3½	..	Feb, Aug	..	..
1	1/0	Metropolitan Elec. Tramways Ord.....	⅞—1	..	..	⅞	⅞
1	..	Do. Deferred	⅛—⅜	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—⅝	5 7 6	Feb, Aug	⅝	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	96 —99	4 11 0	Jan, July	98½	96
St.	39/6	†Do. 5 per Cent. Db. Stk	95 —97	5 2 6	..	95	..
St.	1½%	Metropolitan Railway Consolidated.....	38 —38½	2 18 6	Feb, Aug	38½	37½
St.	2½%	Do. Surplus Lands Stocks.....	65 —67	4 2 0	Feb, Aug	65½	..
St.	3½%	Do. 3½ per Cent. Preference.....	87 —89	3 18 9	Feb, Aug	88½	87½
St.	3½%	Do. 3½ per Cent. "A" Preference	84 —86	4 1 6	Feb, Aug	84½	..
St.	3½%	Do. 3½ per Cent. Convertible Pref.	84 —86	4 1 6	Feb, Aug	85⅜	85
St.	3½%	Do. 3½ per Cent. Debenture Stock	91 —93	3 15 6	Jan, July	92	91½

* In calculating the yield allowance has been made for accrued interest, but *not* for redemption.
† Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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UNIVERSITY OF CALIFORNIA

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Share	Last Dividend	Name.	Price Wed. Oct. 5.	Rate per cent. Yielded.	Dividend Due.	Business Week to Oct. 5. Highest.	Lowest.
		Electric Railways and Tramways—*Continued.*		£ s. d.			
St.	3½%	Met. Rly. 3½ per Cent. "A" Deb. Stock..	90 —92	3 15 6	Jan, July	90½	..
St.	..	Metropolitan District Railway Ord.....	21¼—21⅜	..	Feb, Aug	21⅜	..
St.	3%	Do. 4½% First Pref.	79 —81	3 14 0	Feb, Aug	79½	..
St.	3½%	Do. Assented Ext. Pref. (Int. Guar. by Und. Elec. Rlys. Co. of London, Ltd.)	73 —75	4 13 0	Feb, Aug	74	72
St.	3%	Do. 3 per Cent. Consoltd. Rent-charge	74 —76	3 19 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Midland Rent-charge	100 —103	4 0 0	Jan, July	..	..
St.	6%	Do. 6 per Cent. Perp. Deb. Stock.....	141 —143	4 3 9	Jan, July	142½	..
St.	4%	Do. 4 per Cent. Ditto.....	95 —97	4 2 6	Jan, July	96½	..
1	4½d.	Potteries Electric Traction Ord.	⅛—¼	..	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅞—1⅛	7 4 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent, Deb. Stock.....	82 —85	5 5 3	May, Nov	..	..
1	7½d.	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜—½	..	..	..	..
St.	4%	Dc. 4 per Cent. Deb. Stock.....	66 —70	5 14 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1stMtDb.	..	8 4 0	Jan, July	..	..
..	..	Undergd E. Rys. Lon. 6% In. bds. withcoup6	37 —39	..	June, Dec	..	..
..	5%	Do. 5% Prior Lien Bonds.....	103 —104	4 16 0	..	103½	..
..	4½%	Do. 4½% Bonds with coup. 6	92 —94	4 15 9	..	93½	93
..	4%	Do. 4 per Cent 1st Power Ho. Dbs. ..	97 —99	4 1 0	..	98½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.....	⅛—⅜	..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2½	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.....	77 —80	5 12 6	Jan, July	..	..
		Electric Manufacturing, &c.					
	4½%	Anchor Cable Co. 4½ % Deb. Stock	101½—103½	4 7 0	..	..	..
	..	Aron Electricity Meter Ord.....	⅜—⅝	..	..	⅜	..
	1/9½	Do. 6% Cum. Pf.	⅝—⅞	6 16 0	April, Oct	..	..
1	2/0	†Babcock & Wilcox Ord.....	5½—5¾	4 7 3	April, Oct	5⅝	5⅝
1	0/7½	†Do. Pref.....	1⅛—1½	4 0 0	..	..	..
5	4/0	British Insulated & Helsby Cables Ord...	6½—7½	6 18 0	July, Feb	6⅝	..
5	3/0	Dc. 6 per Cent. Pref.....	6 —6½	4 12 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)..	101 —104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	98 —101	4 12 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref....	⅞—1⅛	..	Feb, Aug	..	..
100	6%	Do. 6 per Cent. Prior Lien Dbs. (rd.)..	98 —100	6 0 0	..	100	..
St.	..	Do. 4 per Cent. Mort. Deb. Stock.....	61½—63½	6 6 0	Jan, July	62½	..
St.	4½%	BritishE.Eng. Co. 4½% Perp. 1st Deb.Stock	37 —42	10 14 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock.....	22 —26	17 6 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9½—9¾	7 14 0	Jan, July	9⅝	9½
5	2/6	Do. 5 per Cent. Cum. Pref.....	4⅛—5⅛	4 16 3	Jan, July	5⅛	4⅝
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red)..	103½—105½	4 5 3	Nov, May	..	..
1	1/3	Castner-Kellner Alkali Co.....	3⅛—3⅜	4 6 0	May, Nov	3⅛	3⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red)..	105 —108	4 3 6	Feb, Aug	..	..
1	1/0	Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	5 19 0	March ..	..	..
1	0/8½	Consolidated Electrical Co.....	⅛—⅜	5 18 9	August ..	..	..
1	0/6	Consolidated Signal Co.....	⅛—⅜	5 12 0	April, Oct	..	..
1	0/7½	Do. 6 per cent. Cum. Pref.	⅛—⅜	6 8 0	April, Oct	..	..
3	..	Crompton & Co (Nos. 1 to 85,000)	½—¾	15 0 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red)..	83 —86	5 16 0	Jan, July	..	..
1	0/7½	Davis & Timmins	¾—1½	..	Mar, Sept	..	..
5	1/2½	Dick, Kerr & Co. Ord.....	¼—1	6 0 0	Sept.	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.....	1⅛—1⅜	5 13 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock.....	98 —101	4 9 0	Jan, July	..	..
5	..	Edison & Swan United ("A" Sh.) (£3 pd.)	⅞—⅞	..	Feb, Aug	..	..
	..	Do. (£5 paid)	1 —1⅛	9 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	63 —68	5 18 0	June, Dec	..	..
St.	5%	†Do. 5 per Cent. 2nd Deb. Stock.....	77 —80	6 5 0	Mar, Sept	..	..
..	..	Edmundson's Elec. Corp. Ord.....	⅞—1	..	Jan, July	..	..
5	..	Do. 6 per Cent. Cum. Pref.....	1½—2	..	May, Nov	..	..
St.	4½%	Do 4½ per cent. 1st Mort. Deb. (red.)..	75 —78	5 15 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅛—⅜	..	Jan, July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.....	1⅛—1½	4 13 6	July	1⅜	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs..	59 —64	6 5 0	Jan, July	61½	..
10	5/0	General Electric (1900) 5% Cum. Pref. ..	7½—8	6 5 0	June, Dec	..	..
St.	4%	†Dc. 4 per Cent. 1st Mort. Debs.....	80 —84	4 15 0	Mar, Sept	..	..
5	5/0	Henley's Telegraph Works Ord.....	12½—12¾	5 17 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5⅛—5⅜	4 4 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107½—109½	4 2 0	Mar, Sept	..	..
10	5/0	India Rubber, Gut. Per., &c., Works....	14½—15½	6 11 0	Feb, Aug	15⅛	..
10	5/0	Do 5 per Cent. Cum. Pref.	10⅜—11	4 14 0	..	..	..
100	4%	Do. 4 per Cent. Debs. (red.)	93 —100	4 0 0	April, Oct	..	..
1	..	National Elec. Construction Co.	⅛—⅜	..	April	..	..
1	..	Richardsons, Westgarth & Co., Ltd. Ord.	⅛—⅜	..	Nov.	..	..
1	..	Do. 6 per Cent. Cum. Pref.	⅛—⅜	..	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock....	78 —83	5 8 6	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5 —5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance..	35½—37½	5 12 0	Mar, July	37½	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909)	101 —103	3 17 6	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.....	2 —2⅛	4 11 0	..	2⅛	2
1	0/6	Dc 5 per Cent. non-Cum. Preference..	1⅜—1½	4 1 6	..	1⅜	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred ..	108 —111	4 10 0	..	..	..
St.	4%	Do 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	104 —106	4 5 0	June, Dec	105	..
100	5%	Do. 5 per Cent. 3rd Mort. Debs Scrip...	105 —107	4 13 6	..	106	105½
10	10%	J. G. White & Co. 6% Cum. Pref.	12½—13½	7 8 0	..	13	..
1	..	Willans & Robinson Ord.....	⅛—⅜	..	Apr, Oct	..	..
5	1/6	Do. 6 per Cent. Cum. Pref.....	1 —1½	4 0 0	Apr, Oct	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	60 —70	5 14 0	May, Nov	..	..
		Telegraphs.					
10	..	Amazon Telegraph	3½—4½	..	June, Dec	..	..
100	20/2	Do. 5 per Cent. Debs. (red.) Scrip	95 —97	4 17 6	Jan, July	95⅝	..
St.	15/0	Anglo-American	67 —69	5 8 9	F,My,Ag,N	68	..
St.	30/0	Do. Preferred	109 —111	5 8 0	F,My,Ag,N	110	109
St.	25/0	Do. Deferred	26½—27	4 12 6	F,My,Ag,N	27	26⅜
St.	4%	†Commercial Cable 4 per Cent. Deb. Stk...	84½—86½	4 12 6	Jn,Ap,Jy,O	..	..
10	6/0	Cuba Submarine Ord.	8½—9½	6 6 0	Feb, Aug	9⅛	..
10	10/0	Do. Preference 10 per Cent.	16½—17½	5 13 9	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.	3⅛—3½	5 3 0	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.....	8½—9	5 11 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.	101 —103	4 17 6	Jan, July	..	..
20	6/0	Direct United States Cable.....	16½—16¾	5 7 6	Ja,Ap,Jy,O	16⅞	16⅜
100	4½%	Direct West India Cable 4½% Rg.Db.(rd.).	101 —102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	133 —136	5 4 6	Ja,My,Jy,O	135	133½
St.	17/6	Do. 3½ per Cent. Pref. Stock.....	84 —86	4 1 6	Ja,My,Jy,O	84½	84
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)..	102½—104½	3 17 9	May, Nov	..	..
St.	2/6	Eastern Extension	12½—13½	5 6 0	Ja, Ap, Jy, O	13½	12½
100	4%	Dc. 4 per Cent. Deb. Stock	100 —102	3 18 6	Feb, Aug	100½	..
25	4%	Eastern and S.Af., 4% Mauritius Sub.Debs	100½—102½	3 18 0	May, Nov	..	..
10	5/0	G.N (of Copenhagen), with Coupon 80 ..	30½—31½	5 14 3	Jan, July	..	..
25	52/6	Indo-European	53 —55	5 18 6	May, Nov	..	..
100	5%	†Mackay Companies Common	94 —97	5 3 0	Ja,Ap,Jy,O	..	..
100	4%	†Do. Preference	75 —80	5 0 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.....	⅜—½	..	April	⅜	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	98 —100	4 0 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅜—1⅝	4 7 0	May	..	..
100	4%	Do. 4 per Cent. Debs.....	96 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	1⅛—1½	..	May, Nov	1½	1⅜
10	6/0	Do. 6 per Cent. 1st Pref.	9⅛—10⅛	5 18 0	May, Nov	9⅜	9⅛
10	9/0	Do. 6% 2nd Pref.	9⅛—9⅜	6 1 0	May, Nov	9⅜	9⅛
100	5%	Do. 5 per Cent. Debs.....	101½—103½	4 16 6	Jan, July	..	..
10	3/0	Western Telegraph	13½—14½	4 16 9	Mr,Jn,O,D	14	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 —102	3 19 0	June, Dec	..	..
1	4%	Western Union Telegraph. $1,000 4% Bds	103 —106	3 15 3	—	..	..

Share	Last Dividend	Name.	Price Wed., Oct. 5.	Rate per cent. Yielded.	Dividend Due.	Business Week to Oct. 5. Highest.	Lowest.
		Telephones.		£ s. d.			
100	2$	†Amer. Telephn. & Telegh. Cap. St.	141 —144	5 10 0	..	..	..
	4%	Do. Coll. Trust $1,000 4 per Cent. Bds.	94 —96	4 3 3	Jan, July	..	..
St.	4%	Do. 4% Cons. Bonds 1936	106 —108	3 14 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101½—103½	4 15 6	Mar, Sept	..	..
5	5/0	Chili Telephone	9¼—10⅛	3 17 0	August ..	10⅛	10
1	0/7½	Monte Video Telephone Ord.....	⅜—⅝	6 0 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	½—¾	5 12 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock.....	104½—105½	5 14 0	Feb, Aug	105½	104½
St.	6%	Do. Def. Stock	121½—123½	4 17 0	Feb, Aug	122½	121½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.....	10 —10½	5 8 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.....	10 —10½	5 8 6	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref.....	5⅛—5⅜	4 8 0	Feb, Aug	5⅜	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.).....	98 —100	3 10 0	June, Dec	99½	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	99 —101	3 19 0	Jan, July	100½	99
	4%	New York Telephone Co. 30 yr. Bnds.....	100 —101	4 9 0	..	100⅛	99
1	1/0	Oriental	1⅛—1⅜	4 19 6	April, Oct	..	..
1	0/7½	Dc 6 per Cent. Cum. Pref.	1⅛—1⅜	4 7 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock.....	87 —89	4 10 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	99 —101	4 9 0	Jan, July	..	..
5	5/0	United River Plate Ord. ex rights	7⅛—7⅜	5 8 6	July	7⅛	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜—5½	4 9 0	June, Dec	..	..
St.	4½%	Do. 4½ Deb. St. Red.....	103 —105	4 5 6	Jan, July	..	..
		Financial, Investment, &c.					
	3/0	†Elec. & Gen. Investment 6% Cum. Pref...	2⅜—3⅛	9 4 6	Jan, July	..	..
10	2/0	†Globe Telegraph & Trust	10⅛—10⅝	5 9 6	Sp,DcMrJu	10⅛	..
10	3/0	Do. 6 per Cent. Pref.	13⅛—13¾	4 7 0	Sp,DcMrJu	13⅛	13⅛
10	6%	Submarine Cables Trust (Cert.)	133 —136	4 8 3	April, Oct	..	..
		Colonial and Foreign Electric Railways, Tramways, &c.					
St.	4½%	Anglo-Argentine 5% Cum. 1st Pref.	4⅛—4⅞	5 2 0	April, Oct	4⅛	4⅛
St.	4½%	Do. 5% Cum. 2nd Pref.....	4⅜—4⅞	5 10 0	Jan, July	4⅜	4⅛
5	..	Do. 4% Deb. Stock	92 —93½	4 5 6	June, Dec	93⅛	92
100	6%	Do. 4½% Deb. Stock	95 —97	4 12 6	..	96⅛	95½
St.	4½%	Auckland Elec. Trams. 5% Deb. (red.).....	103 —105	4 15 3	Jan, July	..	..
St.	5%	Brisbane Electric Trams. Invest. Ord	6 —6½	6 3 0	May	6	..
5	4/0	Do. 5 per Cent. Cum. Pref.	4½—5⅛	4 15 0	May, Nov	..	..
5	2/6	Do. 4½ per Cent. Db. Prov. Certs.....	99 —102	4 8 6	Jan, July	..	..
St.	4½%	British Columbia El. Rly. Df. Ord. ex rights	137 —141	5 12 6	Mar, Sept	139½	138
St.	8%	Do. Pref. Ord. Stock ..... ex rights	117 —121	4 19 0	May, Nov	120⅛	119
St.	£3	Do. 5% Cum. Perp. Pref. Stock.....	107 —111	4 10 3	Jan, July	110⅜	108
St.	5%	Do. 4½ per Cent. 1st Mort. Debs.....	102 —104	4 6 6	April, Oct	..	..
40	4½%	Do. Vancouver Power Debs.	100 —103	4 7 6	Jan, July	..	..
100	4½%	Do. 4½% Perp. Con. Deb. St.	103 —105	4 5 0	..	104⅛	103½
St.	4½%	Buenos Ayres Lacroze Trams 1st Mt. Db.	98 —100	5 0 0	Mar, Sept	—	..
St.	6%	Buenos Ayres Port & City Tram, 1st Mt. Deb. Stock	97 —100	6 0 0	Feb, Aug	98½	..
100	5%	Calcutta Tramways (1 to 137,610).....	4½—5	4 10 0	Mar, Sept	4⅜	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5⅛	4 17 6	Jan, July	..	..
1	2/6	Do. 4½% 1st Deb. Stock (red).....	96 —99	4 11 0	Jan, July	..	..
St.	..	Cape Electric Tram Shares	⅜—⅝	..	..	..	..
1	1/3	City of Buenos Ayres Trams Co. (1904) Sh.	5⅜—5⅝	4 5 6	F,My,A,N	5⅝	5⅛
St.	4%	Dc. 4 per Cent. Deb. Stock.....	99 —102	3 18 0	June, Dec	..	..
5	5/0	Colombo Tr. & Ltg. 5% 1st Mt. Db.....	97 —100	5 0 0	May, Nov	..	..
100	5%	Electric Traction Co. of Hong Kong 5 per Cent. 1st Mort. Debs.	79 —82	6 2 0	June, Dec	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	99 —101	5 4 0	Feb, Aug	98½	98
1	..	Kalgoorlie Elec. Trams Sh.	⅛—¼	..	..	..	..
100	5%	Do. 5 per Cent. "A" Deb. Stock.....	92 —95	5 5 0	Jan, July	..	..
5	6%	Do. 6 per Cent. "B" Ditto	71 —75	8 0 0	Jan, July	..	..
5	0/7½	Lisbon Elec. Trams. Ord.	1⅜—1⅝	4 15 6	July	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 16 0	Jan, July	1⅜	..
5	5%	Do. 5 per Cent. Reg. Mort. Debs.	98 —102	4 18 0	Jan, July	..	..
100	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —98	5 2 0	Jan, July	..	..
5½	5%	Manaos Trams and Lt. Co. 5% Debs	87½—89½	5 12 6	..	89½	88
100	5%	Manila Elec. Ry. $1,000 Gold Bonds.....	97½—99½	5 0 6	Feb, Aug	98½	..
100	$12	Mexico Trams Co. Com. St.	130 —132	4 13 0	..	130½	129
..	5%	Do. Gen. Con. 1st Mort. 5% Gold Bds.	97½—98½	5 1 0	..	98½	97½
..	6%	Do. 6% 50 yr. Mort. Bds.....	103½—105½	5 13 6	..	104½	103½
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922) (Nos. 601 to 2,000)	101 —103	4 7 0	Feb, Aug	..	..
		Do. do. (Nos. 1 to 4,600)	102 —104	4 6 0	..	103½	..
1	0/6	Perth Elec. Trams Ord.	¾—1	2 10 0	May	..	..
St.	5%	Do. 1st Mt. Db. Stock	100 —103	4 17 6	Jan, July	..	..
5	3/0	Rangoon Elec. Trams & Supply Co. 6% Cum. Pf.	5½—5¾	5 4 3	..	5½	..
St.	4½%	Do. 4½% 1st Mort. Deb. Stk.	99 —102	4 18 0	..	..	..
100	$12	Rio Janeiro Tram, Lt. & P. Co.....	105 —106	3 19 0	..	122⅜	105½
100	5%	Do. 30 yr. Gold Bnds.	99 —100	5 0 0	..	99⅝	98½
100	5%	†Do. 50 yr. Mt. Bnds	92 —93	5 7 6	..	93½	92
..	$2½	†Sao Paulo Tramway, Light & Power Co. $100 Stock	153 —155	6 9 0	..	155½	..
5	5%	Do. 5 per Cent. 1st Mt. $500 Db.	101 —103	4 17 0	June, Dec	102	101½
100	4½%	Toronto Ry. Co. 1st Mt. 4½% Ster. Bonds	100 —102	4 8 0	Feb, Aug	..	..
		Colonial and Foreign Electricity Supply, &c.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.....	5½—5¾	5 4 0	Mar, Sept	..	..
10	6/0	Bombay E.S. & T. 6% Cm. Pf.....	10½—11¼	5 5 9	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red).....	94 —96	4 13 6	Jan, July	..	..
5	4/9	Do. 5 per Cent. 2nd Mort. Deb. Stock..	97 —99	5 1 0	..	..	..
100	7/2½	Calcutta Elec. Supply Ord.	6⅛—6⅜	5 16 0	April, Oct	6⅜	..
100	$3½	Canadian Gen. Elec. Co. Com. St.....	108 —112	6 5 0	..	112½	111
100	5%	Do. 7% Cm. Pf. Stock	118 —121	5 15 6	..	..	..
100	5%	Castner Electrolytic Alkali Co.(of U.S.A.) 1st Mort. Stl. Debs.	95 —99	4 19 0	Jan, July	..	..
500	5%	Elect Development Co. of Ontario.....	82½—85½	5 17 0	..	84½	84
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	85 —88	5 14 0	Jan, July	..	..
5	..	Indian Elec. Sup. & Trac. Co.	1⅛—1⅜	..	..	..	..
10s	..	Kalgoorlie Elec. Power & Ltg. Ord.	⅛—¼	..	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	8 —8½	2 6	April, Oct	..	..
5	5%	Kaministiquia Power Co. 5% Gold Bnds...	100½—102½	5 0 6	..	..	..
5	..	Madras E. S. Corp. Ord.....	2¾—3	..	..	2¾	..
..	..	Melbourne E. S. Co. 6% Cum. Pref.....	33 —38	..	..	..	..
St.	5%	Do. 5% 1st Mortg. Deb. Stock.....	90½—92½	5 9 0	..	91⅛	..
500	5%	Mexican Elec. Light Co. 5% 1st Mort. Gold Bonds	90½—91½	5 10 0	..	91	9
St.	$1	Mexican Lt. & Power Co. Com. St.	88½—89½	4 12 6	..	89½	8
St.	$3½	Do. 7% Cum. Pref. St.	108½—109½	6 8 0	..	109½	1
500	5%	Do. 5% 1st Mort. Gold Bnds.	94 —95	5 5 6	..	95	9
100	$1½	Montreal Lt. Ht. & Power Co. Cap. St.	145 —150	4 13 6	F,My,A,N	143½	.
St.	£2	River Plate Electricity Co. Ord. Stk	210 —225	4 0 0	April	219	.
6%	6%	Do. 6 per Cent. non-Cum. Pref. Stk. ..	105 —115	5 5 0	May	..	.
5%	5%	Do. 5 per Cent. Deb. Stock	100½—102½	4 17 6	Jan, July	102½	.
5	3/0	Rosario Ele . Co. Ord.	8½—9	..	..	..	.
100	6%	Do. 6% Pref. (1-20,000)	6 —6½	4 12 0	April, Oct	..	.
100	$1	Do 2nd Pref.	8½—8¾	6 14 6	..	..	.
100	5%	Shawinigan Water & Power Co. Ca	104 —107	3 14 9	..	106	105
100	5%	Do. 5 per Cent. Bds.	108 —110	4 19 0	Jan, July	..	.
10	3/0	Do. 4½ Per Con. Mt. Db. St.	102 —104	4 6 0	..	..	.
St.	4½%	Toronto Power Co. 4½% Db. St.	100 —102	4 8 0	..	..	.
	4%	Victoria Falls Power Co. Pref. (1 to 806,000)	⅜—½	5 6 6	Jan, July	..	.
		Do. (803,081 to 1,200,000)	⅛—¼	..	..	..	.

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